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FISHERIES ENHANCEMENT AFTER HYDROLOGICAL INTERVENTION IN CHILIKA LAGOON AND STRATEGIES FOR RESPONSIBLE MANAGEMENT

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Chilika lagoon situated in the state of Orissa on the east coast of India is a hotspot of aquatic biodiversity including fish germplasms. Fishery yield from the lagoon contributes 71% to the total economic valuation of the ecosystem. The ecosystem suffered rapid degradation during the last few decades due to anthropogenic pressure and natural changes. Fish yield from mid-eighties onwards until hydrological intervention made by Chilika Development Authority during September, 2000 showed declining trend, registering lowest ever landings of 1274 t during 1995-96 and 1746 t in 1999-2000, immediately before opening of the new lagoon mouth. The opening of artificial mouth by dredging the sand spit reduced the 1ength of outer channel by 18 km. The hydrological intervention has resulted in many positive impacts such as spectacular increase in fishery yield and biodiversity, improvement in overall salinity regime, natural eradication of freshwater weeds, flushing out of silt etc. Sudden increase in fishery yield during 2000-01 immediately after opening of the new mouth registered 185.42% increase over the pre-mouth base year (1999-2000) and an all time high yield of 11,988.88 t during 2001-02, showing 586.74% increase over the base year has been recorded whose economic valuation was estimated at Rs.571.6 million. The average fishery yield for three years (2000-01 to 2002-03), economic valuation of fish catch, fishery diversity, migratory fish component, commercial fish groups, average productivity, per capita income and catch per unit effort (CPUE) during the post-mouth period registered 432.06%, 621.47%, 19.85%, 7.20%, 42.86%, 482.59%, 373.15% and 432.27% increase, respectively over the base year, 1999-2000.

INTRODUCTION

Chilika lagoon, the largest coastal wetland ecosystem and a Ramsar Site in the sub-continent, situated in the state of Orissa on the east coast between 19°28′ and 19°54′ North latitude and 85°05′ and 85°38′ East longitudes is a hotspot of aquatic biodiversity including fish germplasms. The lagoon has been a steady source of fishery which has been providing food and livelihood security to more than 0.15 million people living in and around the lagoon. Fisheries resources of the lagoon have remained the biggest contributor with 71% to the economic value of the ecosystem in terms of user benefits.

The ecosystem suffered rapid degradation during the last few decades due to incessant anthropogenic pressure and natural changes and, in the process, the fisheries resources became the worst casualty. The ecosystem degradation was largely contributed by rapid siltation, shifting of mouth north-eastward increasing the outer channel length to more than 30 km, decrease in salinity regime, increase in invasive species, aquaculture activities reducing the capture fishery areas, eutrophication, excessive extraction of bioresources, explosive growth of freshwater weeds and overall loss of biodiversity. Chilika was included in the Montreux Record (threatened list of Ramsar Sites) in 1993. The summer water spread area (WSA) as per Last Sat-5 data dated 25.5.1986 was 790 sq km showing 4.3% shrinkage over 1972-73. The weed covered area in 1993 became 398 sq km (CDA, 2002). The enhancement process of the degradation of the lagoon ecosystem together with human-induced activities like unregulated excess fishing pressure, illegal prawn ghery aquaculture within the ecosystem, agricultural activities etc. largely contributed to the fast decline in fish landings/yield. Thus, the serious eco-degradation process and adverse impact on its bio-resources called for responsible interventions to restore the ecosystem and its living aquatic resources.

HYDROLOGICAL INTERVENTION

In the process of eco-degradation, both environmental values and resource development opportunities were threatened by the potential loss of the marine influence and lagoon characteristics. The Chilika Development Authority (CDA) which was established in 1992 as a Nodal Body for the overall development of the lagoon commissioned the services of premier Scientific Institutes of the country and abroad to identify critical reasons for eco-degradation and to gather data essential for formulation of a sustainable comprehensive management plan. The data generation indicated that due to choking of outer channel and its mouth opening into the sea, the exchange of water between the sea and the lagoon is gradually decreasing, affecting the biodiversity of the lagoon (CDA, 2004). CDA commissioned the services of the Central Water and Power Research Station (CWPRS), Pune to address this problem who recommended to desilt by dredging the silt-choked link between the outer channel and the lagoon proper near Magarmukh which is considered as the gateway between Chilika and the sea (Pattnaik, 2001).

