OPEN WATER FISHERIES TECHNOLOGIES AND EXTENSION METHODS

Bull. No. 96 November 1999

CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
BARRACKPORE - 743 101 WEST BENGAL

OPEN WATER SYSTEMS AND EXTENSION METHOD

ISSN 0970 - 616X

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Published by : The Director,
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Foreword

India is bestowed with a vast expanse of open inland waters in the form of rivers, canals, estuaries, lagoons, reservoirs and lakes. The inland fish production in the country has registered a phenomenal increase during last few decades. This chequered achievement has been made possible due to the efforts of the Scientists, Extension personnel and Fish farmers/ Fishermen. Still the country is lagging behind from producing targeted fish of this 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.

Technology development and its dissemination and transfer to the ultimate users depends upon the availability of trained manpower to conduct research, extension activities and an environment in which it could be successfully applied.

Considering the above in view and to enrich and update the knowledge, skill and attitude of the Developmental Officials/Extension functionaries/Subject Matter Specialists, working under State Fisheries Departments of the country, a 8-day training course on "Open water fisheries technologies and extension methods" was organised at the Institute during November 2-9, 1999 with the financial assistance of the Directorate of Extension, Ministry of Agriculture, Government of India. The 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

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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.

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

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 a. Freshwater bheries b. Saline bheries	9,600 33,000	-	No data available on catch
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

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.

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).

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.

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

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 spactral 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 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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UTILIZATION OF SEWAGE IN FISH FARMING WITH SPECIAL EMPHASIS ON MANAGEMENT OF WETLANDS

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INTRODUCTION

The Calcutta city is blessed with a vast natural spill area situated in the eastern out skirts of the city. The wetlands situated in this low lying area, covering about 4,000 ha, receive large volume of city sewage and are examples of very low cost waste utilization through aquafarming. This sewage fed fisheries having its origin in early 1930's is probably the largest of its kind in the world. These wetlands are also of immense importance as they form a most effective natural sewage treatment system.

The sewage fed wetland fisheries is practised in water bodies having varied eco-climatic conditions. Besides the freshwater sewage fed fisheries, which extends from Calcutta city limits to Kulti-lock gate, saline sewage fed fisheries is practised in an area of about 10,000 ha in the Minakhan, Sandeshkhali-Haroa area on the east of Kulti-lock gate.

The freshwater sewage fed wetlands can be sub-divided into three types - i) Those receiving strong sewage, ii) Those receiving moderately diluted sewage, and iii) Those receiving diluted sewage.

The brackishwater sewage fed wetlands draw saline-water mixed very diluted sewage from Kulti estuary.

Sewage intake :

The ecological conditions of a sewage fed impoundment are latrgely governed by the nature of the sewage and the extent of organic loading in the water body. Bacterial breakdown of different organic compounds help releasing nutrients and minerals which are utiised by different fish food organisms for their growth. The Calcutta city sewage is drained by a 33 km long sewage canal which discharges the city sewage into the Kulti estuary. At the entry point of the canal the city sewage has a high BOD which decreases gradually, as the sewage flows through the canal and declines to the level around 75.0 mg/l at the discharge point at Kulti-lock gate. The sewage from the main canal passes through narrower canals before being drawn into the wetlands through wooden sluices at the entry point. Generally only the surface portion of the effluent is taken into the wetlands by regulating the flow. The sewage water is then allowed to stand for a few days till the BOD is reduced and algal bloom appears. Algal growth results in photosynthetic activity and the BOD is further reduced to 25 to 30 ppm.

In saline sewage fed wetlands below Kulti-lock gate the diluted sewage mixed saline water is drawn into the wetlands from river Sakha Vidyadhari during high tide. The water exchange in both the saline and freshwater sewage fed wetlands is frequent depdnding upon distance of the source of water and tide level. In the freshwater sewage fed wetlands the sewage water sometimes is drawn in and allowed to stand for about two weeks in some portion and then the water, locally called "sada jal", is pumped into the main wetland.

As has already been stated distinct differences have been observed in the physico-chemical and biological properties of wetlands depending upon their distance from the main sewage discharge point.

A. Ecology of sewage fed wetlands

a. Freshwater sewage fed wetlands:

These wetlands generally have water depth ranging from 50 to 90 cm or even less.

Investigations conducted on the ecological parameters of freshwater sewage fed wetlands revealed that D.O. (Sampled between 7-30 and 10-00 a.m.) ranges between 2.6 and 8.2 ppm in Salt lake, 3.0 and 9.2 ppm in Bantala, both receiving strong sewage. The D.O. rangwes between 6.0 and 10.5 ppm in Kantatala area (receiving moderately strong sewage) and 2.6 and 7.6 ppm in Handipota receiving least concentrated sewage. Diurnal studies indicated that the D.O. goes down to nil/traces during mid-night and to as high as 16.00 - 20.00 ppm during mid-day. All these wetlands has salinity in traces to 1.2 ppt. The total alkalinity in these water bodies ranges as 108 to 320 ppm and the gross production from 280 $mgC/m^3/hr$ to 1800 $mgC/m^3/hr$. Primary production has been found to be higher in wetlands receiving strong and moderately strong sewage compared to wetlands receiving low concentration of the sewage. These wetlands are rich in nutrients and generally have good quantity of NO_3-N, NH_4-N and PO_4-P. The water pH ranges between 7.0 and 8.6 and Sacchi disc transparency from as low as 9.5 to 24.0 cm.

The freshwater sewage fed wetlands generally have a sizable crop of plankters which form the principal food items for the fishes cultivated in such wetlands. High nutrients in the standing water may sometimes pose problem of algal bloom inspite of heavy rate of fish stocking in these water bodies. The plankton concentration in these wetlands vary from 0.15 to 3.5 ml /50 l. In wetlands receiving diluted sewage, however, plankton concentration is generally lower and ranges from trace to 0.5 ml/50 l. The numerical abundance may be to the tune of 200 u/l to around 17,000 u/l. The principal phytoplanktonic forms include *Scenedesmus sp., Pediastrum sp., Chlorella sp., Spirogyra sp., Ulothrix sp., Lyngbya sp., Oscillatoria sp., Spirulina sp., Anabaena sp., Merismopedia sp., Microcystis sp., Phacus sp., Euglaena sp., Amphora sp., Pinnularia sp, Coscinodiscus sp., Synedra sp.*, etc., while zooplankters are mainly represented by *Brachionus sp., Keratella sp., Filinia sp., Asplanchna sp., Moina sp., Hexartha sp., Daphnia sp., Bosmina sp., Cyclops sp., Diaptomus* sp., nauplii of copepods etc., Macrozoobenthic fauna in these wetlands is constituted of chironmid and other insect larvae, odonate nymphs, gastropods, e.g., *Bellamya sp., Thiara sp., Lymnaea sp.,* *Indoplanorbis* sp., etc. and bivalves and sometimes annelids. Most of these wetlands harbour macrovegetations like *Eichhornia sp., Ipomaea sp., Calocasia sp., Spirodella sp., Lemna sp.,* and at places Vallisnaria spiralis etc.

b. Low/Medium Saline sewage fed wetlands:

These wetlands are also shallow and the water depth dseldom exceeds one metre. Though the salinity goes down even below 1.0 ppt during monsoon the salinity during winter to summer months goes upto 10.0 ppt or even more. The water transparency generally remains in the range of 15.0 to 30.0 cm. DO of these water bodies remains in the range between 4.0 and 10.60 ppm. Diurnal studies indicated that D.O. does not go down to nil even in the mid-night. The total alkalinity generally ranges between 120 and 160 ppm but may sometimes be higher. The growss priamry production generally ranges between 300 and 600 mgC/m3/hr. NH_4-N, NO_3-N and PO_4-P are generally lower than those of freshwater sewage fed wetlands.

The plankton concentration in these wetlands remains in the range of 0.1 ml to 2.5 ml/50 l, but may sometimes exceed because of the presence of mysids or copepods in good number. The numerical count may vary from a few units/l to more than 1,000 u/l. The principal phytoplankters encountered in these wetlands include *Oscillatoria sp., Spirulina sp., Lyngbya sp., Nostoc sp., Anabaena sp., Microcystis sp., Gyrosigma sp., Nitzschia sp., Amphora sp., Coscinodiscus sp., Synedra sp., Cladophora sp., Closterium sp., Euglaena sp.*, etc. while zooplankters are constitured by *Brachionus sp., Keratella sp., Hexartha sp., Filinia sp., cyclops sp., Diaptomus sp., Gamarus sp.*, nauplii of copepods, *Bosmina* sp. etc. Besides molluscs, insect larvae, amphipods, tanaids and annelids constitute the benthic macrofauna.

The macro-vegetation in these wetlands is represented by forms like *Enteromorpha tubolosa, Ruppia sp., Panium sp. etc. Lemna sp., and Spirodella sp.*, are also encountered particularly during monsoon and post monsoon months.

B. Fish and prawn cultured in different systems:

In freshwater wetlands Indian major carps, silver carp and sometimes *Cyprinus carpio* together with *Oreochromis mossambicus* and *O. Niliticus*, and *Labeo bata* are reared generally in heavy stocking density of 40,000 per ha or even more. Generally continuous stocking and harvesting is practised and size of fishes harvested ranges from 150 - 350 g on an average. Rarely table size fishes of more than 500 g are encountered in the catch. Miscellaneous species of fishes like *Glossogobius giuris, Mystus gulio* and *Puntius* spp., are also generally present in this system. Even in the recent past giant freshwater prawn culture was not a practice and there was virutally no organised prawn culture in this area. Scientists of CICFRI first demonstrated the possibility of *Macrobrachium rosenbergii* culture in moderately strong sewage fed wetlands.

In the low and medium saline sewage fed wetlands *Penaeus monodon* and *L. parsia* are the most important shell fish and fin fish cultured. *Lates calcarifer* are al found to exist in these wetlands. They are not generally stocked but enter such syste with the ingress water. *Oreochromis mossambicus* and *O. niloticus* are also reared these systems and these species contribute substantially to the total production from the wetlands. In many such wetlands paddy-cum-fish culture is practised taking advantage desalination following monsoon precipitation. During this phase major and minor carps a reared. Till recnet past there was no organised farming for giant freshwater prawn in th region. CICFRI, however, has demonstrated successfully the rearing possibility *of M rosenbergii* in these wetlands. *Glossogobius giuris, Sigmatogobius* sp., *Mystus gulio* ar some smaller species of Peneid prawns usually are present in this sytem. *Scattophagu argus* and *Gobioides rubicundus* are also encountered rarely in medium saline wetlands. low saline zone, where salinity has gone down considerably, carp culture is practise during monsoon months.

Production from sewage fed wetland systems:

The production from sewage fed wetland systems vary greatly depending upon th quality of sewage, stocking and management practices adopted.

The proudction in different sewage fed systems may vary from 6,000 to 14,00 kg/ha/yr (in wetlands receiving strong sewage) 2,000 - 3,000 kg/ha/yr (in wetland receiving diluted sewage). According to an estimate the average yield rate is 1,00 kg/acre from the freshwater sewage fed wetlands in the Calcutta spill area.

In saline sewage fed wetlands the production ranges from 1,000 kg to 4,000 kg/h in the low saline sewage fed area where because of decrease in salinity carp culture ha also been taken up. In medium saline zone the production, however, is much lowe ranging from 400 kg to 750 kg/ha/yr. The percentage contribution of P. monodon to tota production varies greatly and according to some estimates it is around 7.97% in low salin zone. Recent studies indicated that contribution may vary from 1.5 to 16.0%. In mediur saline zone the average percentage contribution of P. mondon is usually 29.0% (recen studies in some wetlands, however, indicated a range of 38.9 to 41.6%) .

Problems and remedial measures:

1. Dyke management:

Normally, due to large expanse of the wetlands, there are lot of wave actions in the water surface, resulting in dyke erosion. This poses a big threat to the farming system. By erecting bamboo barricade parallel to the banks leaving a metre narrow lane like space in between the bank and the barricade, the floating weed, *Eichhornia crassipes* may be released. The weed spread in the lane like space, and act as a buffer for the waves. Thus the eroding effect of waves on the dykes can be prevented. The barricade also prevent free spreading of the weed over the entire water surface of the wetland.

2. Water quality management

Sewage effluents contain easily biodegradable organic matters which cause rapid depletion of DO. If the interval between sewage intake is kept at least one week or so the problem of depletion of DO can be avoided to a good extent. This will also help reducing nutrient concedntration, the problem of eutrophicatin and increasing the water transparency to above 15.0 cm. Intake of strong sewage may be restricted to about 1/4th to 1/3rd of the existing volume of water. This will also help avoiding sudden depletion of dissolved oxygen. The sewage should be drawn during the day time when the DO concentration is generally high. The water intake shold be regulated in such a way that the water column is maintained atleast at 0.5 to 1.0 m.

In saline sewage fed wetlands the sewage mixed saline water is drawn in during high tide. It should be kept in mind that this ingress water not only replenishes the standing water but also brings in seeds of fish and prawn. Therefore, during draining out the water the sluices should be properly guarded. The ingressing water flow should be regulated in such a way so that the water depth is maintained at around 1.0 m and the water does not extert excessive pressure on the dykes.

The sewage fed fisheries is based on recycling of wastes, i.e., the residue of the resources that the community has metabolised.

The sewage effluents are rich in nutrients and therefore, no fertilization is required in this type of aquafarming. Use of organic manure may increase the organic load, thereby the BOD and render the environment difficult for fish/prawn life. Proper aeration facilities are required to be provided to stocked animals particularly during night hours when the animals remain under stressed condition due to depletion of dissolved oxygen.

Liming, however, may be done at a low rate of 100-200 kg/ha. This establishes a strong pH buffer system which prevents wide fluctuations in the pH of water. It helps in releasing nutrients from the organic matters and application of lime therefore, should be regulated depending upon the nutrient status of water. Liming also keeps the water a little alkaline besides maintaining a hygienic condition of the wetland.

3. Feeding :

Feeding is normally not practised in sewage fed fisheries as these ecosystem are naturally rich in fish food organisms. Feeding, however, is done by some farmers particularly for shrimp farming. It should be ensured that no residual feed is left in the pond after feeding, since this will add to the organic load and cause detremental effects by further polluting the environment.

The scientists of CICFRI, while conducting freshwater giant prawn culture in a sewage fed impoundment, fed the prawns with boiled *Lamellidens* meat @3% of body weight and ensured removal of left out food as far as practicable to avoid decompositi of the left out food and the experiemnt aiming at evaluating whether the giant prawns c withstand the prevailing ecological conditions in a moderately strong sewage fed wetlar yielded positive results.

In another experiment of 160 days duration without any provision of feeding, t survival of giant prawns in a saline sewage fed wetland was almost cent percent.

4. Fish stock management:

This forms an important part of wetland management. Fishes should be stock after assessing qulaity and quantity of fish food organisms. Tilapias - O. mossambicus ar *O. niloticus* are voracious feeders and keeps the algal bloom under control but at the san time both these species are prolific breeders and their recruitment rate is high ar therefore, may vitiate the stocking density altogether. Tilapia fry may be netted out as f as practicable and stocked in a separate part of the weltand where culture of *Lat calcarifer* can be taken up using *O. mossambicus* and *O. niloticus* as foratge fish. This w ensure getting marketable size of tilapias and at the same time production of good quanti of delecious and priced bhetki. Proper care, however, should be taken so that all the *Lat* are removed from the system. It should also be ensured that *Lates calcarifer* may n enter the main wetland. Any accidental entry of *Lates calcarifer* may cause heavy damag to the fish and shrimp crops. Removal of other carnivorous fishes like *G. giuris* from th ecosystem is also a prime requisite in wetland fisheries as such fishes may take a heavy to of commercial fish fry and juvenile prawns.

In wetlands receiving diluted sewage the plankton concentration is loweer an therefore, stockings of tilapias may offer severe food competition to the carps. Some o the wetlands are found to be rich in molluscan, particularly gastropod populatio Introduction of *Pangasius pangasius* may help curbing excessive molluscan populatio and at the same time getting a good crop of this fish species of high market value.

5. Control of Aquatic Weeds:

Freshwater sewage fed wetlands often get infestations of aquatic weeds lik *Eichhornia crassipes* or *Vallisnaria spiralis*. Luxurient growth of such aquatic vegetatio reduces the biological productivity of the water body. Application of weedicides wi contribute to enhance the pollutional load and therefore, is not advisable. Removal b mechanical means is possibly the only way of eradicating *Eichhornia* in sewage fe wetlands. *Eichhornia*, however, may be utilised suitably to prevent dyke erosion and fo providng shed to the cultivated fishes and prawns. It is, however, essential to restrict thes floating plants towards the sides or at the corners of the water-body by erecting bamboo barricades.

Biological control of *Vallisnaria* by introducting grass carp may some times be effective to some extent. Dewatering the wetland, sun drying and ploughing the botton may give good results. Where immediate dewatering is not possible for some reason or the other, covering the water surface with water hyacinth for few days and thus cutting off the sunlight, may yield good result if the infestation is scanty or thin.

In brackishwater sewage fed wetlands the main weed is *Enteromorpha* and mechanical removal of the alga is very much in practice and probably is the best means.

6. Control of Algal bloom:

Algal blooms may develop in freshwater sewage fed wetlands particularly during post-witer and summer months. *Microcystis sp., Euglaena sp., Phacus sp., Anabaena sp.,* etc. cause the bloom. These blooms besides imparting colour of water (the water colour may become deep green, brownish, reddish etc.) also emit foul odours. These algal blooms are detrimental to fish life and may cause heavy mortality since they liberate toxic substances as end products of metabolism, may depelete DO level during cloudy days or physically choking the gills. The algal blooms therefore, should be controlled by chemical menas like application or $CuSO_4$ solution etc. The tilapias and silver carp if present in the system can be instrumental in biocontrolling algal bloom.

7. Disease :

heavy loss of fish crops due to diseases is not generally encountered either in freshwater or in low/medium saline sewage fed impoundments, but loss of shrimp crops due to white spot desease in recent times has posed tremendous problem to the tiger shrimp growers. The sewage fed wetlands demonstrate high pH of water and during day time the DO level also is generally high. Such environmental conditions geenerally produce a hygienic atmosphere and reduce the possibility of deseases. But fish diseases, though not to a vry great extent, are encountered in both fresh and saline sewage fed wetlands. Ulcerative diseases are found to occur during post monsoon and early winter months and in freshwater zone *Channa punctatus, Cirrhinus mrigala, Cyprinus carpio, Mystus spp,* etc. are generally found to be affected. In low/medium saline zone *Liza parsia* is also found to be affected by this disease.

