REPORT ON THE EXPERT GROUP MEETING

TO DEVELOP INDICATORS TO ASSESS COASTAL ECOSYSTEM HEALTH

Organized by
Chilika Development Authority (CDA)
and
National Centre for Sustainable Coastal Management (NCSCM)
Ministry of Environment and Forests, Government of India

in partnership with

Institute for Ocean Management, Anna University, Chennai
United Nations Environment Programme (UNEP)
Bay of Bengal Large Marine Ecosystem Project (BOBLME)
and other partners of the
UNEP/GEF Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle Project.

June 2012

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Introduction and background

Chilka Lake is a brackish water lagoon, spread over the three districts (Puri, Khurda and Ganjam) of Orissa state on the east coast of India, at the mouth of the Daya River, flowing into the Bay of Bengal, covering an area of over 1,100 km^2. It is the largest coastal lagoon in India and the second largest lagoon in the World. It is the largest wintering ground for migratory birds on the Indian sub-continent. The lake is home to a number of threatened species of plants and animals. In 1981, Chilika Lake was designated the first Indian wetland of international importance under the Ramsar Convention.

The lake is an ecosystem with large fishery resources. The highly productive Chilika lagoon eco-system with its rich fishery resources sustains the livelihood for many fisher men who live in and near the Lagoon. According to some estimate it sustains more than 150,000 fisher–folk living in 132 villages on the shore and islands. The water spread area of the Lagoon ranges between 1165 to 906 km^2 during the monsoon and summer respectively. A 32 km long, narrow, outer channel connects the lagoon to the Bay of Bengal. Three hydrological subsystems control the hydrology of the lake. The land based system comprises distributaries of the Mahanadi River on the northern side, 52 river channels from the western side and the Bay of Bengal on the eastern side. Two of the three southern branches of the Mahanadi River that trifurcates at Cuttack, feed the lake. 61% (850 cubic metres per second (30,000 cu ft/s) of the total fresh water inflow into the lake is contributed by these two branches.

For the sustainable management of the Chilka lake, the Chilika Development Authority (CDA), a parastatal body has been created under the administrative jurisdiction of the Ministry of Forest and Environment, Government of Odisha, India. The CDA is mandated among others; to protect the Lake ecosystem with all its genetic diversity; to formulate the management plan for integrated resource management and wise use of the lake's resources by the community depending on it; to execute multidimensional and multidisciplinary developmental activities either itself or through other agencies and to collaborate with various national and international institutions for development of the lake.

Given the dynamic nature of wetland ecosystems, Chilika is also open to influence from several natural and human factors taking place within the Mahanadi River Basin as well as the coastal processes within the Bay of Bengal. It was therefore considered important to develop a plan for or better understanding of the ecosystem linkages and its health and how the Chilika ecosystem needs to be managed. Given this perspective, to make informed choices and allocating scarce resources to their most productive use, the CDA entered into dialogues with various partners and also joined Global partnership on Nutrient Management (GPNM), which among others was advocating for application of "ecosystem health report card" as a tool to monitor among others the impacts of nutrients load into coastal waters.

This pilot initiative to develop and use the 'ecosystems health report card' in Chilika lake, has been supported by the United Nations Environment Programme (UNEP), Bay of Bengal Large Marine Ecosystem Project (BOBLME), Institute for Ocean Management, Anna University, Chennai India; National Centre for Sustainable Coastal Management (NCSCM), Ministry of Environment and Forests, Government of India and other partners within the framework of the UNEP/GEF Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle.

The Expert Group Workshop

The Chilika Development Authority (CDA), Government of Odisha, India with technical inputs from the Institute for Ocean Management, Anna University, Chennai and National Centre for Sustainable Coastal Management (NCSCM), India organized an expert group meeting and an inception workshop, to develop indicators and values for establishing ecological thresholds in determining the coastal ecosystem health report card. This three day workshop was held from 25th to 27th June, 2012 at the Wetland Research & Training Centre, of Chilika Development Authority (see Annex 1 for the agenda).

The Inception workshop and the Expert Group Meeting were inaugurated by Dr. Anjan Datta, Programme Officer, UNEP on 25th June, 2012. The prime focus of the workshop was to integrate and assemble the different stakeholders in the coastal management in a common platform to deliberate on the ecosystem health. The agenda of the technical sessions of the workshop are given in Annexure I. The workshop was attended by thirty participants from ten leading organisations of international, regional and national importance and also by the non-governmental organisations and representatives of the Primary Fisherman Cooperative Societies (PFCS). The list of the participants is given in Annex 2.

The deliberations included six technical sessions with 16 papers on related issues in Lake Management. Besides the technical session; there was an exclusive participatory session on the stakeholder's response; which was participated by the grass root level local NGOs and members of the PFCS.

The tools for assessment of nutrients load into the Chilika Lake vis-a-vis the tools for the health report card was elaborately discussed for arriving on the essential parameters for the report card assessment by the scientists from the National Centre for Sustainable Coastal Management. The use of similar monitoring tools and experiences of Manila Bay was presented by Mr. Robert Jara, Programme Officer, Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) who are working among others to restore the health of the Manila Bay, Philippines, while Ms. Adelina, C. Santos Borja, Officer-in-charge of Resource Management and Development Department of Laguna Lake Development Authority, Philippines shared their experiences of nutrient management in Laguna de Bay and discussed on the need for such monitoring tools in respect of Laguna de Bay. Prof. Bijoy Mishra of Harvard University/NASA, USA provided valuable feedback on the various presentations and was also very generous to share his ideas on the way forward particularly issues that should be attended to in the development of the management plan.

In technical sessions of this expert group meeting, there was a broad consensus that human impacts now dominate the global nitrogen cycle. Over the last century the world has changed massive change in the global nitrogen cycle which had been relatively unchanged for millions of years. Population, affluence, and technology (P-A-T) continue to be critical determinants of nutrient loading. From various presentations it was also evident that global use of nutrients (nitrogen and phosphorus) continues to accelerate, particularly in Asia, and present modus of agricultural production system and animal husbandry are major drivers. Further, climate change has already had a noticeable effect on sensitivity of coastal systems to nutrient pollution. The participants therefore deliberated in understanding the scale and magnitudes of global nitrogen cycle change, and deciding on "Tools" not only for prediction but to integrate observational data to allow more meaningful cross-system and baseline comparisons for stakeholders and decision makers. Therefore it was considered important for ongoing monitoring of the Chilika Lake to understand dynamics of anthropogenic loads of nutrients. The meeting reiterated that 'we will not be able to correct problems if we choose not to observe them'.

Following from above, it was decided that the data on physical, chemical, biological and microbiological parameters; that are collected on a regularly basis from different ecological sectors by CDA for assessing water quality parameters would form the basis for generation of the report card. Accordingly, the data was shared by Chilika Development Authority with the NCSCM, Chennai, based on this NCSCM has proposed a report card and also prepared a report outlining the ecosystem health index and this is summarised in the technical report that follows.

In the stakeholder meeting, which was attended by the non-governmental organisations and the representatives of the Primary Fisherman Cooperative Societies, it was observed that there was an overwhelming acceptance on the idea of report card model for Chilika Lake. In the stakeholder discussions, the following critical issues were also flagged by the members, they include: need for inclusion of data on fishery resources as a criterion in the health card, besides the other criteria like growing menace of *Phragmitis karka*, overfishing and prawn *gherries* (lake water partly enclosed for cultivation of prawn) would also be included as a tool in the assessment. The participants agreed to incorporate fishery data in the proposed ecosystem health report card that should be used as a monitoring tool in the Chilka.

The valedictory session of the three day workshop was chaired by Shri. R. K. Sharma, IAS, Principal Secretary, Forests and Environment Department, Government of Odisha, who impressed upon the need of the health report card of Chilika Lake to be user friendly especially to the local communities and stakeholders. The summary of the three day deliberations was presented by Dr. Anjan Datta, Programme Officer, UNEP and by Dr. Ajit Kumar Pattnaik, IFS, Chief Executive, Chilika Development Authority. The workshop also included a field visit to give the participants some exposures to the lake ecosystem and the management interventions presently on-going in the Chilika Lake.

Indicators to assess the Coastal Ecosystem Health

1.0 Introduction

Ecosystem health report card is effective means of tracking and reporting the health of a waterway at both local and regional scales. Often, health of rivers, estuaries and the bays can be affected by elevated nutrient and sediment loads; resulting in the overall degradation of water quality and biotic (biological) resources. For the report card; river, estuary and the bay health is defined as the improvement (in this case) for selected six indicators towards established ecological thresholds.

The aim of this report card is to provide a transparent, timely and regionally detailed integrated ecosystem health assessment by setting the ecological thresholds for Chilika system based on the review of published scientific literature and technical reports. Ecosystem health is defined as the progress of three water quality indicators (Chl-*a*, DO, water clarity) and three biotic indicators (seagrass, phytoplankton and benthic community) toward scientifically derived ecological thresholds. The six indicators are combined into one overarching Ecosystem Health Index, which can be presented as the report card score.

