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**ROOT CAUSES OF BIODIVERSITY LOSSES
IN CHILIKA LAKE**

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1. INTRODUCTION

Chilika lake is the largest lagoon in Asia on the east coast peninsular India covering about hundred thousand hectares of land, one among six Indian wetlands declared under the Ramsar convention in 1982. It is a very rich preserve of ecological diversity with over four hundred vertebrates of both brackish and fresh water species, over one million migratory waterfowls and shore birds gathering during winter, with several recorded endangered and threatened and vulnerable species. Being a very large lake with a drainage basin of over four thousand three hundred sq. km, it links with fisheries the lifeline of over hundred thousand fisherfolks, as well as contributing to India's foreign exchange balance through export of prawn and fish and tourism.

Though severe ecological degradation has been observed here over time, not much attention has been given to it at the local, national and international levels. Normally, forest degradation, human interference such as market orientation and changing international scene are portrayed as the main causes for such degradation. The truth of the matter lies in understanding

various direct and indirect causes at the local, regional, national and global levels, on a relative basis. Such an approach alone can throw some light on the right direction of policy formulation for better preservation of this pristine biodiversity.

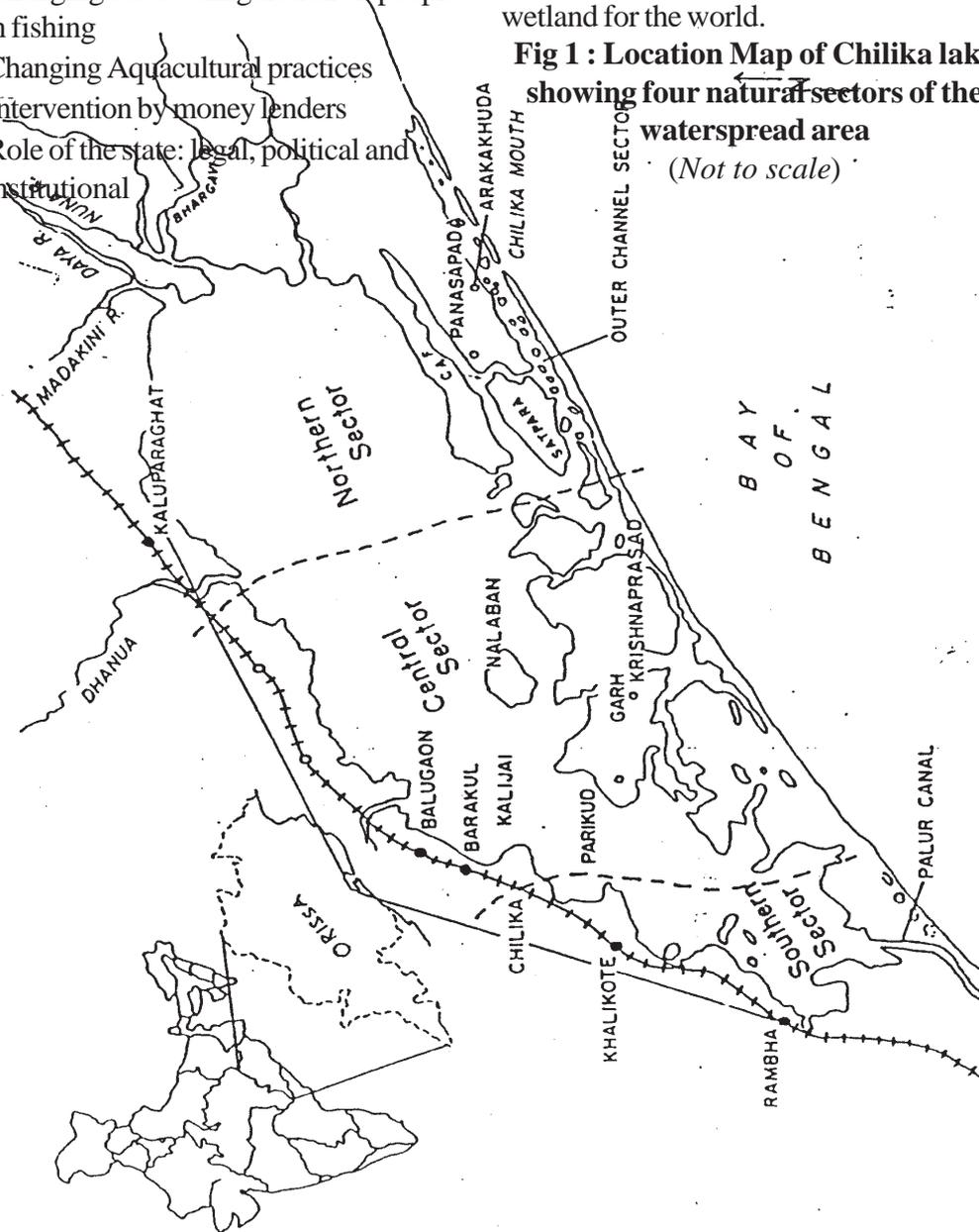
Like many wetland situations all over the world, Chilika lake is also subjected to a multiplicity of pressures and impacts, ranging from local to global in geographical scales, impacting over short to very long periods, with ultimate effects on the socio-economic state of development in India. All these are partly driven by market forces and partly due to socio-political situations and compulsions. In each case, different sets of root causes of biodiversity changes are identifiable. Specifically, some of the plausible socio-economic root causes of biodiversity losses in Chilika lake are:

- ◆ Population growth
- ◆ Urbanisation and industrialisation
- ◆ Pressure on land, conversion of lake area to agriculture
- ◆ Intensification of land use and changing cropping pattern
- ◆ Deforestation in the catchment

- ◆ Increased demand for fish and prawn
- ◆ Pricing and growth of market system
- ◆ Caste conflicts
- ◆ Changing caste configuration of people in fishing
- ◆ Changing Aquacultural practices
- ◆ Intervention by money lenders
- ◆ Role of the state: legal, political and Institutional

Therefore, with a backdrop of such highly diversified and plausible root causes, it makes it important to study this wetland more closely with a view to save this wetland for the world.

