Chilika Lagoon: Restoring ecological balance and livelihoods through re-salinization

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Abstract
This paper reviews the past and present conditions and management of Chilika Lagoon, the largest lagoon on India’s eastern coast. Spatial and temporal salinity gradients, because of freshwater river inflow and seasonal seawater influx, have created unique characteristics of an estuarine ecosystem, and exercised a continuous, selective influence on the biota. Unfortunately, its biodiversity and the livelihoods that depend on it were being lost at a fast rate because of a blockage of the lagoon’s mouth by silt coming from upstream catchments, as well as oceanic long-shore transport. Projects to restore the dynamic characteristics of the lagoon included dredging a new mouth to the ocean, as well as prevention of soil erosion in upstream areas. Management efforts resulted in a dramatic revival of this ecosystem, and contributed to a sharp rise in the incomes of fisherfolk. The institutional aspects of implementing such large-scale policy changes also are discussed, and the remaining issues and lessons learned are presented.

Key words
biodiversity, Chilika Lagoon, ecosystem restoration, lake basin management, salinity, sedimentation, stakeholder participation.

INTRODUCTION
The Chilika Lagoon (also referred to here as Lake Chilika, Chilika Lake, or simply ‘Chilika’) is the biggest lagoon on India’s eastern coast (Fig. 1). Its size fluctuates substantially within the course of a year, with a maximum area of 1165 km² during the monsoon season, and a minimum of 906 km² during the dry season. It is of relatively recent origin, being formed several thousand years ago. Freshwater run-off from the drainage basin, combined with saline water inflows from the ocean, results in a wide range of fresh, brackish and saline water environments within the lagoon, and this spatially and temporally diverse water environment supports an exceptionally productive ecosystem.

The lagoon is a well-known wintering site for migrating birds; approximately half of the over 211 species recorded at Chilika are intercontinental migrants from far parts of Asia, including the Caspian Sea, Lake Baikal and Siberia. The lagoon is only one of two lagoons in the world that is home to the Irrawaddy dolphin, Orcaella brevirostris (the other being the Songkhla Lagoon in Thailand). Its rich biodiversity, along with the beautiful scenery of the area, attracts many bird watchers and ecotourists. The lagoon is also extremely important for the local population, not only as a source of livelihoods (mainly though its fisheries), but also as a focus for cultural, religious and spiritual activities.

Unfortunately, Chilika was facing a series of problems by the 1990s that impaired many of its uses. Its major problems were related to a decreased salinity in the lagoon, caused by a narrowing of the lagoon’s mouth. The gradual choking of this outlet to (and inlet from) the sea was a result of the accumulation of sediment entering the lagoon from its drainage basin. As the tidal flux was disturbed, the lagoon’s salinity decreased, thereby altering the natural ecosystem. The area and depth of the lagoon decreased; the area covered by freshwater macrophytes increased; its biodiversity decreased; and its fish catches declined. Some lands near the lakeshore also were waterlogged at certain times because the natural release of floodwaters through the lagoon’s mouth was constrained. In addition to the clogging of the lagoon’s mouth and the salinity-related problems, there also have been changes in...
the quantities and timing of freshwater flows because of the upstream riverine impoundments utilized for irrigation and flood control. There also has been a general increase in pollution from agricultural, aquacultural and domestic sources in the drainage basin.

Traditional fisherfolk were particularly hard hit by these problems. The decline in fish catches led many to use smaller-mesh-size nets, thereby putting even greater pressure on the fisheries and further complicating the problems. Pressure to maintain livelihoods seems to have contributed to poaching of migratory birds, and to logging activities in the watershed. Compounding this difficult situation was a change in government policy regarding the leasing of fishing grounds (which affected fishing rights), resulting in the loss of access by traditional fisherfolk to many fishing grounds, and a rise of commercial prawn culturing. Conflicts over this issue resulted in violent clashes and several deaths.

The Chilika Development Authority (CDA) was created in 1992 as a coordinating body between the wide range of institutions and people with a stake in the lagoon and its basin. The CDA has worked closely with the departments of the State Government of Orissa to improve the conditions in the lagoon. The most noticeable decision to date under the guidance of the CDA was the cutting in 2000 of a new opening to the Bay of Bengal, and dredging the channel between the outer channel and the rest of the lagoon. The result was a restoration of the flow regime, leading to a dramatic improvement in the lagoon’s salinity conditions, and amelioration of many problems caused by the declining salinity. As examples, fish and crab catches (and related income for fisherfolk) have markedly increased; macrophyte coverage has declined; and some rare and endangered fish species have returned. A monitoring programme was instituted, a management plan was developed, and environmental flow releases are being
negotiated from the upstream irrigation impoundments. It is notable that the decision to open the new mouth and dredge the channel was based on both scientific studies and extensive stakeholder consultations.

Challenges undoubtedly remain. Addressing the upstream problems (e.g. siltation, untreated sewage, changes in the hydrological regime) will require much effort. Conflicts over fishing, however, have abated mainly because of the enhancement of the fishery resource. Furthermore, it is encouraging to note that the Chilika Lagoon, after being placed in 1993 on the Montreux Record (Ramsar’s list of sites undergoing ecological degradation), was awarded the prestigious Ramsar Wetland Award in 2002 in recognition of the improvements. It also has been removed from the Montreux Record as a result of the successful restoration of the lagoon’s ecosystem by the CDA.

**BACKGROUND**

**Biophysical features**

The Chilika Lagoon (19°28′–19°54′N and 85°05′–85°38′E), located in the east coast of the State of Orissa, India, is the largest lagoon in Asia. It is separated from the Bay of Bengal by a sandbar whose width varies between 100 and 1.5 km; a long outer 32-km channel connects the main lagoon with the Bay of Bengal near the village of Arakhukuda. The pear-shaped lagoon has a maximum linear axis of 64.3 km, with an average mean width of 20.1 km.

The lagoon is spread over three coastal districts of the state: Puri, Khurda and Ganjam. In the early twentieth century, the lagoon area is reported to have varied between 1165 km² in the monsoon season, and 906 km² in summer (Annandale 1915–1924). However, land reclamation for agriculture, aquaculture and human settlements, along with sediment inflows from the catchment, had reduced the average lagoon area to 760 km², based on the late 1990s satellite images. Figure 1 depicts the lagoon at its lower level.

Hydrologically, Chilika is influenced by three sub-systems, including the Mahanadi river system (Fig. 2), rivers flowing in the lagoon from the western catchment, and the Bay of Bengal. The lagoon receives freshwater from a series of 52 channels, the larger ones being depicted in Figure 1. The Chilika drainage basin, including the lagoon itself, covers an area of over 4300 km² (Das & Samal 1988). The watershed boundaries lie between the

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**Fig. 2.** The Mahanadi River basin.
water flowing into the Mahanadi and Chilika in the north, while the areas draining into the Bhargavi River make up the north-east watershed; in the west and south-west, the watershed boundary lies between the streams flowing into the Rushikulya River, and those flowing into Chilika (Ram et al. 1994).

