"MANAGEMENT OF FISHERIES IN OPEN WATER SYSTEMS AND EXTENSION METHODS"

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CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
BARRACKPORE 743 101 West Bengal

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Content

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FOREWORD

The last two decades have seen a considerable rise in inland fish production triggered off by new scientific innovations and their use in commercial scale. This has imparted new dynamism to inland fisheries development and has given a new hope and confidence to large number of fish farmers/fishermen. Country's commendable achievements in this sector have been made possible due to the efforts of the Scientists, Extension Personnel and Fish farmers/Fishermen.

But there is still ample scope and requirement to double the inland fish production in the first two decades of 21st Century. It would only be possible if the available scientific technologies are brought to bear with the production process and programmes. This would require focussing more on transferring out new technologies, away from the confines of the laboratories, to the clientele so as to make them result and work oriented.

Keeping above in view and to enrich and update the knowledge and skills of the Developmental Officers/Subject Matter Specialists, working under State Fisheries Departments of the country, a 8-day training course on "Management of Fisheries in Open Water Systems and Extension Methods" was organised at the Institute during November 10-17, 1998 with financial assistance of the Directorate of Extension, Ministry of Agriculture, Government of India. This booklet is the compendium of lectures delivered by the experts in their respective fields during the training course. It is hoped that this booklet will be beneficial to all.

M. SINHA
DIRECTOR

Inland Fisheries resources of India and their utilization

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1. INTRODUCTION

Inland fish production in the country has registered a phenomenal increase during last about four decades. As against 0.2 million t produced in 1951, the production of inland fish in the country during 1995-96 is estimated at 2.2 million t. The projected domestic requirement in the country by 2002 AD is 12 million t, a half of which has to come from the inland sector. To achieve this national goal, proper development/conservation of inland open waters is a must for which a scientific understanding of all types of inland fisheries resources is imperative to back up their optimum exploitation. In addition to its capability of achieving the goal of required fish production, the inland open water fisheries being a labour intensive activity its development has the potential to improve the quality of life of some of the most vulnerable sections of the society. Out of the estimated 0.71 million fishers in the country, 0.49 million are inland fishers who live in abject poverty. Number of fishers per km of river stretch has been estimated to be 3.2 in Narmada to 7.8 in Ganga, the average being 6.5. However, there exists as many opportunities to augment the yield from inland fisheries resources as there are constraints which operate against them.

Inland fishery resources of India, comprising vast expanse of rivers, canals, estuaries, lagoons, reservoirs and floodplain wetlands (lakes) are noted for their variety as well as their rich production potential. (Table 1). The enormity and diversity of these systems demand separate, sector-wise approach in their development as they portray different pictures of environmental parameters and production dynamics. Dotted with floodplains, oxbow lakes, quiescent backwaters and interspersed deep pools, the rivers possess a mosaic of varying biotopes ranging from lotic to lentic habitats. A large number of river valley projects have been built and commissioned since independence, as a part of our developmental activities, resulting in a chain of new aquatic resources like irrigation canals and reservoirs. Extensive areas under floodplain wetlands in the form of *mauns, beels, chaurs, jheels* are available in eastern U.P., northern Bihar, West Bengal, Assam, Tripura, Manipur, Arunachal Pradesh and Meghalaya. These are shallow nutrient rich water bodies formed mainly due to change in river courses (or tectonic actions) and offer ample scope for culture-cum-capture fisheries. The end saline areas of the river systems, known as estuaries, and lagoons also form an important component of fishery resources of the country.

Table 1. Inland Fishery Resources of India (compiled)

Rivers	45,000 km
Reservoirs	3.15 million ha
Estuaries	2.7 million ha
Lagoons	0.19 million ha
Floodplain wetlands	0.24 million ha

2. RIVERINE FISHERIES

The extensive network of Indian rivers alongwith their tributaries, with a total length of over 45,000 km constitute one of the major inland fisheries resource of the country. Indian rivers carry a surface run off of 167.23 million ha metres which is 5.6% of the total run off flowing in all the rivers of the world. The river systems of the country comprise 14 major rivers, each draining a catchment of more than 20,000 km^2, 44 medium rivers, having catchment between 2000 and 20,000 km^2 and innumerable small rivers and streams that have a drainage of less than 2,000 km^2.

The Ganga river system, with its main tributaries like Yamuna, Ramganga, Ghagra, Gomti, Kosi, Gandak, Chambal, Sone etc., is the original habitat of the three major carp species of the sub-continent *viz.*, catla, rohu, and mrigal, better known as Indian major carps, and continues to be the source of its original germ plasm. The Gangetic system alone harbours not less than 265 species of fishes. Similarly 126 species belonging to 26 families have been recorded from the Brahmaputra system. The peninsular rivers have been reported to bear at least 76 fish species.

The riverine scene, however, is a complex mix of artisanal, subsistence and traditional fisheries with a highly dispersed and unorganised marketting system which frustrates all attempts to collect regular data on fish yield. A firm database being elusive, for production trends, one has to depend on the information collected by CIFRI from selected stretches of rivers Ganga, Brahmaputra, Narmada, Tapti, Godavari and Krishna. Based on the studies made by CIFRI the fish yield in these rivers vary from 0.64 to 1.6 t per km. The catch statistics over the years indicate some disturbing trends in the riverine sector, especially the Ganga. The biologically and economically desirable species have started giving way to the low value species, exhibiting an alarming swing in the population structure of Gangetic carps. The average yield of major carps has declined from 26.62 kg/ha/yr during 1958-61 to 2.55 kg/ha/yr during 1989-95. (Table 2).

Table 2. Estimated yield of Indian major carps in the river Ganga (in kg/ha/yr)
(Jhingran, 1992 + Personal communication)

Centres	1958-61	1961-69	1980-86	1989-95
Kanpur	83.5	24.3	-	-
Allahabad	15.6	21.5	9.29	1.72
Buxar	17.1	3.8	7.00	-
Patna	13.3	13.3	5.08	3.04
Bhagalpur	3.6	7.5	2.90	2.90
Mean	***26.62***	***14.08***	***6.07***	***2.55***

A survey of river Brahmaputra in the state of Assam brought to light a decline in the fishery of the middle and lower stretches of the river since 1972. The survey also revealed large-scale destruction of brood fishes and juveniles. A detailed survey conducted earlier in the Godavari also indicated a depletion in fish yield. The production potential in lower Ganga was estimated at 198.28 kg/ha/yr, whereas the actual fish yield was 30.03 kg/ha/yr and thus, only 15.15% of the potential is harvested. In the middle stretch the utilisation of the potential is marginally better than the lower stretch. However, in general, the potential is not fully utilised and there is enough scope for further improvement.

Unfortunately, the anadromous hilsa fishery has almost disappeared from the stretch of river Ganga above the Farakka barrage where it used to contribute a lucrative fishery upto 1,500 km up the sea mouth (up to Kanpur). Collapse of hilsa fisheries (Table 3) due to this river course modification has affected the lives of thousands of fishers along the riparian stretches in Uttar Pradesh and Bihar. Catadromous migrants like eels, freshwater prawn and *Pangasius* also seem to have been affected by such river course modifications.

Table 3. Average landings (in tons) of hilsa in middle stretch of river Ganga during pre-Farakka and post-Farakka periods. *(Jhingran, 1992)*

Centres	Pre-Farakka	Post-Farakka
Allahabad	19.30	1.04 (94.61)
Buxar	31.97	0.60 (98.12)
Bhagalpur	3.95	0.68 (83.05)

Figures in parentheses denote % decline

A significant development with regard to hilsa fisheries has been the attempts to practice its aquaranching for its revitalization. CIFRI has been successful in developing a hatchery management practice for hilsa to stock the depleted stretches of the river with the produced seed. Attempts in this direction have borne fruits and a sample consignment of hilsa seed has been stocked in the Ganga above Farakka barrage as well as in Ukai reservoir (Gujarat). This is the beginning of an ambitious plan to set up a hilsa hatchery at Farakka and to take up a regular stocking programme. But the practicability and success of this ranching programme is still a subject of controversy.

Recent tagging studies of hilsa by CIFRI have conclusively proved that the fish is able to negotiate the barrage during monsoons when the level of water on both sides is equal. Evidence of its breeding upstream have also been found. But its usefulness in rejuvenating the hilsa fishery is a matter of debate because of the required both way migration of fish in different stages of its life cycle.

2.1 Factors influencing fish yield

A recent study (1995-96) by CIFRI covering 43 centres on river Ganga from its origin to the sea mouth has revealed few starting facts of this aquatic environment. Environmental aberrations like sandification of river bed upto Patna (over 90% sand), blanketing the river bed productivity, and marked reduction in water volume due to increased sedimentation (caused due to deforestation in the catchment areas) and increased water abstraction, accompanied with river course modifications and irrational fishing practices appear to be key factors responsible for decline in fishery. Taking the river water as a whole, following the method of composite sampling across the river, pollution levels have been observed to be well within tolerance limits of fish and fish food organisms. This is quite in contrast to earlier observations of polluted stretches based on point sampling in and around effluxion points. The present ecological condition of Ganga water may also be a direct result of Ganga Action Plan (Phase I) launched in the year 1985.

Flood control measures, sedimentation and increased water abstraction also effect the flood regime and inundation of grounds needed for feeding and breeding. In the Ganga basin, 33.5 billion m^3 of water is presently held in storage reservoirs behind the weir and barrages apart from 18 major canal networks diverting the water to irrigate 7 m ha of agricultural land.

3. FISHERIES OF ESTUARIES AND LAGOONS

The various estuaries and lagoons in the country (Table 4) form an important component of fisheries resources of the country. The fisheries of estuaries of India are above the subsistence level and contribute significantly to the production. The average yield is estimated to sway from 45 to 75 kg/ha. The Hooghly-Matlah estuarine system, Chilka lagoon, Adyar and Mankanam estuaries, Pulicat lagoon, coastal belt of East Godavari, Vembanad lagoon and Mandovi estuary have also been identified to be excellent sources of naturally ocurring fish and prawn seed for exploitation for aquaculture purposes.

Table 4. Important Resources of Estuarine & Lagoon fisheries in India
(Updated from Jhingran, 1992)

Estuarine system	Estimated area (ha)	Production level (t)	Major fisheries
Hooghly-Matlah	802,900	20,000-40,000	Hilsa, *Harpodon, Trichiurus, Lates, prawns* etc.
Godavary estuary	18,000	c.5,000	Mullets, prawns
Mahanadi estuary	3,000	c.550	Mullets, bhetki, sciaenids, prawns
Narmada estuary	30,000	11148-13954	Prawn, Hilsa
Peninsular estuarine systems (Vasista, Vinatheyam, Adyar, Karuvoli, Ponniar, Vellar, Killai & Coleroon)	-	c.2,000	Mullets, prawns, clupieds, crabs
Chilka lagoon	62,000	c.4,000	Prawns, mullets, catfishes clupeids, perches, threadfins, sciaenids
Pulicat lake	36,900	760-1,370 (20.6-37.2 kg/ha)	Prawns, mullets, bhetki, pearlspot, chanos
Vembanad lake and Kerala backwaters	50,000	14,000-17,000 (fishes) 88,000 (live clams) 1,70,000 (dead shells)	Prawns, mullets, tilapia, bhetki
Wetlands of West Bengal			No data available on catch
a. Freshwater bheries	9,600	-	
b. Saline bheries	33,000		
Mangroves	1,36,200	-	No data available on catch

Mangroves are biologically sensitive ecosystems which play a vital role in breeding and nursery phases of many riverine and marine organisms of commercial value besides contributing through its own fishery. Nearly 85% of the Indian mangroves are restricted to Sunderbans in West Bengal and Bay Islands. The Indian share of Sunderbans covers an area of 4,264 km^2 of which 3,106 km^2 has already been lost due to reclamation, leaving only 1158 km^2. Several of its creeks are ideal sites for fish and prawn seed collection which sustains the aquaculture in the region, providing livelihood to thousands of fishers. The Sunderbans fishery comprises 18 species of prawn, 34 species of crabs and 120 species of fish besides 4 species of turtles.

River course modifications have played their part in estuarine fisheries also. A glaring example of the same is the over all decline in the salinity of Hooghly-Matlah estuary after commissioning of Farakka barrage (Sinha *et al.*, 1996) with gradient and marine zones being pushed down towards sea. This has brought about distinct change in the species composition of fishes caught, with freshwater species making their appearance in tidal zone and few neritic species disappearing. However, the stock of hilsa continues to be the prime fish of this estuary contributing 10-15% of the catch.

The likely impact of taming of river Narmada on its estuarine fishery is another such example. In a desk review (Anon, 1994) of likely impact of Narmada Sagar and Sardar Sarovar on the fisheries downstream, carried out by CIFRI for Narmada control Authority, it has been pointed out that as per report of the Narmada Water Dispute Tribunal (Anon, 1978) there would be 72.71% reduction in water availability downstream at 30 years of commencement of construction. It may not change the salinity regime during non-monsoon months but the annual event of dilution during monsoon months shall not be maintained. This shall effect the migratory fauna, particularly *Tenualosa ilisha* and *Macrobrachium rosenbergii*, and accordingly the fish yield of the downstream will decline. Stage attained at 45 years from the commencement of construction, when freshwater release from Sardar Sarovar shall cease, will be very critical as it shall be associated with steep hike in salinity and in absence of compromising factor (freshwater flow), the tidal ingress shall be more towards river side. It is most likely that the whole estuary shall undergo a transformation into a biotope characterised by hypersaline condition with salinity tongue further invading inland. Fishery shall drastically change. There shall be a total collapse of prevailing floodplains providing congenial breeding and feeding sites to fishes. Mangroves shall also be affected and the rich fishery harboured by them shall undergo a drastic change.

With the present height of 80.3 m attained by Sardar Sarovar dam, impact of impoundment are already discernible in the water downstream. They are in form of increased transparency, significant increase in dissolved oxygen, decline in the nutrient status and localized spurts in planktonic biomass. Presently, there seems to be no adverse impact due to present level of freshwater crunch in the downstream, but with further increase in dam height it is likely that consequences may be felt more prominently.

Recently conducted survey of Chilka lagoon in 1995-96 by CIFRI has indicated that regulated discharge in coming rivers, siltation and anthropogenic pressure have made marked negative impact on its fishery. Considerable decrease in size (from 906 sq.km. in 1965 to 620 sq.km. in 1995), siltation of lagoon bed and its connecting channel with the sea, profuse weed infestation, decrease in salinity (from 7.0 - 25.5 ppt in November, 1957 to 1.41 - 2.69 ppt in November 1995) and qualitative (28% prawn in 1965 to 14.4% prawn in 1995) as well as quantitative decline in the fishery (4237 tons in 1990 to 1672 tons in 1995) of this lagoon has been observed.

4. RESERVOIR FISHERIES

Large number of river valley projects have been built and commissioned in our country since independence as part of developmental activities. More such projects are on the arvil. Though created basically for irrigation or power, it forms the most important fishery resource in the country, at present, simply because of its magnitude. (Table 1).

Indian reservoirs are classified into large, medium and small (Table 5) based on their area. The fish yield from reservoirs in India is frustratingly low. At the present level of management, they yield, on an average about 30 kg/ha whereas, a production of 50-100 kg/ha can easily be realised from large and medium reservoirs. The small reservoirs have the potential to yield even more (100-300 kg/ha).

Table 5. Reservoir fishery resources of India *(After Sugunan, 1995 a)*

Category	Number	Area (ha)
Smal (< 1000 ha)	19,134	14,85,557
Medium (1000-5000 ha)	180	5,27,541
Large (> 5000 ha)	56	11,40,268
Total	**19,370**	**31,53,366**

The biological potential of reservoirs was not evaluated to any reliable level till 1970 when CIFRI took up an All India Coordinated Research Project on Ecology and Fisheries of Reservoirs and gave a new dimension to the sporadic work carried out until then. These studies brought about an improvement in technical capabilities and provided guidelines for managing the reservoir fisheries. The three pronged strategy comprising enlargement of mesh size, increase in fishing effort and stocking support has paid rich dividends (Table 6, Table 7). In large and medium reservoir the stocking support is for the purpose of establishing a breeding population of suitable species, whereas, in small reservoirs it is for the purpose of extensive aquaculture.

Table 6. Increase in fish yield obtained in medium and large reservoirs as a result of scientific management technique *(Anon, 1997)*

Reservoirs	**Yield (kg/ha)**	
	Before	***After***
Yeldari (Maharashtra)	3	37
Girna (Maharashtra)	15	45
Gandhisagar (Madhya Pradesh)	1	44
Ukai (Gujarat)	30	110
Gobindsagar (Himachal Pradesh)	20	100
Pong (Himachal Pradesh)	8	64
Bhavanisagar (Tamil Nadu)	30	94
Sathanur (Tamil Nadu)	26	108

In contrast to the large multi-purpose reservoirs, the small irrigation reservoirs, created on small intermittent water courses, serve to trap the surface run off for its abstraction during seasonal irrigation demands. Experience has revealed that these water bodies offer immense potential for fish husbandry through extensive aquaculture. Considering the urgent need to enhance inland fish production in the country, emphasis need be laid on a management approach of such water bodies based on optimum stocking of suitable species and effective recapture (culture based capture fisheries). A good response to this management option is discernible in many of the small Indian reservoirs raising their yield to 70-275 kg/ha/yr (Table 7).

Table 7. Increase in fish yield obtained in small reservoirs after adopting scientific management technique *(Anon, 1997)*

Reservoirs	Yield (kg/ha)	
	Before	*After*
Chulliar (Kerala)	35	275
Meenkara (Kerala)	10	105
Markonhalli (Karnataka)	5	70
Gulariya (U.P.)	33	170
Bachhra (U.P.)	NA	150
Baghla (U.P.)	NA	110
Thirumoorthy (Tamil Nadu)	70	200
Aliyar (Tamil Nadu)	27	215

Reservoir fisheries development is a must for a quantum jump in inland fish production in future as well as improving the socio-economic condition of 0.49 million fishers of the country. Sugunan (1995a) has compiled the present level of fish production and potential of different categories of reservoirs in the country (Table 8). It is evident therefrom that this resource alone has the potential to yield 0.24 million ton of fish, with modest targets of average production, if managed on scientific lines.

Table 8. Present yield and potential of production from different categories of reservoirs in India *(After Sugunan, 1995 a)*

Category	Total available area (ha)	Present		Potential	
		Avg. Production (kg/ha)	*Fish production (t)*	*Avg. Production (kg/ha)*	*Fish production (t)*
Small	1485557	49.90	74129	100	148556
Medium	527541	12.30	6488	75	39565
Large	1140268	11.43	13033	50	57013
Total	3153366	29.7	93650	77.7	245134

5. FISHERIES OF FLOODPLAIN WETLANDS

India has extensive riverine wetlands in the form of oxbow lakes (locally called *mauns, chaurs, beels, jheels)* especially in the states of Assam, Bihar, eastern U.P. and West Bengal. State-wise areas of wetlands associated with the floodplains of the riverine systems of Ganga and Brahmaputra are depicted in Table 9.

Table 9. Distribution of floodplain wetland in India *(Sugunan, 1995 b)*

State	River basins	Local names	Area (ha)
Arunachal Pradesh	Kameng, Subansiri, Dibang, Lohit, Dihing & Tira	*beel*	2,500
Assam	Brahmaputra & Barak	*beel*	1,00,000
Bihar	Gandak & Kosi	*mauns, chaurs*	40,000
Manipur	Iral, Imphal, Thoubal	*pat*	16,500
Meghalaya	Someshwari & Jinjiram	*beel*	213
Tripura	Gumti	*beel*	500
West Bengal	Ganga & Ichamati, Hooghly & Matlah	*beel, bheries*	42,500 40,000
Total			**2,42,213**

Floodplain wetlands can be broadly divided into two categories. Those which have retained their connection with the parent river through narrow channels atleast during monsoon are called open *beels*, while the ones which are cut off permanently from the parent rivers are called closed *beels*. Besides occuppying a prominent position among the culture based capture fisheries of India, by way of their magnitude as well as production potential, the open type of floodplain wetlands have vital bearing on the recruitment of population in the riverine ecosystem and provide excellent nursery grounds for several fish species and a host of other fauna and flora.

Nutrient-wise these bodies are extremely rich as reflected by rich organic carbon and high levels of available nitrogen and phosphorous in their soil. But these nutrients are usually locked up in the form of large aquatic plants, especially water hyacinth, and thus unable to contribute to fish productivity. The ecologically degraded condition of floodplain wetlands and lack of proper management measures have resulted in their swampification and rather paltry fish yield (100-300 kg/ha/yr), against a production potential of 1000-1800 kg/ha/yr through scientific management, leaving a significantly wide gap between the actual yield and their harvest potential.

In most of the *beels*, marginal areas are utilised for agricultural purposes. These water bodies are subjected to a variety of environmental stresses especially from pesticides and other agricultural run off, municipal wastes and siltation. The siltation adversely effects the reproduction of fish by accumulation of sediments in the marginal areas of the beels which form the breeding grounds for the fish. Adverse breeding conditions in open beels also adverselyeffects the concerned river's fishery as they are the ideal breeding grounds for riverine fish populations.

The floodplain wetlands, by virtue of their productive potential as well as magnitude, constitute one of the frontline areas, capable of contributing substantially to country's fish production. The management strategy for this vital sector should be based on a category-wise approach. Optimum exploitation of floodplains with riverine connection should revolve round the concept of keeping the deeper central portion exclusively for capture fisheries and utilization of margins and pockets for culture fisheries. Capture fisheries would entail monitoring of recruitment and subsequent growth of natural population. In closed wetlands stocking is the mainstay of management, whereas in weed choked lakes, clearance of weeds and a detritivore-oriented stocking schedule would enhance the yield rate considerably (Yadava, 1987).These lakes also provide ideal conditions for pen culture operations. CIFRI has evolved and demonstrated technologies for production of 3-4 t/ha/6 months of major carps and 1,000-1,300 kg/ha/3 months of freshwater prawn through pen culture in such water bodies.

6. MAJOR CONSTRAINTS IN DEVELOPMENT OF INLAND FISHERIES

A number of diverse and complex problems confront the inland fishery managers. The constraints can be broadly grouped under four major heads *viz.*, biological, environmental, socio-economic and legal.

6.1. Biological constraints

The extraction of fish riches from the rivers, based on the principle of maximum sustained yield, has not been possible in the Indian context. Fishing has been guided by the principles of economic profit rather than biological principles. The intensity of fishing, nature of exploitation and species orientation in the characteristic artisanal fisheries of Indian rivers are governed by *(1) seasonality of riverine fishing activity; (2) unstable catch composition; (3) conflicting multiple use of river water; (4) cultural stresses leading to nutrient loading; (5) lack of understanding of the fluvial system and infirm data base; (6) fragmentary and outmoded conservation measures lacking enforcement machinery; (7) inadequacyy of infrastructure and supporting services; (8) defective marketing and distribution systems ; (9) demand directed by availability; affordability, and palatability, and (10) socio-economic and socio-cultural determinants* (Jhingran, 1984).

Infirm database of inland fisheries resources has been another serious constraint plaguing the development process. Even market intelligence statistics suffered from various drawbacks due to disposal of appreciable quantity of fish that passed directly from the primary producers to consumers. Through a Central Sector Scheme on Inland Fisheries Statistics, launched during Seventh Plan by Union Ministry of Agriculture, CIFRI has been able to evolve a methodology for data collection on inland fisheries. It is expected that in years to come the database in this field would also be firm.

Absence of suitable fish yield models for the multi-species fisheries of our open waters is a major biological constraint for formulating a successful management strategy. Developing such a model, keeping an eye on hydrology and fish stocks, accompanied with observance of closed season and setting up of fish sanctuaries will definitely prove its efficacy in fostering recovery of impaired open water fishery of our country.

6.2 *Environmental constraints*

Notwithstanding the rather discouraging picture the riverine sector portrays, conservation and management of the biological resources of the rivers assume greater significance in the Indian context. Some definite steps have been taken in this direction during the last few years, among which the Ganga Action Plan (GAP) is worth mentioning. GAP is a massive national project launched in the year 1985 with a view to halting and reversing the process of environmental degradation in India's prime river, the Ganga. The main objectives were to improve the water quality of the river Ganga and its tributaries to acceptable standards and to oversee the implementation of a long-term programme for undertaking suitable measures for restoring the water quality of the river Ganga. Till 1991, 368 mld of domestic sewage has been diverted through the efforts of GAP. Water quality of river Ganga has shown definite improvement at the stations that completed pollution abatement schemes (Table 10).

But the problem of sedimentation and water abstraction, two main factors adversely effecting fisheries of rivers and floodplain wetlands have not been given due attention so far in the fishery perspective.

Table 10 : Ecological changes in the river Ganga at Kanpur due to diversion of sewage effluents *(After Jhingran 1992)*

Zone	Before diversion				After diversion			
	1	*2*	*3*	*4*	*1*	*2*	*3*	*4*
Energy fixed by producers (cal/m^2/day)	4152	2968	3913	222	4352	3212	5309	5256
Photosynthetic efficiency (%)	0.355	0.254	0.330	0.019	0.372	0.272	0.454	4.50
Fish production potential (kg/ha/yr)	144	103	136	8	151	111	184	182

6.3 *Socio-economic constraints*

The riverine fishers constitute a section of economically weak, tradition-bound society. Most of them live at subsistence level or below poverty line. The environmental degradations and the resultant decline in fish populations have deprived them of a steady catch. The problems are further compounded by the competition among fishers due to increase in their population.

Socio-economic milieu under which the inland fishermen operate is not conducive enough to attract credit and infrastructure support for required modern crafts and gear from traditional banking and financial Institutions. A sector's ability to attract finance and specially loanable funds depends largely on evaluation of risk elements by prospective funding agencies. The migratory character, seasonality of fishing activity and unstable catch composition of capture fishery does adversely effect investment appraisal and assessment of funding possibilities because of various reasons. There is an inescapable need to evolve some distinct criteria for financing the capture and culture based capture fisheries of inland open waters where the input-output relations are relatively less precise. This would need evolving a new set of criteria for the creditworthiness and repaying capacity of such fishers.

6.4 *Legal constraints*

Fisheries legislation in the country is, by and large, guided by the Indian Fisheries Act 1897, which stipulates the closed season, defines the irrational fishing practices to be prohibited and limits the minimum size of fishes and the mesh sizes to be employed. Prepared basically on empirical knowledge available at that time, this act can be termed, at best, as a reference material for law makers. In India, fisheries being a state subject, it is the prerogative of the state governments to frame rules on conservation and management of riverine fisheries resources. Many states in India like West Bengal (till recently) and the states in North East have no fisheries legislation. Rajasthan enacted fisheries legislation in 1984. Some states like Uttar Pradesh, Andhra Pradesh, Madhya Pradesh and Kerala have some rules for regulation of fisheries but they have played a subordinate role owing to enforcement problems. More efforts and emphasis are needed for strict enforcement of the legal provisions.

The complexity of factors involved in regulation of fisheries in India stems largely from the common property nature of resources, difficulties in enforcing a limited access concept, divergent auctioning and leasing policies followed by different states and the multiplicity of agencies that control the water resources and regulate the environmental parameters. Considering the urgent need for a comprehensive legislation, a legal sub committee has been constituted under the Ganga Action Plan and a draft legislation prepared.

7. CONCLUSION

The development of inland fisheries in India is a must to obtain the required quantity of fish but it is at a critical point in its development. Degradation and loss of fisheries habitats are increasing and a national perspective is essential for the sustainable development and exploitation of our inland fisheries resources. Ecosystems are threatened by fast changing coastal configurations, wetlands loss, environmental perturbations and destructive fishing practices. These resources in developing countries are specially vulnerable because the national priorities for their development are often in conflict with the norms of conservation. Development strategies need to have a holistic approach suiting to all aspects of the resource. In the integrated development of multipurpose use systems, it should be mandatory to develop all living resources together.

Thus, a system which links the management of fisheries, forestry and agriculture to agro-industrial and hydro-electric units will facilitate optimization of production from the river basin. Sound environmental protection norms, keeping fisheries in perspective, accompanied with due priority for proper utilisation of available inland fisheries resources is a must for sustainable development. CIFRI would continue to provide the required research back up to combine the environmental norms and sustainable development of inland fisheries resources in order to meet the requirement of the country. It is essential that all concerned (scientists, planners and development agencies) work together for utilisation of this most important resource bestowed to us by nature.

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Estimation of Inland Fishery resources by conventional and remote sensing techniques

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In terms of food requirement, aquaculture perhaps stands next to agriculture. Rapidly growing population of the world has resulted into growing demand for food, drinking water, energy and livable environment. The problem of food has become more acute in developing countries due to their low productivity, poor animal husbandry and fisheries as these countries occupies 55% of the geographical area while carrying over 75% of the world population. The continued environmental degradation caused due to indescriminate resource depletion ultimately lead to disastrous situations instead of bringing in prosperity and self sufficiency to the region. The countries especially south asian region are facing acute problem related to management of their natural resources and environment. The future seems grim for them unless better management is planned for the socio-economic development and optimum management of natural resources with a long term perspective.

Thus, it becomes imperative that reliable and timely data base on various fisheries resources should be available for their optimum development without adversely affecting the other resources and/or environment. Inland fisheries resource management aims at inventoring, monitoring and management of surface water resources which harbour the fish and aquatic biodiversity. Hence, basic data on resource and levels of production of fisheries is a prerequiste for formulating development plans for economic and social advancement. For this purpose, it becomes necessary to collect relevant information on the extent of resources and production in order to derive maximum sustainable benefits. Data on various aspects of fisheries are also needed at community development blocks level in India for fixing the targets of production and for assessing the progress of various development programmes being conducted.

Methods of Assessment

Inland capture and culture fisheries is a widely dispersed activity in most of the countries. Hence, monitoring and enumeration of these resources need large human and financial resources in order to collect reliable data. Total enumeration/census of these resources is a very costly and complicated operation and hence can be avoided taking into consideration of cost and benefit factors. The sample surveys based on sound statistical methods with larger coverage through point-source measurements may be the way out of this impass in order to develop comprehensive and reliable data base useful for planners to formulate appropriate strategy for development of inland fisheries. Other methods which may be employed on a large scale to estimate the surface water spread, their shape and distribution may be remote sensing techniques. In the succeeding text we will discuss these two methods in details for employing those for assessment of these resources.

Convention Methods based on Point Source Measurement

As discussed earlier, sample survey techniques are mostly used to gather information on inland fisheries resources and productivity. For accurate and reliable assessment of production, it is essential that some sample survey methods are designed with high degree of precision. But before we discuss these methods which are based on the exploitation and marketing intelligence information, we would look into all the typical resource categories and suggest appropriate classification so that suitable sampling procedure may be formulated for each class and sampling estimates are derived.

Inland fisheries resources cover diverse nature of water bodies which can be summarised below :

Fresh water resources

1. Aquaculture ponds and tanks
2. Large irrigation tanks
3. Ox-bow lakes/cut off meanders
4. Reservoirs
5. Swamps
6. Palays
7. Waterlogged
8. Quarries
9. Ash ponds
10. Excavations
11. Rivers and canals

Saline water

1. Lagoons
2. Estuaries
3. Creek
4. Mangrove
5. Salt pans
6. Marsh
7. Other impoundments (such as berries of West Bengal)

So many of the above water contribute very meagrely to the total catch, and, therefore, can be left out from the purview of the classification for the purpose of fish production assessment. Hence, for assessment and evaluation of significantly importantly resources, we classify them into three broad categories and suggest methods of sample surveys for estimation.

Group - I (Water bodies upto 10 ha. of water spread area)

1. Aquaculture ponds and tanks
2. Brackishwater impoundments
3. Waterlogged areas

Group - II

1. Large irrigation tanks
2. Reservoirs and check dams
3. Lakes

Group - III

1. Rivers
2. Canals
3. Estuaries
4. Lagoons
5. Back waters

Sampling Design

The whole state is divided into three nearly homogenous groups called strata (each stratum comprising a number of districts) on the basis of certain characteristics such as climate, rainfall, soil quality etc. Strata should be formed in such a way that geographical contiguity of districts within the stratum is maintained. From each stratum a sample of 30% districts may be selected at random for the sample survey. Further sampling within each selected district is discussed for each group separately in the succeeding paragraphs.

Sampling procedure for Group I water bodies

Sampling frame should be prepared for each selected district by making a list of villages. This can be achieved by using the census records. Villages having water bodies of this group may be highlighted and clusters of five nearby villages is formed from among the pond bearing villages. From these clusters a sample of nine clusters is selected by random sampling for assessment of water spread area. A further sampling of five ponds in each cluster is recommended for estimation of fish production.

The whole selection procedure may be encompassed under stratified three stage sampling where districts, clusters and ponds are first, second and third stage units of selection respectively.

Sampling procedure for Group II water bodies

As far as area statistics is concerned, a total inventory of resource under each stratum for group-II should be prepared and a sub group of small, medium and large units as defined elsewhere in the text made. 25 to 30% sample water bodies at random from each sub-group of each stratum is selected for collection of data on fish catch. Catch data from selected waterbodies is recorded in the following manner.

Investigations have shown that two types of exploitation pattern is adopted in these waterbodies. They are :

(1) Waterbodies which are harvested for a short interval extending from a fortnight to about a month during the year. These waterbodies are mostly small reservoirs and lakes which fall under the purview of state departments and exploitation is affected either by auctioning them to private contractors under certain terms and conditions or exploited departmentally by engaging contract labour. Hence, the bulk of harvest is a one time operation which continues for a fortnight to about a month. Data for such waterbodies may be collected on total enumeration basis.

(2) Water bodies which are exploited round the year by fishermen cooperatives or individual fishermen on the basis of licenses, free fishing, royalty or any other such mode. In such situation 4 to 6 days may be selected for on the spot observation of catch and production may be assessed as per the formula given under estimation procedure.

Sampling procedure for Group III water bodies

Sampling frame for this group is prepared by enlisting district-wise all the fishing villages/landing centres in each of the strata. 25 to 30% of these units are selected by random sampling from amongst the selected districts of each stratum at the second stage. For each selected unit 4 to 6 sampling days within a month are further selected at the third stage for collection of catch data.

Limitations of conventional methods

The conventional methods tend to be slow, costly, arduous, require large manpower and suffer from the hazards of subjectivity. Moreover, in the conventional approach, there is no satisfactory solution for resource mapping in inaccessible or poorly accesible areas. Further these methods are inaccurate and time cosuming.

Remote Sensing Methods

These methods offer the advantage of reliability, speed, and cost effectiveness over the conventional procedure. As a cosequence, remote sensing methods are advancing very rapidly and the technology is increasingly used as an operational modern procedure rather than an alternative experimental tool. The advantahe of RS is providing synoptic view and repetitive coverage of large areas to enable better understanding of the interrelationships among the different crops and their land uses, physiographic units and environmental functions.

Remote sensing is the science of deriving information about an object from measurement made at a distance from the object, i.e. without coming into contact with it. This is accomplished by measuring electromagnetic radiation (EMR) reflected or emitted by the object on the surface of the earth. Different objects return different amounts of energy at different wavelength of the EMR. These return energies are detected by air-borne and space-borne sensors and are subsequently converted into different forms of data. The problem of misinterpretation of a few objects, having similar spectral response, is overcome by sample checking through truth data collection.