In recent years white spot disease in tiger shrimp leading to heavy loss of stocked prawns in both low- and medium saline sewage fed wetlands has virtually become the most severe problem for the prawn growers. No treatment of the diseawe is known and as such maintenance of proper sanitation, as far as practicable is suggested. The affected prawns may be netted out and destroyed. If possible the waterbody should be dried up, the bottom exposed to sun, ploughed and treated with lime. Besides the diseases mentioned above, incidence of bacterial, protozoan, helminth and crustacean parasites are rarely encountered. Facultative parasites like fish leech and insects are also often come across in freshwater zone.

Treatments, though have been suggested for some of these diseases it is rather impossible to offer treatment to the diseased animals in such vast aquatic systems.

Moreover, such treatments will expose the unaffected animals to drugs alongwith t target animals. If the intensity of infection is low then the affected specimens can be nett out and treated in plastic pools or small ponds by the side of the main wetland. It th appears that in sewage fed wetlands prophylaxis is better than therapeutic treatment.

Discussion:

Sewage fed fisheries in the east of Calcutta should not be considered just as a ki of aquafarming but also as a most effective sewage recycling ecosystem in combating riv pollution. According to some authorities increasing D.O. and pH in the ecosystem reduc the rate of infection of coliforms. Some report on the sewage effluents indicate that wh it enters the wetland system contains *E. coli* upto 10,000,000/ml where as in the wat drained out from the sewage fed wetlands the count comes down to 10-100/n Investigations conducted abroad clearly demonstrated absence of human pathogens fishes grown in sewage fertilized pond systems and drastic reductions in coliform Microbial decomposition of various organic matters help releasing ammonia which consumed by the fish food organisms. The phosphate is made available through t microbial transformation of organic and inorganic phosphatic materials particularly duri anoxic condition. The system is thus quite efficient from the point of view of utilsing t wastes in the same manner as organic fertilizers.

The waste water fertliised ponds by way of providing substantial quantity natural food to fish reduce the cost on supplementary feed. Investigations conducted b CICFRI have clearly demonstrated that concentration of city sewage decreases graduall from the entry point to the discharge point at Kulti estuary. This has been found to b associated with a gradual decline of the BOD level from 520 mg/l to 75/mg/l. The exce of Zn, Cr, etc. are removed from the system as insoluble sulphide or hydroxide in presenc of ammonia and H_2S.

From the foregoing discussions it is evident that the vast wetland in the easter fringe area of the City of Calcutta is a gift of the nature and form an effective wast recycling system for the city sewage for productive purposes. The local people have lear the management practices through experience. Scientific approach to evolve suitabl management techniques, however, is needed to augment fish and prawn productions fro such waste recycling system. The waste waters may sometimes get contaminated b various substances and thus may be deleterious to fish and prawns. Proper managemen measures, like waste water treatment, regulation of treated sewage intake so that BOI load remains at desired level, testing the water quality before introduction of fishes etc. ar likely to enhance production from such water bodies. Taking the sewage fed fisheries o Calcutta spill area as the basic model sewage fed fisheries in other parts of the country ca be developed. Conservations of such wetlands is a prime need of the day and if th wetlands are not protected from the greed of the land hungry people the whole sewerag system of the city will face severe problems, the fishery on which a large section of th rural population is thriving, will loose their job and finally will imbalance the ecology as a whole.

STATUS OF FISHERIES OF THE HOOGHLY-MATLAH ESTUARINE SYSTEM AND REQUIRED CONSERVATION.

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INTRODUCTION

The estuary is defined as "a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage" (Pritchard, 1967). While Fairbridge (1980) gave a more comprehensive definition that "an estuary is an inlet of the sea reaching into a river valley as far as the upper limit of tidal rise, usually being divided into three sectors; (a) a marine or lower estuary, in free connection with the open sea; (b) a middle estuary subject to strong salt and freshwater mixing; and (c) an upper or fluvial estuary, characterized by fresh water but subject to daily tidal action. The limits between these sectors are variable, and subject to constant changes in the river discharge:. A new functional definition of estuary has been proposed by Kjerfve (1988) as "an estuarine system is a coastal indentation that has a restricted connection to the ocean and remains open at least intermittently. The estuarine system can be subdivided into three regions *viz*., (a) a tidal zone, (b) a mixing zone - the estuary proper and (c) a near shore turbid zone". This definition of estuaries includes the adjacent coastal waters.

In general, estuaries are the most productive ecosystem in the world as compared to other natural water bodies. The total extent of the estuarine areas including estuarine impoundments in India and West Bengal is estimated to be 14.12 and 2.10 lakh ha. respectively. The complex Hooghly-Matlah estuarine system on the Indian coast is one of the largest estuarine systems in the country covering a major portion of the Gangatic delta. It is located in the State of West Bengal latitude 21-23°N and longitude 88-89°E. The deltaic region of the system is occupied with a vast marshy area cris-crossed by many major and minor estuaries of the system called Sunderbans- the world's largest mangrove ecosystem. The entire estuarine system is estimated to be about 8,029 km^2 and the total area of the sundarbans estuarine water is about 2,340 km^2 . The principal components of the estuarine system are the main Hooghly channel, its five tributaries *viz.*, Jalangi, Churni, Damodar, Rupnarayan, Haldi and the adjacent estuaries such as , Saptamukhi, Thakuran, Matlah, Gosaba, Haringbhanga, Ichamati and Raymangal. The latter seven estuaries are since long disconnected from the main Hooghly due to heavy deposition of sediment in the upper reaches of these estuaries. As a result they are now considered as estuarine inlets of the area.

Estuaries are among the most productive natural ecosystem in the world. Hooghly-Matlah estuarine system is not an exception to this as is recognised to be the most productive estuarine system of the country. The entire system offers bounteous biological wealth characterised by its diversified rich flora and fauna including fisheries. It also provides rich breeding and nursery grounds for innumerable numbers of marir freshwater fin and shell fish species as they are physiologically suitable environmer respect to temperature, salinity and other physico-chemical parameters. Therefor complex Hooghly - Matlah estuarine system plays a vital role in fisheries and ac potential source of fish and prawn seed.

The main channel Hooghly (the end portion of river Ganga) of the syste positive estuary of the mixohaline type with the pattern of increasing salinity towar mouth of the estuary. The dynamic estuarine ecosystem is subject to rapid chang natural or manmade interferences. In case of Hooghly-Matlah estuarine system, a change in the water quality and fishery resources was noticed after the construct barrage across the river Ganga at Farakka. Prior to the construction of barrage, the channel Hooghly was deprived of getting sufficient freshwater and gradually b inactive as bulk of discharge used to flow through river Padma, the other off-sh river Ganga. After commissioning of Farakka barrage in 1975, the main Hooghly e is fed directly by the Ganga through feeder canal and Bhagirathi.The additional disc of freshwater into the system has changed the ecology of the estuary. These ch significantly affect the biological and physico-chemical factors responsible for pla benthos and fish production. The present communication deals with major chang ecology, fish population trends and also suggests for its conservation for a susta production.

ECOLOGY:

A critical analysis of the earlier works during pre-Farakka barrage period (Du *al.*, 1954; Bose, 1956; Shetty *et al.*, 1961; Basu and Ghosh, 1970; Saha *et al.*, 197 post Farakka period (Nandy *et al.*, 1983 and Sinha *et al.*, 1998) relevant to hydr revealed that additional discharge of freshwater through Farakka barrage had change ecology of the system significantly by reducing salinity and converting the earlier gra zone into almost freshwater one. Presently, the salinity incursion of the Hooghly es was observed up to Diamond Harbour situated 60 km from the mouth of estuary. O contrary, the salinity incursion of the Hooghly estuary during pre-Farakka barrage p was observed up to Konnagar situated 162 km from the mouth of estuary. The Ho estuarine system being a positive estuary, showed distinct levels of salinity grad Presently the upper freshwater zone has extended downwards for a distance of 23 from Nabadwip to Diamond Harbour. Nabadwip and Diamond Harbour are locate and 60 km respectively from the sea face. The gradient zone Diamond Harbo Kakdwip and marine zone Kakdwip to sea face have been very much reduced and p back towards the mouth of the estuary. (Fig. 1). During pre-Farakka period the u freshwater zone was extending from Nabadwip to Konnagar, middle gradient zone Nabadwip to Diamond Harbour and marine zone from Diamond Harbour to sea face present salinity values in the upper freshwater zone ranged between 0.04 and 0.1 while in the gradient and lower marine zones the values varied from 0.32 to 4.54 g/ 1.58 to 32.5 g/l respectively. The salinity in the main Hooghly channel inclu Muriganga was always lower than the other distributaries of the estuarine system v fluctuations of salinity are brought about only by the freshwater received fro catchment areas and overflow from adjoining Hooghly during monsoon month estuaries around Sunderbans had high salinity. The salinity values in Saptar Thakuran, Matlah, Roymangal and Ichamati varied between 4.54 and 29.6 g/l, 7.8 29.7 g/l, 2.92 and 27.62 g/l, 7.25 and 17.2 g/l and 0.39 and 13.54 g/l respectively.

As regards physico-chemical parameters of the estuary during pre and Farakka period an appreciable change in the values of certain parameters was observe present an increase value of dissolved oxygen in the Hooghly estuarine system at Ul (5.8 to 7.2 mg/l), Diamond Harbour (Roychowk) (6.4 to 7.9 mg/l) and Kakdwip (8/2 mg/l) in the present study as compared to earlier study during 1953-55 whe values varied from 2.3 to 4.6 mg/l at Uluberia, 2.1 to 6.8 mg/l at Diamond Ha (Roychowk) and 3.4 to 5.1 mg/l at Kakdwip may be due to increased infl freshwater in the estuary after commissioning of Farakka barrage. Phosphate, nitrat silicate contents of the estuarine waters were very low during pre-Farakka period, after commissioning of Farakka barrage, the phosphate, nitrate and silicate co increased and almost similar values were observed up to recent years.

PLANKTON:

The overall plankton production in the Hooghly estuary during post-Fa barrge period was high when compared with the earlier studies during pre-Fa barrage period. The total plankton production for the Hooghly estuarine stretch maximum at Frezerganj (1262 units/l) and minimum at certain stretches of freshwa well as gradient zones of the estuary. The low production of plankton at these stre may be due to discharge of industrial effluent which caused maximum adverse effe production of plankton. The bulk of plankton in the Hooghly was constitute phytoplankton. Bacillariophyceae, Chlorophyceae and Cyanophyceae are the prin groups in order of abundance. Phytoplaknkton production was maximum at Frazerg the Hooghly estuary as compared to other distributaries *viz.* Saptamukhi, Thak Matlah, Roymangal and Ichamati. The range of annual plankton production varied 79 to 392 u/l in the Saptamukhi estuary at Bhagabatpur, from 76 to 221 u/l i Thakuran estuary at Moipeeth, from 52 to 585 u/l and 19 to 594 u/l in the Matlah es at Canning and Jharkhali respectively, from 50 to 298 u/l in the Roymangal estua Bagna and from 42 to 237 u/l in the Ichamati estuary at Hasnabad. At Bagna (298 Jharkhali (594 u/l) and Bhagabatpur (392 u/l) plankton production was maximum d summer and at Moipeeth (221 u/l) during winter, while maximum production observed at Canning (585 u/l) and Hasnabad (237 u/l) during monsoon months.

MACRO-ZOOBENTHIC FAUNA

Information on macrozoobenthic fauna of Hooghly estuarine system during and post-Farakka barrage periods are very scanty. At present the overall populatio macrozoobenthos ranged between 37 and 5207 units/m^2 and the maximum production observed in freshwater zone of the estuary. In the freshwater zone, the dominant sp under gastropods were *Thiara tuberculata, T. lineata, T. scabra, Bellamya bengalensis, B. dissimilis, Assaminea francissi, Brotia costula, Carbicula noetlingi, Indoplanorbis exastus, Neritima smithi, N. vislacea, Gangetica miliacea, Pila globosa, Mactra luzonica, Segmentina calatha,* contributing 65 to 100% of the total population. Other community available were *N. polybrancia* (Polychaeta), *Tubifex* (Oligochaeta), *Ocypodid* sp. (Crab), *P. faridens* (bivalve).

In the gradient and lower marine zones of Hooghly estuary the macrozoo-benthos density ranged between 92 (Haldia) and 828 units/m^2 (Frazerganj), 254 (Frazerganj) and 561 units/m^2 (Haldia) and 37 (Kakdwip) and 1049 units/m^2 (Frazerganj) during summer, monsoon and winter seasons.

The annual production of macro-zoobenthos in Saptamukhi estuary at Bhagabatpur (184 to 991units/m^2), Thakuran estuary at Moipeeth (256 to 1472 units/m^2), Matlah estuary at Canning (82 to 294 units/m^2), Roymangal estuary at Bagna (74 to 331 units/m^2) and Ichamati estuary at Hasnabad (239 to 294 units/m^2) also exhibited the dominance of gastropods in the population. *Cerithidea cingulata, Columbella duclosiana, Natica tigrina, Neritina auriculata, Telescopium telescopium* were the dominant gastropod species in the lower marine zone of the Hooghly as well as estuaries of Sunderbans.

FISHERY:

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 encountered the region. The fish and prawn fauna available in the stretch between Nabadwip and Calcutta were *Tenualosa ilisha, Aorichthys seenghala, Eutropiichthys vacha, Clupisoma garua, Setipinna phasa, Ailia coila, Puntius ticto, Mastacembelus armatus, Bagarius bagarius, Pangasius pangasius, Xenentodon cancila, Amphipnous cuchia, Mystus cavasius, Ompak pabo, M. gulio, Notopterus notopterus, N. chitala, Wallago attu, Labeo rohita, L. calbasu, Catla catla, Cirrhinus mrigala, L.bata, Chela* spp. Among prawns, *Macrobrachium rosenbergii, M. malcolmsonii, M. rude, M. villosimanus, M. lamarrei, M. mirabiles, M. birminicum, M. scabriculum and M. dayanum* were available in the stretch. The availability of feather back (*N. notopterus and N. chitala)* and carps *(Labeo rohita, L. calbasu, Catla catla, Cirrhinus mrigala, L. bata*) was mostly confined to the stretch between Nabadwip and Tribeni and their abundance was poor in comparison to total catch. The important fish available in the stretch between Uluberia and Diamond Harbour were *Pama pama, S. phasa, T. ilisha, Polynemus paradiseus, Silaginopsis panijus and Rhinomugil corsula*. Among prawns, *M. rosenbergii, M. mirabile* and *Metapenaeus brevicornis* were the most dominant species. Freshwater species *viz*., *E. vacha* and *C. garua* were available upto Uluberia.

Dominant species in the gradient as well as marine zone of Hooghly including other estuaries of Sunderbans were *Harpodon nehereus, Trichiurus* spp., *T. ilisha*

Setipinna spp. (mostly *S. taty*), *P. pama* and prawns (*Parapenaeopsis sculptilis, P. stylifera, Metapenaeus brevicornis, M. monoceros, Penaeus monodon, P. indicus, P. semisulcatus, Expalaemon stylifera, E. tenuipes and Leptocarpus fluminicola*). Next to these other important fish species were *P. paradiseus, Eleutheronema tetradactylum, Lates calcarifer, Polydactylus paradiseus, Polynemus indicus, Coilia spp. Stromateus cinereus, Arius sona, A. sagor, Ilisha elongata, Osteogeniosus militaris, Ototithoides biauritus, S. Panijus, Liza parsia, L. tade, Chirocentrus dorab, Raconda russeliana, Plotosus canius, Cynoglossus spp. Anchoviella commersonii, Scatophagus argus, Etrophus suratensis, Therapon jarbua, Synbranchus bengalensis and Strongylura strongylura.*

The annual average fish and prawn yield from the estuarine system has increased from 3,204 tonnes during the period 1960-63 to 51,126.1 tonnes during 1996-97. In the Hooghly estuarine system, fishing exploitation by migratory bagnet was an important feature of the lower estuarine zone during wintger months 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. neheecus, Trichurus spp. Setipinna spp., Arius spp., P. pama and Coila 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 contributions were *H. Neherus, Trichiurus spp. Setipinna spp.* and prawns.

The present trend of catch statistics shows that some fish species *viz., Liza tade, Plotosus canius, Pangasius pangasius, Lates calcarifer* of the estuarine system have shown a sharp declining trend during post-Farakka barrage period. Reduction in overall salinity coupled with over exploitation and destruction of brackishwater fish and prawn seed for selective stocking of *Penaeus monodon* in coastal aquaculture are apparently the probable reasons for the decline of these fisheries.

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 7,000 tonnes in recent years.

Sunderbans estuarine system is a potential source of estuarine fish and prawn seed. The present observations on the abundance of commercially important prawn and fish seed in the Sunderbans during post-Farakka barrage period revealed that the magnitude of abundance of certain prawn and fish seed has reduced to a great extent as compared to pre-Farakka barrage period. The seed of most commercially important prawn *P. 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 upstream from the seaface while during pre-Farakka barrage period seeds of *P. monodon* and *P. indicus* were available from Uluberia and Noorpur centre of Hooghly main channel located 113 and 83 km respectively above the mouth of the main estuary. Reduction in salinity due to increased freshwater discharge is apparently the probable reason for this. The overall availability of seed in the lower estuarine system was found to have declined.

Giant freshwater prawn, *Macrobrachium rosenbergii* contributes to a fairly good fishery in the freshwater zone of Hooghly estuarine system. The range of down stream migration of the species during pre-Farakka barrage period was upto Noorpur (1.90 to 21.2 ppt salinity) located 83 km upstream from the estuary mouth. The species now migrates further downstream towards seaface as far as Diamond Harbour, Kakdwip, Namkhana, Sonakhali, Basanti, Jharkhali, Nazat, Hasnabad areas of Sunderbans indicating a long range migration. The migration of berried females in particular, takes place in the water bodies (2.30 to 19.00 ppt salinity) of Sunderbans usually during early in March/April and continues upto July. The downstream migration of the species upto that extent was not observed during pre-Farakka barrage period.

It is observed that a huge quantity of both commercial and non-commercial prawn and fish seed is being destroyed during selective collection of bagda seed (*P. monodon*). The present exploitation of bagda seed during the peak abundance period from February to June was estimated for five consecutive years of 1993-97. The average yearly (February-June) exploitation of bagda seed was estimated to be 885.5 million from Sunderbans region. It is also recorded that bagda seed constitute only 5 to 10% of the total catch of the nets. The total amount of seed destroyed over a period of five months during February to June was estimated to range from 9,139.5 million to 19,294.5 million. This wanton destruction of seed is detrimental and may lead to decline of estuarine as well as marine fisheries in future.