Fig 1 : Location Map of Chilika lake showing four natural sectors of the waterspread area
(Not to scale)



Methodologically it is far too complex to point out at a unique set of 'root causes' of biodiversity losses in this wetland. One of the major findings of this study is the fact that the root causes of ecological changes in Chilika lie outside of the natural ecological changes. They themselves do not seem to have brought so much degradation as the case has been made to be. The study brings out very clearly that the major root causes, in order of their importance, are population dynamics, globalisation and aquacultural technology, and lastly if any, forest degradation or other ecological changes. This is an extremely exceptional finding. The major conclusion is that the root causes for biodiversity changes of the lake lie in the socio-economic aspects of the region. The significance of population pressure on the lake and land ecology is to be seen from the point of sustainable regional and human development. Excessive population concentration in prawn culture areas over the years has brought lot of pressure on the lake in terms of over-fishing and extended agriculture in the lake margins. Together with the recent development of marketisation and globalisation, at the cost of local benefits, the national and global benefits have attained over-riding importance, thereby affecting the lake ecology significantly.

2. SITE DESCRIPTION

This wetland is actually an estuarine lake or lagoon because of its connection with the Bay of Bengal. Hemmed in between

the green hills in the south and the sea in the north-east, the lake is dotted with numerous small rocky islands with their reflections on the still water enhancing its pristine beauties exceedingly picturesque. It is this beauty which has for centuries fascinated the people of the region and all over the world, found references in the folklore and literature as well. For over a century, it has attracted the attention of biologists, fishery scientists, geologists, oceanographers, planners and administrators, and in recent years of ecologists, naturalists and conservationists.

The lake is about 64.5 km long (NE-SW) with the width varying from 18.5 km in the northern part to 5 km in the southern part. The lake has a major link with the sea, the Bay of Bengal, on its southern end through an irregular 29 km long channel (starting from Satapada) with several small sandy and usually ephemeral islands. About 1.5 km wide, the channel runs parallel to the sea and is separated from it by a very narrow spit, 183-274 meter wide, locally known as *Magarmatha Muhan*. The lake also has another link at its southern end (through Palur canal starting from Rambha bay upto the mouth of estuary of Rishikulya river lying about 18 km down the coast), and is separated from Chilika by low lands, some of which are used as salt pans.

Several small islands can be seen in the lake, specially in the Central and Southern sectors. Largest among them, Nalbana, a low lying flat marshy island 35

km long, covered with low vegetation, has been designated as a bird sanctuary since 1973 and represents the only protected part of the lake. Generally, it is completely submerged after the monsoon. Several rocky islands in the southern sector such as, *Kalijai*, *Somolo*, *Dumkudi*, *Honeymoon*, *Breakfast* and *Bird island* etc., represent the inundated remnants of the Eastern Ghats. On the coastal side, there are many islands made up of entrenched sand dunes covering about 728 sq. km. area.

The drainage basin of Chilika lake lie between the rivers flowing into Mahanadi and Chilika in the north, while in the north-east, areas draining into the Bhargavi river make up the watershed. In the west and south-west, the watershed boundary lies between streams flowing into the Rishikulya river and those flowing into Chilika. There are also many other smaller rivers and rivulets and tributaries.

Apart from about 1100 sq. km. water-spread area of the lake, rest of the drainage basin of Chilika comprises 2,325 sq. km. of agricultural land (mostly dry land), 526 sq. km. of forests, 192 sq. km. of permanent vegetation comprising predominantly plantations, swamps over 71 sq. km., and wetland with grassy mud flats over 91 sq. km. in north-eastern parts of the drainage basin. Only 52 sq. km. of the basin area is occupied by human settlements, roads, railways, etc.

Chilika Lake is home to several ecologically important species of flora and fauna. Some of the most common varieties of crab species found in Chilika lake are: *Scylla Serrata*, *Neptunus Pelagicus*, *Varuna Litterata*, *Ocypoda Sp.*, *Paratelphusa Sp.* The mud Crab (*S.Serrata*), commonly known as Chilika's famous "*Tiger Crab*" is the most important species and occurs in greater numbers than all other species combined. But they are entering the list of vulnerable species due to over-exploitation. There are 5 species of prawns which contribute maximum to the commercial fishery in Chilika lake. These are: *Penaesus Monodon*, *P.Indicus*, *Metapenaesus Monoceros*, *M.Affins* and *M.Dodsoni*. *P.Monodon* is the famous "*Tiger Prawn*" of Chilika, which is also over-exploited due to the fast growing prawn culture.

Biodiversity losses in Chilika lake are tremendous. The number of fish species seem to have come down from 126 in 1920s to around 69 in 1988. Chilika, once used to be a prawn abundant lake on which variety of other fishes used to prey has become prawn scarcity lake, which gets reflected through excessive decline in both fish and prawn landings. Chilika used to be popular for a variety of marine animals like crocodile, green sea turtles, gharials, etc., which have become extinct from the lake areas.

Some of the ecological changes that are taking place are worth noting. The rate

of annual siltation in the lake has reached alarming proportions. Progressive increase in silt predominantly because of deforestation in Chilika drainage basin has reached to the present rate of almost 13 million tons annually, being brought into the lake by the estimated 3,75,000 million cusec of fresh water flow per year. If the rate of siltation is not checked now, the whole lake area may become sandy and clayey in another 200 to 250 years.

Lake shrinkage is another important ecological transformation. This may be due to several factors, both natural and human. The annual current rate of lake shrinkage is about 14.7 sq. kms in the peripheral size. The rate of shrinkage of the water spread area has been approximately 1.5 sq. kms per year. The chief cause of the lake shrinkage has been the influx of silt. As against the fast fresh water inflow, particularly during the monsoon months, the outflow is slow due to the constricted channel of 35 kms length. This channel, being through sandy trough and exposed to sea hazards, frequently suffers topogenic deformity through the shifting of the sea mouth. The mouth of the lake has been shifting towards north at a rate of 3 kms in every 10 years, thus making the channel longer every year. The width of the sea inlet has also been narrowing down over time. At present the width is about 180 meters as against 195 meters in 1992!

Progressive decline in average salinity from around 22.3 ppt in 1957-58 to present levels of 3.60 is another serious matter. This is mainly due to increasing flux of fresh water from the north and clogging and shifting of lake mouth from the sea in the south. This is affecting the entire spectrum of aquaculture practice, between brackish water to fresh water species, changing aquaculture technology from traditional methods (*jano, diano and bahani*) to net and pen culture.

Pollution and eutrophication in the lake have been increasing because of growing chemical based industries in the catchment areas, agricultural intensification in Chilika basin and sprawling of prawn culture ponds especially since mid 1980s. Presence of fatalistic heavy metals like mercury, lead, copper, chromium and nickel in the lake have been reported. The net effect of eutrophication is the excessive weed growth (because of high influx of organic rich silt and sedimentation over the years and progressive decline in salinity). Weed spread is increasing at a rate of 14.3 sq. kms per year since 1973. The lake area infested with weed growth has come to alarming proportions of around 52 percent in 1996.