The long-shore sediment transport (littoral drift) along the coast of the Bay of Bengal is ≈ 0.1 million MT annually, and tends to shift the lagoon’s mouth opening to the sea every year, thereby adversely affecting tidal exchange. Although this phenomenon was used to significantly affect the salinity regime, the flushing pattern and consequent natural recruitment of biological species, a new mouth to the ocean has since been created, ameliorating the situation. The spatial and temporal salinity gradients, as a result of freshwater flows from the riverine system and seasonal seawater influx, have given Chilika unique characteristics of an estuarine ecosystem, and exercised a continuous, selective influence on the biota.

The Eastern Ghat mountain range forms a part of the west and south-west drainage area, with an elevation of over 600 m and strands of forests of sal (Shorea), Dillenia and Pterospermum spp. These hilly tracts serve as the headwater region of several streams flowing into the lagoon (Asthana 1979). In addition to the natural forest plantations of cashews, casuarinas and eucalyptus are found around the parts of the lagoon. The remaining catchment land is covered by human settlements or cultivated lands (CDA, unpubl. data, 2002).

The salinity level in the lagoon is dictated by river discharges during different seasons, wind action, and the extent of tidal influx carrying marine water from the Bay of Bengal. Before the new mouth was opened, the average salinity had been reduced by a third by the late 1995–1996, severely affecting the biota of this saline ecosystem. The seasonality of rainfall also leads to large fluctuations in the size of the lagoon. Data from 1992 to 1997 on the maximum and minimum depths of the lagoon are presented in Table 1, demonstrating the wide range of depths seen throughout the year, as well as the interannual changes reflecting rainfall fluctuations between years.

Lagoons generally are highly productive ecosystems, because of large nutrient inputs from their drainage basins, as well as high nutrient cycling and a wide range of habitats supported by the salinity gradient. Chilika is no exception and, in recognition of its important biodiversity, the lagoon was declared a wetland of international importance in 1981, thereby becoming a Ramsar site. The Nalabana Island was declared a bird sanctuary in 1973.

The lagoon system now hosts over 211 species of birds in the peak migratory season, with 97 being intercontinental migrants from the Caspian Sea, Baikal, Aral Sea, remote parts of Russia, Kirghiz Steppes of Mongolia, Central and South-East Asia, Ladakh and the great Himalayas (Dev 1990). As it is in the central Asia flyway, this list includes some rare birds. The important bird species of the lagoon are Anas clypeata, Aythya ferina, Anas querquedula, Anas penelope, Anas fuligula, Anser strepera, Limnodromus semipalmatus and Euryorhynchus pygmeus. Other interesting and threatened species include the spoon-billed sandpiper (E. pygmeus), Asian sowithcher (L. semipalmatus), spot-billed pelican (Pelecanus philippensis), dalmatian pelican (Pelecanus crispus), and pallas fishing eagle (Haliaeetus leucoryphus).

The most recent account of the flora was made by Pattnaik (2003), who reported the existence of 726 species of angiosperms, belonging to 496 genera under 120 families from the lagoon and its immediate neighbourhood, including its islands, sandbar and shorelines, which represents about one-fourth of the flora of the State of Orissa (estimated at 2900 species). The predominance of members of Leguminosae, Poaceae and Cyperaceae was a striking feature of its flora. The occurrence of an apparent endemic species (Casipoura ceylanica) was recorded (in badly degraded condition) from Barkuda and Sanakuda Islands, which is also known to occur in the coast of Madras and Sri Lanka.

A few mangrove associates, such as Aegiceras corniculatum, Excoecaria agallocha, Salvadoria persica, Pontamia pinnata, and C. ceylanica have been recorded by Pattnaik (2003). The plant species recorded from Chilika during the present CDA study under the category of rare, vulnerable or threatened plants include C. ceylanica (Rhizophoraceae), Colubrina asiatica (Rhamnaceae), Capparis roxburghii (Capparaceae), Maerua oblongifolia (Capparaceae), Macrytyma ciliatum (Fabaceae), Indigofera aspalathoides (Fabaceae), and Halophila beccarii (Hydrocharitaceae).

Pattnaik (2003) enumerated the economic and useful plants of the lagoon and their environments, including

### Table 1. Average depth of Chilika Lagoon, 1992–1997

<table>
<thead>
<tr>
<th>Year</th>
<th>Maximum (cm)</th>
<th>Minimum (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992–1993</td>
<td>340</td>
<td>74</td>
</tr>
<tr>
<td>1993–1994</td>
<td>210</td>
<td>65</td>
</tr>
<tr>
<td>1994–1995</td>
<td>332</td>
<td>58</td>
</tr>
<tr>
<td>1995–1996</td>
<td>382</td>
<td>60</td>
</tr>
<tr>
<td>1996–1997</td>
<td>142</td>
<td>42</td>
</tr>
</tbody>
</table>

medicinal and aromatic plants, wild relatives of cultivated species, wild plants of horticultural importance and interesting plant groups like insectivorous plants, epiphytes, parasites, and lithophytes, among others.

The diversity and extent of seagrass distribution in Chilika Lagoon has been assessed by Pattnaik (2003), with the occurrence of five species of seagrass in their true sense (Halodule uninervis, Halodule pinifolia, Halophila ovalis, Halophila ovata, H. beccarii) being reported. The occurrence of H. uninervis, H. pinifolia and H. ovata from the lagoon was a new distributional record.

**Political and socioeconomic features**

The lagoon has a history spanning more than 5000 years, during which it provided livelihoods for local inhabitants, as well as inspiration for philosophers, poets and naturalists with its picturesque beauty and panoramic view of the Eastern Ghats (hills) in the background. Tourists are drawn to the region by the thousands every year. The lagoon was once a part of the Bay of Bengal, and was created through the process of embayment because of the long-shore sediment transport. The lagoon’s mouth used to serve as an excellent port. Commercial boats used to sail from the lagoon to Cambodia and Indonesia. To this day, the villagers around Chilika observe an annual festival (‘Bali Yatra’, which means ‘Journey to Bali’ in Indonesia). A place called Manikpatna is considered the port.

The local community also has deep religious attachments to Chilika, with the Kalijai temple situated on yet another island at the middle of the lagoon. The goddess Kalijai is venerated in folklore and legend. Ancient deities (e.g. Nabagraha located near the village Berhampur along the lagoon’s outer channel; the Shiva temple in the village Alupatna in the same area) also are venerated.

The Chilika Lagoon remains a vital lifeline for >200 000 people living around the lagoon in 141 villages. The historical records indicate the use of the lagoon system for capture fisheries, through the formation of 92 primary fishery cooperatives. Six types of traditional fishing methods are used in practice. The steady fish landing records provide evidence of a sustainable fishing strategy, using ecological zones, different contraptions and traditional experience.

