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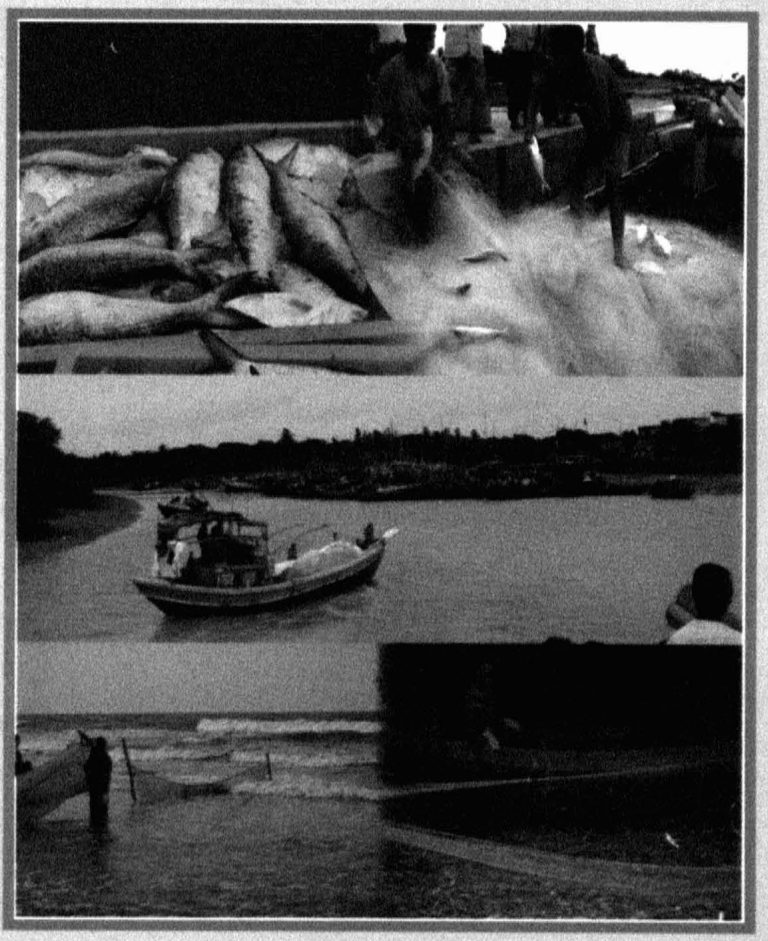
ESTUARINE FISHERIES MANAGEMENT
— OPTIONS & STRATEGIES



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Estuarine Fisheries Management — Options & Strategies

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— Options & Strategies

1. INTRODUCTION

India has a long coastline of 7500 km with an exclusive economic zone (EEZ) of $2.015X10^6$ km^2, which accounts for 61% of the total land area of the country. The country has 14 major, 44 medium and 162 minor rivers, draining $3.12 X 10^6$ km^2 of catchment area and in the bargain discharge 1645 km^3 of freshwater into the sea through various estuaries. Among the major rivers Ganga, Mahanadi, Godavari, Krishna, Cauveri (East Coast) and Narmada, Tapti, Mandovi, Zuari (West coast) are most prominent, forming highly productive estuarine systems, especially in relation to fisheries. The biological integrity and fisheries of various estuaries of the country are, rather on a declining spree, due to various man-induced activities like river valley modifications and dumping of wastes. The resultant impact is loss of biodiversity and fish stock consequently, eroding the livelihood support of the traditional fishers to a large extent, besides affecting other ecological services.

Estuaries are an important and distinct component of the coastal landscape with highly complex ecosystems, varying physico-chemical properties and highly diverse flora and fauna. Estuaries are of different shapes and sizes, and are known by different names, such as 'river mouth', 'bays', 'lagoons', 'harbours' or 'inlets'.

Estuaries being a dynamic system provide diverse habitats for the proliferation of distinctly diverse biota, but in the face of increased anthropogenic activities, resultant imbalances at various trophic levels, leading to loss of ecological services and biodiversity, have become the hallmark in all most all estuarine ecosystems of the country. Even so, the paradox is that estuaries are extremely exploited ecosystems, due to their proximity to major civilization throughout the globe. Evidently, therefore, suitable policy guidelines is the imperative need of the hour for the rational management of estuarine resources, including the fishery, which are incidentally not available in the Indian context. In the backdrop of this gap, an effort has been made here to propose a set of guidelines and action plans, based on the experiences gained at CIFRI during the last fifty years of continued

research in different estuaries of the country, for the effective management of estuarine environment, especially in the fisheries context to India.

2. ISSUES AND CHALLENGES FOR ESTUARINE ENVIRONMENT & FISHERIES

No other inland water has been used or abused more than the estuaries. Being the finest natural harbours, supporting a number of commercial activities and highly rich in biodiversity, they are exploited continuously for addressing the livelihood concerns, especially for the riparian traditional fishers. In recent times, however, most of the estuaries of the world, including India, have been degraded enormously due to increased man-induced activities, such as dumping of composite city wastes, both liquid and solid, together with an over-exploitation of harvestable biotic communities like fish, leading to considerable ecological imbalances. Regulated freshwater supply due to the construction of dams, barrages and other civil structures across river systems has also impacted the estuarine environment, including the fishery. The anadromous and catadromous fish species have been the worst victims due to hydraulic alterations. The natural fishery of the estuaries is under severe stress, causing almost irreversible loss of livelihood support to traditional fishers.

Presently, the estuaries of the world, including India, are facing a number of problems. However, the most glaring problems, which need to be addressed on a priority basis are:

- *Lack of effective planning and coordination among the stakeholders in the implementation of management protocols*
- *Lack of adequate knowledge on ecological principles as well as on the management of resources*
- *Negligible or very low level of awareness among the target groups on the sustainable use of resources and conservation of estuarine environment and biodiversity.*

A number of issues and challenges are inherently associated with these nagging problems of estuaries in India. The specific issues which have affected the estuarine environment in the country are:

- **WATER FLOW**
  - Changes in water flow in various estuaries, either far in excess or much lower than required (e.g., Hooghly, Narmada, Krishna, Godavari, Pulicat etc.)