1.1 Background to the Studies

Increasing non-tidal nutrient inputs to receiving waters have been associated with rising human population densities, changes in land use and the intensification of agricultural practices in watersheds (Williams et al., 2009). Problems associated with water quality degradation are nutrient enrichment, phytoplankton bloom, increasing extent and duration of hypoxic and anoxic waters. These issues are threat to aquatic systems worldwide; particularly in urban estuaries and lakes (Howarth et al., 2000). Multimetric indices are important resource and ecosystem management tools that can give a robust indication of ecosystem status. Different ecosystem indices; both physico-chemical and biological parameters combined together create an ecosystem health index. Scientific representation of ecosystem health indexes with spatially explicit maps which are readily understandable by policy-makers, scientists and most importantly local-level stakeholders. The Ecosystem Health Report Card provides the scientific information in clear and simple languages as well as graphics which serves as a basis for better understanding of the health of the system and also provides opportunity to evaluate the impacts of management actions that are pursued to reach the desired goal. In various parts of the world (as noted below); integrated ecosystem health assessment approach and report card system have been used to monitor and assess the health of the coastal ecosystems (estuaries, bays, lakes) and drawing from these experiences the ecosystem health report card for the Chilika Lake has been designed during the noted expert group consultation workshop and details of which is reported in the subsequent sections.

Ecosystem	Coast
Chesapeake Bay	USA
Gulf of Mexico	
Sassafras River system	
Anacostia River system	
Chester River system	
Nanticoke Watershed	
Great Barrier Reef system, Australia	Australia
Cape York reef system, Australia	
Baltimore Harbor area	USA
Magothy River system	
South River System	
Chilika Lake, India	India (Ongoing)

2. The Context:Chilika Lake

Chilika Lake, a semi-enclosed coastal lagoon on the east coast of India, is the largest brackish water lake in tropical Asia. It is a shallow coastal water body separated from the Bay of Bengal by a long sand bar extending about 180-275 m wide. The Lake is a unique assemblage of marine, brackish and fresh water ecosystem with estuarine characters. The Chilika Lake is an ecosystem with large fishery resources and sustains more than 150,000 fisher–folk living in 132 villages on the shore and islands. It is one of the largest wintering grounds for the migratory waterfowl on the Indian Sub-continent and hosts over 160 species of birds in the peak migratory season. On account of its rich biodiversity; Chilika Lake was designated as a "Ramsar Site" i.e. a wetland of international importance in 1981.

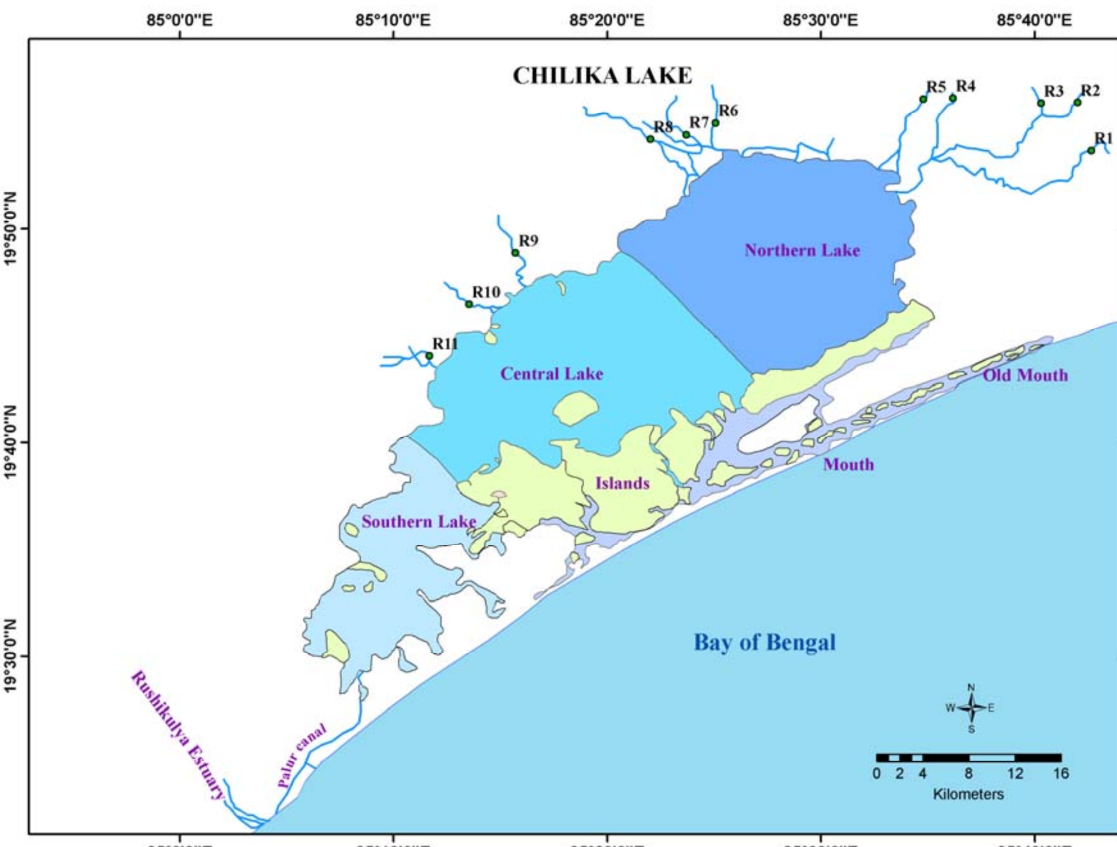
The pear shaped lake is about 64.5 km long and varies in width from 18 km in north to 5 km in south. The average water spread area of the lake is 906 km^2 in dry season (December-June) and 1165 km^2 in the rainy season (July-October) (Ghosh and Pattnaik, 2005). The water depth in the lake varies from 0.9 to 2.6 m in dry season and from 1.8 to 3.7 m in the rainy season.

The Chilika Lake was earlier connected to the Bay of Bengal via a long outer channel with several shoals restricting the water movement bi-directionally to and from the Bay. To regulate the water flow and maintain salinity gradient in the lake; a new mouth was opened on 23rd September 2000 at the northeastern end of the lake which is 14 km from the main lake and has reduced the outflow from the lake by 18km. The lake is also connected at the southern end through a canal from Rambha Bay to the mouth of the Rushikulya estuary to a distance of 18 km which is separated from the lake by lowlands; some of which are salt pans(Refer Fig:1).

The Chilika drainage basin, including the lake itself, covers an area of almost 4300 km^2 (Das and Samal, 1988). The watershed boundaries lie between water flowing into the Mahanadi and Chilika in the north, while areas draining into the Bhargavi River make up the northeast watershed; in the west and southwest, the watershed boundary lies between streams flowing into the Rushikulya River and those flowing into Chilika (Ram et al., 1994). In addition to 1165 km^2 area of the lake itself, the drainage basin of the lake includes 2325 km^2 of agricultural land, 525 km^2 of forests, 190 km^2 of permanent vegetation used for plantations, 70 km^2 of swamps and wetlands and 90 km^2 of grassy mud flats (Kadekoli et al., 2005).

About 52 small rivers and streams are draining to Chilika Lake and the large Mahanadi River enters the lake in its north-eastern end. The flow pattern coincides with high discharge during peak flood seasons of the SW monsoons and low during rest of the year. The main tributaries of Mahanadi (such as Bhargavi, Daya and Makara) accounts for almost 61% (850 m^3 s^{-1}) of the total fresh water flow into the lake and 39% (536 m^3 s^{-1}) is from non-perennial rivers from the western catchments. The major silt load to the lake is carried by the Daya, Bhargavi and Makara, the tributaries of Mahanadi River system.