Methodology

Analysis of satellite data is carried out using visual analysis techniques. Identification and discrimination of various water bodies require quantitative use of subtle differences in their spectral data, and rely mostly on digital image processing techniques. The area estimation procedure broadly consists of identifying water bodies on the image based on ground truth collected, generation of signatures and classifying the image using training statistics. Estimation is carried out by analysing pre and post monsoon data.

Base map preparation

Base maps on 1:250 000 scale is prepared for the state using available 1:250 000 scale SOI topographical maps and by enlarging 1:1M scale SOI maps (for those areas, for which SOI topographical maps were not available at 1:250 000 scale). Various prominent features like rivers, reservoirs, roads, railways and major settlements are marked on the base maps to serve as controls during interpretation.

RS Data Interpretation

RS Data Interpretation for surface waterbodies can be defined as detecting, delineating and identifying water bodies at the chosen categories levels (controlled by the scale of mapping as well as by spatial and spectral resolutions of RS data) based on their spectral signatures gained as a result of ground truth. Two set of temporal data namely pre-monsoon and post-monsoon may be preferred for analysis to detect the changes in the surface water area over an year.

Ground Data Collection

Ground truth is an integral part of the RS. These observations should be distinguished throughout the survey area, covering all types of waterbodies. Success of ground truth collection in the context of image interpretation of necessity depends on the accurate location of the observation site. One method to achieve this accuracy is to pin-prick the imagery at the site location using detectable ground reference points. The pin-prick is circled on the back of the imagery and numbered corresponding to the number on the field form. Period of ground truth collection should preferably match the period of satellite pass within reasonable variations.

Visual Interpretation

The availability of remotely sensed data from new sensors with better resolution in different wavelength regions and a variety of data products have improved their uses for the purpose of surface water and catchment area mapping by manual methods. Single band black and white imagery, standard false colour composites or enhanced colour composites in the form of paper prints or transparencies are used in visual interpretation. Visual image interpretation involves an understanding of spectral nature of the objects (water bodies, vegetation) and the basic large characteristics namely greytone/colour, texture, pattern, shape, size, shadow, location and association. Other factors influencing image interpretability are spatial resolution, scale and the date of imagery.

The basic principles of Visual interpretation are :

1. The RS imagery is a pictorial representation of the pattern of landscapes.
2. The pattern is composed of elements which reflect physical, biological and cultural components of the landscapes.
3. Similar conditions in similar environments reflect similar pattern and unlike conditions reflect unlike patterns.

4. The type and amount of information which can be extracted is proportional to the knowledge (reference level), experience, skill, interest and local knowledge of the interpreter, the methods used and the awareness of the limitations.

Visual interpretation allows human logic and intuition in translating the image into meaningful information. Techniques such as stratification based on variations in geology, landform and elevation and natural vegetation corresponding to the parent material, topography and biotic factors of pedogenesis, improve the interpretability to a great extent. Normally visual interpretation is performed either with single band black and white imagery or false colour composite. Interpretation of enhanced image provides better information than is possible from raw data image.

The visual interpretation generally precedes from general considerations to specific details and from known to unknown classes. Major land forms are first delineated using detectable patterns on the imagery. It may not be always possible to correlate the pattern per se with landform but by reference to corresponding topographical map and by employing the principle of conjugate evidence it would be possible to identify the patterns as 'probably, possibly or certainly' a specific landform.

Advantages of remote sensing estimation

The remote sensing technique has manifold advantages over the conventional methods of gathering information about the earth's surface. The remote sensing data provide a synoptic view of the terrain which helps in rapid reconnaissance studies at regional level and thereby in minimising the field surveys. The technique offers high-speed computerised automatic data processing on spatial and real time basis which enables timely action to be taken. Since the data outputs are in the form of paper prints and computer compatible tapes (CCT), these become permanent records of the terrain and land cover as existing on the date of observation and can be used in the laboratory itself as and when required. The large number of satellites in the orbit provide temporal data. For example, Landsat IV and V had repetitive cycles of 16 days and were so spaced in the orbit that data for any particular area could be obtained every 8 days using these two satellites together.

ROLE OF ABIOTIC FACTORS IN MANAGEMENT OF FISHERIES IN OPEN WATER FISHERIES SYSTEMS

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INTRODUCTION

More than 3 million ha, of water area are available in the country in the form of large , medium and small reservoirs while more than 2 la. ha., in the form of both open and closed Beels mainly in eastern U.P., Bihar (north) and West Bengal, Assam and other northern States. Reservoirs are characterised by release of deep water, existence of both lotic and lentic components and wide seasonal fluctuations in water level, although in small reservoirs some of these characters do not exist. Beels on the other hand, are comparatively shallow in nature and rich in soil status with penetration of light at the bottom resulting in infestation of aquatic macrophytes with varying magnitudes. It is essential to have a critical examination of the ecosystem itself and the various factors responsible for its production process. The abiotic habitats variables, dynamics of chemical constituents and effective circulation of nutrients are some of the basic processes which have been great bearing on the production of the ecosystems. In addition to beels and small reservoirs, some large reservoirs have also been considered for better understanding of the role these parameters in the production process.

PRODUCTIVITY INDICES

CLIMATE, EDAPHIC AND MORPHOMETERIC FEATURES

Biological productivity of any water body is influenced by climate, edaphic and morphometric features. The climate (Air temperature, Wind Velocity, and Rainfall.) have great bearing on productivity. The wide seasonal variation in air temperature, with low values during winter and high during summer have great influence on the thermal features of the Sub- tropical water bodies although in Southern peninsular India the seasonal differences are narrow. The incident solar radiation on the water surface also shows considerable variations with the location (latitude).

Water Level, Depth, Shore Development, Volume

The water level, depth, water discharge (both in and out), shore development, Volume development (morphometric factors) etc., also have great bearing on the circulation of nutrients and energy in the aquatic biotopes. Climate and edaphic factors provide essential source of energy and nutrients as such they are very important. morphometric factors which serve as modifying which determine heat and nutrient characteristics are second in order of importance. Rawson (1952) observed inverse relationship between mean depth and productivity based on the fact that shallower water bodies provide better circulation of nutrients. North cote & Larkin (1956) recorded that waters with high dissolved solids (TDS) are more productive than those with low values and recorded a direct relation between TDS (edaphic characters) and productivity. In Morpho–Edaphic Index (MEI) which is the ratio of an edaphic character (dissolved solids) and mean depth, a morphometric character, and this is used as an index of productivity.

PRODUCTIVITY AND CHEMICAL CONSTITUENTS

The water in an aquatic system consists of two fundamentally different regions one below the other as per biological productivity in which opposing processes take place. These are the regions of photosynthetic production (the trophogenic-zone) over the regions of breakdown (tropholytic-zone) . In photosynthetic zone carbon- di-oxide is taken up by the photosynthetic organisms, resulting in decrease in bicarbonates and increase in carbonate and pH ($2HCO_3 = CO_2 + CO_3 + H_2O$). Oxygen is liberated and increase in concentration ($6\ CO_2 + 6H_2O = C_6\ H_{12}\ O_6 + 6\ O_2$). In the tropholytic zone Oxygen is consumed, carbon dioxide is liberated, carbonate is converted to bicarbonate ($C_6H_{12}\ O_6 + 6O_2 = 6\ CO_2 + 6H_2O\ CO_2 + H_2O = 2HCO_3$) and pH decreases with increase in hydrogen ion concentration ($CO_2 + H_2O = H_2CO_3 = H+ + HCO_3$ -)

At night when there is no photosynthesis, the reactions at trophogenic and tropholytic zones are the same. If the rates of reactions in the two phases are high the water body will show sharp variations in the chemical parameters either with the progress of the day (diel-variations) or in depth profile during stagnation period. In deep waters the two zones are separate (in case of reservoirs) but in shallow waters variations in the chemical parameters reflect the intensity of reactions in both the zones . As the rate of above reactions are directly related to the production (P) and the consumption (C) processes the relative productivity of the water body can be evaluated from the magnitude of their variations.

This index gives correct indication of productivity in natural lakes which is applied in reservoirs, with fluctuating morphometeric characters and the edaphic characters being more influenced by catchments this index does not always yield the accurate results. For example many shallow reservoir with high values of morpho-edaphic indices are low productive while many deep reservoirs are highly productive. Total alkalinity (a correlate of total dissolved solids) has been used for index calculation. Thus one has to be very cautious in using this index for productivity evaluations. This is more true in case of small reservoirs where depth is generally less with more dominant edaphic characters.

HYDROLOGICAL CHARACTERISTICS

Open water bodies and closed water bodies (small reservoirs & beels) both vary widely in respect of their water quality parameters. Water with higher alkalinity , conductance, dissolved salts are more productive than those with lower values (Northcote & Larkin, 1956). Water with moderate alkaline pH, alkalinity above 50 mg/l, conductance above 200 m. mhos./cm, hardness above 25 mg/l , organic carbon around 1mg/l or above nitrate above 0.5 mg/l are considered to be productive . In beels generally the nutrients status in the water phase is poor despite the very high values in the soil phase. Since, most of the nutrients are used and locked by the infested macrophytes and are removed from circulation, as such water always shows nutrient deficiency.

Some of the physico-chemical parameters which are essential for determining productivity of open water bodies are as under:

Suspended Matter, Turbidity and Transparency

The type and concentration of suspended matter controls the turbidity and transparency. Suspended matter consists of silt, Clay fine particles & organic and inorganic matter, soluble organic compounds, plankton and other microscopic organisms. Heavy rainfall can also result in hourly variations in turbidity. Turbidity determines the primary productivity in the aquatic systems.

PH, Acidity, and Alkalinity

It is an important variables in water quality assessment as it influences many biological and chemical processes within a water body and all processes associated with water supply and treatment are influenced with it. When measuring the effects of an effluent discharge, it can be used to help determine the extent of the effluent plume in the water body.
The pH is a measure of the acid balance of a solution and is defined as the negatively of the logarithem to the base 10 , of the hydrogen ion concentration . In unpolluted water, pH is principally controlled by the balance between the Carbon dioxide, Carbonate, and Bicarbonate ions as well as other natural compounds such as humic acid, fulvic acids . Diel variations in pH can be caused by the photosynthesis and respirations cycles of algae in eutrophic water. The pH of the most water is between 6.0-8.5.Acidity and alkalinity are the base and acid neutralizing capacity of water.

Dissolved Oxygen

Oxygen is essential to all forms of aquatic life including those organisms responsible for the self purification processes in natural waterways. The Oxygen content in natural waters varies with temperature, Salinity, turbulence, the photosynthetic activity of the algae and plants and atmospheric pressure. The solubility of the Oxygen decreases as temperature & salinity increases. Determination of DO concentration is a fundamental part of a water quality assessment ,since Oxygen is involved in or influences nearly all chemical and biological processes within water bodies. Below 5 mg/l may adversely affect the functioning and survival of biological communities and below 2 mg/l may lead to death of most of the fish. The measurement of DO can be used to indicate the degree of pollution by organic matter , the destruction of organic substances and the level of self purification of the water. Its determination is also used in the measurement of biochemical oxygen demand (BOD).

Carbon-dioxide

It is highly soluble in water and atmospheric CO_2 is absorbed at the air water interface. In addition CO_2 is produced within water bodies by the respiration of aquatic biota, during aerobic and anaerobic metamorphic decomposition of suspended and sediment organic matter. Carbon dioxide is dissolved in natural water is part of an equilibrium involving bicarbonate and carbonate ions.

Nitrogen

Nitrogen is essential for living organisms as an important constituent of proteins, including genetic material. Plants and microorganisms convert inorganic nitrogen to organic forms. In the environment inorganic nitrogen occurs in a range of oxidation states as (NO_3 -) NO_2 - , the NH_4 + and molecular transformations in the environment as part of the nitrogen cycle. The major non-biological processes involve phase transformation such as volatilization , sorption, and sedimentation. The biological transformation consists (a) assimilation of inorganic forms (ammonia and nitrate) by plants & micro-organisms to form organic nitrogen e.g., amino acids, (b) reduction of nitrogen gas to ammonia and organic nitrogen by micro-organisms, (c) Complex heterotrophic conversions from one organisms to another. (d), Oxidation of ammonia to nitrate and nitrite (Nitrification) , (e) ammonification of organic nitrogen to produce ammonia during the decomposition of organic matter , (f)bacterial reduction of nitrate to nitrous oxide (N_2O) and molecular nitrogen (N_2) under anoxic conditions (denitrification).

Ammonia

Ammonia occurs in water bodies arising from the breakdown of nitrogenous organic and inorganic matter in soil and water, excretion by biota, reduction of nitrogen gas in water by micro-organisms and from gas exchange with the atmosphere. It is also discharged into water bodies by some industrial processes (Pulp and paper industries) and also as a component of municipal or community waste. At certain pH levels high concentrations of NH_3 are toxic to aquatic life and therefore, detrimental to the ecological balance of water bodies.

Nitrate and Nitrite

The nitrate ion (NO_3-) is the common form of combined nitrogen found in natural water. It may be bio-chemically reduced to nitrite (NO_2-) by denitrification processes usually under anaerobic conditions. The nitrite ion is rapidly oxidised to nitrate. Natural sources of nitrate to surface water include igneous rocks land drainage, and plant and animal debris. Nitrate is an essential nutrient for aquatic plants and seasonal fluctuations can be caused by plant growth decay. Determination of nitrate plus nitrite in surface waters gives a general indication of the nutrient status and level of organic pollution.

Organic Nitrogen

It consists mainly of protein substances (e.g., amino acids, nucleic acids, & Urine) and the product of their biochemical transformations (e.g., humic acids & fulvic acids).

Phosphorous

Phosphorous is an essential nutrient for living organisms and exists in water bodies as both dissolved and particulate species. It is generally the limiting nutrient for algal growth and, therefore, controls the primary productivity of water bodies. Artificial increases in concentration due to human activities are the principal causes of eutrophication. In natural water and in waste-waters, phosphorous occurs mostly as dissolved orthophosphates and polyphosphate and organically bound phosphates. Changes between their forms occur continuously due to decomposition and synthesis of organically bound forms and oxidised inorganic forms. Natural sources of Phosphorous are mainly weathering of phosphorous bearing rocks and the decomposition of organic matter. Phosphorous from 0.005 to 0.020mg /l found in natural waters. High concentration of Phosphates can indicate the presence of pollution and are responsible for eutrophic condition. Phosphorous concentrations are generally determined as orthophosphates, total inorganic phosphates or total phosphorous (Organically) combined phosphorous.

COD

It is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant , such as dichromate. The COD is widely used as a measure of the susceptibility to oxidation of organic and inorganic materials present in water bodies and in the effluents from sewage and industrial plants. The standard method for measurement of COD is oxidation of the sample with Potassium dichromate in a sulphuric acid solution followed by a titration.

BOD

The biochemical oxygen demand is an approximate measure of the amount of bio-chemically degradable organic matter present in water sample. It is defined by the amount of oxygen required for the aerobic micro-organisms present in the sample to oxidise the organic matter to a stable inorganic form. Un-polluted wastes typically have BOD values of 2 mg/l O2 or less.

Calcium

It is present in all water as a Ca + and is readily dissolved from rocks rich in Calcium minerals, particularly as Carbonates and Sulphates, especially limestone & gypsum. Calcium compounds are stable in water when Carbon- dioxide is present , but Calcium concentration can fall when $CaCO_3$ precipitates due to increased water temperature, photosynthetic activity or loss of CO_2 due to increase in pressure.

Calcium is an essential dominant nutrient for all organisms and is incorporated into the shells of many aquatic in-vertibrates; as well as the bones of vertibrates.

QUALITY OF SOIL

The quality of basin soil and catchment area are important for determining fertility of a large water bodies.The soil quality relatively poor in water bodies was not seen in water quality which appeared to be related more to soil conditions of the catchment area than to those of the basin alone. In case of beels rich nutrients status of soil was not reflected in water phase probably because of accumulation of large amount of nutrients by the macrophytes and effective removal from circulation.

ENERGY DYANIMICS

Biotic communities in an aquatic ecosystem can be divided into various components on the basis of their trophic functions, such as primary producers, herbivores, detrivores, carnivores and decomposers. Energy enters the biological system by fixation of solar energy through photosynthesis and gets degraded as it passes from one trophic level to the other according to the laws of thermodynamics. For estimation of energy dynamics of water body from solar radiation to the end product (fish), three types of studied needed.

1. Transformation of solar energy into chemical energy by producers.

2. Pathways of energy transformation that lead to the end product i.e.,flow of energy from producers to consumers.

3. Energy transformation efficiency at different trophic levels.

ENERGY TRANSFORMATION

Rate of conversion of solar energy to chemical energy gives a dependable parameter to assess the productivity potential of an aquatic system. The redox process of energy transformation is represented as under:

$6\ CO_2 + 6H_2O \rightarrow 609\ \text{Cal of} \rightarrow C_6H_{12}O_6 + 6O_2$
solar energy
or
$n\ CO_2 + n\ (\text{H donar}) \rightarrow \text{solar energy} \rightarrow (CH_2O)n + n\ (\text{Oxidised doner})$

This process is endergonic in nature and consequently plants can store large amounts of energy in the form of rich organic compound. The efficiency of energy transformation is known as photosynthetic efficiency.

$$\text{Photosynthetic Efficiency} = \frac{\text{Energy Fixed by Producers X 100}}{\text{Solar Energy available in Water Surface}}$$

The energy required to liberate one milligram of Oxygen through photosynthesis is approximately 3.68 Calories and hence the amount of Oxygen liberated gives a measure of solar energy trapped as chemical energy by producers. In reservoirs the energy transformation is mainly by phytoplankton while in beels aquatic macrophytes are the main primary producers.

Total energy available in the system = energy import + Energy fixed by
from all alloch   photosynthetic
thonous source.   organisms

ENERGY FLOW FROM PRODUCERS TO CONSUMERS
(Energy transformation)

The biotic communities in aquatic system are inter-linked with one another with energy chains. As such proper understanding of the trophic dynamics help in formulating policies for stock manipulation. There are two main routes through which the energy flows in an aquatic system.

1.Grazing of green organisms (Producers) by herbivores or plant feeders which are in turn taken by Predators (Energy from Producers level flows to various levels of consumers) ,**Grazing Food Chain.**

2. Flow of energy through dead organic matter or Detritus complex and path is known as **Detritus Food Chain** [all energy represented by producers is not utilised mostly by consumers directly and the un-utilised energy is deposited at the bottom after the death of the organisms. In beels infested with macrophytes, the primary energy fixed by macrophyte is not utilised by herbivores and unused is deposited at the bottom.

When decay occurs , these macrophytes contribute to rich organic detritus pool.

Energy at 1st Trophic level → Herbivores→ Predators → Grazing food chain
(Producer level)

Decay of organic Matter → Detritus feeders → Predators → Detritus food chain
(Organic detritus) Detritivores

Due to selective feeding nature of the consumer organisms number of restricting conditions for the transfer of energy from the primary producers to secondary and tertiary consumers exist. All the energy represented by producer is not always utilised by consumers directly and the unused energy is utilised by consumers directly and the unused energy is utilised through detritus chain. In some aquatic systems Grazing path predominates while in others most of the energy flows through detritus chain. The distinction between Grazing and Detritus chain is of importance as there is a time lag between direct consumption of living plants and the ultimate utilization of dead organic matter.

Nikolsky (1963) stated the manner the useful end product (Fish) stands to the first link in the food chain the higher the yield from the water mass as the loss of energy will be much higher; if the chain is longer. If the water body has the dominance of primary consumers (either herbivores or detrivores) the efficiency of conversion and the energy harvest will be higher. Mann (1969) and Odum (1975) used the energy flow approach for fish productivity potential of aquatic ecosystem keeping in view that in passing from one trophic level to the next almost 90% of the energy is lost. Odum (1962) opined that large water bodies, which have wide range of fish population belonging to various trophic level, the productivity potential can be taken as 1% of gross or 0.5% of the energy fixed at producer level. The energy dynamics of an ecosystem do take into account the various trophic levels but it has disadvantage that many animals are omnivorous and thus can not be assigned to a particular level. The feeding habit of the animal do change with the availability of the food. It has been established by many workers that the most important single channel of energy flow leading to fish production is organic detritus complex.

CONCLUSION

Natural events and anthropogenic influences can affect aquatic environment in many ways, which ultimately affect the fishery management in open water systems. Synthetic substances may be added to the water, the hydro-biological regimes may be altered or the physical or chemical nature of the water may be changed. Most organisms living in a water body and sensitive to any changes in the environment, whether natural (increased turbidity during floods) or un-natural (such as chemical contamination or decreased dissolved oxygen arising from sewage inputs. A full appreciation of natural changes and the anthropogenic influences in a water body can only be achieved by means of combination of ecological methods and biotopes. We find that abiotic factors have significant role in management of fisheries of open waters. Their inter-related reactions and nutrient dynamics play a very vital role in fisheries management.

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ROLE OF BIOTIC FACTORS IN MANAGEMENT OF FISHERIES IN OPEN WATER SYSTEM

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Inland fish yield in the country recorded ten-fold increase in last four decades from 0.22 million metric ton in 1951 to 2.1 million metric ton with growth rate of 5.06% in the year 1994. While massive fish production from 8000 km coastline of the country has been houring around 2.3-2.8 million metric ton for the last six years. Mechanised fishing and deep sea fishing has been exerting pressure on fish stock and population recruitment threatened. Against this scenario of marine fisheries, the contribution on Inland Fisheries to total production has increased from 28.9% to over 41.1%, indicating the potentials of the sector. The projected achievable targets of 8 million metric ton of fish to be realised by the turn of century, the estimated contribution from inland sector would be to the tune of 4.5 million metric tone. To achieve this the fishery of open water system, is to be judiciously managed through optimum utilisation of its biotops which plays vital role on augmenting the fish productivity.

The open water resource of the country in term of both water areas and species of fish and shell fish are rich and varied. India is endowed with a vast expanse of inland waters with an annual run of 167.23 million hectare – meters. The major rivers and their important tributaries dissect many geographical and climatic zones exhibiting high diversity in their biotic and abiotic components. Amongst inland open waters, rivers, its tributaries, canals, flood plains, ox-bow lakes, backwaters, deep pools, lakes, reservoirs, estuaries and lagoons, harbours varying biotops ranging from lotic to lentic habitats. The pressure of the food demand by the increasing population has prompted more intensive harvest of natural fish stocks. Thus appropriate management strategies are to be adopted for judicious utilisation of biotops to optimise fish yield from open water system.

Rivers and river-flood plain systems

The steep and torrential upper course of river generally having low temperature and turbulence though water is usually well oxygenated but shallow depth prevails. During floods, plankton is scanty, although during low water transient blooms may occur. Vegetation is restricted to some resistant forms attached to the rocks and to rooted, floating leaved or emergent forms in the pools. The assemblage of micro flora and fauna occurs as mats of periphyton or of benthos, covering the bottom substract. The fish fauna is entirely rheophilic. Fish fauna comprises small sized fishes provided with clinging apparatus *(Glyptosternum sp.* and *Glyptothorax sp.*) and other type having long sinuous shape (*Mastocembelus sp.*) and fishes (*Barbus* & *Salmo sp.*) capable of swimming sufficiently fast against the current.

The flat and slow flowing river course comprises lotic and lentic waters and its ecology is more complex than steep and torrential upper course. There is usually a well defined river channel flanked by floodplain. The main river, which may branch and recombine to form anabranches, generally consists of a regular succession of meander bends. Floating and emergent vegetation usually line the river banks and submerged vegetation may appear in its inner convex bank consists of sandy or sedimented areas which have slack current at low water while at high water these are submerged. The plankton population is closely related to flow conditions. Biotic factors of such river course has significant role in influencing the behavior of fish communities. The growth of large areas of higher vegetation on the floodplain during the flood provide favourable breeding, feeding and nursery areas for most species of fish. Fish species show seasonality of behavior whereby they breed early in the floods, feed and grow on the floodplain. Fishes of this river zone are also well adopted to survive in low water level and low oxygen concentration. They are characterised with complex breeding habits with multiple spawning and a great degree of parental care. The other category of fishes utilises the rich habitat provided by the floodplain during the floods but escape the severe dry season condition by lateral movement off the plain and longitudinal migration within the main river channel. According to Welcomme (1983) standing stocks and biological fish production from this zone of river course are difficult to calculate.

Functional differences between river-floodplain systems and rivers indicate that river system of the former has little in common with rivers lacking floodplains. Understanding of river floodplains is not helped by simply dividing into lotic and lentic subsystems, mainly because of significant interaction of biotops are involved. However, the extreme dynamic nature of the river-floodplain produces short and long term instability causing qualitatively similar groups of mechanisms to behave differently. According to Welcomme, 1975 and 1979 and Holcick and Bastl, 1976, the nature of river-floodplain systems with reference to their fish populations is being recognised. Thus, indicating the role of biotic factors in governing their fisheries potentiality. There are considerable abiotic interactions, which influence biotic productivity based on hydrology and associated nutrient distribution. In floodplain the most nutrients released from newly-flooded ground, are directly contributed by river. The direct nutrient contribution by the river will depend on the degree of flooding. Production of floating macrophytes *Eichhornia, Pistia* etc. deriving nutrients from the water column appears to be more significant in river floodplains. However, this production is minor compared with that of emergent macrophytes rooted in the substrate. In the inshore zones of river floodplains, nutrient appear to be mostly directly from the benthic substrate with larger concentration in the upper layers. Associated with the submerged parts of macrophytes are large quantities of periphyton and perizoon. The considerable biomass of detrital aggregate, derived mainly from the macrophytes, contains a high biomass of detritivores. According to Junk (1973) and Lim and Funtado (1975) the large water level fluctuations in floodplains probably increase the productivity of associated invertebrates resulting in large biomass. Direct input of dissolved nutrients from rivers into river-floodplain system is probably more important in the system for long term benefits, rather than controlling year-to-year production. Localised decanting of solids does, however, cause high phytoplankton production (Schmidt, 1973). The resulting zooplankton production may be important for young fish of many species.

River-floodplain systems having significant forest areas are regularly inundated and contribute to the production of larger individuals of many fish species which may be due to the allochthonous contribution of heavily forested streams.

Strategies for management of biotops in rivers and river-floodplain ecosystems

The major causative factors like environmental aberrations (Sandification and blanketing the river bed productivity) marked reduction in water volume and increased water abstraction accompanied with river course modifications, appears to have altered the riverine ecology through interaction of biotops at its different trophic levels. Also indiscriminate fishing in rivers particularly killing of brood fishes and juveniles of commercially important species is adversely affecting their recruitment and resulting decline in fish yields. Thus, indiscriminate fishing needs to be checked by strict fishery laws. Also well planned conservation measures by creating fish sanctuaries at suitable places needs to be implemented for revival of fastly dwindling fishery in major river systems.

Appropriate biotop management in floodplain wetlands should be based on category-wise approach. For such openwaters the culture-based capture fisheries techniques are most suitable by adopting pen culture and providing stocking support.

Lakes and Reservoirs

In both the lakes and reservoirs nutrients are added to the system either through allochthonous source or mostly directly from the benthic substrate with larger concentration in the upper layers. Wetzel (1975) has maintained that in most of the lakes, organic and nutrient input resulting from macrophytes production usually exceeds from other sources put together. In large and deep lakes or reservoirs, phytoplankton production may be more important than littoral production (Welcome, 1979; Bonetto et.al. 1969). However, secondary productivity in littoral zones is still significant. High zooplankton biomass but limited production, may be due to restricted access of fish to inshore areas of dense vegetation (Pieczynska, 1973 and Straskraba, 1965). According to Wetzel (1975), the macrophyte-detritus cycle in the littoral zones adds stability to the lecustrine system. This is possible because of the physical stability of the biotop as well as the nature of the mechanisms involved.

The production processes and productivity level of biotops of the reservoirs are to be assessed through limnological studies. General holistic and comparative approaches, relying on statistical methods, are necessary. Consideration of climatic and topographical parameters is essential for recruitment and establishment of appropriate fish species having commercial importance. More accurate and comprehensive resource evaluation, such as by remote sensing coupled with ground truth information is essential. When combined with limnological data and indices of fish production (such as fish catch and effort data), comparison between systems will allow important variables to be identified.

Strategies for management of biotops of Lacustrine and Reservoir Ecosystems

Depending upon the productivity potentials of lacustrine or reservoir ecosystems, its biotic potentials are to be aptly utilised for optimising fish yields from these open water bodies. For large water bodies, the management approach like enlargement of mesh size, increasing fishing efforts and stocking support for the purpose of establishing a breeding population of suitable fish species, is to be adopted. Whereas for small reservoirs, culture-based capture fisheries seems to be more appropriate for optimum utilisation of its biotops.

Estuaries and lagoons

Biotic ecology of estuaries is greatly influenced because of its physical features due to water movements, the mixing processes and distribution of salinity. The interactions of these forces make the estuary a very turbulent and complex system of water circulation. The morphology of basin of the estuary and river channel modify and determine the stream and tidal dynamics. Stream flow varies seasonally with rainfall while tidal amplitude and current are linked with lunar effects and wind. Estuaries of arid regions and lagoons differ from other estuaries being hypersaline but posses a moderate oxygen concentration at depths. Bottom mud is generally poor in organic content.

Ecological classification of estuarine biotic categories is mainly based on their salinity tolerance capacity. According to Carriker (1967) depending upon salinity tolerance the estuarine organisms may be grouped as (i) Oligohaline freshwater forms inhabiting rivers which usually cannot tolerate variations in salinity of more than 0.1 ppt, (ii) True estuarine forms which are adopted to tolerate a wide range of salinity and representing in upper and middle reaches in low salinities but have marine affinities, (iii) Euryhaline marine forms which can tolerate salinity as low as 15 ppt and these are majority of total estuarine biota with their distribution from sea to the upper reaches of the estuary, (iv) Stenohaline marine organisms restricted upto the mouths of estuaries as these forms cannot tolerate salinities below 25 ppt and (v) Migrants which include certain euryhaline marine migrants spend only a part of their lives in estuaries as many of them are predators subsisting on resident estuarine benthic organisms.

Another well linked openwater resource of mangroves which has important role in estuarine ecosystem, represents country's 85% in Sunderbans. Role of biotops in mangrove ecosystem play vital role in breeding and nursing phases of many riverine and marine organisms. Several of its creeks are ideal for fish and prawn seed collection which sustains aquaculture in the region.

Strategies for management of biotops in estuarine ecosystem

Average yield of estuaries which sway 45-75 kg/ha appeares to be quite significant. But the river valley projects like Farakka Barrage and Sardar Sarovar are adversely affecting the estuarine ecosystems. Farakka Barrage has caused decline in the salinity of Hooghly-Matlah estuary. Its marine zones being pushed down towards sea. These have considerably changed biotic composition as freshwater species are appearing in tidal zone. Thus appropriate fishing efforts for estuaries, lagoons and mangroves need to be adopted for conserving their rich and diversified biotic communities. Also mass destruction of fish and prawn seed, while being collected from its natural resources, needs to be checked for proper interaction of biotops in the estuarine ecosystem. Fast reclamation of mangroves of Sunderbans is a matter of great concern for conservation of its habitat of commercially important prawn and fishes. Thus the openwater estuarine ecosystems must be given special attention for preservation and conservation of its varied and rich biotops through appropriate management measures. The only sustainable yield of fish and shell fish could be achieved from such a vulnerable open water resource.

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WASTE WATER UTILIZATION FOR FISH FARMING WITH REFERENCE TO WETLAND MANAGEMENT

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INTRODUCTION

The use of westewater in agriculture in what was called "sewage farming" was started in Australia, France, Germany, India, the United Kingdom and the USA in the latter part of the 19th century and in Mexico in 1904. However, in certain temperate regions, with the ever increasing volumes of sewage being collected and the diminishing availability of land close to cities, the area required for sewage farming became so large as to be prohibitive. Of the countries mentioned, only Australia, India, West Germany, Hungary and Mexico continue to use wastewater in this way. Indirect reuse occurs throughout the world.

Wastewater reuse, once an idealistic dream, is now becoming a necessity. People in densely populated areas of developing and developed countries alike are facing the reality of a shortage of freshwater for drinking, cooking, irrigation and other uses.

The production of fish in ponds fertilized with human wastes is an age old practice in many parts of Asia, where macrophytes are also cultivated in this way and was also known in medieval Europe. The use of wastewater in aquaculture was developed in Germany at the end of 19th Century and independently and indigenously in Calcutta in 1930, which now has the largest wastewater aquaculture system in the world. Because of the high BOD level of wastewater and the resulting deoxygenation of the water during night fish usually can not be cultured directly in the wastewater itself. Measures must be taken to reduce the BOD.

The usually is brought about by one of the following methods:

a. Treating the wastewater to such a degree that it does not create any hazards to fish;
b. Diluting the wastewater before its introduction into the pond. This is the method adopted by the classical example of Munich's (Germany) wastewater fish ponds;
c. Diluting the wastewater in the pond by the water contained in the pond. The pond waste may be freshwater or aged and stablized wastewater. The best example for this system is that of Calcutta (Basu, 1949 and Nair, 1944).

i. Increased waste treatment capacity:

A. Bacterial and BOD reduction:

The capacity of aquaculture ponds to purify wastewater is greater, than the conventional treatment methods (Kisskalt and Ilzhofar, 1937). According to them on the basis of studies at Munich's wastewater fish farm the reduction of total bacterial count by the trickling filter method was about 89% and by the activated sludge method about 90%, the reduction of bacterial count in fish ponds receiving the water reached 99.6%. Bhowmik *et. al.* (1997) also reported same trend of reduction. Schroeder (1974, 11975) and Wllny (1966) demonstrated the presence of fish in wastewater ponds improves the quality of treatment in the light of reduction in bacterial load and BOD level. Oswald (1972) reported that increasing D.O. and pH in an aquatic system, increases the rate of disinfection from coliform.

B. Nutrient removal:

The high concentration of nutrients, especially Phospates and Nitrogen, in wastewater affect the ecology of natural water bodies into which the water is discharged. The fate of these two nutrients in fish ponds has been studied from the view point of beneficial fertilization of the water for increasing the ponds productivity. Most of the Phosphorus and Nitrogen added to the water is lost to the mud or to the atomosphere (Matida, 1956; Hopher, 1958). For phsophorus this is due to an aqullibrium between its soluble state and insoluble phosphate in the mud (Hayes et al., 1952; Olsen, 1958, 1964; Hopher, 1966) in which the amoaunt of the insoluble Phosphate is far greater than the soluble, phase. The addition of soluble Phosphate to the water affects the aquilibrium but it tends to be restored quickly by precipitation as Iron Phsophate and Managanese Phsophate or adsorption of their hydrates in water rich in these metal and low in pH. The precipitation of Calcium Phosphate seems to be much more common as it occurs at a higher pH. The removal of phosphate in this process depends on the contration of Calcium, alkalinity and the pH of the water.