- Modifications of the estuarine catchments (e.g. Most of the estuaries)

- **POLLUTION & WATER QUALITY**
  - Pollution through industries and combined city sewage (e.g., all the estuaries)
- **RECREATION AND TOURISM**
  - Recreational boating (e.g., Hooghly, WB; Chilika, Orrisa)
  - Recreational fishing (e.g., Chilika)
  - Navigation (e.g., Hooghly)
- **PORTS & SHIPPING**
  - Dredging (e.g., Hooghly)
  - Shipping (e.g., Hooghly)
- **LAND USE**
  - Expansion of urban and rural settlements (e.g., Hooghly, WB, Krishna, Cauveri, Pulicat, TN)
  - Marinas, groynes, land reclamation and other structures (e.g., Hooghly, Pulicat)
  - Mining & Industries (e.g., Hooghly, WB; Zuari, Goa)
  - Agriculture (e.g., all the Estuaries)
  - Dumping of solid wastes (e.g. all the estuaries)
- **COMMERCIAL FISHING & AQUACULTURE**
  - Over exploitation of target fish stock due to increased demand (e.g., all the estuaries)
  - Reclaiming the fringed areas for intensive aquaculture in pens (*Gheries*), obstructing the migratory routes of fish and prawn recruitment (e.g., Chilika, Pulicat)
  - Polluting the environment through feeding of stocked fish and prawn in pens (Chilika)
  - Destruction of biodiversity through prawn seed collection and operation of small-meshed nets (e.g., Hooghly, Chilika, Pulicat)

- **CLIMATE CHANGE**
  - Submergence of catchment areas due to rise in water level (e.g., all the major estuaries)
  - Change in biodiversity profile, affecting the production and productivity (e.g., all major the estuaries)

3. A HEALTHY ESTUARY

A healthy estuary supports a host of plants and animals. It stores and recycles nutrients, traps sediment and forms a buffer between coastal catchments and the marine environment. It also absorbs, traps and detoxifies pollutants, acting as a natural water filter. When all such processes remain functional an estuary is considered to be in healthy state.

Estuaries support diverse habitats, such as mangroves, salt marshes, sea-grass, mudflats etc. Each habitat has its own characteristics and specific functions to keep an estuarine system healthy (Table 1). Better understanding of such criteria helps in setting priorities for the management of estuaries.

Table 1: Criteria for healthy habitats of estuaries

Habitat	Criteria for healthy estuary
Saltmarsh	Saltmarsh should have free tidal exchange, good drainage and enough space to allow for coastal retreat
Mangroves	Mangroves should have free tidal exchange, good drainage and enough space to allow for coastal retreat
Mudflats	Mudflats should have regular tidal exchange favourable to dependent population of organisms, such as invertebrates and birds
Open-water	Open-water habitats should have free from or within permissible limit of pollution and turbidity
Sea-grass	Sea-grass communities/meadows should be stable with regard to dependent population of organisms
Diadromus fish species	The migratory fish species, both anadromus and catadromus, should have hassle free movement for breeding, recruitment and feeding purposes.

4. WHY ARE ESTUARIES IMPORTANT?

Estuaries are highly complex, but very productive ecosystems with a larger economic, social and environmental significance. They are one of the finest nurseries and breeding grounds for a number of commercially as well as ecologically important species of fish, prawn and other organisms like crabs, dolphins and alligators. The Indian estuaries are known to support fisheries of stocks like hilsa, mullets, prawns, crabs etc, with high market demand, fetching good return to the fishers. Many estuaries of the country, including the famed Sunderbans of Hooghly estuarine system, also support dense mangrove forest, which not only have great ecological significance, but also provide livelihood support to a sizeable section of the population in terms of timber, fuel, honey and other by-products.

Estuaries being highly productive ecosystems provide useful goods and services to the community, such as water resources, sheltered anchorages and fish nurseries. It may be extremely difficult to estimate the total contribution of estuaries to India's economy in monetary terms. Yet, there are some measurable and important economic indicators, for a first hand assessment of the commercial fisheries, navigation and others. To ensure that the estuaries continue to provide our future needs, effective management is essential to maintain the ecosystem in a healthy state with all the utility functions in place.

The environmental, social and economic values of Indian estuaries could be summarized as under:

ENVIRONMENTAL VALUES

- ***Water quality regulation and groundwater recharge*** : estuaries act as natural water filters besides recharging groundwater supplies in the coastal areas.
- ***Habitat, breeding and nursery grounds for plants and animals*** : estuaries are essential to the survival of many plants and animals. They provide habitats for fish, birds and other wildlife serving as the essential feeding and breeding grounds. Many types of fin and shellfish, crustaceans and other marine animals rely on the sheltered waters as protected places to breed and lay their eggs.
- ***Biological productivity*** : Biologically, estuaries have been described as one of highly productive areas in the world. With high nutrient levels and generally sheltered waters, estuaries provide ideal environments for breeding and feeding of a number of fish and other animals.

SOCIAL VALUES

- ***Community values :*** Generally, estuaries are popular and most preferred residential locations and often serve as focal points for community activities.
- ***Indigenous values :*** estuaries are the important indigenous cultural sites.
- ***Recreation values :*** fishing, boating, hunting, bird watching and camping are all undertaken in estuaries. The Chilika is a renowned eco-tourism site, popular with fishers, dolphin watchers and bird watchers.
- ***Knowledge/Research values :*** The estuaries and their associated riparian habitats are the excellent sites for rich biodiversity and complex habitats, which offer tremendous opportunities for ecologists, limnologists, biologists and fisheries scientists to understand and study various facets of ecological as well as production functions.

ECONOMIC VALUES

- ***Commercial fishing :*** estuaries are essential and indispensable areas for many commercially important fish and crustaceans, which contribute considerably to the South Australian economy.
- ***Ports and harbours :*** estuaries are often the sites of ports and harbours, vital for shipping, transport and industry. Port Adelaide and Port Pirie are two significant ports built upon estuaries. The cultural and historical features also support a growing tourism industry.
- ***Tourism :*** many tourism and ecotourism industries in South Australia are located in estuarine areas.
- ***Agriculture, aquaculture and industry :*** in some areas of South Australia, estuaries support agriculture, aquaculture and other industry activities. Power stations in the Port Adelaide estuary, for example, use estuarine water for cooling.
- ***Storm and erosion protection :*** estuaries provide protection to life and property by acting as natural buffers to water erosion from both the land and the sea.