The avifauna of the Chilika lake boasts of 150 species of birds. Dowitcher, one of the least known asian shorebirds and the spoonbill sandpiper, one of the rarest stint are some of the interesting bird fauna

of the lake. But the biodiversity changes have not spared this fauna ecology. The effects of weed growth is felt not only on aquaculture but more so in terms of drastically reducing these valued visitors particularly noticed near the Nalabana bird sanctuary in the parts of the lake. Also noticed is a decline in quantity and variety of fishes on which these birds used to prey. Partly deforestation in the Chilika basin and also hunting of birds to the tune of almost 15,000-20,000 every year, also must be contributing to this decline. All these have, in turn, resulted in substantial decline in eco-tourism and international tourists, which used to contribute greatly towards improvement in economic conditions of the people around Chilika lake.

3. AQUACULTURAL PRACTICE

Because of its strong life supporting links with the habitat around the lake, it is very important to note the changing aquacultural practice in this region. Chilika lake provides an excellent brackishwater environment with more than 6000 hectares of area for prawn/fish culture which shares about 19 percent of the total available brackishwater resources in the State of Orissa. For centuries the people of this region maintained the traditional methods of fishing. Prawn culturing in the lake is a relatively new activity to the area.

During the early '80s, brackish water prawn farming in a scientific manner

started in a big way in and around the lake. Large-scale and rampant conversion of various types of traditional fishery sources in the lake has taken place after the advent of culture system of fishery. While diano and uthapani fisheries were converted to culture sources by the non-fishermen and Government, other fishery sources like bahani and jano areas have been converted both by the Government and some primary fishermen co-operative societies either by themselves or through subletting to third parties.

Under a programme for landless and rural poor, developed under the Brackishwater Fisheries Development Agency and strongly supported by the Orissa State Fisheries Department, 1550 ponds covering an area of 487 hectares were started in the lake periphery. Several financial institutions invested more than 1.1 million rupees credit in these projects. About 600 families of the poorest of the poor in the Chilika area have been economically rehabilitated through prawn culture under the scheme "Economic Rehabilitation of Rural Pools" sponsored by the State Government. Besides, 165 private agencies developed their prawn farming projects in the lake area through bank credit and 20 IRDP farmers were engaged in prawn farming under the central government sponsored scheme "Area Development Approach Programme". Most of the projects had come up in the north-east and south-east part of the lagoon. Recently there has been

an attempt to opt for small-scale brackishwater shrimp culture which has less ecological impacts on the lake. Development of low-cost technology for culturing prawn has made it possible for fast progress of aquaculture in confined brackishwater ponds as well as in seasonal dry areas in the lake periphery and in the adjacent cultivable areas of saline soil.

4. RESEARCH METHODOLOGY

By now it is clear that like many wetland situations all over the world, Chilika lake is also subjected to a multiplicity of pressures and impacts, partly driven by market forces and partly due to socio-political situations and compulsions. Basically the ecological factors influencing one another together with the plausible socio-economic root causes listed in the introduction are analysed using statistical techniques to arrive at priorities in terms of policy prescriptions.

The issues are however, far more complex in terms of geographical or spatial, temporal and economic configurations. Different social groups, entities and agents are involved in these, with differing perceptions about the state of lake biodiversity. As a methodology, a close look at these different socio-economic entities and agencies is the first step. They are grouped as:

Spatial Groups:

- *Locals:* The people of the villages around the lake, about 0.1 million people spread in about 128 villages (though this is not a homogeneous set either),
- *Regional:* The people of the districts around the lake (Khurda, Puri and Ganjam),
- *State and National:* The State of Orissa, government of Orissa and of the Indian Union,
- *Global:* The middlemen, NGOs, market operators, exporters and importers, and so on.

Inter-generational Groups:

- Present generation
- Future generation

Economic Groups, Entities:

- Fishermen, non-fishermen: inequality, livelihood, basic need
- Profit earners in aquaculture
- Export earners
- Eco-tourists

Social Groups:

- Class and caste groups
- Money lenders
- Politicians

Therefore, even though several measures and indicators can possibly be developed on each of the ecological and socio-economic root-cause factors, it may not be easy to assign weights to the perceptions of all such agents and groups involved in the Chilika lake system as a whole, and to rank them uniquely on any cardinal scale. Secondly, many of the root causes are cause and effects within the set itself. For instance, population pressure can effect the pressure on land. Deforestation of the forests can lead to more of eutrophication and hence changing aquacultural practices.

As a working methodology therefore, the effects or impacts of such factors or root causes, without being concerned about the varying perceptions of different agents in the society are quantified first. A variety of secondary level data are collected for this purpose, with which cause-effect response elasticities between the root causes and ecological changes are estimated. Independently, perceptions of various groups mentioned above are assessed based on primary surveys using CVM/PRA/RRA techniques next. Finally, the cause and effect elasticities are interpreted along with the perceptions of the people involved at different levels mentioned above. Some representative sample of data collected are summarily shown in Table 1.

A comment on the data and information on the wetland is warranted here.

One does not find among the existing literature, information on the socio-economic and anthropological factors as much as available on ecological factors and dimensions. A suggestion has been made in the report to establish a cell in Chilika Development Authority, exclusively to monitor the data and information regularly.

The entire lake area is divided into four ecological sectors as: northern, central, southern and outer channel. This division is based on salinity and depth criteria. It is hypothesised that (a) normally the salinity would increase from the north to the outer channel, and (b) with the increasing nutrition and fresh water inflows from the northern sector and clogging of the lake mouth in the outer channel, the central and southern sectors would lose their independent identity in the course of time. If that ever happens, the biodiversity losses would be rated as the maximum.

On similar lines, the villages around the lake have been grouped in to five geographical zones, referred as zone I to V. There are about 128 fishermen villages around the lake. The zoning is done on the basis of (a) demographic structure and transition, (b) classification of fishing communities, and their fishing and agricultural practices and, (c) geographical contiguity. It is hypothesised that aquacultural practice should be designed based on a concept of human rights, dignity and livelihood support, without which the

population dynamics of the region will lead to social conflicts, over-exploitation through prawn culture for global exports, increasing income equality and immiserisation.