In the early 1990, the non-fishermen communities of Chilika filed a petition in the High Court of Orissa to recognize their fishing rights in Chilika, challenging the principle of the State of Orissa’s Revenue Department, which used to lease out the fishing rights only to the traditional fishermen (Kholamuham PFCS v. State of Orissa, 1990). In a 1992 verdict, the high court directed the state government to settle 30% of the fishery sources of the lagoon with the non-fishermen communities, and 70% with the fishermen communities. The local fishermen resented this decision, as the non-fishermen introduced shrimp culture by virtue of the order. In the mean time, however, the Supreme Court of India (the apex court) imposed a complete ban in 1996 on shrimp culture in the lagoon, and within 1000 m periphery.

**Institutional and management features**

Until 1992, the management of Chilika Lagoon was basically related to the activities of two major stakeholder departments; namely, the State Fisheries and the State Tourism Departments. In addition, the State Forest (Wildlife) Division was entrusted with responsibility for the Nalabana Sanctuary within Chilika. The lagoon was included in the Ramsar’s Montreux Record, as a result of the changes in its ecological character and degradation of the lagoon’s ecosystem. In response, the Government of Orissa created the CDA in 1992 through Societies Registration Act 1860. The CDA is a registered society borne under the administrative jurisdiction of the Forest and Environment Department of the Government of Orissa. It is governed by a governing body chaired by the Chief Minister of the State. Secretaries from the key departments, experts, eminent scientists, people’s representatives (members of parliament and legislative assembly), and representative of fisherfolk communities are members of the governing body. The CDA’s mandate includes:

1. Protecting the lagoon’s ecosystem and its genetic biodiversity.
2. Surveying, planning and preparing a proposal for integrated resource management in, and around, the lagoon.
3. Understanding the multidimensional and multi-disciplinary development activities.
4. Cooperating and collaborating with other institutions for development of the lagoon.
5. Restoring the lagoon and its catchment with active community participation.

Although created in 1992, the CDA was almost in a moribund condition, because of the lack of effective networking, partnership and coordinated action. To create more flexible procedures and quicker decisions, an executive committee was constituted in 1998, with adequate delegation of financial power. The CDA is headed by a chief executive officer (CEO) nominated by the authorities for a fixed-term period. The current CEO (as of late 2005) is on deputation from the State Forest Department, having served in the position since November 1997. This institutional structure has facilitated
integration and coordination between the stakeholder departments and organizations.

The CDA executive body currently is delegated with adequate financial power to make quick decisions. The institutional development was facilitated with additional funding received from the national government’s 10th and 11th Finance Commissions. The restoration was carried out through an adaptive planning process with active community participation. This was achieved through a strategic framework for organizing the existing scientific information and knowledge about the lagoon’s ecosystem, for its incorporation into the planning of the restoration process. The adaptive management planning process for developing a management plan was based on an explicit set of assumptions and hypotheses about the elements and components of the lagoon’s ecosystem, as well as man-made systems, and how they function and interact. The flexible adaptive management plan provided an opportunity for learning by doing, rather than waiting for the outputs from long-term scientific studies, the latter being both time- and cost-intensive.

**BIOPHYSICAL ENVIRONMENT**

**Biodiversity**

Chilika Lagoon’s faunal diversity was first studied between 1915 and 1924 by Annandale and colleagues from the Indian Museum and Zoological Survey of India. Ghosh (1995) carried out a comprehensive study of the fauna in the mid-1980s. Table 2 compares the results of these two surveys, which demonstrate the changes in biodiversity through time. At least three species of brackish water Porifera, and a number of crustaceans (Brachyura, Decapods), have disappeared over the past 60 years. Of the 74 species of molluscs, at least 50 species could not be traced during these year-long surveys, even though the total number of species increased to 87. Of the 69 fish species noted in the lagoon during the 1980s, 24 species

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**Table 2. Faunal diversity in Lagoon Chilika between 1914−1915 to 1985−1987: A changing profile**

<table>
<thead>
<tr>
<th>Type</th>
<th>Annandale (1915−1924)</th>
<th>Ghosh (1995)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protozoa</td>
<td>Few</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>Porifera</td>
<td>7</td>
<td>2</td>
<td>As a result of decline in salinity</td>
</tr>
<tr>
<td>Coelenterate</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Platyhelminthes Digenia</td>
<td>NA</td>
<td>29</td>
<td>Two new genera, eight new species</td>
</tr>
<tr>
<td>Nematode</td>
<td>4</td>
<td>37</td>
<td>Five new species</td>
</tr>
<tr>
<td>Polychaetes</td>
<td>NA</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Crustacea Stomatopod</td>
<td>3</td>
<td>2</td>
<td>As a result of decline in salinity</td>
</tr>
<tr>
<td>Crustacea Brachyura</td>
<td>36*</td>
<td>28</td>
<td>*(29 described as new by Annandale and Kemp, 1915)</td>
</tr>
<tr>
<td>Crustacea Decapoda</td>
<td>30</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>(Prawn and shrimps)</td>
<td>NA</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Anamuran (hermit crabs)</td>
<td>74</td>
<td>87</td>
<td>Type of locality for 60 species; three freshwater molluscs not present in 1995 due to declining salinity; 50 species recorded in 1916 not found now</td>
</tr>
<tr>
<td>Molluscs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sipuncula</td>
<td>NA</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Echiura</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Echinodermata</td>
<td>5 (other study)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Protochordate</td>
<td>NA</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pisces</td>
<td>217 (all sources)</td>
<td>69*</td>
<td>*(24 freshwater species)</td>
</tr>
<tr>
<td>Amphibian and reptiles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amphibia</td>
<td>4</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Reptilia</td>
<td>22</td>
<td>23*</td>
<td>*Eight species of 1915−1924 not found in 1995</td>
</tr>
<tr>
<td>Birds</td>
<td>NA</td>
<td>156</td>
<td></td>
</tr>
<tr>
<td>Mammals</td>
<td>18</td>
<td>18*</td>
<td>*(five new entrant in place of five earlier records)</td>
</tr>
</tbody>
</table>

Sources: Annandale (1915−1924) and Ghosh (1995).

NA, not available; *, Out of the 39 species of Crustacea Brachyura reported by Annandale and Kemp, 36 were new report.
were freshwater fishes. The decline in total fish diversity from the earlier-recorded 217 species to 69 is perhaps the most startling. While the lagoon generally has been known as a type locality (the place where a given species was first discovered) for nearly 30 species of crustaceans, and 60 species of molluscs (besides others in the past that are no longer present), the profile of species diversity has clearly changed over 60 years. It also should be noted that the Irrawady dolphin is found in the lagoon, being considered a ‘flagship’ species.

Unfortunately, similar accounts of flora over time are not available. The most recent account (Roy 2001) of floral diversity (before the new mouth was opened in September 2000), however, provides a listing of 72 phytoplankton genera and eight seaweed genera from different sectors of the lagoon in different seasons, which plays a key role in the food chain of this lagoon’s ecosystem. The macrophyte concentration seems most dense in the northern sector, followed by the outer channel and the southern sector.

It is further reported (Roy 2001) that the Chilika Lagoon system harbours at least 185 species of plants in the aquatic and terrestrial islands of known medicinal properties. Of the total floral diversity in the lagoon area, at least 10 species are used as local vegetables, 15 as fodder, six for thatching, 12 as fish food, and 56 for bird feeding and nesting, in addition to the 185 plant species for medicinal purposes. Such use of plant resources provides a vital resource base for the local community, as well as for birds, fishes and other biota.