Following the recommendations of CWPRS, an artificial mouth was opened on 23rd September, 2000 which reduced the length of the outer channel by 18 km being located at a shorter distance of only 11 km from the Magarmukh. Desiltation of a 3.2 km lead channel at Magarmukh was completed before opening of the new mouth. The environmental impact assessment (EIA) was also carried out by NIO, Goa before and after opening of the new mouth. Regular monitoring results indicated that after the opening of the new mouth there have been marked improvements in the water quality particularly,

the salinity regime and there have been substantial increase in fish, prawn and crab production as well as species diversity including the reappearance of the threatened species (CDA, 2004). The lead channel at Magarmukh has been further extended up to the river confluence in the northern sector during 2002-03. The Palur canal is currently under renovation to re-establish free flow of water between the southern sector and the Rushikulya river mouth.

FISHERIES SCENARIO BEFORE INTERVENTION

The Chilika lagoon lost its pristine glory of having rich fishery resources in the face of continued human-induced activities coupled with natural upheavals. The distinct sign of aberration in production functions at all trophic levels, particularly the adverse impact on fishery yield, catch composition, biodiversity etc. Continued decrease in fisheries output during last one and half decade before the hydrological intervention brought miseries to the traditional fishing communities. The fisheries resource of the lagoon which largely depend on the migratory species (more than 70%) became seriously affected during the eco-degradation phase when the recruitment from the sea decreased due to shifting of lake mouth, silt choking at the Magarmukh and siltation of the Palur canal.

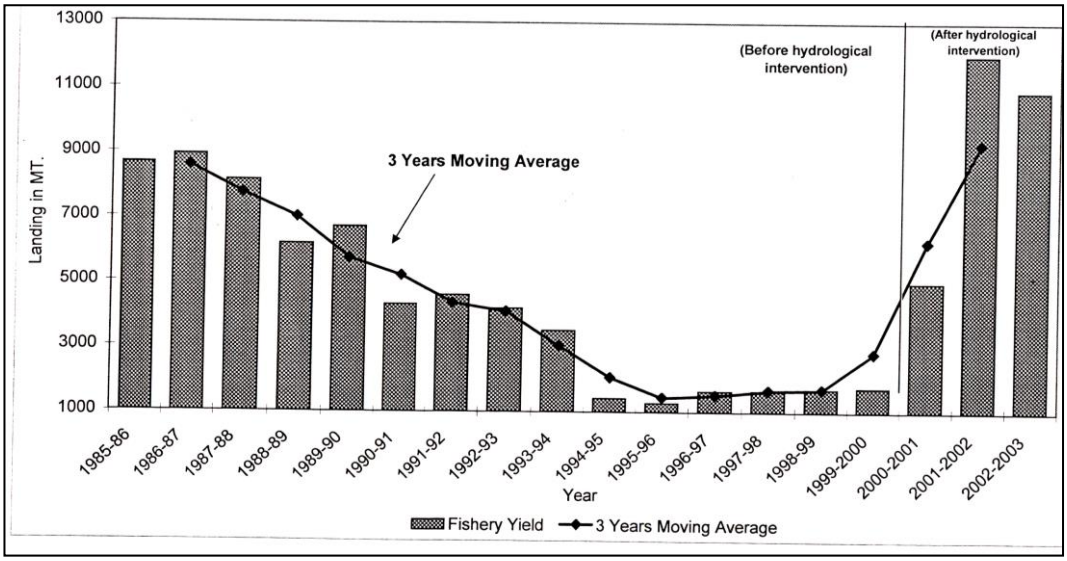
FISH ECOLOGY AND BIODIVERSITY

The freshwater flow from rivers and western catchments into the northern sector of the lagoon during monsoon and salt water influx from the sea with moderate tidal amplitude exhibit the characteristics of a normal estuary with high hydrological variability between dry and flood season which leads to succession of fish and crustacean faunas from marine and freshwater origin depending on the seasons. The high species richness which results mostly from antagonistic hydrological process got adversely affected due to weak water exchange at Magarmukh, the link between the outer channel connected to the sea at a longer distance of about 30 km and the lagoon proper. Hydrodynamics and hydrochemical properties structure the fish population/communities and their distribution in the lagoon, which was affected during eco-degradation period and the freshwater elements particularly the weed/forage fishes.