Fig. 1:Map of the sampling locations showing different lake sectors

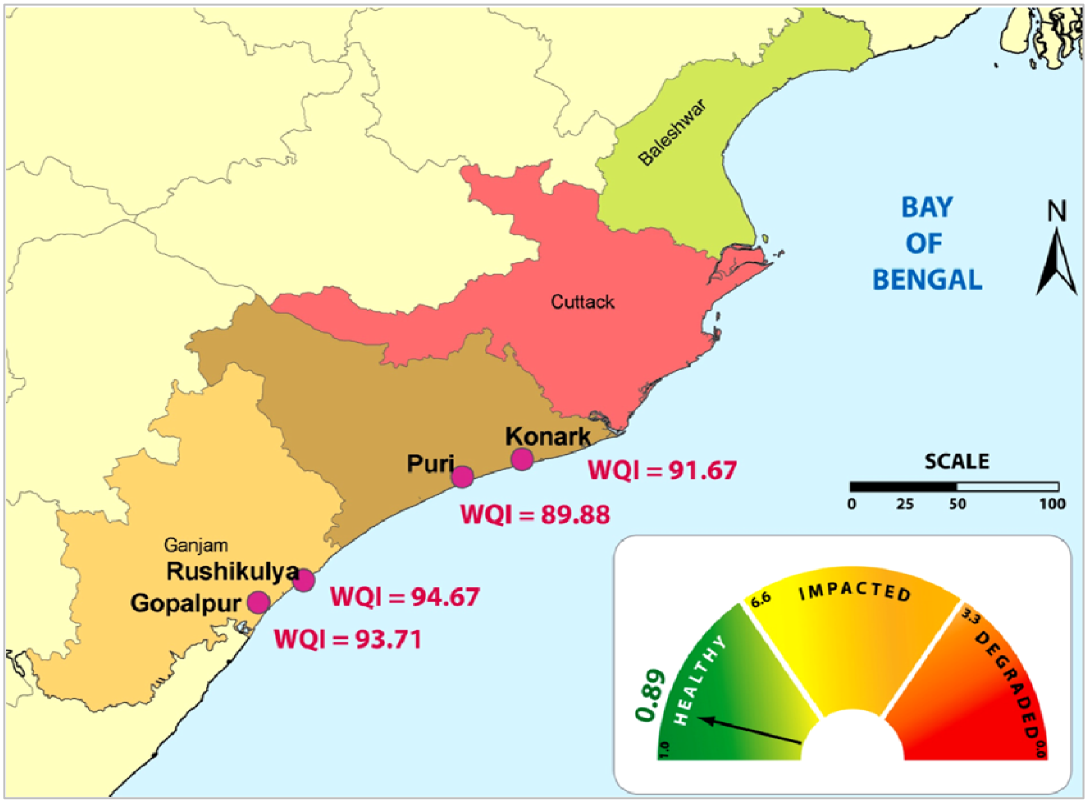


Approximately 1.5 million tons of sediment per year enters the lake in the north from the distributaries of the Mahanadi River and 0.3 million tons per year enters the lake from the western catchment (Pattnaik, 2002). The lake and the rivers experience heavy flooding during monsoon months. In association with strong wind, the sea level is elevated and affects the drainage of flood water to the sea. Therefore, the lake that receives large amount of silt load and fresh water obviously has no out flow to the sea and act as a sink of terrestrial material slowly increasing its shallowness, creating a chaotic environmental condition. The reason behind this sedimentation process also includes automatic closing of the inlet mouth due to littoral drift.

Salinity gradation in the lake ranges from seawater strength to freshwater, due to the influence of both semi-diurnal tides and perennial freshwater inflow from one of the largest rivers in India, the Mahanadi. Salinity is one of the most dominant factors which determine the ecosystem of the lake. However the sediment buildup at the mouth of Chilika and the Palur canal connecting the lake with the ocean had reduced the saline water influx over a time period. Ghosh and Pattanaik, 2005; observed a sharp decline in average salinity in the Lake from ~22.0 to ~2.00 in between 1957-58 to 1995 and according to them, this reduced salinity is due to the reduced inflow of saline water caused by narrowing of the lagoon mouth.

The Chilika Development Authority (CDA) has opened a new mouth in 2000, by which the salinity gradient in the lake changed with significant improvement of the lake ecosystem. Siltation, declining salinity and nutrient inflows led to extensive macrophyte growth. The lake is characterized by dense macrophyte vegetation in the northern and western bank of the lake. Macrophytes belonging to Algae, Pteridophytes and Angiosperms are identified and are further divided into submerged, emergent and floating but also rooted vegetation type.

Fig. 2: Water Quality Indices for the Orissa Coast



Later improved salinity conditions in the lake resulted in a significant decrease in the coverage of invasive freshwater weeds, with the infested area declining from 523 km^2 from October, 2000 to 352 km^2 by May 2001 (Ghosh and Pattanaik, 2005).

Topographically Chilika Lake is divided into four natural ecological sectors depending on salinity and depth; as the Northern, Central, Southern sectors and the Outer channel (www.chilika.com).

Studies on biogeochemical cycling and fluxes of carbon and nitrogen in Chilika Lake revealed for the first time, a strong seasonal and spatial variability associated with the salinity. The lake was studied during both monsoon (July, 2005 and July-August, 2006) and pre-monsoon (May, 2006 and March-April, 2007) in 35 selected locations including the 11 major rivers and two tidal locations. The lake exchange water with the sea (Bay of Bengal) and several rivers open into it.

The dominance of nitrification is evident during pre-monsoon due to the prevalence of oxygenated conditions in the lake. N_2O concentration was higher by 68 % and NO_3^- by 33% during pre-monsoon than in monsoon due to coupled nitrification-de-nitrification. Air-water flux of N_2O varied considerably from sink to being an atmospheric source both in time and space. The significant diel variation of nutrients along with O_2, exhibited an apparent coupled nitrification-denitrification phenomenon mostly in presence of macrophytes in the lake. The present study indicates that the Chilka Lake is an N-dominated ecosystem in terms of biological transformation of N species and finally the N_2O fluxes from the lake surface. Therefore, in order to better predict the future N_2O emissions in the lake, it is crucial to develop a long-term assessment of the biological mechanisms that produce the N_2O and the environmental factors that influences these mechanisms.

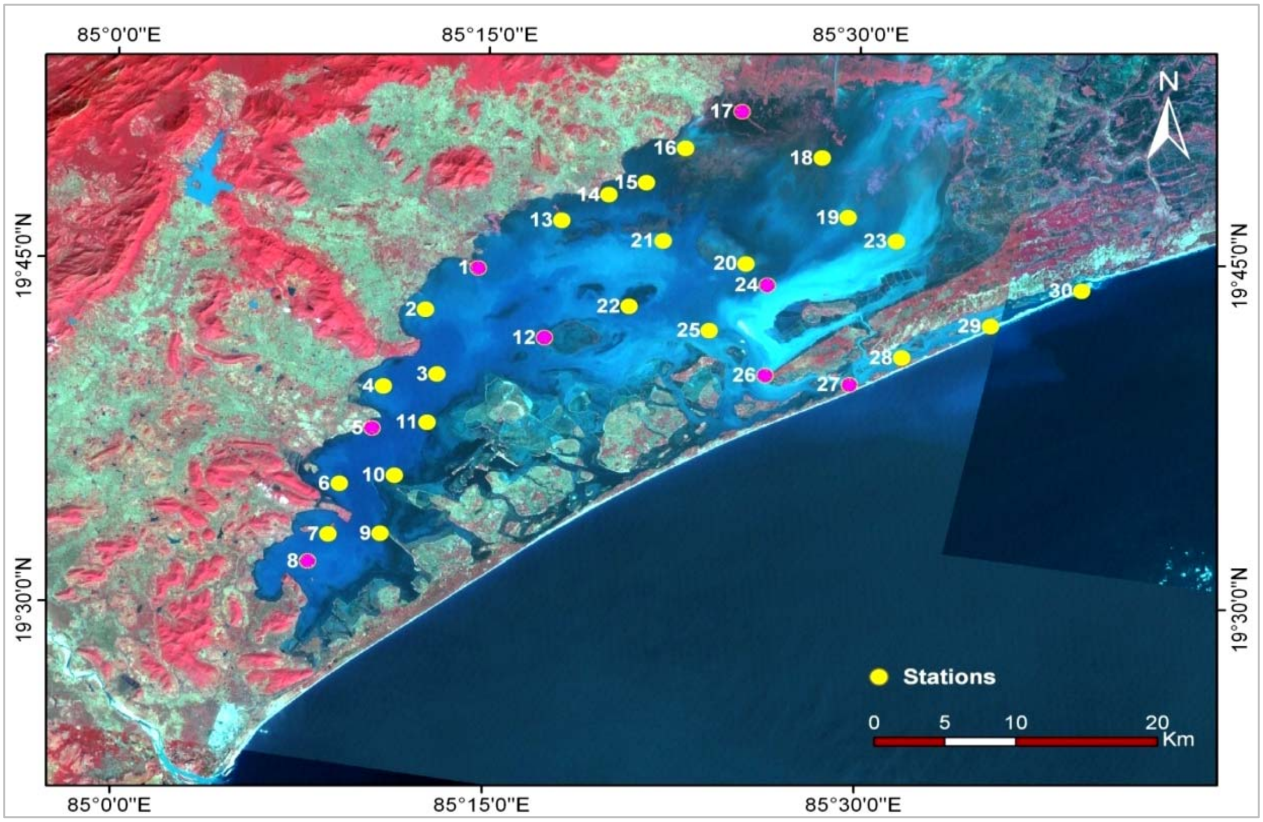
3.0 Tools for Nutrient Assessment of Chilika Lake

The Institute for Ocean Management (IOM), Anna University, Chennai received the data on various physical, chemical, biological and microbiological parameters collected at different locations of water quality parameters from CDA in the EXCEL Format. Data were analyzed in GIS (Geographical Information System) and other modelling software for easy interpretation of the observed data.