RECOMMENDATIONS FOR THE CONSERVATION OF ESTUARINE FISHERIES:

(i) Fish exploitation in the estuarine system is rather unbalanced. Now a days exploitation level of natural fish and prawn resources in certain potential estuarine areas has reached its maximum limit. It has been observed that such overfishing has gradually declined the recruitment level of many commercially important fish populations. The estuarine environment should be judiciously exploited so that natural resources of fish and prawn stocks and their recruitment level are not damaged or destroyed.

(ii) Indiscriminate fishing, irrational exploitation, wasteful utilization of resources should be avoided through proper planning, development and management.

(iii) The breeding periods of fin and shell fishes are to be critically studied to suggest regulatory measures for their exploitation by observing close period in time and space.

iv) Remedial measures should be taken with regard to intensive fishing or over exploitation of hilsa in the estuarine system. Hence, there is a need to reduce the intensity of hilsa fishing.

(v) The mesh size of fishing gears for drift gill net, drag net, scine net should be adjusted to ensure non-capture of juvenile stocks of prawn and fish.

(vi) Intensive seed collection from wild for stocking estuarine impoundments should be stopped and only hatchery produced seeds should be used for stocking. Over stocking of the water area should be discouraged. Implimentation of lagislative measures against indiscriminate destruction of shrimp and fish seed during peak abundance period particularly in regions where these seed resources are abundant.

vii) The bycatch discard has to be reduced by setting up by-catch processing plant at major fish landing centres to produce quality fish meal.

viii) Chemicals, antibiotics, pesticides etc. should not be used in estuarine impoundments (bheries).

ix) Berthing facilities should be provided at major landing centres of the estuarine system.

x) Provision for infrastructure facilities such as, approach road, sufficient drinking water for fisherfolk, feezing plants, mark outlets. Good marketing systems have to be evolved with proper management strategies establishing fishermen's co-operatives in all major landing centres all along the coast.

xi) Destruction of mangrove forests and ecologically sensitive estuarine wetlands should not be done.

xii) There is an utmost need to protect estuarine enviornment from pollutional hazards by agricultural, industrial and domestic effluents. To avoid any such health hazards, permanent pollution abatement measures are to be recommended for planning estuarine enviornment.

xiii) Necessary training should be extended to fishfolk for the improvement of their socio-economic conditions.

RETROSPECTION OF 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 area (north of 22.30' latitudes) of the estuaries was comparatively less saline than the southern zone. The salinity content 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 stock 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, Macrobrachium 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 wat aquaculture in West Bengal. The survey revealed the presence of 1334 nos. of bheries in the ar covering 32,930 ha. The annual fish and prawn seed availability was found to vary between 60 and 800 million which could cater the need of the farmers (Laha et al. 1988). The bheries we categorised into three groups based on prevailing a water salinity and existing cultural patter

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 a 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's nos. / Ha. Liming, manuring and supplementary feeding were practice 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 nat ural food organisms mainly plankton. The planktonavailability 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 fertilizers 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 management practices like use of supplimentary feeding, liming, manuring and fertilization, stock mani pulation and water management facilities etc. may improve level of these water bodies.

Statistical interpretation of physico-chemical properties of water and plankton.

The co-efficient of correlation of net primary productivity, physico-chemical parameters and plankton availability were calculated separately. The correlation co-efficient between primary productivity and available phosphate of water at high saline zone was found to be significant ($P<0.05$). A linear multiple regression model of primary productivity, phosphate of water, water pH and total plankton of high saline area was also worked out. The model is capable of explaining nearby two third ($R2 = 0.66$) of the variability in net primary productivity.

Constraints :

i) Due to rapid siltation of the canals, tidal creaks and estuarine inlet, bheries are poorly supplied with tidal water from the estuaries. Naturally the low and medium saline zones are gradually turning into fresh water bodies. The intake of dilute sewage with the tidal water is another cause of this type of transformation.

ii) With the introduction of semi-scientific methods the annual rent value has increased exorbitently. During 1994 the rent value was recorded from Rs. 3000 - 6500 / bigha/yr. As against Rs. 1500 - 2000 /bigha/yr. in 1992.

iii) Cost of *P.monodon* post larvae from natural sources has increased tremendously from (Rs 500/thousand to Rs. 2500/thousand).

All the above factors have restricted the farmers to take up any bold step towards the adoption of scientific farming to achieve higher production of fish and prawn presently from the brackishwater bheries.

Conservation measures :

Since the, estuaries and continental shalves are the basic componentents of human civilization and are under use from unknown period they need proper attention for survey . Geomorphological, hydrological and climatological survey of the coastal areas were made by conventional methods from time to time. These conventional methods monitoring and collecting data are very difficult, time consuming and expensive besides, they are not always fact finders. The satellites have opened possibilities of surveilance/monitoring more precisely and accurately. This method of remote sensing has to be employed for the estuarine and coastal environment studies and accordingly the programmes have to be chalked out. The data buoys have to be utilized for collecting the environmental data.

In India, the estuarine wetlands exhibit a wide ranged environmental condition and sustain a rich fishery of fin-fishes and shell-fishes. As such, for sustained yield, parasitological studies are very important aspects of managing fisheries of such wetlands. Further, in this type of capture - cum-culture fishery, fishes face changes environment which have both advantages as well as disadvantages. Worth-mentioning advantage for the fishes is losing some parasites which can not tolerate the change in salinity of water. The greate disadvantage faced by the estuarine fishes in the impoundment is the ecological imbalance; as fishes are poikilothermal in nature they become subject to `stress` and face greate trouble to maintain their homeostasis and as a result they become easy prey of the parasites. On the maintenance of homeostasis estuarine fishes are classified as eurihaline and stenohaline. The former can tolerate wide fluctuation of salinity bu the latter can not. Eventually fishes grown up in estuarine wetlands are in general eurihalin species. However, in low-saline wetlands where salinity generally does not exceed 10 ppt. Majo carps are also stocked after monsoon when salinity drops down to 5 ppt. Or less. In estuarin wetlands *Oreochromis mossambicus* is also stocked as consumers` preference. Common carp 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 earnin commodity, in most of the impoundments of Hooghly estuarine complex.

The nature of parasitism needs little consideration while the relationship between hosts an parasites is explained. Parasites are either obligate or facultative in nature. The latter can liv without a host for a part of its life cycle but obligate parasites always require a host for the sustenance. Obligate parasites may not always be dangerous as some helminths can help the hosts, but such parasites can be the cause of extermination of the hosts when environmenta 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 result both host and parasite perish if the latter does not simultaneously find out another suitabl hosts for its existence. Control measure of parasitic afflictions in estuarine wetlands should b improved by means of managerial practices such as sanitation of the impoundment, stockin density of fishes, pre-stocking measure, environmental monitoring as well fish-health monitorin

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RIVERINE FISHERIES OF INDIA, PRODUCTION POTENTIAL AND MANAGEMENT MEASURES FOR ENHANCING FISH PRODUCTION

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Introduction

Since time immemorial rivers are used by mankind more than any other type of ecosystem. River offers a continuously renewable physical resource, the major source of water for multiple use such as agriculture domestic, industrial and for rapid removal of waste substances generated due to anthropogenic activities. They have also been subjected to other uses such as transport, harvesting of food and recreational activities. Further, rivers have also been regarded a hazards by flooding vast area, changing course in response to process of erosion, obstructing transport system across valleys and aiding in the transmission of water associated diseases.

Human race is irrationally exploiting riverine resources together with their floodplain on account of this cultural eutrophication only a few large river systems of the world retain their original functional integrity and many have probably lost much of their capacity to adjust and recover from severe perturbation. It is one of the most striking manifestation of the human failure to utilize renewable resources without deterioration of their natural basin. When, we examine the status of Indian rivers in the above context, we found the same is valid for our rivers too. Most of the rivers have lost natural purity of water and are in the process of loosing biodiversity too. Thus, there is an urgent need for understanding the causes of eco-degradation and formulation of policies for recovery of aquatic wealth. Suitable management strategies have to be formed for thorough assessment of fish stock population alongwith regulatory measures for fishing. Thus, the understanding of river's ecology and estimation of fish production and forecasting of future catch become a basic pre-requisite for formulation of management policies.

Riverine Resource of India

Nature has bestowed India vast expanse of open inland waters in the form of rivers, lakes, oxbow lakes and estuaries. These water bodies harbour the original germplasm of 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.

The total length of Indian rivers is about 45000 Km which includes 14 major rivers, each draining a catchment area of above 20,000 Km^2 . 44 medium rivers with catchment area between 2000-20,000 Km^2 and the innumerable small rivers and desert streams that have a drainage of less than 2000 Km^2. The major river systems of India on the basis of drainage, can be divided broadly into two; (i) Himalayan river system (Ganga, Indus and Brahamputra) and (ii) Peninsular river system(East coast and West coast river system). The details of the area and potential fish yield of the major rivers is furnished in Table 1 and brief description of fisheries resources is given below.

1. **Ganga river system** : It is one of the largest river systems of the world, having a combined length (including tributaries) of 12500 km. After originating from Himalaya, it drains into the Bay of Bengal, after traversing a distance of 2225 km. The Ganga river system harbours about 265 fish species, out of these 34 species are of commercial value including the prized Gangetic carps, large catfishes, feather backs and murrels.

In mountainous region, from source to Haradwar the fisheries is dominated by *Schizothorax* spp.; catfishes, *Mahseers* and *Labe*o spp. The commercial fisheries in this zone is non-existing due to sparse population, unaccessible terrain and poor communication between fishing grounds and landing centres. However, commercial fisheries assumes importance in 1005 km middle stretch of the river (Kanpur to Farakka).The important landing centres are Kanpur, Allahabad, Patna, Buxar and Bhagalpur. The mainstay of fishery are the species belonging to cyprindae (176 species) and siluridae (catfishes). The important species are: Gangetic major carps, catfishes, murrles, clupeids and featherbacks besides migratory hilsa. On an average fish yields has fluctuated in the stretch between a high of 230 t to a low of 12.74 t during 1958 to 1995 and yield of major carps on Kg ha^{-1} yr^{-1} basis from 83.5 to 2.55 during the above period. The main reasons for decline in fish yield may be attributed to (1) sandification of the river bed (upto Patna) which reduced the rivers productivity due to blanket effect (2) marked reduction in the water volume on account of increased sedimentation (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^{-1} and 629.8 Kg Km^{-1} yr^{-1} in 1990's respectively. The estimated mean annual fish landings of the some important landing centres on river Ganga is depicted in Table 2.

Decline in Hilsa Fishery : The commissioning of Farakka barrage in 1975 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 and at Bhagalpur, 1.47 to 9.79 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 and 0.01 to 2.18 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, 28.69 Kg ha^{-1} during 1980-86 and 15.19 Kg ha^{-1} during 1989-93. But 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^{-1} is currently harvested (Table 3). Thus, in general the fish yield potential is unadequately utilized in all the sectors leaving scope for further improvement.

Brahamaputra River System : The Brahamputra river originates from a glacier (Kubiangiri) in Tibet and has a combined length of 4025 km including its tributaries. The geological nascent 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 by c 4.5 m due to deposition of silt. Like Ganga basin, the Brahamputra valley is also dotted with abandoned beds called beels which support rich fishery. The major portion of the river lies in Tibet and in Indian territory river flows about 700 Km only. It is joined by Ganga in Bangladesh, forming the largest delta in the world.

Fish stock composition: The upper 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. 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 form substantial fisheries of the potamon 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 dominate (54.14%), followed by cat fishes (28.40%) and major carps (17.46%), while in middle stretch catfishes (28%) have replaced 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%). Prawn contribution in the total landing of the mid-stretch is restricted to only 4 to 7%.

In another survey conducted by CIFRI, during 1973-79 at 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 catfishes 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 exploitation of brooders (ujaimara activity) and as well as of juveniles.

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: *Salmo trutta fario*, *S. gairdneri*, *Tor tor, T. putitora*, *Schizothorax* spp. *Labeo dero*, *Gara gotyla*; *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 reported to support commercial fisheries. The species caught are : *Shizothorax* spp., *Labeo dero, L. dyocheilus, Crossocheilus latius, Puntius conchonius, Cyprinus carpio (C. communis and C. specularis*) loaches and *Glyptothorax* spp.

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

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 Godavari : The headwater 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 Bumnagudum anicut), a fish yield between 218 and 330 t was estimated. 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 (1990's) river is maintaining a fish production of 1 tonne/km/annum 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. Among miscellaneous fishes, *Chela argentina*, *P. aurulius* and *P. conchonius* dominate the catch.

The Mahanandi River : The upper reaches harbour game fishes but commercial fishery is non existent 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 : A number of dams have been constructed on this river which has altered the ecology of this river. In general, the physiography and fish fauna of the Krishna river resembles to Godavari river system. The headwaters support rich fishery when compared to mid-stretch, which is rocky and unaccessible. According to a report (1963) about 91 to 136 kg of fish was caught in the river Vijaywada. No information is available on its present fishery and catch statistics.

Cauvery River : 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 deltaic 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. childreni*. Data on catch statistics is not available.

West Coast River System : The main westward flowing rivers are Narmada and Tapti.

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). According to an estimate from a 48 km stretch (Hoshangabad to Shahganj) of the river, a monthly yield of 32.8 to 52.7 tonnes was reported in 1967. Since then, no perceptible change either in fish catch or in fish composition has been observed. 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) obliterating the riverine habitat.

Tapti river : Not much informaion on fish stock composition and fish yield is available. About 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*.

Management measures

Biological and ecological studies have revealed that the fish communities are very sensitive to flood regime because of their dependence on the seasonal floods to inundate the ground needed for feeding and breeding. Any change in the pattern and form of flood curves 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. An intelligent management strategy has to take cognisance of key parameters such as hydrology, fish stocks and dynamics of their population together with regularity 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.

Future approach:

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 as well as help in conservation of original germplasm.

Conclusion

Finally it may be concluded that the decision taken by legislators and politicians will have a greater impact on the future of the riverine ecosystems than any amount of limnological work. The biological solutions to many environmental problems are within reach, given the *political will and suitable legislation*. However, ecological viable management strategies will fail if do not address socio-economic and cultural contexts, or are considered in isolation from the aspirations of the local populace. The implications are clear: we must continue to contribute to the academic development of limnology, but make greater effects to disseminate our knowledge of river ecosystems and communicate with those planning large scale development as well as those whose activities have a direct effect on the ecosystems at issue. Otherwise species loss an further degradation of rivers will result from a failure to engage in wide-rangin discourse. Time has come that we should weigh our priorities, should we increase ou put of scientific papers, while ignoring the *realpolitik* of conservation and managemen or should we devote more effort to communicating the revealance and importance o our science. Further most of the rivers are interstate and each state has its own priorities. A common property approach prevails for much of the system an management is restricted to the auction of fishing rights for river stretches, withou restriction on size of catch, size of fish or fishing season. Large scale capture of broo stocks while migrating during monsoon, large scale poaching, destruction of fish i their summer refugia and enormous destruction of juveniles are more a rule than a exception. Moreover no states want to spend money on developmental auspects an their attitude is that of a spendthrift. Under these circumstances, for sustainabl exploitation and development of riverine resources, there is an urgent need fo establishing, a central organisation which should be responsible for holisti development of the riverine resources of the nation.

Table 1. 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	Stream length b tonne
Himalayan river				
Ganga	2525	0.88	17443	17142
Yamuna	1376	0.37	5243	8588
Brahamaputra	800	0.19	1782	3958
East Coast rivers				
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 and Tyagi, 1996)

MANAGEMENT OF FLOODPLAIN WETLANDS FOR SUSTAINABLE FISHERIES AND BIODIVERSITY CONSERVATION

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Introduction

India, specially the Eastern and North - Eastern parts, is bestowed with aquatic resources in abundance and amongst these the floodplain wetlands remain the prime source for fish and fisheries since their inception. The distribution of wetlands in India is, however, widespread from the cold deserts of Ladakh to highly wet Manipur, the warm desert of Rajasthan & Gujarat to the monsooning Central India and in the higher humid zones of South. The floodplain wetlands cover a wide variety of dynamic ecosystems from perennial rivers, streams, estuaries including mangrove swamps, natural depressions & marshes (locally known as beels, chaurs, dhars, pats etc), ox-bow lakes, ponds & tanks and seasonally inundated water areas. In India the estimated area of wetland is about 4.1 million ha besides 6740 km^2 coastal wetlands/mangroves (80% area falls under Sunderbans in West Bengal).

Floodplain Wetlands of Ganga and Brahamputra basins

The floodplain wetlands of Ganga and Brahamputra basins can be classified into two categories, depending upon their origin and geo-morphological features:

I) The ox-bow lakes
ii) The tectonic lakes

The **wetlands of Gangetic plain** are known for their utility under various developmental sectors since time immemorial. East Calcutta wetlands (W.B), Chaurs (Bihar), oxbow lakes (Bihar,U.P.), Chambal wetlands (M.P.) and Keoladeo Ghana national park (Rajasthan) are highly significant under the Gangetic plain. In recent years various multi-purpose river valley projects have taken shape giving birth to a large number of man-made wetlands in the Indo-Gangetic plain, such as Harike Barrage (Beas-Sutlej Confluence), Bhakhra and Nangal dams (H.P.and Punjab), Kosi barrage (Bhainsalotan, Bihar) and many more.

The Indo-gangetic region of the country is bestowed with extensive expansion of wetlands and incidently the area has the distinction of possessing the largest wetland tract in the country. State-wise areas of wetlands as important fishery resources are indicated in Table 1.

The 7500 km **coastline of India has extensive areas of wetlands** dominated by mangroves, salt marshes & lagoons. Pulicate lake, Periyar lake, Chilka lake, Kolleru lake etc. are some of the important coastal wetlands. The southern peninsula as well as the Decean region, though poor is natural wetlands, are very rich is man-made wetlands in the form of small reservoirs and tanks.

Table 1: Floodplain Wetlands as prime fishery resource

State	Natural Area (ha)
Assam	100000
Bihar	48000
West Bengal	42000

Values and roles of wetlands

The wetlands are fragile ecosystems but very sensitive biologically with high to very high productivity potential. Historically they are known to perform a number of functions and are highly significant from ecological, commercial and socio-economic point of views. Dugan (1990) has described their functions in detail, such as:

- *perform a kind of safety valve function ecologically by acting as reservoirs and reducing factors of floods,*
- *as a repository of huge biodiversity,*
- *as an ultimate sink for pollutants,*
- *as ground water recharger and dechargers,*
- *as a stabilizer of local climatic conditions*
- *as shoreline stabilizer of river basins*

Besides the ecological functions the wetlands are also known for their commercial and socio-economic values such as:

- *supporting desirable food chains leading to harvestable crop for human welfare.*
- *important source for fishery activities, a traditional occupation for poorest of the poor section of the society in rural areas.*
- *source for aquafarming like 'makhana'(Euryale ferox), 'singhara' () and 'kamal' ()*
- *refuge of Avian fauna and an excelllent habitat for many other wild lives*
- *water transport, irrigation,* etc.