Nitrogen added in the water is lost partly by denitrification process when partial anaerobic conditions exist near bottom; however, most of the Nitrogen loss is due transition of NH_4 to gaseus NH_3 to the atmosphere. The equillibrium between NH_3 and NH_4 depends mainly on pH and C.H.C. of mud soil. At pH 9.5 and at a temperature of 25°C, over 60% of the total ammonium compounds will be in the gaseous state. Increasing temperature of pH further increased the shift towards the gaseous state. Stocking of fish in waste treatment ponds results in higher pH probably, because of the grazing of fish on the plankton maintains the ponds in a better ecological balance. Oxygen production and respiration are more in balance and excess of CO_2, which depress pH, do not occur.

It is obvious that aquaculture may be the only solution for the utilization of the wastewater for production of food. Aquaculture is much less demanding on the quality of water and soil than are the common agricultural crops. Soil quality also is less of a limiting factor in aquaculture than it is in terrestrial agriculture. Organic matters produced in the pond water can clog the interestices even of pure sand and reduce seepage to the rates normal for humic soil. Draining of a wastewater treated pond facilitate sun drying of the pond bottom which is most important from fish harvest point of view on the other hand from reduction of residual pathogenic organisms as well. Without this proper management of wastewater fed pond fish farming is impossible.

ii. Effects on the food chanin:

The source of the high fish yields in ponds receiving organic wastes appears to rest on the high yield of natural food produced by the wastes. The organic wastes supply nutrients to the chain of natural foods by two distinct processes. The chemicals carried by the wastes, not only Nitrogen and Phosphorus but also the trace elements provide the basic building blocks for phytoplankton. This link in the food chain provides exygen to the pond via photosynthetic production is however limited by the reduction of light penetration into the water at high plankton densities. At a certain level of fertilization, because of reduced light penetration into the deeper layers of the water, primary production in these layers decreased and the rate of primary production per unit area reached a plateau.

It is because of this limit on photosyntheitc production that the second process of nutrient supply by organic wastes is important. The solid fraction of the waste, especially the suspended "fines" appear to supply a food directly to the second link of the natural food chain, the zooplankton and the benthos. Thus, the sun-limited photosynthetic production of phytoplankton is by passed. In aquatic systems receiving organic wastes, zooplankton can be observed to graze directly on the suspended solids. It may be that the solids while suspended in the water provide a plate for bacterial culture. When the solids are ingested by the zooplankton the bacteria are digested providing the zooplankton with a protein and vitamin rich food.

iii. Effects on fish yields:

The benefits of using wastewater in aquaculture on yield of fish and efficiency as feed utilization have been well demonstrated by Hepher and Schroeder (1975). They have opined that fish farming in wastewdater is beneficial from production as well as economic point of view. Fish grow in wastewater may contain some pathogenic bacteria in their body. As a safety precaution for consumers the fish are given a "flushout" period of several days in freshwater in some countries.

The waste stabilization pond system in general involves the retention of the wastewater in a pond or lagoon for periods upto several weeks. If such ponds are designed well and operated effectively, well over 90% of the BOD is removed and the microflora is much reduced. These ponds have an advantage of providing a fairly high degree of treatment at relatively low cost, with little equipment and skilled operation. As such, this method is most suitable in many developing countries, particularly in the tropical regions. A conventional oxidation pond retains the settled sewage at a depth of 1 to 2 m for a period of 25 to 30 days. This pond contain the algal-bacterial cultures which oxidise the organic matter to CO_2, H_2O, and NH_3 and other decomposition products that are used as nutrients by the algae. The oxygen produced photosynthetically by algae is used by bacteria. The retention time used should be sufficient to allow auto-oxidation of newly formed cells. Usually there is no sludge accumulation but some inert and mainly mineral sludge often accumulates which needs to be cleaned periodically.

Methodology for fish culture using domestic sewage

The main factor governing successful fish culture with waste-water is to fertilise the ponds effectively. Application doses for purpose should be chosen as to allow the fish ponds to remain aerobic through the day and night during the period of culture.

Normally composite fish culture with six or four species combination is adopted.

The technology for sewage-fed-fish culture mainly involves (i) Characterization of sewage quality (ii) Pre-stocking fertilization and liming (iii) Dilution of sewage with freshwater in appropriate rations depending on BOD of sewage (iv) Stablization of pond (v) Intensive and judicious stocking and Indian and exotic fish fingerling (vi) Post stocking fertilization using sewage and monitoring of D.B. in fish pond (vii) Periodic harvest of marketable size of fish and replanishment with same variety and number and (viii) Final harvesting by drying the pond.

By following the process a production of 5-7 t/ha/yr may be obtained. A production upto 11 t/ha/yr has also been reported through better management practices.

PROBLEMS IN USING WASTEWATER FOR AQUACULTURE

Pathogenic organisms in wastes:

In addition to chemical and biochemical problems the presence of pathogenic organisms in faeces and wastewater are of great concern where human wastes are to be used for aquaculture. The level of concern is greatest in those countries where practice of wastewater aquaculture might be beneficial. In many cases, health risks are more preceived than demonstrated with supporting scientific evidence. In those countries where human wastes are used routinely for the production of fish, public health questions are seldom raised, because most of the diseases associated with this practice are endemic. While fish are not susceptible to infection by most human pathogens, they can serve as carrier and thus transmit many of the diseases.

PUBLIC HEALTH HAZARDS OF WASTEWATER AQUACULTURE

There are three distinct health problems associated with the reuse of sewage in ponds.

1. Passive transfer of pathogens by contaminated fish.
2. Transmission of helminths in which fish are intermediate hosts.
3. Transmission of helminths in which other pond fauna are intermediate hosts.

The first is cause for worldwise concern. The second and third occur only in areas with particular eating habits or where the helminths are endemic or both.

It is generally accepted that the intestinal bacteria of warm-blooded animals (human and livestock) do not cause disease in fish and are absent from fish caught in unpolluted water. There is no permanent coliform or streptococcai bacterial flora in the intestinal tract of fish. Salmonollae have never been found to cause disease in aquatic animals.

Improved methods of sewage treatment through aquaculture, assessment of the quality of the aquaculture products together with changing attitudes towards the needs and benefits of waste recycling and the associated economic and nergy savings thereby will create an environment in which combined aquaculture waste treatment systems will prove universally acceptable and desirable.

Wetland Management Consideration:

Wastewater ecossytem the famous wetlands of the world repair that our environment and provide us with food in the form of fishes and other crops. These two basic utilities of welands are well documented. Wetland disposal as a technology option in municipal sanitation is already being researched and standardized while wetland aquaculture and agriculture are established resource recovery practices. More recently, we have started knowing about the fascinating ecosystem in the wetlands that uniquely combines the two above properties of wetlands.

The East Calcutta Wetland are the biggest and most significant freshwater wetlands in the world. They are unique not for their size (5000 ha) but for their role in recycling 680 MLD of sewage and 2500 t of garbage.

Inspite of the unique features of these wetlands there are two challenges faced for their conservation and maintenance. At the first instance unplanned and unauthorised urban expansion which requires intense mobilization of conservation efforts. The second challenge is to preserve the heritage. The unique know how of using municipal wastewater, being predominantly retained in an oral tradition (Ghosh, 1998).

Establishment of planned intervention will develop a resource efficient approach in using wetlands for waste disposal. Calcutta can give a lead particularly for such needs in developing countries. Given the valuable experience of an age-old, time-tested practice of waste recovery, there cannot be any reason why Calcutta System of sewage treatment should not succeed to introduce new alternatives in low-cost sanitation technology and become an international centre for training and research in this field.

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Hydrological changes, fish population trends and production potential of Hooghly estuarine ecosystem with special emphasis of Hilsa

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Introduction

The Hooghly estuarine system located in the state West Bengal, India, between latitude 21-23^{0}N and longitude 88-89^{0}E is the largest among the estuaries on the Indian coast covering the gangetic delta called the Sunderbans. It is the world's largest delta which supports many important commercial fisheries. The Sunderbans area is criss-crossed by many major and minor estuaries and dominated by intertidal and flats as well as rich mangrove forests. The total area of the entire estuarine system is about 8,029 km^2. The principal components of the estuarine system are the main Hooghly channel, its five tributaries *viz.*, Jalangi, Churni, Damodar, Rupnarayan and Haldi and the adjacent estuaries *viz.*, Saptamukhi, Thakuran, Matlah, Gosaba, Harinbhanga, Ichamati and Raimangal situated in the lower marine zone. These estuaries are disconnected since long from the main Hooghly channel due to heavy deposition of silt in their upper reaches. The Hooghly main channel is a distributary of the Ganga which is considered as the second major river of the world in terms of suspended load, discharging 1451X10^6 tons annually. It is the main contributor of sediments to the Bengal Fan which is the largest deep sea fan in the world. The heavy deposition of sediments, carried by the Ganga-Hooghly resulted into formation of cluster of islands in the lower estuarine areas - the Sunderbans.

The Hooghly estuary is a positive estuary of mixohaline type and a pattern of increasing salinity towards the mouth of the estuary. The dynamic estuarine ecosystem is subject to rapid changes by natural or man-made interferences. A major change in the water quality and fishery resources was observed in the Highly estuarine system after commissioning of Farakka barrage across the river Ganga at Farakka. Prior to the construction of Farakka barrage both the river Bhagirathi and Hooghly estuary were deprived of receiving sufficient freshwater and gradually becoming in active as bulk of discharge used to flow through river Padma, the other off-shoot of river Ganga. After commissioning of Farakka barrage in 1975, the main Hooghly estuary is fed directly by the Ganga through man made feeder canal and Bhagirathi river. The additional discharge of freshwater into the system has sufficiently changed the ecology of the estuary. These changes significantly affect the biological and physico-chemical factors responsible for plankton, benthos and fish production.

Status of the estuary during pre and post-Farakka barrage period

The present study on water quality, plankton, macro-zoobenthos and fishery resources revealed that there is a considerable drop in the values of salinity as well as change in the availability of plankton, macro-zoobenthos in the estuary as compared to pre-Farakka barrage period. It is well known that salinity parameter of an estuary restricts the distribution limit of its flora and fauna. A critical analysis of the earlier works during pre and post-Farakka barrage period relevant to hydrology revealed that additional discharge of freshwater through Farakka barrage had changed the ecology of the system significantly by reducing the turbidity as well as salinity and converting the earlier gradient zone into almost freshwater one. Presently the salinity incursion of the Hooghly estuary was observed upto Diamond Harbour situated 60 km from the mouth of estuary. The estuary showed distinct levels of salinity gradient.

Presently, the upper freshwater zone has extended downward for a distance of 238 km from Nabadwip to Diamond Harbour. Nabadwip and Diamond Harbour are located 298 and 60 km respectively from the sea face. The middle gradient zone from Diamond Harbour to Kakdwip (35 km from the sea face) and lower marine zone from Kakdwip to sea face have been very much reduced and pushed back towards the mouth of the estuary (Fig. 1). On the contrary, during pre-Farakka barrage period the upper freshwater zone was extending from Nabadwip to Konnagar, middle gradient zone from Konnagar to Diamond Harbour and lower marine zone from Diamond Harbour to sea face. The present salinity values in the lower zone ranged between 15.7 and 27.8 g/l, while in the gradient and upper freshwater zones the values varied from 0.07 to 18.2 g/l and 0.04 to 3.3 g/l respectively.

As regards physico-chemical parameters of the estuary during pre and post-Farakka period an appreciable change in the values of certain parameters was observed.

At present an increase value of dissolved oxygen in the Hooghly estuarine system at Uluberia, Diamond Harbour and kåkdwip was noticed as compared to pre-Farakka barrage period. This may be due to increased influx of freshwater in the estuary after commissioning of Farakka barrage (Table-1). Phosphate, nitrate and silicate contents of the estuarine waters were very low during pre-Farakka period, while after commissioning of Farakka barrage, the phosphate, nitrate and silicate contents increased and almost similar values were observed upto recent years.

Table - 1 : Physico-chemical characteristics of three centres of the main Hooghly channel during pre and post Farakka barrage period.

Centre	Uluberia		Diamond Harbour		Kakdwip	
Year	1954	1996	1954	1996	1954	1996
Parameter						
D.O. (mg/l)	2.3-4.6	6.0-6.8	2.1-5.0	6.3-7.0	3.4-5.1	8.0-8.2
Phosphate (mg/l)	0.002-0.003	0.05-0.10	Tr	0.07-0.10	Tr	0.06-0.08
Nitrate (mg/l)	Tr	0.08-0.26	Tr	0.07-0.22	0.03-0.11	0.05-0.11
Silicate (mg/l)	0.09-0.36	6.7-20.0	0.05-0.20	4.2-8.0	0.04-7.8	3.9-6.0

Plankton

The overall plankton production in the Hooghly estuary during post-Farakka barrage period was high when compared with the earlier studies during pre-Farakka barrage period. The total plankton production for the Hooghly estuarine stretch was maximum at Frazerganj (1262 u/l) and minimum at certain stretches of freshwater as well as gradient zones of the estuary. The low production of plankton at these stretches may be due to discharge of industrial effluent which caused maximum adverse effect on production of plankton. The bulk of plankton in the Hooghly was constituted by phytoplankton. Bacillariophyceae, Chlorophyceae and Cyanophyceae are the principal groups in order of abundance. Phytoplankton production was maximum at Frazerganj in the Hooghly estuary as compared to other distributaries *viz.* Saptamukhi, Thakuran, Matlah, Roymangal and Ichamati.

Table - 2 : Maximum plankton density (unit/liter) in the Hooghly estuarine system during pre and post Farakka barrage period

Estuary	Zone	1956-61	1971-72	1996-97
Hooghly	Upper (Freshwater)	298	304	920
	Middle (Gradient)	293	223	414
	Lower (Marine)	61	145	1267
Matlah	-	356	-	585

Zooplankton communities were found to be represented by the copepods, rotifers and caldocerans and protozoans in order of abundance.

Macrozoobenthic fauna

Information on macrozoobenthic fauna of Hooghly estuarine system during pre and post- Farakka barrage periods are very scanty. At present the overall population of macrozoobenthos ranged between $182/m^2$ and $1428/m^2$ and the maximum production was observed in freshwater zone of the estuary at Nabadwip. The overall composition of the bottom macrofauna of the estuary was gastropods. The next important groups were annilids and *bivalves*. Among gastropods, the dominant species viz. *Thiara tuberculata*, *T. scabra*, *T. lineata*, *Bellamya bengalensis*, *B. dissimilis*, *Brotia costula*, and *Assaminea francassiae* were observed in the freshwater zone, while *Cerithidea cingulata*, *C. obtusa*, *Barnia candida*, *Neritina anriculata*, *Columbella duclosiana*, *Natica tigrina*, *Telescopium telescopium* were maximum in lower marine zone of the estuary.

Fishery

The annual average prawn and fish yield from the estuarine system has increased from 9,481 tonnes during pre-barrage period to 43,000 tonnes during post-barrage period.

A wide variety of fish and prawn diversity was observed in the freshwater zone, particularly in the lower stretch of this zone from Uluberia to Diamond Harbour being the admixtured of fresh and saline water, euryhaline species were also encountred in the region. The important fish and prawn fauna available in the upper freshwater zone were *Tenualosa ilisha, Mystus seenghala, Eutropichthys. vacha, Clupisoma garua, Setipinna phasa, Ailia coila, Mastacembelus armetus, Pangasius pangasius, Xenentodon cansula, Mystus cavasius, Ompok pavo, Mystus gulio, Notopterus notopterus, N. chitala, Wallago attu*. Among prawns *Macrobrachium rosenbergii, M.malcolmsomii, M.rude, M.villosimanus* and *M.lamarrci, M. mirabiles, M.birminicum birminicum, M.scabriculum* and *M.dayanum* were available in the stretch. The commercially important fish available in the lower stretch of freshwater zone were *Pama pama, S. phasa, T. ilisa, Polynemous paradiseus, Silago panijus* and *Rhinomugil corsula*. Among prawns, *Macrobrachium rosenbergii, M. mirabile* and *Metapenaeus brevicornis* were the most dominant species. *P.pama* and *S.phasa* were mostly abundant during October to November, while peak fishing season for *P. paradiseus* was March and April.

Dominant species in the gradient as well as marine zone of Hooghly including other estuaries of Sunderbans (distributaries of Hooghly) were *Harpodon nehereus, Trichurus spp., T. ilisha, Setipinna spp. P. pama* and prawns (*Parapenaeopsis sculptilis, P. stylifera, Metapeneous brevicornis, M.monoceros, Peaeus monodon, P.indicus, Explaemon stylifera, E.tunifres*. Next to these other important fish species were *P.paradiseus, Eleutheronema tetradactylum, Lates calcarifer, Polynemus indicus, Coilia spp. Stromateus cinereus, Tachysurus jella, Ilisha elongata, Raconda russelliana, Chirocentrus dorab, S.panijus, Sciaena biauritus, Liza parsia, L.tade, Plotosus canius, Osteogeniosus militaris* etc. etc.

In the Hooghly estuarine system, fishing exploitation by migratory bagnet was an important feature of the lower estuarine zone during winter month from November to January. The winter migratory bagnet fishery contributed to the tune of 65-75% of the total yield of the estuary. More than 90% catches are marketed as dry fish. The dominant species contributing in the winter migratory bagnet fishery were *H. nehereus, Trichiurus* spp. *Setipinna* spp., *T.jella, P.pama* and *Coilia* spp. On the whole, the lower marine zone of the estuarine system during post Farakka barrage period contributed about 95% of the total catch of the entire Hooghly estuary and Sunderbans deltaic region and the maximum contributors were *H. nehereus* (23.5-26.7%), *Trichiurus spp.* (13.1-15.2%), *Setipinna spp.* (13.1- %) and Prawns (6.6-6.9%).

The present trend of catch statistics shows that some fish species viz. *Liza parsia, Lates calcarifer, Pangasius pangasius, Elutheronema tetradactylum, Harpodon nehereus, Trichirus* spp. of the estuarine system have shown a sharp declining trend or total absence in the upper and gradient zones of the estuary during post-Farakka barrage period. The average annual catch of *Polynemus paradiseus* in the post barrage period have increased significantly in gradient zone. *Harpodon nehereus, Trichiurus jella, Setipinna spp.* and *Pama pama* have also shown an improved catch in the marine zone during post barrage period. On the contrary certain freshwater fish and prawn species viz. *Eutropichthys vacha, Clupisoma garua, Rita rita, Wallago attu, Mystus seenghala, M. aor, Catla catla, Labeo bata, Macrobrachium rosenbergii* have made their appearance in the estuarine system. Contribution of dominant fish and prawn of Hooghly estuarine system during pre and post-Farakka barrage period is presented in Table-3.

Hooghly estuarine system is a potential source of estuarine fish or prawn seed. The marine fish production is by and large dependent on estuaries since these serve as breeding and nursery grounds for important sea fishes and prawns. The seed of commercially important prawn *Penaeus monodon* are available extensively alongwith seeds of other important penaeid (*P. indicus*) and Metapenaeid (*Metapenaeus brevicornis* and *M. monoceros*) prawn as well as fishes (*Liza parsia*, *L. tade* and *Lates calcarifer*). At present, the upper limit of availability of the marine fish and prawn seed has become restricted to 50-60 km while during pre-Farakka barrage period seeds of *P.monodon* and *P.indicus* were available from Uluberia and Nurpur centres of Hooghly main channel located 113 and 83 km respectively above the mouth of the main estuary. The ranges of salinity around Nurpur and Uluberia fluctuated between 0.09 and 21.15 g/l and 0.50 and 9.45 g/l respectively (Chakraborty *et. al* 1982) while during post-Farakka barrage period the salinity had gone down which varied between 0.021 and 2.25 g/l at Nurpur and 0.014 and 0.04 g/l at Uluberia (Table-4).

Thus reduction in salinity due to increased freshwater discharge is apparently the probable reason for this. The overall availability of seed in the Hooghly estuarine system was found to be declined (Table-5).

Table - 3 : Contribution of dominant fishes and prawns (in t) of Hooghly estuarine system.

		Pre - Farakka barrage period		**Post - Farakka barrage period**
Sl. No.		**1960-61 to 1962-63**	**1966-67 to 1974-75**	**1984-85 to 1994-95**
1.	**Hilsa** *Tennalosa ilisha*	743.9	1457.1	2336.6
2.	Mullets *Liza parsia* *L.tade*	39.5	30.8	18.2
3.	**Threadfin** *Polynemus paradiseus* *P. indicus* *Eleutheronema tetradactylum*	74.4	63.9	296.7
4.	**Perch** *Lates calcarifer*	45.9	24.5	49.9
5.	**Sciaenids** *Pama pama* *Sciaena biauritus*	118.9	203.7	4327.7
6.	**Catfishes** *Osteogenious militaris* *Tachysurus jella* *Pangasius pangasius*	152.5	109.6	992.9

		Pre - Farakka barrage period		Post - Farakka barrage period
Sl. No.		1960-61 to 1962-63	1966-67 to 1974-75	1984-85 to 1994-95
7.	**Other clupieds** *Setipinna spp.* *Ilisha elongata* *Chirocentrus dorab*	136.2	437.8	4081.6
8.	**Ribbon fish** *Trichiurus sp.*	83.1	454.0	2835.5
9.	**Bombay Duck** *Harpodon nehereus*	797.1	2067.9	5301.0
10.	**Prompet** *Stromateus cinereus*	Recorded under others	71.6	866.3
11.	**Prawns**	574.1	1338.3	2939.3
12.	**Others**	438.4	3222.3	9295.7
13.	***Total***	***3204.0***	***9481.5***	***33341.4***

Table - 4 : Maximum abundance of prawn seed at Nurpur and Uluberia centres of Hooghly estuary during pre and post Farakka barrage period

Centre	Species	Pre-Farakka barrage period	Post-Farakka barrage period
Nurpur	*P. monodon*	1,169	78
	P. indicus	30,485	Absent
	Salinity (g/l)	1.90-21.15	0.021-2.25
Uluberia	*P. monodon*	504	Absent
	P. indicus	1,380	Absent
	Salinity (g/l)	0.50-9.45	0.014-0.04

Table - 5 : Maximum numbers of seed collected per shooting net per hour at different stretches of the estuarine system during pre and post Farakka barrage period.

Species	Pre - Farakka barrage period	Post - Farakka barrage period
P. monodon	56-2,000	64-2,332
P. indicus	80-30,485	9-8,940
M. brevicornis	7-1,910	43-2,240
M. monoceros	77-2,590	18,1,386
L. persia	11-28,077	14-456
L. tade	10-300	4-31
L. calcarifer	40-598	2-25
C. chanos	8-1,292	Absent
Salinity range (g/l)	23.94-34.59	12.81-21.12

On the contrary, seeds of *M. rosenbergii* were moderately available during May to July in certain areas of Sunderbans, which was not reported from Sunderbans prior to construction of Farakka barrage, as the species started their downstream migration towards sea face for spawning purposes. The range of downstream migration of the species during pre-Farakka barrage period was found upto Uluberia and Nurpur. Reduiction in salinity in Sunderbans might be one of the probable reasons for its extended downstream migration.

Hilsa fisheries

The ecological changes in the Hooghly estuarine system as a result of increased freshwater discharge into the system through the Farakka barrage have an influence on the biology and fishery of the anadromous hilsa. The general habitat of migratory hilsa in the estuarine system has improved for its migration, breeding and growth. The average annual landings of the species which remained at 1,500 tonnes prior to 1975 has increased to more than 5,000 tonnes in recent years. Hilsa is the major component of estuarine fishery accounting 15-20% of the total yield from Hooghly estuary. The up-stream migration of hilsa towards the Hooghly estuary from the foreshore area is mainly for spawning. The upstream migration of Hilsa in the estuary is found with the advent of South-West monsoon *i.e.* July to August and continuous upto February to March. The upstream migration of the fish is found associated mainly with the state of sexual maturity as well as volume of freshwater discharge from the estuary caused by rains or melting of the snow. Hilsa is a prolific breeder. Though the peak spawning period of the species is remarkably noticed during September to early November, the spawning is extended for a prolonged period upto February/March. With regard to the size and age composition of migratory hilsa, it is revealed that hilsa fishery is contributed mainly by the individuals belonging to size range from 340 - 419 mm (3 years), 420-451 mm (4 years) and 460-479 mm (5 years) and formed 37-42, 22-23 and 11-16% by numbers. During post-Farakka barrage period, the species spawns in the entire freshwater zone by the estuary (Daimond Harbour to Nabadwip), while earlier observations inferred that the lower and upper limits of the spawning grounds of hilsa in the river were Baghbazar (Calcutta) to Madgachi a distance of about 155 and 250 km respectively from the sea face. The probable raeson for extension of spawning ground, observed during post barrage period may be due to increased discharge of freshwater into the estuary. The barrage has changed the ecology signaificantly by reducing salinity as well as turbidity and converting the gradient zone into almost freshwater zone. This change makes the environmental condition of the Hooghly estuary more conducive for the spawning of hilsa.

FISHERIES MANAGEMENT IN ESTUARINE WETLANDS

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INTRODUCTION

Estuaries are formed in the narrow boundary zone between the sea and the land and their life is generally short. Their form and extent are being constantly altered by erosion and deposition of sediment and drastic effects are caused by a small raising or lowering sea level. This sea level alterations may be eustatic, (variations in the volume of water in the oceans), or isostatic, (variations in the level of the land). In the geological past there have been very large eustatic changes in the sea level. About 18000 years ago the sea level stood about 100 m below its present level, the water being locked up in extensive continental ice sheets. As the ice retreated the sea rose at a rate of about one m a century, drowning the valleys incised by the rivers.

A positive estuary is an estuary where the fresh water inflow derived from river discharge and precipitation exceeds the outflow caused by evaporation. Surface salinities are consequently lower within the estuary than in the open sea.

Marshes, swamps, mangroves and bogs have been well-known terms for estuaries, but only recently attempts have been made to group these landscape units under a single term " Wetland". This general term has grown out of the need to understand and describe the characteristics and values of various water logged areas between terrestrial and aquatic ecosystems where the water table is usually at or near the surface and the land is temporarily or permanently covered by shallow water.

The abundance of natural seed of brackish water fish and prawn in the estuaries, creeks and canals have attracted local people of the area to undertake cultural practices since early years of this century. The topography coupled with favourable climatic conditions of deltaic West Bengal favoured tidal ingress deep into the main lands and offered a lucrative fishery. More than 0.4 million hectare areas were developed for this type of culture.

In the traditional system of culture, the tidal fed shallow and marshy water bodies were stocked with tide-borne fish and prawn seed and periodically harvested after an interval of a growth phase.

Central Inland Fisheries Research Institute has monitored these brackish water impoundments since its inception. With the progress of time the traditional system of culture is also changing at a slow pace and for the present it has reached a semi-scientific stage.

The estuarine wetlands constitute one of the important fishery resources in and around Calcutta and adjacent 24 - Parganas districts. Locally the wetland is known as Bhery and from a very important productive unit for raising both freshwater and brackish fish and prawn. These water bodies harbour a rich biomass of bacteria, protozoa and other planktonic micro and macro organisms to raise fish food chain. It apart from meeting the protein needs of the people of Calcutta Metropolis also helps in earning of valuable foreign exchange through export of a tiger prawn, *Penaeus monodon.* Fisheries' management in estuarine wetlands was undertaken to deal with different aspects of ecology, hydrology, soil and water characteristics in relation to fish and prawn productions, both under freshwater and brackish water conditions.

RETROSPECTION

During the period: 1961 - 1970

Pakrashi (1965) reported the culture techniques practised in brackish water impoundments (Bheries) of West Bengal. Together 151 tidal fed bheries with water spread area between 6.6 and 266.7 ha each were surveyed covering 14 police stations of 24-Parganas in West Bengal. In addition to auto- stocking, fry and young ones of euryhaline fish and prawn species were released at random at these bheries without paying heed to their stocking rate and feeding habit. The selective stocks of economically important species in these impoundments were not in vogue. The yield varied from 324 - 2323 kg/ha/yr. An estimated annual production of 3000 tones was reported from these brackish water bheries. Pakrashi et al. (1964) stated that the upper reaches (north of $22^{0}30'$ latitudes) of the estuaries was comparatively less saline than the southern zone. The salinity of different tributaries feeding these impoundments was reported as below:

Estuary	Season	Salinity
Saptamukhi	Summer	Trace to 22.2 ppt.
Thakuran	Rainy	Trace to 14.2 ppt.
Matlah	Winter	Trace to 10.4 ppt.

The lease amount of bheries varies from RS. 40.0 - 45.0/bigha/yr. No regular fish trade or marketing facility was available during the period due to lack of transport facilities and remoteness of the area. The culture period was from February - September. The wild sock cultured was mostly of fishes like mullets (*Liza persia, L. tade, Rhinomugil corsula), Lates calcarifer, Eleutheronema tetradactylum, Mystus gulio, Setipina phasa*, etc. and prawns (*Peneaus monodon, P. indicus, Metapenaeus monoceros, M. brevicornis, Leander sp., Macrobrachium rosenbergii etc.)*

Gradually the increasing demand of tiger shrimp (*P.monodon*) in local as well as foreign market has attracted the attention of bhery owners and prompted them to increase prawn production from these impoundments. Accordingly, the culture practice had also improved considerably resulting in the increase of production from the bheries.

During the period : 1980 - 1990

During the period Saha *et al.* (1986) made a detailed study of the areas under brackish water aquaculture in West Bengal. The survey revealed the presence of 1334 nos. of bheries in the area covering 32,930 ha. The annual fish and prawn seed availability was found to vary between 600 and 800 million which could cater the need of the farmers (Laha et al. 1988). The bheries were categorised into three groups based on prevailing a water salinity and existing cultural pattern.

Zone's	Salinity regime
I Low salinity (Oligohaline) *	Trace to 10 ppt.
II Medium saline (Mesohaline) *	Trace to 20 ppt.
III High saline (Polyhaline) *	20 ppt. And above

* International norms of a salinity regime (Arch. Ocean. Limnol.) Vol.-II, 1959

Oligohaline	Salinity between 0.5 - 5.0 ppt.
Mesohaline	Salinity between 5.0 - 18. 0 ppt.
Polyhaline	Salinity between 18.0 - 30. 0 ppt.
Mixohaline	Salinity between 30.0 - 40.0 ppt.

They also made detailed study of water qualities,soil characteristics, fertility statuses, plankton, bottom biota,primary productivity etc.of the bheries from different zones. (Table - 1).

In both low and medium saline bheries a freshwater regime prevails during monsoon season. Due to this phenomenon, it has been possible to raise both freshwater and brackish water fish and prawn from low and medium saline bheries.

A total of 120 soil samples revealed that phosphorus was high. The soil samples from high saline bheries were found to contain higher level of available phosphorus and lower level of nitrogen reverse in case of low saline bheries.

The survey also revealed that with the change of ecological condition the culture practices were also modified. Introduction of sewage enriched water into the low and partly medium saline bheries prompted the bhery owners to culture Indian and exotic major carps during monsoon months along with the existing euryhaline fish and prawn. The early hatchlings and juveniles of prawn and fish were collected from natural resources and reared in the nurseries for conditioning and growth before stocking into the main bheries. In addition to acute stocking, selective stocking of desired varieties of fish and prawn were also practised. The rate of stocking was maintained as 40 - 50 thousand nos. / ha. Liming, manuring and supplementary feeding were practiced by certain percentage of farmers in an emperical way.

PRESENT SCENARIO

During the period : 1991 onwards.

A project to study on the ecological conditions of bheries under three different saline regime has been undertaken to evolve a scientific management practice to obtain optimum production. Two bheries had been selected from each zone for assessment of production,study of physico-chemical properties and penculture of *P. monodon*.

Adoption of semi- scientific methods

The farmers are getting better production of fish and prawn by adopting semi-scientific culture practices and they are inclined for selective stocking. So most of the bheries are sundried during December - January after final harvesting. Liming and manuring are done in emperical way without analysing the soil and water. Efforts are being made to minimise infiltration of carnivorous fishes by putting screen at the inlets.As the cost of *P.monodon* seed is soaring higher and higher, the farmers are taking special care for nursery rearing and stocking them as per recommendation. But the high saline area auto-stocking is still prevailing along with selective stocking of bagda juveniles.

During monsoon months in low and medium saline area Indian and exotic carps, fresh water prawn and Tilapia are also being cultured with mullets and *P.monodon*. Some farmers are providing supplimentary feeds intertmittently to achieve better production.

Pen culture experiment

For better utilization of water area for a short span of time with controlled management, the monoculture of *P.monodon* were tried in pens (100 m2 area each) within bheries. Trials have already been undertaken in all the three saline zones. The result showed better survival of the juveniles in high saline zone (60-70%) than low (40-45%) and medium saline (50-52%) zones. Comparatively better growth has been observed in low saline bheries (30gm) than the medium (25 gm) and high saline zone(23 gm) in a culture period of 4 months from an initial stocking size (12-15 mm/0.04 gm) during summer. Mangrove plants are found to be cogenial for *P. monodon* culture as evident from experiments in high saline zone area. In addition soil, water, plankton, bottom biota, periphyton, macrovegitation etc. were studied to find out the relationship of these parameters with productivity.

From 1994 onwards the study revealed that water depth was found to fluctuate between 0.29 and 1.0 m at fresh water zone 0.40 and 1.40 m at low saline zone, while at high saline zone it ranged from 0.45 to 1.5 m. The dissolved oxygen content was found to be on the higher side (3.1 to 18.8 ppm.) But on an average it varied from 6 to 10 ppm in all the bheries. The pH was recorded between 7.0 and 8.4 but on an average it was 7.2 and 8.1 which was congenial for brackishwater fishery. At freshwater zone the salinity was always below 1 ppt, but at low saline area during monsoon it was 0.2 ppt. At high saline zone the salinity was always varied from 5.7 to 20.6 ppt.

The salinity values at low and high saline areas were observed to have declined from previous observation which may be due to less ingress of tidal water.

The chemical characteristics of sediments in different bheries were observed that due to higher salinity the conductance values are very high in bheries from high saline zone. But the nutrients in .terms of availble nitrogen and organic carbon values are low in high saline bheries, in comparison to low saline and freshwater bheries, but the contents of available phosphorus show almost similar values.

The higher production of Plankton, Peryphyton and Macrophytes in bheries depends not only upon soil water condition and availability of natiural food organisms mainly plankton. The plankto availability of the bheries has been recorded as traces to 1.5 c.c/50 litres of water at fresh wate zone, traces to 5.0 c.c./50litres of water at low saline zone and traces to 2.0 c.c./550 litres of water zone. The mothly variation of species diversity index (SDI), of plankton were 1.38 to 2.67, 1.10 to 2.83 and 1.20 to 2.40 at fresh water, low saline and high saline zones respectively. Species Diversity Index in all the zones has indicated a moderately polluted category with immediate environmental stress. The dominent periphytic flora were *Spirogyra sp., Ulothrix sp., Oscillatoria sp., Anabaena sp.*, etc. in freshwater area; *Oscillatoria sp., Oedogonium sp., Lola sp., Enteromorpha sp.*, etc. from low saline area and *Enteromorpha sp., Oscillatoria sp., Oedogonium sp.m Lola sp., Caetomorpha sp., Rhozoclonium sp.*, etc. from high saline area. The main forms of macrovegitation available from different zone were *Colocaseia,Panicum, Ipomea, Eubydea, Ludwigia, Ephedra, Acanthus, Scripus and Avecinia* among the marginal plants. Among the floating forms main plants were *Lemna, Eichornia, Spirodella, Azolla.* While the submerged forms were by *Ceratophyllum,Chara, Monochoria, Nechamandra, Ruppia* and *Lola.* The main benthic flora available at freshwater bheries were *Oscillatoria Sp., Navicula sp., Anabaena sp., Spirogyra sp., and Ulothrix sp.,;* at low saline area *Oscillatoria sp., Oedogonium sp., Pleurosigma* sp., etc and at high saline area *Oscillatoria sp., Oedogonium sp., Pleurosigma sp., Gyrosigma sp., and Spirogyra sp.* were encountered. The main forms of fauna available were Gastropod shell, *Acetes sp.*, Amphipods and Tanaids in all the zones. At low saline zone bheries, Amphipods and Tanaids were found more in numbers with increase of salinity. In addition, Polychaete worms were available at high saline zone with increase of salinity and temperature.

