Introduction

The health report card of an ecosystem serves as an effective communication tool that simplifies complex data and information into a format accessible to diverse audiences, including local communities, policymakers, and stakeholders. In this context, Chilika Lagoon has been scientifically assessed to develop a health report card aimed at facilitating improved ecosystem management.

The first Chilika Health Report Card was introduced in 2012 and subsequently updated in 2014, 2016, 2018, 2020, and 2022. This initiative emerged from a collaborative project titled "Global Foundations for Reducing Nutrient Enrichment and Oxygen Depletion from Land-Based Pollution, in Support of the Global Nutrient Cycle", jointly undertaken by the Chilika Development Authority (CDA), the National Centre for Sustainable Coastal Management (NCSCM), and the United Nations Environment Program (UNEP/GEF), in partnership with the Application Network from the University of Maryland Center for Environmental Science, USA.

The health report cards not only provide insights into the status of the lagoon's ecological health but also raise awareness about the pressures impacting its ecological values and services. Report card-based assessments have proven to be an effective monitoring framework for the Chilika Lagoon, enabling stakeholders to track changes in ecological health over time.

The current report card, the seventh in the production series, will serve as a valuable tool for comparing health trends across multiple years. By identifying key environmental variables responsible for these changes, it will support the development of strategic interventions for the sustainable management of Chilika Lagoon.

Measures of Ecosystem Health

The ecosystem health of the Chilika lagoon was assessed by taking into consideration 9 indicators organized into three main indices: Water quality, Fisheries, and Biodiversity. Together, these indicators represented the ecosystem features of Chilika lagoon that were valued (e.g., fishing, tourism, and biodiversity) and the threats (overfishing and illegal aquaculture, pollution and sedimentation) to these values.

Water Quality

Water clarity refers to the amount of light that penetrates through the water column and plays a critical role in determining the distribution and abundance of macrophytes, seagrasses, and phytoplankton. It is primarily influenced by factors such as wind-induced sediment churning, phytoplankton biomass, colored dissolved organic matter (CDOM), and sediment influx from surrounding rivers.
Dissolved oxygen (DO) is a vital parameter for the survival and vitality of aquatic organisms, with species-specific oxygen requirements. DO levels in an aquatic system are influenced by the rate of oxygen production through photosynthesis by phytoplankton, macrophytes, and seagrasses, as well as oxygen consumption during respiration by microorganisms and other aquatic life.
Chlorophyll-a, a measure of phytoplankton biomass, serves as a reliable indicator of ecosystem health (Smith et al., 1999). Its concentration in an aquatic environment is largely determined by nutrient stoichiometry and water clarity, making it a key metric for assessing ecosystem productivity and balance.

Fisheries

The total catch of fish, prawn, and crab was recorded monthly at 35 landing stations around the lagoon. The fish landing monitoring allows lagoon managers to know the annual yield in comparison to a calculated maximum sustainable yield (CIFRI-ICAR, 2005). Commercial species diversity is the number of species landed each year that are commercially important for the livelihood of the fishermen. The body length of Bagada or tiger prawns (Penaeus monodon), Khainga or mullet (Mugil cephalus), and Chilika Crabs (Scylla serrata) should be above (or between) a prescribed length to ensure the sustainability of the species.

Biodiversity

Bird count and richness: Count the number of birds and bird species utilizing the lagoon for feeding, resting, and breeding. Chilika lagoon is the largest wintering ground for migratory waterfowl found anywhere on the Indian sub-continent.

Dolphin abundance: Count of the endangered Irrawaddy dolphins surveyed annually in the lagoon.

Phytoplankton diversity (microalgae): Simpson's Index of Diversity (D) is also used to assess the condition of this microscopic algal community through analysis of the number of species present, and the abundance of each species. Phytoplankton is an important component of the lagoon's food web.

Threshold for Each Indicator

Desired conditions were based on available guidelines, current scientific knowledge, and historical data and trends, and taking into account the influence of a variable climate from year to year. The table below outlines the desired condition and threshold values developed or identified for each indicator.

Category	Indicator	Desired condition (Threshold)	Source of data to derive thresholds
Water quality	Water clarity	≤30 NTU	CPCB, New Delhi; The Environment (Protection) Rules, 1986
	Dissolved oxygen	≥ 4 mg/L or 60% sat.	CPCB, New Delhi; The Environment (Protection) Rules, 1986
	Chlorophyll-a	≤ 9 µg/L	Smith et al.1999
Fisheries	Total catch	%deviation above or below maximum sustainable yield (11,500t/yr)	CIFRI-ICAR, 2005
	Commercial species diversity	Ratio of species landed: desired (45 sp. desired)	CDA
	Size	Proportion of species landed above a sustainable size limit. M.cephalus:262-495mm; P.monodon: 124-197mm; S.serrata: 85mm	CDA
Bio diversity	Bird count and richness	Ratio to maximum bird count and diversity recorded since 2003	CDA/CWD*
	Dolphin abundance	Ratio to maximum dolphin count recorded since 2001	CDA/CWD
	Phytoplankton diversity	Simpson's Index of Diversity(1-D)	CDA

**CWD: Chilika Wildlife Division*

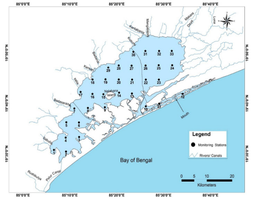
Deciding Zonal Grades

Chilika lagoon was divided into four zones depending on the environmental conditions as reported by Muduli et al., 2013. The scientific data recorded from January 2023 to December 2024 were divided into four zones: Northern zone (NZ), southern zone (SZ), central zone (CZ), and Outer channel zone (OCZ). The grades were calculated for each zone from the average data of water quality, fisheries, and biodiversity indices.