Table 1 : Ecological and other Parameters of the Lake

Variable		Units	1986-87	1996-97	CGR
Weed area		Sq.km.	395	500	0.0238
Weed area		Sq.km.	790-805		1.5 per year decline;-0.0018
Forest	Dense	Sq.km.	92.99	69.71	-0.0284
	Sparse+Degraded	Sq.km.	89.04	145.24	0.0501
Degraded Plantation		Sq.km.	18.31	212.07	0.2775
Agricultural land		Sq.km.	697.1	1112.24	0.0478
Lake depth	Northern sector	M.	0.92	0.72	-0.0242
	Central sector	M.	1.5	1.6	-0.0065*
	Southern sector	M.	1.64	1.89	-0.0143*
	Lake average	M.	1.35	1.4	-0.0036*
Salinity	Northern sector	ppt	3.1	0.82	-0.1245
	Central sector	ppt	8.28	8.94	-0.0077*
	Southern sector	ppt	10.7	8.42	-0.0237
	Lake average	ppt	7.02	3.6	-0.0646
No.of PFCS		No.	48 in 1959	92 in 1998	NA
Aquaculture	Fish production	MT	6873	1352	-0.15
	Shrimp production	MT	1241	281	-0.138
	Fish export	MT	6623	1000	-0.1723
	Shrimp export	MT	1540	703	-0.0754
No.of boats	Mechanised	No.	253 in 1992	454	0.157
	Country	No.	4147 in 1992	4971	0.046
No. of nets		No.	31668	19190	-0.048
Population	Total		91430 in 1981	115457 in 1991	0.0236
	Fishermen		85	104	0.02
	Non-fishermen		17707	25704	0.037
	Active fishermen		20.2	27.2	0.03
No. of tourists		000	83.46 in 1983	148.06 in 1994	0.0535
Population Density		No./sq km.	2.34 in 1981	3.1 in 1991	0.0285
Prices	Fish	Rs./kg.	20 in 1992	36 in 1998	0.1029
	Prawn	Rs./kg.	200 in 1992	495 in 1998	0.163

Note : CGR=Compound growth rate ¹*1 =Represents the assumed CGR based on field data.

The socio-economic aspects and factors are linked with ecological dimensions and characteristics using a conceptual model. The model is developed around the ecological framework of the lake, as if being impacted by the socio-economic pressures and in turn, being the cause for socio-economic changes. Linkages between economic, social, demographic and ecological variables are estimated using statistical techniques. Such a conceptual model is then simulated to derive various scenarios. The major ones are :

- i. Impact of globalisation: Price changes, mix of fish in exports, tax and subsidy policy changes
- ii. Impact of demographic changes: Literacy, mortality, fertility, migration
- iii. Impact of legal changes: licensing, lease policy
- iv. Natural ecological changes: deforestation, floods, changing lake mouth
- v. Technological interventions: Aquaculture practices, dredging in the lake.

5. RESEARCH FINDINGS : THE LOCAL CONTEXT

The major findings which have been highlighted in the introduction are reviewed in the context of the local region. The local region refers to the lake periphery and basin spreading in three districts of Orissa (Puri, Ganjam and Khurda). Several demographic, social, economic, ecological,

institutional and legal characteristics and dimensions are relevant in this context.

The first question is about sustainable fishing rate in the lake. This is a matter of dependency of local population on fishing. Till the 1970's the population growth and fish production were consistently growing almost at the same rate of about 2 percent per year. There was nothing special about exclusive prawn fishing (or intensive farming for prawns). Then came the phase of high population growth rate escalating slowly, going upto 4 percent per year in the 90s. Also came the period in the 80s, of shifting to exclusive prawn fishing , and hence the growth of prawn farming as a new technology (distinct from traditional technology). Prawn (44.6 percent) and crab (16.9 percent) occupied their main catches. Traditional jano and bahani techniques were gradually replaced by pen and cage culture. The prawn culture also attracted non-fishermen to enter in the trade, as it did not require any traditional knowledge in fishing. The number of active fishermen swelled from 8079 in 1957 to 27,200 by 1996. The population growth rate, together with moving of non-fishermen to fishing have forced the active fishermen to opt for the new intensive prawn farming as an accepted culture. All these continued till the early 90s. In the third phase, came the effects of globalisation. The fast rising prices of prawns, as against that of traditional fish have enabled exporting to become commercially attractive, which attracted middlemen,

politicians and money lenders into the business. As against conventionally or legally assigned fishing sights, people started prawn farming in open areas and lake peripheries. Needless to mention that per family catch or landing came down drastically. Therefore, the primary root cause for the biodiversity loss is identified as the population dynamics.

Some thing more needs to be said about the state of aquaculture in the lake region. Multiplication of fishing grounds is one of the main causes for overfishing in Chilika lake and its outer channel. This has seriously affected the movement of adult prawns in monsoon and December months into the sea for breeding purposes and post larvae return to the lake through the mouth in August-September and February-May periods. Larvae movement during June-October and January-April and catching of juvenile prawns for sale to prawn culture ponds, have adversely affected the mature prawns in Chilika. This is followed by the decline of several fish species who prey upon prawns. Thus over-harvesting of prawns from the commercial angle since mid 1980s has gravely affected the self sustained ecosystem of Chilika over centuries. No wonder the yield rates came down drastically since 1986 onwards.

How does prawn culture in Chilika compare with rest of the region? The most appropriate comparison can be at the Orissa state level. Very interestingly enough, while the landing rates of prawn have been coming

down in Chilika, the overall landings are increasing in the state as a whole! In 1985-86 the share in total production from Chilika was 22 percent, which has now reduced to 2 percent in 1995-96.

The second most important local level issue is about the link between the sick aquaculture practice and the neglect of lake biodiversity. The study once again strongly reveals that it is via the socio-economic conditions of the people that the ultimate effect is felt on lake biodiversity. The starting point is the rate of exploitation of the people and their predicament regarding fishery and ecology. The fishermen seem to be in perpetual debt on account of loan taken for fishery and recovery methods. As many as 67 percent of fishermen stated that they are unable to repay the loans on time and the major reason for this has been the declining rate of fish catch. Another important fact to be noted is that, even with some education and exposure to the external world, almost 87.8 percent of the households reported that they have nothing to do with the forward fish trade! One would have liked, keeping the profession as one of life support to the people of the region, more and more vertical linkages with processing, marketing and sale, and distribution activities. That would have helped the management of the lake on a sustainable basis. Catching of juvenile prawn and crabs, social conflicts mentioned above, over-exploitation of lake marine products, growth of weeds, declining salinity, shrinkage of lake all have adversely affected the

biodiversity of the lake. The people of the region seem to understand all of the above but are acting helpless because of their poor economic conditions.

Breaking of caste based division of work and tasks in fishing profession is another major local level social root cause. It is interesting to note that traditionally the fishermen group is stratified in terms of their professional skills in aquacultural practices (divided as boat and fishing gear making, net making, fishing and trade and so on), a social dimension which lost its meaning in the process of globalisation.