The annual fish and prawn production from different saline brackish water bheries has been reported during different period with a range from 391.6 to 2540.5 kg/ha/year in low saline,600.0 to 1763.4 kg/ha/year in medium saline and 400.0 to 764.3 kg/ha/year from high saline systems of the study areas.

But recently, comparatively higher production was registered in the bheries of freshwater area. The production from these bheries varied from 5675.0 to 7970.0 kg/ha/year. The present soil and water conditions reveal that the sewage fed systems are receiving now less nutrient in the form of nitrogen and phosphorus than reported previously. Now farmers are applying inorganic fertiligers and occassionaly supplimentary feed to get better growth of carps and tilapia. The plankton production is hindered by overgrowth of macrovegetation which may be the cause of poor production of fish and prawn. Dumping feed in the brackishwater bheries led to hyper - nutrification or excess deposit of nutrients in the water. In traditional farming system too, the farmers use chicken and pig excreta in copious quantities as feed for the prawn which recently caused damage to crops. In addition to the scarcity of prawn seed (*P. monodon*) and exorbitant price hike of post larvae resulted in understocking. The outbreak of white spot disease in *P. monodon* among other factors was also responsible for less production from low and high saline bheries. The weak tidal ingress, insufficiency of healthy stocking materials, dearth of proper management methods etc. are some of the prevailing factors responsible for declining fish and prawn yields from the bheries of low and high saline zones. However, adoption of proper classified as eurihaline and stenohaline. The former can tolerate wide fluctuation of salinity but the latter can not. Eventuallyy fishes grown up in estuarine wetlands are in general eurihaline species. However, in low-saline wetlands where salinity generally does not exceed 10 ppt. Major carps are also stocked after monsoon when salinity drops down to 5 ppt. Or less. In estuarine wetlands *Oreochromis mossambicus* is also stocked as consumers` preference. Common carps are also grown in low saline wetlands where salinity is more than 10 ppt. even after rains. However, the main thrust lies on on the culture of *P. monodon*, the foreign exchange earning commodity, in most of the impoundments of Hooghly estuarine complex.

The nature of parasitism needs little consideration while the relationship between hosts and parasites is explained. Parasites are either obligate or facultative in nature. The latter can live without a host for a part of its life cycle but obligate parasites always require a host for their sustenance. Obligate parasites may not always be dangerous as some helminths can help their hosts, but such parasites can be the cause of extermination of the hosts when environmental conditions do change . As such, successful parasites keep the hosts alive so that they can grow and multiply. But virulent obligate parasites do cause extermination of the host in no time; as a result both host and parasite perish if the latter does not simultaneously find out another suitable hosts for its existence. Control measure of parasitic afflictions in estuarine wetlands should be improved by means of managerial practices such as sanitation of the impoundment, stocking density of fishes, pre-stocking measure, environmental monitoring as well fish-health monitoring.

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RIVERINE FISHERIES OF INDIA WITH SPECIAL REFERENCE TO GANGA RIVER SYSTEM

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Introduction

Nature has bestowed India vast expanse of open inland waters in the form of rivers, lakes, oxbow lakes and estuaries. These water bodies harbour one of the richest and diversified fish fauna of the world, comprising 930 fish species belonging to 326 genera out of 25000 total fish species.

Till, a few decades ago, the aquatic environment of the country was in a healthy state and its fishery in a steady state. The rapid industrialization, irrational deforestation causing siltation of river's bed, construction of dams and barrages leading to over abstraction of water and pollution due to urban, agricultural and domestic run off have exerted tremendous strain on the aquatic ecosystem. These intensive developmental activities have resulted in low fish yield due to mortality of fish food organisms and fishes; destruction of their spawning grounds due to change in flood pattern and obstruction in run of migratory fishes (*Hilsa ilisha, Pangasius pangasius and Tor putitora).* However, the fishes of lesser economic importance have successfully endured environmental degradation and consequently improved their progeny at the cost of prized fishes, heralding a downswing in their population. In biological parley this phenomenon known "Pauly's Ecosystem Over Fishing Syndrome". Similarly, the spawn of major carps has been reported to drastically declined in most of the rivers. Consequently, contribution of riverine spawn dwindled to less than 30% in 1980's from that of 90% in 1970's.

The riverine scene is a complex mix of artisinal, subsistance and traditional fisheries with a highly dispersed and unorganised market system which frustrate all attempts to collect regular data on fish yield. A firm data base being absent, for knowing production trend, one has to depend on information collected by CIFRI from selected stretches of rivers Ganga, Brahamputra, Narmada, Tapti, Godavari and Krishna. The same data has been utilized in the present communication.

Riverine Resource of India

The river system of the country has a total length of about 45000 Km which includes major rivers each draining a catchment area of 20,000 Km^2 and the innumerable small rivers and desert streams that have a drainage of less than 2000 Km^2, medium rivers carry a surface runoff of 167.23 million ha metres (mhm) which is 5.6% of the total runoff flowing in all the rivers of the world (Rao, 1979).

The major river systems of India on the basis of drainage be divided broadly into two 1. Himalayan river system 2. Peninsular river system.

Himalayan river system

This comprised of 1) Ganga river system, 2) Indus river system and 3) Brahamputra river system.

1. **Ganga river system** : It is one of the largest river systems of the world, having a combined length of 12,500 km and accounts about 29% of the total river length of the country. The Ganga river originates from "Gaumukh" glacier in Garhwal Himalayas (30°55'N, 70° 7'E) and drains into the Bay of Bengal, after traversing a distance of about 2525 km. The main tributaries are the Yamuna, and the Sone on the left bank and the Ram Ganga, the Gomti and the Ghagra onthe right bank besides Kosi, Damodar and Barakar rivers which join in Bihar and Bengal. The system has a catchment area of 97.6 mha with a mean discharge rate of 19000 m^3/sec. and average rainfall of 111.0 cm/A. The Ganga river system harbours about 265 fish species, out of these 34 species are of commercial value including the Gangetic major carps, large catfishes, feather backs and murrels.

Fisheries of rhithron stretch : Fishery of this stretch extends from the source to Haradwar covering a distance of about 250 km. The fishery comprised of *Schizothorax* spp. cat fishes Mahseer (*Tor tor; T. putitora*) and *Labeo* spp. The commercial fishery in this zone is non-existing due to sparse population of commercially important fishes, unaccessible terrain and poor communication between fishing grounds and landing centres.

Fisheries of upper stretch: This stretch extends from Rishikesh to Allahabad (770 km) . Here fishery has assumed some commercial importance. The fishery is dominated by major carps followed by catfishes, murrels, feather-backs and miscellaneous fishes.

Fisheries of middle stretch : This stretch extends from Allahabad to Farakka (1005 km) and fall under this category. This stretch runs through states of U.P., Bihar and West Bengal. In Bihar, the river is characterized by meanders, loops, ox-bow lakes and extension flood plains. Fishing in river is of very high magnitude. The important landing centres are Allahabad, Patna, Buxar and Bhagalpur. The mainstay of fishery are the species belonging to cyprindae (176 species) and siluridae (cat fishes). The important species are: Gangetic major carps, catfishes, murrles, clupeids and feather backs besides migratory hilsa. The fish yield especially of major carps is alarmingly declining year after year. It has gone down from 26.62 kg/ha/yr during 1958-61 to 2.55 kg/ha/yr during 1989-95. The fish yield of major carps at various centres of Ganga is given in Table I.

Table 1 : Estimated yield of Indian major carps in the river Ganga (kg/ha/yr)

Centres/year	1958-61	1961-69	1980-86	1989-95
Kanpur	83.5	24.3	-	-
Allahabad	15.6	21.5	9.29	17.2
Buxar	17.1	3.8	7.0	-
Patna	13.3	13.3	5.08	3.04
Bhagalpur	3.6	7.5	2.9	2.9
Mean	26.62	14.08	6.07	2.55

The total landing (average) at selected landing centres is given in Table 2 for having an idea of fish catch in the middle stretch of Ganga.

The perusal of the Table 2 reveals that a general decline in fish production is perceptible from 1958 to 1984-93 on all the centres for which data is available. The main reasons for declining in fish yield may be attributed to (1) sandification of the river bed (upto Patna) which reduced the river's productivity due to blanket effect (2) marked reduction in the river volume on account of increased sedimentation (caused due to deforestation) (3) increased water abstraction and (4) irrational fishing. These are the main reasons for decline in fish yield, e.g. the fish yield has come down at Allahabad and Patna landing centres from 950 kg Km^{-1} yr^{-1} and 1811.2 Kg Km^{-1} yr^{-1} in 1960's to 311.6 Kg Km^{-1} yr and 629.8 kg Km yr in 1990's respectively.

Decline in Hilsa Fishery : The commissioning of Farakka barrage in 1972 caused an adverse effect on hilsa fishery, being migratory in nature. In pre-Farakka period (1958-72), the yield of hilsa at Allahabad varied from 7.87 to 40.16 t, at Buxar from 7.38 to 113.36 t, at Bhagalpur, 1.47 to 9.79 t and at Lalgola 3.70 to 363.24 t. The scenario has adversely changed in post-Farakka period and hilsa yield has come down to 0.13 to 2.04 t, 0.07 to 2.60 t, 0.01 to 2.18 t and 7.02 to 283.21 t respectively at the above centres. This is a classical example of adverse effect of construction of dams/barrages on the yield of migratory fishes. Similar problem is observed in migration of mahseers in upland rivers due to construction of barrages. This has resulted in dwindling of their population.

Potential fish yield: Actual fish production from the river at Allahabad was 21.33 during 1972-79 and 28.69 Kg ha^{-1} during 1980-86. Thus only 13.29-13.74% of the potential is being harvested. At Patna and Bhagalpur, 25.19% to 26.30% of the potential is harvested. The overall utilization of fish yield potential in the upper and middle Ganga comes to only 22.80%. In the lower Ganga, against a potential yield of 198.28 Kg ha^{-1} , only 30.03 Kg ha is currently harvested. Thus, in general the fish yield potential is unadequately utilized in all the sectors leaving scope for further improvement (Table 3).

The potential fish yield of some of the important rivers based on physiographic characteristics is depicted in Table 4.

Table 2 : Estimated mean annual landings (metric tonnes) at different landing centres.

Centres	1958-59 to 61-62	62-63 to 65-66	73-74 to 76-77	77-78 to 80-81	81-82 to 85-86	1989-93
Allahabad	183.73	230.60	111.48	147.78	163.5	72.66
Buxar	91.53	40.10	12.74	14.43	25.65	-
Bhagalpur	77.01	86.85	73.37	97.63	97.45	-
Patna	-	108.86	-	-	62.45 (86-88 only)	37.79

Brahamaputra River System : The Brahamputra river originates from a glacier (Kubiangiri) in Tibet and had a combined length of 4025 km including its tributaries. The catchment area is 580000 Km^{-2} , with an average run off 38 million hectare metre (mhm). The annual discharge rate is of the order of 510450 million cubic feet. The geological nescent state of Himalayas from where this river originates has substantially contributed to the high silt in the main channel. On account of this, Brahamputra river bed has risen during 1937-97 c 4.5 m due to deposition of silt.

Characteristically, the northern tributaries are large with steep, shallow braided channels carrying high silt discharge (666.7 m^{-3} Km^{-2}), contrary to those of southern bank (tributaries) which are deeper with maize channels, low gradient and lesser silt load (66.7 to 95.7 Km^{-2}) like Ganga basin, the Brahamputra valley is also dotted with abandoned beds called beels which support rich fishery. The beels are in abundance in the districts of Nowgowng, Lakhimpur, Goalpar and North Kamrup. The river has got a number of tributaries. The major portion of the river lies in Tibet and in Indian teritory river flows about 800 Km only. It is joined by Ganga in Bangladesh, forming the largest delta in the world.

Fish stock composition: The rhithron sector of the river is not having commercial fishery of any significance. This segment harbours cold water fishes such as *Tor tor, T. putitora, T. mosal, T. progeneius, Acrossocheilus hexagonolepis* and large cat fish *Bagarius bagarius*. A total of 126 fish species belonging to 26 families out of which 41 are of commercial importance have been reported. The fish fauna is a mixture of torrential fauna, specific to northern bank and that of southern bank is of a mixed type. Further, 33 species belonged to eastern Himalaya and 11 species of Mayanar origin while 23 species are endemic. The major constituents of potamic stretch fisheries are: Gangetic major carps, medium carps, minor carps, catfishes (*W. attu, M. seenghala, M. aor, M. vitattus, B. bagarius, S. silondia, C. garua, P. pangasius, Rita rita, H. fossilis, O. bimaculatus, A. coila*) and *Hilsa ilisha*. Miscellaneous fishes such as *S. phasa, G. chapra, M. armatus., M. aculeatus, G. giuris, Pama pama, Ambassis* spp. and feather-backs (*Notopterus notopterus, N. chitala*) also formed substantial fisheries of the potomon region.

The average catch at four important landing centres was estimated at 847 t in 1970's . The fisheries in the upper, middle and lower stretches of the river is dominated by catfishes. In the upper middle stretch miscellaneous fishes dominated (54.14%) followed by cat fishes (28.40%) and major carps (17.46%), while in middle stretch catfishes (28%) replaced to the miscellaneous fishes followed by major carps (26%) and hilsa (18%)., while fisheries of lower mid-stretch is again dominated by miscellaneous group (34%) followed by catfishes (24%), minor carps (20%) major carps (11%) and hilsa (7%). Prawns contribution in the total landing of the mid-stretch is restricted to only 4 to 7%.

In another survey conducted by CICFRI, during 1973-79 on the landing centres of Guwahati revealed that the fish landing has decreased to about 6-folds from 233.44 t in 1973 to a low of 39.02 t in 1979. The major carps yield has drastically declined to the tune of 5.6-fold (47.61 to 8.5 t) of cat fishes by 8-folds (58.7 t to 7.3 t), and of hilsa by 2.7-folds (21.63 t to 8.02 t). Similarly, the yield per Km. of river stretch has also declined from 2.3 to 0.4 t during the above period.

The decline in major carps yield may be attributed to heavy exploitatin of brooders (ujaimara activity) and as well as of juveniles. Domination of miscellaneous fishes over quality fish indicates symptoms of Pauly's ecosystem over fishing syndrome similar to Ganga river.

Indus river system : The major portion of Indus river system lies within Pakistan but its five tributaries viz., the Jhelum, the Chainab, the Ravi, the Beas and the Sutlej originate from western Himalayas.

Fish stock composition: In head waters of these rivers commerical fisheries is absent. The common fish species inhabiting are: brown trout (Salmo trutta fario), rainbow trout (*S. gairdneri*), mahseers (*Tor tor, T. putitora*), snow trouts (*Schizothorax* spp.) certain cyprinids

(*Labeo dero*, *Gara gotyla*); loaches (*Botia* spp.) and *Nemacheilus* spp. The beas and Sutlej rivers contain indigenous carps and catfishes akin to Ganga river. The commercial fishery operations only takes place in middle and lower reaches of these rivers, but catch data is not available. Heavy water abstraction from these rivers has been reported to be responsible for reducing fish stock. Further, faulty designed fish-ladders and fish passes in the dams, weirs and barrages for providing ascend to fishes are not functioning properly and rather act as fish traps instead of fish passes.

Jhelum in Jammu and Kashmir is reproted to support commercial fisheries. The species caught are : S*hizothorax* spp., *Labeo dero, L. dyocheilus, Crossocheilus latius, Puntius conchonius, Cyprinus carpio (C. communis and C. specularis*) loaches and *Glyptothorax* spp.

Penninsular river system : This sytem may be broadly categorised into two (1) East coast river system and (2) West coast river sytstem.

1. **East coast river system** : The combined length of the four rivers which constitutes this system *viz*., the Godavari, the Mahanadi, the Krishna and the Cauvery is about 6437 km with a total catchment area of 121 mha. The annual runoff is 41.19 mha with an average rainfall of 109 cm.

The Godavari : This river is about 1440 km long, covering an area of about 315 980 km^2 and drains the region of central India and Westerenghat. The rhithron region harbours a variety of game fishes but donot support commercial fishery. According to a survey conducted by CICFRI (1963-69) for a riverine stretch of 189 km (between Dowlaiswarum and Pumnagudum anicut) estimated a fish yield between 218 and 330 t. The fish yield kg/ha ranged between 6.14 kg (1969) to 9.36 kg (1963), indicating a declining trend. It has been observed that at present river is maintaining a fish production of 1 tonne/km/Annum (Kamal, 1991) against a fish production of 1.392 t/km^{-1}yr^{-1} in 1960's.

Fish Stock Composition :-The commercial fisheries consists of carps (*major carps* and *L.fimbriatus*), large cat fishes (*Mystus spp*., *Wallago attu*, *S.childreni* and *B.bagarius*) and fresh water prawn (*M.malcomsonii*). Hilsa formed a lucrative fisheries and its landing fluctuated widely between 15.5t to 46.3t during the 1963-69. The Indian major carps planted in the river in the beginning of 19th century are thriving well and contributing to the commercial fisheries (David, 1963). Among miscellaneous fishes, *Chela argentina*, *P. aurulius* and *P. conchonius* dominate the catch (shivaprakash, 1990).

The Mahanandi River :-The river is 860 km long and flows throgh the state of Orissa and Madhya-Pradesh. The upper reaches harbour game fishes but commercial fishery is non existant due to unaccessible terrain. The ichthyofauna is similar to Ganga with addition of peninsular species. Hilsa is confined to lower reaches and together with major carps and catfishes forms lucrative fishery. Data on fish production and catch per unit effort is not available.

Krishna River : The river originates from westernghat ranges south of the Pune and drains into Bay of Bengal on the east coast. It has a length of 1,120 Km with a catchment area of 2,33,229 Km^{-2}. Bhima and Tungabhadra are the main tributaries. A number of dams have been constructed on these rivers which has altered the ecology of these rivers. In general, the physiography and fish fauna of the Krishna river resembles to Godavari river system (David, 1963). The headwaters support rich fishery when compared to mid-stretch, whcih is rocky and unaccessible. David (loc. cit) has reported that 91 to 136 Kg fish is daily captured at Vijaywada alone. No informaiton is available on fishery and catchstatistics.

Cauvery River : The river rises from Brahimgiri hills on the westernghat and flows in south-easterly direction before emptying in the Bay of Bengal. It has a combined length of 800 Km. Bhavani and kabbani are the main tributaries. The water resource of the river is extensively exploited, as numerous reservoirs, anicuts and barrages have been built on the river.

The river exhibits substantial variation in its fauna. The game fishes like *Tor khudri* and *T. mussullah* are found all along the river's length except the deltoid stretch. Eighty species of fish belonging to 23 families have been reported. It's fish fauna differs signficiantly from Krishna and Godavari. The commercial fisheries comprised of carps (*Tor* spp., *P. carnaticus*, *P. dubius*, *Acrossocheilus hexagonolepis*, *Labeo kontius*) cat fishes (*Glyptothorax madraspatanus*, *Mystus* spp., *P. pangasius*, *W. attu*, and *S. silondia*. Data on catch statistics is not available.

West Coast River System : The main westward flowing rivers are Narmada and Tapti. The combined length of the two rivers is c 3380 Km. The catchment area of these rivers extends to 69.16 mhm with annual run off 31.06 mham, and experience an average rainfall of 122 cm.

Composition of fish stock : Narmada river harbours eightyfour fish species belonging to 23 genera. The contribution of carps in commercial fishery is of the order of 57.47 to 62.40% (Mahseer, 23.7 to 27%), *Labeo fimbriatus*, 18.20 to 19.20%; *L. calbasu*, 52-6.40%) followed by catfishes, 34 to 38% (Rita spp. 12.0 to 14%, *M. seenghala*, 7.80 - 9.80%, *M. aor* 4.7 to 5.0%, *W. attu*, 7.40 to 8.20%, *M. cavasius* 0.5 to 0.8% and miscellaneous fishes 4 to 5% (*Channa* spp., *Mastacembalus* spp., *N. notopterus* and minnows). Karamchandani *et. al.* (1967) had reported from a 48 km stretch (Hoshangabad to Shahganj) of the river, a monthly yield of 32.8 to 52.7 tonnes. Since then, no perceptible change either in fish catch or in fish composition has been observed (Rao *et al.*, 1991). However, now the river ecology might undergo a sea change with the proposed irrigation projects which will transform the river into a chain of reservoirs (major 450, medium and minor 350) obliteratiing the riverine habitat.

Tapti river : Not much informaion on fish stock composition and fish yield is available. According to karamchandani and Pisolkar, (1967), 2.60 tonnes of fish/day is captured from the river. The commercial fishery is mainly consists of *Tor tor*, *Labeo fimbriatus*, *L. boggut and L. calbasu* among carps followed by cafishes such as *Mystus* spp. and *W. attu.*

Factors influencing fish yield from rivers

Biological and ecological studies have revealed that the fish communities are very sensitive to flood regime because of their dependance on the seasonal floods to innundates the ground needed for feeding and breeding. Any change in the pattern and form of flood curve result in the alternation of fish community structure. A characteristics feature of a river system is the nature of the input governing the productivity pattern. In the upper stretch of the rivers, such inputs are mainly allochthonous but in the potomon region encompassing the flood plains, the major inputs are silt and dissolved nutrients. There is a gap of knowledge on the relationship between these inputs and energy flow and productivity trends in these systems.

The intensity of fishing, nature of exploitation and species orientation are the characteristic of the artisinal riverine fisheries and are governed by :(1) seasonality of riverine fishing activity; (ii) unstable catch composition; (iii) conflicting multiple use of river water, (iv) cultural stresses leading to nutrients loading and pollution; (v) lack of understanding of the fluvial system and infirm data base; (vi) fragmentary and out moded conversation measures lacking enforcement of machinery; (vii) inadequacy of infrastructure and supporting services (viii) affordability and palatability and (ix) socio economic and socio-cultural determinant (Jhingran, 1984).

An intelligent management strategy has to take cognisance of key parameters such as hydrology, fish stocks and dynamics of their population together with regulartory measures for fishing. Observance of closed seasons and setting up of fish sanctuaries have proved their efficacy in fostering recovery of impaired fisheries. Experience has indicated that gear control measures are liable to fail in yielding results until the artisanal level of fisheries exploitation is significantly changed.

There is an urgent need of integrated riverine management which envisages:

i) basin-wise approach, taking into account, the multiple use of river water and the impact of developmental activities on the biotic wealth;
ii) comprehensive computer model for environmental impact assessment;
iii) a judicious water allocation policy for various sectors taking into consideration the biological threshold levels; and
iv) keeping fisheries at par with other developmental and conservation activities in the river basin.

If these measures are religiously followed, the fish yield from Indian rivers is bound to enhance which will provide not only high quality of protein but will uplift the status of fishers in this country.

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Table 3. Energy transformation, fish production potential and extent of utilisation of potential fish yield in river Ganga at different centres

Centre	Year	Av. Carbon production mgCm^{-2} day^{-1}	Av. Rate of energy transformation calm^{-2} day^{-1}	Photosynthetic efficiency %	Fish production potential kgha^{-1} yr^{-1}	Actual harvest kgh^{-1} yr^{-1}	Extent of utilisation %
Kanpur	1987-88	234.5	1419	0.077	50.10	-	-
Allahabad	1974	-	4501	0.241	160.44	21.33	13.29
	1987-88	730.5	5906	0.316	208.70	28.69	13.74
Varanasi	1987-88	589.1	3243	0.173	112.20	-	-
Patna	1987-88	293.0	3534	0.190	122.40	30.84	25.19
Bhagalpur	1972	-	3586	0.186	120.68	31.64	26.30
	1987-88	420.0	4124	0.220	142.80	36.75	25.73

(After Jhingran & Pathak, 1988)

Table 4. Showing the potential fish yield from Indian rivers based on their length and basin area

River	Length (km)	Basin area (million km^2)	Catch Area based tonnes	 Strem length based tonnes
Himalayan river				
Ganga	2525	0.88	17443	17142
yamuna	1376	0.37	5243	8588
Brahamaputra	800	0.19	1782	3958
East Coast rivers				
Godavari	1465	0.31	5936	6364
Krishna	1401	0.26	5434	5365
Cauvery	800	0.09	1791	1917
Mahanadi	880	0.14	2088	2943
West coast rivers				
Narmada	1312	0.10	4844	2124
Tapti	720	0.06	1454	1294
Mahi	533	0.02	802	446

(After Khan, 1997)

ECODYNAMICS AND IMPORTANCE OF MANGROVES IN SUSTAINING THE COASTAL FISHERIES AND AQUATIC BIODIVERSITY

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Introduction

Mangroves, the unique ecosystem, spread over an estimated area of about 14 million hectares in the tropical and sub-tropical regions of the Globe of these, the dominant mangrove zones in the world are restricted within the latitude 30°00′ S and 31°00′ N of the Tropical and Sub-tropical deltaic lands, sheltered bays, coast lines, estuarine mouths and edges of the islands, where these lands are frequently or periodically inundated with tidal sea water and also wash with up stream freshwater or bath with the frequent monsoon precipitation

In these mangrove zones, generally the temperature fluctuates between 20°C and 35°C, though these temperature ranges occasionally varies in some scrub-mangrove zones, *i.e.*, 2°C- 4°C at 38°4′ S latitude in S. E. Australia (with the dominant species like ***Avicennia marina***) and 31°0′N latitude in Japan (with the dominant species like ***Kandelia candel***) The most dominant world mangrove zones are reported from this Old World, the Indo - West Pacific regions, *viz.*, East African coast, Malagasy, Seychelles, Pakistan, Maldives, Sri Lanka, both east and west coast of India, Andaman & Nicobar Islands, Bangladesh, most of the coastal zones of S.E. Asian countries, Tropical Australia, New Zealand etc. The other important New World mangals are also reported from west coast of Africa, both the east & west coasts of tropical S. America, Mexico and the coastal areas of N. America .

Most of these world mangrove zones and areas have also been reported as the productive ecosystem with diverse groups of salt water loving flora and fauna; which are also very much important in regards to its interesting bio-diversity or being the world's most important heritage site within this sea-land interphase mangrove ecosystem (Naskar, 1996). The ideal mangrove ecosystem alternately inundate with tidal sea water during high tides and also exposed during tidal receding time or low tides. As such, these mangrove soil is saline, silty clay and semi-fluid to compact in nature; where large group of both aquatic and terestrial fauna find their preferred habitats for food and shelter. Besides these, large number algal flora also grow in these soil substratum as benthos and most of these algae are identified as the most preferred natural food for both shell fish and fish species of these estuarine ecosystems or mangals.

Tomlinson (1986) had reported only 40 species as the '**major and minor elements of mangroves**' or '**true mangrove species**' of the Old World, while in the New World the true mangrove species are only 8. But, Chapman (1976) had reported the total mangroves of the World as 90 species; furthermore, **UNESCO** (1983) had reported only 65 true mangrove species from the tropical and sub-tropical zones of the World. In another publication, Mepham & Mepham (1984) had reported more than 900 angiosperm flora from the world mangrove zones and they had grouped these 963 species either under the list of true mangroves, mangrove associates, back mangals and others. Mepham & Mepham (1984) had also raised several pertaining questions regarding the definition and strict boundary of these world mangroves. These important mangrove zones or the ecosystems are the natural habitats, breeding and grazing grounds or the nursery beds for large number of estuarine and off-shore shell-fish and fin-fish species, insects, reptiles, amphibians, birds, mammals etc. ~~(Mac Nae, 1968)~~. Mac Nae (1968) had also mentioned that "**mangroves are the natures' own aquaculture system**" and he had cautioned that "**no mangrove no prawn**"; that is the prawn farming cannot be viable without the existence of mangroves. Tomlinson (1968) had mentioned '**the sea-land interphace, inter-tidal or tidal habitat tropical and sub-tropical woody plants are mangroves**' and '**the community of these mangroves are mangals**'. Lear & Turner (1977) had also suggested that '**mangrove is the coastal ecosystem in a holistic manner**', which includes its common habitat or inhabiting flora and fauna; this mangrove is the depository of diverse flora and fauna.

As such, it is now worth mentioning that mangroves or the mangrove ecosystem or mangals includes certain group of flowering plants, cryptogamic flora, *viz.*, fungi, algae, bryophytes, ferns and varied groups of fauna, *viz.*, aquatic, mud-dwelling, terrestrial, tree living animal species and / or Avi fauna. Biotic communities of this composite ecosystem thus can be grouped in a broad sense as flora and fauna of the mangroves or mangals. All these have vital and great role in moulding the mangrove ecosystem in a perfect and holistic manner.

Definition of Mangroves

Several mangrove workers have recognised and defined the term '**mangrove**' differently; but for the clear idea and understanding the uniform characterization of these mangroves are essential. Few of these definitions of these mangroves are as follows :

a) Davies (1940) defined the mangrove as - "**Plants which live in muddy, loose, wet - soils in tropical tide waters are mangroves**".

b) Mac Nae (1968) defined the mangrove as - "**Trees or bushes, growing between the level of high water of spring tide and level close to but above the mean sea level**". Mac Nae (1968) had also used the term '**mangal**' for referring to the mangrove forest community, while the term '**mangrove**' for individual kind of tree species.

c) Aubreville (1970) defined the mangrove as - "**Mangroves are the coastal tropical formations, found along the border of the sea and lagoons, reaching upto the edges of the river to the point where the water is saline, growing in swampy soil and covered by sea water during high tides**".

d) Geriech (1973) reported that, mangrove occur at the edges of the tropical and sub-tropical seas, in bays, lagoons and estuarine regions. Thus **"Mangroves are trees of various species of several families, which grow only where they come into permanent contact with sea water or brackishwater"**.

e) Blasco (1975 & 1977) defined mangrove as - **"The mangrove is a type of coastal woody vegetation that fringes muddy saline shores and estuaries in tropical and sub-tropical regions".**

f) Arroyo (1977) defined the mangrove as - **"A small group of true mangrove plants and associated species belonging to systematically unrelated families, possessing similar physiological characteristics and structural adaptations with common preference to the inter tidal habitat"**. The term '**mangrove**' is also used for the -

(i). Forest Ecosystem ,
(ii). The Component Vegetation, and
(iii). Both Forest Ecosystem and Forest Vegetation.

g) Clough (1982) defined mangrove as - **" They are the only trees amongst relatively small group of higher plants, those have been remarkably successful in colonising the intertidal zone at the inter phase between land and sea".**

h) Tomlinson (1986) referred the term mangrove -**'Either to the constituent of plants of tropical intertidal forest communities or to the community itself'.** Tomlinson (1986) had critically analysed and stated these mangroves on the cosmopolitan basis; these are basically three types, *i.e.*, a) **major elements of mangals**, b) **minor elements of mangals**, c) **mangrove associates**, including the coastal species like back mangal, salt marsh flora, wet coastal communities, beach or coastal communities, low land swamp species, coastal swamps and swamp forest flora.

Mangrove in the more limited sense may thus be defined as - the' **Tropical trees restricted to intertidal and adjacent communities'** or **'Mangroves is a community that contain mangrove plants'**.

(i) Mepham & Mepham (1984) had also critically analysed 963 Angiosperm plants and fern species of the tidal and above tidal forests of the Indo-West Pacific Regions and highlighted them thoroughly, citing several most interesting examples, as well as, raised several debatable questions between the relationship and correct definition of '**Mangroves**'.

In this context, it is very much urgent to ascertain or draw a clear cut boundary line or define the term mangrove, prior to initiate any discussion on mangroves or mangals.

Area and Geographical Position of The Mangroves In Indian Sundarbans

Sundarbans, the largest deltaic tropical plain of India, is located in the southern part of both the districts 24- Parganas South and 24 Parganas North and in the coastal belt of West Bengal. It lies between the longitude 88°10'E and 89°10'E and latitude between 21°30'N and 22°15'N. These tidal delta Reserve forest area is about 4267 sq km, including both the mangrove forest land and water ways; of which, 1750 sq km is under the tidal rivers, creeks and brackishwater lagoons. The actual mangrove forest area in the estuarine belt/ deltaic zone of Indian Sundarbans is about 2179.05 sq km (with dense mangrove covers = 1952.87sq km + 226.18 sparse mangrove covers) and the rest is the naked beach or river flats. The entire area is intersected by large number of criss -cross network of tidal rivers, canals and creeks, which divides the region into 75 forest compartments under about 54 mangrove dominated islands futhermore, about 50 islands of these deltaic region were converted to human habitation, agricultural field. The denuded forest bed lying on the river banks, sand chars, forest floors and sea-shores is about 216.6 sq km (Naskar & Guha Bakshi, 1987). The delta embraces several true estuaries and off-shoots of the Bay of Bengal, *viz.*, Hooghly, Baratala or Muriganga, Saptamukhi, Thakuran, Matla, Goasoba, Harinbari etc. along with large number of east to west flowing tidal rivers, creeks and canals (Naskar & Guha Bakshi,1987).

Since the later half of the eighteenth Century, more than 50% of the mangrove forests in the Indian Sundarbans were cleared or reclaimed for the human habitations, agicultural lands and brackishwater fisheries etc. (Naskar,1985). Out of the total 9630 sq km Sundarbans regions of the Indian part, 13 rural blocks in the South 24 Parganas and 6 rural blocks of the North 24 Parganas are now densely populated with more than 32 lakh rural people (Census,1991); majority of them were migrated from the adjacent district Midnapore and also the refugees from Bangladesh. Most of these rural people are living much below abject proverty and they are solely or partly dependant on these virgin, fragile and degraded mangals of the Indian Sundarbans. Inspite of providing the longterm natural resources, *viz.*, shell-fish and fin-fish, timber, fuel wood, honey and wax, these coastal facing dense mangrove forests act as the wall and protect this newly silted up and frequent tidal inundated cyclone prone and problem stricken areas. But, poverty and greediness of the local people and business classes these nature's most interesting and world's most important heritage site are ignored while the protection measures and /or conservation activities are less feeble in these Sundarbans mangals.