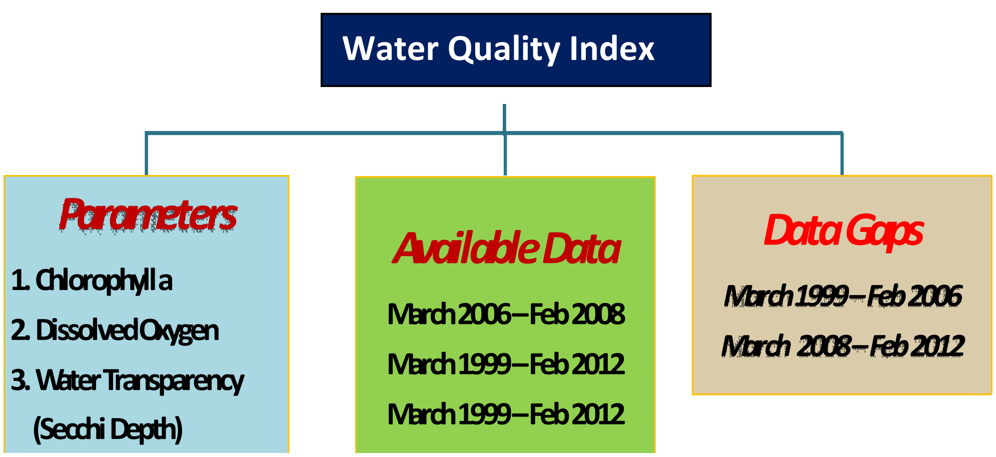
3.1 Location of Data Collection Points

There are 30 sampling points spread at different distances at the Chilika Lake covering an area of over 1100 km^2. Stations Stn-1, Stn-2, Stn-3, Stn-4, Stn-5, Stn-6, Stn-7, Stn-8, Stn-9, Stn-10, Stn-11 are located Southern Sector (Oligotrophic waters), Stn-12, Stn-13, Stn-14, Stn-15, Stn-16, Stn-17, Stn-18, Stn-21, Stn-22 are located in Northern Sector (Mesotrophic waters) and Stn-19, Stn-20, Stn-23, Stn-24, Stn-25, Stn-26, Stn-27, Stn-28, Stn-29, Stn-30 are located in the Central Sector (Eutrophic waters).

Fig. 3: Sampling Sites in Chilika Lake



3.2 Data Inventory



3.3 Tools for Assessment and Reporting (vizualisation)

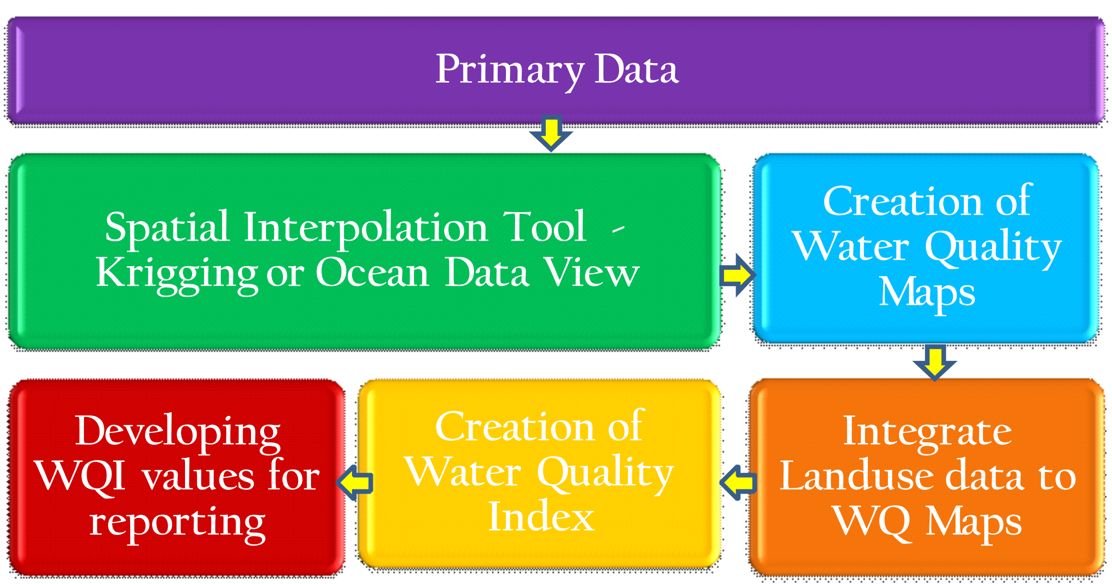
- Ecosystem Health Report Card
- Trend Analysis of Nutrient & Physico-Chemical Parameters
- Assessment of Estuarine Trophic Status
- LOICZ Nutrient Budget Model
- Driver-Pressure-State-Impact-Response (DPSIR) Framework
- Schematic representation (Conceptual Diagrams)
- Assessment of Harmful Algal Blooms

4.0 METHODOLOGY: Water Quality Index

4.1 Purpose of Ecosystem Health Report Card

Annual assessment of the key indicators is to provide an integrated assessment of the ecosystem's conditions. The indicators are key water quality conditions (e.g., dissolved oxygen, chlorophyll-a, water clarity), living resources populations (e.g., fisheries catch, independent data on oysters, crabs, fish), and their supporting prey (e.g., plankton, benthos, forage fish) and habitats (e.g., underwater aquatic grasses, tidal wetlands and other living resources). An integrated ecosystem health assessment for the Chilika Lake ecosystem and its tidal tributaries is produced using the identified reporting indicators and top level indices. A ranking valuation scheme is applied to compare ecosystem health assessments both geographically and over time (annual assessments).

Fig.4: Analysis of Primary Data for Chilika Lake Database



The task is to develop an improved assessment capacity by improving the timeliness of various data processing steps, developing additional key indicators and effectively communicating the integrated ecosystem health assessments with spatially explicit maps and rigorous scientific analyses to relevant stakeholders including the policy makers and the coastal community.

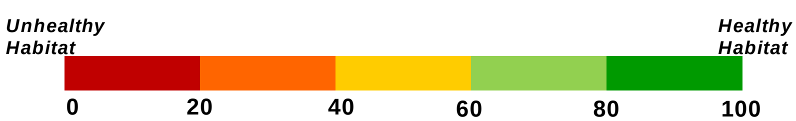
4.2 Goal

- Develop an **integrated ecosystem health report card for assessing the state of** the Chilika Lake and its tidal tributaries using the identified reporting indicators and top-level indices, which could be used a monitoring and communication tool to improve decision making at various levels.

To achieve the state goal the following key activities are envisaged

- Undertake a **ranking valuation scheme** to compare ecosystem health assessments both geographically and over time (annual assessments).
- Effectively **communicate the integrated ecosystem health assessments** with spatially explicit maps and rigorous scientific analyses to all stakeholders (i.e., the policy makers, managers, resource users and the larger community members whose actions impact the health of the Chilika Lake.

The Ecosystem Health Report Card will be presented to policy maker in a simple form in colour and indicated values (see below).



This report card will be supported by rigorous scientific analyses of hard data collected on several key parameters and this is illustrated in the subsequent sections based on the analyses of available data.

5.0 Results

5.1 Chilika Lake: Ecosystem Health Report Card

In this report, Coastal Ecosystem Health Index is defined as the progress of six water quality and biotic indicators towards established ecological thresholds. This choice is made based on review of experiences and lessons learned in monitoring and assessment of ecosystem health in estuaries, bays and lakes in other parts of the world refereed in section 1.1. The three water quality indicators are i) *chlorophyll-a,* ii) *dissolved oxygen* and iii) *water clarity* and the three biotic indicators are i) *bay grasses (submerged aquatic vegetation)*, ii) *Benthic Index of Biotic Integrity (soft bottom only)* and iii) *Phytoplankton Index of Biotic Integrity.*