At least 63 species and subspecies of plants reported between 1913 and 1988 could not be traced during the 1996–2000 period, with at least 15 species being aquatic or semiaquatic plants. The impact of opening the lagoon’s mouth and increasing the salinity is likely to cause some changes in the aquatic vegetation of the lagoon, and only future research can provide information on the changing profile. As a result of the increasing salinity, the area occupied by freshwater invasive species in the northern sector is declining. Similarly, smaller fluctuations in salinity favoured the growth of seagrass in the central sector.

The lagoon also provided a unique habitat for both resident and migratory avian fauna, which led to the establishment of the Nalabana Sanctuary. The peak bird population varied between 447 511 (1985) to 756 396 (in 1993). According to the Wetlands International, it reached 1 454 186 in 1996 (noting that the arrival of the migratory species is determined by many factors starting from their home land, making it unwise to draw conclusions based on their number during a particular season). The tourists visiting the lagoon during the same period obtained the greatest benefit from the vast wetland habitat, as did the waterfowl. At least 20 species of reptiles, birds and mammals recorded in Chilika, however, are considered threatened or vulnerable.

Salinity

Salinity is the most dominant factor determining the lagoon’s ecology. As previously mentioned, the lagoon is connected to the Bay of Bengal by a narrow inlet and constricted outer channel. In the past, the inlet frequently tended to shift to the north, affecting the tidal influx into the main lagoon. The mean surface salinity is affected by an influx of freshwater from the western catchment (approximate average of 536 m³ s⁻¹), and from the distributaries of the Mahanadi River (mainly the Daya, Nuna, Bhargavi Rivers; approximate average of 850 m² s⁻³). The sediment build-up at the mouth of Chilika, and the Palur Canal in the Ganjam District connecting the lagoon with the ocean, had reduced the saline water influx over time (Table 3).

The reduced salinity has caused a significant change in the fish catch composition and quantity. Such changes are attributed to the gradual decline in the recruitment rate of marine elements, because of the blockade at the mouth and the inhospitable habitat of lower salinity.

Sedimentation

The major silt load to the lagoon is carried by the Daya, Bhargavi and Nuna Rivers, distributaries of the Mahanadi River system. A sediment flow monitoring programme initiated by the Department of Water Resources in five rivers (Bhargavi, Daya and Malaguni in the northern sector; Kusumi and Salia in the western sector) showed that ≈ 1.5 million tons year⁻¹ of sediment enter the lagoon in the north from the distributaries of the Mahanadi River, and 0.3 million tons year⁻¹ enter the lagoon from the western catchment (Pattnaik 2002). The vertical accumulation of sediment has exceeded the relative sea level (RSL) rise. The fate of the lagoon depends on a combination of accretion and the local RSL rise, which determines the lagoon’s volumetric capacity.

<table>
<thead>
<tr>
<th>Year</th>
<th>Salinity (p.p.t., parts per thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957–1958</td>
<td>22.3</td>
</tr>
<tr>
<td>1960–1961</td>
<td>13.2</td>
</tr>
<tr>
<td>1961–1964</td>
<td>9.4–11.8</td>
</tr>
<tr>
<td>1995</td>
<td>1.4–6.3</td>
</tr>
</tbody>
</table>

Source: Chilika Development Authority.

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The upstream erosion and sedimentation process in the lagoon directly contributed to the loss of lagoon bed depth, as well as the choking of the mouth. This led, in turn, to a declining salinity. Furthermore, the introduction of prawn culture, ghori or bund fishery in 1991 led to the process of changes in hydrology and sediment transport, mainly as a result of the use of split bamboo and very fine mesh nets encircling the culture area, which prevented free sediment flow. The siltation and reduced salinity resulted in rapid growth of the invasive weed species in the northern sector, and restricted the free movement of juveniles of prawns and mullets from the sea into the lagoon. The breeding and spawning grounds of many important fishes, molluscs and paenid prawns have been affected because of siltation.

**Other issues**

High nitrate concentrations are observed in the winter months, resulting from drainage of agricultural fertilizers. Data collected from eight monitoring stations for the years 1986–1987 to 1997–1998 indicate that the use of fertilizer has nearly doubled within a decade. Agriculture run-off became severe as a result of lack of adequate soil conservation measures. Furthermore, untreated wastewater from the capital city in Bhubaneshwar finds its way to the lagoon. As with the agricultural run-off, however, it is difficult to estimate how much of this material makes it to the lagoon, and how much settles out or is otherwise transformed along the way.

Siltation, declining salinity and nutrient inflows led to extensive macrophyte growth. Free-floating invasive species (e.g. *Azolla, Eichhornia, Pistia*) and emerging species (e.g. *Ipomea*) have become a common sight. Weed infestation increased from 20 km² in 1973 to 440 km² in 1998. *Paspalum vaginatum*, *Paspalidium punctatum*, *Potamogeton nodosus* and *Potamogeton pectinatus* dominate the macrophyte community. *Potamogeton* alone accounts for 78% of the invasion. A study by Utkal University (1998) indicated that, while a positive correlation can be established between macrophyte growth and total phosphorus and nitrate–nitrogen concentrations, the pH level had no apparent influence on macrophyte growths. The CDA’s monitoring shows that the nitrate–nitrogen concentration ranges between 0.0062 and 1.321 mg L⁻¹, and the orthophosphate between 0.003 and 0.533 mg L⁻¹ (CDA, unpubl. data, 2005).

It also is noted that in order to assess the impact of the proposed Naraj barrage upstream of the River Kathajuri, an environmental flow assessment study is being carried out to assess the quantity of freshwater essential to maintain the lagoon’s ecological integrity.

**LAKE AND DRAINAGE BASIN RESOURCE CONFLICTS**

A major conflict in the Chilika Lagoon resulted from a reallocation of fishing rights from traditional fishermen to include the local non-fishermen. Table 4 summarizes the four main phases of the allocation of the fishing rights at Chilika. Before the change in the allocation of the fishery sources (1990s), traditional fisherfolk had developed a complex system of rights and restrictions on techniques, gears, etc., that led to more-or-less sustainable fishing in the lagoon. Over time, however, prawn farming became more and more lucrative because of the significant increase of the price of the tiger prawn in the international market, thereby attracting the interest of outsiders. In the lagoon area itself, conflict began with a change in basic policy, entitling the non-fishermen community to use water-spread areas for traditional culture fishery. Major conflicts began when large investments poured in from other parts of the State of Orissa, and even outside the State. The functioning of the Primary Fishermen Co-operative Societies gradually deceased, almost ceasing to work.