Threat to wetlands

It has become increasingly clear that the wetlands are in a phase of natural transition. The water depth is on the decrease at an alarming pace and threatening to convert into a dry environment. Obviously, the ecosystems are self destructive in nature. Normally,however, the process of such natural transition is, generally slow. The increased human interventions in recent years, such as flood control measures, reclamation of arable lands for agricultural activities, channelisation and abstraction of excessive water for various purposes, irrational discharge of liquid and solid wastes and the change in land use patterns in their catchment areas have accelerated the loss of wetlands to a large extent (Sinha and Jha1977).

The increased and irrational human interferences, at various trophic levels of these fragile ecosystems, under Ganga and Brahamputra basins have been so intense that the production functions have developed irreversible aberrations in many cases. It is a matter of serious concern not only to production managers but to the conservationist also. The net outcome of such unholy developments have not only adversely affected the sustainability in the production front but even the very survivability of their physical entity has become doubtful (Jha, 1995, Sinha and Jha, 1977, Sugunan, 1995 Yadava 1995). It is well known that the multipurpose utility of these waters was mainly responsible for large scale human settlement in the vicinity of the lake areas. The settlers gradually organised and developed various production systems along the subsistence economy from these wetlands. In the past few decades, however, the productive properties of wetlands have been over exploited in the face of increased population pressure and for harnessing more & more produce, income and other livelihood needs.

Traditionally the wetlands were used for fishery, agroforestry, pasture and navigation. In last few decades, however, the scenario has completely been changed due to many fold increase in the demand of lands for cultivation and human settlement, which in turn proving to be the main destroying factors of these waters.

Developmental impact on floodplain lakes

Man induced river valley modifications have manifested into rapid and significant ecological changes leading to impaired production and productivity. The immediate impact of such developments might have improved the food security in terms of food grains production and surface transport infrastructures, but these gains may prove to be short-lived. The adverse impact of irrational exploitation of such ecosystems can be summarised as under:

1. Biodiversity/Environmental impacts

Most of the biological resources of wetlands are passing through a critical phase of ecological succession. The wetlands are known for their excellent biodiversity reserves in the form of wildlife, plants and animals. Presently, however, the loss of biodiversity at an alarming rate has assumed a serious proportion and needs immediate attention. Fishery, which remains a high priority area traditionally has suffered a great deal in recent years affecting the rural economy adversely. The wetlands in the country have been subjected to indiscriminate and disproportionate exploitation to the extent that many fish species have either became endangered or a number of them have already vanished from the scene. Undesirable growth of fish food organisms and subsequent alteration in food chains have engineered significant shift in the composition of fish catch structure, such as:

- *Highly prized carp dominant fishery to less valued minnows dominant fishery and in the bargain more proliferation of predators, resulting in considerable decline in harvestable fish crop.*

Most of the lakes in Ganga and Brahmaputra basins are reeling under massive growth of unwanted macrophytes, which has manifested into a chaotic condition either due to the creation of a under water desert on account of surface coverage of floating weeds or nutrient deficient ambient water phase affecting the growth of desirable grazing chains. *Macrophyte dominated water phase* and *molluscs dominated benthic niche* have become the hallmark o wetlands currently. Interestingly, neither the macrophytes nor the molluscs are able to penetrat the grazing chain in absence of efficient fish grazers. Evidently, non conversion of major bio production at the primary and secondary levels into fish flesh is a matter of serious concern a the harvest of fish biomass suitable for human-welfare has declined alarmingly. The carp fisher in floodplain lakes of Gandak basin has been found to be a meagre 1.50-8.0%, contrary t minnows which accounted for more than 60% in many cases (Jha, 1995; Sinha and Jha 1997, Jh and Chandra, 1997).

Alarming decline in desirable fish species and their population appear to be one of th major factors for low fish yield from wetlands. Poor ingress of brooders/ spawn from riverin stock due to river valley modifications and subsequent choking or siltation of connectin passages is the another factor responsible for low yield.

Wetlands and socio-economic

The floodplain lakes have tremendous impact on socio-economic values of rural India, specially in the fields of Agriculture and Fisheries. During the time of early settlements the local inhabitants generally relied on natural resources like forests, pastures and waters for food and other economic activities. Fishery remains an important resource of gainful employment to a large section of the society specially for landless or marginal farmers. During the last few decades the pressure on fishing in these lakes has taken a quantum jump in the face of increasing human population. This singular phenomenon has led to over exploitation and the concept that *these lakes are renewable source of energy in the form of fish biomass* has almost lost its validity. The lucrative fishery from floodplain lakes has become a matter of past as it has converted into an activity of subsidiary occupation only. The over-all dwindling fishery of floodplain lakes is one of the important push factors affecting large scale exodus of rural population for want of gainful occupation.

Increased population ☞ more and more per unit efforts ☞ diminishing biological resources like syndrome has triggered social conflicts amongst the various user groups. Clandestine loss of fishery resources, aberration and reduction in biodiversity including fish fauna, decline in wildlife habitat etc. have been found responsible for shift in occupation of traditional artisans from water based occupation to petty odd jobs and as a result substantial erosion in the age old socio-economic scenario in such areas where floodplain lakes used to be the centric force of major economic activities.

Sustainable fishery development in floodplain wetlands

The wetlands of Assam, Bihar and West Bengal under Ganga and Brahamputra basins have indicated high fish production potential in the range of 1000-2000 kg/ha/yr. Contrary to reservoirs with estimated average fish yield of 20 kg/ha/yr (Sugunan 1995), floodplain lakes have indicated an average yield of more than 160 kg/ha/yr even at unmanaged level.

Present status

The floodplain lakes have suffered a lot on account of negligence, ignorance and over exploitation.The current level of management is not only inadequate but lacks rationality too. Certain lakes under various States are partially managed on the line of aquaculture like stocking and harvesting of fish biomass. It has been observed, however, that the fisheries management of wetlands is more of an ad-hoc type rather than based on solid scientific principles. In case of the partially managed wetlands, fishermen Cooperative Societies manage such lakes on share basis. Harvesting of fish from the wetlands is considered to be renewable in nature due to their riverine connection. However, currently most of the wetlands have lost this vital characteristic due to a number of factors. The wetland ecosystem remains no more lucrative in terms of fish out-put for which the following factors may be held responsible.

- *Destruction of habitat at an alarming rate on account of river valley modifications like deforestation, civil constructions etc.*
- *Large scale reclamation of the marginal areas of wetlands either for agriculture or for human settlements.*
- *Leaching of agriculture wastes, industrial and domestic wastes and high input of autochthonic nutrients have led to high degree of eutrophication affecting the fish and fishery adversely.*
- *Poor autostocking of prized fish seeds together with wanton killing of juveniles and brood fish stock.*
- *Irrational and conflicting land use pattern in the catchment areas.*
- *Lack of scientific innovations and poor state of management.*
- *Poor financial status of fishermen community and irrational application of nets and crafts.*
- *Poor understanding of ecological intricacies and conservation methods.*

Prospects

The high productivity potential and very low level of its present realisation, has left enough scope for improvement through scientific management of these precious ecosystems. The sustainable fisheries development may be the answer for effective conservation not only to biological resources but also the physical status of the wetlands.

Fish and fisheries has a long history in wetlands since the very early civilisation. Besides fishery has a significant role to play in the overall socio-economic status of people in wetland dominated States. Conservation of these natural resources is a must to keep going the age old social fabric. However, for sustainable fisheries development, the conservation norms have to be incorporated in their right earnest to achieve the goal of sustainability. In order to do that a balanced approach has to be made at the *'micro'* and *'macro'* level planning.

The **macro-level planning** has greater and long term role to play and as such it requires serious attention. The following aspects have to be addressed to for sustainable development of fish and fisheries.

- *The technology transfer mechanism needs effective strengthening.*

- *Environmental awareness/education must be persued with vengeance and be made mandatory, specially amongst the target group i.e. fishermen community*

- *Fishermen Cooperative Societies must be made truly functional and accountable.*

- *The credit and subsidy schemes should be rationalized with clear objectivity.*

- *The training component amongst the fishermen folk needs greater emphasis for better understanding of production functions.*

- *Like other crop, insurance Scheme should be extended to fishery sector also*

- *Prioritisation of wetlands based on economic, cultural, aesthetic and socio-economic considerations.*

- *Monitoring of biodiversity in time series to understand the trend of its shift so as to develop effective conservation protocol.*

The **micro level planning** needs to take care the following aspects:

- *Holistic approach of development identifying the activities to be implemented.*

- *Adequate and timely arrangement of finance for effective execution of the project or projects concerned.*

- *Proper monitoring of activities in the frame-work of environmental variables* etc.

Conclusion

The floodplain lakes are the finest fishery resources traditionally with tremendous scope for fishery development. It is unfortunate, however, that these lakes have been brutally assaulted and subjected to over exploitation without caring for the impact on their fishery as well as on biodiversity. The floodplain lakes are used or abused for so many activities but fish and fishery remain the most important economic activity as a very large chunk of human population directly associated in this activity since centuries. The recent view that pursuance of fishery, casts a negative impact on such ecosystems is unfounded. We have experienced while working in different wetland ecosystems of Bihar , West Bengal and Assam that the lakes where fisheries activities are practised regularly maitain relatively better aquatic environment as compared to lakes which remained virgin and no fisheries activities are undertaken. Thick stand of macrophytes creating hostile aquatic regime for many organisms has been found to be the hall mark of environmental degradation in such lakes. The process of swampification has been found rapid too in such lakes. Detailed survey of lake districts of North Bihar, West Bengal and Assam has indicated that within a period of 30 years almost 35% of the wetlands have lost their aquatic characteristics. It is imperative, therefore, that we should seriously aim at conserving the physical resource as a whole rather than being bogged down on conflicting issues. The question of conserving biodiversity becomes irrelevant if the wetlands are lost. *Sustainable development implies rational utilisation of resources, both physical and biological, without compromising the ability of future generation to garner its needs.* It is essential that greater and cancerated efforts are being initiated immediately to conserve the floodplain resource as a whole so that the precious aquatic biodiversity can also be conserved logically.

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Pen and Cage culture of fish and prawn

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Introduction

Both cage and pen culture are types of enclosure cultures and involving holding of organisms captive within an enclosed space maintaining free exchange of water. The two methods are distinct by different from one another. A cage is totally enclosed on all sides or all but the top side by mesh or netting, whereas, in pen culture, the bottom of the enclosure is formed by the bottom of the water body. For the last few years, the cage culture in inland waters has spread throughout the world. Cages are usually floated in rafts and either anchored to the bottom of the water body or alternatively connected to shore by a wooden walkway. Pen culture originated in the inland sea area of Japan in the early 1920s. Pen construction has not much changed from that of the original one, except that nylon or polyethylene mesh nets have replaced the traditional split bamboo fences.

Because of their smaller size and easy handling facility cages are more adaptable than pens and can be used not only for grow-out of fish to market size, but also for breeding and fry production. Pens are largely restricted to lentic water bodies whereas fixed and floating cages are also used in rivers and streams. However, in most cages both systems are used for monoculture.

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.

Advantages of pen and cage farming

Although the initial costs of cage and pen culture may be considerable, their operational costs are relatively low. The advantages of pen and cage culture are listed below :

1. Put no pressure on the land
2. Better utilization of water area
3. Fish production is intensified
4. Optimum utilization of artificial feed for growth

5. Competitors and predators are easily controlled
6. Daily observation promotes better management and early detection of disease or other problems.
7. Fish handling and mortality is reduced
8. Harvesting is easy and flexible.

In Malaysia and Singapore, the culture and harvesting of planktivorous species is said to clean up eutrophic waters.

Disadvantages of pen and cage farming

There may be some detrimental environmental effects of enclosure cultures. Intensive culture of fishes in cages with feed and fertilization leads to eutrophication of the water body. When large number of cages and pens are constructed without taking care of the carrying capacity of the water body dissolved oxygen level may be decreased which causes mortality of the animals.

According to Balarin and Haller the disadvantages of cage or pen farming are :-

1. Affected by rough weather
2. Adequate water exchange through cages is not there
3. Rapid fouling necessitates frequent cleaning
4. Absolute dependence on artificial feeding and the food is easily lost through the cage/pen walls.
5. Small fish from outside can enter and compete for food or can introduce diseases.
6. Poaching is easy
7. Labour costs are relatively high
8. Blockading the spawning areas of wild fishes.

There is a general feeling that the pen or cage construction will interfere with free navigation through the water body. In south Asian countries reservoirs are not generally used for navigation. While doing site selection for cage/pen construction, this point can be taken care in case of wetlands.These are conflicting reports about the effect of enclosure culture on water quality.

Pen and cage construction

The following aspects are to be considered before the construction of pen or cage

Site selection- Site selection is the most important item 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 be with a gentle gradient. The site for pen installation should be shallow with a minimum depth of 1-2 m. Low depth helps in keeping the pen area hygienic, productive and easily manageable. However, less than 1 m depth leads to thermal stress to the stocked animals during summer. For cage construction bottom soil has no importance as it is covered on all the four sides. 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.

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.

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.

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 area of enclosure.

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* 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. Monoculture of priced species followed in cages.

Stocking size and rate

In carp culture large fingerlings of 100-200 mm size are to be stocked for better survival. Stocking size of prawn juveniles is much smaller between 65-75 mm. Stocking rate is fixed on the basis of carrying capacity of the enclosure.

Culture frequency

While enclosure farming can be done round the year 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

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. Cage culture is always intensive.

Conclusion

Keeping all the advantages and disadvantages, a cautious approach in pen and cage farming can give very positive results. Major constraints are the poor understanding of the limnological and biological situation of each water body and the lack of technical knowhow of enclosure cultures. Blind adoption of a successful technology can be a problem than profit.

MANAGEMENT NORMS OF LARGE, MEDIUM AND SMALL RESERVOIR

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Introduction

Reservoirs or artificial lakes are formed on account of damming of rivers. These are constructed mainly to supply water to the bourgeosing industrial use, irrigation, power generation and for flood controls measures. The area of reservoirs is increasing year after year to fullfil the developmental need of the country. According to Sugunan (1995), there are 19000 small reservoirs with a total water spread area of 14,85557 ha and about 180 medium and 56 large reservoirs of 527541 and 1,140268 ha respectively. The reservoirs are arbitrarily classified as small (<1000 ha) medium (1000 to 5000 ha) and large (> 5,000 ha). Fish yield from Indian reservoirs is very low being on an average 20 kg ha-1 yr^{-1} in case of large reservoirs and 50 kg ha^{-1} yr^{-1} for small reservoirs respectively, while it is 88 kg/ha/yr in USSR and 100 kg/ha/yr in Sri Lanka. The reasons for this low yield may be attributed to unscientific management. Studies conducted by CIFRI in large medium and small reservoirs in different clinatological regions of the country (DVC reservoirs, Loni, Bachhra, Baghla, Aliyar, Rihand Nagarjunasagar or etc) from middle of 1960's have indicated that substantial increase in fish production can be achieved provided scientific management based on ecological parameter's is adapted. In the discussion which followed, the methodology developed by CIFRI for enhancement in fish production from reservoirs is described.

Characteristics of the lacustrine ecosystem

Construction of dams dramatically change riverine habitat both upstream and downstream of the river farming new artificial aquatic environment. The quality of impounded water varies from watershed to watershed and within the water shed, depending on soil, climatic conditions and human activities. It also varies with shape of the reservoir basin, exposure to light and wind action and the amount of water change. Owing to these variables although generalisation about the productivity of reservoirs can be made evaluation of specifics of water quality have to be made separately for different set of families of reservoirs sharing the similar eco-climatic conditions.

For successful fish farming in man-made lakes, it is a must to know proper understanding of the alterations the impoundments has caused in the environment and organisms. The fish food organisms characteristics of riverine system are replaced by lacustrine forms. Soon after impoundment, there occurs a phase of high fertility caused by a nutrients leaching from the submerged vegetation and other organic matters. This accelerate the growth of the bacteria, phytoplankton, zooplankton and benthos. The maximum productivity in newly filled reservoirs is attained within the first few years of their existence. However, this production is not sustained for long and within a period of few years (1-7), it declines to much lower level, partly due to diminution of bottom leaching as volume of impounded water increases and partly as nutrients are used up by aquatic vegetation when it becomes established in greater quantity. The productivity ultimately gets stabilised near half the magnitude of initial phase.

Potential Fish Yield

A first approximation of the fish yield potential of a reservoir is of utmost importance to have an idea of the expected harvest before large scale management measures are taken up. several methods are available in the literature (Ryder, 1965, Mellack, 1976, Oglessby, 1977) with specific assumption and variable. Ryder (1965) proposed the morpho-edaphic index (MEI) and establish it to be an effective tool for production of fish yield from lakes and reservoir. The index comprises two limnological variables *viz.*, total dissolved solids (TDS), and edaphic factor and mean depth (z) a morphometric factor. The relationship is expressed as:

$$MEI = TDS/Z$$

And the fish yield can be calculated from the equation:

$$Y = K x^a$$

where Y= fish yield; x = MEI and K= a constant that represents a coefficient for climatic effects and 'a' an exponent.

While Mellack (op. cit) and oglesby (op.cit) had advocated trophodynamics model based on gross primary production to fish yield in small reservoirs this model has given good corelation with the productivity to fish yield (Jhingran, 1986).

Management strategies in large reservoir

A thorough understanding of ecological conditions alongwith existing fish population in the reservoirs located in different agroclimatic region of the counry is a must for their scientific management. The management policies for stabilizing fish populations and increasing yield are generally grouped under 3 categories (I) the manipulation of habitats (ii) the regulation of fish population, and their food supply, and (iii) the regulation and control of fisheries. To achieve the above objectives, it is desirable to know changed pattern of fish populations in reservoirs such as the formation of fish population, fish population dynamics, the abundance of fish in the stocks and their biomass, and maximum yield which the reservoir could maintain.

The reservoir fisheries is basically extractive in nature and policy for its development is mainly based on capture lines i.e. stock monitoring vis-a-vis fishing effort. Sometimes stocking become essential to widen species spectrum and to correct the imbalance in utilization of different ecological niches by the commercial species. During first 2-3 years of impoundment, reservoir pass through a 'trophic burst' characterisied by abundant supply of fish food organisms. This is the best time for stock manipulation by introducing desirable species with special emphasis on fishes with shorter food chain fishes (Indian major carp).