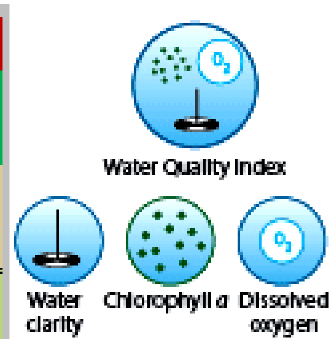
5.2 Water Quality Index

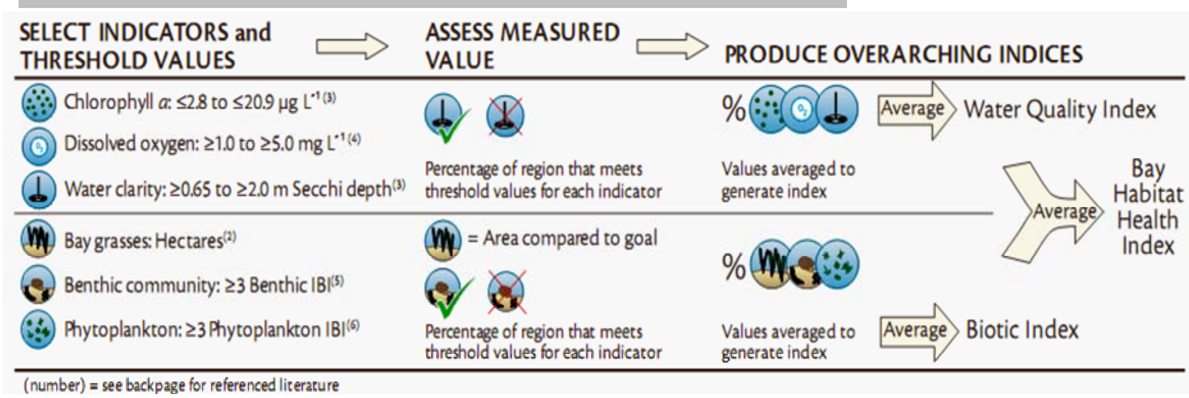
The Water Quality Index (WQI) needs to be sensitive to changes in the amount of nutrients delivered to the Chilika Lake, so that future changes in management actions can be detected. The methods and thresholds used to calculate WQI scores proved to be sensitive to nutrients. Water quality measures of chlorophyll-a, dissolved oxygen and water clarity (Secchi depth) were averaged to create the Water Quality Index (WQI), as given below:

Interpolations of average water quality conditions were produced to show spatial variability. The frequency that each water quality parameter exceeded established thresholds at every site was then calculated and mapped. The Water Quality Index was calculated by averaging the area weighted scores for water clarity, dissolved oxygen and chlorophyll-a, for each reporting region. It is then combined into a single score, the Water Quality Index (WQI) and then mapped.

Fig.5: Analysis of Primary Data for Chilika Lake Database

Water Quality	Habitat & Lower Foodweb
Dissolved Oxygen	Submerged Aquatic Vegetation (SAV)
Water Clarity (Secchi Disc)	Phytoplankton-Index of Biotic Integrity (P-IBI)
Chlorophyll a	Benthic-Index of Biotic Integrity (B-IBI)





a) Setting Thresholds

In general, within each coastal region, threshold values were determined for key metrics based on a comparison to "best sites". The best and worst quality sites were identified from water quality and habitat quality information.

Table.1: Thresholds used for each constituent of the Water Quality Index (WQI)

WQI	Oxygen Saturation	Water Clarity	Chlorophyll-a:
Threshold Values	Oligotrophic waters: >80% Mesotrophic waters: 10-80% Eutrophic waters: <10%	Oligotrophic waters:>4m Mesotrophic waters: 2–4m Eutrophic waters: <2m	Oligotrophic waters: >4 µg l^{-1} Mesotrophic waters 4-10 µg l^{-1} Eutrophic waters: >10 µg l^{-1}

b) Benthic Index of Biotic Integrity

Aquatic grasses (and Submerged Aquatic Vegetation) provide critical habitat to key certain species of crabs and fishes and can improve water clarity, Benthic IBI evaluates the health of the benthic or bottom-dwelling community (in soft-bottomed areas only) and Phytoplankton (microalgae) is an important component of Chilika Lake's food web.

Samples for assessing benthic community (bottom habitat) were collected at approximately 30 by the Chilika Lake Benthic Monitoring Program. Data from each sampling station is used to calculate a Benthic Index of Biotic Integrity (BIBI) score. The proportion of the reporting regions area meeting the Benthic Index of Biological Integrity score is calculated and mapped.

c) Phytoplankton Index of Biotic Integrity

Phytoplankton (microalgae) is an important component of the lake's food web. The Phytoplankton Index of Biotic Integrity (PIBI) is a measure of the microscopic algal community condition.

- Species Richness = no. of Species in known volume of sample
- Shannon Weiver Diversity index(H)= $\sum_{i=1}^{s} Pi \ InPi$

  $H_{max} = InS$
- Species Evenness(E)

  $Evenness(E) = H/H_{max} = H/Ins$

Index Range	*Water Quality w.r.t Plankton*
1.0 - 2.0	Poor
2.0 - 2.67	Fair-Poor
2.67 - 3.33	Fair
3.33 - 4.0	Fair-Good
4.0 - 5.0	Good

Fig.6: Index range of Water Quality Indices

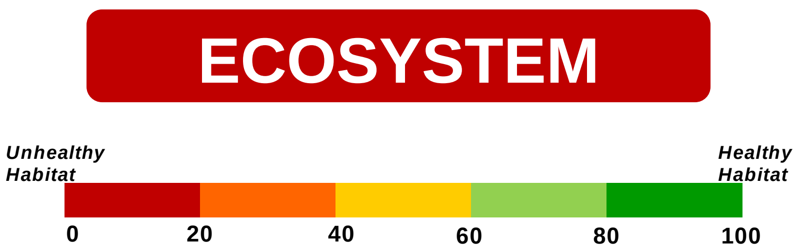
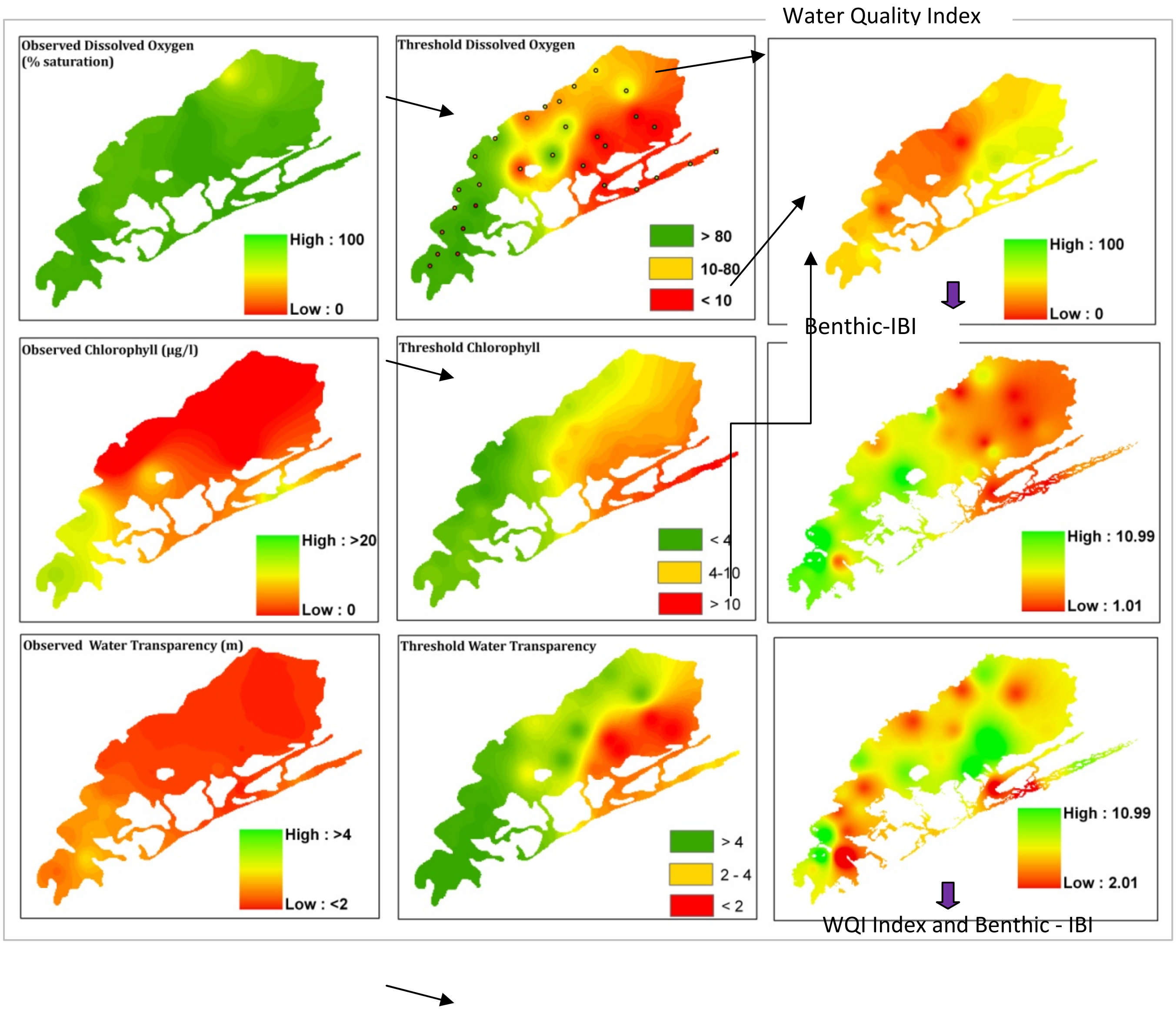


