Nature Index - India Report
A Pilot Study in Chilika Lake and Great Himalayan National Park

Centre for Biodiversity Policy and Law
National Biodiversity Authority
2019
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A Pilot Study in Chilika Lake and Great Himalayan National Park

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Ms. Maja Stade Aaronæs & Dr. Rupam Mandal

Centre for Biodiversity Policy and Law
National Biodiversity Authority
2019
List of Abbreviations

ABS  Access and Benefit Sharing
BiosCS  Biodiversity Conservation Society
BNHS  Bombay Natural History Society
BSI  Botanical Survey of India
CBD  Convention on Biological Diversity
CBET  Community Based Ecotourism
CDA  Chilika Development Authority
CEBPOL  Centre for Biodiversity Policy and Law
COP  Conference of the Parties
EIA  Environmental Impact Assessment
ENVIS  Environmental Information System
GHNP  Great Himalayan National Park
IBA  Important Bird Area
IDWH  Integrated development of Wildlife Habitats
IPBES  Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.
IUCN  International Union for Conservation of Nature
MEAs  Multilateral Environmental Agreements
MoEFCC  Ministry of Environment, Forest and Climate Change
MPAs  Marine Protected Areas
NBAP  National Biodiversity Action Plan
NBA  National Biodiversity Authority
NBT  National Biodiversity Target
NEA  Norwegian Environment Agency
NI  Nature Index
NINA  Norwegian Institute for Nature Research
NS  Northern Sector
OCS  Outer Channel Sector
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tr>
<td>PA</td>
<td>Protected Area</td>
</tr>
<tr>
<td>PBR</td>
<td>People’s Biodiversity Register</td>
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<tr>
<td>SBB</td>
<td>State Biodiversity Board</td>
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<tr>
<td>SBSTTA</td>
<td>Subsidiary Body on Scientific Technical and Technological Advice</td>
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<tr>
<td>SDG</td>
<td>Sustainable Development Goal</td>
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<tr>
<td>SoER</td>
<td>State of Environment Report</td>
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<tr>
<td>SP</td>
<td>Strategic Plan</td>
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<tr>
<td>SS</td>
<td>Southern Sector</td>
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<tr>
<td>SSB</td>
<td>Spawning Stock Biomass</td>
</tr>
<tr>
<td>TEEB</td>
<td>The Economics of Ecosystems and Biodiversity</td>
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<tr>
<td>WII</td>
<td>Wildlife Institute of India</td>
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<tr>
<td>WHS</td>
<td>World Heritage Site</td>
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<td>WSCG</td>
<td>Women Saving Credit Groups</td>
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<tr>
<td>UNESCO</td>
<td>United Nations Education Scientific and Cultural Organization</td>
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<tr>
<td>ZSI</td>
<td>Zoological Survey of India</td>
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</table>
I would like to thank the Norwegian Embassy, New Delhi, for providing the financial support for carrying out the Nature Index pilot study in the two selected sites: Chilika Lake and Great Himalayan National Park in India. I am extremely thankful to Dr. Amita Prasad, Former Additional Secretary, and Mr. Arun Kumar Mehta, Additional Secretary, Ministry of Environment Forest and Climate Change (MoEFCC), Government of India (GoI) and Dr. Sujata Arora, Adviser, MoEFCC, GoI for their involvement, encouragement and necessary administrative support for undertaking this study.

I express my sincere thanks to Ms. Maja Stade Aarnæs and Mr. Andreas Benjamin from the Norwegian Environment Agency (NEA). I also appreciate the efforts taken by Dr. Signe Nybø and Dr. Stein Are Sæther from the Norwegian Institute for Nature Research (NINA) for customising the Nature Index database, preparing graphs and maps for this report and providing necessary training for the Indian experts.

I gratefully acknowledge Dr. Ajit Kumar Pattnaik, Former Chief Executive, Chilika Development Authority (CDA), Dr. R. N. Samal, Scientific Officer and Dr. Surya K. Mohanty, Fishery Consultant, CDA for providing necessary time series data on fishes and birds of the Chilika Lake.

I appreciate the efforts taken by Dr. R. S. Patial, Conservator of Forest, Great Himalayan National Park (GHNP) and Dr. Kirupasankar, District Forest Officer, GHNP for providing necessary time series data on birds and mammals of GHNP and help in entering the data into the Nature Index database. I sincerely acknowledge the technical inputs provided by Dr. S. Balachandran, Deputy Director, Bombay Natural History Society.

I thank Shri T. Rabikumar, Secretary, NBA, for providing necessary administrative support, coordination and networking with the concerned officials to collect scientific data for the compilation of this report. I would like to thank Mr. N. Singaram, IT Executive, CEBPOL, for helping us in collecting and entering the data into the database. I appreciate the support rendered by Dr. Suhas Nimbalkar and Dr. Rupam Mandal, Programme Managers, CEBPOL, for coordinating this study.