Any lapse in these important management policy may likely result in proliferation of weeds fishes on account of trophic burst and these fishes in term may provide the forage base for catfishes. Moreover trash fishes like *Ambassis nama, A. ranga, Ostebrama cotio* and *Gadusia chapra* compete with *Catla catla* for food and reduce latter's productivity. Similarly some carps minnows compete for food with *Cirrhinus mrigala, Labeo rohita* and *L. Calbasu.*

The whole situation becomes undesirable because of considerable energy dissipation at all levels from primary resource to catfishes stocking also become necessary to correct situations coming out of erratic breeding of desirable fishes. Sometimes, even after successful breading the offsprings fail to survive due to certain unfavourable features of reservoir morphometry. Thus an imperfect understanding of the ecology of the reservoirs has set in train a new set of unfavourable biological equilibrium in which weed fishes and catfishes dominate.

Selection of suitable species for stocking

Fish farming in artificial lakes largely consists of selection of suitable species for stocking at the initial stage and at a latter stage reservoirs could be developed into capture fisheries. Therefore, it is imperative that the stocked fishes breed resulting in autostocking. Management involving persistent stocking escalate the input costs. Primarily selection of fishes for stocking is based on the assessment of existing biotic communities and their efficiency in covering perimary trophic resources to harvestable products.

Reservoir management in India largely emphasizes on the development of carp fishery, especially the Indian major carps. These fishes by virtue of their feeding habits close to primary producers and their fast growth rate are indispensible in reservoir management. But at the same time Indian major carps are ill equipped to utilize the phytoplankton, the most domminant component of plankton in reservoirs. Hence, a suitable indegenous fish like Sandhkol carp (*Thynnichthys sandhkhol)* a native of Godavari basin which subsists on algae may be given a trial in north Indian reservoirs . Though, the exotic silver carp is an excellent phytoplankton feeder but their introduction in Indian water is still a subject of countroversy due to the possible adverse effects on the indigenous fauna. *Pangasius pangasius* is suitable for the reservoir rich in molluscan fauna. Similarly *Puntius* group are known to consume insect larvae, macrovegetation and molluscs. *Mystus cavasius* and *Ompok bimaculatus* which subsists on insects and molluscs are also desirable additions. For reservoir situated at higher altitude and with cold water regime, the fishes like *L. dero, Tor* spp. *Schizothorax* spp and *Orienus* spp are suitable. Trout has been stocked in some of the impoundments in Nilgris. *Tilapia mossambica* has shown great promise in a few reservoirs in Tamil Nadue but they proved harmful to carp fishery. Great caution is to be observed before this fish is considered for stocking in the reservoir in India.

A rate of 250 fingerlings per ha has been recommended for reservoirs without catfishes and 600 fingerlings (4" in length) with rich catfish population. But for new reservoirs, the stocking rate should be at higher level (1,000 kg/ha). Irrational stocking of fingerlings was a deletarious effect on reservoir fisheries. However, a rational approach for formulating stocking policy is through estimation of potential fish yield of the reservoir and adjustment of stocking rate in such a manner as to obtain the yield close to the potential productivity.

Role of ecological niches in the context of reservoir productivity

Sometime stocking policy in large reservoirs can not be successfully implemented on account of dearth of stocking material. In an ideal situation, the commercial fishes share the ecological niches in such a way that the trophic resources are utilise to the optimum. At the same time the fishes should be of short food chain, in order to obtain maximum efficiency in transforming the primary food resources into harvestable matrials. However, in reservoirs this ideal situation seldom exists. By and large, the ecosystem has a wide spectrum of biotic communities (phytoplankton, zooplankton, benthos periphyton and submerged weed). Significantly, many of the above niches, with the exception of insects, myxophyceae and molluscs, are shared niches between Gangetic major carps and weed fishes focussing the importance of controlling carp minnows and other trash fishes. The ecosystem-oriented management approach envisages due emphasis on trophic strata in terms of shared, under share and vacant niches. Due to bad management most of the Indian reservoirs fish fauna has been tilted either in favour of catfishes (Rihand reservoir) or carpminnow and other weed fishes (Keetham reservoir).

Fishing and mesh regulation

Reservoirs that have converted into autostocking reservoirs offer lasser problem in their management. In such cases the management measures involve deployment of optimum fishing effort and selecting right type of gear. Raising the fishing effort to the optimum, coupled with monitoring of stock abundance by catch per unit of effort, is a recognized tool for improving stock productivity. Such type of management has paid rich dividens in Bhawani Sagar and Govind Sagar reservoirs.

Finally, it may be concluded that for integrated development of reservoirs continuous supply of stocking material is a must for which construction of fish farm attached to reservoir should get a priority and their functional operation should be under supervision of dedicated workers otherwise it would become defunct as the case is at present with most of the reservoir attached fish farms.

Fish culture in medium reservoir

These reservoirs can be developed on the pattern of large reservoirs.

Aquaculture techniques in small reservoirs

The aquaculture, practised in these impoundmnets, may be described as *'extensive'*, where cultured fingerlings are raised in water bodies with few or no modification of the habitat. This is in contrast to the intensive culture practised in ponds receways etc. where abiotic and biotic components are under control. The capture and culture fishery principles grade into each other in small reservoirs where the fishery depends on stocked fingerlings.

Past and present status of small reservoir fisheries

Fish culture in the small reservoirs, hitherto being practised by the state Governments consists of supplementing the natural stocks of economic fishes with stocking on arbitrary basis without any definite levels or ratios based on the biogenic capacity of the ecosystem. Stocking rates wherever prescribed do not appear to have been followed strictly. Despite the arbitrary stocking a few reservoirs, have been reported to show high fish production with repeated regular stocking. Keetham reservoir (250 ha) in U. P. for example, produced 530 kg/ha in 1959-60 although the yield declined drastically in the later years. This emphasises the need to focus attention towards fish culture in such ecosystems based on an understanding of the environmental and biological parameters, basic productivity levels and ecological relationships. Some of the important parameters responsible for higher fish production on listed in table 3.

Stocking policy

Stocking of fish in small reservoirs has proved to be a useful tool for developing their fisheries potential. Stocking of economically important, fast growing fishes from outside is aimed at colonizing all the diverse niches of the biotope for harvesting maximum sustainable crop from them.

This widespread management practice has been proved to be highly remunerative in such small water bodies where almost complete annual harvesting is possible. This has amply been demonstrated in Gularya, Bachhra and Baghla reservoirs (U.P.) and Aliyar reservoir in Tamil Nadu (Table 2). Stocking is not merely a simple matter of releasing of appropriate species into an ecosystem but needs evaluation of an array of factions *viz.,* biogenic capacity of the environment, the growth rate of the desired species and the population density as regulated by predatory and competitive pressure

During summer months, small reserovirs either dry up completely or else the water level in them gets so drastically reduced that through over fishing no brood stock is left over to contribute to the succeeding years fishery through natural recuritment. Consequently, the entire catch from these water bodies depend on the fishes stocked from outside to offset this loss. There is thus established a direct correlation between the stocking rate and catch per unit effort in such heavily fished waters. Stocking is therefore a useful tool for the management of small reservoirs where stocks can be maintained at levels higher than the natural carrying capacity of the environment through supplemental fertilization. The number of fish to be stocked per unit area was to be based on the natural productivity of the system, growth rate of fishes, natural mortality rate and escapement through the irrigation canal and spill-way.

Determination of stocking rate

Stocking in small reservoirs is mainstay of their fisheries management and is therefore of utmost imortance. The stocking rate can be calculated based on the average growth rate of the individual fish and the expected production by using the formula.

$$\text{Stocking rate (no. of fingerlings ha}^{-1}) = \frac{\text{Expected production (kg)}}{\text{Av. Individual growth rate (kg)}} + \text{loss due to mortality and escapement (\%)}$$

Case studies of some small reservoirs

To establish a baseline for evolving suitable management measures towards fishery development in small reservoirs, the Central Inland Fisheries Research Institute (CIFRI) initiated investigations on small reservoirs of M. P. *Viz.,* Loni, Kulgarhi, Govindsagarh and Naktara; Gulariya, Bachhra and Baghla in U. P., Aliyar Reservoir in Tamil Nadu and Kyrdemkulai in Meghalaya. Investigations on hydrology primary productivity, plankton, macrobenthos, macrovegetation, soil characteristics, experimental fishing and biology of commercial fishes have been conducted. Range of certain abiotic and biotic parameters in some small reservoirs of India are summerised in Table 1 and the fish production and stocking (numbers) of fingerlings in some small reservoirs in Table 2. A critical evaluation of these parameters indicates that they can support moderate to high fish production.

Planning criteria

A systematic and integrated approach towards scientific studies and planning criteria for undertaking fish culture in small reservoirs should have an understanding of the following factors.

1. The reservoir morphometry and water resident time
2. The physico-chemical characteristics of water and soil
3. The animal and plant inhabitants
4. The relation between the inhabitants and the physico-chemical aspects of the environment in terms of population and community dynamics.

In tune with the need for rapid assessment of the country's small reservoirs resources, the following planning criteria are suggested for the resource assessment.

i). Preparation of an inventory of such small ecosystems alongwith their estimated potential yields. This can be further divided into:-

a) Reservoirs which are best developed as capture fisheries
b) Reservoirs mostly of local interest having significant potential for fish culture
c) Reservoirs intermediate in size and potential yield.

General consideration

ii) Since the breeding of the major carps has been repeatedly observed to take place above the spill way, resulting in heavy escapement of the brood, this poses a serious problem for building up stocks of desirable fishers in such reserovirs. The situation is further worsened by heavy escapement of fingerlings and adults through irrigation canals. Development of fisheries in such water bodies, therefore requires suitable screening of the spillway and the canal mouth. Such protective measures have already been installed in Loni, Bachhra, Baghla and Gulariya reservoirs and have paid rich dividends in enhancing the fish yield from these reserovirs (Table 2). In some of the reservoirs fishes have also been observed to move up the spillways into the reservoir whereas in others the spillways provide an insurmountable barrier to fish moving up the dam. To minimize losses by way of escapement of fish through spillway and canal, it would be an economic proposition to have an annual cropping policy so that the reserovir is stocked in August-September and harvested by June end next year.

iii) Vegetation should not be planted in the reservoir, since the wrong kinds can choke up the reservoir and the canal.

iv) Methods for predator control and check of weed fishes are already available in literature.

v) Aquaculture in small reserovirs can also play an impaortant role in integrated rural development since it can be profitably combined with duckery and piggery.

Summing up, it may be stated that small reservoirs occupy a unique position in limnology analogous to field plots used in agriculture science *ie.* a means of assessing effects of environmental modifications on the ecosystem on a reduced scale.

Table 1. Range of certain physico-chemical and biotic parameters of small reservoirs.

Parameters	Reservoirs					
	Gulariya	Bachhra	Baghla	Aliyar	Chapparwara	Kyrdemkulai
Transparency (cm)	11-80.0	17-145	9-204	108-182	-	2.20-2.84
D. O. mgl^{-1}	4.9-9.0	2.5-8.60	2.40-12.80	4.2-11.6	6.10-10.0	6.70-7.10
pH	7.2-8.4	6.96-8.30	7.32-8.84	6.6-6.8	8.0-8.40	6.8-7.0
Free CO2 mgl^{-1}	Nil-4.0	Nil-7.20	Nil-3.0	Nil-10.0	Nil	2.0-2.60
Alkalinity mgl^{-1}	38-80	95-190	42-106	16-72	76-100	22-32
Hardness mgl^{-1}	13-34	21-80	-	-	-	18.56-27.84
Nitrate mgl^{-1}	0.08-0.20	0.085-0.180	0.28-0.33	-	0.40-1.10	0.02-3.61
Phosphate mgl^{-1}	0.05-0.13	0.06-0.250	0.28-0.36	Trace-0.4	0.11-0.16	Trace-0.02
Silicate mgl^{-1}	5.0-14.0	6.80-14	2.4-4.9	Trace-0.2	1.92-8.0	1.0-10.0
Plankton u/l	245-4060	70-8432	58-40000	-	3100-20100	8420*
Macrobenthos u/m^2	95-4169	342-4620	976-2132	-	110-947	134*
Macrovegetation u/m^2	Absent	Absent	250-2200	Absent	470-1350	Absent

(* indicates average value) After khan, 1997

Table 2. High yields obtained in small reservoirs due to management based on stocking from (*modified after Sugunan, 1995*)

Reservoirs	State	Area ha.	Stocking rate mo ha^{-1}	Yield Kg ha^{-1}
Aliyar	Tamil Nadu	650	353	194
Meenkara	Kerala	259	1226	107
Chulliyar	Kerala	159	937	316
Gularya	Uttar Pradesh	300	517	150
Bachhra	Uttar Pradesh	140	763	140
Baghla	Uttar Pradesh	250	-	102
Bundhk Beratha	Rajasthan	-	164	94
Chapparwara	Rajasthan	200	300	79

Table 3. Range of physicochemical features in reservoir ecosystems

Parameters	**Range of values**		
	Low productive reservoirs	**Medium productive reservoirs**	**Highly productive reservoirs**
A. Water			
pH	< 6.0	6.0-8.5	> 8.5
Carbonates (ppm)	<35.0	35-80	> 80.0
Alkalinity (ppm)	<40.0	40-90	>90.0
Nitrate available (ppm)	Negligible	Upto 0.2	0.2-0.5
Phosphates (ppm)	Negligible	Upto 0.1	0.1-0.2
Total dissolved solids (Sp. Cond. micromhos cm^{-1})		Upto 200	>200
Temperature (^{0}C) (With minimal stratification: i.e.,>5.0)	18	18-22	22
B. Soil			
pH	<6.5	6.5-7.5	>7.5
Available P (mg 100 g^{-1})	<3.0	3.0-6.0	>6.0
Available N (mg 100 g^{-1})	<25.0	25-60	>60.0
Organic carbon	0.5	0.5-1.5	1.5-2.5

(after Jhingran, 1991)

Table 2. Estimated mean annual landing (metric tonnes) at different centres in Ganga

Centres	1959-66	1973-81	1981-89	1989-97
Allahabad	207.17	129.63	128.46	67.55
Buxar	65.85	13.59	25.65	N.A.
Patna	81.93	85.5	70.84	N.A.
Bhagalpur	108.86	N.A.	62.45	37.79

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 transform-ation $calm^{-2}day^{-1}$	Photosynethetic efficiency %	Fish production potential kg ha-1yr-1	Actual harvest $kgha^{-1}yr^{-1}$	Extent of utilisation %
Kanpur	1987-88	234.5	1419	0.077	50.10	-	-
Allahabad	1974	-	4501	0.241	160.44	21.33	13.29
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

Table 4. 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	7.2
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	4.38

ROLE OF VARIOUS EXTENSION SYSTEMS FOR ENHANCEMENT OF FISH PRODUCTION FOR OPEN WATER SYSTEM

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In Indian context, there are 3 major organisational streams devoted to extension work as below for fisheries.

1. The 1st line extension system, comprising mainly the Indian Council of Agricultural Research(ICAR) Institutes and Agricultural Universities.

2. Extension system of the Union Fisheries Division, Ministry of Agriculture & State Fisheries Departments.

3. Extension & Development work by the Non-Government Organisations (NGOs), Input establishments etc.

The ICAR Institutes and the Agricultural Universities play a major role through organising demonstrations, training, advisory services, fish farmers' days, distribution of pamphlets, participation in Exhibitions, using Mass Media of communication etc. on a limited scale, but forceful enough to have a catalytic influence on other extension systems and sub-systems.

The main Agency for coordination of extension work is the Fisheries Division of the Union of Agriculture at the national level and development of fisheries by the Deptt. of Fisheries at the State level. The most important and effective functionery is the state level extension.

Extension & Development work by the Voluntary Organisations constitute a major part of the extension work by the NGOs. They mainly implement the projects funded by the ICAR, State Departments. They work as per guidelines of each project. Some NGOs are well known for their dedication to serve the people and as efficient extension agencies.

The Input houses like M/s. Nil Ratan Ghosh, M/s. Chatterjee Brothers etc. of West Bengal extend their services for propagation of aquaculture in more convincing manner at grass-root level.

Table 1 : Fisheries and Aquaculture Extension Programmes in India

Sl. No	Organisation	Programme	Operational design
1.	Fisheries Division, Ministry of Agriculture & Cooperation, GOI and State/UTs Deptts. of Fisheries	FFDA (Freshwater Aquaculture) & BFDA (Brackishwater Aqulcture)	Mobilising water area on lease Technical advice Assistance inmobilising institutional credit. Subsidy assistance Seed supply on cost basis Method and result demonstration Training Field days Distribution of printed materials.
2.	Indian Council of Agricultural Research (ICAR)	KVK/TTC/ORP/NDP/AIC RP/LLP and other TOT programmes conducted by Institutes/SAUs.	Method and result demonstrations Farming system research trials Limited input assistance under certain programmes Training to fish farmers Training to fisheries operatives Training to extension and field workers Technical advice Solutions to field problems.
3.	MPEDA. Ministry of Commerce. GOI	Export promotion Brackishwater shrimp & Freshwater prawn culture	Technical advice Subsidy assistance Training to entrepreneur and farmer Assistance in marketing and experts Assistance in export duty reduction Assistance in project preparation & mobilizing institutional finance Distribution of printed materials.
4.	DBT. GOI	R & D efforts to improve the technology package and pilot scale demonstration.	Demonstrations at pilot scale Training to entrepreneurs. farmers and fisheries officers Support in preparation of printed materials and distribution.
5.	NGOs	Integrated rural development	Organising rural poor Mobilizing public waterbodies on lease Input assistance Training Credit Group savings.

Fisheries Extension Services in West Bengal

Extension Programme (Specific)

FFDA
BFDA
Fish Production Group
Socio-economic development programme
Social Fishery
River ranching

Extension Methods

Individual Contact
Group Contact = Technical Advice
Mass Contact = Seed supply
Fish Farmers' Days = Arranging credit
Farmers Training Programme = Providing subsidy
Distribution of pamphlets = Leasing of water areas
Demonstraions
Use of mass media.

Adoption of Aquaculture Practices

The rate of production in aquaculture, by and large, is proportional to adoption of level of recommended practices as observed by Das (1984). If the package of practices are accepted as per recommendation, the production of fish is bound to be high. But for various reasons the levels of adoption of the practices are variable as in the Tables below (Bhaumik & Saha, 1998).