The agitated fishermen made writ petition, organized themselves under the banner of ‘The Chilika Matsyajibi Mahasangh’, and submitted a memorandum to the government demanding abolition of unauthorized shrimp culture within the water-spread area of the lagoon. The national Supreme Court (through their 1996 verdict)

| Table 4. Major changes in fishery rights for Chilika Lagoon |
|----------------------------------|----------------------------------|
| **Period** | **System** |
| Zamindar and Jagirdary period (British colonial rule) | Royalty to Raja of Purikud, Raja of Kalikote, Jagirdars. |
| Anchal Adhikari of Chilika (1953–59) | Open auction lease, mostly to fishermen. |
| Central Fishermen Cooperative Marketing Society (CFCMS) (1959–1988) | Lease out to Primary Fishermen Co-operative Societies; limited access to non-fishermen. |
| Orissa High Court verdict in 1992 | Thirty per cent of rights to non-fishermen. |

Source: Ghosh (1999b).
banned the shrimp culture in the lagoon, and within 1000 m from the high waterline of Chilika (Jagannathan v. Union of India, 1994). Unfortunately, however, the state government could not effectively implement the court order. Implementation of this restriction could have stopped all prawn culture activities. This situation brewed discontent among the fishermen, especially as the unauthorized shrimp culture is mostly carried out by the non-fishermen. Two incidences of police firing leading to a loss of life (the last one in May 1999) led the government to issue an executive instruction in 1999 banning all culture fishery in the lagoon. During this period (in early 1990s), the house of Tata’s, one of the top three industrial houses, had proposed a large aquaculture project. Local agitation, however, forced the government and the investor to withdraw. The conversion of capture fishery (locally called ‘Jano’) in fringe areas of the lagoon in Puri district from 1988–1992 led to 61 new culture ponds. The district administration in Puri allowed 30% of the area to be changed to culture fisheries, which also fuelled agitation by traditional fishermen.

Overall, the repetitive administrative failure to arrive at a firm policy decision, alleged nexus between politicians and prawn culturists, and denial of rights to the traditional fishermen community for their livelihood sustenance, led to a gunfire on 29 May 1999 that resulted in the death of four fishermen.

Finally, several upstream–downstream issues also could be seen as ‘resource conflicts’. Land-use practices in the upper catchment that lead to high sedimentation rates in the lagoon, for example, adversely affected the direct uses of the lagoon. Furthermore, changes in the hydrological regime, because of barrages on upstream rivers, also have an impact on the natural ecosystem of the lagoon. Although these issues have not caused the bloody conflicts that characterized the fishing rights issue, they nevertheless represent different users impacting each other in unfavourable ways. As a result of land degradation and the change in the land-use pattern in the drainage basin, productivity had declined significantly, adversely affecting the livelihood of the local communities.

**MANAGEMENT ENVIRONMENT**

**Lake management programmes and processes**

Management issues associated with restoration of this complex ecosystem were so vast in scale ecologically, hydrologically and socioeconomically that meticulous integrated planning was necessary to address them. Until the mid-1990s, lagoon management activities were limited and fragmented. To address this situation, the CDA facilitated a consultation process at the national and international level, with an objective to initiate key targeted studies essential to a management-directed understanding of the ecosystem, and to trace the root cause of its degradation, and appropriate corrective measures to restore the ecological integrity and functionality of the lagoon and its drainage basin.

An integrated management plan was formulated with wide stakeholder consultation using an adaptive approach. It relied heavily on stakeholder participation to establish goals and targets, to manage competing objectives, and to weigh options and trade-offs. Formulation of a credible management plan paved the way for funding support from the Government of India. The CDA received an amount of INR 270 million from a ‘special problem grant’ from the Ministry of Finance, Government of India under the 10th Finance Commission (1996–2000) for restoration of the lagoon. This was followed by a further grant of INR 300 million from the 11th Finance Commission for consolidation of the activities carried out with the support from the 10th Finance Commission. The strategy adopted was for a more ecologically beneficial hydrological regime to improve the water quality, recovery of the lost habitat of the important species, enhancement of the productivity, control of the invasive species in the lagoon, and an integrated water resource management practice in the drainage basin.

Furthermore, the World Bank-supported Orissa Water Resource Consolidation Project (OWRCP) recognized ‘Lake Chilika’ as a component of the OWRCP, allocating funds for hydrobiological monitoring of the lagoon; the objective was to assess the impact of the Naraj barrage by the Water Resource Department. In addition, a specialist consultancy to prepare an ‘Integrated Management Action Plan for Chilika Lagoon’ was also supported. Although that plan was not formally adopted, many of its components were nevertheless implemented.

The restoration strategy adopted by the CDA derives its uniqueness from the strong participation by local communities, grassroot-level non-government organizations (NGOs), community-based organizations (CBOs), and strategic partnerships with various national and international organizations and experts, government agencies and stakeholder government institutions. The key to the success has been strategic partnership built up through networking, consultation and coordination with the stakeholders. For example, the CDA maintains institutional linkages with seven state government organizations, 33 NGOs and CBOs, three national government ministries, six other national organizations, 11 international organizations, 13 research institutions.
and 55 different categories of community groups. This difficult task of coordinating and strategic partnership could be accomplished through strong networking.

An innovative participatory microwatershed management concept also was adopted, with a ‘sustainable rural livelihood’ approach for holistic management of natural resources. The drainage basin of the lagoon, which spreads over 4100 km², was the logical starting point for planning and management actions for sustainable management. The objective of this concept was to facilitate the community through empowerment to take decisions, and build capacity to work collectively. The participation of local communities and stakeholders in planning and implementing management of natural resources, and in sharing the responsibilities of decision-making, is a key feature of the ecosystem approach adopted by the CDA for management of the drainage basin. The local community has considerable, relevant knowledge of the ecosystem, and the ways in which it can be sustainably managed. The basic approach was to create an enabling environment, through capacity building of the community, CBOs and NGOs at the outset, and a series of need-based training programmes to facilitate an integrated and holistic management of microwatersheds by the community. The goal was to facilitate the community to manage and reverse degradation of life support systems within the watershed, particularly land and water, to enhance the productivity, resulting in alleviation of poverty and promoting improvements in livelihood of agricultural communities. To achieve this, an innovative grassroots approach was adopted by the CDA, in formulating a microplan, blended with indigenous knowledge and appropriate experts’ input, for optimum utilization of the natural resources in a sustainable manner, and to increase productivity and provide equal opportunity for livelihood for the landless, marginal farmers and women.

The CDA also addressed the issue of illegal bird hunting by working with local NGOs and CBOs and the wildlife wing of the Forest Department of Orissa to form ‘Bird Protection Committees’, which have assisted in developing alternative economic activities through soft loans. The current CDA policy to link socioeconomic activities in support of local communities was commended by a Ramsar Mission that visited Chilika on 9–13 December 2001, stating that ‘CDA has developed an integrated approach to managing the lagoon which can be regarded as an excellent example of the whole ecosystem approach’ (Ramsar Bureau 2001). The previously discussed participatory microwatershed management is one such programme.