How is the state of fishing affecting the livelihood of the people? It was found that very little amount of good fishes are consumed by the active fishermen and their families and the local people. Bulk of the fish catch from Chilika lake goes to the local market and get exported mainly to Calcutta and abroad. For instance, in 1996-97, out of total production of 1,633 MT of fish from Chilika lake, only about 20 percent (other than Shrimp/Prawn) are consumed by the local active fishermen and local people and their families, whereas 80 percent of it is exported to other states and foreign countries. Similarly out of total shrimp production only 22 percent is consumed by these people in Chilika whereas rest of the 78 percent are sent to the markets across states or to foreign countries. Though no direct estimate of income from fishing was possible, income from agriculture among

fishermen and non-fishermen families were found to be about Rs 4332 and Rs 8520 per year, respectively. Field survey indicates that income from fishing is not better either.

A close examination of the primary data indicated that the percentage of fishermen class and dependency on fishing as an occupation is inversely correlated with the literacy and educational levels. Literacy rate is also correlated with high rates of out-migrations from the region for jobs elsewhere. But the present literacy rate is quite low (about 43 percent). This factor should be used in designing a balanced regional development with human development.

What is the role of the government at these local level issues? The people of Chilika seem to see the root causes to be class conflicts, illegal encroachments, the role of mafia, government and also the politicians. They have also expressed that the government should give priority to restricting the entry of non-fishermen into fishery, weed removal and protecting the lake mouth from clogging and shifting. The state government on the other hand, seems to have treated the problem of social conflicts and degrading biodiversity as a law and order issue. The Revenue department is considering to have armed policing in the lake. Moreover, the usual approach to restrict over-exploiting the lake and to reduce the conflicts that comes handy is to restrict new fishing licences. Orders after

orders have been passed to restrict illegal and unauthorised farming, banning of intensive prawn farming, conversion of diano and uthapani leases into pen or net fishing, banning of unregistered societies, imposing strict lease policies for both fishing and licensing of motorised boats and so on. At the same rate, the communities and individuals have been going to the courts, exposing such social conflicts. The district authorities are unable to check either the conflicts or the increasing cases of court cases.

The major thrust on exploiting marine and wetland resources came in the nineties, when a process of structural adjustment and liberalisation was started in India in 1991. This has set a price gap between traditional and exotic varieties (such as prawn and crabs). Aqua farms, cold storages, export houses specialised in marine products have started mushrooming all over the coastal regions in the country. Several multi-national companies started their ventures in this marine rich country. Chilika lake is not spared from this process of globalisation.

The second most important national level link is in respect of eco-tourism. The government of India as much as the state government of Orissa have dealt with this wetland ecology under the Ramsar Convention. After recognising the honoured visiting avifauna guests during the winter months, several spots in the lake area have

been recognised as important tourist areas. Nalbana island of about 35 sq.km is declared as a natural bird sanctuary, completely barred from any human interference. Though the lake offers tourism opportunities of religious, aesthetic and marine and avifauna values, very little has been done to facilitate eco-tourism. Over the last ten years, the tourist population has increased from 83,000 in 1983 to 1,48,000 in 1994 (registering an average growth rate of 3-4 percent). There is still a lot more scope for this sector to grow, which can bring indirect pressure on preserving the biodiversity of the lake.

The national concern about the loss of biodiversity of this lake (as much as many others) was registered only when a historic judgement from the Supreme Court came in 1996. The judgement strongly advocated setting up of an Authority to implement the protection of coastal zones on a principle of 'precaution and polluter pay'. Demolition of aquacultural lands and industries in the coastal zones, creation of 'Environment Protection Fund', ban on converting agricultural, mangroves and forest lands into shrimp ponds and many other guidelines were set by this order. One only hopes that this national concern is converted in to a reality.

6. REFLECTIONS ON GLOBAL - ISATION

Like many sectors of the economy, the development of fishery in Chilika also

went through the motion of liberalisation, globalisation and market orientation. It is this aspect of the transformation that has been analysed more closely. Here, both the spatial and economic dimensions are involved.

As far as fishery is concerned the process of market orientation began in the 80's. After the recent new economic policy of the Indian government since 1991, the process only galloped further. Therefore, the two phases of globalisation are distinguished separately.

There is sufficient evidence to say that till 1970's the fishermen of this region, known for their community orientation, had restrained their fishing mainly for local and domestic use. During the period 1929 to 1970, the highest fish production of 5,707 metric tonnes (MT) was recorded in only one year, namely in 1957-58. During the entire period of those forty years, only in four years, the production exceeded 5,000 metric tonnes per year. Otherwise, in most years, the production levels were around 3,094 MT on average. The average rate of growth of fish farming then was about 2 percent, which was almost close to that of the population growth in that region (2.03 percent). In other words, there was no unduly extraneous force of marketisation to bring about growth in fish farming. There was also not much pressure on exporting fish products from this region.

From 1970 onwards, there was a jump in fish production from Chilika. The highest production was registered in 1972-73 with 8,882 metric tonnes. In the period from 1970's to 80's, fish landings were hovering between 5 and 6 thousand MT, with a negative annual growth rate of about 1.7 percent. But much of the growth of fish landings are attributable to growing national demands and slowly picked up foreign demands.

Initially, more than globalisation, the price effects have changed the scenario in the 80s. It was in the 80s that export of fish picked up, with an average of about 85 percent of the landings exported to foreign markets, as against a low of 60-75 percent of landings exported in the 70s. This trend shifted up substantially after that period. The prices of prawn and crabs went up substantially since 1980's. Till then, though they were rising, the production and export responses were inelastic. In fact, in certain years after the 80's, exports of fish and prawns were as high as 97 percent of the landings (e.g., in 1983-84).

Subsequent to the 80's, the production rates kept up around 6 to 7 thousand - and MT per year, touching once again the highest in 1986-87 (with 8,872 MT). After the boom in fish production in 1986-87, the production rates gradually started coming down, touching a low of 1,269 MT in 1995-96. A process of globalisation encroached upon Chilika lake aquaculture as well.