Table 2 : Distribution of fish farmers according to level of adoption

Level of adoption	Frequency	percentage
High	32	8
Medium	88	22
Low	280	70

Table 3 : Adoption of package of practices

N= 400

Package of practices	Frequency (Adoption)							
	High		Medium		Low		Total	% not adopted
	No	gap in % use of practice	No	gap in % use of practice	No	gap in % use of practice		
Control of aquatic weeds	32	0	88	-	258	-	378	6
Application of Mahua oil cake for predator control	32	0	88	50	280	75	400	0
Liming	32	0	88	60	280	80	400	0
Organic manuring	32	0	88	80	280	90	400	0
Inorganic fertilization	32	0	88	80	69	93	189	53
Stocking (density ratio, size)	32	0	88	Double	-	-	120	70
Supplementary feeding	32	-	-	-	-	-	32	92
Sampling	32	-	-	-	-	-	32	92
Stocking manipulation	32	-	-	-	-	-	32	92

(Modified after Bhaumik & Saha, 1998)

Bridging the Gap

The CIFRI studies (Bhaumik & Saha, 1998) in four districts viz. 24-Parganas(N). 24-Parganas(S), Howrah and Hooghly under the FFDA and LLP covered areas provide an indication about the status of adoption of composite fish culture package of practices and some other relevant aspects.

The column 'gap% in level of adoption' has been computed by the author from the generalised data available for West Bengal as a whole. It is clear that the gaps have to be narrowed down for the desired higher production.

In meeting the gap the Extension Officer has to work hand with the farmer on Down to Top Model with the participatory Approach by the farmer and if necessary, some modification/refinement of the technology may also be brought at the local interest.

Appropriate Technology Introduction

This is important since attempt in popularising in appropriate technology would yield negative result frustating the extension effort.

By the current decade of the 20th century it is seen that huge number of resource poor farmers who operate under complex, diverse and risk-prone situations have not adopted many of the recommended technologies. It was realised that effective diffusion of technologies can take place if these are approved, adaptable and useable to the socio-economic and cultural setting of the farmers. The technology assessment and refinement project of the ICAR has been presently meeting the challenge.

Hence approprite available packages of practices need be popularised in relevant field.

Technological Assessment and Refinement

Generally recommended technology may be necessary to assess in particular situations and if necessary, refinement may be done in some aspects through adaptive trials. This obviously need not be in research farms but in farmers field and invariably with their participation.

The generalised technology of Composite Fish Culture may generally need little modifications in different agro-climatic and soil zones. This may be done by the extension man in participation with the farmer.

Participatory Approach

The agriculture extension approach in different decades have undergone quite interesting changes. The belief and modes in agriculture as tabulated by Chatterjee (1988). This work may be made to mderately in our situation of fisheries as well. During 1950s the extension prescription in agriculture used to be extensional education which was removed of constraints during 1970s. During 1990s it is farmers participation in technology assessment and refinement.

With a view to narrowing down the gap in use of a practice overall technological gap and also the gap of the farmers knowledge, the most modern and appropriate system is farmers participatory approach.

Though fisheries and aquaculture technologies are high yielding, each technology recommended by FEO may not be appropriate in all situations.

It is, therefore, necessary to work with the farmers understand his problems, know his interest. The FEO may work with them in their fields and make the farmers understand the value and role of different inputs in the production, so that the farmer himself takes a positive attitude on the ncessity of supplying full recommended quantity of critical inputs and thus narrowing the gap and enhancing production.

Hence, participatory approach only on gaps on priority basis should be taken as the prescription for further TOT programme in fisheries and aquaculture.

Change from Directive to Education System

In Indonesia (FAO, 1997) the experience in Farmers Field Schools indicate that educating farmers informally on aquaculture is a far better method than one effecting transfer of technology.

In Tanzania (Roling, 1997) their experience of Entertainment Education through Mass Media indicate probably due to the multiple effect of Radio including the entertainment component. Indian experience also lends in the above efforts.

New Concept of Fishery Estate

Identification of low lying areas, swamps, inundated fallow areas along the irrigation canals, development of such areas into grow-out ponds; provision of infrastructural facilities such as hatcheries, nursery and rearing ponds; ice plant and training centre leasing out of one pond to one individual fishermen/pondless farm family are the functional component of the concept.

Initially the aquaculture estate development is carried out by the State as it involves investment, but gradually the management of the entire estate is transferred to the organisation of the lease holders who also undertake the responsibility for the recovery of loans. Such a complex is being established at Sultanpur in U.P. where the local FFDA would be monitoring the progress of work of the farmers who were selected by Gram Panchayat.

Holistic participatory approach

This would yield still better results. Since the farmers, in this sytem, participate at all 4 levels/steps/systems i.e. Research System, Extension System, Client System and Support System. It is holistic because it takes care of full range of human and community potential.

Responsible fishing approach in Extension

The rational use and conservation of the fish genetic resources in the open waters shold be the aim of Extension for open waters. Precautionery use of living aquatic resources which are sustainable, in harmony with the environment leads to responsible fisheries where the capture and culture technologies do not impair or destroy so that ecological quality and environmental integrity are maintained.

Conclusion: A combination of different extension systems may be applied for a success in fisheries development in open waters of the country.

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

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Environment, in particular 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 lead 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 environmental 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 involved 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.

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

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INTRODUCTION

In open water system a successful management strategy has to take into consideration the important physico chemical factors, fish stocks and the population dynamics together with fishing regulations. The open water bodies are wetlands, reservoirs, rivers, and estuaries, canals, lagoons and lakes. India has 14 major rivers each having catchment area of 20,000 sq. Km and above, 44 medium rivers having an catchment area between 2000 and 20,000 km^2 and 55 small rivers with catchment area of 2000 km^2. India has more than 19000 small reservoirs with a total water area of 1485557 ha and 180 medium and 56 large reservoirs of 5275541 and 1140268 ha respectively. The flood plains wetlands (beels) in U.P., Bihar, West Bengal, Assam, Tripura, Manipur, Arunachal Pradesh and Meghalaya having an area of more than 200,000 ha offer ample scope for culture based fisheries. The estuarine capture fisheries (2.6 m ha) form an important component of fishery resources of the country.

Role of physico chemical factor in fish production: From the study of physico chemical qualities of a water body, it is possible to predict the fish production potential of the system.

Fish ponds : Study of important physico chemical factror of a pond idnicates proper management practices for achieving high fish production in the water body. Problems of water body such as water and soil acidity, poor nutrient status DO depletion, low alkalinity, metal toxicity etc. may be properly identified fromthe physico chemical studies and the pond productivity may be improved manyfold by proper application of lime, fertilizers and organic manures. In fact the fish `production from a small water body has been improved many times in recent years by adoption of scientific management.

For larger water bodies such as beels and small reservoirs study of abiotic parameters indicates its productivity potential i.e. the physico chemical studies indicate wheather it is low productive, or medium productive or high productive. If the physico chemical parameter showed that the water body is of high productive nature but actual production was poor, than one should look for other management norms (such as proper stocking of fish, removal of aquatic vegetation, removal of weed fishes and predatory fishes etc.) which may bring higher fish production. In fact, most of the beels of West Bengal, Assam and Bihar are nutrient rich as reflected by their soil quality and bottom sediments. In terms of potential, they are capable of producing 1-1.5 ton fish/ha/yr. The ecologically degraded condition (weed infestation, siltation etc.) And poor management practices have resulted in poor fish yield (120-320 kg/ha/yr) from most of the beels, leaving a significantly wide gap between actual yield and their potential yield. If the beel or the reservoir is small in size, their productivity may be enhanced easily by adoption of suitable management practices (liming, fertilization, stocking etc.) based on the study of some abiotic parameters.

Large reservoirs, rivers and estuaries: Studies on physico chemical regime and primary production of large water bodies are very useful for determination of their nutrient status and productive potential. In large reservoirs and rivers, modification of water and soil qualities by manuring and fertilization is not possible, but productivity may be enhanced in large reservoirs by adequate stocking of suitable fast growing fishes and taking other management norms. From the study of physico chemical parameters, it is possible to assess the environmental stress from pesticide, heavy metals, industrial and municipal effluents on the open water systems. Agricultural run off and municipal effluent contains pesticides such as DDT, endosulphan,methyl parathion, HCH, ethyl parathion, carbaryl etc.

The aquatic organisms and fish are very sensitive to these pesticides and toxic heavy metals.

Physico chemical factors influencing aquatic productivity:

Temperature: Fish production in a water body depends greatly on the temperature of the growing season which may vary from year to year. This year to year variation of water temeperature may be responsible for considerable variation in fish yields. Since metabolic activity is nearly doubled for every 10°C rise in temperature, fish growth is highly dependent on water temperature. With the increase in temperature microbial activity is also increased and hence the nutrient release from the decomposition of organic matter at the bottom sediment is more with consequent increase in nutrient status of water. Fish production is generally maximum when the water temperature ranged from 23°C to 30°C.

Transparency: Transparency is a measure of light penetration in the water body. In open water system, transparency is generally high during summer and winter, favouring high carbon synthesis, while during monsoon the transparency is low and photosynthesis is poor. Neither very highly transparent nor very highly turbid water is conducive for the growth of fish, for both the conditions are index of poor availabilityof fish food organisms.

Dissolved Oxygen: For respiration of fish and other aquatic and soil organisms adequate dissolved oxygen must be present in the water body. Oxygen deficit at the bottom is a characteristic feature of productive reservoir. Photosynthesis at the surface and tropholytic activity at the bottom cause klinograde oxygen distribution which was recorded in many reservoirs in India. In unproductive reservoirs, the oxygen curves parallel the temperature curve since it is temperature dependent. In Konar, Tilaya, Rihand and Tungabhadra reservoirs, such orthograde oxygen distribution was found along with low productivity.

In Ganga and Narmada rivers, the dissolved oxygen contents (5-8 ppm) were, in general, conducive for fish growth. Low D.O. contents in these rivers were noted in regions where industrial effluents having high BOD load were discharged. The D.O. contents in Hooghly and Narmada estuaries are, in general, conducive for high fish production. For optimum fish production, a minimum of 5 ppm D.O. is required in the open water system.

The availability of oxygen is critical specially to the benthos because they often live in zones which are oxygen deficient.

pH : Slightly alkaline water reaction (pH 7.4-8.2) is conducive for fish growth in fish ponds and open water systems. The Ganga and Narmada rivers and Hooghly estuaries have slightly alkaline water reaction, which imparts higher productivity to them. However, water bodies at high altitude may have acidic water and soil reaction. Beels and ponds of Assam and North Bengal generally have acidic soil and water reactions which leads to low productivity to those water bodies. Fish production is very poor in systems having strongly acidic water reaction (pH 4-5).

Alkalinity : Total alkalinity which is a measure of bicarbonate and carbonate concentrations is a very useful factor for predicting the productivity of a open water system. The open water system having alkalinity between 80-200 ppm is generally high productive. Poor production is noted in water bodies having poor total alkalinity (20 ppm or lower). The Ganga, Narmada and Hooghly estuary have total alkalinity in the conducive range. But water bodies in Assam, North Bengal and other North Eastern States generally have low to medium total alkalinity which may result in lower productivity. In reservoirs with Klinograde oxygen distribution, the CO_2 and carbonate show an inverse relation to oxygen i.e. CO_2 and bicarbonate increases with depth. But in low productive reservoirs, CO_2 content may or may not increase with depth.

Depth : Mean depth, defined as the volume of the reservoir divided by area is considered as the most important morphometric parameter. It is indicative of the extent of euphotic littoral zone i.e. the depth zone which permits the light penetration for growth of plankton and also provides shallower shore area for attachment of algae and macrophyte. Infish ponds and beels maximum productivity was recorded when their depth ranged between 2 and 3 metres. Diurnal fluctuations of temperature, oxygen and pH may be considerably high in very shallow water bodies and they may be infested with submerged macrophytes which may reduce their productivity. Even the Narmada river was infested with submerged macrophyte during winter and summer, when its depth was reduced between 1 and 2 meters.

Salinity : The salinity of freshwater rivers, lakes, beels and reservoirs is generally low. Sudden increase in salinity in a zone of a river or reservoir indicates pollution due to indusrial and municipal effluents. In Ganga river salinity was higher at Benaras, Mirzapur, Ghazipur and Buxer indicating aquatic pollution in those areas (Shukla *et al.* 1989). However, salinity of Hooghly and other estuaries are high at the gradient zone and very high salinity is present at the marine zone. But estuarine salinity is not due to pollution, it is due to influx of sea water during high tide.

Free CO_2 : In open water sysems such as rivers, lakes and reservoirs free CO_2 ranged between trace to 10 ppm. CO_2 content is maximum in the morning and minimum or absent during noon or afternoon due to photosynthesis by phytoplankton and submerged macrophyte present in the water body. However, high CO_2 content in water (20 ppm and above) indicates aquatic pollution presumably due to industrial or municipal effluents. In fish ponds 5-10 ppm free CO_2 is conducive for high fish production. In lakes and reservoirs, absence of free CO_2 for prolong periods generally indicate their unproductive nature.

Dissolved Nitrogen: As a constituent of protein, nitrogen is a very important nutrient for aquatic productivity. Nitrogen is present in water in organic and inorganic forms, but the phytoplankton utilise the inorganic nitrogen compounds as nitrate or ammonium salts. However, green algae can use nitrogen in all the forms.

Freshwater rivers and lakes generally have low nitrogen levels. The nutrient enters into river system from the adjoining catchment areas (agricultural lands, forests etc.) during monsoon flood. Municipal effluents and industrial effluents are also rich in nitrogen. Beels also are very rich in nitrogen but here most of the nitrogen is locked in organic matter in bottom sediment and the water body may not receive this nitrogen for utilisation by phytoplankton. Fish culture ponds are generally nitrogen rich and most productive.

Phosphorus: Phosphorus is the most important element responsible for aquatic productivity. Freshwater rivers such as Ganga and Narmada have low phosphorus contents and natural lakes and reservoirs also are mostly phosphorus deficient. In beels, most of the nutrient is fixed in unavailable forms. Phosphorus occurs in two forms - inorganic and organic but the soluble inorganic form is more important due to its active nature. Concentration of orthophosphate increases almost immediately after the water bodies are fertilized but declines rapidly to near pretreatment level since it is quickly absorbed by bacteria, phytoplankton and macrophtes. Studies using radio active phosphorus showed that phytoplankton can absorb orthophosphate very quickly with a large percentage of the total uptake occurring within a few minutes. Phosphorus that is not absorbed by phytoplankton and macrophyte is rapidly absorbed by muds. In general, muds that are strongly acidic or strongly alkaline absorbs phosphorus more rapidly than neutral muds. In estuarine wetlands (Bheris) the phosphorus content in water is poor, since the added phsophate reacts with calcium and magnesium and precipitated from the water. The beels of Assam and North Bengal is poorly productive due to phosphate deficiency since in their acid soil the phosphate reacts with iron and aluminium forming iron and aluminium phosphates. Phsophorus content in water above 0.2 ppm is considered optimum for high fish production (Nath et al., 1994).

Primary production:

Primary production of a water body depends on intensity of solar radiation, transparency and turbulance of water, concentration of phytoplankton or aquatic macrophyte and nutrient status of water. If the primary production is high secondary production (zooplankton etc.) and tertiary production (fish) is also high. Primary production in fertilized fish ponds is very high (Nath and Tripathi, 1997) ranging between 2.4-9.14 g C/M3/day. Primary production in beels of West Bengal and Assam was slightly low due to nutrient limitation. In Hooghly Matla estuarine system, maximum primary production was found at Frajerganj, while minimum production was noted at Nawabganj, presumably due to industrial pollution (Bachi and Nath, 1998).

Primary productivity study may be employed as an useful tool for classifying the water body. The primary productivity was trace (Nil-6 mgC/M3/hr) in a pond having acidic soil reaction (pH 3.5) which was found to be unsuitable for fish culture (Nath, 1986). Primary productivity studies is useful for management of open water systems. A sudden decrease of primary production in a system indicate industrial pollution or other stress in that water body. On the other hand very high primary production also shows excess nutrient load, particularly phosphate and nitrogen, leading to algal bloom in the system. Excessive algal bloom is not conducive for natural ecosystem.

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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 o the genus *Vibrio* including bacterial shell disease and black gill.

Systemic infections appear to be the most common form of vibriosis eithe 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 (ChI_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.

COMMUNICATION PROCESS AND METHODS USED IN TRANSFER OF TECHNOLOGIES

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INTRODUCTION

One of the major tasks of an extension worker is to communicate technical information to its users. Technical knowledge is of no use unless it is accepted and adopted by concerned families. Extension worker not only transfers technology merely to increase production, but he also ensures that the receivers grow as human beings. Ability to communicate properly determines to a large extent the success or failure of an of an extension worker.

DEFINITION:

Basically, the word communication means 'sharing' or 'common'. Wilbur Schramm (1956) treats 'communication as the exchange of knowledge, Skills and attitude among persons or among social groupings'. Steinberg (1958) defines communication as the 'process of relaying or transmitting a sign or symbol - verbal, Written or pictorial - from a specific source to a specific audience or receiver by means of any one or all of several media that act as channels'. According to Laswell (1960) convenient way to describe an act of communication is to answer the following questions:

who,
says what,
in which channel,
to whom,
with what effect?

Leagans (1961) describes 'Communication is 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'. According to Singh (1987) ' the communication is the process of transmitting meanings between individuals'.

In the simplest sense, communication means that a sender, and a receiver tuned together for a message.

Importance of Communication

1. Good communication is the essence of good teaching. If one can not teach, one can not communicate.
2. Communication is essential to all human association.
3. The success in extension work comes only when people understand, accept and act on new knowledge - not when they have been only explored to it.

4. Good subject matter and effective communications are the key to successful extension teaching in villages.
5. Good communication does not consists of merely of giving orders or even of imparting knowledge, but of creating understanding and helping people make use of that knowledge.
6. Leadership in extension requires skillful communication. This can be achieved by saying the right thing at the right time in the right way, to the right people is the formula for good communication.

Elements of communication

There are six elements of the communication process:

1. The communicator
2. The Message
3. The Channels
4. The treatment of message
5. The audience and
6. The audience response.

Success of the crucial task of communication requires through understanding of these pricniples and elements of communication.

1. The communicator

The communicator is the key element of the whole communication process. The effectiveness of communication depends upon the knowledge and abilities of the communicator. Communicator acts as a source or originator of the message(s). This is the person who starts the process of communication. A good communicator must possess the following qualities:

1. He must have knowledge about

a) His objectives - which should be clearly and specifically defined.
b) His audience - needs, ability, interests and predisposition.
c) His message - contents, validity, usefulness, importance.
d) Channels - that will reach the audience.
e) How to organise and treat his message.
f) His professional abilities and limitations.

2. He should be interested in

a) Audience and their welfare
b) His message and how it can help the community.
c) Results of communication and its evaluation.
d) Communication process
e) Communication channels - their proper use and limitations
f) How to improve his communication skills.

3. He should Prepare

a) A teaching plan for communication.
b) Communication material and equipments .
c) A plan for evaluation of results.

4. He must have skills in

a) Selection of message pertaining to their needs.
b) Treating message - pertaining to the channel.
c) Expressing message - verbal and written.
d) Selection and use of channels.
e) Understanding his audience.
f) Collecting evidnece of results.