Reduction in stresses and lake environment improvements

The basic programme of opening a new lagoon mouth, a major recommendation from studies carried out in the 1990s by the National Institute of Oceanography and the Central Water and Power Research Station (CWPRS), can be considered a first step in improving the lagoon environment. Interestingly, this was also a long-standing demand of the local communities, reflecting the value of local knowledge. Environmental impact assessments, undertaken before and after the artificial mouth was opened, showed marked improvements in terms of salinity flux, weed-free areas, recruitment of marine elements, flushing of silts and, finally, increased the productivity for both fish and shellfish. The new mouth also reduced the distance between the lagoon and the sea by 18 km, facilitating migration of both anadromous species (fish that migrate from fresh to saline water to spawn) and anadromous species (fish that migrate from saline to fresh water to spawn) (Pattnaik 2000). Detailed improvements in the lagoon environment are discussed below.

Improved flow regime

Dredging of the lead channel, and opening the new mouth on 23 September 2000, have significantly changed the lagoon’s hydrology, returning it to a more natural state than existed before excessive siltation affected the tidal flows in and out of the lagoon. The management intervention to improve the tidal influx and salinity in the lagoon can be assessed by the remarkable change in salinity between May 2000 (Fig. 3) and May 2001 (Fig. 4). Furthermore, the opening of the mouth, and consequent changes in tidal flux, led to significant flushing of sediment from the channel, thereby increasing its depth to the 30–45 cm level. The newly restored hydrological system also led to rapid freshwater discharges through the new mouth. Consequently, peripheral and island villages were not affected by floods and water-logged land after 2001. Before the intervention, the peripheral villages suffered from inundation, especially in the Kanas and Bramhagri Development Block areas, leading to crop losses of >50 000 ha of paddy fields.

Improved fish catches and recruitment of marine species

Opening the new mouth at Chilika had a dramatically positive effect on fish catches and, therefore, on fisherfolk’s incomes. Figure 5 shows how fish, prawn and crab catches declined, but then made a dramatic comeback after the hydrological intervention of 2000. The main reasons for this occurrence were the restoration of
Fig. 3. Salinity variation in Chilika Lagoon in May 2000. (Source: Chilika Development Authority).

Fig. 4. Salinity variation in Chilika Lagoon in May 2001. (Source: Chilika Development Authority).
salinity regime, improved auto-recruitment from the ocean and free-breeding migration. More than 75% economic species of the lagoon maintain a phased life cycle Available data indicate the fish landings reached an all-time low at the most degraded lagoon condition in 1997–1998 (1600 MT). Following the intervention, however, a record yield of 11 878 MT was attained in 2001–2002. The crab landing data also showed a 10-fold increase from 10 to 111.07 MT. The recruitment of marine species, especially Mugil cephalus and Liza macrolepes, which became increasingly rare during the lagoon’s degraded period, has markedly increased. About 40% of the typical fish catch originally depended on seawater migration. This proportion has been reportedly restored after the intervention. Recruitment from February to May became highest because of the opening of the outlet. The seaward migration of prawn and lakeward migration of mullet fingerlings are now ensured through the Muggermukh area because of dredging and de-siltation. The fish and crab landing data further indicate a significant increase in auto-recruitment from the sea into the lagoon after the intervention. The shrimp species (Penaeus indicus) alone exhibited a record yield of 438 MT, higher than any other figure in the previous decade.

Important for the local economy, the total financial return as a result of enhanced fish, prawn and crab yield, based on the average-weighted price, increased by nearly INR 680 million (≈ US$15.1 million). The average annual income per family increased by INR 50 000 (≈ US$1100).

**Decrease in weed coverage**

Improved salinity conditions resulted in a significant decrease in the coverage of invasive freshwater weeds. The infested area declined from 523.01 km² in October 2000 (just before opening of the new mouth), to 351.01 km² by May 2001. This situation occurred because the freshwater macrophytes have difficulty existing in the higher-salinity water (Table 5).

### Table 5. Declining Weed Cover in Chilika Lagoon

<table>
<thead>
<tr>
<th>Weed category</th>
<th>October 2000 (area in km²)</th>
<th>May 2001 (area in km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent weeds (Eichhornia, Salvinia, Nymphaea)</td>
<td>86.07</td>
<td>71.62</td>
</tr>
<tr>
<td>Free-floating weeds (Potamogeton, Hydrilla)</td>
<td>110.74</td>
<td>51.81</td>
</tr>
<tr>
<td>Submerged weeds (Potamogeton, Hydrilla)</td>
<td>170.76</td>
<td>122.24</td>
</tr>
<tr>
<td>Other submerged weeds (Najas, Hydrilla)</td>
<td>155.44</td>
<td>105.34</td>
</tr>
<tr>
<td>Weed-free area</td>
<td>333.82</td>
<td>505.82</td>
</tr>
<tr>
<td>Total</td>
<td>856.83</td>
<td>856.83</td>
</tr>
</tbody>
</table>

Source: Chilika Development Authority.
Improved biodiversity and return of threatened species

The lagoon system hosts over 160 species of birds in the peak migratory season, with at least 97 being intercontinental migrants (Ram et al. 1994). The Bombay Natural History Society has been conducting a study since December 2001, using birds as a bioindicator. After implementation of the restoration programme, the Society’s team recorded nesting colonies of gull-billed tern in Nalabana, establishing its southern breeding range extension. During the same period (2002), the Indian River tern, a lesser-studied group, was found to nest on Nalabana Island (540 nest records). These records further established the significant positive changes in the lagoon environment, illustrating that the management programme’s component on Nalabana Bird Sanctuary Habitat Improvement Program yielded some positive results within a short period of time.

In addition to the return of flagship mullet species, a shrimp species (Paenaeus indicus) reappeared in the lagoon system because of environmental improvement, constituting nearly 50% of the total shrimp landing. The crustacean species, which were rare during the period of degradation, comprised 2486 MT (20.51%) of the total catch of 11 989 MT in 2001. The crustacean landings further increased to 2629 MT from 2002–2003, accounting for 24.13% of the total landings. It also is noteworthy that six other fish species once considered threatened have since reappeared in the lagoon during the post-intervention period, including Hilsa (Tenuealosa) ilisha, Chanos chanos, Megalops cyprinoides, Elops machnata, Rhabdosargus berda and Rhinomugil corsula.

The restoration process helped improve seagrass meadows and their species diversity, with improved water level variations during tidal cycle turning the lagoon into a pulsating mode. Finally, Irrawady dolphins have again become well distributed in the central and southern sectors of the lagoon, whereas they were previously mainly reported only in the outer channel.

Reduction in silt loading from catchment

The lagoon environment is also directly linked with the land-use patterns and agricultural practices in the basin area. The drainage basin is delineated into micro-watersheds, based on the latest satellite imagery. The most degraded microwatersheds are treated on the basis of the experience from a participatory microwatershed management initiated on a pilot basis in three villages (covering 640.45 ha). The objective was capacity-building at the community level through a series of training programmes directed towards integrated and holistic management of microwatersheds. This model is already providing encouraging results, in terms of effective training for income generation activities through proper water resource management. In conjunction with trapping of significant silt loads at the Naraj Barrage, it will likely reduce the annual silt flow into the lagoon.

Remaining problems

The above story clearly illustrates that the management interventions at Chilika have had much success, resulting in direct improvements in the lagoon environment and local economy. However, it is incorrect to assume that all problems have been successfully addressed. Some remaining issues are discussed below.