Considering these ecological roles, economical potentialities and degrading nature, since 1973 about 2585 sq. km S.E. part of the Indian Sundarbans was declared as the 'Sundarbans Tiger Reserve', since 1976 the estuarine crocodile, ***Crocodilus porosus*** was also breeded and reared in the crocodile farm at Bhagbatpur at Namkhana Range and 3 Wildlife Sanctuaries, *viz.*, Sajnakhali, Holiday Island and Luthian Island started functioning and the Sundarbans mangrove forest was also declared as the 'National Park' since 1987. Besides these, with the objectives of overall conservation of the Sundarbans, *i.e.*, 9630 sq km is declared as the '**Sundarbans Man and Biosphere Reserve'**.

As such, for detailed clarification of different zones of the Sundarbans areas alongwith the population are shown below:

Total Sundarbans Areas	**= 9630.00sq km**
Total Mangrove Areas in Sundarbans	= 4266.60sq km
Mangrove Forest Zone	= 2179.05sq km
Estuarine Rivers, tidal creeks & canals	= 1800.00sq km(approx.)
Naked mudflats, sea-shore & river banks	= 277.55sq km(approx.)
Mangrove Reclaimed Zones & Human habitations	= 5363.40sq km(approx.)
Total Population in the Sundarbans (19 Rural Blocks) is about 32 lakh (Census -1991)	

All these interesting and unique flora and fauna of the Sundarbans mangals and the mangroves of the other regions have some close relationship or interaction with each other. These mangrove flora and the mangrove habitat faunal biodiversity have immence value and most economic potentialities in the sustained production of large number and huge quantities of the natural resources for the human soicety, which need only careful observation and for undertaking sympathetic conservation of all these biota.

Climatic And Physiognomic Factors Of The Mangroves

The mangrove species preferably grow in the saline soil and brackishwater zones, with the ranges 10 to 45 ppt, but for the effective mangrove seed germination and in the juvenile conditions, these mangroves thrive well in the less saline conditions. As such, most mangrove species bloom during the winter and summer months and the mature seeds become ready for germination during onset of the monsoon months, when the soil and water salinity becomes less due to monsoon precipitation and also due to adequate supply of upstream freshwater. These mangrove zones are spread over in the tropical and sub-tropical zones, with the average temperature ranges between 20°C and 35°C along with the average monsoon precipitation, *i.e.*, 1000 mm to 3000 mm annually; these also require coastal aeridity and high humidity; but the mangrove cannot thrive well or cannot show better growth in the lower temperature ranges or near the freezing point or on the frost. Besides these, the silted up clayee, loamy soil and the river carried sediments are also preferred by most of these mangrove species. For having the salt excretory mechanism, salt accumulation techniques, *viz.*, the adaptations like - salt exclusion, salt intrusion and salt accumulation, the major mangroves develop some specialised morphological features like develoment of air breathing and mechanical supporting pneumatophores, knee roots, buttress roots, stilt roots, bow roots, blind root suckers, plank like roots, pneumatothods etc. The adaptations, like viviparous germination, fleshy and leathery leaf textures, sunken stomata are also the unique morphological characters; all these help these mangroves to grow and survive in these salt water and saline soil phases, where other non mangrove plants can not grow.

Topography and Physiognomy

The Sundarbans fall under the Ganga - Brahmaputra delta system; the tidal flushing of sea water from Bay of Bengal through the network of tidal rivers and creeks have turned the water and soil of this deltaic land highly saline (Sah, *et. al.*, 1987). The river Hooghly in the west and the Ichhamati-Bidya in the east mostly carry fresh water from the upper stretches (Ganga-Brahmaputra system). The land evolution of this estuarine delta is very much devastating due to limited supply of fresh water from the upper streams; which is also reported for having the tilting effect (neo-tectonic movement) of the flow of the river Bhagirathi-Hooghly towards Padma of Bangladesh. Large areas in these deltaic mangrove forests are flooded with salt water during high tidal phase, while these vast tidal wetlands are covered by dense mangroves or halophytic herbs, shrubs and trees and the flat river beds or sand dunes are naked without any forest coverage, remain exposed during low tide (Naskar, 1983). These typical estuarine halophytic zones play dominant role in protecting the coastal areas. However, due to neo-tectonic, geomorphic, edaphic factors and rapid increasing human pressure and several other biotic interferences, several hectares mangrove free denuded tidal lands remain fallow as waste wetlands, which show higher salinity levels in comparison to mangrove forest covered areas (Deb,1956).

Soil Phase In The Mangals

The coastal strip extends to about 50 km - 70 km width from the Bay of Bengal. Coastal saline soils having an area of about 0.82 M ha have shown silty-clay to silty-clay-loam texture, chloride and sulphate of sodium (Yadav *et al.*, 1983); the coastal saline soil is deficient in Nitrogen and richness in Potassium (Bandopadhyay & Bandopadhyay, 1984). Coarse sand to clay or clay loam soil texture with varying organic matter have also been reported in the soil of the mangrove delta (Natarajan & Ghosh, 1985). Rudra & Halder (1987) while studying the soil characteristics of Sundarbans have indicated a good percentage of acid soil and a variation of soil texture from heavy clay to light soil in a few blocks. Adhikari *et al.* (1987) have detected appreciable amount of copper, manganese and potassium and low concentration of nitrogen. Detritus derived from molluscan and crustacean shells and especially mangroves decomposing leaves in tidal river basin soils deserves the study as it adds to the fertility of the soil (D'Souza and D'Souza, 1979) and for sustaining the growth of the mangrove herbs, shrubs and trees, besides fish and prawns (Choudhury, 1978). The electrochemical proportion of the mangrove muds of the Sundarbans were studied by Sah *et. al.* (1985). The percentage of organic carbon and humus carbon in the surface muds of the intertidal mangrove forests are due to the dense growth of the mangrove flora and very dominant mangrove dwelling biota.

Water Phase In The Mangals

Water salinity plays a dominant role on the survival and growth of different species of mangroves and algal flora and recruitment of certain types of fishes and prawns. Richness in nutrients in brackishwater of the Sundarbans has been found favourable for growth of a variety of euryhaline fishes and prawns from their larval stage to fingerlings (Ghosh, 1980).

Stresses on the Indian Mangroves

Mencer and Hamilton (1984) have reported that during the last two centuries vast areas of these mangrove ecosystems of the World have been reclaimed to shrimp farms in the S. E. Asian countries. Saengar, *et al.* (1983) emphasised that over increasing population pressure and pollutant discharge from industries, oil refinaries, tanaries and urban areas caused dramatic change on these mangrove ecosystems, throughout the world. Naskar (1985) has reported that during the last two centuries more than 50% mangrove areas in the Indian Sundarbans are reclaimed and converted to agricultural fields, brackishwater fisheries and rural habitations. Chanda (1977) has also reported that the mangrove areas of the undivided Sundarbans reduced to more than 50% during the last two centuries.

During the recent times and for the sake of development of port and harbours, roadways, tourism and for other human needs vast mangrove areas in India and all over the globe have been converted dramatically which have very detrimental effect in this fragile ecosystem. As the mangrove habitat and the tidal influenced water are ideal for development of seed farm, several hectares mangrove habitat lands have been cleared and reclaimed for prawn farms and brackishwater fisheries or for crab culture purposes throughout the S. E. Asian countries and in Indian mangals, as well. For making more profit, dramatic and drastic collection of prawn seeds and exploitation of other prawn and fish juveniles have been identified as an alarming situation throughout the mangrove habitats in India and other S. E. Asian countries. Besides all these, leaking of oil from the country boats and the pollutant discharge from the urban areas have also several alarming effect on the natural habitats of mangrove flora and fauna.

Roles Played by these Mangroves

Large number of fin-fish and shell-fish (prawns, crabs and molluscs) species are found as the common inhabitants on the mangrove waterways (rivers, creeks, canals, marshes, lagoons and wetlands) or these estuarine, off-shore and marine species are fully or partly dependent on these unique mangrove ecosystem. But it was not possible to assess or draw a clear demarcating line between these species of mangrove-dwelling, mangrove dependent, non-mangrove dependent and obligatory dependent on mangroves.

These quantitative estimation of mangrove dwelling and mangrove dependent fish and fisheries are very much limited, as most of these fin-fish and shell fish species are used to migrate from place to place during different season and different parts of their life-cycle. The only exceptions are the commercially important species of molluscs and resident crabs, gastropods etc. The present day's fishery statistics are mostly based on the fish landing data, collected from the different seasons, times and from the different parts of the mangrove habitats. All these data are not much much authentic, as because these data collections are based on different heterogenous group of workers, whose collected data may have over or under estimation. Besides these, the use of diverse fishing crafts, gears and mesh size of the nets and also the fishing operations (effort) or the degree of involvement of fishing community from zone to zone or from country to country these landing data may reflect a different picture and that may not be correlated with the mangroves of different parts of the Globe.

The only possibilities for near accurate estimation and quantification are to investigate critically the habits and habitats of different species of fin-fish and shell-fish species of these mangrove habitats and comparison can also be made with that of the mangrove cleared or reclaimed coastal or estuarine areas. Besides these, the investigation on the life cycle of each and every individual species along with their food habit, estimation of their migratory pathways and abundance or dominant harvest may help in this quantitative processes.

In these context, few important and well documented publications are mentioned for supporting the views of the direct correlation of mangroves with abundance of shell-fish species in the Indo-West Pacific regions, where mangroves are dominant on the estuarine mouths, sheltered coasts and lagoons. These important publications are -

(i) **Mac Nae (1968, 1974)** reported that the rivers, canals and lagoons in and around the dense mangroves are the natural habitats and nursery grounds of varied fin - fish and shell - fish species, which are commercially much important; among these few most important species are *Chanos chanos*, *Mugil* spp., *Hilsa* spp. and *Pomadasys* sp.

(ii) **Macintosh (1982)** reviewed the different publications of different workers of the different countries and highlighted an average 100 mangrove dwelling fish species from the different mangrove habitats. These important publications are made by Odum & Heald (1972) for Florida, Ong (1978) for Malaysia, Prince Jeyaseelam & Krishnamurthy (1980) for India, Collette & Trott (1980) for New Guinea. Jothy (1984) has also reported that 29 commercial fin-fish species under 23 families from the Malaysian mangrove waterways; among these few mentioned can be made for the *Chanos chanos, Hilsa macrura, Lates calcarifer, Epinephelus tauvina, Liza* spp., *Plotosus canius*.

(iii) Besides these, **Jothy (1984)** has listed 13 commercial species of shell fish and five commercially important species of molluscs from the Malaysian mangrove waterways. These important edible molluscs/ cockles of the Malaysian mangroves are *Anadara granosa*; the other Oyster species are *Crassosthea* spp. and green mussel is *Perna viridis*.

(iv) **Hall (1962)** also attempted to relate marine prawn fisheries in the mangrove habitat water ways and **Namin (1977)** has also explained that higher yield of prawns were desired from mangrove associated tropical coastline.

(v) **Daughery (1975)** had also highlighted that the destruction of mangroves is one of the major constraints for the declining trends of prawn catches.

(vi) **Jana *et al*.** (1974) supported and explained that several important fishes and prawns are now declining from the Indian Sundarbans mangals or estuarine zones due to deterioration of the mangrove vegetation.

(vii) **Umali, *et al*. (1987)** have also highlighted that mangroves not only support or export the fishery within its own ecosystem boundary, but also supply or export nutrients in the fisheries of the adjacent coastal areas; these mangrove waterways and mangrove ecosystems are identified as the nursery grounds for many fish species.

Among the large number of important observation and publications few mention may be made here for the mangrove dependent fish and fisheries in India in general and the Sundarbans mangals of West Bengal in particular. These important workers and publications are Naidu(1942), Hora & Nair(1944), Mukherjee, *et al*. (1940), Pillay(1954), David (1959),Gopalkrishnan (1968), Ghosh (1973), Luthar (1973), Annonymous (1978), Ghosh (1980), Chakraborty, et al. (1981), Jhingran (1982), Natarajan (1983), Naskar & Chakraborty (1984), Chakraborty & Naskar (1986), Naskar & Guha Bakshi (1987), Naskar & Ghosh (1989), Sanyal (1996), Das & Nandi (1996) Naskar & Ghosh (1997) and several others. All these publications have highlighted the direct correlation of the mangroves and the dominance of estuarine or off-shore fish and fisheries in and around the mangrove habitats of the Indian Sundarbans.

In addition to these economic and potential values, the mangrove forest flora also yield strong,durable hard timber and wood; mangrove reclaimed land is also identified as fertile land for paddy cultivation in several S.E. Asian countries, though in some cases these mangrove renovated areas has the problem of acidity, particularly the dominance of acid sulphate soil. Mangroves have several other economic and most valuable role in the human society, *viz.*, mangrove bark yield tannin, mangrove flower nectar produce honey and wax, mangrove forest is the only preferred habitats for large number of threatened, endemic, endangered and rare fauna in three tier system,*i.e.*, aquatic form from tidal water, terrestrial form from mangrove forest flora and avifauna like birds and others. As such, the mangrove ecosystem and forest areas are the attractive place for the tourist to meet their aesthetic needs, scientists and the ecologist for their virgin field for investigations and the fisheries scientists, as well. For all such reasons, these are unresolved conflict between the workers of these diverse fields and each of them claim mangrove ecosystem is their own and they may think that they are the authority and mangrove should be under their domain or jurisdiction.; though these complex ecosystem is not the property of any individual group.

Besides all these direct economic impacts, mangroves also protect the coastal zones from the cyclonic thrust and surges from the bay, alongwith the mitigation role played by these mangroves by protecting the deltaic lands from gradual erosion process of soil with the tidal flashing and also abate pollution.

Need for Conservation of Mangroves

During the recent times mangroves and the mangrove ecosystem are identified as the centre for rich diversity of different, interesting groups of flora and fauna. For their immense value, the mangroves and the mangrove ecosystem are now considered under strict protection and conservation measures for sustainable productivity and coastal land stability. The mangrove is the world's most important heritage site and the importance of several flora and fauna are identified as most essential for the well being of human society.

Remarks and Comments

On the basis of previous observations and studies, it is felt very much imperative to undertake few measures by imposing strict rules and making the rural people aware to protect the environment, natural resources and educating them for healthy living and thinking for their own existence. The following line of works may be suggested in this above context:

a) Assure their daily meal by improving agriculture, aquaculture, goaterry, piggery, dairy, poultry etc., based on the available local resources, possibilities and by providing training, financing, marketing and transport facilities. These approaches must provide employment opportunity for large number of rural people including rural women, those who mostly belong to S.C./S.T./OBC/Minority communities.

b) Need to stop monoculture of prawn and to encourage the fishery owner in polyculture, like the earlier years, by adopting the scientific methods formulated by the Central or State Fishery Research Institutes. These polyculture practices must help to stop prawn seed collection and damage of natural fish and prawn juveniles and the forest destruction must be checked.

c) Strict ban on operation of fine mesh nylon nets is essential and it is also necessary to stop netting of brood fish and prawn during the breeding season.

d) Exploitation of mangrove wood for fuel requires to be banned on an urgent basis as the growth of mangroves is very slow in this saline soil and tidal inundated mangrove forest zone. These mangrove forests of the Sundarbans are already suffering and getting degraded since the last two centuries or more, due to tilting effect and neotectonic movement of the freshwater flow of the river Ganga towards Padma, since the 16th Century. Large scale forest destruction, clearing of forest area for human habitation or agricultural or brackishwater fish cultural purposes during the last two Centuries, *i.e.*, since the time of Tilman Henckel (1781) and migration of the refugees from Bangladesh, Midnapore, Orissa and Chhotanagpur Hill are identified as the main cause for destruction of Sundarbans mangal; the Sundarbans is now over populated with a total population of more than 32 lakh (1991 Census) in an area of about 5000 sq km., *i.e.*, about 650 people / sq km. This Sundarbans area is also situated in the tidal/cyclone prone coastal belt of Bengal and these mangrove forest act as the buffer agent and are known to minimise the cyclone effect by about 50 - 60%; the existence of the dense coverage of the mangrove forest flora on the silted up flat deltaic intertidal lands also add nutrients via decomposition and mineralisation processes of the mangrove litters, which is also estimated by others to be about 6000 t /ha/yr.

Besides all these, fish, prawn, crab, honey and wax, wood and timber and other natural resources, *viz*, fertile agricultural and aquacultural lands of the Sundarbans directly and indirectly help the rural economy. So, only for the fire wood purposes the Sundarbans mangrove forest exploitation is uneconomic and illogical use of the natural forest products, particularly when the forest is in an alarming state.

e) Without education, these rural people cannot be made conscious about their entity as human beings and cannot think about living as civilized human beings and this results in unlimited population growth, health hazard, scarcity for domestic place, ill mentality and all these together must be reflected on the civilized people in the urban areas.

1 2 3

"Socio-Economy <> Education <> Population Growth"

These three urgent questions need to be solved urgently giving uniform stress on these three points simultaneously; otherwise, by single or by limited approach beyond these three urgent points may not solve the problems of the Sundarbans mangals and it is sure that if the present trend of exploitation continues for another 50 years, the so many important 'gene pool' will get vanished from these Sundarbans and the glamour of 'world heritage site' will be lost within no time. Man is the highest biotic component in any ecosystem, so without protecting the interest of man the ecosystem protection will be a fruitless effort.

Definition, classification, productive potential and management of floodplain wetlands and biodiversity conservation

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Introduction

Wetlands are unique ecosystems representing the transitional phase between the terrestrial and aquatic systems as the water table is usually at or near the surface or the land is covered with shallow depth of water. Depending upon the state of wetness and its duration, the pattern of ecological succession operates in such systems and accordingly categorisation of its use as resource is delineated. The wetland ecosystems have been of prime concern to ecologists because of their fragile nature. The wetlands which have the substrate of pre-dominantly undrained hydric soils, due to perennial coverage of water, are highly productive in nature owing to extended Eu-photic zone right up to its bottom and thus support rich biological diversity including fish fauna. Fisheries though one of the major activities in such water bodies, practice since time immemorial, the wetlands have much wider spectrum of utilities such as:

-re-charging & de-charging of ground water, accumulation of flood water, shore-line stabilisation, trapping of toxic substances, trapping of nutrients, abode for many plants & animal species, sources of direct or indirect entertainments, protection & development of aquatic food chains,breeding, grazing grounds for riverine fish stock, regulator of local climate and so on.

The floodplains of Ganga and Brahamputra basins of India have extensive distribution of wetlands of different origins and of various categories. The people living in these parts of the country have very intimate relationship with the wetland ecosystems since centuries as most of their economic activities of rural population be it agriculture, horticulture, fisheries or cottage industries are wholly or partially dependent on these water bodies. To be precise the utility and importance of wetlands should be viewed under three broad aspects such as *economic*, *aesthetic* and *cultural*. In recent years, however, the wetlands have been subjected to indiscriminate exploitation in the face of ever increasing human population and subsequent developmental activities in and around such water bodies. Changing characteristics of river valleys on account of changing demographic and land use patterns have made the situation still grave due to conflicting demands and as a result the process of degradation has been accelerated many folds through- out the globe in general and developing countries in particular. Most of the wetlands are reeling under the threat of their extinction at an alarming rate. Utter neglect in the past and over exploitation in the present have made such ecosystems highly vulnerable in relation to their production functions and biodiversity. Currently the floodplain wetlands are passing through a critical phase of eutrophication leading to swampification at a faster pace. The sustained destruction of all-important wetland ecosystems for one reasons or the other has starting posing many environmental problems in the areas of their existence. It is time that a concerted efforts are being made to conserve the wetlands so as to conserve not only the aquatic biodiversity but the human civilization as a whole.

Definition of wetlands

The concept of wetlands, which covers a wide range of water bodies, is rather hazy. Framing of a precise or definite definition for wetlands, therefore, is very difficult. Many persons have attempted to define wetlands in their own way and as a result many definitions came to the fore (Maltby, 1991, welcome, 1979, Hutchinson, 1967, Leopold,1964 etc.) . According to Ramsar Convention, however- *the marshes, the fens, the peatlands(either natural or artificial, permanent or temprory, static or flowing, fresh, brackish or salty) are the areas covered under wetlands* . One fact, however, has been accepted by one and all that wetlands are transitory systems, representing both aquatic as well as terrestrial characteristics thereby neither can be defined exclusively as aquatic nor purely terrestrial. But referring wetlands in the context of fish and fisheries is automatically implied to such ecosystems where fishery is an important component and thereby it must be an aquatic system with reasonable water depth.

Floodplain wetlands

The floodplain wetlands are considered as one of the prime fishery resources besides being the repository of very rich biodiversity.The floodplain wetlands or the floodplain lakes as commonly referred to are the continuum of rivers, hence play a pivotal role in the development and conservation of fish germ plasm of riverine stock. There can't be a separate or specific definition for these water bodies except the fact that these are associated with the floodplain of certain major river systems. The nomenclature of floodplain lakes or floodplain wetlands, as may be called, has been coined for the sake of operational convenience only. The Ganga and Brahamputra river systems of India have the distinction of being very rich in floodplain wetlands (c 2 lakh ha) because of the geo-morphological features of the land-scape. Locally these lakes are known by different names such as *mauns, chaurs, Dhars, tals, jheel* (Bihar); *Jheel, tal* (Uttar Pradesh); *beel* (Assam & West Bengal);*pat* (Manipur) and so on. The local population of these States of India are associated with such lakes from time immemorial for economic gains and, therefore, the floodplain lakes have tremendous bearing on the social and economic spheres of the society.

Origin of floodplain lakes

Three main reasons have been attributed for the formation of lakes such as *constructive, obstructive* and *destructive.* The origin of floodplain lakes fall under the categories of the later two such as:

- The origin of a typical ox-bow lake is a phenomenon of fluviatile activities of a river course wherein a portion of the river is being obstructed due to excess transportation and deposition of silt and ultimately the river channel diverted to some other route,leaving behind an isolated meander bend called as ox-bows. Meandering of river courses has been found more pronounced in floodplain where the intensity of flood used to be forceful and recurring in nature. Rivers ascending to the flat lands suddenly from higher gradient have been found to be more prone to produce meandering bend out of which some such meanders used to transform into ox-bow lakes due to obstruction in its hydrology. The ox-bow lakes available in the Gandak basin of Ganga river system in the State of Bihar represent this pattern of lake formation as most of the rivers after

travelling at the higher gradient of foot-hills of lower Himalayas in Nepal suddenly debouch to the flat and tectonically depressed land of North Bihar with high current velocity and huge load of silt which gradually become instrumental in the formation of loop-like or serpentine ox-bow lakes.

- The origin of tectonic lakes locally known as chaurs, pats, dhars, beels etc. is a function of geo-morphological changes brought about on the earth crust, leaving behind a trail of depressed land scape where monsoon run-off and flood waters accumulate and assume the states of lakes of varied shape, dimension and depths. The tectonic lakes are generally shallow and saucer shaped in extension. They may either be perennial or seasonal depending upon the depth of the depression. The North-Eastern portion of North Bihar and Assam have plenty of such lake area. These water bodies are known for their rich biodiversity reserves and beautiful refuge for migratory and resident avian fauna. The Kusheshwar sthan, Kabartal, Simri-Baktiarpur and Goga beel of North Bihar are the famous lake area (chaurs) of such type and are known to play very significant role in the over all ecological climate of the area besides performing a host of economic activities(Jha & Chandra, 1997).

The difference between the Ox- bow lakes and tectonic lakes (*chaurs*) has been presented in Table 1.

Classification of floodplain wetlands

Broadly the floodplain wetlands can be classified into two groups such as A) Ox-bow lakes and B) Tectonic lakes based on their origin. However, each lake type can further be classified as under.

A. Physically the ox-bow lakes can be of various types based on their riverine connection (Sinha & Jha,1997 b) :

I) lakes with riverine connection intact.
ii) lakes without or defunct connecting channels.
iii) lakes locked in between river and embankment and flood during monsoon.
iv) incomplete lakes between the embankments and rivers which get lost during monsoon.

The ox-bow lakes can also be classified, artificially, as :

I) *live* or *open* lakes with functional connecting channels with the parent river or its tributaries.
ii) *dead* or *closed* lakes without or defunct connecting channels.
iii) partially fluviatile lakes between the embankments and rivers.

B. Physically the tectonic lakes of Ganga and Brahamputra river systems can be classified in various ways, such as a) based on their seasonality b) based on major bio-production etc. (Sinha & Jha, 1997 a) :

a) based on duration of water retention or seasonality:

I) permanent or perennial chaurs.
ii) temprory or seasonal chaurs.

b) based on major bio-production:

I) chaurs where cultivation of makhana (*Ferox eurryale*), singhara (*Trapa spinosa*), etc. remains the major economic activities.
ii) chaurs where fish and fisheries remain the major activity.

Besides above said artificial or arbitrary classification more pragmatic approach for their classification can be adopted and accordingly the floodplain lakes need be classified on the basis of their trophocity or boidiversity for better management of their biological resources.

Ecological status of floodplain lakes in India
(Jha, 1989, 95, 97, Jha and Chandra 1997, Sinha and Jha1997 b, Sugunan, 1995b, Yadava,1989)

- Very high concentration of dissolved organic matter in the soil phase indicating constant in-put of vegetative matter.

- Wide fluctuations in dissolved oxygen values.As low as almost nil to as high as 18 mg/l or even more. The low values indicating stressed condition on account of waste discharge in the system whereas high values indicating super- saturated condition, typical of weed infested waters.

- Generally poor level of nutrients at water phase as they are locked in the macrophytic chain.

- Moderate to very high values of conductance subject to the nature of effluents in the system. Systems receiving sewage or other effluens indicate higher values as compared to lakes free from such ingress.

- Primary production values through phytoplanktonic chain have been found to be of poor to moderate ranges, depending upon the quantum and texture of phytoplankton abundance.

- The floodplain wetlands generally harbour poor density of plankton, a typical reflection of weed infested water body. Poor availability of plant nutrients, PO_4 & NO_3, owing to their locking in the hydrophytic chain.

-The nannoplanktonic assemblage has been found to be much larger as compared to net plankton and dominated by the high incidence of bacterioplankton. The phenomenon is a reflection of stressed aquatic regime, menifested by thick stand of macrophytes in such systems besides an indication of broken grazing chain for healthy propogation of carp fishery.

- The floodplain wetlands of Ganga and Brahamputra river systems are passing through a critical phase of advanced eutrophication as reflected from high density of macrophytes to the tune of even 30 kg/m^2 at times.All kinds of macrophytes viz. Submerged, emergent, free-floating and marginal have been found to dominate the floodplain wetlands.

- The benthic niche of most of such lakes has been found to be worst affected as the solid-liquid interface is either blanketted by the over growth of submerged vegetation or covered under vegetational canopy of floting macrophytes creating a under water desert and inhibit the growth of desired benth-ic organisms on one hand, while the oxidative-microzones responsible for the release of nutrients in the ambient water are being shielded on the other.

Transfer of energy and productivity potential

The floodplain wetlands due to their shallow nature and riverine connection are highly productive but fragile ecosystems.In recent years, however, the channelisation of energy has visciated from beneficial bio-production for human welfare to unwanted production due to a number of reasons, both man-induced and natural. In an aquatic ecosystem the resident biotic communities are known to linked each other for their survival and growth. This complex inter dependence in a food chain and the flow of energy in the community metabolism are the key of production functions.Proper understanding of trophic dynamics in a given aquatic ecosystem is essential to draw management packages. The transfer of energy in floodplain lakes and for that matter in all the quantic systems follows two established routes as under :

1) Energy fixed at
primary producers level-----to------- herbivores-----to-------predators (*normal grazing chain*)

2) Energy fixed at the level
of producers------to-----dead vegetative matters------to------ detritus feeders(*detritus chain*)

The normal grazing chain of floodplain wetlands has gone wary in the face of fast changing aquatic regime of such water bodies. Over colonisation of macrophytes in these systems has made the production functions topsy-Turvey. The focus has now shifted to the continuos pilation of detrital load at the bottom which remain largely unutilized in absence of efficient grazers. The present fish yield from the lakes is only a fraction of the total energy fixed at primary or producers level. The floodplain lakes being weed choked in characteristics exhibit very high detrital load, even to the tune of 400-500 gm^2 . The primary production and energy conversion of some such lakes have been presented in Table 2. The photosynthetic efficiency of these lakes has been found to be governed by two things viz., the level of management and the influx of waste materials in the system. It has been observed that the photosynthetic efficiency in case of floodplain lakes of Bihar ranged between 3.26 %(stressed lakes) and 4.86 %(partially managed nonstressed lakes).Based on the level of primary production the productivity potential of floodplain lakes available in the States of Assam, West Bengal & Bihar has been worked-out in the range of 1000 to 2000 kg ha^1 yr^1. Against this potential, however, the present level of yield ranges between 30 to 300 kg ha^{1} yr^{1} only and as such there exists enough scope for fisheries development. Primary production and conversion of energy of a group of floodplain lakes of Bihar wetlands have been presented in Table II & III.

Biodiversity Conservation

Biodiversity or biological diversity is the variability and variety of plants, animals and micro-organisms in an ecosystem in a given time. All our essential goods and services depend on biodiversity. Healthy the ecosystem better the gene-pool, species and population and thereby more secured we are so far as our daily needs are concerned such as food, clothes, medicines, housing and other essentials. The dwindling biodiversity in recent years has

Conservation of biodiversity has become the focal theme on a global scale to achieve sustainable bioproduction which has relevance to human welfare.In the face population explosion, more acute in developing countries, has infact accelerated the pace of human interferences on natural resources. The aquatic ecosystems have been tampered to the extent that in many cases the situation has turned to be irreparable and in the bargain the natural biodiversity of an ecosystem has become the worst casuality. Evidently, to conserve the biodiversity of a particular system resource conservation should occupy the centre stage and when we attain that the conservation of biodiversity becomes much easier. The floodplain lakes by virtue of their riverine connection are highly significant biologically and may be considered the repository of biodiversity.

The aquatic biodiversity remained as poorly explored area, though play very significant role in the development of human civilization. It is believed that the aquatic resources, which covers nearly 75 % of the earth's surface, would play a very significant role in the food scenerio of the world in the face of increasing population and subsequent diminishing return of biological resources of terrestrial origin. The most immediate causes for biodiversity loss may be attributed to habitat destruction and niche disturbances. However, socio-economic factors such as developmental pressure, market failure etc. are other important factors responsible for the loss of biodiversity. It is essential, therefore, that the problem of biodiversity should not teckled in isolation rather whole gammut of issues need be viewed in its totality. The issues that are emerging from biodiversity have to be identified properly before embarking on its redressal. The conservation strategies have to be attempted synthesing the developmental activities and environmental facets for sustainable utilization of biological resources. Conservation of biodiversity needs some serious thinking such as :

- In situ protection of ecosystem and ex-situ conservation of biological resources and gene-pools should be the approch for resource management.

- Introduction of bio-technology to develop genetically improved varieties to cop-up the changing ecological scenerio. And for the restoration of economically depleted species.

- Proper identification of biodiversity threats with greater emphasis on endangered and rare species.

- Blending of traditional knowledges and modern tools for effective management of biodiversity.

- Proper appraisal of relationship between social, economic and cultural factors affecting biodiversity.

- Rational exploitation of biological resources tis a must to maintain biodiversity balance in an ecosystem. Etc.

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Table 1. Difference between ox-bows and tectonic floodplain lakes (after Sinha & Jha.1997)

Ox-bow lakes	Chaurs(tectonic lakes)
1. The outer boundary of the lakes are generally fixed.	The boundary of the lakes are never fixed rather changes with the quantity of water ingress. Large scale swelling during monsoon and considerable shrinkage in lean months are the hall-mark of such lakes.
2.Ox-bow lakes are the obstructed bends of rivers as such generally serpentine in physical extension.	Chaurs are not the part of any river and they have no definite physical structure.The physical extension depends on the shape of the depression. However, most of them are generally saucer shaped.
3.The shore-line of ox-bows are invariably straight, being the cut-off portion of rivers.	The tectonic lakes generally represent very irregular and zig-zag shoreline.
4.Ox-bows are relatively deeper than chaurs.	Chaurs are always shallow in characteristics
5. The ingress of riverine water may or may not take place.If connecting channels exists and are functional river water would entre otherwise not.	The topographical distribution of chaurs in floodplains, where occurrence of flood is a regular phenomenon, are such that ingress of flood water is almost certain.
6. Less fluctuation in water spread area besides the ingress of waters, from rivers or catchment, used to have meagre or no current velocity which can uproot the prevailing plants in the system and, therefore, the ox-bow lakes provide relatively stable niche for the higher colonisation of aquatic vegetation.	Characteristically the chaurs exhibit very high fluctuation in water expansion.The excess of flood waters used to gush-in with greater force in such lakes as result the vegetations are being uprooted to a large extent, preventing greater colonisation of aquatic vegetations as compared to ox-bows.

Table II : Status and pattern of primary production n certain floodplain lakes of Gandak basin, Bihar (Jha & Chandra,1997)

lakes	primary production $MgCm^3 hr^1$	energy fixation Cal m^3d^1	Available bottom energy Cal m^2
Larail	98.07-154.11	26136	$38.66x10^4$
Mahisath	75.08-110.0	19988	$39.13x10^4$
Dabadih	95.20-103.05	21411	$46.29x10^4$
Kamaldaha	41.09-190.06	24975	$51.26x10^4$

Table III : Transfer of energy in certain floodplain wetlands under Gandak basin Bihar (Sinha & Jha, 1997a)

lake	**Status**	**primary production to fish %**	**solar energy to fish %**
Muktapur	Free from external stress & partially managed for fishery	0.1622-0.2408	0.00335-0.01037
Kanti	Highly stressed by thermal ash slury. No fishery management	0.1209-0.1873	0.00241-0.009653
Manika	External stress factors negligible, partially managed	0.1831-0.3015	0.00463-0.018431

ENVIRONMENTAL MONITORING IN OPENWATER SYSTEM VIS-A-VIS CONSERVATION MEASURES

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Environment, imparticular that of aquatic standing is fast changing and has been a matter of great concern over the recent decades. World-wide research in this line emerged with various technologies applicable for monitoring ecological alterations and consequential stress evaluation on the community structures. The problem of environmental contamination in more complicated and difficult to manage as far as the open-water systems are concerned. As such, any effort directed to monitor vis-a-vis development of conservation measures for open-water systems must focus on resource evaluation and in vitro and in vivo short and long term effect of various pollutants, sediment quality assessment and biocommunity structures and functioning.

Environment

In common parlance, the environment means surroundings or conditions influencing growth and development. Better environment thus indicates relatively better conditions of the surroundings supporting condusive relationship between habitat and inhabitant population, while conditions leading to imbalanced relation between these two components is considered as to be an unhealthy environment.

Aquatic environment and problems

Water resources on global distribution are the receipients for all kinds of wastes/waste waters generated naturally or anthropogenetically; and consequently exposed to environmental hazards of diversed nature and varying magnitude. The sources of pollution for aquatic systems can broadly be categorised as :

a. Geomorphometrical alterations due to land slides, earthquakes, floods, cyclons etc.
b. Surface denudation and erosion as an effect of agricultural, industrial and other activities causing deforestation.
c. Resource encroachment in the process of resource mobilisation.
d. Anthropogenic waste dumping/draining.

These pollutional sources by virtue of diversed nature and magnitude create environmental distorsions of qualitative and quantitative variations.