2. The message or content

Without the subject matter there is no communication, therefore subject matter is the important thing to be communicated. It is the information which extension worker wishes to communicate to the local people for wide acceptance and adoption. The message communicated by the extension worker may be scientific knowledge about fish farming, agriculture, home making, cattle raising etc. The good message should have the following points.

Characteristics of Good Message

1. It should be in the line with the objectives of the people.
2. It should be clear and understandable by the audience.
3. It should be within the reach of the people i.e. economic, social, mental and physical etc.
4. It should be pertaining to the needs, interest and values of the audience.
5. It should be specific, simple and accurate.
6. It should be timely and adequate.
7. It should be supported by the facts.
8. It shold be appropriate to the channels.
9. It should be applicable and manageable within the resources of the learner.

3. The channels of communication

A channel is the medium or vehicle which carries the message. The sender and the receiver of message must be connected or 'tuned' with each other for this purpose channels of communication are necessary. Communication channels are the physical bridge between the senders and the receivers of the message. This link is absolutely necessary in the communication process without which there is no communicaton of ideas. All the extension teaching methods are channels of communication. It may be radio, books, letters, newspapers, personal contacts, press, publications, exhibitions, visual aids, films etc. are employed for effective information communication channels can be localite or cosmopolite, but their selection and use depend upon the need and type of audience.

While selecting the channels the extension worker should consider the following points in his mind:

1. The specific objective of the message.
2. The nature of message - scope, timing, level of difficulty.
3. The size of audience and their needs and interests.
4. Knowledge of the subject to the audience and to the channel.
5. Channels of communication available in the community.
6. Relative cost and effectiveness of channels.
7. The availability of time with the communicator and the audience.
8. Time available - communicator and audience.
9. Extent of hearing, seeing and doing.
10. Extent of cumulative effects.

All the media of information communication such as radio, publications, visual aids, films etc. are employed for effective information communication. Special emphasis is laid on the production and utilization of audio-visual aids in support of various development programmes.

4. Treatment of message

The treatment of message is related with the ways of handling the message to get proper performance from the audience. Its purpose is to make the message clear, understandable and realistic to the audience. This requires knowledge of the subject matter in sight in to the pricniples of human behaviour and skill in creating and using improved techniques of presentation of a message. Treatment deals with the design of methods for presenting messages. Designing relates the technique employed for presentation intend the situation provided by a message and a channel.

Ways of treating the message

a) General organisation - Matters of
i) Preparation of ideas and concepts.
ii) Presenting, contrasting of ideas.
iii) Presenting ideas in chronological order.
iv) Use of inductive or deductive approaches.
v) Use of emotional or logical appeals.
vi) Starting with strong arguments compared to saving them unit the end of presentation.

b) Matters of speaking and achieving (Acting)

i) Limit the scope of presentation to a few basic ideas and to the time allotted. Too many ideas at one time are confusing.
ii) The extension worker should know the facts.
iii) Strive to be clear yourself but not clever.
iv) He should follow the notes instead of reading a speech.

v) He must establish rapport with the audience and respond to them (know the audience)
vi) He should take to the people.
vii) Decide on the dramatic effect desired.
viii) Use attractive communications.
ix) Recommend audience is a psychological bridge.
x) Limit times.

c) Devices for presenting ideas

i) Word symbols - speech.
ii) Real objects
iii) Models and specimens
iv) Charts, diagrams, posters, photographs and graphs.
v) Motion pictures.
vi) Slides and film strips.
vii) Puppets and drama etc.

Following are some of the suggestions for the treatment of the message

a) Use alternative communicator and communication devices of audio, visual or audio-visual aids.
b) Limit the presentation to the time allotted.
c) Experienced thinking and planning should be utilized in treating the message.
d) Only reliable, realistic, relevant and understandable message should be communicated.

5. The Audience:

The receiver of tghe message is known as audience. An audience may consist of one or more persons, may be men, women, youth, villagers, their leaders formed in various occupational groups, like farmers, educators, specialists, extension workers etc. The more homogenous an audience is the greater, the chance of successful communication. Likewise the more a communicator knows his audience and can pinpoint its characteristics, the more likjely he is to make an impact.

Types of Audience:

i) The potential audience
ii) The available audience
iii) The action audience - physical and psychological.
iv) The intended audience - This may be of two types.

A. Listener or Attender
1. Listener who act on the message.
2. Listener who do not act.

B. Non Listener or non-attenders.

It is important that the communicator should know the audience and their objectives, without this knowledge the communicator can not move forward with assurance and success. Following are the ways to know the audience. We, as an Extension worker should try to know.

Nature of an audience and move to reach it

i) The communication channels established by the community.
ii) The value system of the audience.
iii) Forces influencing group conformity - customs, traditions.
iv) Individual personality factors - education, economic and social levels.
v) Pressure of occupational responsibility (susceptibility to change).
vi) Needs of the audience.
vii) Study of the situation i.e. resources available with them.

6. Audience Response :

It is the important factor in the whole process of communication. It is the mental and/or physical reaction on the part of the audience with the message. The audience response to a message can be judged by the following ways.

i) Understanding V/S knowledge

Understanding of a fact is attained only when one is able to attach meaning to the facts. People only act when understanding of fact is gained. Therefore, communication must promote understanding in the people.

ii) Acceptance V/S Rejection.

Before taking any action it requires mental acceptance of the thing.

iii) Remembering V/S Forgetting

If the action is delayed forgetting starts, therefore, tranmitting the message to the right people at the right time is an important factors in successful communication.

iv) Mental V/S Physical Action

Dr. Leagans says that changes in the mind of man must precede changes in the actions, therefore, for mental change physical action is necessary. This is some times referred to as "lip service".

v) Right V/S Wrong

For many reasons people often fail to behave precisely according to instructions, even when they understand and accept them. In this case action will be wrong.

Models of Communication Process

Some sociologists, educationists, psychologists, anthropologists and rural sociologists have described the process through various models. Their usefulness lies in manner in which they are used (Dahama and Bhatnagar, 1980).

1. Aristole's model

SPEAKER — SPEECH — AUDIENCE

Aristole says that all these three ingredients or elements are essential for communication. Such communication takes place in a face-to-face situation, or in direct communication. The speech is either a message, an idea, a thought or a feeling.

2. Shanon - Weaver Model

SOURCE — TRANSMITTER — SIGNAL — RECEIVER — DESTINATION

If translate the source into speaker, the signal into speech and destination into listener we have the Aristole's Model Plus two mere ingredients; or transmitter which sends out the message and the receiver which catches the message to take it to its destination.

3. Westley and Machean Model

SENDER — ENCODER — CHANNEL — DECODER — RECEIVER

This also have five elements/ingredients on the lines of the Shanon and Weaver's Model. Here the sender encodes the message which is passed through a channel and is then decoded and its meaning is drawn after the message is clear to the receiver.

4. Leagan's Model

COMMUNICATOR — MESSAGE — CHANNEL — TREATMENT

AUDIENCE — RESPONSE OF AUDIENCE

It has six elements. It is more or less designed on the pattern of the Westlay and Machean's Model. Though the terminology is different, most of the elements are common. Audience response is the sixth element, about which Leagans says that it is vital to the process especially when it is meant to bring about change in people.

5. Berlo Model

SOURCE — **ENCODER** — **MESSAGE** — **CHANNEL** — **DECODER** — **RECEIVER**

It has also six ingredients. The difference from the Westley and Machean Model is that Berlo adds Message, to his model.

METHODS USED IN TRANSFER OF TECHNOLOGIES

Extension Teaching Methods

In the communication process extension teaching methods or channels of communication are the tools in the hands of extension workers in transferring new ideas. An extension worker has to deal with many rural people. One of the methods to deal with them is personal visits by the extension workers to the farms or homes of the farmers. A personal visit represents a best learning situation but it may not be always possible to visit the farmers. The extension worker has therefore to use other teaching methods for reaching the maximum number of people effectively.

Definitions of Extension Teaching Methods

1. According to Leagans (1961) Teaching methods are the devices used to create situations in which communication can take place between instructor and the learners.

2. The extension techniques are the tools in approaching, working with and inifluencing the village people.

3. In simple terms, it can be said that there are the methods used by the extension agents to communicate their ideas to the clients.

Importance of Extension Teaching Methods

The extension worker has to choose the suitable extension methods according to the programme, situation, availability, resources and time. As a mechanic needs tools like machines, wrenches and hammers to perform his job, similarly the extension methods or techniques are the tools required by the extension workers to perform their job. An efficient mechanic not only has the tools required for a given piece of work, but also knows how to select and use them. His effectiveness as a mechanic lies in his ability to do many complicated jobs. This in turn depends on his having access to the required tools and on his knowledge how to use them properly. Availability of appropriate methods and the required skill in their selection and use are crucial to successful extension education. It is generally taken for granted that every extension worker has the knowledge and ability to employ extension methods effectively and skillfully.

Classification of Extension Methods Used in Transfer of Technologies

Several extension methods are available, whcih can be used by extension workers to educate the people. No two situations are exactly the same and no two persons possess the same physical strength, intellectual ability and experiences. Therefore, no single method or group of methods can be used under all the situation. From this point of view the extension methods are classified and presented in the following manner.

1. Classification according to use

One way of classifying the extension methods according to their use and nature of contact. Based upon the nature of contact, they are dividied into individual, group and mass contact methods.

Individual contact methods

Extension methods under this category provide opportunities for face to face or person to person contact between the rural people and the extension workers. These methods are very effective in teaching new skills and creating good will between farmers and the extension workers.

Group Contact Methods

Under this category the rural people of farmers are contacted in a group which usually consists of 20 to 25 persons. These groups are usually formed around a common iterest. These methods also ivolve a face to face contact with the people and prvide opportunity for the exchange of ideas, for discussion on problems and technical recommendations and finally for deciding the future course of action.

Mass Contact Methods

An extension worker has to approaqch a large number of people for disseminating a new information and helping them to use it. This can be done through mass contact methods conveniently. These methods are more usefull for making people aware of the new agricultural as well as fish farming technology quickly.

Important extension methods under these categories listed in the following chart.

Chart I : Classficiation of Extension methods according to their use

Individual contacts	Group contacts	Mass contacts
Farm and home visits, office cals, telephone calls, personal letters, result demonstrations.	Method demonstration. All types of meetings Training Courses, Tours, Result demonstration meetings.	Bulletine, leaflets, Nes-stories, circular letters, radio, television, exhibits posters, charts etc.

2. Classification According to Farm

Extension teaching methods are classified according to´their forms, such as written, spoken and audio-visual, some of the important methods under each of these three categories are given in Chart - 2.

Chart 2 : Classification of Extension Methods According to their form

Written	Spoken	Objectives or Visual
Bulletins, leaflets, News articles, Personal letters, Circular letters	General and special meetings, farm and home visits, office calls, telephone calls, radio	Result demonstrations, exhibits, posters and charts, motion picture, slides and other visual aids, method demonstrations, meetings at result demonstrations, television, film show, meetings with audio visual aids.

3. Audio-visual aids

While using the foregoing methods the extensions worker uses these methods independently or takes the help of certain audio visual aids. The word audio-visual aid comprises three words namely (Supe, 1990).

Audio - refers to sense of hearing
Visual- refers to sense of seeing
Aid - instructional device.

The audio-visual aids are classified in two ways. One is to divide them into the following three categories.

Audio	Visual	Audio-visual
Tape recorder Radio Recordings	Flash cards Black board Pictures	Cinema Projector Television Drama

An other method of classification is to devide the aids into Projected and Non Projected aids.

Projected aids	Non-Projected aids
Cinema Projector Slide Prjector Overhead Prjector Opaque Prjector	Flash Cards Flannel graph Charts Pictures

FACTORS AFFECTING CHOICE AND USE OF METHODS

Lack of proper selection and inefficient use leads to the following consequences:

i) The benefit of extension programme will not reach as many people as it should have.
ii) There will be considerable delay in changing the behaviour and out look of the people.
iii) Many inovations might not be accepted by the people, since they were not properly presented.
iv) The extension worker might developed frustation by indifferent responses.
v) People might lose confidence in the extension programmes.
vi) much wastage of resources.
vii) Execution of further development work becomes difficult.

SELECTION OF EXTENSION METHODS

The following considerations should be taken into account in the selection of extension methods.

i) The type of farmers/audience
ii) The number of the persons to be contacted or the size of the audience.
iii) The teaching objectives of the extension programme.
iv) The nature of the subject matter.
v) The significance of the programme.
vi) How much time the extension worker has at his disposal.
vii) The length of time the programme has been going on in the area.
viii) Needs, problems and technological level of the people.
ix) Social, economical and educational status of the people.
x) General and local condition.
xi) Relative cost of extent method.
xii) Training of the extension worker for proper handling of the selected methods.
xiii) Availability of communication media.
xiv) Extgension workers familiarity.

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PROGRAMME PLANNING *VIS-A-VIS* PEOPLE'S PARTICIPATION FOR SUSTAINABLE FISH PRODUCTION

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Inland fishery occupies a strategic position in the economic development in India. Relating to its importance the country is in the process of modernizing its inland fish production programmes which in turn, depends largely upon application of improved practices based on science and technology. It is possible only through proper planning of fisheries extension programmes.

Such a programme is the total educational job being done in a particular setting. It is a prospectus or a statement issued to promote understanding and interest in an enterprise. According to Kelsey and Hearne (1967), an EXTENSION PROGRAMME is a statement of situation, objectives, problems and solutions. It is relatively permanent but requires constant revision. It forms the basis for extension plans.

Planning is a process which involves studying the past and present in order to forecast the future and in the light of that forecast determine the goals to be achieved and what must be done to reach them. PROGRAMME PLANNING is a decision making process involving critical analysis of the existing situation and the problems, evaluation of the various alternatives to solve these problems and the selection of the relevant ones, giving necessary priorities based upon local needs and resources by the cooperative efforts of the people both official and non-official with a view to facilitate the individual and community growth and development.

Objectives of Having a Programme in Fisheries Extension:

The general objective of having fisheries extension programme is to influence fish farmers/fishermen to make changes in their way of life and in making a living. The assumption is that there is need for change and if they are not aware, it is necessary to make them aware of this; and to develop their needs. Following Kelsey and Hearne (1967) the reasons for having programme may be specifically stated as follows:

1. To ensure careful consideration of what is to be done and why.
2. To furnish a guide against which to judge all new proposals.
3. To establish objectives towards which progress can be measured and evaluated.
4. To have a means of choosing the important (deep rooted) from incidental (minor, less important) problems and the permanent from the temporary changes.
5. To develop a common understanding about the means and ends between various functionaries and organizations.
6. To ensure continuity during changes in personnel.
7. To help develop leadership.
8. To avoid waste of time and money and promote efficiency.
9. To justify expenditure and to ensure flow of funds.
10. To have available in written form a statement for public use.

The concept of Need

People's needs are the basis for developing meaningful programmes. Leagans (1961) defined people's needs as the differences between what is, what could be, and what ought to be. What is indicates the present state of affairs, and may be determined by a study of the existing situation. This involves collection of facts about the people, their attitudes, knowledge, level of living etc. physical factors like soils, crops, livestock, levels of production and the like.

Research results may indicate what could be. This is an ideal situation, which in many cases may remain unattainable by the people. Many of us know that the yield levels of the research stations are seldom attained by the farmers in their own fields. The yield level which is attainable, i.e. the realistic goal which the people select with or without outside help, indicates what ought to be NEED implies a gap between what is, the existing situation; and what ought to be, the desirable situation. The nature and extent of the gap indicates significance of the problem.

From a psychological standpoint, needs may be classified into two categories. One is, felt need or consciously recognized need i.e. the need of which the people are not aware of at present. People may, however, be made aware of unfelt need i.e. unfelt need may be brought to the level of felt need, through appropriate motivational techniques.

Even if the people have a felt need, i.e. aware of a need, they may or may not act on it. In many cases the people are to be motivated to act on their felt need. For example, in an area where every year there is inundation which causes damage to crops and sufferings to the people; people are aware of the problem, but they may not act on it. It may require motivation of the people by the extension agent and mobilization of resources and funds, before the people come forward to dig out a drainage channel and solve the problem permanently. This is a case where the felt need has been developed to social action for converting an undesirable situation to a desirable one.

There may be a water body of low fish yield which the people consider to be natural. They do not recognize the problem, till the potential for high yield is demonstrated to them by the extension agent. As the people begin to realize the problem and come to know how to solve it, they gradually feel the need of raising the fish yield. The farmers then seek advice and assistance from the extension agent to satisfy their need for high yield. In this case, the unfelt need of the people is transformed to felt need and then developed to group action for changing the undesirable situation to a desirable one.

It may be mentioned here that many of our basic social needs like need for better health, need for better education, need for energy (plantation) etc. remain in the masses as unfelt needs, which must be brought to the level of felt needs, before we can expect the people to act on them. People have to recognize the gap between the actual and the desirable, and place value on attaining the desirable, before they will be motivated to change in the desirable directions.

A gap of some magnitude nearly always exists between the existing and the desirable condition. Recognition of this fact gives rise to programmes for promoting change. After such programmes have been carried out, gaps usually will still be present between the anticipated and the attained. Each change in the behavior of people in a desirable direction constitutes progress towards a goal which in turn brings other goals into focus that lie further towards the ultimate condition desired for the people. The essence of progress is found in this process (Leagans, 1961).

Assumptions in Fisheries Extension Planning

Boyle (1965), listed some assumptions relating to extension planning. These are-

1. Planned change is a necessary prerequisite to effective social progress for people and communities.
2. The most desirable change is predetermined and democratically achieved.
3. Extension education programmes, if properly planned and implemented, can make a significant contribution to planned change.
4. It is possible to select, organize and administer a programme that will contribute to the social and economic progress of the people.
5. People and communities need the guidance, leadership, and help of extension educators to solve their problems in a planned and systematic way.

Principles of Extension Programme Planning in Fisheries

Extension programmes have the definite purpose of improving rural life through individual, group and community action. Extension programme planning has certain principles which hold good irrespective of the nature of the clientele and the enterprises they may be pursuing.

1. Extension programmes should be based on an analysis of the past experiences, present situation and future needs. For programme determination adequate information about the people and their situation have to be collected. The present situation is to be analysed and interpreted on the basis of past experiences by taking local people into confidence.

2. Extension programmes should have clear and significant objectives which could satisfy important needs of the people. The ultimate objective of programme building is to satisfy the needs of the people. For this purpose, significant objectives pertaining to important needs of the people should be selected and clearly stated. The emphasis shall be on what is attainable rather than on what is ideal; although one should not lose sight of the latter.