As reported earlier, construction of prawn culture ponds which began in early 1980s was intensified over the period subsequently. By then the fishing technology has also undergone a sea-change. New capital intensive fishing techniques using fine-meshed nylon nets, outboard motorised boats, bigger prawn culture ponds, etc., have been effectively drawn in. A number of ice plants (24) and fish processing plants (3) with a total capacity of 166 metric tons/day have been effectively working around Chilika lake. As far as the switching of fishing technique is concerned, it may be noted that by 1993, prawn and diano fishing grounds swelled to 69 and 88, respectively and most of the jano fishing grounds have been converted to prawn culture. Today there are as many as 5000 licensed boats, many of which are motorised. The fishermen have opted for more and more boats, that too motorised ones, even though the average cost of each boat is about Rs.40,000! Interestingly enough, the field survey reveals that 49.7 percent of financing for the boats came from the money lenders. Thus, more investments, new technology and introduction of new people in the profession, all went together hand in hand since the 1980's, under the globalisation process.

What is the end result of globalisation and ecological degradation of the lake reported earlier? Both these processes have severely affected aquaculture in turn. The total fish landings from Chilika started coming down sharply

since 1986-87. Annual fish landings crashed to 4,273 MT in 1990-91 from 6,670 MT in the previous year. It further declined to just 1,269 MT in 1995-96, which was just about 14 percent of the all time high production of 8,872 MT in 1986-87. The fish landings from Chilika picked up marginally in 1996-97 to 1,633 MT, which is still just about 18 percent of the fish landings in 1986-87.

Thus, declining trend in fish (and also shrimp and crab) landings over the years clearly depict loss of fauna in the Chilika lake, much below its carrying capacity. Though, these brackish water species are of commercial interest and thus production has been reflected in the official statistics, equivalent loss of aquatic life of other species can not be ruled out. In response to a specific question on specie losses in the field survey, 85.5 percent of people expressed their awareness of specie extinction!

Thus the sharp decline in the fish catch since 1986-87 poses threat to the traditional poor fishermen's livelihood. If this decreasing trend continues for another few years and no comprehensive action is taken by the Government and other agencies, fishing in Chilika lake will be a story of the past. Drastic reduction in fish and shrimp landings can possibly be explained in terms of overfishing in the lake peripheries. Furthermore, a shallower and choked mouth, and very intensive fishing at the lake mouth make increasingly difficult for mature

prawns and gravid fishes to reach the sea and for juveniles to enter the lake. Ultimately, over-exploitation of any aqua-life species for whatever reasons amounts to loss of biodiversity.

How does the prawn culture still continue to exist despite the fact that the lake is ecologically degrading, threatening the livelihood of the people? The answer lies in the economic factor of pricing.

The market price of prawn varies with the size (measured as 10 to 50 counts; e.g., 10 counts means 10 nos./kg) and type (juvenile and tiger etc.), from Rs 45 to Rs 500 per Kg (observed in July, 1998). The price of export brand P.Monodon (Tiger prawn) of Chilika skyrocketed from Rs.3.5/kg in 1930 to well over Rs.280/kg in 1992. In 1996-97 it further increased to Rs.420/kg. As against these, the prices for the fish were as low as Rs 180/kg in 1988, which increased to Rs 300 by 1996-97.

An important comment on the rate of exploitation of the local resources can be made at this stage. A comparison of the local value of exported shrimps with the FOB unit values as per Director General of Commercial Intelligence and Statistics (DGCIS) indicates that the degree of exploitation of local resources in the name of export earnings has been increasing over time. A close perusal of available data shows that as compared to the local prices of exported prawns, the FOB unit values are

atleast 50 percent higher. The local values of exports have increased only marginally from Rs.43 per kg in 1986-87 to Rs.98 in 1995-96. Whereas, during the same period, the FOB unit values soared from Rs.76 to Rs.227 by 1994-95.

Thus, the declining rates of landing of prawn (and also crabs) are being more than compensated by the sharp increase in prices. It is this price effect (or call it economic factor) that has kept the Chilika lake prawn culture going, despite of its ecological degradation.

Effects of Globalisation and Market Orientation in summary are:

- ◆ Adverse income distributional effects, leaving a large section of the population out side of the beneficiary group,
- ◆ Leading to artificially high domestic prices, even for the traditional varieties of fish,
- ◆ Creating social tension and conflicts between fishermen and non-fishermen castes,
- ◆ Conflicts within societies (e.g., court cases), money lenders (e.g., perpetual debt), mafias (e.g.,threat of life),
- ◆ Loss of cultural identity (e.g., disappearance of Co-operative fishing),
- ◆ Drain of local resources and income to out side of the region,

- ◆ Ecological degradation of the lake due to over-fishing, encroachment and unsound fishing techniques, and
- ◆ Leaving the human rights question totally neglected (e.g., right to live, right to employment and rights on local resources, gender balance).

7. CONCLUSIONS

The conclusion drawn in this study are based on the conceptual model developed as shown in Figure 2.

Some of the major indicators were presented in the section on Research Methodology. Both the model and the empirically estimated elasticities are used to draw major conclusions in this study. The elasticity estimates thus derived do not necessarily reflect any causality, but give dimensions of direct (i.e., via causality) and indirect relationships (i.e., via various other linkages). But the usefulness of those elasticity indicators can not be underscored. They are indicative of direct and indirect (i.e., ultimate) effects of changes in any one factor upon the other.