Evidently, in view of high economic, social and environmental values, the estuaries deserve adequate attention and rational management for protecting the utility functions associated with these systems.

5. ESTUARINE RESOURCES OF INDIA

The Indian coastline is more than 7500 km in length with an exclusive economic zone of 2.015 X 10^6 km^2 that accounts for 61% of the total land area. The country commands a distinct position with more than 55 estuaries, located on the East and West coasts (Table 2). The estuarine resource, including the associated waters, of India has been estimated approximately at 30,000,00 ha. The area of certain major estuaries and associated waters are given in Table 3.

Table 2: Important Estuaries in India, their location and type

EAST COAST		
Hooghly	21°40'N lat. & 57°47' E long., West Bengal	Major
Mahanadi	20°18'N lat. & 86°43' E long., Orissa	Major
Rushikuliya	19°24'N lat. & 85°04' E long., Orissa	Major
Bahuda	19°20'N lat. & 85°05' E long., Orissa	Minor
Godavari	16°15'N lat. & 82°05' E long., Andhra	Major
Krishna	16°15'N lat. & 82°05' E long., Andhra	Major
Gosthani	16°15'N lat. & 82°05' E long., Andhra	Minor
Kandaleru	16°15'N lat. & 82°05' E long., Andhra	Minor
Swarnmukhi	13°48'N lat. & 80°09' E long., Andhra	Minor
Konderu	13°50'N lat. & 80°15' E long., Andhra	Minor
Araniar	13°25'N lat. & 80°15' E long., Tamil Nadu	Minor
Ennore	13°15'N lat. & 80°19' E long., Tamil Nadu	Minor
Cooum	13°10'N lat. & 80°16' E long., Tamil Nadu	Minor
Adyar	13°10'N lat. & 80°17' E long., Tamil Nadu	Minor
Muttukadu backwaters	12°46'N lat. & 80°18' E long., Tamil Nadu	Minor
Edaiyur-Sadras estuarine complex	12°33'N lat. & 80°10' E long., Tamil Nadu	Minor
Uppanar	11°42'N lat. & 79°46' E long., Tamil Nadu	Minor
Vellar	11°29'N lat. & 79°46' E long., Tamil Nadu	Minor
Kollidam	11°29'N lat. & 79°50' E long., Tamil Nadu	Minor
Cauveri	11°07'N lat. & 79°50' E long., Tamil Nadu	Major
Agniar	10°20'N lat. & 79°23' E long., Tamil Nadu	Minor
Kallar	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
Pinnakayal	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
Pullavazhi	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor

Table 2: Important Estuaries in India, their location and type *(contd.)*

Athankarai	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
Kajirangudi	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
Kottakkarai	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
Uppar	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
Vaigai	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
Kottakkudy	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
Thengapattanam	09°45'N lat. & 78°20' E long., Tamil Nadu	Minor
WEST COAST ESTUARIES		
Ashthamudi	08°31'N lat. & 76°31' E long., Kerela	Minor
Kadinamkulum	08°35'N lat. & 76°45' E long., Kerela	Minor
Estuaries of Kochi	09°28'N lat. & 76°13' E long., Kerela	Minor
Korapuzha	11°34'N lat. & 75°35' E long., Kerela	Minor
Beypore	11°08'N lat. & 75°51' E long., Kerela	Major
Olippuram Kadavu Backwaters	11°34'N lat. & 75°35' E long., Kerela	Major
Edava-Nadyara & paravur Backwaters	11°34'N lat. & 75°35' E long., Kerela	Minor
Poonthura	08°25'N lat. & 76°55' E long., Kerela	Minor
Puthupannani	12°34'N lat. & 74°35' E long., Karnataka	Minor
Neteravati and Gurupur	12°50'N lat. & 74°50' E long., Karnataka	Minor
Mulki	13°04'N lat. & 74°17' E long., Karnataka	Minor
Pavenje	13°70'N lat. & 74°30' E long., Karnataka	Minor
Gangolli	13°38'N lat. & 74°39' E long., Karnataka	Minor
Kali	14°50'N lat. & 74°07' E long., Karnataka	Minor
Mandovi-Zuari	14°54'N lat. & 73°40' E long., Goa	Major
Estuaries of Mumbai	18°45'N lat. & 73°10' E long., Maharashtra	Minor
Waghotana	16°33'N lat. & 73°20' E long., Maharashtra	Minor
Purna	21°55'N lat. & 72°45' E long., Gujarat	Minor
Mahi	22°17'N lat. & 72°13' E long., Gujarat	Major
Damanganga	South Gujarat	Minor
Tapti	Gujarat	Major
Narmada	Gujarat	Major

Table 3: Areal magnitude of important estuarine fisheries resources of India

[illegible]	[illegible]
Hooghly-Matlah Estuarine system	2,34,000
Godavari estuary	18,000 (330 sq km)
Mahanadi-Devi estuary	7,400
Narmada estuary	30,000
Krishna estuary	15,000 (320 sq.km)
Chilika lagoon	1,03,600
Pulicat lake	36,900
Vembanad lake and Kerela backwaters	50,000
Saline wetlands of West Bengal	33,000
Mangrove areas	3,56,500

6. PRESENT STATUS OF FISH PRODUCTION & PRODUCTIVITY

The estuarine fisheries in India are always above the subsistence level, contributing size- ably to the inland fish basket in the country. The fish productivity of various estuaries of the country has been estimated in the range of 45-75 kg/ha. The annual fish production trends along with major fisheries of various estuaries are given in Table 4.