The faunal records for fish, prawn and crab prior to 2000-01 were 225, 24 and 28 species, respectively, which indicated that 112 fish species in 58 years, and 4 prawn species and 2 crab species in 84 years were added to the fauna of the Lake (Table 1). However, no inventorial survey to verify the actual occurrence of fish and crustacean species had been undertaken before the eco-restorative measures were taken by CDA in 2000.

Fishery yield

Fish, prawn and crab components constitute the lagoon fishery and in total 21 groups/species (14 fish, 5 prawn and 2 crab) formed the commercial fishery before intervention. Decadal average fish yield during 1980's and 1990's worked out to 7206.2 t and 2586 t, respectively, registering 178.7% decrease. The highest ever yield of fish, prawn and crab components before the recent hydrological interventions were 7283 t (1986-87), 1862.53 t (1965) and 141.4 t (1983-84), respectively. The highest fishery yield of 8926 t was recorded during 1986-87 and thereafter started declining rapidly to register the lowest ever yield of 1274 t during 1995-96. During the period 1995-96 to 1999-2000 (immediately before the opening of the new mouth) the low fishery yield continued with minimum fluctuation in the range of 471.75 t. Thus, two distinct scenarios of fishery yield during 1986-87 to 1999-2000 are seen (Fig. 1). The average yield of fish, prawn and crab during the last three years before the opening of the new mouth were 1534.68 t, 155.61 t and 9.71 t, respectively (Table 2). Fisheries productivity and catch per unit effort (CPUE), averaged for three years before opening of the new mouth were estimated at 1.84 t/km^2 and 1.13 kg/boat/day. Economic value of fishery yield and per capita income during 1999-2000 (before new mouth) were estimated at Rs.64.5 million and Rs.3362, respectively (Table 1).



FISHERIES SCENARIO AFTER INTERVENTION

During the last three years (2000-01 to 2002-03) after the hydrological intervention, spectacular enhancement in the lagoon fisheries has been noticed.

Fishery yield

Year-wise fishery yields during post-intervention period show high percentage increase over the base year of 1999-2000 (pre-mouth) ranging from 185.4-586.7 and the average yield for three years after opening of the new mouth registers 446.4% increase over the average yield for three years immediately before opening of the new mouth (Table 2). Average yield growth in the individual components of fish, prawn and crab after new mouth over those of pre-mouth period were 364.55%, 1211.58% and 1116.68%, respectively. Average productivity, catch per unit effort (CPUE) and per capita income after opening of the new mouth registered 445.7%, 390.3% and 373.1% increase over the pre-mouth period (Table 1). Fishery yield of 11,988.88 t during 2001-02 was the all time high record.

Economic values of fishery yield during 2000-01 to 2002-03 after opening of the new mouth ranged from Rs. 341.75-571.60 million as per prices prevailing at the landing centres of the lagoon. The average value for three years yields after new mouth (Rs.465.35 million) registered 421.5% increase over the economic value worked out for the base year (1999-2000) as furnished in Table 1.

Table 1. Fisheries enhancement in Chilika lagoon after hydrological intervention

Assessment parameter	Species record up to 1999	New record during 2000-03	Total	% Increase
Fisheries constituents and faunal diversity				
Fish	1941-99: 225 (112 in 58 yrs)	43	268	19.11
Prawn	1915-99: 24 (4 in 84 yrs)	4	28	16.66
Crab	1915-99: 28 (2 in 84 Yrs)	6	34	21.43
Lobster	No record	2	2	00.00
Total	277	55	332	19.85
Faunal inventorization (Diversity verification)	Not done	Done		
Fish	-	180		67.16
Prawn	-	13		46.43
Crab	-	12		35.29
Lobster	-	2 (New)		100.0
Migratory and resident/endemic (Relative abundance)				
Migratory (%)	73.32	78.60		+ 7.20
Resident (%)	26.68	21.40		- 19.79
Commercially important species/groups				
Fish (group)	14	20		42.85
Prawn (No)	5	7		40.00