Siltation

As a physical factor, causing gradual dimishment of inland water resources, siltation is amongst the major non-toxic sources of environmental distortion throughout the world. This unwanted process may be resulted from land slide, due to earthquake, soil/sand drifting following floods and cyclones, and deposition of surface erosions on the aquatic basins. Siltation, beside encroaching the basin dimensions destroies habitats for biotic colonisation.

Pollutants intrusion

Perhaps, not a single sheet of water on the earth is untouched as far as environmental contamination is concerned. Increasing urge for human food, comfort and protection leads development of more and more advanced technologies utilising diversed rough materials and causes generation of complex waste products of toxic nature. Metal residues from industrial establishments, run off pesticides from agricultural fields, oil spillage, atomic wastes etc. are amongst the pollutants most toxic to aquatic communities.

Biological antagonism

Many of biological activities or processes are equally harmful as the foreign toxicants. Uncontrolled growth of a species or group of organism not only dominates over others in respect of space but also makes the system unfavourable for others sustenance. Besides, there are number organism known to emit toxins as metabolic end products and harm others. *Microcystis* sp. a plantonic oranism is one of such biota which in bloom cause detrimental effect on others due to the toxin released by them in the environment.

Environmental monitoring

Evaluation of environmental impact in aquatic ecosystems consider numerous problems, local, regional and of national perspective. As a result, the programmes include acute, long-term and large-scale monitoring to assess the conditions at points, regions and the aquatic system in totality.

Acute toxicity assessment

Acute toxicity considers 'rapid damage to the organisms by the fastest acting mechanism of poisoning, fatal unless the organisms escape the toxic environment at an early state'. Mortality of exposed organisms in 96 hrs. is the accepted method of acute toxicity evaluation of the contaminants. Such experiments termed 'bioassay' are useful for toxicity evaluaiton in field conditions i.e. in situ as well as controlled conditions of laboratory. Flow-through laboratory tests are designed for the bioassay to replace toxicant and the dilution water either continuously or at intermittent intervals. Flow through tests are generally thought of as being superior to static test because they maintain much higher water quality and ensure the health of the test organisms. In situe acute toxicity bioassay performed in natural flowing water for a discharged effluent, exposes test organisms in small enclosures at selective points adjoining the discharge resource considering variability in the dilution rates. The results for in situ and labroatory acute bioassay are expressed in terms of lethal time (LT) or lethal concentration (LC) which ever is appropriate cosnidering the nature of toxicants and the mode of their contaminating the environment.

Chronic toxicity assessment

In chronic toxicity tests the organisms are exposed to a toxicant/contaminant over a significant portion of their life cycle, typically one tenth or more of the organisms life time. Chronic studies usually measures contaminant's effect on growth, reproduction and also changes in behaviour, physiology and biochemical constituents under sublethal concentration. These studies exposed embryos and young ones to toxicants. The early embryonic developmental stages of major carp have been most effectively used as test organism for acute toxicity bioassay in laboratory conditions for various toxicant and in situ experiments in evaluating the toxic effect of effluents in river ecosystems.

Long term ecotoxicological assessment

For toxicity bioassay there has been lacking in field toxicity and exposure assessment on community structure sensitve to the complex aspects of chemical and physical environments. Most advance method to measure these aspects involves rating of community strucutre on index values. The criteria for selecting indices of ecosystem and recovery include:

i) Intrinsic importance, emphasising endangered or commercially important species,
ii) Early warning indicators;
iii) Sensetive indicators;
iv) Process indicators.

It may be noted that the more complex the ecosystems, the more field data are required to understand the cause and effect relationship. Such complication in environment arises when ability to regulate water quality remains insufficient or ineffective in some respects due to tremendous number of chemical in use. It becomes difficult to predict in situ toxicity under conditions of pulsed releases from complex mixtures in areas such as hazardous water sites or from nonpoint sources affecting the down stream aquatic communities. Complicated relationships between the environment and the organisms in such a situation can be drawn on understanding the water and soil quality contamination, bioconcentration, bioaccumulation and stress effect evaluation in the organisms of different trophic levels.

Water and soil quality monitoring

The principle media for aquatic sustenance, water and bottom sediments, control qualitative also quantitative distribution of the organisms. Physico-chemical qualities like temperature, transparency, dissolved oxygen, pH, alkalinity, hardness, chlorinity etc. are adequate in predicting the inhabitant population structure. For sediments, richness in nutrients, organic percent and mechanical compositions are indicative of the possible flora-faunal composition on the bottom of the aquatic systems. Spatio-temporal monitoring of water and sediment qualities provides information in time scale shifting in biocommunity structure with environmental changes.

Contaminant assessment

Organic refuses which form bulk of contaminants are non-persistant and non-residual materials and thus produce toxicity effect for restricted period limited to the areas of contamination problems are with non-biodegradable contaminants like metals, pesticides and radioactive material. However, toxic effect may have on the biocomponants, these contaminants toxify the water and sediments first which immediately or in the long run contaminate the inhabitant population. Advancement in sophistication of instruments and analytical methods resulted simplified and percised estimation of toxicants from water, sediments and biotic samples.

Biocontration estimation

Bioconcentration is the accumulation of water born chemicals by the aquatic animals and plants through non dietary routs i.e., as the results of completing rates of chemical uptake and elimination. The bioconcentration of metals and other non-biodegradable materials varies greatly with the species and the specific contaminants. Size of organisms can also influence bioconcentration rate. Metals initially accumulates in the gills of both invertebrates and fish. Putting altogether, bioconcentration is considered a complex system dependent upon the species or organism, exposure concentration and period, environemntal factors and the specific toxicant. Methods of various toxicant estimation are available for suitable adoption.

Stress effect evaluation

In ecotoxicolgoy the stress effect evaluation is a complex process utilising the biological state of affairs for ascertaining time scale changes in individual biolgoical constituents and community structure as a whole. The reasons of such testing undertaken are to assess responses of individual and population of a community under actual exposure conditions, to assess the potential contaminant for indirect and sublethal effects; and to determine if threshold levels for effect, measured in the laboratory, have any validity for ecosystem.

In ecotoxicological biomonitoring programme a sound experimental design is critical to the assessment of ecological damages (Karr, 1991). The design requires an understanding of the complexity of the aquatic system such that confounding factors like current velocity, depth, transparency, organic matter, nutrients etc. are accounted for in sample comparison. Sampling approach need be unbiased for better ascribing of changes in the flora and fauna to anthropocentric activities. The index of biotic integrity designed to reveal the integrative nature of fish communities responding to changes in water quality has been developed for application. Problems in biological activities like growth, reproduction and recruitment potential of fish are also ascertained as supportive evidences for changes in community structure.

Conservation

Conservatin is an act of broad scope application which for aquatic systems mainly concerns restoration of resources with diversities and sustenance of normalcy in ecological functions. The first component i.e. resource restoration and mobilisation is a matter under the state control and is dealt with national priorities. However, eco-sustenance unlike direct use for human consumption and irrigational purposes is a mean of aquatic resource utilisation through upliftment and rational exploitation of biological potentialities following scientific managements. This process conjugates multidisciplinary knowledge to understand the prevailing physico-chemical environments and their impact on bio-communities.

In an agriculture based and densly populated country like ours the conservation measures in respect of aquatic systems mainly focus on the problems of organic contamination. As a result sewage treatment plants, crematoria, biogass-slurry plants etc. have been given priority in conserving the aquatic environment.

Contaminants when inorganic substances like metals, pesticides, atomic wastes etc. persist in the environment for non-degradable properties. Protection from these pollutants thus is inevitable and need precautionary measures to prevent entry into the systems. If at all these toxic substances are to be released in natural waters, the admissible limits must be worked out on the basis of short and long term experiments.

Conservation measures

By and large conservation is successful when the people are aware of the ill effects of wastes/waste water they proposed to deal with. Further, the policy makers or the managers must be conversant with the technologies applicable for abetting different contaminants.

Awareness

Public awareness about the enivironmental issues plays significant role in maintaining cleanliness of the resources they depend upon for livelihood, health and habitation. Government agencies concerning environmental protection, educational institutions and NGOs' need active participation in educating people with problems and remedies of pollution in every sphere of human activities. Introduction of environmental issues in academic curriculum, Symposium/Seminar for common people and audio-visual programmes in rural areas are the possible means for the purpose.

Agricultural Contamination Control

In India though agriculture provides livelihood for greater percentage of population the persons involved i.e. farmers are either ignorant or misinformed about the modern agricultural technologies. Pesticides have wider application in this respect. But the procedures are yet to be knowledged by the farmers. However, the problems of pesticide contamination can be handled following the measure

i) Informing the application techniques and pollutional hazards to the farmers
ii) Planning irrigation systems more scientifically
iii) Adopting suitable and effective flood control measures

Industrial Contamination Control

Industrial refuses mostly find their way into the natural waterbodies like rivers, esturies, lakes, reservoirs etc. The problems are also much complicated in comparison to the agricultural contaminants. Obviously, the abatement measures also involve high technologies and capital investments. The most significant role in industrial pollution control is to be played by the industrialists. However, for small scale industries the Government can look after the pollutional problems in collective manners where the owners should meet up the cost involvement if not wholly to a sizeable percentage. The common measures in industrial pollution control would be

i) Abatement of pollutional problems by the industrialists at the source and release of effluents with zero toxicitry effect
ii) Finding admissible limits for different pollutants by the scientific testing methods
iii) Establishment of alike industrial agglomeration and treating the effluents in a common plant.

Pen and cage culture of fish and prawn

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Introduction

India has extensive riverine wetlands in the form of floodplain lakes especially in the States of Assam (1,00,000 ha), Bihar (40,000 ha), West Bengal (42,000 ha) Manipur (16,500 ha), Arunachal Pradesh (2,500 ha), Tripura (500 ha) and Meghalaya (213 ha). These lakes are considered as biologically sensitive areas as they have vital bearing on the recruitment of population in the riverine ecosystem and provide excellent nursery grounds for several fish species besides a host of other fauna and flora. At present there is a very low level of fish production i.e. 100-200 kg/ha/yr. Studies on this ecosystem showed that there is a potential of 1,000-2,000 kg/ha/yr. If managed in a scientific line. As a management measure especially in the weed choked beels, pen and cage cultures of fishes and prawns are recommended. The advantages of pen and cage cultures are (i) optimal use of fish food organisms for the growth of the cultured animal, (ii) utilisation of available water resources and (iii) complete harvest of the stocked animals. Among fish farmers there exists a confusion regarding the terms cage culture and pen culture. In North America sea pens and sea cages describe almost the same type of culture method (Novotny,1975). Milne (1975) describes about enclosure culture and is precisely nothing other than pen or cage culture. Though cage and pen cultures are enclosure cultures they are distinct from one another. Cages are totally enclosed on all sides or leaving alone the top side and are usually floated in rafts or anchored to the bottom or connected to shore by a wooden walkway. Pens on the other hand are always fixed constructions to the sea or lake bottom.

Cage Culture

Like most other types of aquaculture, cage culture also began in Southeast Asia (Ling,1979). In two countries cage culture was developed independently. According to Pantalu (1979) the oldest record of cage culture is from Kampuchea where fishermen around the Great Lake were keeping *Clarias spp.* in bamboo cages and baskets until ready to market. The fishes were fed with kitchen scraps. This method was practiced since end of last century and later spread to the lower Mekong area of the country and to Vietnam, Thailand and other Indo-Chinese countries. A similar type of cage culture using floating bamboo cages was practised in Mudung

Lake, Jambi, Indonesia since 1922 (Reksalegora,1979) which was extended to other parts of southern Sumatra. Since early 1940s there existed yet another form of cage culture in Java in submerged bamboo cages for carps. The cages were anchored to the bottoms of streams where the carps fed on organic materials and benthic organisms carried in the drifts (Vass and Sachlan,1957).This method has not yet been spread to other countries. In the last 15 years,the practice of cage culture in inland waters has spread throughout the world to more than 35 countries in the Europe, Asia, Africa and America and more than 70 species of freshwater fish had been experimentally grown in cages (Coche,1978).

In many of the places wood and bamboo are replaced by nylon, plastic, polyethylene and more costly steel mesh. They have much longer life and permit better water exchange. Most designs currently in use are of floating type only. These floating cages are rely either on buoyant collars made of bamboo or from steel or plastic pipes. Supplementary floatation in the form of oil drums or styrofoam are also used frequently. In China and Philippines fixed cages are used in shallow waters (<8m) with muddy bottom. The cages are made of synthetic fibre nets and attached to the posts anchored to the bottom. This type of cage culture is far more simpler and economical than with the buoyant collar which can account for more than 50% of the capital outlay (IDRC/SEAFDEC,1979).

Cages are generally smaller in size (1000m^2 surface area) and therefore they are easier to manage. They can also be used for breeding and fry production of fishes and for nursing planktivorous juvenile stages of carps, white fish and pike (Bronisz,1979). Moreover, cages both floating and fixed are used in rivers and streams.

Pen culture

Pen culture also had its origin in Asia. In the early 1920s in the Inland Sea area of Japan it originated. It was adopted by China in 1950s for rearing carps in freshwater lakes. Between 1968-70 it was spread to the Philippines for the rearing of milkfish (*Chanos chanos*) in the Laguna Lake (PCARRD,1981). Pen culture is practised in commercial basis in the Philippines, Indonesia and China. The principal species being cultured in these countries according to Beveridge (1984) are milk fish and carps like grass carp (*Ctenopharingodon idella*), bighead carp (*Aristichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*). Some experimental pen culture of carps have been conducted in oxbow lakes in Hungary (Muller,1979). In the Philippines tilapias are being cultured in net pens. Generally pens are constructed in larger water bodies like sea, lakes and reservoirs.

Classification of pen and cage culture

Broadly pen and cage culture also can be classified under three divisions viz. Extensive, Semi-intensive and Intensive on the basis of feeding. In Extensive, the animals are not provided any supplementary feeding. They rely exclusively on the natural food available in the enclosure. In semi-intensive system along with natural food some low protein(<10%) feed which are prepared out of locally available plants or agricultural byproducts being supplied. In Intensive culture system, the animals are fed with artificial feed contains more protein (>20%). Extensive and semi-intensive methods are suitable only for fish which are planktivorous, detritivorous or which feed on benthos. Fish with high protein requirements are to be cultured under intensive method. Intensive culture is not generally practised in pens probably due to their access to benthic organisms and detritus. Moreover, intensive culture is usually practised for highly priced animals because the feed alone represents 40-60% of the total operating costs (ADCP,1983).

Environmental impacts of pen and cage culture

The impacts can be of three principal ways – (i) Space, (ii) Flow regime and (iii) Aesthetic qualities.

Space -: Enclosure cultures are generally conducted along the littoral regions of the water bodies where rooted, emergent and submerged vegetation occurs. These are the spawning grounds of many species and these areas are also used by animals to avoid predators. Many of the pen and cage structures block traditional fishing grounds and main navigation routes.

Water flow -: The flow of water through enclosures is affected by drag forces exerted by the frame work and netting(Inone,1972). Sediment transportation in an aquatic ecosystem is mainly determined by current flow (Smith,1975). Reduction in flow can cause sudden increase of sedimentation which can affect benthic communities.

Aesthetics -: The enclosure culture if boomed can transform the appearance of the water body. In many countries under conservation laws, provision has been made to preserve natural beauty when such constructions are made.

Pen and cage construction

The following aspects are to be considered before the construction of pen or cage. In this part of the country, pen culture is more popular. Therefore the details of pen culture are explained here. An overall picture of cage culture conducted abroad is given in Table 1.

Site selection - Site selection is the most important activity of any culture activity. Success or failure of any culture venture depends mainly on the site where it is conducted. An engineering survey should be undertaken to get an idea of the kind of terrain and the nature of surrounding catchment area before constructing the enclosure. If prawn is to be cultured in pen the bottom should have sandy-loamy or sandy-clayey soil. Clayey soil is to be avoided for a better retrieval of prawns during harvest. The shoreline should with a gentle gradient. The site for pen installation should be shallow with a minimum depth of 1-2m. Low depth helps in keeping the pen area hygienic, productive and easily manageable. However, less than 1m depth leads to thermal stress to the stocked animals during summer. If the construction is towards the bank it allows easy approach for management measures and harvesting as well as it cuts down the construction cost. Pollution free site is to be selected. Other important factors are the presence of a good approach road and the availability of construction materials in the locality. Prevailing social atmosphere of the locality also should be taken into consideration in order to avoid poaching of the product.

Size and design - The pen may be of square, rectangular, oval, elongated or horseshoe shaped depending on the nature of the shore, land and the depth of water. Pen of >2m size needs special protection measures. Less water area (covered area) i.e. between 0.1 and 0.2 ha may be maintained for better management.

Materials - The main construction materials are (i) frame, (ii) screen and (iii) net lining. Using locally available materials will be economically feasible. Bamboo is the most commonly available frame material particularly in the states like Assam, West Bengal and Bihar where it is cheaper. The bamboo should be of 30' or more in length and 6"to 8"in diameter. If cheaper logs can be used as a suitable substitute. For durability and rigidity of the structure galvanised iron pipe frame also can be used if budget permits. Screen may be of varying sizes according to the requirements. Split bamboo or canes are preferred as screen material. Iron mesh can be used, though it is very costly. If there is not any problem of crabs or any such biotic agents which can destroy the screen material, synthetic nets are the most suitable screen material considering their durability. In the Southeast Asian countries synthetic nets are very popular. Coir ropes or synthetic threads are the best weaving materials. According to the initial size of the animals to be stocked, the mesh size of the screen can be decided. Net lining gives protection against unwanted entry and exit of organisms in the pen. Nylon nets fixed to the frame should be cleaned periodically for facilitating water exchange and aeration inside the pen area.

Pen preparation

The pen area must be cleaned before stocking. Most of the wetlands are thickly infested with macrovegetation and unwanted fauna. Deweeding can be manual considering the smaller area of water body which is cheaper also. Eradication of unwanted fauna from the pen can be done by repeated netting. Through netting other unwanted biotic communities like molluscs, insects etc. can be removed. Liming is very important for quick mineralisation of organic matter in the water. Use of quick lime @ 400-500kg/ha pen area is recommended with an initial dose @ 200-300kg/ha followed by monthly installments @ 50-75kg/ha.

Pen management

Water:- Generally monsoon season is avoided for pen culture operations because of flood. Extreme summer also is avoided as the water level recedes due to high rate of evaporation and water lifting for irrigation. Water temperature range of 30-36^{0}C is ideal for faster growth of the cultured animals. Other desirable parameters are, dissolved oxygen (4-8mg/l), carbon-di-oxide(1-2mg/l), alkalinity (50-150mg/l), pH (7.0-8.0) and moderate nutrients (N-2.0mg/l and P-1.5mg/l).

Soil:- Very high organic content of bed soil can lead to anearobic condition at the bottom which is detrimental to the bottom dwellers specially prawn. For better production 1-2% of organic matter and 50-70g/m^2 of detritus are ideal. The bottom soil should be sandy-clayey in case of prawns. For cage culture, the type of bottom soil is immaterial.

Species selection

In pen farming there is no intensive culture. Therefore, species belonging to the groups planktophagous, detritivores and bottom feeders are preferred. Omnivorous species are suitable for any such cultures. Phytophagous can also be introduced to control weeds. The suitable species for mixed culture of carps are catla, rohu, silver carp and mrigal. Under mixed culture along with carps, the giant freshwater prawn, *Macrobrachium rosenbergii* can be considered. However, in monoculture, prawn grows faster with higher survival rate than in mixed culture along with carps.

Species ratio

According to the available food in the environment, seed availability, depth of water body etc. the species ratio can be fixed. The species ratio suggested is, 35% of surface feeders (20% catla *Catla catla* and 15% Silver carp, *Hypophthalmichthys molitrix*) 20% of column feeder (rohu, *Labeo rohita*) and 45% of bottom feeder (mrigal, *Cirrhinus mrigala*). The bottom slot of mrigal can be replaced with prawn in mixed culture.

Stocking size and rate

In carp culture large fingerlings of 100-200mm size are to be stocked for better survival. Stocking size of prawn juveniles is much smaller between 65-75mm. Stocking rate is fixed on the basis of carrying capacity of the enclosure. In monoculture of carps, the recommended density is between 4000-5000 nos/ha. In mixed culture, the density of carps and prawn could be 3000-4000 and 1000-2000 nos/ha respectively while in monoculture of prawn the stocking rate could be as high as 20,000-40,000nos/ha.

Culture frequency

Enclosure farming can be done round the year, but it is advisable to avoid monsoon as well as summer months. Two crops per year can be raised without any problem from such culture systems.

Supplementary feeding

Role of supplementary feeding is not there in extensive culture and only marginal if semi-intensive culture is adopted. If prawn is grown it needs highly proteinous diet for better and faster growth. The prawn is fed once in a day @2-5% of body weight during evening hours depending on the availability of natural food. Supplementary feeding may be done with commercially available pelletised feed or locally made mixture of animal protein with carbohydrate and fat. Cockle flesh and fish meal are well known sources of protein. Feeding in trays saves loss of feed.

Conclusion

Every culture activity should take care of the environmental and socio-economic impacts such a measure can cause. Enclosure culture may be started keeping all these in mind in order to achieve full success in the venture.

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Table 1

Extensive cage tilapia production figures from the Philippines

Lake	*Cage Size(m)*	*Stocking density (no. m^{-3})*	*Culture period (months)*	*Size at harvest (g)*	*Production (kg m^{-3} $month^{-1}$)*
Bunot	20 x 25 x 5	4	4	250	0.24
Laguna de Bay	5 x 10 x 3 - 10 x 20 x 5	4-8	4-5	100	0.07-0.18
Sampaloc	10 x 10 x 9 - 25 x 20 x 9	1.6-2.0	6-9	225-300	0.05-0.08
Taal	10 x 5 x 3	50	4	100	1.25
Bato	-	50	4	160	1.90
Buluan	5 x 10 x 5	10	5	200	0.40

COMMUNICATION METHODS USED IN THE DISSEMINATION OF TECHNOLOGIES IN OPEN WATER SYSTEM

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The term communication stems from the Latin word 'Communis', meaning common. According to Rogers and Shoemaker "Communication is the process by which messages are transferred from a source to receiver". Van den Ban and Hawkins defined communication as the process of sending and receiving messages through channels which establishes common meanings between a source and a receiver. Leagans defined communication as the process by which two or more people exchange ideas, facts, feelings or impressions in ways that each gains a common understanding of the meaning, intent and use of messages. Communication, thus is an attitutde and the like with others.

COMMUNICATION METHODS

A methods is a procedure or process for attaining an objective. The choice of a channel or method of communication, also known as extension teaching method, generally depends on the number and location of the target audience and the time available for communication. They are categorized as individual method, group method and mass method. Each method has both advantages and limitations. The extension agent has to choose a particular method or combination of methods according to the needs and the prevailing situation.

INDIVIDUAL METHOD

In this method, the extension agent communicates with the people individually, maintaining separate identity of each person. This method is followed when the number of people to be contacted are few and conveniently located close to the communicator with sufficient time available for contact. Examples : farm and home visit, fish farmer's call etc.

Advantages:

1. Helps the extension agent in building rapport
2. Facilitates gaining first hand knowledge of farm and home
3. Helps in selecting demonstrators and local leaders
4 Helps in changing the attitude of the people
5 Facilitates transfer of technology quickly
6 Facilitates getting feedback information and closer interaction

Limitations:

1. This method is time consuming and relatively expensive
2 Has low coverage of audience
3 Extension agent may develop favouritism or bias towards some persons

GROUP METHOD

A group may be defined as an aggregate of small number of people in reciprocal communication and interaction round some common interest. In this method, the extension agent communicates with the people in groups and not as individual person. This method is adopted when it is necessary to communicate with a number of people simultaneously, who are located not far off from the communicator, and reasonably good time is available for communication. Here group participation and formation of group opinion are important.

In this situation, there may be a few communicators such as the extension agent and some subject matter specialists. The size of small group may be from 15 to 25, a medium group from 25 to 50 and large group from 50 to 100 persons. Examples of group method are result demonstration, method demonstration, group meeting, small group training, field day or farmers' day, study tour etc.

Advantages:

1 Enables the extension agent to have face-to-face contact with a number of people at a time
2 Can reach a selected part of the target group
3 Facilitates sharing of knowledge and experience and thereby strengthen learning of the group members
4 Reach fewer people, but offer more opportunities for interaction and feedback
5 Motivate people to accept change due to group influence

Limitations:

1 Wide diversity in the interest of group members may create a difficult learning situation.
2 Holding the meeting may be regarded as an objective in itself

MASS METHOD

In this method, the extension agent communicates with a vast and heterogeneous mass of people, without taking into consideration their individual or group identity. The normal group boundary gets obliterated.

This method is followed where a large and widely dispersed audience is to be communicated within a short time. There may be a few communicators such as the extension agent and some subject matter specialists. The size of the audience may be a few hundreds in mass meeting, few thousands in campaign and exhibition and millions in newspaper, radio and television.

Advantages:

1. Suitable for creating general awareness amongst the people.
2. Large number of people may be communicated within a short time.
3. Facilities quick communication in times of emergency.
4. Less expensive due to more coverage

Limitations:

1. Less intensive method
2. Little scope for personal contact with the audience
3. Little opportunity for interaction with and amongst the audience
4. Difficulty in getting feedback information and evaluation of results

An understanding of the environment in which the rural people live and work is essential for effective communication. Ecosystems may be friendly (favourable with little or no risk), inhospitable (unfavourable with appreciable risk) or hostile (hazardous with high level of risk and uncertainty) etc. With increase in the degree of risk and uncertainty of the ecosystem the people shall respond favourably to individual and group methods.

CLASSIFICATION OF COMMUNICATION METHODS:

The communication methods adopted in open water fisheries extension may be classified as follows:

Individual method	Group method	Mass method
1. Farm and home visit	1. Result demonstration	1. Farm publication
2. Farmer's call	2. Method demonstration	2. Mass meeting
3. Personal letter	3. Group meeting	3. Campaign
4. Adaptive or minikit trial	4. Small group training	4. Exhibition
5. Farm clinic	5. Field day or farmers' day	5. Newspaper
	6. Study tour	6. Radio
		7. Television.

INDIVIDUAL METHODS

1. Farm and Home visit

Farm and Home visit is direct and face-to-face contact by the extension agent with the fish farmer or homemaker at their farm or home for extension work.

Objectives:

1. To get acquainted with and gain confidence of farmers and homemakers.
2. To obtain and/or give first hand information on matters relating to farm and home.
3. To advise and assist in solving specific problems and teach skills.

Technique:

Planning and preparation:

- Decide on the audience and the objective-whom to meet and what for ?
- Get adequate information about the topic. Contact research if needed.
- Collect relevant publications and materials to be handed over.

Implementation:

- Visit on the scheduled date and time or according to convenience of the fish farmer and when the person is likely to listen
- Create interest of the fish farmer and allow the individual to talk first
- Present the message or points of view and explain upto the satisfaction of the farmer
- Answer to questions raised and clarify doubts. Handover publications

2. Farmer's Call

Farmers call is a signal made by a fish farmer or fisherman at the working place of the extension agent for obtaining information and assistance.

Objectives:

1. To get quick solution of problems relating to farm and home
2. To enable the fish farmer and fisherman to bring specimens for proper identification of the problem

Technique:

Planning and preparation:

- Keep the office neat, orderly and attractive
- Remain present in the office on fixed days and hours
- Make alternative arrangements to provide information and assistance to the caller in case of absence

Implementation:

- Allow the visitor to talk first and make the inquiry
- Discuss about the problems and prescribe solutions. If necessary, take the person to the Subject Matter Specialist

3. Personal letter:

Personal letter is written by the extension agent to particular fish farmer or fisherman in connection with extension work. This should not be regarded as a substitute for personal contact.

Objectives:

1. To answer to queries relating to problems of farm and home
2. To send information or seek cooperation on important extension activities

Technique:

- Send the letter in time, or if a letter has already been received, send a prompt reply
- The content should be clear, complete, to the point and applicable to fish farmer's own situation
- Use simple and courteous language

4. Adaptive:

ADAPTIVE is a method of determining the suitability or otherwise of a new practice in farmer's situation. This may be regarded as an on-farm participatory technology development process in which farmer's choice and farmer's opinion about the practice are most important. This is the first stage of a new and improved practice passess through, before it is taken up for result or method demonstration, or recommended for large scale adoption. Minikits are, however, distributed in some States for assisting the poor farmers or in times of distress, to maintain farm productivity.

Objectives:

1. To test a new and promising practice under the resources, constraints and abilities of the farmer
2. To find out the benefits of the new practice in comparision to the existing one

Technique:

Planning and preparation:

- Select new and promising practices suitable for the area in consultation with research and farmers
- Select a small number of inovative fish farmers for conducting the trials

Implementation:

- Explain the objective to the farmers. Make it clear that it is a simple trial in a small portion of the plot and does not involve great risk
- Supply the critical inputs in time and supervise all important steps personally
- Assist the farmers to maintain accurate records

5. Farm Clinic:

FARM CLINIC is a facility developed and extended to the fish farmers for diagnosis and treatment of farm problems and to provide some specialists advice to individual fish farmer. The extension agency may set up farm clinics in the village and/or in the organization's headquarters and sub-centres, where the relevant Subject Matter Specialists, in collaboration with the extension agents discuss, diagnose and prescribe treatment to fish farmers' problems, meeting those present individually, on a fixed place, day and time. The specialists may visit the local area if needed for an on-the-spot diagnosis and guidance or follow-up. This method is suitable for treatment and prevention of fish disease out-break and other immediate problems.

GROUP METHODS

1. Result Demonstration

RESULT DEMONSTRATION is a method of motivating the people for adoption of new practice by showing its distinctly superior result. The demonstrations are conducted in the fish farm or open waterbodies and are utilized to educate and motivate groups of people in their neighbourhood. This is a very effective method for the transfer of technology in a community.

Demonstrations may stimulate fish farmers to try out innovations themselves, or may even replace a test of the innovation by the fish farmer. They can show the causes of problems and their possible solutions without complicated technical details. A great advantage of demonstration is observing how an innovation works in field/farm.

Conducting demonstrations with own hands shall encourage the fish farmers to act on scientific basis with confidence rather than something which is magical. Demonstrations are effective when these are integrated with the total extension programme.

Objectives:

1. To show the advantage and applicability of a newly recommended practice in farmer's own situation
2. To motivate groups of people in a community to adopt a new practice by showing its results
3. To build up confidence of the farmers and extension agents
4. To develop innovation leadership

Technique:

Planning and preparation:

- Analyse fish farmers' situations and select relevant profitable practices, in consultation with specialists and farmers.
- Select a few responsible cooperating fish farmers/fisherman having adequate resources and facilities and having acceptance in the local community for conducting the demonstration. This however, does not mean that big fish farmers are to be selected.
- Select representative locations for conducting the demonstrations where it will be easily catch the eye of a large number of people in the community.

Implementation:

- Explain the objectives and steps to the demonstrating fish farmers
- Organize materials and equipments necessary for conducting the demonstrations
- Start the demonstrations on the scheduled date and time, in front of those who may be present to explain the objectives to those who are present
- Arrange method demonstration where a new skill is involved
- Put up suitable signboards for each demonstration in prominent places. The signboards should be colourful and visible from a distance. Local language should invariably be used on the signboard
- Ensure that all critical operations are done in time and try to supervise them personally
- Conduct field day or fish farmers' day around successful demonstrations
- Motivate as many farmers as possible to remain present at the time of final assessmentr of the result
- Let the demonstrating fish farmers explain to the visitors as far as practicable
- Analyze and interpret the results, and compare them with the fish farmers' existing practice
- Emphasize applicability of the new practice in the fish farmers' own situations

2. Method Demonstration:

A METHOD DEMONSTRATION is given before a group of people to show how to carry out an entirely new practice or an old practice in a improved way. It is essentially a skill training where the emphasis is on effectively carrying out a job, which shall improve upon the result. It involves seeing, hearing, participating and practising in group which shall stimulate interest and action. Method demonstration is sometimes used as complementary to result demonstration.

Objectives:

1. To teach skills and stimulate people to action
2. To improve upon the result by doing a job in a better way
3. To build up learners' confidence and satisfaction on the practice

Technique

Planning and prepration:

- Decide on the topic, target audience and venue of demonstration
- Contact subject matter specialists and ensure their participation
- Identify the steps in conducting the demonstration. Practise the demonstration, to be sure about its correct presentation
- Decide on the date and time in consultation with the local leaders and give timely Intimation to all concerned
- Complete all arrangements for the demonstration

Implementation:

- Start the demonstration on the scheduled date and time
- Show each operation step-by-step, explaining clearly whey and how it is being done
- Ensure that all the participants have seen the demonstration and have understood it Repeat difficult steps, if required
- Invite the participants one by one or in small batches to clarify doubts and answer to their questions

3. Group Meeting:

GROUP MEETING is a method of democratically arriving at certain decisions by a group of people, by taking into consideration the mebers' point of view. The convenient group size of conducting meeting or discussion may be around 15 to 25 which may be extended up to about 50.

Group discussion is a very important extension method, as it provides opportunity to influence the participants' behaviour. It can play an important role in increasing knowledge and changing attitude, as well as in changing behaviour. It provides a means of two-way communication between the extension agent and Subject Matter Specialists on one hand and the participants on the other. It helps in collective decision making.

Objectives

1. To prepare a favourable climate for discussion and help in better understanding of the problems by pooling the knowledge and experience of a number of persons
2. To facilitate in-depth discussion by involving a small number of participants
3. To generate new ideas and methods, and select the rational ones through group interaction
4. To develop a favourable attitude and commitment for action through group involvment

Technique:

Planning and preparation:

- Decide on the topic to be discussed and the persons to be involved
- Collect relevant information. Contact specialist, if required
- Collect relevant information. Contact specialist, if required
- May request resource persons and subject matter specialists to participate

Implementation:

- Start the meeting on the scheduled date and time
- Introduce the topic to the group and initiate discussion
- Allow the members to talk and interact
- Facilitate discussion by further explaining the points already made and giving new points, if required
- Encourage the less vocal members to participate in the discussion
- Assist the group to take decisions and to record the most important items to be take care of

4. Small Group Training:

SMALL GROUP TRAINING is a technique of imparting specific skills to a group of people who need them by creating an appropriate learning situation. This is an effective method for transfer of technology.

Objectives:

1. To impart the needed skills to a small group of people
2. To motivate people to adopt new practices through skill training

Technique:

Planning and preparation:

- Identify a technology for which there is a need in the community
- Decide on the time and duration of the training programme
- Select trainers having both theoretical knowledge and practical experience about the technology

- Prepare a written programme allocating topics to different trainers
- Collect relevant materials, publications and audio-visual aids

Implementation:

- Start the training programme on the appointed date and time
- Distribute publications and materials
- Invite the trainers as per programme and allow enough time for discussion and the trainees to react
- Use visual aids like chalk board, models, slide projectors, film show etc.
- Arrange practical demonstration and give enough time to each trainee for practising the skill

5. Field Day or Fish Farmers' Day

FIELD DAY OR FISH FARMERS' DAY is a method of motivating the people to adopt a new practice by showing what has actually been achieved by applying the practice under field conditions.