Wastewater treatment and pollution control

An important area requiring further attention is the prevention of inflows of untreated domestic wastewater from each of the five sewage discharge zones of the capital city, Bhubaneshwar (~550 million litre day$^{-1}$), as well as untreated domestic wastewater from the 141 villages around the lagoon. A positive suggestion in this regard was given in the OWRCP plan; namely, a possible linkage with the Bhubaneshwar Development Authority and Orissa State Pollution Control Board (OSPCB). Analysis of the capital city’s wastewater indicates suspended solids concentrations of roughly 275 mg L$^{-1}$, well over the permissible limit of 30 mg L$^{-1}$. The biochemical oxygen demand likewise shows an average value of 110 mg L$^{-1}$, well over the permissible limit of 20 mg L$^{-1}$ (OSPCB, unpubl. data, 1998). ‘Project Water’ is currently being launched, with Indo Canadian Environment Facility funding, for treating the wastewater of the capital city, although only on a limited scale.

The Orissa Water Supply and Sewage Board, Government of Orissa, has formulated a proposal for the Integrated Sewage and Waste Disposal scheme for abatement of pollution in the River Kuakhai and Daya, draining into Chilika at Bhubaneswar City, at a cost of $US108 million.

Run-off from upstream lands

Despite the prevention plans within the Agricultural Intensification Program and OWRCP, fertilizer-laden run-off water still flows into the lagoon from the basin, as pointed out in unpublished 1998 and 1999 reports of the OWRCP. The interest of drainage basin inhabitants in the delta, especially agricultural farmers, is apparently not high because it is difficult to highlight their linkage to lagoon-related resource management. The current efforts to involve NGOs (e.g. ‘Campaign for Conservation of

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Chilika Lagoon’ and Pallishree), however, could help motivate upstream people to adopt sustainable agricultural practices.

**Palur canal restoration**
The OWRCP plan not only recommended dredging of the lagoon’s mouth, but also of the 17 km Palur Canal, a connecting link from the Ganjam side (Fig. 1), which is now under control of the Minor Port and Harbour Department. The canal provides an extra inlet both for saline water intrusion into the lagoon, and for recruitment of marine species. As a result of the siltation of the canal bed and extensive interventions along the entire canal length, the dynamics of the system had reached a moribund condition. The Palur Canal was renovated in 2004, which is likely to improve the fishery resources of the southern sector of the lagoon.

**Ecotourism**
The present tourism activity at Chilika is focused around Rambha, Barkul and Satpada. During the OWRCP study, a tourism growth rate of nearly 30% was recorded between 1987 and 1997. The introduction of motorized boats in the lagoon (in contrast to conventional sail boats), and the lack of a specifically demarcated channel to Nalabana Island, has led to uncontrolled tourist activity. A report on tourism development, prepared by Tata Consultancy Services in 1993, focused on ecotourism. The Wetland International also subsequently prepared a document on ecotourism involving Chilika. More meaningful dialogues must be established between the CDA and the State Tourism Department, in order to implement a community-based ecotourism programme at Chilika (Lenka 2002). The Tourism Department of the Government of Orissa commissioned the services of a consultant for developing an ecotourism master plan, and an orientation/training programme for boatmen transporting tourists in the lagoon has been started.

**Environmental flows**
The total impact of the projected 49 irrigation projects, involving dams and barrage constructions in the Mahanadi basin of Chilika, has not been linked with the Chilika management plan, even though it was mentioned in the second technical report on Chilika Lagoon under OWRCP (Ghosh 1999a).

In particular, the construction of the Naraj barrage upstream has the definite potential to affect the lagoon’s hydrology. To determine the optimum flow allocations and other key ecological functions, an environmental flow assessment supported by the World Bank is currently underway (as of late 2005). To determine different flow scenarios related to the construction of the Naraj barrage, hydrological, hydrodynamic, biological, and socio-economic modelling, as well as stakeholder consultation, was carried out. This effort involved the Water Resource Department, the Wetlands International South Asia, the CWPRS, the Department of Fishery Resources, the World Bank, the Center for Water Resources Development and Management, a number of NGOs and CBOs and an expert from the Australian Commonwealth Scientific and Research Organization (William Young), with extensive stakeholder consultation.

**The critical policy and institutional framework for management**
The institutional framework for Chilika is based on a principle of multisectoral collaboration, with the CDA playing the role of central coordinating authority. The earlier problem of overlapping areas of authority, and the conflicts arising thereof, will be further addressed with the newly proposed ‘Orissa Fishing in Chilika (Regulation) Bill’ of the Government of Orissa. While acknowledging the right of the District Collector to grant leases to the Orissa State Fishermen Cooperative Federation Ltd. regarding the entire leasable area, the bill also made it mandatory to communicate the details of such leases or subleases to the CDA. The bill identified the CDA as the central authority for all other matters, empowering it to make regular inspections, demolish illegal structures, search and seize any article of objection, and seek the help of the police wherever needed. The present CDA activities show a clear perception about the importance of functioning with civil society organizations, both in the basin and in the lagoon area, ensuring a positive role of the CDA as an institution.

The policies and laws that can be correlated with the administration of Chilika include the Indian Wildlife Protection Act, 1972; the Water Act, 1974; the Forest (Conservation) Act, 1980; the Coastal Zone Regulation Rules, 1991; the National Water Policy, 2002; and the Biological Diversity Act, 2003. These federal acts and policies, along with the State Marine Fisheries Act and Fishing in the 2002 Chilika Bill, provide a strong foundation for implementing a process of conservation and sustainable use.

**Stakeholder involvement, awareness and access to information**
There has been a steady increase in fish landings after the hydrological intervention, which facilitated self-initiated good practices (e.g. regulation of mesh size, discouraging
implement some vital components indicates the need for management plan components can be lauded, failure to of resources. Thus, while the success of many of the planned activities is the timely flow of funds and availability of resources. Thus, while the success of many of the management plan components can be lauded, failure to implement some vital components indicates the need for

A network of the NGOs and CBOs working in and around Chilika has been developed, with an outreach programme being carried out through this network. The work of ‘Pallishree’, a grassroots-level NGO working with the support of the Japan Fund for Global Environment, Ramsar Center Japan–Asia and the CDA, can be cited as a good example of creating public awareness. The NGO has established 10 small centres, one for four villages in and around the Chilika area. These centres (Center for Environment Awareness and Education) provide both non-formal education through trained facilitators, and formal education through school-level textbooks in the local language on the Chilika Lagoon environment, birds of Chilika, fishes of Chilika and plants of Chilika. Each centre has a small museum and library, audiovisual material, facilities for environmental games, etc. A quarterly newsletter in the local language also is regularly published, with most of the articles contributed by local stakeholders.

The launch of the Chilika website (http://www.chilika.com) provided a new source for detailed information on wetland studies sponsored by the CDA, including restoration history, ecological characteristics, socioeconomic features, forests and agriculture in the basin area, physical characteristics, and a special focus on birds and dolphins. The website can be used as a vehicle to keep other organizations and the public aware of the progress with Chilika restoration and protection efforts. A visitors’ centre has been established at Satapada, a major entry point to the lagoon. The entire Chilika ecosystem is showcased at the centre, via interactive exhibits. Wetland education programmes also are presented in the centre for school children and stakeholders.