Fig.7: The Coastal Ecosystem Health Index (CHI) value is ranked in ascending order from the worst (dark red) to the best water quality (green)



6.0 ANNUAL & MONTHLY TRENDS IN WATER QUALITY

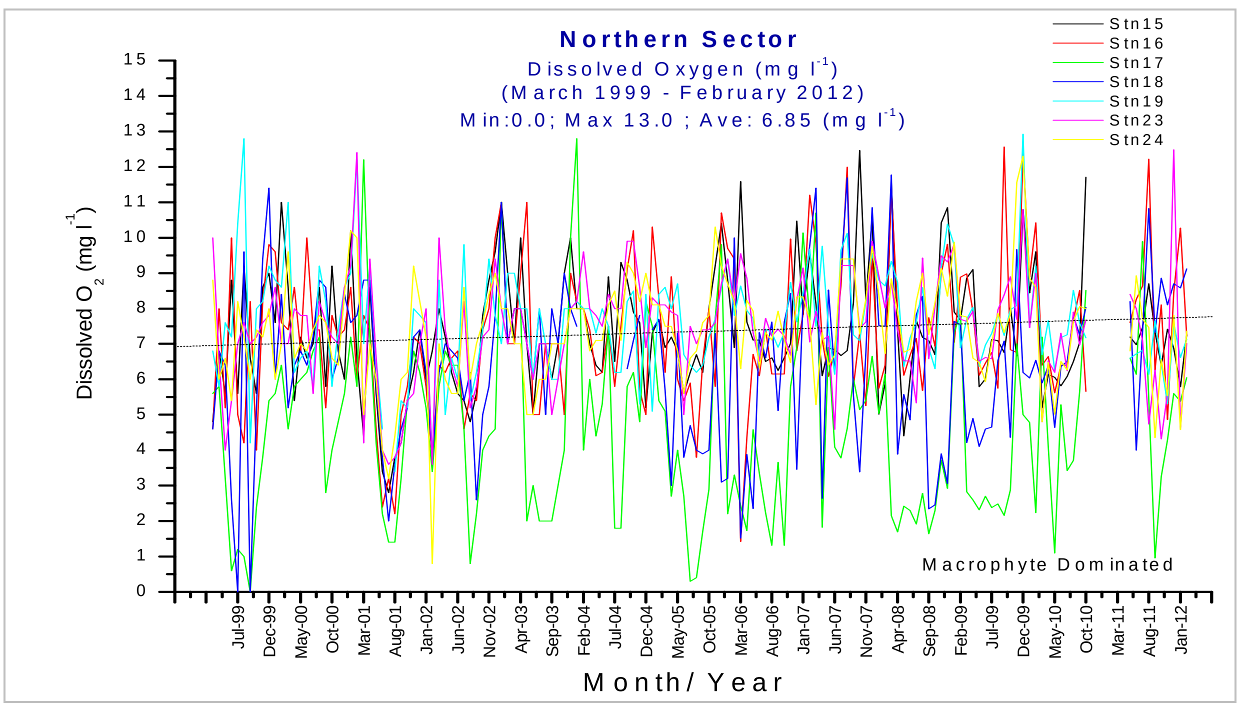
6.1 Water Quality of Chilika Lake

The annual and inter-annual variability of water quality along the Chilika coast and the adjacent offshore waters have been analyzed covering a time period of 13 years 1999 to 2012. A few selected critical nutrient parameters have been analyzed to understand the long-term variations, to detect any changes in Chilika Lake Water Quality and in particularly to understand the impacts of physical intervention that was carried out in 2000.

a) *Dissolved O_2*

Anoxic conditions (0.0 mg/1) prevailed in station Stn. 18 during July 1999. This abnormality may be attributed to the decomposition of the fresh water species of weed. The overall trend of dissolved oxygen indicates fluctuation and increasing in recent years. Maximum of 13.0 mg/l was observed at stn.19 during December 2009 in Chilika Lake waters.

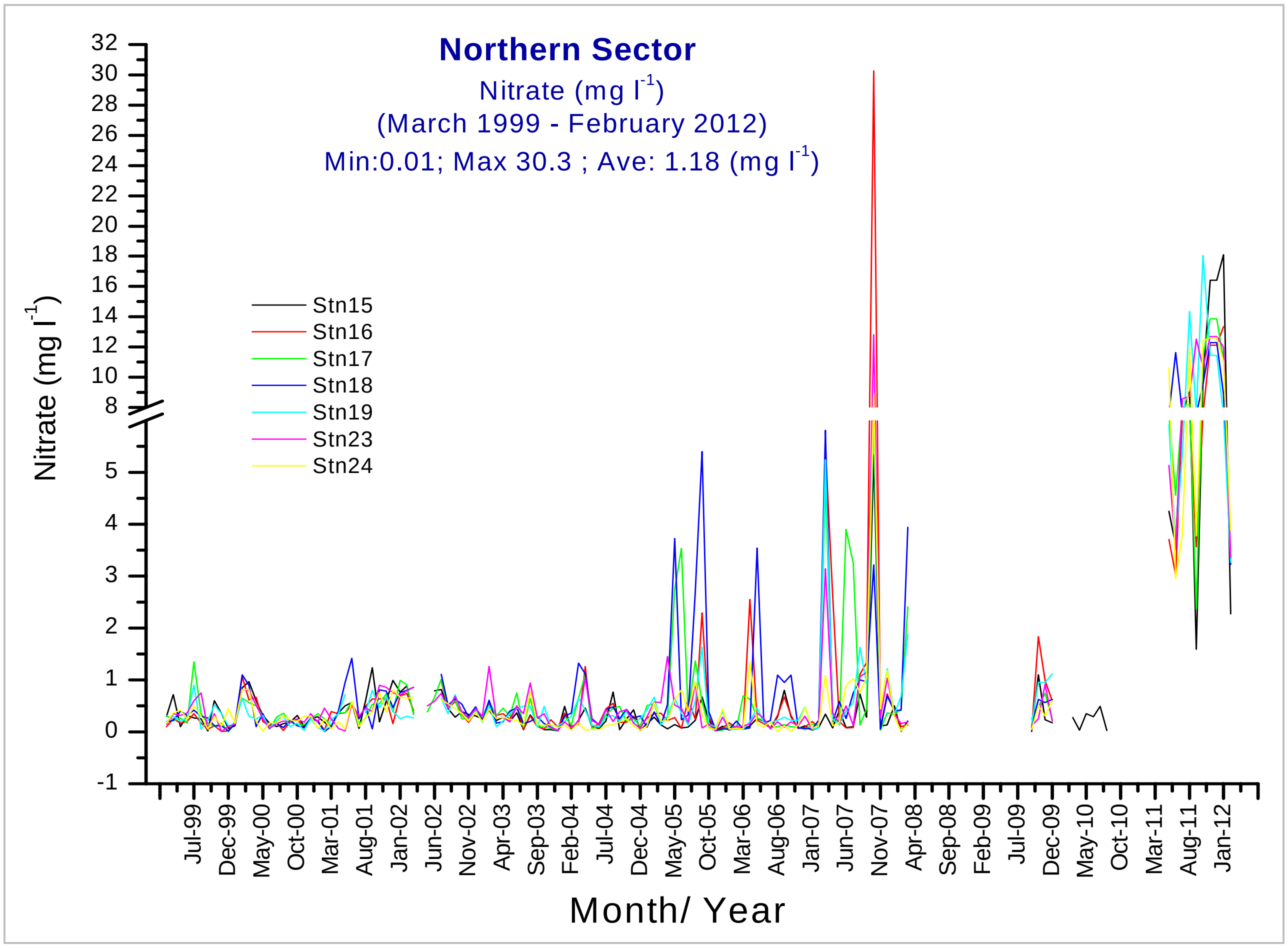
Fig.8: Trend Observed for Dissolved Oxygen in Chilika Lake waters