3. Extension programmes should fix up priority on the basis of available resources and time. The rural people, particularly in the developing countries, have a multitude of problems'. All problems can not be taken up at time for solution, because of the limitations of trained personnel; availability of funds, facilities and other resources. Time is also a limiting factor as both the people and the funding agencies can not wait

for an indefinite period of time to get the results. Considering all these parameters it is essential to fix up priorities in the programme.

4. Extension programmes should clearly indicate the availability and utilization of resources. An extension programme should clearly state whereform the funds, facilities, supplies and the needed personel shall be available and how these shall be utilized. This shall make the programme practical and workable.

5. Extension programmes should have a general agreement at various levels. Programmes prepared at the various levels such as village, district, state and national levels should conform to each other and shall not work at cross purposes. Similarly, the extension programme of a particular department should not be in conflict or contradiction with the extension programme of another department.

6. Extension programmes should involve people at the local level. Extension programmes are implemented at the local level. Local people should, therefore, be involved all through, from programme formulation to programme implementation.

7. Extension programmes should involve relevant institutions and organizations. Extension programmes can not be implemented in isolation. It requires the support of many institutions and organizations. the programme should broadly indicate the institutions and organizations to be involved and how they shall contribute in attaining the programme objectives.

8. Extension programme should have definite plan of work. The plan of work may be separately drawn up or incorporated in the programme. the programme should at least broadly indicate how it will be executed. Unless the plan of work is drawn up, the programme remains a theoretical exercise.

9. Extension programmes should provide for evaluation of results and reconsideration of the programme Extension programme is not a static outline of activities. The programme should make provision for periodical monitoring and evaluation of results to judge its progress. On the basis of the findings of evaluation, the programme should be suitably modified to facilitate its reaching the objective within the stipulated period of time.

10. Extension programmes should provide for equable distribution of benefits amongst the members of the community. It has been found that, in a community generally the resource-rich persons benefit more in comparison to the resource-poor, from the implementation of extension programmes. As this may generate social disparity and social tensions, the planning of extension programmes should give adequate emphasis on the weaker sections of the community.

Steps in Extension Programme Planning

The principles of extension programme planning indicated earlier, shall help up to develop the logical steps in programme planning process. Fig. 1 shows that there are eight steps which form a continuous cycle of programme determination and programme implementation in extension.

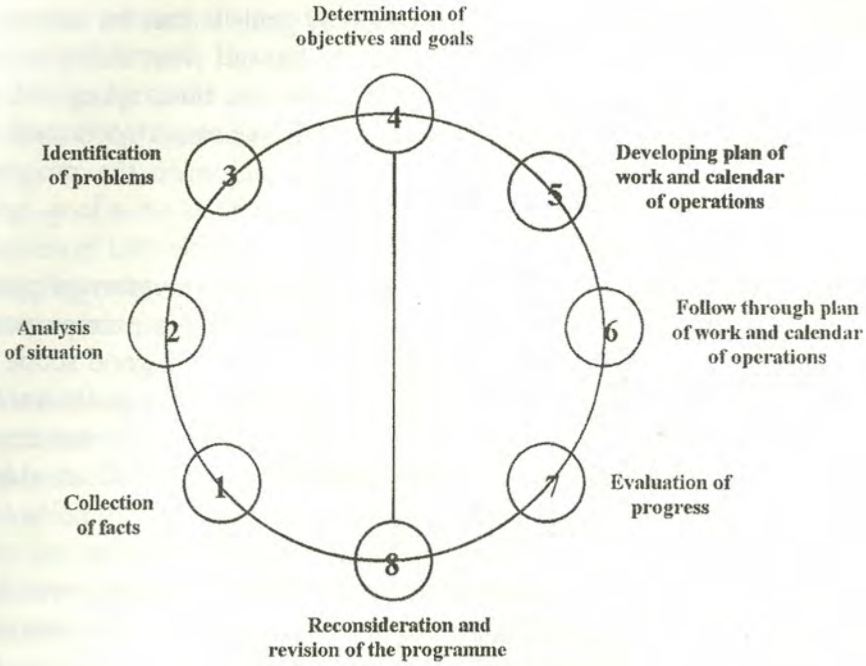

Fig. I : Steps in Extension Programme Planning

1. **Collection of facts.** It is the starting point of programme planning process. Pertinent data may be collected from the available records and by survey of the area. Information relating to the people, their enterprises, levels of technology, facilities and constraints, values etc. relevant to programme building may be collected. Information may also be collected from Panchayats, Cooperatives and other organizations in the area.

2. **Analysis of situation.** The data and information collected are then analyzed in an unbiased way, keeping in view the feelings expressed by the client system. This shall help in understanding the situation in its proper perspective.

3. **Identification of problems.** A correct analysis and interpretation of the data shall help in correctly identifying the problems. There may be many problems, but only the urgent and significant ones which may be solved with the available resources and within the limits of time, should be selected. Selection of a large number of problems which can not be properly managed may lead to a failure of the programme and generate frustration among the people.

In the present example, after analysis of the data and relevant information with the local people, three most important problems are identified, which need immediate solution. These are, for example, low levels of income, employment and nutrition in the farm families.

4. **Determination of objectives and goals.** The objectives are then set forth on the basis of the significant needs identified. The objectives should be direct and stated

in clear terms. In the present example, the objectives then become to increase the levels of income, employment and nutrition of the farm families in the village.

To make the objectives realistic and actionable, there is need to state them in terms of specific goals. In the determination of goals it may be necessary to again go through the data and information analyzed; to find out what could actually be done in the existing situation, with the available resources and time, which will be compatible and with which the people shall cooperate. It is necessary to discuss with the local people and local institutions, which shall also legitimize the programme planning process.

In the example, it is found that the village has a number of ponds with ample water throughout the year. These were used mainly for domestic purposes and not for irrigation as the fields were away. There appeared to be a good scope of introducing the technology of duck-cum-fish farming in the village. The goals were then finalized after checking up cultural compatibilty with the farmers; technical compatibility with the scientists and financial compatibility with the banks and Govt. departments. The goals were then set up as follows-

a) to raise the yield of fish to 4000 Kg per hectare per year by resorting to composite fish culture in about one-third of the ponds in the first year and covering all the ponds in a period of three years.

b) to introduce Khaki Campbell duck rearing in about one-fourth of the ponds in the first year and covering all the ponds in a period of four years, to obtain 250 eggs per female bird per year.

The generation of additional income and employment, and the availability of additional protein food for the participating farm families per year were calculated and found to be satisfactory both by the farmers and the extension agent.

5. **Developing plan of work and calendar of operations.** The plan of work should be in written form and shall indicate who shall do what job i.e. what the change agent system and the client system shall do; which institutions, organizations, service departments shall be involved; what will be the financial requirement and how it shall be met; what arrangements shall be made for marketing of the produce, training of the farmers and so on. The plan should have all the essential details and no important point should be left out.

6. **Follow through plan of work and calendar of operations.** This is not a routine type of work as many people may think. Training of participants, communication of information, conducting method demonstrations, making regular visits and monitoring are some of the important functions the extension agent shall perform at this stage. The work shall include solving unforeseen problems and taking corrective steps where needed. The performance of the extension agent and the organizational support received at this stage may make the difference between success or failure of a programme. Obtaining feedback information as to what is happening to the farmers after introduction of new technology is extremely important at this stage.

7. Evaluation of progress. Evaluation is the process of determining the extent to which we have been able to attain our objectives. All programmes must have an in-built system of evaluation to know how well the work is done. It should be a continuous process not only to measure the end result but also to ensure that all the steps are correctly followed. Evaluation may be formal or informal, depending on the importance of the programme and also on the availability of trained manpower, funds, facilities and time. Programme evaluation involves the following three essential steps-

Setting up of some standards or criteria in relation to the objectives.
Collection of information.
Making jugement, and drawing some unbiased and valid conclusions.

Evaluation has a number of advantages. Following Kelsey and Hearne (1967), these are-

-Evaluation helps to establish a 'bench mark' - the situation at the start of the programme.
- Evaluaiton shows how far our plans have progressed.
- Evaluation shows whether we are proceeding in the right direction. It may point out omissions, recommend changes and suggest new directions.
-Evaluation indicates the effectiveness of a programme.
-Evaluation helps to locate strong and weak points in any programme of plan.
-Evaluation improves our skills in working with the people.
-Evaluation helps us to determine priorities for activities in the plan of work.
-Evaluation brings confidence and satisfaction to our work.

In case there have been shortfalls, evaluation indicates the degree of shortfalls, and pinpoints why it has been so, and what should be done to remove the deficiencies.

8. Recosnideration and revision of the programme. On the basis of the results of evaluation, the programme shold be reconsidered, and revised if needed. This reconsideration should be done not only with the participants; butalso with the scientists, adminsitrators in extension organization and local bodies like panchayats etc.

Reconsideration shall help in making necessary correctrions and modifications in the programme. In reconsideration, emphasis should be on the removal of technical defectrs if any, and how to obtain more cooperation and involvement of the participants and various organizations. The purpose of such an exercise is to make the extension programme more effective by removing the defects.

Planning and Implementaiton of Transfer of Technology Projects in Fisheries

Transfer of Technology (TOT) projects, whether land-based for example, forest development in wastelands or water-based such as prawn culture in brackishwater, have some practical aspects which are important and should be taken into consideration by the extension agency for effective planning and implementation. The generalized guidelines for transfer of technology presented here, may be applied judiciously.

1. Study the present situation and understand how it has developed. Identify the socio-cultural and historical perspectives of the situation.

2. Study the tenure system and find out who benefits from the ownership of land of water resource.
3. When the ownership or control of land or water resource vest in the Government or a public body, the extent to which the local people, particularly the landless and resource-poor, shall have access to their management and benefit sharing.
4. Identify technolgies which are compatible with the ecosystem and as well as with the needs of the people. Blend technolgies with local experiences, resources, skills and management capabilities. Application of the technolgoies should benefit not only the individuals, but also the community over the long run.
5. Identify the role of fish farmers, farm women, rural youth and landless people in project planning and implementation.
6. Identify the social, cultural and economic perceptions people have about the products and benefits, and whether these satisfy their most important needs.
7. Find out whether people need incentivwes, and if so, in which form, when and where.
8. Involve organizations and institutions at the local level. Take Panchayats and voluntary organizations in confidence.
9. Assess the nature and amount of communication and training support to be provided to the people.
10. Identify the infrastructural facilities like provision of critical inputs and services, credit, marketing etc. which are to be made available.
11. provide for monitoring and evaluation of the ongoing projects. Be on the look out whether implementation of projects bring sustainable benefits to the participants whether implementations of projects bring sustainable benefits to the participants or generate any negative output i.e deterioration in different system like ecosystem, social system etc.
12. Assess the training and communication needs of the extension agents which shall give them the required skill and confidence to plan and implement the projects efficiently.

13. Nature of the Programme Planning Process

1. Programme planning is an educational process and involves both teaching and learning. It teaches skills to the people in finding, analyzing, deliberating and focusing problems. It teaches facts i.e. gives more knowledge to the people. It changes the attitude of the people towards the planning process.

2. Programme planning is an unifying and integrating process. Through the process of identifying problems, fixing priorities, establishing objectives and goals, and providing continuity and evaluation, people get a total picture of where they are, what they shall do and where they are likely to reach.

3. Programme planning is a coordinating process. It requires coordination of the efforts and activities between officials and non-officials, between institutions and organizations, between people and materials, and the like.

4. Programme planning is an evaluating process. Evaluation of accomplishment is not the only criterion. It also provides for evaluation of the planning process and organization.

Role of Extension Agent in Programme Planning

The sequence of roles the extension agent shall perform in programme planning or technology transfer are summarized, following Rogers and Shoemaker(1971). These are to be performed with the client system, from their point of view, in a consultative and persuasive manner.

1. Develop need for change. At the outset, help the clients to become aware of the need to alter their behaviour.
2. Establish a change relationship. Develop rapport with the clients. Extension agent's credibility and empathy with the needs and problems of the clients are important. The clients must accept the extension agent, before they accept the innovations which are promoted.
3. Ddiagnose the problems. Analyze the clients' problem situation in order to determine why the existing alternatives do not meet their needs.
4. Create intent to change in the clients. Motivate the clients to mentally accept the change.
5. Translate the intent into action. Assist the clients to put the recommendations in practice. Emphasize on getting action or behavioural change of the clients.
6. Stabilize change and prevent discontinuance. Take steps to stabilize (freeze) the new behaviours by frnishing reinforcing messages to the clients who have adopted.
7. Achieve a terminal relationship. Generate a self-renewing behaviour of the clients. That is, shift the clients from a position of reliance on the extension agent to reliance on themselves.

The concept of Marketing

Planning in agricultural extension is never complete without an element of marketing, as even a subsistence farmer may have to sell some of the produce to purchase other necessities for the family. In view of economic liberlizaiton, marketing is obviously very important.

According to Shukla (1995), selling and marketing are not synonymous. Selling is just selling across, without any knowledge of prevailing prices or qulaity in other markets, or the specific requirements or preferences of the consumers. Marketing, on the other hand, includes all functions and services needed to move the goods starting from the farm to the ultimate consumer. In this process, the production adds form or time utilities etc. Marketing, therefore, includes all the fucnitons like assembly, grading, packing, transport, storage, process, inlsurance and even export etc.

Marketing provides a bridge between the producer and the consumer. It is here that the physical movement of agricultural production takes place, and in this process it changes hand and the producer/farmer gets cash. It is, therefore, a very important economic activity. A marketing system hastens the distribution process and meets the specific needs of the consumers wherever they are. An orderly and efficient marketing system is a big incentive to produciton.

The prime motive factors behind this economic activity are the specific tastes and preferences of the consumer, quality, price, the time, the form and the type of packing required by the consumer. The regulation of markets and provision of market information aim at giving the farmer a fair deal and improve market efficiency.

People's Participation

People's participation is of crucial importance for the success of fisheries extension pprogrammes. Nothing can be imposed on the people,volunatry participation ofthe 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

Some of the factors which influence participaition of the rural people in agriculture and rural development programmes are-

i. the extent of personal interest one feels in the programme,
ii. the extent to whicfh a programme is based on the felt needs of the people,
iii. future advantages of the programme for the memebrs of the family,
iv. cost and labour involved in relation to the return,
v. timeliness of the recommendations in relation to operation,
vi. ease or difficulty with which the change can be made,
vii. consistency of the proposed action in relation to the previous programmes,
viii. confidence of the people in the extension agent and the organization the person represents, and
ix. approval or encouragement by neighbours and others who are held in high esteem.

The values which result from the participation of people at local level are-

i. satisfies the ego of the people; people feel important, they feel that it is their programme,
ii. people accept the programmes in which they or their recognized leaders have been involved,
iii. a two-way communication between local people and the exension agent makes the programme sound and realistic,
iv. the assurance that the programme is based on local needs and local situation, avoids imaginary to unrealistic programmes,
v. involvement of the local people in decision making generates their commitment for implementation of the programme, and
vi. increased ability of the people to take responsibility enhance their competence in solving their own problems.

More specifically, participation by intended beneficiaries in the agricultural development programmes, according to Samanta (1990), may yield the following advantages and positive outcome.

1. During the design phase of a programme, intended beneficiaries can provide cultural, ecological, economic and technical indigenous knowledge. Designers or planners can avoid costly mistakes as they and the beneficiaries determine which techniques and programme objectives are most appropriate for the community.

2. Programme participants can moblize the local resources, in the form of cash, labour, materials, managerial talent and political support which are critical to programme success. voluntary commitment of their resources is a necessary condition for breaking development of paternalism which reinforce the people's passivity and dependency. Farmers are more likely to contribute resources toa project they have helped to select and design than to one chosen by an outsider.

3. The fields and the livestock pens of the farmers are the best testing grounds for proposed agricultural innovations. Farming System Researchers have concluded that on-farm trials are more appropriate to local needs, faster and less expensive where farmers participate in all stages, including experimental design, of those trials.

4. Programmes involving participation of the people are more likely to be sustained after outside funding and support are reduced or withdrawn. The motivation, training and financial arrangements necessary to maintain programme activities can best be developed when the beneficiaries have been involved in the programme from the beginning.

5. When community memebrs participate in the programme's implementaiton phase as para-professionals, they extend the benefits to a greater number of people than scare professionals could reach. New ideas are more likely to be accepted when introduced or demonstrated by the trusted ones.

6. Participation by the poorer elements of society may prevent the 'hijacking' of programme beenfits by wealthier members of the community.

Organization of BENEFICIARIES GROUPS, which provides for sharing of project benefits by the members, is one of the practical and effective methods to ensure people's participation and to attain extension objectives. Example, Forest Protection Committees, Beneficiaries Committees in irrigation command areas etc.

Why Programmes Fails?

There may bemany reasons for which a programme may fail. It is necessary for the extension personnel to be aware of the important ones so that necessry precaution could be taken to prevent them. These are-

-Lack of commitment. Lack of commitment by any or all concerned i.e. the participant, extension agents and organizations may lead to the failure of a progamme.

-Lack of meaningful objectives and goals. Progammes can not be effective unless the goals are clear (people understand them), attainable (can be accomplished) and actionable (can be put to practice).

-Failure to develop and implement strategies. Without a sound strategy i.e. a synthesis of objectives, goals and action plan, programmes are likely to go astray. Moreover, unless the strategy is implemented, the programme remains only a statement of wishes and hopes.

-Failure to see programme planning as a national process. Programme planning is a practical exercise in rationality. Going through the steps without reasoning or skipping the steps may adversely affect the programme.

-Excessive reliance on experience. Experience is essential, but it can not be a substitute for current scientific information. Excessive dependence odn experience may make a development programme ineffective.

-Failure to identify the limitting factors. Inspite of everything appearing alright, there may be one or two limitting factors which may adversely affect the programme.

-Lack of organizational support. Unless the extension functionary gets adequate support from the organization and has clear delegation of authority to take decisions, the programme may fall through.

-Resistance to change. A programme implies something new. It means change. Unless the human mind is amenable to change, the programme may get stuck up.

Conditions Favouring Change

Programme planning is the process of bringing change in people not only in their making a living but also in their level of living. A knowledge of the conditiions favouring change may help in accelerating the process of change. Following Besse (1957), some of the important conditions favouring change are-

1. Change is more acceptable when it is understood than when it is not.
2. Change is more acceptable when it does not threaten security than when it does.
3. Change is more acceptable when those affected have helped to create it than when it is imposed from outside.
4. Change is more acceptable when it follows a series of successful changes than when it follows a series of failures.
5. Change is more acceptable when it is introduce after prior change has been assimilated than when it is introduced during the confusion of other major changes.
6. Change is more acceptable if it is planned than when it is sought to be introduced through trial and error.
7. Change is more acceptable to people who share in the benefits of change than to those who do not.

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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