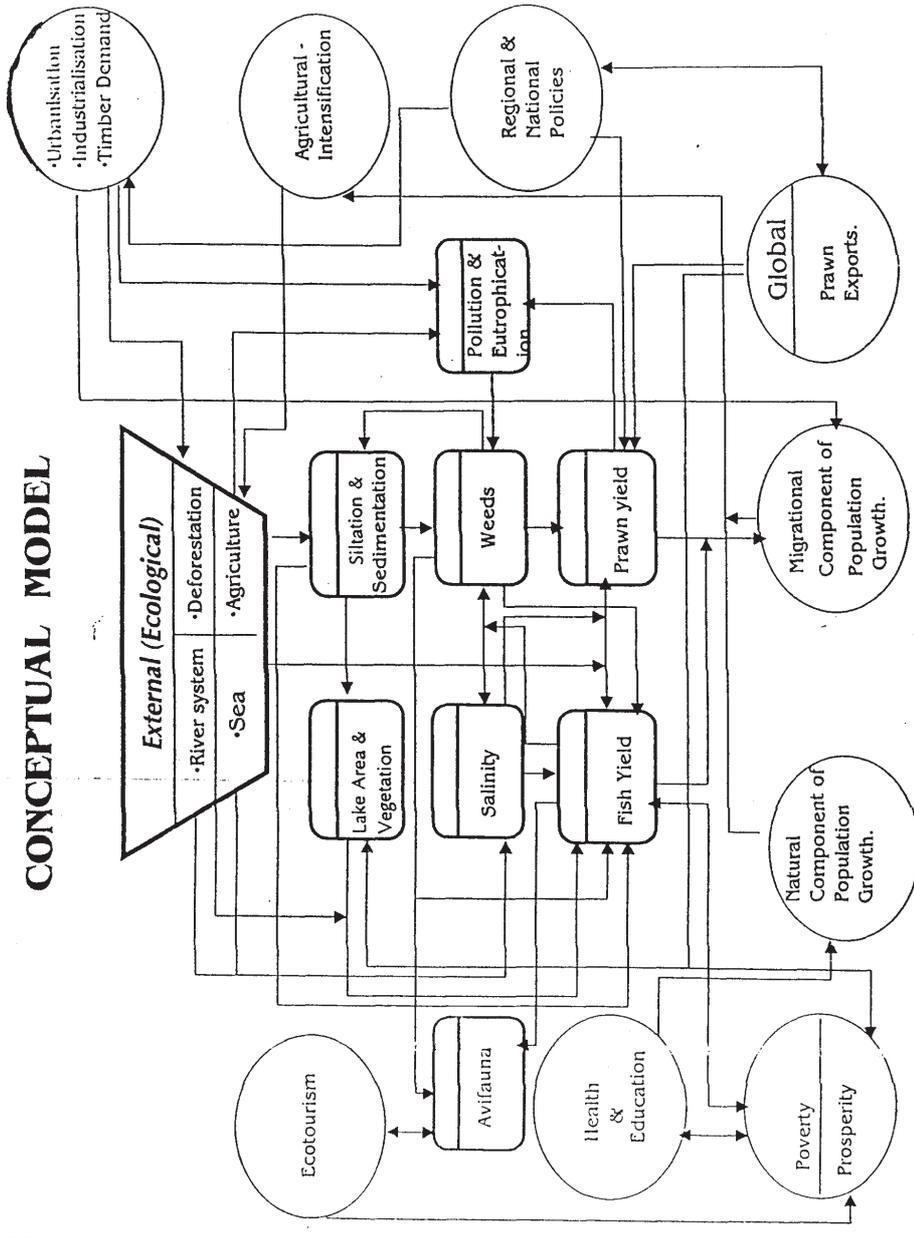
One of the major findings of this study is the fact that the root causes of ecological changes of this wetland lie outside of the ecological factors. They themselves do not seem to have brought so much degradation as the case has been made to be. The ecological factors or indicators can be viewed separately from the point of lake biodiversity and landscape biodiversity. One

of the issues then is to find out whether the lake peripheral changes are affecting the lake ecology. In terms of measurable elasticity indicators, one would then ask whether the land related ecological changes have any major effects on the lake related indicators. The land related changes include, deforestation in the catchment area, conversion of lake periphery into agricultural land, changes in the rainfall pattern etc. Important lake related ecological indicators are salinity, weed growth, lake depth, siltation and lake shrinkage. A very important finding on this is that, contrary to expectation, the land related biodiversity factors do not seem to affect the lake ecology as much as, the latter does to the land ecology. On the other hand, the lake related ecological changes bring about changes in the landscape around the lake, but only indirectly, by making certain demands on them. The demands on landscape however, are due to many factors outside of ecological factors.

The major conclusion is that the root causes for biodiversity changes of the lake lie elsewhere. This is where the socio-economic, technological, global and other scales are to be understood.

What are the root causes then? The study brings out very clearly that the major root causes, in order of their importance, are population dynamics, globalisation and aquacultural technology. This is, once again, an extremely exceptional finding. Till the 1970's the population growth and fish production were

Fig 2 : Conceptual Model for Chilika Eco-System



consistently growing almost at the same rate. Till then, there was nothing special about exclusive prawn fishing (or intensive farming for prawns). Then came the period of shifting to prawn fishing exclusively, and hence the growth of prawn farming as a new technology (distinct from traditional technology). Coming of pen culture, shifting away from jano and bahani techniques was gradually replaced by pen and cage culture. The population growth rate, together with moving of non-fishermen to fishing have forced the active fishermen to opt for the new intensive prawn farming as an accepted culture.

In the third phase, came the effects of globalisation. The fast rising prices of prawns, as against that of traditional fish have enabled exporting to become commercially attractive.

8. RECOMMENDATIONS

8.1 MEASURES ON SOCIO-ECONOMIC FRONT

a. Population dynamics

The significance of population pressure on the lake and land ecology is to be seen from the point of sustainable regional development. Excessive population concentration in prawn culture areas like Rambha and Satpada/Panaspada over the years has brought lot of pressure on the lake in terms of over-fishing and extended agriculture in the lake margins. However, compared to many coastal regions of India,

the population growth rate in Chilika is not alarmingly high. It is 2.03 percent per annum on a compound rate basis. But the exploitation of lake ecology is unsustainable at this rate of population growth. Chilika is life and culture for the people of this region. Therefore, it should emerge more as a human rights support than means of economic support. The people of the region should get all the opportunity of living with fish culture, grow with it in terms of their own growth. That is possible if fishing is made to provide both food, social status and employment.

A three prone policy is required. First, the views of the people are to be given due weightage in determining the fishing sights, aquacultural practice (types of fishing), medium of financing, marketing avenues and secondary level employment opportunities. As was the age old tradition, in all walks of fishing culture different segments of the people of this region should alone get the opportunity. Otherwise, as emerged from the field survey, the fishermen try to migrate from this region, to be replaced by non-fishermen in activities such as trade, financing and marketing. That trend of managing the culture in this region will become socially unsustainable. Second, the scope of Chilika fishing should be expanded to include marine fishing as well. The Chilika Development Authority (CDA) can play an important role here, by training the fishermen in modern marine fishing, providing financial assistance, organising marketing and

monitoring aquaculture. At present the Directorate of Fisheries collects data on aquaculture, that too on a selective basis. This task be transferred to the CDA. Thirdly, a network of small scale units should be encouraged by CDA and Orissa government, around fishing, cold storage, marketing, processing and so on. Fishermen communities can be encouraged to come forward to take up these activities, in addition to routine fishing. With an educated population of around 20-30 percent, and a literacy rate of 40-50 percent, such a move towards balanced regional development should be aimed.

b. Globalisation and technology

The impact of globalisation directly and indirectly has been affecting the ecology of the region. Technical solutions such as dredging in the lake, developing cold storages, introducing mechanised boats, and financing exclusively for fish export purposes and so on, all have been designed as prompted by the price differences between prawn and other fish. Such a globalisation process has led to selective fishing, which was not permitted in traditional fishing. Fishermen co-operatives in traditional fishing should be encouraged. They should receive price support for traditional fishing. Financing and boat licensing should be strictly monitored by an independent agency such as Chilika Development Authority.