Table 4: Fish Production & Productivity in major Estuaries of India

[illegible]	[illegible]	[illegible]
Hooghly-Matlah	20,000 (Pre-Farakka) 72,098 (Post-Farakka)	*Harpodon nehreus, Tenualosa ilisha, Pama pama Trichiurus spp, Lates calcarifer, Setipina* spp. Prawn etc.
Godavari	3000-4000	Mullets (*L. parsia, M. cephalus*), Prawn (*P. monodon, P. indicus*)
Krishna	496-540	Mullets (*L. parsia, M. cephalus*), Clupeids (*T. ilisha, T. kelee*), Perches, Sciaenids, Catfish, Penaeid Prawn (*P. indicus*), crabs (*Scylla serrata*)
Mahanadi	¢ 550	Mullets, *Lates*, Sciaenids, Prawns
Narmada	¢ 4000	*T. ilisha*, Mullets, Prawn

Table 4: Fish Production & Productivity in major Estuaries of India *(contd.)*

Peninsular estuarine systems	ç 2000-3000	Mullets, Prawn, Clupieds, Crabs
Chilika Lagoon	4000-13,000	Prawn (*P. monodon, P. indicus*), Mullets, Catfish, Clupeids, Perches, Sciaenids, Eutroplus, Crabs (*Scylla serrata*)
Pulicat	760-1370	*P. indicus, P. monodon* Mullets, *Etroplus, Chanos, Lates*, Crabs, Tilapia
Vembanad backwaters	14,000-17,000	Prawn, Mullets, *Lates, Eutroplus, Chanos*
Estuarine wetlands, WB	ç 37500	Prawn, Mullets, Tilapia, *Lates*,

7. ECOLOGY AND FISHERIES OF SELECTED ESTUARIES & ASSOCIATED WATERS - CIFRI CASE STUDIES

HOOGHLY ESTUARY

The Hooghly, the largest estuarine systems in the country with a width of 02 km to 12 km, is a live estuary supporting rich biodiversity and better known for its lucrative winter fishery, the famous Sunderban mangroves (>40 plants) and Hilsa fishery.

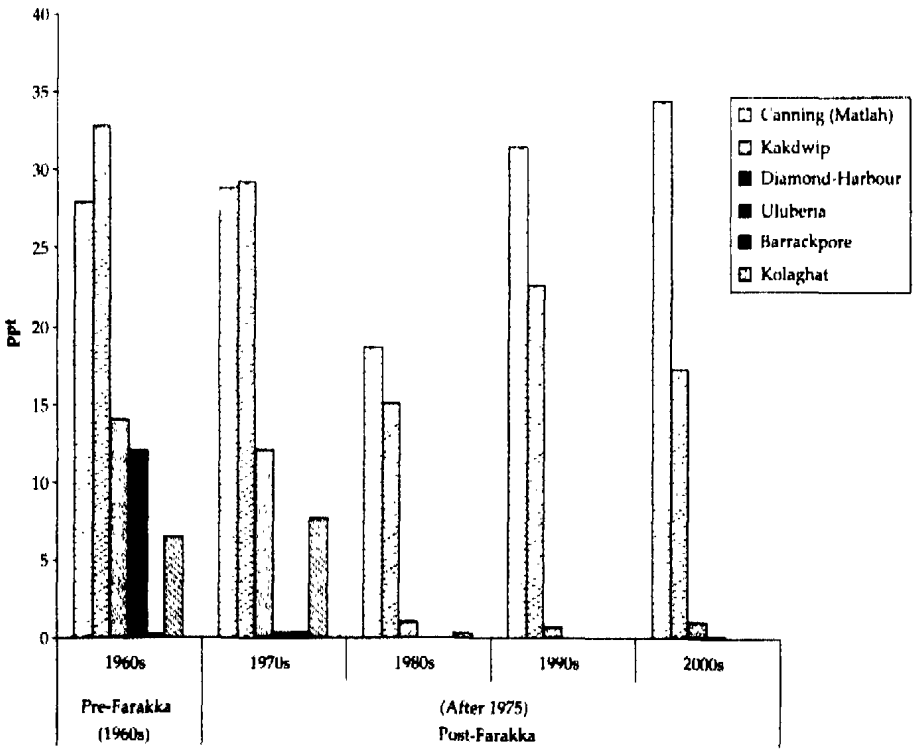
Physico-chemical profile

Data generated at CIFRI on various environmental factors indicate changing profile of salinity gradient, due to regulated freshwater supply from Farakka barrage (Table 5). The estuarine tongue of the system has been pushed downward to the extent of >100 km, which in turn has brought about a significant change in biodiversity profile, including the fish fauna and other density-independent factors like fish stock. This change in the habitat of Hooghly estuarine system has brought about significant changes in the biotic composition, such as plankton, benthos and fish, from estuarine species dominated community structures to freshwater species dominated community structures in a substantially large stretch of the system. Currently, the stretch between Nabadwip to Diamond-Harbour has almost been converted into a freshwater stretch, as evidenced from availability of a host of fish species known to have freshwater specific distribution like *Sicamugil cascasia, Labeo bata, Doryychthys cunculus, Eutropicthys vacha, Satipina*

phasa, Amblypharygodon mola and others on a regular basis and in good quantity. The same has been the case with the brackish-water phytoplankton like *Coscinodiscus centralis, C. nanni* and other centric diatoms, which were common in the upper stretch of the estuary. This stretch has now paved the way to freshwater forms belonging to chlorococcales, euglenoids and cyanobacteria. The diversity of fish and plankton thus indicates substantial erosion in salinity gradient leading to the loss of estuarine habitat to a large extent.

Table 5: Trends of salinity profile (gl^{-1}) in Hooghly estuarine system

Canning (Matlah)	28.0	28.9	18.7	31.4	34.3
Kakdwip	32.8	29.2	15.1	22.6	17.2
Diamond-Harbour	14.02	12.03	1.02	0.69	1.05
Uluberia	12.01	0.379	0.028	0.042	0.094
Barrackpore	0.24	0.30	0.019	0.054	0.055
Kolaghat	6.5	7.6	0.343	0.044	0.035



Status of Pollution

The heavy metal concentrations in water-phase of Hooghly estuary generally indicated low values, such as chromium (0.024 and 0.056 mgl^{-1}), Zinc (0.022 and 0.045 mgl^{-1}), Mangenese (0.016 and 0.041 mgl^{-1}), and Iron (0.13 and 0.22 mgl^{-1}). Evidently the levels of heavy metals in water phase were within the permissible range. The Cr content, however, occasionally showed slightly higher values at Saptamukhi, Thakuran and Matla estuarine systems. The heavy metal contents in bottom sediments have been found to be significantly high, especially the Iron content followed by manganese and zinc. The Cr content, which showed high value in water, has been low in the sediment phase. The heavy metals in soils were mostly in an insoluble bound state and very low quantities were liberated into water phase at the soil- water interface.