**Past and ongoing financial investments**

The largest Chilika investment to date is the Special Problem Grants of the national government’s 10th and 11th Finance Commissions. The total funding level was approximately INR 570 million (or US$12.7 million). Furthermore, the OWRCP made INR 10 million (US$0.22 million) available to the CDA for the hydrobiological monitoring of the lagoon.

A major key to achieving complete success of the planned activities is the timely flow of funds and availability of resources. Thus, while the success of many of the management plan components can be lauded, failure to implement some vital components indicates the need for more concerted efforts. The failures are more likely the result of the lack of financial resources, rather than the lack of concept and willingness by the executing agency. To this end, it would be worthwhile to determine the feasibility of undertaking work through self-financing from fisheries and ecotourism.

The CDA itself is supported by funding from both the State and the Central Government. The human resource and institutional development aspect can be judged from the existing staff component of the CDA at the capital city of Bhubaneshwar, which does not exceed 10 people at any given time. The linkages with more than 40 national and regional institutions are a good example of an integrated collaborative approach, and the emerging results are encouraging. This process of multi-institutional involvement can be sustained only through a well-planned programme and funding support. As each department has its own agenda and annual work plan, however, the expectations from these agencies for carrying out the work relevant to lake management can only be realized through annual budgetary allocations for outsourcing work.

**LESSONS LEARNED**

**Danger of unilateral decisions on established rights of stakeholders**

Unless the government is well-informed about the existing lagoon management, and considers the interests of local communities and their informal management methods, biophysical and social destruction can result. The management history of Chilika Lagoon demonstrates that clear perception and strong political will ensure better management results. Effective and strong coordination could be possible because of the governing body headed by the Chief Minister. Some bold decisions, like the ban on shrimp farming, and strong commitment of the state government for sustainable management of the lagoon resources, are possible because of strong political commitment.

The fisher community traditionally had a positive role in managing the lagoon through indigenous and sustainable fishing systems. The fishermen cooperatives further ensured a mechanism of equitable sharing of benefits. The decision of the Supreme Court to change the fishing rights resulted in the loss of some rights held by traditional fisherfolk. The opinion of the traditional communities was ignored, with the Fishery Department of the State Government also forced to play a minor role. Earlier reports indicated that the involvement of the Fishery Department in lagoon management efforts had a positive effect on fish yields.

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Vital role of science

One of the most significant lessons learned from the Chilika experience was the vital role the scientific information can play in achieving management goals. The data generated on the freshwater flows, silt loads, the nature and characteristics of weed infestation, salinity and nutrients, depth and possible impacts of dredging, constitute vital research information. For effective management of the drainage basin, delineation of the most degraded microwatershed was based on satellite imagery. The application of remote sensing and geographical information system serves as an important management and monitoring tool, and the scientific results obtained from the targeted studies and modelling efforts provided vital clues for restoring the lagoon’s salinity gradient. The prediction of a rapid salinity return was then put to the test, demonstrating the connection between research efforts and the management initiative.

The postoperative phase already has resulted in significant changes in the lagoon environment, increased prawn and fish yields, and the active participation of stakeholders. The lesson learned from this exercise illustrates how scientific research can lead to better management of wetland ecosystems. Amelioration of the ecosystem, both in the lagoon and in the basin, resulted in enhanced lagoon productivity, thereby leading to poverty alleviation as well.

Importance of coordination and diverse funding

Despite the ineffectiveness of the CDA in the early 1990s, attempts to establish sustainable institutions to address multisectoral issues and multistakeholder interests finally appeared to succeed during the post-1997 period. The observation that the lack of coordination can create more chaos was a positive lesson learned, thereby highlighting the need for strong linkages and scheduled monitoring.

It is worthwhile to note that Chilika Lagoon is located in a province of a developing country with severe resource limitations. With appropriate entrepreneurial skill and strategic partnership, however, the huge restoration task could be accomplished with the limited available resources. Indeed, it can be mentioned that such efforts could be achieved without any external funding or loans from any financial institutions. With strategic planning and sound financial management, and the limited resources available in the form of grants from the government of India, the entire restoration task could be accomplished.

Need for long-term policies

No comprehensive ‘lagoon management policy’ for Chilika has yet been publicly announced. That the absence of a lagoon management policy can create a crisis, even in the future, should be a lesson learned from the immediate past. It is essential therefore to formulate a long-term policy on Chilika to ensure its sustainable management. The management programme since 1999–2000 emphasized stakeholder participation in major decision-making. Indeed, a key lesson from the conflict in 1999 was that unilateral decisions can create serious problems for both the people and the lagoon. The changed policy emphasizing stakeholder involvement and agreement led to recovery of the lagoon, thereby ensuring benefits to the stakeholders. The ‘Chilika Fishery Regulation Act’ is now under active consideration by select committees of the Orissa Legislative Assembly. The Act prohibits culture fisheries in Chilika and, if approved, will further reinforce the executive instruction by the Revenue Authority of Orissa banning shrimp culture, in effect from the year 2000.

Stakeholder participation can lead to self-initiated good practices

The network of the NGOs and CBOs, widespread stakeholder consultation, and watershed associations are some of the positive elements in the participatory management approach adopted by the CDA. As a result of good rapport with the local communities and community-based organizations, the restoration activities carried out by the CDA were strongly supported and endorsed by the community as the latter were consulted and taken into confidence at all planning stages. Communication, education and public awareness were used as tools for enhancing the knowledge, thereby empowering them. To achieve community participation, exchange of information, mutual enhanced understanding, and facilitation of cooperation between different user groups were ensured through the outreach programme. The self-initiated good practices (e.g. mesh-size restrictions) are indications of the confidence the stakeholders have regained regarding the lagoon’s ecosystem.

Links between poverty alleviation and ecosystem restoration

Investments for the restoration of the Chilika ecosystem also provide a lesson of positive return, in terms of fishery productivity and poverty alleviation. In addition to the benefits from the fishery sector, Chilika Lagoon tourism is expected to exhibit an upwardly mobile trend from three different streams of visitors, including winter tourism in the Nalabana Sanctuary for viewing migratory birds, tourists coming from other states throughout the year for aesthetic and recreational purposes, and local pilgrims visiting Kaliaji Temple and other places of worship.
Investments for promoting ecotourism, by training local boatmen, would be a worthwhile venture. Private sector investments on boats, nets, ice factories and transportation of produce are likely to increase with the increasing lagoon productivity. No quantified data are available, however, and further investigation on this topic would be valuable.

Although the process of good management of Chilika Lagoon has begun, it still has ‘miles to go’, particularly in regard to basin management, ecotourism and installing self-financing mechanisms. Nevertheless, the Chilika story shows how effective the application of scientific and technological methods can be in the context of a well-financed management intervention process, especially when such methods are supported by local participation.

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