For the preparation of the Health Report Card for the period 2023–2024, the data from the Chilika monitoring programme were used for grade score calculations by comparing the measured values with the prescribed threshold levels. To derive the grades for the water quality indicators, data from 33 locations for DO (January 2023-December 2024), turbidity (January 2023-September 2023), and chlorophyll-a (January 2023-December 2023) were utilized for analysis and threshold comparison. For phytoplankton, data collected during January–May 2023 (33 stations), November 2023 (14 stations), January 2024 (33 stations), and September (15 stations)- October 2024 (17 stations) covering all the sectors of the lagoon were used. Data recorded during 2023 and 2024 from the annual bird and dolphin census carried out during winter season by Chilika Wildlife Division were used. The fishery statistics were computed from the fish landing centers' data (January-December 2023 and 2024) collected by CDA.

What does the Grade Imply?

- 80 to 100%. All water quality and biological health indicators meet the desired levels The quality of water in these locations tends to be very good, most often leading to very good habitat conditions for fish and shellfish.
- 60 to 80%. Most water quality and biological health indicators meet the desired levels. The quality of water in these locations tends to be good, often leading to good habitat conditions for fish and shellfish.
- 40 to 60%. There is a mix of good and poor levels of water quality and biological health indicators. The quality of water in these locations tends to be fair, leading to fair habitat conditions for fish and shellfish.
- 20 to 40%. Some or few water quality and biological health indicators meet the desired levels. The quality of water in these locations tends to be poor, often leading to poor habitat conditions for fish and shellfish.
- 0–20%. Very few or no water quality and biological health indicators meet the desired levels. The quality of water in these locations tends to be very poor, most often leading to very poor habitat conditions for fish and shellfish.
- Grades denoted with a +ve or –ve indicate a score that is within 2% of a score's high or low boundary. For example, a B+ve is indicative of 78-80%.



Sampling stations for water quality and phytoplankton sample collection from Chilika

Chilika Lagoon 2023-2024 Report Card

Overall, Chilika lagoon scored a B+ for ecosystem health based on the performance of water quality, fisheries, and biodiversity indices. The lagoon as a whole displayed excellent (A) dissolved oxygen concentration, chlorophyll-a, phytoplankton biodiversity and fish size. The Dolphin indicator scored C and the rest of the indicators scored B. Scores of the nine indicators that were assessed within water quality, fisheries, and biodiversity are as follows: 85 % (A) in the Southern Zone followed by 84% (A) in the Outer Channel Zone, 74 % (B) in the Central Zone, and 70% (B) in the Northern Zone. A breakdown of these indicators by zone is provided below.

Northern Zone (B):

The Northern Zone displayed excellent results for the indicators of water quality (except water clarity indicator). This zone maintained good biodiversity due to the abundance of bird count and richness with the exception to Dolphin abundance. This zone also maintained good fisheries due to excellent commercial species diversity.

Southern Zone (A):

The Southern Zone displayed excellent results for water quality, and biodiversity and good results for fisheries. In fishery, size recorded excellent results, whereas the commercial species diversity and total catch showed mix of good and poor results.

Central Zone (B):

The Central Zone displayed excellent results for water quality, and good results for biodiversity and fisheries. However, poor results were recorded for dolphin.

Outer Channel Zone (A):

The Outer Channel Zone displayed excellent results for all the indicators. Water clarity, Bird count and richness showed good results whereas, commercial species diversity showed poor result.

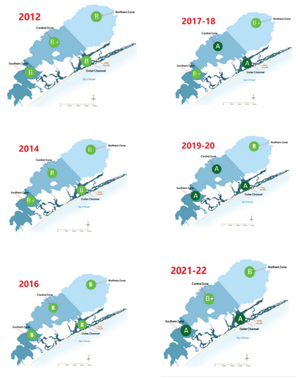
How does the Chilika health report card for 2023-24 compare with earlier report cards:

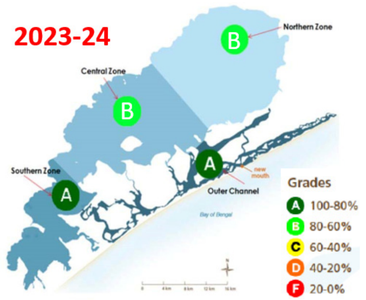
As compared to report cards published so far, 2023-24 report cards indicated the health of the lagoon is better as compared to the health condition during 2012 (Overall score changed from grade B to B+). The scores of the individual sectors also evidence this (except for the central zone). The present report card showed a significant change in the southern and outer channel zone as compared to 2012 (B to A). In comparison to the previous report card (2021-22), only the central zone recorded a change from B+ to B.