Crab (No)	2	3	50.00
Total	21	30	42.86
Fishery yield (MT) (Fish, Prawn & Crab) (Average for 3 Years)	1997-1998 to 1999-2000	2000-2001 to 2002-2003	
Fish	1534.68	7129.38	364.55
Prawn	155.61	2040.95	1211.58
Crab	9.71	118.14	1116.68
Total	1700.00	9288.47	446.38
Economic value of fishery yield (in million rupees)	64.50 (1999-2000)	465.35 (Av. for 3 Years)	621.47
Economic valuation of Chilika lagoon (ecosystem) & Contribution of Fisheries Yield. (Rs. in million)	Not done	2001-2002	
Fisheries		583.8 (71.24%)	
Aquatic plants		19.7 (2.40%)	
Inland navigation		5.6 (0.68%)	
Tourism		210.4 (25.68%)	
Total		819.5 (100.00%)	
Av. productivity (fisheries) in MT sq km^{-1}	1.84 (1997-98 to 1999-2000)	10.04 (2000-01 to 2002-2003)	445.65
Catch per Unit Effort (CPUE) – kg. $Boat\text{-}day^{-1}$ (average for 3 years)	1.13 (1997-98 to 1999-2000)	5.54 (2000-01 to 2002-2003)	390.26
Per-capita income (Rs.)	3362 (1999-2000)	15907 (2000-01 to 2002-2003)	373.14
Re-appearance of threatened species	Six species were almost missing:		
	Hilsa *(Tenualosa)* ilisha	Re-appeared and formed fishery	
	Elops machnata	Re-appeared and formed fishery	
	Rhinomugil corsula	Re-appeared and formed fishery	
	Chanos chanos	Re-appeared and formed fishery	
	Megalops cyprinoides	Re-appeared and formed fishery	
	Acanthopagrus berda	Reappeared and yet to form fishery	

Table 2. Fishery yield from Chilika lagoon before and after opening of the new mouth

Year	Fish	Prawn	Crab	Total
Before opening of new mouth				
1997-98	1491.99	149.51	10.40	1651.90
1998-99	1555.75	136.93	9.68	1702.36
1999-2000	1556.32	180.40	9.03	1745.75
Average	1534.68	155.61	9.71	1700.00
After opening of new mouth				
2000-01	3592.97	1296.23	93.54	4982.74
2001-02	9530.03	2347.78	111.07	11988.88
2002-03	8265.16	2478.82	149.81	10893.79
Average	7129.38	2040.95	118.14	9288.47
% increase	364.55	1211.58	1116.68	446.38

RELATIVE CATCHES OF DOMINANT GROUPS/SPECIES

Relative average catch of twelve fish groups, five prawn species and one crab group (mud crab) during both pre and post-new mouth positions are shown in Table 3, which indicated that the clupeoides contributed highest (27.67%) followed by catfishes (16.17%) during post-mouth period. Mullets, perches, croakers etc. constituted 2.69%-10.01% of total catch. Similarly, the *Metapenaeus monoceros* registered highest catch (31.58%) followed by *M. dobsoni* (29.23%). *Penaeus monodon* and *Fenneropenaeus indicus* formed 12.24% and 13.30% of total crustacean yield, respectively. In all cases, positive growth over pre-mouth data was indicated ranging from 61.48% to 804.08% among fishes and 814.06% to 1577.54 % among crustaceans.

Faunal diversity and recruitment enhancement

Recent accounts on the fish and crustacean faunas of Chilika lagoon are given by Rao (1995), Reddy (1995), Maya Dev (1995) and Bhatta *et al.* (2001). Mohanty (2002) has reported the updated position of fishery biodiversity of Chilika lagoon and the progress of inventorization. During the last three years (2001-01 to 2002-03) after opening of the new mouth, the desilted outer channel between the mouth and Magarmukh functioned as the main recruitment route which resulted in a far earlier recruitment of prawn and crab seed into the lagoon, and their retention for a far longer period, presumably due to the maintenance of higher salinities for longer periods. Densities of prawns and crabs in the lagoon were far higher compared to data from pre-intervention years. During the post-mouth period, 43 fish, 4 prawn and 6 crab species were recorded as new to the fish and crustacean faunas of the lagoon. For the first time, two lobster species (*Panulirus ornatus* and *panulirus polyphagus*) have been recorded from Chilika lagoon and were added to the

fauna of the Chilika lake, making the total record of fish and crustacean species to 268 and 64, respectively, which indicated 19.85% increase over the pre-mouth data. Many marine species from the sea entering into the outer channel are being retained for longer duration due to prevalence of marine salinity during the late winter and summer indicating high species richness (SR) during the period.