A field day or fish farmers' day may be held in a reseach farm or in a farmer's field or home. If the number of participants is large, they should be divided into small groups of about 20 to 25 persons each, who shall visit the spots in rotation.

Objectives:

1. To convince the participants about the applicability of the practice in their own situations
2. To motivate them to adopt the practice by showing its performance and profitability under field conditions
3. To remove doubts, superstitions and unfavourable attitude about the new practice

Technique:

Planning and preparation:

- Decide about the practice, location, date, time and the participants. Involve media persons
- Contact Subject Matter Specialists and ensure their participantion
- Make festoons and colourful labels for display
- Arrange a place of meeting close to the site where the practice has been applied
- Inform participants, workers and media persons in time

Implementation:

- Assemble the participants and welcome them on arrival. Give a short introduction about the purpose of field day and how the groups shall move
- Assist each spot with specialists capable of explaining the practice and replying to the visitors' queries
- Invite a few visitors to give their reactions. Answer the questions raised by the participants

6. **Study Tour** :

IN STUDY TOUR, a group of interested pesons accompanied and guided by one or more extension agents move out of their neighbourhood to study and learn significant improvements in farm and home. The main purpose is to motivate the visitors by showing what others have been able to achieve. The programme may include visit to fish farmers' place as well as Research Stations and may be held within the district, outside the district or even outside the State. A group of 30 to 50 persons may be convenient for study tour.

Objectives:

1. To expose the visitors to a new and different situation which shall help in changing their outlook and extend their mental horizon
2. To understand the gap in technology adoption
3. To explore the feasibility of adopting new practices in visitors' own situation

Technique:

Planning and Preparation:

- Decide on the objective, number and type of participants, duration and places of visit
- Make correspondence well in advance and get confirmation of the programme, accommodation etc.
- Discuss with the participants and finalize the travel plan
- Make a meaningful programme, which is compact, but not crowded. Allow some loose time to cope with unforeseen situations

Implementation:

- Keep the interest of the group uppermost in mind
- Let everyone see, hear, discuss, and if possible participate in the activities at the places of visit
- Incase of language barrier act as an interpreter
- Allow time for question and answer
- Collect publications for the participants and help them to take note of interesting and useful information

MASS METHODS

FARM PUBLICATION is a class of publication prepared by the extension agency in printed form, containing information relating to the improvement of farm and home. Farm publications are of various types such as leaflet, folder, bulletin, newsletter, journal and magazine. Farm publications may be used singly or in combination with other extension methods.

Leaflet: It is a single printed sheet of paper of small size, containing preliminary information relating to a topic. It is prepared as and when needed. Generally distributed free-of-cost.

Folder: It is a single printed sheet of paper of big size, folded once or twice, and gives essential information relating to a particular topic. It is printed as and when required generally distributed free-of-cost.

Bulletin: It is a printed, bound booklet with a number of pages, containing comprehensive information about a topic. It is made as and when necessary. A token price may be fixed on some important bulletins.

Newsletter : It is a miniature newspaper in good quality paper containing information relating to the activities and achievements of the organization. It has a fixed periodicity of publication and generally distributed free-of-cost.

Journal & Magazine: These are periodicals, containing information related to various topics of interest not only for the farmers but also for the extension agents. It has a fixed periodicity of publication. Generally supplied against pre-payment of subscription for a particular period.

Farm publications are extremely useful to the literate fish farmers. Even illiterate fish farmers can make use of them with the help of literate members in their family. Farm publicaions are used by all types of extension functionaries, input dealers, bank personnel and media-persons. These may be used in most of the individual, group and mass methods. Colourful sketches are added to make it attractive.

Objectives:

1. To reach a large number of people quickly and simultaneously at a low cost
2. To provide accurate, motivating credible and distortion-free information

Technique:

Planning and preparation:

- Select a topic of economic and practical importance, for which information is needed by the audience
- Estimate the time required to prepare the manuscript, print and despatch, and plan the publication in such a way that it reaches the audience in time

Implementation:

- Collect relevant information on the topic from all available sources
- Contact specialists relating to relevant disciplines
- Prepare the draft in clear, simple, short and direct sentences, keeping the target audience in view
- Arrange in short paragraphs in a logical sequence
- Give suitable title to the publication and sub-heads to the paragraphs
- Devote the first paragraph in highlighting the economic and other benefits. Print this in bold letter
- Present all weights and measures clearly and directly
- Revise the draft twice or thrice. Discuss the draft with specialists also. Avoid writing more than what is necessary

- A write-up for the farmers may be pretested with sample farmers which shall enhance its understandability
- Select suitable photographs and diagrams and idnicate where these are to be placed, photographs and diagrams should be simple bold and contrasting
- Be in close personal contact with the press and get the publication printed as desired

2. Mass Meeting:

MASS MEETING is held to communicate interesting and useful information to a large audience at a time. The size of the audience for mass meeting may be a few hundreds, but at the time of fairs or festivals it may be few thousands. Mass meeting may be held in a covered or in an open place. Public address system is essential for conducting mass meeting. Slide or film show may enhance effectiveness of the meeting.

Objectives:

1 To focus attention of the people on some important aspect
2 To create general awareness about a programme or project and to announce its progress

Technique:

Planning and preparation:

- Decide on the topic, occasion and the audience
- Select a limited number of speakers, including one or two local leaders
- Decide with the local leaders on the venue, date and time and communicate the same to all concerned well in advance
- Procure audio-visual aids, publications etc. and complete all arrangements at the site

Implementation:
- Select a suitable Chairperson
- Start the meeting in time and cut down the formalities to minimum
- Prevent speech-making and keep the meeting moving on schedule
- Use appropriate audio-visual aids where necessary
- Watch reaction of the audience. Encourage audience participation during discussio.
- Distribute relevant publications

3. Campaign:

A CAMPAIGN is an intense educational activity for motivating and mobilizing a community to action, to solve a problem or satisfy a need urgently felt by it. A campaign may be held by involving a small number of people in a few villages, or by involving an entire community or the entire nation over the whole country, campaign on certain themes (say, environment, disease control etc) may be organized over the whole world.. Campaign around a theme may be organised only once, or may be repeated year after year, till the goal is satisfactorily reached.

Objectives:

1. To create mass awareness about an important problem or felt need of the community and encourage them to solve it.

2. To induce emotional participation of the community at the local level and create a favourable psychological climate for adoption of new practices.

Technique :

Planning and preparation:

- Identify with the local leaders and important problems or need of the community
- List out specialists, local leaders and other persons who could be involved in solving them
- Decide with the local leaders about the time of holding the campaign and its duration.
- Prepare a written programme of the campaign
- Give wide publicity and put up posters at strategic points throughout the area. Use mass media to warm up the community

Implementation:

- Carry out the campaign as per programme
- Hold group meeting with the people, discuss about the origin and nature of the problem. Suggest practical and effective solution
- Arrange method demonstration and training programme where needed
- Keep close watch on the campaign and take corrective steps, if necessary
- Arrange mass media coverage

4. Exhibition:

AN EXHIBITION is a systematic display of models, specimen, charts, photographs, pictures, posters, information etc. in a sequence around a theme to create awareness and interest in the community. This method is suitable for reaching all types of people. Exhibitions may be held at the Village, Block, Sub-division, District, State, National and International ievels. fish Fish Farmers' Fairs and Krishi Melas held by the Agricultural Universities, Institutes and various other organizations in which field visit,, training programmes, etc. are combined with exhibition to make effective and popular.

Objectives :

1. To acquaint people with better standards
2. To create interest in a wide range of people
3. To motivate people to adopt better practices

5. Newspaper

NEWSPAPER is a bunch of loose printed papers properly folded, which contrains news, views, advertisements etc. and is offered for sale at regular intervals, particularly daily or weekly.

Role of Newspapers in extension:

Extension agent can not exercise any control over the newspapers, big or small. However, by establishing a good rapport with the editors, reporters etc. a responsble support for extension work may be obtained. Newspapers may support extension work by publishing news of extension activities and achievements, extension recommendations, package of practices, success stories, market news, focussing fish farmers problems, advertisements issued by extension organizations, input dealers etc.

6. Radio :

RADIO is an electronic audio-medium for broadcasting programmes to the audience. This medium is cosmopolite in approach and is suitable for communication to millions of people widely dispersed and situated in remote areas. Availability of low cost transistor sets has helped radio to penetrate deeply into the rural life.

Radio is suitable for creating general awareness amongst the people, help to change their attitude and to reinforce learning.

7. Television:

Television is an electronic audio-visual medium which provides pictures with synchronised sound. This medium is cosmopolite in approach and can be used to create instant mass awareness. Television combines the immedicacy of Radio with the mobility of Cinema and can carry messages over long distances at a relatively low cost unit.

Implementation:

i) Arrange programme, plan out the location, subjects etc.
ii) Take the Producer, the staff and equipments to the location in time
iii) Cooperate and assist the TV personnel
iv) Narration must be in regional language
v) Inform time, date and encourage as many persons as possible to see the telecast

PEOPLE'S PARTICIPATION AND ITS ROLE IN TECHNOLOGY DISSEMINATION TO ACHIEVE SUSTAINABLE YIELD FROM OPEN WATERS

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INTRODUCTION

The important role played by fisheries in Indian economy does not need any mention. Development of fisheries especially inland fisheries sector decisively determines the progress and prosperity of the country. At the advent of planning era in India, the priority in the development strategy promoted aquaculture to the status of an industry.

Inland fish production in the country has registered a phenomenal increase during last 4 decades. As against 0.2 million tonnes produced in 1950-51, the production of inland fish is estimated to be 2.2 million tonnes in 1995-96. The domestic demand of fish in the country is said to be as 8.5 million tonnes by 2000 A.D., a half of which has to come from the inland sector. The ultimate aim, therefore, is to bridge the gap between normative demand and supply of fish for removal of mal-nutrition, especially to weaker sections inhabiting in the rural areas and to uplift their socio-economic status. The only way to achieve this objective is to encourage aquaculture, resource management and fish conservation in all the potential inland waters viz., ponds, tanks, reservoirs, lakes, derelict waterbodies, brackishwater lakes, lagoons, swamps etc. This demands concerted extension efforts in effective manner.

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 involve 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 cocerned with open water fisheries, therefore, has to understand its characteristics in order to select approprite 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.

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 than the product or process put to use.

Local participation is not the only new criteria by which the management of fisheries need 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 involves 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 prioritize 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 efforts can not stipulate people's participation as in initial condition, such participation should be actively 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.

Role of people's participation in open water fisheries management

People's participation is of crucial importance for the success of any open water fisheries extension programme. Nothing can be imposed on the people, voluntary participation of the people have to be encouraged and obtained. Participation in planning and implementation of programmes is important because through this process people learn to change their behaviour for their own development. 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 at 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 phase 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 organisation of the potentially-affected community;
vi) the degree of people's participation in terms of labour and money inputs.

Participation, with its peculier 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 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, now-a-days do something for the beneficieries, whether this involves transfering technology or building infrastructure, or whatever other tasks, the effort is that of the Agency.

Participatory Rural Appraisal

The rich experience of thefish farmers or fishermen generally do not get priority in planning, as the action plans for development of their areas are mostly prepared elsewhere. What is generally done is the incorporation of technologies which are developed and tested elsewhere for increasing production and productivity. The micro-environments by and large remain unobserved. While development plans contain quite a lot of improved technologies, they severely lack the local farmers' innovation and their experience in handling the nature and micro-environments. It has been increasingly felt that a more participatory approach may reduce the gap in unifying the farmers' choice and wisdom with developmental efforts made by the outside agencies. This gave rise to the concept of participatory rural appraisal.

PARTICIPATORY RURAL APPRAISAL(PRA) is the process of involving local people in the analysis and interpretation of a rural situation. The local people i.e. the participants take a leadership role in collecting, analysing, interpreting and presenting information, and in the process impart knowledge and development insight to the specialists and extension agents.

This is a collective process in which information about a village is obtained and analyzed by involving the local community, instead of interviewing several villagers individually by using an interviedw schedule. The concept of participatory rural appraisal emerged from the concept of 'Rapid Rural Appraisal'. The concept 'participatory', however, appears to be more appropriate and important, as in the whole process emphasis is on participation of the local people, rather than doing the job rapidly and saving some time.

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 develolper-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 indegenous learnings 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 extend 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, a help it to form an organisation in the community or help it to form a new organisation. Governments and Research/Extension agencies in relevence 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 encouraging.

In India, Government perceives the Cooperatives as a channel for development benefits to the community. It considers underdevelopment 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 and livelihood.

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 foster 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.

Have 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 farmers/fishermen, scientists, extension functionaries, developmental officials, have not only to respect each group but also 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 is they want. The agencies have their ownf mandate and the people have their own. Not only the content, but the priorities may also vary. But if successful participation is the aim, the begining 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 participatory managtement 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 characteristic 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 indegenous.

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 limiations 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 prioritised 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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Economics of inland open water fisheries in India

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Introduction

The fisheries in India date back to time immemorial. But the data base on fish production and related aspects has been available only after independence. The fisheries sector observed one of the highest growth rate among agriculture and its allied activities. The annual fish production of our country has increased from 0.75 m t in 1950-51 to 4.95 m t in 1995-96, which is above 6.5 times. In case of inland sector it has increased at much faster rate and become about 11 folds (0.21 - 2.24 m t) during this period. The percentage contribution of this sector in gross domestic product also increased significantly. Although, the data on fishery parameters are available on macro or national level, but the micro-level studies towards realistic economic evaluation of fisheries operations are very few. The inland open waters is in no way exception. Some research workers have conducted isolated studies, but their validity and applicability to general situation is questioned. It is due to the very nature of these aqua-resources having multiple uses; and low level of literacy and poor socio-economic status of fishers. The paucity and unreliability of available primary and secondary data both for pre and post harvest fisheries operations, further exaggerated the problem. These facts emphsised the need to evolve reliable methods of data collection on economic aspects. It is therefore, the present communication briefly describe the Indian open water resources, fishing practices followed in these waters, economic decision making and valuation process for pre and post harvest practices; and the most common methods of economic analysis for fish production and marketing.

Inland open waters in India

The rivers, reservoirs, floodplain wetlands and estuaries are the inland open waters of our country. Indian rivers are classified into five river systems , namely, the Indus, the Ganga, the Brahamputra, the East Coast and the West Coast. These systems are comprised 14 major, 44 medium and innumerable small rivers, desert streams and canals (Sinha, 1997). These have a length of over 0.17 m kms (Anonymous, 1996). The state of Uttar Pradesh has the maximum riverine stretch (31.2 thousand km) followed by Jammu and Kashmir (27.8 thousand km). The reservoirs are the man made water bodies created by erecting a dam of any description on a river, stream or any water course. After independence, a chain of hydro-electric and irrigation projects or river valley projects have been commissioned, resulting in large number of reservoirs These artificial impoundments have total water spread area of 3.15 m ha including 1.49 m ha under small (< 1000 ha), 0.52 m ha under medium (1000-5000 ha.) and 1.14 m ha under large (>5000 ha.) reservoirs (Sugunan, 1995). Madhya Pradesh has the maximum area under reservoirs followed by Andhra Pradesh and Karnataka. The floodplain lakes are the oxbow and derelict waters concentrated in Orissa, Uttar Pradesh, Bihar West Bengal and Assam with an expanse of 0.79 m ha. In India, the estuarine waters are also important part of inland open waters with 2.6 m ha. area. These include estuaries, brackish water lagoons, bheries and the mangroves in the states of West Bengal, Gujrat, Tamil Nadu, Kerala, etc.

Fishing or fish harvesting practices in inland open waters

For Indian inland open waters fishing practices are more or less common, although, their extent of prevalence varied across them. For some waters and regions these practices are modified according to requirements. For various open waters, these are summarised in table 1 and described below.

Table 1 Major fishing practices in Indian inland open waters

S.no	Type of net	common name	Period of operation
A.	**Drag net**		
1	Without pocket	Mahajal Darwari Karta Chaundhi	November to July Round the year November to July Round the year except flood period
2	With pocket	Do-dandi Chhanta	May to September July to March
B.	**Gill Net**	Phasla, current, Gochail, Ranga	Round the year except flood period February to July
C.	**Purse net**	Bara Kamel Chota Kamel	May to July October to January
D.	**Cast net**	Bhanwar jal	Round the year
E.	**Scoop net**	Jali	Round the year
F.	**Hook and Line**	Jor, Dori	Round the year except flood period
G.	**Traps**		Round the year
H.	**Roak fishing**		Round the year

Most of the Indian rivers have an open access for fishing, except some stretches where fishing rights have been transferred either to fishermen co-operatives and contractors in the form of lease for one to few years or to individual licensee fishermen. In rivers the fish harvesting included either harvesting of mature fish or fish seed in the form of spawn or juveniles. Although, the fishing of mature fishes is done all over the riverine stretches, but the spawn collection is location specific. During past three decades the riverine fisheries have followed declining trend and drastic change in catch composition, which resulted in diminishing returns for the fishing community. It witnessed massive shift in fishing practices to suit the present milieu (Saxena, 1989). The most prevalent fishing nets in the rivers are drag nets (With and without pocket), gill nets, purse nets, cast nets, scoop nets, hook and lines, traps, and roak fishing.

The reservoirs are mainly for the irrigation or hydel power generation and owned by state governments. The fishing operations in these waters are considered as the subsidiary activity. The reservoirs in various states had different fishing rights depending upon the prevailing conditions. These included departmental fishing, license fishing, free license fishing, share system and auction to private contractor or co-operatives. These rights influence the fishing practices. The rights when rest with co-operatives/SFDC or the department of fisheries, mild nets are prevalent, i.e. gill, cast, traps, etc. with bigger mesh size, but in case of open access, license to fishermen and auction to contractors drag nets with smaller mesh size are also in use.

Most of the floodplain wetlands are either managed by fishery co-operatives or privately. The fish harvesting techniques for these waters are very traditional. Various kinds of locally made gears and indigenous methods are in use for exploitation of different fish species and prawns. In Assam these gears are classified into moving and stationary (Choudhury, 1992). The moving nets included drag (Mahari, Ber, Harhari, Moi, Panti) and dip (Jata, Dharma, and Ghoka) nets. The gill nets and traps with some modifications form the stationary nets.

Most of the estuaries are open for fishing activities. The prevalent fishing gears in these waters are bag nets (stationary), drift gill nets, trawl nets, seine nets (large and small), purse nets, lift nets, cast nets, set barrier nets , hook and lines and traps (Mitra *et al.*, 1997). In case of Hoogly-Matlah estuary 74.7% of catch was of bag nets followed by drift gill net at 16.3%. The remaining nets had only 9% of catch.

Economics of fish production in inland open waters

Majority of inland open waters are the common property resources, so, highly vulnerable to irrational mode of exploitation and over concentration of fishing effort in terms of manpower and number of nets (Paul, 1992). In economic terminology, these fishing or fish harvesting practices constitute the production process. For profitable fisheries on sustainable basis, it is emergent to manage harvest activities optimally. As stated earlier, due to very low socio-economic status and literacy level of the fishermen community , it is very difficult to gather the reliable information, particularly on economic parameters. The economic analysis is mainly concerned with the fishermen's investment on fixed and variable inputs and the outcome of fishing activity. The selection of fishing gear is generally based on physiography of water body, nature of fish stock and characteristics of raw material available. But above all, the most important factor for this selection is fishermen's financial capabilities, which force him either to purchase, hire or share the fisheries requisites. *Centris paribus*, following questions and options are involved in economic decision making.

1. Whether to purchase / hire / share the craft and gears?
2. If purchase, at what cost and of which material and dimensions?
3. If hire, at what rent and of which material and dimensions?
4. If hire, for how many months?
5. If share at what conditions?
6. When and where to fish ?
7. For whom to fish at what rate of royalty / price?
8. What should be the intensity and distribution of fishing effort over the year?
9. Whether the remunerations for the catch would cover the costs incurred?

After completion of decision making process, investments are made to conduct the fishing or fish production process. These include investments on gears, crafts and their maintenance, hired or family fishing labour (opportunity cost of fishing effort in case of family labour), any kind of fishing rent, etc. The valuation of these investments formulates the cost structure of fish production process. Its outcome is in the form of fish catch, which may be valued on the basis of remuneration received by the fishers. It completes the whole process of input and output valuation.

To examine the economic feasibility of fish production process, following cost and income analysis (Katiha, 1994) should be done. It would also answer the questions posed above, exploring various options.

A. Cost analysis

1.	Cost A_1	Cash expenditure, license fee, boat rent, depreciation on fixed capital, interest on working capital;
2.	Cost A_2	Cost A_1 + fishing rent
3.	Cost B	Cost A_2 + imputed value of interest on fixed capital; and
4.	Cost C	Cost B + imputed value of family labour.

B. Income analysis

1.	Returns on Cost A_1	Gross income - Cost A_1
2.	Returns on Cost A_2	Gross income - Cost A_2
3.	Returns on Cost B	Gross income - Cost B
4.	Returns on Cost C	Gross income - Cost C

In short run, the fishermen can continue if returns on Cost A_2 are met. It indicates that for a small period, the fishers should continue the fishing operations, if the cash expenses are covered. In the long run the Returns on Cost C must be positive in order to continue the fishing operations. Otherwise, it is advisable for the family members to opt for the next best alternative.

Economics of post-harvest or fish marketing operations

The fish catch from inland open waters mostly feed the domestic demands and is marketed in raw form. The fish processing is very rare. Therefore, the post-harvest fishery practices are the synonym for fish marketing activities. Similar to fishing these practices do not vary significantly across the inland open waters, but slight difference exists due to nature of resource and harvesting personnel. The fish marketing operations for waters are summarised in the forthcoming paragraphs.

Fishing in rivers is mostly in open access regime, so, the fishermen either dispose his catch at river site to local dealers or bring it to fish market for sale or auction. For leased out stretches, the fishermen hand over the catch to contractors or co-operatives, whor market it either themselves or pass over to the wholesalers cum commission agent. The market functionaries either auction it for local consumption or send to secondary or terminal markets.

In reservoirs fishing rights are generally with some organisation or contractor. So, fishermen hand over the catch to them. The fishermen's remuneration is in the form of royalty or prices at some fixed rate. These organisations are disposing off the catch through contractors or wholesalers and commission agents or directly to the consumers. The contractors or wholesaler cum commission agent may export it to bigger or terminal markets.

The floodplain wetlands are either managed by co-operatives or privately. The catch from these water bodies is mostly auctioned at the local landing centre. Local dealers take it to wholesale market or directly sell in retail market. In case of local commission agent fish passes to wholesaler cum commission agent to reach the retailer / secondary or terminal market.

Estuaries being the common property resource, individual fishermen hand over the catch to local dealers, who act as commission agent or retailer. The local dealer either passes it to the wholesaler/ wholesaler cum commission agent or sell directly to consumer.

Based on the above observations the most prevalent marketing channels are enlisted in table 2.

Table 2 Most prevalent marketing channels for fish catches from inland open waters in India

Fisherman - Wholesaler cum commission agent - Retailer - Consumer
Fisherman - Retailer - Consumer
Fisherman - Local dealer/ Local dealer cum commission agent - Consumer
Fisherman - Local dealer - Wholesaler cum commission agent - Retailer - Consumer
Fisherman - Local dealer cum retailer - Consumer
Fisherman - Contractor/ Contractor cum wholesaler - Retailer - Consumer
Fisherman - Co-operative society - Contractor / Contractor cum wholesaler - Retailer - Consumer
Fisherman - Co-operative society - Wholesaler cum commission agent - Retailer - consumer
Fisherman - Co-operative society - Consumer
Fisherman - State Fisheries Department/ SFDC - Contractor - Wholesaler cum commission agent - Retailer - Consumer
Fisherman - Consumer

Due to very low income levels, the fisherman is constrained by financial obligations, which restrict him to follow rational post-harvest practices. Yet, for an economically optimum disposal of catch he has to decide :

1. How to sell ?
2. To whom to sell ? and
3. At what price to sell?

Besides the economic considerations, the answers to these questions vary according to the quantum of catch, fishing as individual / in group / as a member of any fishermen organisation, economic status of the fisher, distance of market from area of operation/ residence; remuneration received, other incentives, etc.

From fisherman viewpoint, the disposal pattern, which rewards him with the maximum price is the best. Further, the methods are available to work out price spread for the fish catch. The price spread indicates the distribution of consumers' rupee or retail price among all the market intermediaries and the fisherman. The price spread may be computed by calculating the gross and net margins for all the market intermediaries and fisherman (Katiha and Chandra, 1990) as mentioned below:

$$GM_i = PR_i - PP_i$$

Where GM_i = gross margins (Rs per kg) for i^{th} intermediary;

PR_i = price received (Rs per kg) by i^{th} intermediary;

PP_i = price paid (Rs per kg) by i^{th} intermediary;

$$NM_i = GM_i - ME_i$$

Where NM_i = net margins (Rs per kg) for i^{th} intermediary; and

ME_i = Market expenditure incurred (Rs per kg) by i^{th} intermediary.

These parameters as per cent of retail price indicate the share of different market functionaries and the fishermen. The marketing channel with higher fishermen's share and lower shares' for intermediaries should be preferred by the fishers.

To work out the economic viability of fish marketing from market functionaries view point, above mentioned cost and income analysis may be conducted for all the market functionaries. The results would indicate the level of profitability for them.

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WATER AND SOIL ANALYSIS OF OPEN WATER SYSTEMS

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Maintenance of a healthy aquatic environment and production of sufficient fish food organisms in a water body are two very important factors for fish production. To keep the water body conducive for fish growth, physical and chemical parameters like temperature, transparency, pH, dissolved oxygen, total alkalinity, free CO_2 and nutrient elements like nitrogen and phosphorus may be monitored regularly. Where the physico chemical factors are in normal range, the water body is usually productive, but when they are present in quantities above or below the optimum range the fishes and other aquatic organisms may be under stress which may lead to fish disease or fish mortality in due course.

1. **Temperature :**

   The temperature is noted with the help of a centigrade thermometer or by temperature selective electrode.
   Optimum range for carp growth : 23 - 30°C.

2. **Transparency :**

   Transparency of a water body is recorded with a Secchi disc. Dip the Secchi disc in water until it is invisible.
   Note the depth of the disc from water surface in cm.
   Optimum range : 20 - 50 cm.

3. **pH :**

   The pH of water sample may be determined accurately by using a pH meter which has been standardised against two buffer solutions of known pH.
   Optimum range : 7.4 - 8.2

4. **Dissolved oxygen :**

   Winkler's method :
   Reagents :
   i. Alkaline iodide : Dissolve 500 gm NaOH and 150 gm Potassium iodide in one litre distilled water. Keep the reagent in polyethylene container.

   ii. Manganous sulphate : Dissolve about 480 gms of Manganous sulphate in one litre distilled water.
   iii. N/40 Sodium thiosulphate : Dissolve 6.205 gms of pure Sodium thiosulphate in one litre of distilled water. Add 1-2 beads of NaOH as stabiliser. Keep in a brown glass bottle. This thiosulphate solution may be standardised against N/40 $K_2Cr_2O_7$ solution.

iv. N/40 $K_2Cr_2O_7$ Solution : Weigh 1.226 gms of pure $K_2Cr_2O_7$ and dissolve it in one litre distilled water. Place 25 ml of dichromate solution in a conical flask, add 1 ml alkaline Iodide, acidify with 2 ml conc. H_2SO_4 and keep in dark for 10 minutes. Dilute with distilled water and titrate the iodine with the (N/40) thiosulphate using starch as indicator. Adjust the strength of thiosulphate to exactly N/40.

v. Starch : Take 1 gm soluble starch in 100ml water, boil for one minute. Add a few drops of acetic acid as stabilizer.

Procedure : Collect water sample in 125 ml D.O. bottle, add 1 ml of Manganous sulphate solution and then 1 ml of alkaline Iodide solution. Replace the stopper and keep the bottle in dark for 10 minutes. Then add 1 ml of conc. H_2SO_4 and shake to dissolve the precipitate. Transfer 50 ml of the solution to a conical flask, add 1-2 drops of starch solution and titrate the solution with N/40 thiosulphate to a colourless end point.

Calculation:

No. of ml of thiosulphate required x 4 = ppm of O_2 .

Optimum range : 5 - 10 ppm.

Ion selective electrode method:

Electrode is first calibrated and then reading is taken accordingly.

5. Free CO_2 :

Reagents : i. N/44 NaOH

Prepare 0.1 N NaOH by dissolving 4 gm of AR NaOH per litre and standardise it against 0.1N H_2SO_4 using phenolphthalein as indicator. Dilute 100 cc of this 0.1 N NaOH to 440 ml with distilled water. This is N/44 NaOH. Store it in a polyethylene bottle.

ii. Phenolphthalein indicator :

Dissolve 0.5 gm phenolphthalein in 100 ml 50% alcohol.

Procedure :

Take 50 ml of water sample in a conical flask, add 2 drops of phenolphthalein indicator. Add N/44 NaOH dropwise till the solution turns slight pink.

Calculation:

No. of ml of N/44 NaOH required x 20 = ppm of free CO_2.

Optimum range for carp culture ponds : 5 - 10 ppm.

6. **Total alkalinity:**

Reagents : I. N/50 H_2SO_4

ii. Methyl orange indicator solution.

Procedure :

Take 50 ml of water sample in a conical flask and add 1-2 drops of methyl orange indicator. Titrate with N/50 H_2SO_4 until the solution turns pink.

Calculation:
ml of N/50 H_2SO_4 consumed x 20 = ppm of total alkalinity.

Optimum range : 80 - 150 ppm.

7. Total hardness:

Estimation : Total hardness is determined by titration with standard ethylene diamine tetra acetic acid (EDTA) disodium salt using Eriochrome black-T as indicator. The end point is from reddish brown to blue (APHA, 1980).

Optimum range : 20 ppm and above

8. Dissolved Inorganic Phosphate :

Reagents :

i. 50% H_2SO_4

ii. Ammonium Molybdate (10%)

iii. Acid ammonium Molybdate
Add 15 ml of 50% H_2SO_4 to 5 ml of 10% ammonium molybdate.

iv. Stannous chloride solution
Dissolve 1 gm stannous chloride AR in 100 ml of glycerine.

v. Standard phosphate solution.
Dissolve 4.388 gm KH_2PO_4 in 1 litre distilled water. This stock solution is 1000 ppm phosphate.
Dilute 10 ml of this stock solution to 1 litre with distilled water. This is 10 ppm phosphate.

Procedure :

Place 50 ml of water sample in a Nessler tube, add 2 ml of acid ammonium Molybdate and 2 drops of stannous chloride. Mix and wait for 10 minutes. Measure the blue colour in a spectrophotometer at 690 nm. Similarly take four standard phosphate solutions in Nessler tubes and develop the blue colour by adding ammonium molybdate and stannous chloride. Measure the colours of the standard solutions by spectrophotometer. Determine the phosphate content of sample from the calibration curve drawn from standard phosphate solutions.

Optimum range for carp culture ponds: 0.2 -0.6 ppm.

9. Nitrate nitrogen :

Reagent :

i) Phenoldisulphonic acid

ii) 12 N NaOH

iii) Standard Nitrate solution (10 ppm)
Dissolve 0.722 gm of KNO_3 in distilled water and make upto 1 litre. Dilute 10 ml of this stock solution to 100 ml containing 0.01 mg N/ml = 10 ppm N.

iv) Aluminium sulphate solution (10%).

Procedure :

Evaporate to dryness 50 ml sample in a white porcelein basin on water bath. Cool and add 2 ml of phenoldisulphonic acid and rub it with a glass rod. Wait for 5 minutes and add 2 ml of Aluminium sulphate solution. Now add 12 N NaOH solution slowly until it is alkaline. Add 20 ml distilled water and filter the solution. Take filtrate, make up the volume to 50 ml. Measure the yellow colour of the solution by spectrophotometer at 410 nm . Prepare four standard solutions of nitrate from the standard nitrate solution (10 ppm). Evaporate the solutions to dryness, add phenoldisulphonic acid, mix by glass rod and then add 12 N NaOH to make the solutions alkaline. Dilute with distilled water and make up the volume (to say 50 ml). Measure the colour of these four solutions by spectrophotometer at 410 nm. Prepare a standard curve from the standard solutions. Determine the concentration of unknown solution from the standard curve.

Optimum total nitrogen content in carp culture ponds : 1.0 - 2.6 ppm.

10. Specific conductivity:

Specific conductivity of water sample may be estimated easily by using a conductivity meter.

Optimum range for carp culture ponds : 250 - 1000 μmho/cm.

SOIL ANALYSIS:

Collection : Collect soil samples from several locations of the water body by Ekman dredge. Mix the samples. Dry the samples in air. Powder it with a wooden hammer, strain through a 2 mm and then a 80 mesh seive and again air dry. Analysis may be done with the air dried sample but result should be expressed on the oven dry basis.

1. Soil pH :

Electrometric method :

Procedure : Take 10 gm soil in 50 c.c. beaker and add 25 ml of distilled water. Shake for half an hour. Dip the electrode of pH meter in the suspension and take the pH reading.

Optimum range : near neutral (6.5 - 7.5).

2. Organic carbon :

Reagents :

i) N $K_2Cr_2O_7$

Weigh exactly 49.04 gm of AR $K_2Cr_2O_7$ and dissolve it in 1 litre of distilled water.

ii) N Ferrous solution

Dissolve 278 gm Ferrous sulphate or 392.13 gm Mohr salt in distilled water, add 15 ml conc. H_2SO_4 and make up the volume to 1 litre. This soluiton should be standardised against N $K_2Cr_2O_7$ so that 1 ml Ferrous solution = 1 ml of N dichromate.

iii) Diphenyl amine indicator.

Dissolve 1 gm Diphenylamine in 200 ml of conc. H_2SO_4 and 40 ml of water.

iv) Phosphoric acid (85%)

v) Conc. H_2SO_4 .

Procedure :

Take 1 gm soil sample in a 500 ml conical flask. Add 10 ml of N $K_2Cr_2O_7$ and 20 ml of conc. H_2SO_4 . Allow the mixture to stand for 30 minutes. Dilute with water to 200 ml and add 10 ml of phosphoric acid. The excess of dichromate is titrated with N $FeSO_4$ using 1 cc of diphenylamine as indicator. The end point is green from a bluish colour.

Calculation :

(10 - No.of ml of $FeSO_4$ solution required) x 0.3 = Organic carbon (%)

Optimum content in carp culture ponds : 1.0 - 2.5%

3. Available phosphorus :

Trough's method :

Reagents :

i) 0.002 N H_2SO_4 .
   Dilute 100 ml of standard 0.02 N H_2SO_4 to 1 litre.
   Adjust the pH to 3.0 with ammonium sulphate.
ii) 50% H_2SO_4
iii) 10% Ammonium Molybdate
iv) Acid ammonium Molybdate reagent
v) Stannous chloride solution.
vi) Standard phosphate solution (1 ml = 0.01 mg P.)
   The methods for preparing reagents are the same as given for determination of phosphate in water.

Procedure :

Place one gm air dried soil sample in a 250 ml bottle. Add 200 ml of 0.002 N H_2SO_4 (pH-3), shake the mixture for 30 minutes in a mechanical shaker. Keep it for 10 minutes and filter. Take 50 ml of filtrate in a Nessler tube and determine its phsophate as for water.