Prevalence of organic pollution (BOD, 31.73-91.46 mg/l; CO_2 (8.08 – 9.93 mg/l) has also been observed in this estuary at certain hot spots receiving sewage and distillery effluents, both in the main channel as well as in important tributaries like Damodar and Rupnarayan.

Trends of Fish Catch

The trend of fish catch in Hooghly indicated significant increase (Fig. 1) during the post Farakka Barrage, primarily due to manifold increase in Hilsa catch. In recent years, between 1998-99 and 2002-2003, the average per annum catch of Hilsa has been estimated at 10,382.9 t with an impressive increase of 63.3% from the corresponding five years (6279.6t). Over the years, however, the mean length of this prime anadromus fish has declined, from 356 mm (1960s) to 325 mm or even less (2000s) - a manifestation of increased efforts, indicating over-fishing. In addition to this, wanton killing of Hilsa juveniles has been rampant in the upper stretch of the estuary, especially during November to May, due to the deployment of small meshed nets. Evidently, the breeding and recruitment of Hilsa may face a rough weather in the long run, affecting the overall fishery of the estuary adversely, unless suitable corrective measures are enforced immediately, including awareness among the fishers.

The important threats associated with the Hooghly estuarine system mainly arise from unregulated freshwater discharge from over-head Farakka barrage leading to a shrinkage in estuarine tongue and a change in salinity profile, destruction of mangrove habitats, wanton killing of hilsa juvenile and other target fish species, unwitting destruction of biodiversity in the process of manual collection of *P. monodon* seeds, especially from the mangrove areas etc.

KRISHNA ESTUARY

Over the years the Krishana estuary (320 km^2) has been subjected to variuos stress factors, especially as the freshwater discharge has been reduced considerably on account of the construction of a number of barrages up-stream. The Prakasam barrage constructed at Vijaywada through which bulk of the river water is diverted for irrigation, leaves practically little for the Krishna estuary, especially during summer and winter months, converting the system more like a tide-fed estuary with average salinity of >18 ppt. Evidently, the low influx of freshwater has been a serious concern in this estuary, barring a brief period during monsoon. This singular factor has changed the whole gamut of ecology, biodiversity and fisheries of Krishna estuary, significantly. For a larger part of the year the salinity concentration lies between 20 and 35 ppt and thus altering the biotic communities from estuarine specific to marine specific. Accordingly, the fishery of the estuary is dependent largely on the marine migrants. This is further substantiated by the observed fishing operation, restricted to lower estuary, only. Mullet still remains the hallmark of Krishna estuary, as of now, but its population is also going down at a rapid pace. Other groups of fish found in the catch include clupeids, perches, scianedis, catfish, penaid prawns and crabs. The annual fish catch during 2004-06 has been estimated at 496.1-540 t with productivity ranging from 83.0 kg/ha to 90 kg/ha. The average catch per unit of effort has been generally low depending on the season, such as 13.6 kg/boat (post-monsoon) and 1.74 kg/boat (pre-monsoon).

The most glaring threat to the fishery of Krishna estuary has emanated from the dismal freshwater discharge into the system from the over-head dams.

GODAVARI

The Godavari estuary in Andhra Pradesh has two distinct distributaries, immediately below the Dowaliswaram barrage *viz.* the east flowing Gautami-Godavari estuary and south flowing Vashista-Godavari estuary. The total area

of the Godavari estuarine system has been estimated at 330 km^2. It is a positive estuary with a mean width of 1.5 km and an average depth of 13 m. Extensive mangrove swamps flank the Gautami-Godavari estuary and creeks, supporting lucrative prawn fishery (*P. indicus, P. monodon, M. monoceros*). In general, however, the Godavari estuary as a whole supports 23 prawn species, among which *M. monceros, M. dobsoni, M. brevicornis, P. indicus, P. monodon, P. semisulcatus, P. merguiensis* and *P. japonicus* are important from fishery point of view. In addition to this palaemonid prawns like *M. rosenbergii, M. malcomsonii, M. scabriculum, M. equidens, Palaemon tenuipes* and *P. styliferus* are also important, restricted to lower estuary only. In recent times, however, the stock of palaemonid prawns has declined due to poor ingress of freshwater from over-head dams and barrages.

Presently, the ecology and fisheries of Godavari estuary is under serious threat due to man-made encroachments, such as industries, natural gas wells and aquaculture practices etc.. Changes in landscape, topography, saline water incursion, tidal extensions, pollution hazards and damming of river up-stream have brought about significant alteration in this fragile ecosystem.

MAHANADI

Mahanadi estuarine system comprises two important estuaries of Orissa viz. Mahanadi and Devi (Map—). A number of dams, barrages, weirs and anicuts have been constructed across the main channel, reducing the freshwater flow, which in turn has affected the ecology and fisheries of the system adversely. The salinity concentration of the estuary varies between 0.6 to 18 ppt.

The fishery of the system indicated the dominance of scianeids followed by mullets, prawn, threat fins, perches and others, contributed by 96 species of fin fish and 10 species of shell fish. The species diversity differs with water depth and salinity concentration of the system. In general, however, relatively higher fish catch, coupled with higher diversity, has been recorded towards the sea mouth as compared to the freshwater stretch. Regulated freshwater flow, resulting in higher shoal formation thereby restricting the tidal ingress, has been the prime causative factor for the decline of fish and fishery in Mahanadi estuarine system. The system is becoming shallow due to poor flushing, which has further affected the fishery adversely.

CHILIKA

The pear-shaped Chilika lagoon (map—) is the largest lagoon in the east coast of India, situated between latitude 19° 28′ and 19° 54′ N and longitude 85° 05′ and

85° 38′ E. The lagoon has distinct marine, brackish and freshwater stands, but it is primarily an estuarine ecosystem. It is one of the hotspots of biodiversity inhabiting a number of endangered species listed in the IUCN red list of threatened species, and also is a designated Ramsar site. It is an avian grandeur and the wintering refuge for more than one million migratory birds. The highly productive lagoon eco-system with its rich fishery resources sustains the livelihood of more than 0.02 million-fisher folk and 0.8 million people living on its catchments.