Table 3. Fish and crustacean landings in Chilika lagoon before and after hydrological intervention

Group/species of commercial importance	Average landing for three year before the hydrological intervention (1997-98 to1999-2000)		Average landing for three years after the hydrological intervention (2000-01 to 2002-03)		Growth (%)
	Quantity (tones)	Composition (%)	Quantity (tones)	Composition (%)	
Fish					
Mullets	158.02	10.30	640.40	8.98	305.26
Clupeids	365.40	23.81	1973.04	27.67	439.97
Perches	147.03	9.58	237.43	3.33	61.48
Polynemids	67.71	4.41	319.94	4.49	372.51
Sciaenids	108.92	7.10	713.78	10.01	555.32
Beloniformes	71.17	4.64	244.98	3.44	244.22
Catfishes	187.22	12.20	1153.00	16.17	515.85
Tripodfish	47.59	3.10	430.25	6.03	809.08
Cichlids	96.09	6.26	353.54	4.96	267.92
Murrels	55.87	3.63	191.91	2.69	244.11
Featherback	90.26	5.88	327.32	4.59	262.64
Others	139.41	9.09	543.79	7.64	290.07
Total fish	1534.69	100.00	7129.38	100.00	364.55
Crustacea					
Penaeus monodon	21.65	13.09	264.33	12.24	1120.92
P. indicus	24.33	14.72	287.19	13.3	1080.39
Metapenaeus monoceros	40.65	24.58	681.92	31.58	1577.54
M. dobsoni	69.04	41.75	631.07	29.23	814.06
Total (Penaeid prawns)	155.67	94.14	1864.51	86.35	1097.73
Non-penaeid prawns (*Macrobrachoum* sp.)	NA	--	176.43	8.17	
Total prawns	155.67	94.14	2040.94	94.52	1211.07
Mucrabs (*Scylla* spp.)	9.7	5.86	118.14	5.48	1117.94
Total crustacea	165.37	100	2159.08	100	1205.6

In the process of continued ecological degradation of the Chilika lagoon during the last few decades, six fish species namely, *Chanos chanos, Megalops cyprinoides, Elops machnata, Acanthopagrus berda, Hilsa (Tenualosa) ilisha* and *Rhinomugil corsula* had almost disappeared and rarely observed in catches. These threatened species have re-appeared in the lagoon after hydrological intervention (Mohanty *et al.,* 2004)

RESPONSIBLE MANAGEMENT STRATEGIES

Aquatic resources, although renewable, are not infinite and need to be properly managed. This is more in dynamic aquatic ecosystem with estuarine character. Destructive fishing methods practiced by the local fishers in the Chilika lagoon are likely to degrade the habitats to a point where they can no longer support a rich variety of aquatic species. In order to gain long-term benefit from the fisheries resources, particularly the livelihood security for a large population depending on fishing in the lagoon, greater emphasis has to be attached to the restoration of fish stock to a maximum sustainable level. Recognizing the long-term sustainable use of fisheries resources as the overriding objective of conservation and management, appropriate measures, based on the best scientific evidence available, which are to be designed to maintain or restore stocks at level capable of producing maximum sustainable yield, as qualified by relevant environmental and economic factors (FAQ, 2003). Before conceptualizing the responsible management measures for the fisheries resources of the Chilika lagoon, presently practiced destructive fishing methods in the lagoon need to be identified and discussed.