Calculation :

ppm of phosphate in solution x 20 = mg P/100 gm soil.

Optimum content in carp culture ponds: 9-19 mg/100 gm soil.

4. Calcium carbonate :

Rapid Titration method :

Reagents : i. N HCl : Dilute 175 ml of conc. HCl to 2 litres.
ii. N NaOH : Take 80 gm of NaOH in 2 litre of water.
iii. Bromothymol Blue indicator.

Procedure : Take 5 gm soil sample in a 250 ml bottle. Add 100 ml of 1 N HCl and shake for one hour. Allow to settle the suspension and pipette out 20 ml of the clear liquid in a conical flask. Titrate it with N NaOH using Bromothymol Blue indicator till it is just blue. Note the reading and carry out a blank taking 20 ml of 1 N HCl in a flask and titrating it in the same way.

Calculation :

(Titre for blank - Titre for soil solution) x 5 = % $CaCO_3$

Optimum content in carp culture ponds : 1.2 - 2.5%.

5. Available Nitrogen:

Reagents :

i. 0.02 N H_2SO_4
   Dilute 100 ml of 0.1 N H_2SO_4 to 500 ml with distilled water.

ii. 0.02 N NaOH
   Dilute 100 ml of 0.1 N NaOH to 500 ml with distilled water.

iii. Methyl red indicator
   Dissolve 0.1 gm methyl red in 25 ml of ethyl alcohol and make up the volume to 50 ml with water.

iv. 0.32% $KMnO_4$
   Dissolve 3.2 gm of $KMnO_4$ in 1 litre distilled water.

v. 2.5% NaOH
   Disssolve 25 gm NaOH in 1 litre distilled water.

Procedure :

Place 10 gm soil sample in a 500 ml Kjeldahl flask. Add 100 ml of 0.32% $KMnO_4$ solution, 100 ml of 2.5% NaOH, 2 ml of liquid paraffin and some glass beads. Distill the mixture and collect the distillate in a conical flask containing 20 ml of 0.02 N H_2SO_4 and a few drops of methyl red indicator. Collect about 75-80 ml of distillate. Titrate the excess of 0.02 N H_2SO_4 with 0.02 N NaOH to a colourless end point.

Calculation:

(20 - No of ml of 0.02 N NaOH) x 2.8 = Available nitrogen (mg/100 g soil).

Optimum content in carp culture ponds: 50-65 mg/100 g.

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Detection of stress and diseases of fish/prawn and their method of control

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INTRODUCTION

The increasing demand of fish as human food in India has gradually converted fish farming in freshwater, and brackishwater as an important economic activity. To enhance fish production new methods of fish culture had been elaborated and is being widely used in India in addition to traditional methods of culture. Fish pathologists are aware that diseases in fishes usually increase when fishes are reared in artificial conditions. High density of fish population and a lot of stressors result in tremendous increase of pathogen population which is not seen in natural ecosystem. In recent years a number of fish/prawn disease epizootics occurred which vitiated fish culture and capture operations.

MAJOR FISH DISEASE EPIZOOTICS ENCOUNTERED

Dropsy : Very commonly encountered in epizootic proportions, mostly in rearing and grow out ponds.

Most affected species : *Catla catla, Labeo rohita, Cirrhinus mrigala.*

Symptoms : Characterised by accumulation of water in the body cavity or in the scale pockets. The abdomen of the fish gets distended. Mild ulceration may occur.

Causative agent : Bacteria *Aeromonas* sp. is responsible for causing dropsy in Indian major carps. The myxozoan *Neothelohanellus catlae* is also found infecting the kidney and causing damage in *C.catla.* Fishes in water areas stressed by high stocking density, low dissolved oxygen and less food are more susceptible to the disease.

Haemorrhagic septicemia : Epizootics occur in rearing and grow out ponds often causing mortality.

Most affected species : *C.catla, L.rohita, C.mrigala, H.molitrix, H.fossilis, C.batrachus.*

Symptoms : Initially it looks like small pimples and gradually the epidermal cells and scales fall off and sores become prominent. Gradually the ulcerations go deeper with big sub-cutaneous lesions.

Causative agent : Bacteria *Aeromonas hydropila* and *Pseudomonas* sp.; other stress factors for fish like high stocking density, low dissolved oxygen, high organic load act as a pre-disposing factor.

Trichodiniasis : Epizootics occur in mostly rearing ponds causing retarded growth and mortality.

Most affected species : *Catla catla, L.rohita, C. mrigala, C.carpio, C.idella, H.molitrix.*

Symptoms : Fishes with heavy infestations have pale coloured gills with creamish coating and fishes often surface in the water.

Causative agent : Urceolariid ciliates, *Trichodina nigra, T. reticulate, Tripartiella bulbosa, T.copiosa, T.obtusa.* The ciliates when present in association with *Dactylogyrus* sp. become fatal to fish.

White scale spot : Epizootics encountered in rearing and grow out water bodies causing significant growth reduction and mortality.

Most affected species *:* *L.rohita* and *C.mrigala.*

Symptoms : The body surface and scales covered with whitish cysts. In advanced cases scales become loose perforated and degenerated with ulcer formation.

Causative agent : Protozoans, *Myxobolus mrigalae, Myxobolus rohitae, M.sphericum.*

Dactylogyrosis : Epizootics frequently encountered in rearing ponds and occasionally in adult and brood stock ponds, causing growth reduction and mortality.

Most affected species : *C.catla, L.rohita* and *C.mrigala.*

Symptoms : In infested gills there is excessive mucus secretion. Affected fishes are lethargic irritable and often surface. There is growth reduction and in some cases mortality.

Causative agent : Monogenetic trematode of the genus *Dactylogyrus* sp. This parasite when present in association with trichodinid prove fatal to the host.

Lernaeosis : Epizootics occur often causing growth reduction and mortality to fishes in culture ponds.

Most affected species : *C.catla, L.rohita.*

Symptoms : Infected fish rub against the sides or bottom of the pond. Heavy infestation lead to emaciation, lethargy, scale degeneration and haemorrhage at the attachment site.

Causative agent : Parasitic copepod of the genus *Lernae.*

Ergasilosis : Epizootics occur mostly in grow out water areas causing growth reduction and mortality of fish.

Most affected species : *H.molitrix, C.idella, L.rohita, C.mrigala, Mugil parsia.*

Symptoms : Heavy infestation in the gills and buccal cavity causes haemorrhage, anaemia, respiratory distress with frequent surfacing, irritability. Growth reduction is significant and frequent mortality occur.

Causative agent : Parasitic copepod of the genus *Ergasilus, Neoergasilus, Mugulicola.*

Argulosis : Epizootics very commonly witnessed in grow out ponds often causing growth reduction and mortality.

Most affected species : *C.catla, L.rohita, C.mrigala, C.idella.*

Symptoms : Infestation is accompanied by excessive mucus secretion, irritability, erratic swimming behaviour and retarded growth. Heavy infestation often lead to circular depression with haemorrhage and ulceration.

Causative agent : Branchuiran species of the genus *Argulus*.

Epizootic ulcerative syndrome : No fish disease in India has been as virulent and menancing as the recent outbreak of Epizootic ulcerative syndrome. The alarming rate of mortality had robbed fishermen of their daily bread and caused repulsion to fish consumers from taking fish.

Most affected species : The disease affected thirty species of freshwater and brackishwater fishes. Certain genera are more susceptible *viz., Channa, Puntius, Mastocembelus, Mystus, Glossogobius, Anabas, Clarius* and *Heteropneustes.*

Symptoms : Initially the disease appear as red colored lesions on the body. These spread and gradually become deeper and assume form of ulcers. With further advancement scales fail off, ulcers become deep necrotising ulcerative lesions with cottom wool fungal growth. Fishes become lethargic and float on the surface of wate and mortality occur.

Causative agent : Investigations on the suspected causative agents *viz.,* virus, bacteria and fungus could not concusively establish the primary causative agent. However, the international consensus is that the prime agent causing the mycotic granuloma and which is also the clinical symptom of EUS is the fungus *Aphanomyces* sp. The environmental factors very often act as predisposing factor for the fungal infection.

Management strategy for disease prevention

The essential features of the strategy for prevention of epizootic fish disease are good husbandry practices and proper monitoring of the water quality. A healthy environment sustain healthy fishes. Any deterioration in water quality variables *viz.,* oxygen, ammonia, hydrogen sulfide, pH, alkalinity from the optimum values create stress to fish and suppress their immune system. Consequently fishes become susceptible to pathogens present in the environment.

There is a common adage for disease outbreak that *'prevention is better that cure'.* Keeping this in view certain prophylactic measures are adopted for fish disease prevention.

i) Water bodies are disinfected by Mahua oil cake @ 250 ppm and lime application @ 50 kg/ha.

ii) Fishery appliances such as nets, buckets, hapas are disinfected by sun drying. During disease epizootic these appliances can be disinfected with 2 ppm bleaching powder.

iii) Disinfection of fish is done by bath treatment as a routine procedure four times a year. The chemicals used are NaCl 3-4% and Potassium Permanganate 4 ppm.

iv) Too high stocking density causes stress to fish moreover the consequent deterioration of water quality due to over stocking cause further stress to fishes.

v) Adequate and nutritious food is essential for good growth, any deficiency in constituents in food make fishes susceptible to infections.

vi) The adult and brood fishes should be kept separated from young ones to avoid transmission of disease.

vii) Raking which is a method of agitating the pond bottom helps in release of obnoxious gases like ammonia, methane, hydrogen sulfide, from the bottom of the water body. Similtaneously the process of release of inorganic nutrients to water phase is accelerated.

Therapeutic measures : It is normally undertaken during disease outbreak when other measures fail. The various chemicals used in India for different diseases are given below.

Dropsy and Columnaris disease : Application of antibiotics (erythromycin or oxytetracyclin @ 60-100 mg/kg of feed. Bath treatment @ 40 mg/l for 5 days, 4 ppm. $KMnO_4$ bath treatment.

Trichodinaiasis : Pond treatment 25@ ppm Formalin, bath treatment with 3-5% Sodium Chloride for 3 minutes, 4 ppm. $KMnO_4$ bath treatment.

White scale spot : Decreasing density of fishes and 3-5% NaCl treatment.

Dactylogyrosis : Bath treatment with 3-5% NaCl and 25 ppm formalin pond treatment, 4 ppm $KMnO_4$ pond treatment.

Ergasilosis and Lernaeosis : Bath treatment with 3-5% NaCl, 1 ppm Gammaxene treatment in pond.

Argulosis : Bath treatment in 3-5% NaCl, Gammaxene treatment in pond @ 1 ppm.

EUS : Prophylactic : Application of CaO @ 50 kg ha and after one week bleaching powder @ 0.5 mg/l.

Therapeutic : Application of Calcium oxide @ 200 kg ha and after one week bleaching powder @ 1.0 mg/l.

Quarantine adoption for disease prevention

In India while introduction of exotic carps for culture significantly enhanced fish production the possibility of introduction of new pathogens have not been given serious attention.

Table 1 : List of exotic parasites which got established in India

Species	Hosts	Records
Tripartiella copiosa	*C.carpio*	Das & Haldarm 1987
T.obtusa	*C.idella*	Das & Haldarm 1987
Trichodina nigra	*O.mossambicus*	Mukherjee & Haldar, 1982
T.reticulata	*H.molitrix*	Das & Mishra, 1994
Neoergasilus japonicus	*C.idella*	Das & Haldar, 1988

With this background it is pertinent to mention that importation of various exotic culture and ornamental fishes in India is being carried out without any restriction or quarantine. This route of possible introduction of exotic pathogen is being neglected.

Within the country there is continuous transfer of post larvae, fry and fingerlings from one state to the other. So far, no quarantine measure are taken prior to transportation. Evidence suggests that these movements caused disease outbreaks in various parts of the country.

Quarantine and certification of fish stocks as a means of preventing the spread of pathogens is becoming important. India urgently need to develop its quarantine system because due to the success of intensive farming, fish disease problems are increasing. Besides the general problem of controlling disease, major disease outbreaks like EUS occurred during the years 1988-1994 causing economic losses.

Through the exact cause of the disease outbreak has not been determined, disease transmission through international fish trade has been considerd a possible source of origin.

MAJOR PRAWN DISEASES ENCOUNTERED

A. Non invasive external fouling

Symptoms : Fuzzy mat on shell and gills. The appearance of prawns with external fouling depends not only on the type of organisms involved but also on any additional debris which become attached. Fouling on the gill frequently causes a dark coloration and can even result in the gills appearing black.

Impact on host : The main effect of fouling is to interfere with movement and respiration. Affected prawns are often attracted to the water at the side of the pond with higher level of dissolved oxygen.

Causative organisms : Protozoans *viz., Epistylis* sp., *Zoothamnium* sp., *Vorticella* sp., *Suctoria* sp., bacteria *viz., Leucothrix* sp., fungi, macro invertebrates *viz.,* barnacles and algae.

Host species : *P.monodon* and *M.rosenbergii.*

Method of control : Any form of treatment for fouling has to address the initial problem as well as the presence of organism. This usually involves improving the water quality to encourage the prawn to be more active and to moult regularly. Chemical treatments is done for cases of external fouling persisting even after improved water quality.

The most commonly used chemical is formalin (37 to 40% formaldehyde) @ 25 to 30 ppm. The prepared solution in water should be distributed uniformly in the water area and dissolved oxygen levels should be maintained.

B. Externally invasive disease

There are a number of infections which start on the outside of the shrimp and invade through the carapace.

Symptoms : Black spot or black or brown areas in different organs or portions of prawn.

Impact on host : Primarily the invasive organisms cause lesions, erosions or depressions in shell and when such invasions affect an inflammatory reaction in the internal tissue either gill or muscle in any portion, it leads to melanization.

Causative organisms : The invasive organisms are, *Vibrio* sp., *Pseudomonas* sp., *Aeromonas* sp., *Fungi, Fusarium* sp.

There are however a large number of other conditions which can result in significant melanization of the gill or the condition knowns as '*black gill*'. Some of the potential causes are;

i) localised bacterial infection *viz., Vibrio* sp.
ii) fungal infection, *Fusarium* sp.
iii) Protozoans
iv) acid waters, soils etc.

Area of the carapace other than the gill can be affected by localized damage. Appendages may be damaged by other shrimp or they can be affected by localised infection due to poor pond bottom condition. In ponds where the prawns cannot avoid the accumulated waste, swollen tail may be seen.

Host species : *P.monodon, M.rosenbergii*

Methods of control : The treatment of all these external invasive conditions depends on the original cause. If the causes ofthe irritation is removed the melanized tissue especially in the gills may be discarded at or before the next moult, returning the gills to normal appearance.

Better pond management in many cases eliminates the disease condition.

C. Vibriosis

The term vibriosis is used to refer to all types of infections caused by species of the genus *Vibrio* including bacterial shell disease and black gill.

Systemic infections appear to be the most common form of vibriosis either associated with poor water quality or with other diseases. In acute form the symptoms though non-specific are :

a) abnormal behaviour *eg.* Prawns at the side or surface of the pond
b) lethargy
c) inappetite
d) discoloration either red or blue.

If prawns are severely stressed or the bacteria are highly pathogenic, a large number of prawns may die within a short period of time. Chronic infections often result in formation of black nodules in many tissues.

Some forms of disease outbreak due to *Vibrio* sp. have been given specific names as under :

i) One month mortality syndrome : In culture ponds if benthic algae are allowed to grow on the pond bottom during early stages of culture the algae may subsequently decompose. The prawns come in close contact with this decomposing material after moulting and are exposed to stressful environment and large number of bacteria. This result in the prawns developing shell lesions and systemic bacterial infections.

Host : *P.monodon, M.rosenbergii*

ii) Black splinter disease : It is a condition in prawn where a chronic melanised lesion develop in the muscle of the abdomen.

Host : *P.monodon*

iii) Luminescent bacterial syndrome : It is very common in hatcheries and growout ponds. It is caused by some species of *Vibrio* which are liminescent. When present in large numbers they may cause the affected animals to glow in the dark.

Host : *P.monodon*

iv) Septic hepatopancreatic necrosis : Here large areas of hepatopancreas is destroyed and the area turns dark. This condition is brought about by *Vibrio* infection. However, there are reports that similar condition is also associated with toxins (aflatoxin) in food or presence of other types of bacteia.

Causative species : *Vibrio parahaemolyticus, V.alginolyticus, V.anguillarium, V.vulnificus, V.fluvials.* certain othe rgram negative rods, including *Pseudomonas* sp.and *Aeromonas* sp. may occasionally incriminate the bacterial disease syndrome in prawns.

Methods of control : *Vibriosis* is very often associated with other problems in the culture ponds. Any mortality of prawn will have some *Vibrio* sp.

Treatment of vibriosis must always involve improving the environment. Maintain adequate water quality with low bacterial biomass, a stable phytoplankton bloom and proper feeding programme. Sterilise or filter recirculated water. Routinely monitor prawn and pond for early diagnosis of a problem. Avoid tempeature extremes, handling, overcrowding and other stressors. Antibiotic therapy.

There are certains norms to be followed before we go for antibiotic therapy (i) it is essential to improve pond environment (ii) use antibiotics only for bacterial infections but not for viruses, fungi or protozoa (iii) use an antibiotic to which the bacteria are sensitive. Antibiotics either oxytetracycline or Erythromycin etc., should be treated for 5 days. Prawns harvested after atleast 14 days.

D. Viral infection in Hepatopancreas

The hepatopancres of prawn is affected by the following viruses :

i) *Monodon baculovirus* (MBV)
ii) *Baculovirus penaei* (PB)
iii) Type *C.baculovirus*
iv) *Hepatopancreatic parva* like virus (HPV)

. These viruses damage the cells of the hepatopancreas and make shrimp more susceptible to stress or other diseases. The severity of their effect and the age at which infected shrimp are most sensitive vary with different viruses. It has proved to be difficult to demonstrate conclusively the effect of these viruses on the health of shrimp populations.

The viruses are detected by their effect within the cells of the hepatopancreas. With the exception of the type C Baculoviruses, they cause inclusion bodies in the nuclei of the affected cells. All these viruses are thought to be spread by excretion in faeces and subsequent ingestion by other shrimp. The infection may spread between the brood stock and the larvae by this route.

Host : *P.monodon*

Methods of control : The pond disinfectants are widely used for reducing the load of bacteria in viral disease. The disinfectants used are buffered iodophores (Chl_3) and calcium hypochlorite. Lime can also be considered to be a pond disinfectant. Chlorine is also used as disinfectant.

Yellow head disease

Symptoms : The disease is characterised by pale body colour with yellowish gills and hepatopancreas. It is commonly seen in 50 to 70 days post stocking.

Impact on host : In this disease abnormalities should be observed, in the haemocytes including shrinking of nuclei, breakdown of neclei and cytoplasmic inclusions.

Host : *P.monodon*

Causative agent : Yellow head baculovirus

Method of control : It is important to differentiate yellow head disease from other causes of mortalities. With yellow head disease the best course of action in most cases is to conduct an emergency harvest, regardless of the stage of production.

White spot disease

Symptoms : White spots appear on the carapace and extend to other parts.

Impact on host : Marked hypertrophy and intra-muscular inflammation.

Host : *P.monodon*

Causative agent : A virus described as SEMBV (Systemic Ectodermal and Mesodermal Baculovirus) no treatment available. Prevention is the best method of control.

Method of control : The methods used for containing these diseases are mainly preventive as discussed

i) Every pond should have a reservoir pond and inlet water should be kept 4-5 days prior to use. This water can be sedimented, disinfected (say @ 30 mgl^{-1} chlorine) and aerated prior to use in culture.

ii) Entry of wild prawn and crabs is prevented.

iii) Used trash fish, crabs and other crustaceans which can serve as potential carrier of SEMBV should be avoided in culture ponds.

iv) Carefully select postlarvae

v) Maintain optimum water quality to avoid stress in prawn.

E. Microsporideans

Symptoms : Prawns appear cooked although alivel. The infected muscle of the abdomen turns opaque and white. The appearance of the muscle has led to the condition being called cottom shrimp or milk shrimp.

Causative agent : The muscles of affected shrimp contains areas that are replaced by a large numbe rof microsporidean cells. Each cell undergoes internal division to produce a small group of spores. The causative organism is *Agmasoma* sp.

Methods of control : There is no suitable treatment and control involves removing affected individual. This is possible because affected shrimp will often swim on the surface of the pond at night.

F. Soft shell syndrome

Symptom : The body muscle is soft and not tight.

Causative agent : It may be associated with exposure to a variety of insecticide as well as a numbe rof different environmental condition *viz.,*

i) poor quality feed
ii) overstocking or underfeeding
iii) low soil pH
iv) low water phosphate

Methods of control : Treatment involves improving the environment wherever possible, avoiding agricultural run off or other sources of pesticides and ensuring high quality feed with 1:1 ratio of calcium to phosphorus.

G. Cramped tail condition

Symptoms : It is described as a condition of prawns having a dorsal flexure of the abdomen which cannot be straightened.

Causative agent : This condition occurs during summer months especially with the handling of shrimp in theair where it is warmer than the culture system. The exact cause is unknown, other stress factor may be the cause of this condition, as reported.

ROLE OF ENVIRONMENT IN FISH DISEASE OUTBREAK

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 disturb this equilibrium resulting in stress response in the fish and making it vulnerable to disease. The reponse 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) reeduced 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 increase or decrease following acute stress can indicate whether haemodilution or haemoconcentration has occurred.

Leucocyte decrease (leucopenia) commonly occur 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.

The physiological tests of importance and their interpretations are given in Table 1.

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.

Metabolic rate : It is a fundamental aspect of animals performance and is affected by stress.

Reproduction : Detrimental effects on reproduction as manifested by oocyte atresia, spawning inhibition and decreased fecundity and hatching success are taken into consideration for assessing stress response.

Disease : Incidence of fish disease is an important indicator of environmental stress. Fish disease is actually the outcome of the interaction between the fish, their pathogens and the environment. If the environment deteriorates stressed fish is unable to resist the pathogens that they normally can resist. Certain diseases are proving to be useful indicators that tolerances of adverse environmental conditions have been exceeded.

Management norms for large, medium and small reservoirs

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The main focus of the India's planned development during the last few decades has been harnessing of the rivers for irrigation, hydel-power generation and flood control. As a direct results of these projects, a chain of man-made lakes has been created across the country covering an estimated area of 3.15 million ha. Although the Indian reservoirs hold tremendous fish production potential, they produce fish at yield rates much below the potential. The current average fish yield of reservoirs in India is 20 kg/ha, compared to 200 to 300 kg/ha obtained in some other developing countries of Asia and Latin America. Factors that retard productivity are many. Reservoirs are created for purposes other than fisheries and once the water body is formed, fish stock management is taken up as a secondary activity. Unlike the aquaculture sub-sector, no package of practices are available for reservoir fisheries management which can be applied universally. This, coupled with the fact that the reservoirs are common property resource with unlimited access to the local community, reservoir fishery management is riddled with many legal, environmental and socio-economic problems. Nevertheless, it has been proved that fish production and yield from this resource can be increased substantially through proper management of the ecosystem.

DEFINITION AND CLASSIFICATION OF RESERVOIRS

All man-made impoundments created by obstructing the surface flow, by erecting a dam of any description, on a river or stream can been reckoned as reservoirs. Water bodies less than 10 ha in size are excluded form this definition. Reservoirs are generally classified as small (<1,000 ha), medium (1,000 to 5,000 ha) and large (> 5,000 ha). Size alone, however, cannot not be considered as a function of yield as the production processes involved in a reservoir depend on a number of other factors. Suitability of the ecosystem for adopting management options such as *culture-based fisheries, various forms of enhancement* or *capture fisheries* is the main criterion. Salient features of the three categories of reservoirs are outlined in Table

Table 1. Salient features of small, medium and large reservoirs

Small Reservoirs	Large reservoirs
• Single purpose reservoirs mostly for minor irrigation	• Multi-purpose reservoirs for flood control, hydro-electric generation, large scale irrigation, etc.
• Dams neither elaborate nor very expensive. Built of earth, stone and masonry work on small seasonal streams	• Dams elaborate, built with precise engineering skill on perennial or long seasonal rivers. Built of cement concrete or stone
• Shallow, biologically more productive per unit area. Aquatic plants common in perennial reservoirs but scanty in seasonal ones	• Deep, biologically less productive per unit area. Usually free of aquatic plants. Subject to heavy drawdowns
• May dry up completely in summer. Notable changes in the water regime	• Do not dry up completely. Changes in water regime slow. Maintain a dead storage
• Sheltered areas absent	• Sheltered areas by way of embayments, coves, etc.,
• Shoreline not very regular. Littoral areas with a gentle slope	• Shoreline more irregular. Littoral areas mostly steep
• Oxygen mostly derived from photosynthesis in these shallow stratified reservoirs, lacking significant wave action	• Although photosynthesis is a source of dissolved oxygen, the process is non-confined to a certain region delimited by vertical range of transmission of light (euphotic zone). Oxygen is also derived from significant wave action
• Provided with concrete or stone spillway, the type and size of the structure depending on the size of the runoff	• Provided with more complex engineering devices
• Breeding of major carps not commonly observed	• Breeding mostly observed in the headwaters or other suitable areas of the reservoir
• Can be subjected to experimental manipulations for testing various ecosystem responses to environmental modifications	• Cannot be subjected to experimental manipulations
• Trophic depression phase can be avoided through chemical treatment and draining. Cycle of fish production can be repeated as often as the reservoir is drained.	• Trophic depression phase sets in
• The annual flooding during rainy season may be compared to overflowing floodplains. Inundation of dry land results in a release of nutrients into reservoir when it fills up resulting in high production of fish food though decomposition of organic matter predominately of plant origin leading to higher fish growth and survival	• Loss of nutrients occurs as they are locked up in bottom sediments. Rapid sedimentation will reduce benthos production
• Through complete fishing or overfishing of seasonal reservoirs, no brood stock is left. Fish stock has to be rebuilt through stocking. There is thus established a direct relationship between stocking rate and catch per unit effort	• Prominent annual fluctuations in recruitment occur and balancing of stock number against natural mortality requires high density stocking of fingerlings. Their capture requires efficient capture methods

Most of the small reservoirs in India are ideally suited for culture-based fisheries where the fish production depends wholly or significantly on the stocked fingerlings. Conversely, the medium and large reservoirs are better managed primarily on capture fishery lines where the catch depends largely on wild stock, which is caught and annually replenished through natural recruitment. The catch can be augmented though stock and species enhancement

SMALL RESERVOIRS

Culture-based fisheries of small reservoirs depend on a number of parameters such as growth rate, natural mortality, fishing mortality and harvesting schedule. Once these parameters are known, fish can be stocked in sufficient numbers, at the right size and recaptured after they attain an optimum growth rate. Stock enhancement, species enhancement and environmental enhancement are the common modes of fisheries enhancement which are relevant to the small reservoirs in India.

Fish yield potential

A rough assessment of fish yield potential is essential for culture-based fishery management. Since the water quality and the depth determine the yield rate to a large extent, some correlation has been established among these parameters. In the morpho-edaphic index (MEI) method, mean depth of a reservoir and the total dissolved solids (TDS) in water are used for estimating the fish yield potential. The following formulae are used for calculating MEI and fish yield potential:

$$\text{MEI} = \frac{\text{Specific conductivity } (\mu \text{ mhos/cm})}{\text{Mean depth (m)}}$$

$$\text{*Yield (kg/ha)} = 14.3136\ \text{MEI}^{0.4681}$$

Stocking

In sharp contrast to the large and medium reservoirs, stocking has been more effective in improving the yield from small reservoirs as success in the management of small reservoirs depends more on recapturing the stocked fish rather than on their building up a breeding population. The smaller water bodies have the advantage of easy stock monitoring and manipulation. Thus, the smaller the reservoirs, the better are the chances of success in the stock and recapture process. In fact, an imaginative stocking and harvesting schedule is the main theme of fisheries management in small, shallow reservoirs. The basic tenets of such a system are:

* *Developed by Henderson and Welcomme (1974) for African lakes*

- Selection of right species depending on the fish food resources available in the system
- Determination of a stocking density on the basis of production potential, growth and mortality rates
- Proper stocking and harvesting schedule including staggered stocking and harvesting allowing maximum grow-out period, taking into account the critical water levels. In case of small irrigation reservoirs with open sluices the season of overflow and the possibilities of water level falling too low or completely drying up are also to be taken into consideration

Selection of species for stocking

The basic principle to be followed in selecting species to be stocked are:

- The planted species should find the environment suitable for maintenance, growth and reproduction.
- It should be quick growing and able to obtain highest efficiency of food utilization.
- A fishery based on high production of herbivorous fishes with shorter food chain is more productive and energy-effective
- The number of fish to be stocked should be such that the food resources of the ecosystem are fully utilized and densest population maintained consistent with normal growth
- The size of the stock should be chosen with the expectation of getting the desired results
- Stock should be readily available without major shift in the cost involved in its transportation
- Cost of stocking and managing the species must be less than the benefits derived from stocking and management

One of the important phases of stocking policy is to know the amount of food available per individual in the environment. This factor has a considerable bearing on determining stocking rates and depends on population density and production. In multi-species systems, fish can occupy different niches where competition is avoided or at least minimized. Species competition for space and food can occur if niches overlap for any life history stage

Stocking rate

The main consideration in determining the stocking density are the growth rate of individual species stocked, the mortality rate, size at stocking and the growing time. A formula to calculate the stocking rate is given below:

$$S = \frac{q.^{P}}{W} e^{-z(tc - to)}$$

S - Number of fish to be stocked (in number/ha),

P - Natural annual potential yield of the water body

q - The proportion of the yield that can come from the species in question

W - Mean weight at capture

tc - Age at capture

to - Age at stocking

-z - Total mortality

P can be estimated through MEI method and the range of mortality rates can be found out from the estimated survival rate. Table 2 illustrates examples of calculating stocking rates based on the formula given above.

Table 2 Calculating stocking density at different level of mortality

Annual per cent survival (estimated)	-z	Number of fish to be stocked (number/ha)
50	0.7	405
37	1.0	739
22	1.5	2,000
13	2.0	5,500

(After Welcomme, 1976)

Environmental enhancement

Improvement of the nutrient status of a water body by selective input of fertilizers is a very common management option adopted in intensive aquaculture. However, a careful consideration of the possible impact on the environment is needed before this option is exercised in reservoirs. It is generally believed that most of the lakes and reservoirs may have sufficient nutrient inputs and any excessive nutrient loading can lead to pollution problems. Moreover, scientific advice to guide the safe application of this type enhancement and the methods to reverse the environmental degradation if any, is still inadequate. On account of all these, this management tool is more of an exception than a general rule under Indian conditions.

LARGE AND MEDIUM RESERVOIRS

In medium and large reservoirs, recapture rate of stocked fish is often very low and therefore any management norm depending heavily on stocking in such water bodies is bound to be unremunerative. The main accent of stock management here should be to maintain a self perpetuating stock of fish and to harvest them on a sustainable basis. Stock enhancement can, however, be resorted to as a supporting measure to augment or replenish the stock. Assessment of fish stock and the dynamics of fish populations are key to capture fishery management. The rate of recruitment, growth and natural mortality are to be estimated accurately in order to determine the level of fishing mortality. The basic objective is to obtain the maximum sustainable yield through effective fishing effort management.

Most of the Indian reservoirs are warm, well-illuminated and rich in essential nutrients, conditions conducive for high rates of primary productivity. However, only a fraction of the energy fixed by the primary producers is harvested as fish. The ratio between the total biomass at the primary producers level and quantity of fish harvested is determined by the species mix of biotic communities, especially the fish. The salient aspects of fishery management in medium and large reservoirs are *environment management, stock management, species management, fishing effort management* and *post-harvest management*.

Environment management

In an ecosystem, the environment represents the synergy of all the physical and chemical factors that are responsible for the existence of biotic communities. Influx of industrial, municipal, agricultural and thermal wastes and other forms of pollution can cause environmental degradation. Undesirable changes in the environment can disturb the food chain and upset the pattern of energy transformation through different trophic levels, leading to reduced fish output. A damage inflicted at any component of the food chain can lead to reduced fish output. Therefore, it essential to conserve the whole ecosystem rather than the target fish species. Besides, conducive conditions for the migration, feeding and breeding of fish species need to be created.

Stock management

Stock management in the context of capture fisheries of large and medium reservoirs is achieved by regulating the fishing effort to keep the yield at sustainable levels. This includes fixing of minimum mesh size to prevent *growth overfishing* and to regulate the number of fishing unit to check *ecosystem overfishing*. Protection of breeding grounds and observance of closed season are the other measures to keep the stock on a sustainable basis. Selective stocking casn be resorted to as a temporary measure in order to correct any imbalances in species spectrum or to compensate recruitment failure, stock loss, *etc*. A fishery totally dependent on regular *stocking-recapture* basis is not advisable for these types of reservoirs. In other words, the stocked fish should have the potential to reproduce and sustain themselves. Fish production potential and stocking rate can be calculated by using the formula suggested for small reservoirs.

Species management

Under the ecosystem-oriented management plan, various food niches should be utilized by the commercial fish species in order to ensure an efficient conversion of energy. It is often found that the reservoirs do not have the right kind of fish species that can utilize the rich plankton resources of the ecosystem. The indigenous species that fulfill the conditions should be encouraged by protecting their breeding grounds, preventing their overfishing and creating other favourable conditions. In the absence of suitable indigenous species to utilize the available fish food resources such as plankton, periphyton and benthos, the species spectrum needs to be broadened by introducing species. However, introduction of exotic species should be subject to the guidelines issued by the Central Government.

Fishing effort management

Deployment of optimum fishing effort and following mesh size regulations are the two key factors that can lead to success in the fishery management of large and medium reservoirs. Undue increase in fishing efforts may lead to overfishing and low fish yield. The level of fishing effort required for each reservoir is determined based on the maximum sustainable yield (MSY) and other stock assessment parameters. Similarly, the mesh size should be regulated depending upon the target species and their age group represented in the catch. Protection of breeding grounds by declaring sanctuaries, and banning of fishing during breeding season will also go a long way in achieving the yield optimization from reservoirs.

Post-harvest management

Many reservoirs lack proper post-harvest infrastructure, especially those related to catch movement and marketing. This not only retards productivity, but also encourages unscrupulous traders and money lenders to exploit the fishers. Since cooperatives in the reservoir fisheries sector are, by and large, ineffective, there is a need to take up special efforts to sensitize the fishers about the virtues of participatory management. Credit and capital needs of fishermen are to be met by the public sector financial institutions as the private institutions are reluctant to advance loans to capture fishery operations of reservoirs. Apart from uncertainties of the catch, they often cannot fulfill the criteria set by financial institutions regarding collateral, sureties *etc*., At the same time, the capture and culture-based fisheries need to be developed as they are environment-friendly and labour productive. By providing access and means of livelihood to the weaker sections of the society, reservoirs serve to meet some social obligations. Unlike the culture systems where the profit accrues to a single investor or a small group of investors, in open water fisheries the advantage of improved yield is more equitably distributed among a large number of beneficiaries. This, being a community-based development process, has a direct bearing on the quality of life of our rural populace.

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