b) *Nitrate*

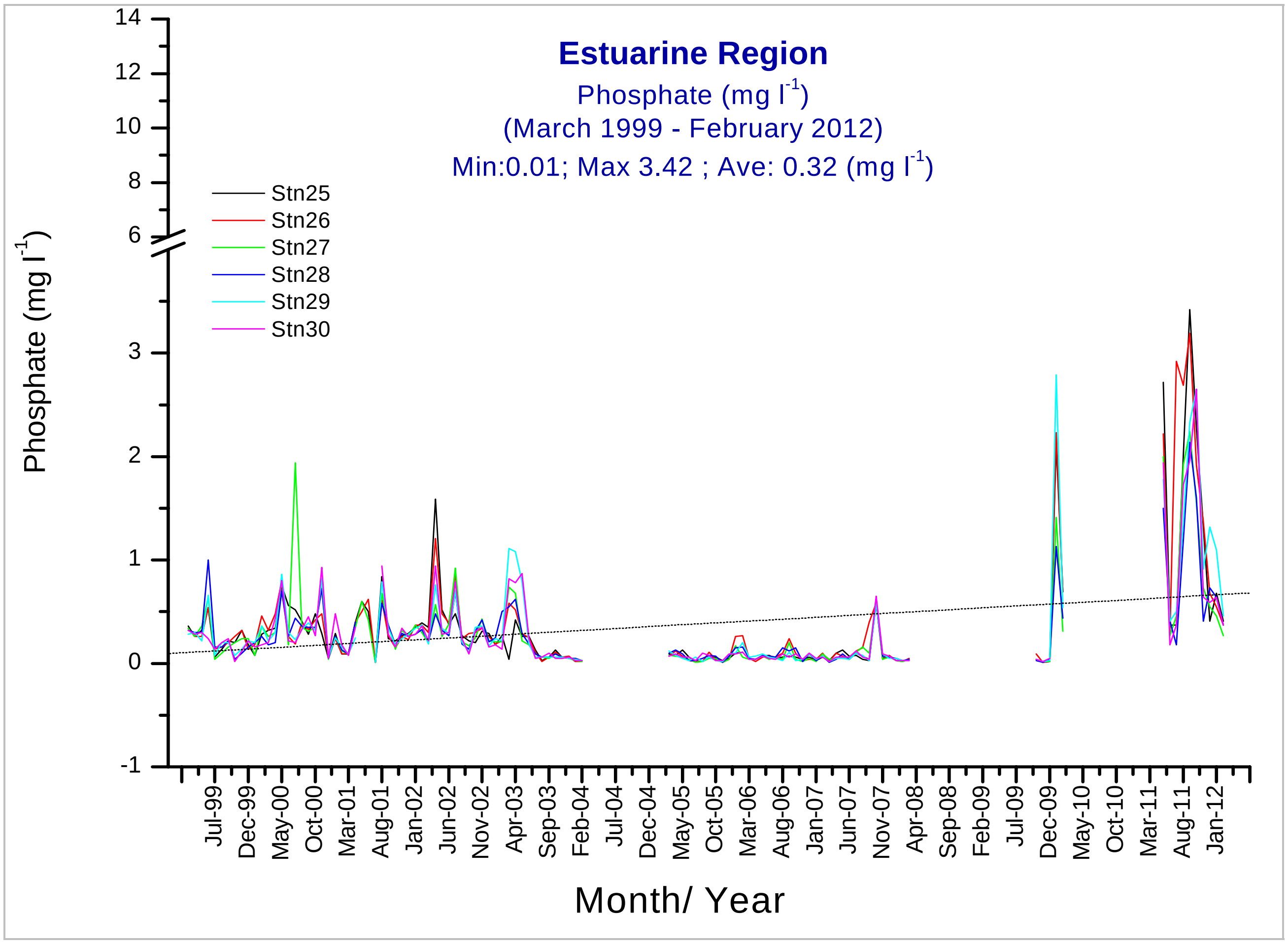
The Nitrate content in coastal waters of Chilika Lake was in the range between 0.01–30.3 µMol/l. The concentration of NO_3 (30.3 mg/l) was observed during the November 2007 at stn. 16. The overall trend in Nitrate is observed to increase in the recent years.

Fig. 9: Trend Observed for Nitrate in Chilika Lake waters



c) ***Phosphate***

Fig. 10: Trend Observed for Phosphate in Chilika Lake waters



The minimum Phosphate in Chilika Lake is about 0.01 mg/l at stn. 28 during 2005 and high concentrations was 3.42 mg/l at stn. 25 during September 2011. The overall trend of Phosphate concentration is increasing in recent years.

7. Assessment of Estuarine Trophic Status [ASSETS]

This section describes an integrated methodology for the Assessment of Estuarine Trophic Status (ASSETS), which may be applied comparatively to rank the eutrophication status of estuaries and coastal areas, and to address management options. It includes quantitative and semi-quantitative components; and uses field data models and expert knowledge to provide Driver Pressure-State-Response (DPSR) indicators.

The eutrophication status of Chilika Lake using ASSETS Model indicates that increased agricultural activity coupled with increased population stress would increase the Eutrophication Status to a higher degree in the Chilika Lake waters in the future.

8. LOICZ Nutrient Budget Model

Land-Ocean Interactions in the Coastal Zone (LOICZ) has developed a biogeochemical model for budgeting of nutrients (Carbon, Nitrogen, Phosphorous) in the aquatic ecosystems. LOICZ considers the coastal biogeochemical processes of these dynamic systems and links the river and the coast. This gives an idea of the behaviour of the system and how much it is contributing to the adjacent coastal and marine ecosystems. LOICZ budgeting assumes that materials are conserved. The difference of imported (inputs) and exported (outputs) materials are explained by the processes within the system, like SOURCE or SINK concept. The budgeting results are based on series of input parameters like System area, System depth, System volume, Evaporation rate, Salinity, Freshwater flows like river, groundwater, direct precipitation, Nutrient concentrations, and Suspended Particulate Matter concentration. Results are displayed in the LOICZ box-diagram format. Modified LOICZ model has considered the effect of Suspended Particulate Matter in the modelling calculation. Hence, the current version of CABARET (Computer Assisted Budget Analysis for Research, Education, and Training) model is for its best application in the muddy ecosystems having high SPM concentration (> 100 mg l^{-1}).

9. D-P-S-I-R Framework

In preparing this preliminary report, efforts have been made to apply the D-P-S-I-R (Driver-Pressure-State-Impact-Response) framework for the coastal waters of India. This multidisciplinary approach originally promoted by OECD in 1993 and further developed within the LOICZ project allows combining the knowledge and experience of natural and social scientists. Data and information are reviewed in such a way as to produce a complex picture of interactions of economic sectoral activities that affect coastal zone ecosystems and social processes, and to reveal further indicator functions and impacts on natural and social values of coastal zone. The analysis assesses the response of society on environmental and anthropogenic changes in the coastal zone.

10. Summary

The ecosystem health report card for Chilika Lake that has been proposed is unique as it provides a geographically detailed and integrated approach to form numerical rankings of 3 reporting regions (Northern, Southern and Central) on an annual basis. This approach complements those focusing on assessment over longer time frames. The geographic detail provided in the report card reflects the complexity of Chilika Lake and its tributaries, and provides information that can help guide and focus restoration efforts. The report card is a product under development, and aims to give a complete assessment of the lake health on a periodical basis. Future report card will also include indicators of fishery status at suitable spatial scales and time frames.

Annex-1

**EXPERT GROUP MEETING TO DEVELOP INDICATORS
TO ASSESS COASTAL ECOSYSTEM HEALTH**

Organized by

**Chilika Development Authority
&
National Centre for Sustainable Coastal Management, MoEF**

Date: 25 – 27 JUNE 2012

Venue:
Wetland Research & Training Center of
Chilika Development Authority, Chandraput, Balugaon
AGENDA

25th June 2012	
Technical session-I:	**Introduction to GPNM and the Project**
10.30 hrs- 11.00hrs	**Inaugural**
11.00 – 11.30 hrs.	Challenges of Nutrient Management and Role of GPNM *Dr. Anjan Datta*
11.30 hrs to 12.00hrs	Introduction to the Chilika GPNM Project Case Study *Dr. A K Pattnaik, Chief Executive, CDA*
12.00 hrs - 12.30hrs	Nutrient Over-enrichment: Causes and Consequences *Dr. Ramesh Ramachandran*
12.30hrs -13.00 hrs	Questions, comments and points of clarification **Facilitated by** : *Dr. Ramesh Ramachandran*
13.00 hrs – 14.00 hrs	**Lunch**
Technical session-II: GPNM - Global Perspectives	
14.00hrs- 14.30hrs	Nutrient Management in Laguna Bay *Ms. Adelina C. Santos-Borja*
14.30hrs–15.00hrs	Nutrient Management in Manila Bay *Mr. Robert Jara*
15.00hrs – 15.30hrs	Monitoring of nutrient flow in to Chilika Lake *Mr. R. N. Samal, Scientific Officer, CDA*
15:30 - 16:00	***Tea/ Coffee***