The lagoon has a maximum length of 64.30 km, whereas the breadth varies between 5 km and 18 km. The water depth fluctuates between 0.38 m and 4.2 m. A total of 52 rivers and rivulets debouch into the lagoon draining a catchments area of 3560 square km. The water-spread area of the lagoon varies between 1165 and 906 km^2 during the monsoon and the summer, respectively.

Till, recently, the 32 km long, narrow outer channel connected the lagoon with the Bay of Bengal. But due to shoal formation along the lead channel the tidal influx into the lagoon had considerably been reduced leading to significant erosion in salinity regimes, which in turn had a cascading impact on the brackish-water flora and fauna. During 2000, a new mouth has been opened, reducing the length of the inlet channel by 18 km, so as to restore the salinity regime of the lake. This hydrological intervention has improved the fishery scenario significantly improving the fish yield manifold, which could be attributed to restoration of salinity gradients, augmentation of auto recruitment besides hassle free breeding migration of fishes, prawns and crabs from the sea into the lagoon and vise-á-versa. The Chilika lagoon has a profound impact on the socio-economics to the state of Orissa, both in terms of livelihood support and export earnings, since centuries. It supports a total of 12,363 fishermen families from 132 fishermen villages located in and around Chilika Lake. The lagoon is known for its marine, brackish and freshwater fisheries besides its reputation as one of the finest repositories of aquatic biodiversity including the dolphin and avian fauna. The lagoon is a potential source for high priced prawn and mullet fisheries contributing significantly to the livelihood security of a large fishing community and also to the overall economy of Orissa.

In the aftermath of the gradual closure of the old mouth, the lagoon had turned almost into a freshwater ecosystem, resulting in substantial change in species composition with significant enhancement in freshwater forms. The restoration

measures like opening of the new mouth, rehabilitation of Palur canal and de-siltation of the lead channel have rejuvenated the ecosystem with a substantial hike in fish catch (Fig.1)

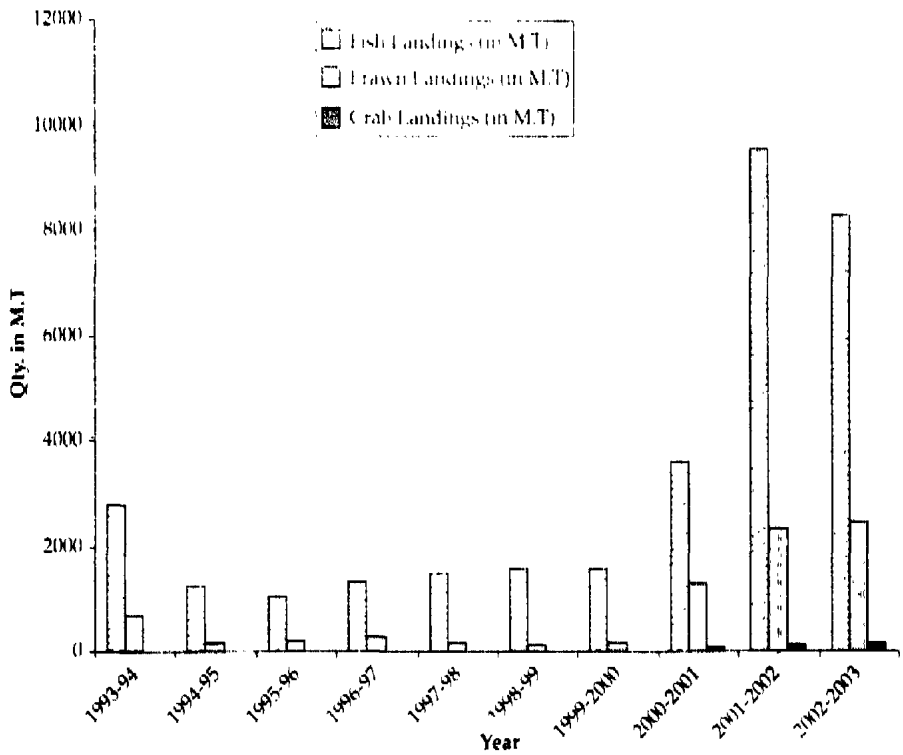


Fig. 1 : Trend of Fish Yield in Chilika Lake

The Chilika lagoon has several hydrological influences *viz.* (i) drainage from the unregulated but degraded catchments along the western and southern boundaries, (ii) drainage from the distributaries of the Mahanadi river delta to the north including the runoff, both from the delta itself and the upper Mahanadi catchments, and (iii) water exchange through the lake mouth with the sea, the Bay of Bengal. These hydrological connections are the key determinants on the character and ecological health of the lake. Any change in the nature of these hydrological attributes can lead to drastic and potentially unexpected consequences, as experienced due to the closure of the natural mouth during 1990s. In addition to hydrology, obstructing the fish recruitment passages through the construction of 'gheries' for prawn farming is another potential threat to the fishery of the lake. Chilika is a shallow lagoon with an average water depth of 1 m, as such plying of large number of boats, for tourism or fishing, with long shaft (>1.5 m) has affected the lake ecology and biodiversity adversely, as it churns the lake bottom continuously, making it turbid.

PULICAT LAKE

Pulicat Lake is the second largest brackish-water lake in India (13°26′and 13°43′ N latitude and 80°03′and 80°18′E) running almost parallel to the Bay of Bengal (Map—). It extends between Ponueri and Gumidi- pundi taluk of Thiruvallum district in Tamil Nadu and Sulurpet and Tada Taluk of Nellore district in Andhra Pradesh, covering an area of about 461 km^2. Presently, however, the lake has been reduced to < 350 km^2. The lake opens into the Bay of Bengal through a narrow passage at its Southern end, near the Pulicat town and at Sriharikota in the Northern side. It is a shallow lake with an average water depth of 0.7 m. Three larger inflows besides a number of minor inflows debouch the lagoon.

Salinity concentration of Pulicat Lake is observed ranging from 7.79 to 28.91 ppt (2008) as against a salinity concentration of 1.0-39.0 ppt in 1980s, indicating a reduction in the flow of freshwater as well as marine water into the system. This could be attributed to regulated discharge of freshwater and closure of bar mouth, especially in its Andhra Pradesh part.