Export targets should have some links with local needs as well. An

environmental cess could be introduced on all exportable marine products on the lines of 'polluter pay' principle. Such a cess should not become part of the general fund of the government treasury but to be retained exclusively for lake development.

On the technological front, measures such as lake dredging etc., should be carried out only after thorough zoological investigations on the lake ecology, specie settlements, juvenile growth rates etc. Secondly, introduction of mechanised boats for both fishing and tourism should be stopped completely, if possible. Heavy 'User Tax' be applied on the users of mechanised boats.

c. Leasing policies and Social harmony

Changes in regional fishery leasing policies, especially since early 1990s, over the years has resulted in encroachment on centuries old fishing rights of the traditional fishermen and fisherfolks. The changing composition of labour force and the people involved clearly reflects influx of non-fishermen into the lake areas. All these have led to social tension and disharmony in the region. Also leasing policies are catering mainly to the interests of businessmen, middlemen and outsiders. The process should be reversed. Heavy fees should be levied on non-fishermen getting in the trade. Prawn and fish exports should come under heavy export duties. The outsiders and non-fishermen should be encouraged in eco-tourism related activities. The industrial

development in the region can certainly accommodate the non-fishermen (including the Bangladeshis).

8.2 MEASURES ON ECOLOGICAL FRONT

On the ecological levels, several scientific measures are also warranted. But this study has not gone in to those. Yet, some comments and observations can be made suggesting possible scientific measures.

The rate of annual siltation in the lake has reached alarming proportions. Progressive increase in silt predominantly because of deforestation in Chilika drainage basin has reached to the present rate of almost 13 million tons annually. Three ecological effects of this are noticeable (also due to salinity decline). They are, shrinkage of the lake, decline in lake depth, and weed growth, all of which are linked to each other. Shallowing of the lake resulting in decline in average depth of more than 0.50 meters with much higher decline in the northern sectors. This has led to shrinkage of lake area almost at the rate of 1.45 sq kms over last 73 years amounting to a loss of almost 106 sq kms of lake area. Such depositional process of river borne suspended load also leads to maximum weed growth in these margins of the lake (about 500 sq km covered now). Shallowing of the lake on

these margins is so much that one can observe herds of buffaloes almost grazing in these parts of the lake village. If the rate of siltation is not checked then the whole lake area may become sandy and clayey in another 200 to 250 years.

Progressive decline in average salinity from around 22.3 ppt in 1957-58 to present levels of 3.60 is a serious matter. As one would expect, the salinity during summer is maximum and reaches a minimum in monsoons and is maximum in the southern margins because of its linkage with sea through the outer channel. The progressive decline in salinity because of higher and higher siltation and sedimentation is also facilitating excessive weed growth in the lake. Recommendations by experts to raise the average salinity levels to 15 ppt should be implemented with a view to sustain several fish species. In this process, measures such as dredging operations of outer lake and other recommended sites near Satpada and Palur canal are to be re-examined by zoologists.

Excessive weed growth because of higher and higher influx of organic rich silt and sedimentation over the years and progressive decline in salinity has resulted in weed spread to the tune of 14.3 sq kms per year since 1973. The lake area infested with weed growth has come to alarming proportions of around 52 percent in 1996. The highest proportion of weed infested area is because of *Potamogeton Pectinatus* (PP), locally known as Charidal. The dominant weed PP grows luxuriantly from the silty northern parts to sandy southern end and can tolerate wide salinity variations (0.26-15.00 ppt). If the trend of progressive weed

growth goes unchecked then the whole lake would be covered by a variety of weeds in another 50 years.

Pollution and eutrophication in the lake because of installation of chemical based industries in the catchment areas, agricultural intensification in Chilika basin and sprawling of prawn culture ponds especially since mid 1980s has been largely responsible for the presence of fatalistic heavy metals like mercury, lead, copper, chromium and nickel in the lake. Agricultural intensification and high doses of chemical fertilisers and pesticides in the Chilika basin areas are due to population pressure and gradual emphasis on cash crops over the years. Sprawling prawn culture ponds all around Chilika, especially around Rambha and Satpada/Panaspada areas have predominantly contributed to higher influx of nutrients facilitating weed growth. The environmental cess proposed on prawn culture should be used to remove the organic matters such as phyto and zoo-plankto, exoskeletons of marine organisms and so on. Special efforts need to be made to arrest flow of phosphorous sedimentation filtration and aeration.

Avifauna of the lake is drastically affected. More than a million migratory birds used to winter here and the number is declining fast because of weed growth near the Nalabana bird sanctuary in the parts of the lake, and decline in quantity and variety of fishes on which these birds use to prey.

Partly deforestation in the Chilika basin and also hunting of birds to the tune of almost 15,000-20,000 every year, also must be contributing to the decline. The decline in avifauna has resulted in substantial decline in eco-tourism and international tourists, which used to contribute greatly towards improvement in economic conditions of the people around Chilika lake. Thus, afforestation in the Chilika basin, ban on hunting of birds and exports of fishes and prawns from the area would greatly help in improvement in avifauna and hence in eco-tourism, which would not only improve the economic and social conditions of poor inhabitants in the surrounding villages but would also sustain biodiversity.

8.3 MEASURES AT GOVERNMENT AND LEGAL LEVELS

At present, the political will to reverse the biodiversity losses of the lake seem to be on a piece-meal basis. The approach should be holistic. The starting point should be bridging the gaps between the fishermen and non-fishermen. The approach should be human dignity, rights and entitlements. The new avenues such as eco-tourism both in the lake basin and in the lake areas should be integrated with aquacultural promotion. Such an integrated approach is possible only if an authority such Chilika Development Authority arms itself with all these tasks together. Logically, the CDA should have a good representation of the people of the region on its board, and not just an official organ of the government. Preservation of the lake should

not be treated as a policing exercise. Instead, the village communities can be involved in all major tasks such as policing, deweeding, technological choices, and secondary employment generation. As the study has revealed, many of the findings are based on only a limited set of data and information about the habitat, culture, aquaculture, ecology and socio-economic conditions. In order to preserve the lake truly as a Ramsar site, it is time that within CDA or otherwise in an organisation such as WWF-India,

a cell be treated to generate and collect scientific data and information on a regular basis. Apart from regular ecological data collection from the selected sites already set up by DST, and NRSA data processing by ORSAC, periodic and continuous surveys, ground thinking, and group discussions should be held with communities. The information and data should be made available to scientific and socio-economic agencies for deducing policies.

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