Technical session-III	GPNM - Global Perspectives
16:00 hrs - 17:30hrs	Mahanadi basin land use and its implications on the nutrient concentrations in Chilika Lake *Dr. Tapan Kumar Adhya, ING*
	Field and model investigation on coastal lagoon ; A case study on Chilika *Dr. V. R. Rao, ICMAM, Chennai*
	Fisheries resources of Chilika lake *Mr. S. K. Mohanty, Fishery Consultant, CDA*
	Strengthening livelihood resilience to changing climate in Chilika Lake *Mr. Ritesh Kumar, WISA*
	Ecosystem Modeling of Chilika Lake *Mr. R. N. Samal, Scientific officer, CDA*
26th June 2012	
Technical Session-IV	**Introduction to Tools and Methods**
10.00 hrs – 11.00 hrs	**Presentation of Past Chilika data by NCSCM & Discussion** Water Quality Index and Report Card Biotic Index Coastal Ecosystem Health Index
11.00 hrs – 11.30 hrs	**Tea**
11.30 hrs – 12.00 hrs	**Presentation of Past Chilika data by NCSCM & Discussion** LOICZ Biogeochemical Budget
12.00 hrs – 12.30 hrs	Tools used in Manila Bay *Mr. Robert Jara*
12.30hrs – 13.00 hrs.	Tools used in Laguna Bay Ms. Adelina C. Santos-Borja
13.00 hrs – 14.00 hrs	**Lunch**
Technical session-V:	**Chilika Project: Next Steps**
14.00 hrs – 14.30hrs	Monitoring Plan of Chilika Lake *Dr. A. K. Pattnaik, Chief Executive, CDA*
14.30hrs – 15.00 hrs	Hydrodynamics of Chilika Lake *Dr. P. Chandramohan , INDOMER, Chennai*
15.00hrs – 15.30hrs	**Future steps and harmonization of tools and methodsDiscussion** Facilitated by *Dr. Ramesh Ramachandran*
15.30hrs – 16.00hrs	***Tea/ Coffee***
16.00hrs–17.00hrs	The NGOs and the local fisherman community to participate Stakeholder response Facilitated by *Dr. A. K. Pattnaik, Chief Executive, CDA*
27th June 2012	
Technical session-VI	**GPNM-Chilika Case Study – Way Forward**
09.00 hrs – 11.00 hrs	Open dialogues to identify key issues for the Report Card and proposed Nutrient Management Plan including institutional arrangements and policy issues Facilitated by *Dr. Anjan Datta*

11.00 hrs – 12.00hrs	**Valedictory to be Chaired by** *Sri Raj Kumar Sharma, IAS, Principal Secretary, Forest & Environment Department, Government of Odisha*
12.00 hrs – 13.00hrs	**Lunch**
13.00 hrs – 17.00 hrs	**Field Trip to Chilika Lake and Its drainage**
28th June 2012	
Field Trip	

Annex 2

INCEPTION WORKSHOP: EXPERT GROUP MEETING TO DEVELOP TO ASSESS COASTAL ECOSYSTEM HEALTH
25-27 June 2012
Wetland Research & Training Center, Barkul
LIST OF PARTICIPANTS

Sl. No.	Name	Designation	Organisation	Address	City
1	Shri. R. K. Sharma, IAS	Principal Secretary, Forests & Environment Department.	Government of Odisha	Forest & Environment Dept., Odisha Secretariat	Bhubaneswar
2	Dr. Anjan Datta	Programme Officer	UNEP/GPA Coordination Office	UNEP	Nairobi, Kenya
3	Dr. Tapan Kumar Adhya	National Coordinator	Indian Nitrogen Group	Flat # B 423 RajendraVihar, Forest Park	Bhubaneswar
4	Dr. P. Chandramohan	Managing Director	INDOMER Coastal Hydraulics(P) Limited	#63, Gandhi Road, AlwarThirunagar, Chennai-600087	Chennai
5	Mr. Ritesh Kumar	Senior Conservation Manager	Wetland Interantional South Asia	Wetlands International - South Asia A-25, 2nd Floor, Defence Colony New Delhi - 110 024	New Delhi
6	Mr. Robert Jara	Programme Specialist	PEMSEA Resource Facility DENR Compound,	Visayas Avenue, Quezon City 1100, Philippines P.O. Box 2502, Quezon City 1165, Philippines	Philippines

7	Ms. Adelina C. Santos-Borja	Officer-in-Charge	Resource Management and Development Department	Head, Carbon Finance Unit Laguna Lake Development Authority Sugar Regulatory Administration Compound North Avenue, Diliman Quezon City PHILIPPINES	Philippines
8	Dr. V. R. Rao	Scientist	ICMAM Project Directorate	Chennai	Chennai
9	Dr. R. Ramesh	Director	NCSCM	Chennai	Chennai
10	Dr. Sathiyabhama. V.P.	Research Fellow	Institute of Ocean Management, Anna University	Chennai	Chennai
11	Dr. R. Purvaja	Consultant	NCSCM	Chennai	Chennai
12	Dr. Kakolee Banarjee	Research Fellow	Institute of Ocean Management, Anna University	Chennai	Chennai
13	Mr. Pradipta Ranjan Muduli	Research Scholar	ICMAM Project Directorate	Chennai	Chennai
14	Dr. A. K. Pattnaik	Chief Executive	Chilika Development Authority	C-11, BJB Nagar, Bhubaneswar.	Bhubaneswar
15	Mr. G. Rajesh	Additional Chief Executive	Chilika Development Authority	C-11, BJB Nagar, Bhubaneswar.	Bhubaneswar
16	Mr. S. K. Mohanty	Fishery Consultant	Chilika Development Authority	C-11, BJB Nagar, Bhubaneswar.	Bhubaneswar
17	Dr. K. S. Bhatta	Limnologist Consultant	Chilika Development Authority	C-11, BJB Nagar, Bhubaneswar.	Bhubaneswar
18	Dr. R. N. Samal	Scientific Officer	Chilika Development Authority	C-11, BJB Nagar, Bhubaneswar.	Bhubaneswar
19	Dr. P. C. Panda	Senior Scientist	Regional Plant Research Center	Bhubaneswar	Bhubaneswar
20	Dr. P. K. Panigrahi	Oceanographer	ICZM Project, Odisha	ICZM Project, Odisha	Bhubaneswar
21	Dr. Mrutyunjay Suar	Director	KIIT University	School of Biotechnology,	Bhubaneswar
22	Mr. Sujit Kumar Mishra	Project scientist, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon

23	Mr. Debasish Mahapatro	Project Fellow,CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
24	Mr. Muntaz Khan	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
25	Mr. Subhasis Pradhan	Project Assistant,CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
26	Mr. Saibala Parida	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
27	Ms. Suchismita Srichandan	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
28	Ms. Swati Dwibedy	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
29	Ms. Shivani Patnaik	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
30	Mr. Manoranjan Mishra	Project Assistant	Chilika Development Authority	WRTC, BARKUL	Balugaon
31	Mr. S. Balaji Patra	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
32	Mr. Saroja Kumar Barik	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
33	Mr. Rakesh Baral	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
34	Mr. Bibhuti Bhusan Dora	Project Assistant, CDA	Chilika Development Authority	WRTC, BARKUL	Balugaon
35	Mr. Mihir Kumar Jena	Secretary	Researcher, NGO	Satapada	Puri
36	Mr. Durga Prasad Biswal	Project assistant	Regional Plant Research Center	Bhubaneswar	Bhubaneswar

37	Dr. Dinabandhu Sahu	SRF	Regional Plant Research Center	Bhubaneswar	Bhubaneswar
38	Mr. Durga Prasad Dash	Secretary	Pallishree, NGO	Bhubaneswar	Bhubaneswar
39	Mr. Bijay Kumar Baral	Secretary	The People, NGO	Puri	Puri
40	Mr. Balaram Das	President	Gangadei PFCS	Pathara	Pathara
41	Mr. Kamal Lochan Behera	Secretary	Gopabandhu Seba Parishada, NGO	Delanga	Delanga
42	Mr. Sujan Tahal	Secretary	Naba Jagarana Nari Sangathana, NGO	Pathara	Pathara
43	Mr. Basant Kumar Nayak	Board of Director	CFCCS*	Balugaon	Balugaon
44	Mr. Deshraj Munjet	Members	CFCCS*	Balugaon	Balugaon
45	Mr. Hiranya Jena	Members	CFCCS*	Balugaon	Balugaon
46	Mr. Bhimasen Behera	Members	CFCCS*	Balugaon	Balugaon
47	Mr. Arabinda Tarai	Members	ARCS**	Balugaon	Balugaon
48	Mr. Suresh Chandra Behera	Members	ARCS	Balugaon	Balugaon
49	Mr. Sudhansu Sekhar Sahu	ACF***	Chilika Development Authority	Bhubaneswar	Bhubaneswar
50	Mr. K.P. Pattnaik	Range Officer, CDA	Chilika Development Authority	Bhubaneswar	Bhubaneswar
51	Mr. Jaya Krishna Behera	Watershed Field Assistant	Chilika Development Authority	Balugaon	Balugaon
52	Mr. Bhabani Sankar Baliarsingh	Watershed Field Assistant	Giri Gobardhan Watershed Association	Balugaon	Balugaon

* CFCCS-Chilika fisherman Central Cooperative society;
**ARCS-Assistant Registrar Cooperative Society
***ACF-Assistant Conservator of Forest