Since more than 70% of fish and prawn stock and almost 100% crab stock of the lagoon are contributed by migratory species and their seed recruitment takes place from the sea, the basic approach to implement ecosystem-oriented management option is to allow successful recruitment by protecting the brooders and juveniles. This could be achieved by restoration of unobstructed migration routes of commercially important fishes, prawns and crabs, protection of spawning grounds for anadromous and resident/endemic species and keeping the recruitment areas/routes free from excess fishing pressure. However, complete removal of illegal prawn culture 'gheries' (large units of pen culture), manipulation of gear selectivity, mesh size regulation in fishing gears etc. will have relevance to the fish stock management through conservation measures. If the penaeid prawn stock in the adjacent coastal water is intensively exploited by trawlers, there may be recruitment failure in spite of favourable environmental conditions. As pointed out by Jhingran and Natarajan (1968, 1969), the problem of over-fishing and depletion of stocks will assume ominous overtones if their intensive exploitation is undertaken in coastal waters. Increase in fisher population by many folds, larger interest among fishing communities to intensify prawn capture due to its high unit price in the international markets and absence of fishing regulation and conservation measures are the basic reasons for destructive fishing practices. The destructive fishing

practices in the lagoon includes: Khanda (net box) fishing in intensive manner at the recruitment areas/routes (Magarmukh, Outer Channel, Palur canal etc.); illegal seed fishery of *P. monodon* in the outer channel and Palur canal and consequential huge loss of by-catches; intensive trap fishing in Palur canal; mass killing of juveniles of economic mullets (*Mugil cephalus* and *Liza macrolepis)* in the outer channel during their lake-ward migration (recruitment) in July-August; mass killing of mullet broodstocks (*M. cephalus* and *L. macrolepis*) in the outer channel during the sea-ward spawning migration from October-January; large-scale capturing of juveniles of commercially important fishes (threadfins, croakers, seabass, pearlspot, milkfish etc) by Khanda fishing, small-meshed drag/seine nets etc.; and killing of juveniles of *P. monodon* (6-16 g) and juveniles/young mud crabs (5-50 g) by Khanda fishing almost throughout the year.

With a view to adopting measures for the long-term conservation and sustainable use of fisheries resources of Chilika lagoon which has significantly improved after hydrological intervention in 2000, the following strategies are contemplated.

- Conservation and management decisions should be based on the scientific evidence/information available, also taking into current traditional knowledge of the resources and habitats as well as relevant environmental, economic and social factors.
- Research and data collection to improve scientific and technical knowledge of fisheries including their interaction with the ecosystem should be prioritized. Complete and reliable statistics on fish catch and fishing effort are of vital importance, which are to be collected and maintained on continual basis. In order to achieve social and economic objectives of sustainable fisheries management, detailed and reliable socio-economic survey of villages situated in and around the lagoon should be completed as early as possible.
- Participation of the local communities/fishers resource users in the effort to protect the habitats and fish biodiversity from human activities that threaten the health and availability of the fishery resources should be given more importance.
- Local fishing communities as well as non-governmental organizations (NGOs) should work to build local community networks and bolster their sense of empowerment, allowing them to challenge the vested interest groups and to cooperate and participate in the strategic development and management process which could prove co-management of fish resources to be a successful strategy.
- Scientific research has to involve multiple partners (fishers, fish traders, government agencies, NGOs, researchers and research institutes etc.) in testing of new ideas/undertaking research concerned with producing more fish in a sustainable manner and with conserving the ecosystem.

- Promoting local strains of fish and other aquatic animals that are resistant to disease and which are more prolific in their growth and reproductive abilities, and to eliminate invasive species is important to sustaining fragile eco-system like Chilika lagoon.
- Existing excess fishing capacity and nature has to be assessed reliably and mechanism to be established (enforcement of legislation, capacity building, awareness campaign, NGO network effort, regular monitoring of fishing capacity etc.) to reduce the capacity to levels commensurate with the productivity capacity of the fishery resources to promote responsible fisheries through economic fishing.
- It should be ensured that the livelihood and rights of local fishers and their access to fishing grounds in the lagoon are not negatively affected by aquaculture development in the lagoon. 'Ghery' prawn aquaculture activity in large-scale has multi-dimensional negative impacts on the ecosystem and capture fisheries of the lagoon (economic deprivation of traditional fishers, damages to the spawning grounds, blockage of recruitment and migration routes, reduction in fishing areas, obstructions in inland navigation, enhancement of siltation process, alteration in shoreline configuration, transmission of shrimp disease virus (WSSV) etc.).
- Enforcement of legislation and effective dissemination through publicity, education and awareness the laws, regulations and legal rules to prevent destructive fishing practices and to promote good practices should be given due importance.

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