Presently, the fisheries of Pulicat lake are largely depend on the catch of *P. indicus*, mullets (*M. cephalus* > *M. tade* > *M. canneaius* > *M. macrolaepis* > *Liza Persia*) and *Chanos chanos*. However, the dominant fishery of *Chanos chanos* in1970s & 1980s has become almost rare. The fisheries of *Plotosus canius*, *Sardinella* sp. and *Hilsa keele*, which were sizeable till 1980s have also declined significantly. The abundance of *P. monodon*, the tiger prawn, which was predominant during 1970s & 1980s has also declined to a negligible level. Other penaeid prawns of importance in the lake are *Metapeneaeus dobsonii*, *M. monoceros* and *M. brevicornis*. The Crab fishery (*Scyella serrata*) is very conspicuous, but its abundance as well as size at catch has declined, indicating over-fishing. The use of destructive gears, especially small mesh-bar nets, has lead to indiscriminate fishing mullets. The average catch per fisher per day has been estimated to be poor at 300 g to 500 g /day, mainly of *P. indicus*.

The Pulicat Lake has been subjected to a number of threats, such as high rate of siltation leading to periodic obstruction of the Bar mouth and reduction in effective water area, periodic closure of the Bar mouth due to shoal formation, considerable reduction in depth profile (av. 0.46 m) again due to siltation, greater colonization of macrophytes and reduction in sea-grass coverage, especially in Andhra region, poor mixing of fresh and marine waters and high rate of evaporation etc.

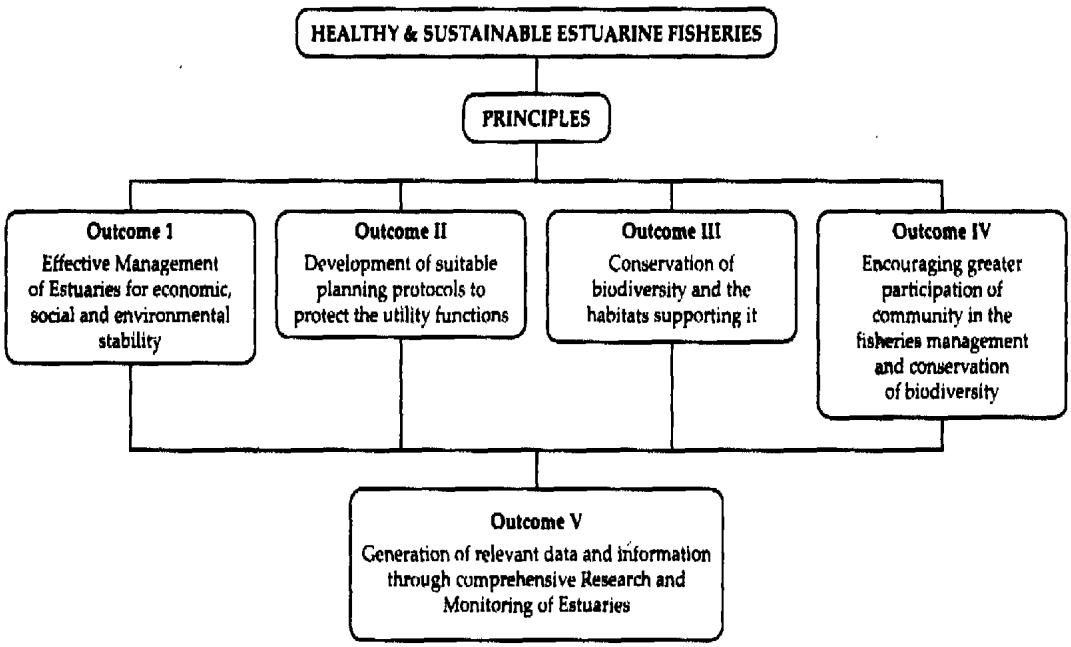
8. CIFRI VISION FOR ESTUARINE MANAGEMENT

CIFRI, being the custodian of estuarine research in the country, envisages the following vision for safe, healthy and sustainable fisheries through rational utilization of the estuarine resources on a long-term basis.

"Healthy & Sustainable Estuarine Environment & Fisheries for Posterity and Prosperity of the Present and the Future Generation"

9. STRATEGIES AND ACTION PLAN OF MANAGEMENT

The success of management strategies to achieve healthy and sustainable fisheries, expected from a healthy estuarine environment, lies on the implementation of sound principles and guidelines with clear-cut objectives and time-bound outcomes, such as:



OUTCOME- I

Effective Management of Estuaries for economic, social and environmental stability

Strategy & Action Plan -I

- Prioritization of activities, including the fisheries, in tune with other stakeholders for invoking suitable management protocols to achieve the

optimum results.

- Defining and describing estuaries and linking them with the adjacent habitats and ecosystems for better management
- Identifying the threats and problems faced by an estuary, focusing more on water quality caused by physical (shrinking of water spread, shoal formation, habitat loss or temperature), chemical (pollution & heavy metals, change in salinity, pH) or biological pressures (nuisance growth of plants, invasive species) for effective management.
- Ensuring and providing the minimum and maximum environmental flow needs for estuaries to conserve their biological integrity and fisheries
- Using the water and sediment quality factors in setting benchmark for environment and fisheries management in tune with the local, regional, national and international perspectives
- Following a coordinated approach with other partners to develop a framework of action plan to be used in an estuary, based on its ecological carrying capacity
- The fisheries management plans, protected area management plans, aquaculture policies or coastal area management plans should work in tandem in an integrated mode for effective estuarine management.
- Monitoring estuaries periodically with focused objectives to suggest remedial action plans for healthy estuaries and sustainable fisheries.