	2012	2014	2016	2017-18	2019-20	2021-22	2023-24
Overall	B	B	B	A-	A	A	B+
Southern Zone	B	B+	B	B+	A	A	A
Central Zone	B+	B	B	A	A	B+	B
Northern Zone	B	B-	B-	B+	B	B	B
Outer channel Zone	B	B	B	A	A	A	A

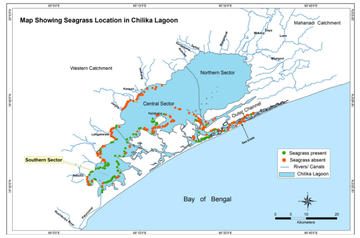
Lagoon Health & Fisheries

During the study period, the fish landing data for two years starts from January to December (2023-2024) were taken into consideration. The average annual total fish landings (fish, prawn & crab) from Chilika lake was estimated at 20657.30tons, while comparing with the average annual total landings for the year 2021 & 2022 (19331.51tons.), it increased by 6.86 %. The value of average total annual landings during the years 2023 and 2024 was 38514.99 Million INR which was increased by 13.64 % as compared with the catch value of the years 2021 & 2022 (33892.39 Million INR). The average annual per capita income of active fishers during the year 2023 & 2024 was estimated at 85001.00 INR which was increased by 2.39% as compared to the income for the years 2021 & 2022. The percentage composition of total landings for the year 2023 & 2024, the fish, prawn, and crab were 67.37 %, 30.49%, and 2.15 %, respectively.





Seagrass and Salt marsh diversity studies in Chilika



Benthic macrophytes, especially seagrasses, are efficient"blue carbon" stock and contribute to climate change mitigation through the uptake of carbon (C) and storing it in their biomass and underneath sediments. These aquatic plants constitute underwater coastal habitats and are referred to as "ecosystem engineers" due to their ability to physically modify their local benthic/pelagic environment. Seagrass meadows due to increased habitat complexity are excellent foraging and breeding habitats for various fauna, especially fisheries. Studies examining the spatial distribution and abundance of seagrasses are limited in the Indian coastal lagoons. Chilika (Odisha) is the largest brackish water lagoon in Asia and also supports the second-largest seagrass meadows in India. CDA conducted a study on Seagrass and Salt Marsh Ecosystems of Chilika Lagoon" funded under ECRICC project. Seagrass survey was conducted from December 2023-March 2024 and samples were collected from different locations for ground truthing. In this survey, dense/sparse and both continuous/patchy meadows of seagrasses have been observed. A total of 68 field observation points were checked across 27 different locations of Chilika. Six seagrass species: Halodule pinifolia, Halodule uninervis, Halophila beccarii, Halophila ovalis, Halophila ovata and Ruppia maritime were noted. Halophila ovalis was the commonly available species in Chilika. Seagrass meadows in Nalabana Island Watch Tower 1 were found in association with Gracillaria verrucosa (red algae), Stuckenia pectinata, and Najas indica. Besides other seaweeds was also found closely associated with seagrass meadows.

In general, seagrasses in Chilika occupied sheltered calm habitats with high water clarity and low fluctuation in salinity. Therefore, southern sector due to its unique geomorphology and sheltered bay habitats provided an ideal habitat for seagrass meadows. Due to the large spatial separation of southern sector from Mahanadi River distributaries, the influence of freshwater discharge was also minimal in this sector resulting in a stable salinity regime across various seasons. Besides, the dominance of sand content in bottom sediments of southern sector could also provide a soft substratum required for the expansion of their rhizomes.

Salt marsh diversity

Field surveys were conducted in March and April 2024 at Barunakuda of Outer Channel and Nalabana. The surveys aimed to estimate the biomass in order to assess the primary productivity of the marshes. Salicornia brachiata was most commonly available saltmarsh species in Nalabana Island. A total of three salt marshes namely Salicornia brachiata, Sesuvium portulacastrum and Suaeda maritima were traced. At Nalabana Tower 1, all three salt marsh species were recorded either in homogenous or mixed patches. While at Nalabana Tower 3 and Barunakuda only the Salicornia brachiata was recorded.

Way Forward

Following the release of the health report cards (2012–2022), studies were undertaken to address knowledge gaps in thematic areas and expand the suite of ecological indicators for evaluating the ecological health of Chilika Lagoon. Indicators such as heavy metal pollution are being considered for inclusion in future report cards as part of the water quality assessment parameters. Given the challenges of establishing accurate threshold values for various ecological indicators, the ideal approach is to sustain a long-term monitoring program. Such efforts will enable the derivation of threshold values specific to this tropical lagoon ecosystem, ensuring robust ecological health assessments and informed management decisions.

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CHILIKA LAGOON

Ecosystem Health Report Card 2023-24

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