Strategy & Action Plan- II

- Using a range of tools provided under the Environment Protection Act (1935) and Costal Fisheries Act (2004) or any other relevant Act to address the issues related to pollution, affecting the estuaries
- Developing specific national policies for the protection of estuarine environment and fisheries
- Assessing the waste disposal facilities in and around estuaries and to identify the agencies having the responsibility to create such facilities. The waste disposal facilities need to be monitored regularly, to keep them functional

- Better management of water affecting activities in riparian areas, in-stream and estuarine habitats
- Ensuring flow control structures, in the catchments and within the estuary and providing adequate flow and fish friendly pass/crossings so that they do not interfere with the tidal exchange, estuarine flow or fish species migration
- Ensuring no seawater incursions affecting estuaries or associated habitats due to groundwater extraction
- Preventing changes to water regimes that may affect inter-tidal sand and mud flats, which provide ideal habitat for shorebirds
- The estuaries and associated ecosystems need effective guidelines for recreation and tourism, such as recreational and commercial boating, recreational fishing etc. In this context the following recommendations merit consideration :
  - Reducing the recreation and commercial impacts on estuaries
  - Introduction of suitable crafts, such as plying of boats with less fuel fouling or shorter shaft boats
  - Effective steps to minimize soil erosion through plantation or preserving the mangrove areas
  - Preventing the obstruction or destruction of passage for fish recruitment or critical fish habitats
  - Not disturbing or killing the rare biodiversity like dolphins, tortoise, fish etc. of local, regional, national or international importance
- Developing ecosystem based 'Fishery Management Plans' by encouraging Greater peoples' participation in tune with the interest of traditional fishers
- Enforcing effective and strict management protocols at ports in relation to appropriate disposal of wastewater, arising out of port activities, through stringent efficient regulations with regards to refueling of vessels, ballast water, sewage and other waste materials.

OUTCOME- II

Development of suitable planning protocols to protect the utility functions

Strategy & Action Plan

- Ensuring that all the developmental plans carried-out in the catchments, which affect the estuarine environment and fisheries, should have a strong component to address the environmental issues related to the estuaries.
- Ensuring the integration of estuarine habitat into the coastal zone development plans with specific guidelines for the management of estuarine fisheries
- Creation of a 'riparian zones' or 'set-back distances' under the control of a Government Agency to avoid non-essential developmental activities in those areas to keep the estuaries free from avoidable encroachments.
- Ensuring retreats of habitation or other developmental activities near or within the estuaries to cater for climate change, sea level rise and land subsidence within the estuaries.

OUTCOME- III

Conservation of biodiversity and the habitats supporting it

Strategy & Action Plan

- Earmarking certain estuaries with unique biodiversity for their conservation together with the habitat and biota.
- Developing a comprehensive action plan for the protected estuaries and bring the relevant estuaries and associated ecosystems under the national or international protection, such as Ramsar sites like Chilika Lagoon.
- Protecting the biodiversity of national or international importance like dolphin, alligators, tortoise or fish.
- Ensuring the protection of breeding and nursery areas as well as the migratory routes of important fish species for effective recruitment thereby good fishery.

OUTCOME-IV

Encouraging greater participation of community in the fisheries management and conservation of biodiversity

Strategy & Action Plan

- Developing estuarine awareness literature in local languages to educate the target groups highlighting the following:
  - The values of estuaries
  - Appropriate land use practices in the catchments as well as adjacent areas of each estuary
  - The impact of habitat destruction or alteration on biotic communities, including the fishery
  - The impact of pollution on estuarine biota and fishery
  - The importance of maintaining the connectivity between a estuary and the sea
  - The wise use of nets and gear for responsible fishery
- Convening regional or national level consultations, periodically, to discuss various issues related to estuaries
- Developing study materials and documents for inclusion at the primary, secondary and tertiary levels of education curricula for better understanding of estuaries among the students
- Raising the level of communication with the up-stream land users on the impacts of land use practices on estuarine environment and fisheries, so as to support better management of estuarine resources

OUTCOME-V

Generation of relevant data and information through comprehensive Research and Monitoring of Estuaries to support effective management of estuaries

Strategy & Action Plan

- Reviewing the status of current knowledge-base on estuaries to identify critical gaps and priorities for improved management of estuarine environment and fisheries
- Pooling up the available estuarine dataset and other information to work-out the trends on ecology, biodiversity and fisheries, over the years
- Establishing an estuarine monitoring program at the level of a national Institute like CIFRI as well as at the level of State Governments to monitor the state and condition of a particular estuary for better management and conservation of estuarine resources, including the fishery
- Ensuring periodical check and balance of estuarine programmes to assess the success or failure of specific management protocol for midterm correction
- Developing effective partnership between the State Department of Fisheries and Research Institutions to undertake research on critical areas of estuarine environment and fisheries
- Investigating the importance of mangroves and other vegetations in relation to the ecological and fisheries stability of estuaries
- Investigating the socio-economic values of estuaries, especially in relation to traditional fishers, in the backdrop of recent mechanization of gear.

10. ROLE OF VARIOUS AGENCIES IN THE IMPLEMENTATION OF ESTUARINE POLICY

The success of estuarine policy would depend on its effective implementation at the ground level, involving a number of agencies. It would, therefore, necessitate defining and earmarking the role of each agency. Further, as the rational management of estuarine environment and fisheries is highly complex in nature, it is essential to involve a number of stakeholders who have to execute their part effectively for rational estuarine management. The action points allocated to various agencies/stakeholders have to be monitored at the national level, either by Ministry of agriculture/ICAR or Ministry of Environment and Forest or a creating a seperate nodal agency, drawing experts from the concerned Ministries. Broadly, the role of each participating agency/stakeholders can be, as under:

	ROLE
State Governments: Departments of Environment & Forest, Fisheries, water resources, Irrigation, etc.	■ Formulation & implementation of laws in accordance with the estuarine policy on environment and fisheries ■ Creation of a separate cell for implementation & monitoring of estuarine policy guidelines ■ Creating awareness among the target groups on the importance of estuaries
Research Organizations: CIFRI, NBFGR, ZSI, BSI, Universities, etc..	■ Research on critical areas of estuarine environment and fisheries as policy support ■ Monitoring of various estuaries of the country in relation to fisheries and biodiversity and suggesting restoration measures in accordance with specific threat perception ■ Developing protocols on environment and fisheries management for estuaries
Govt. of India: Ministry of Agriculture, Ministry of Environment, Ministry of Water resources, etc.	■ Funding relevant projects and Monitoring of Progress of various activities pursued by different agencies
Polluting Industries	■ Ensuring safe disposal of waste materials by adhering to environmental norms
Fishers and other users	■ Protecting the biodiversity by adhering to the principle of responsible fishery