Dr. C. Thomson Jacob
Consultant (Biodiversity Policy)
Centre for Biodiversity Policy and Law
It is our duty as human beings to protect nature. We must preserve the planet’s natural wonders for its own sake and for future generations. It is in our own and our children’s interest to conserve and restore our ecosystems – otherwise we are just biting the hand that feeds us. It is imperative that we make proper investments now to protect biodiversity of the planet’s ecosystems if we are to avoid facing much higher costs later in restoring what has been lost.

The Strategic Plan for Biodiversity 2011-2020, a ten-year framework for action by all countries and stakeholders, calls for effective and urgent action to halt the loss of biodiversity and ensure resilient ecosystems. India, being a “mega-biodiverse country” is placed among the top 20 such countries in the world. With only 2.4 percent of the earth’s land area, it accounts for almost 8 percent of the world’s recorded species. Being home to over 90,000 animal species and nearly 50,000 plant species, India’s management of its natural resources is crucial to protecting global biodiversity.

The Indian government has taken some important steps towards developing policies aimed at protecting the country’s biodiversity, such as designating national parks, wildlife sanctuaries and marine protected areas. However, for effective conservation and to prevent the loss of biodiversity it is essential that ecosystems be regularly and accurately monitored. To this end the Indian and the Norwegian governments have worked together on the establishment of the “Centre for Biodiversity Policy and Law”. Under the aegis of this cooperation, the Norwegian Institute for Nature Research (NINA) provided technical assistance to the Indian partners in testing the Nature Index tool for monitoring the status of biodiversity in an ecosystem.

The present report accounts for a pilot study in which the Nature Index tool was used to assess the status of biodiversity in two very different ecosystems: the Chilika lake in Odisha, and the Great Himalayan National Park in Uttarakhand.

I congratulate Dr. C. Thomson Jacob, Dr. Signe Nybø, and Dr. Stein Are Sæther for their contributions to this important field and for bringing forth this report and I also support the CEBPOL team for their support.

Nils Ragnar Kamsvåg
Ambassador, Royal Norwegian Embassy
New Delhi, India
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Summary

Nature Index (NI) is a policy tool, which synthesises biodiversity data and helps in monitoring the status of biodiversity in an ecosystem. NI measures the state and trend of biodiversity in the major ecosystems based on a large selection of indicators.

In India, a pilot study was carried out in the two identified biodiversity rich areas, namely Chilika Lake (Ramsar Wetland) and Great Himalayan National Park (GHNP) (Heritage site). The National Biodiversity Authority (NBA) and the Norwegian Institute for Nature Research (NINA) have jointly tested this tool in collaboration with the Chilika Development Authority (CDA) and Great Himalayan National Park (GHNP) Authority.

For undertaking the pilot study, 25 indicator species from Chilika Lake and 14 species from GHNP were selected. These indicators were scaled in such a way that they measure deviation from a reference state, which is specified as an ecologically sustainable state for the indicator. NI is an average of the scaled values and values range between 1 (reference state) and 0 (very poor state).

A polygon map of Chilika lagoon was obtained from CDA and the map was divided into 5 distinct ecological sectors based on salinity and depth, namely (i) Southern Sector (SS), (ii) Central Sector (CS), (iii) Northern Sector (NS) and (iv) Outer Channel Sector (OCS). Similarly, GHNP was divided into 3 regions, namely Jeenewal, Sainj and Tirthan ranges and polygon maps were prepared and integrated into the NI database by NINA.

Chilika lake is one of the largest brackish water lagoons in Asia and is an assemblage of marine, brackish and freshwater ecosystems. The analysis results of the fish indicator species have shown that the pearl spot and grey eel-catfish are showing high NI value in all the sectors. These two species are resident species and they are well-adapted to live both in brackish water and freshwater habitats. It was observed that Hilsa shad population was good in NS but declined in other sectors. This might be due to siltation, decrease of depth in the deeper anadromous migratory routes, heavy weed infestation and over exploitation.

The thematic NI value of fish shows that the NI value of OCS was high when compared with other sectors. It was noticed that SS, NS and CS displayed a declining trend from the year 2005. The declined NI value may be due to the capture of immature and juvenile finfishes in absence of enforcement of regulatory measures.

Chilika lake is well known for its migratory water birds. The NI value of bird population was high in OCS, CS and island region when compared with NS and SS. The high value observed was due to the availability of shallowness, natural drawdown, high vegetation density and mudflats with extensive shorelines.
Some of the bird species showing a positive trend are Little cormorant, Lesser whistling duck, Purple swamp hen, Asian open bill stock, Common coot and Brown headed gull. A declining trend was observed in Northern pintail and Eurasian wigeon Gadwall in the NS and SS regions.

Some of the initiatives taken by the CDA, such as protection of migratory waterfowl from poaching, eviction of the illegal prawn gharries, maintenance and dredging of the feeder channel and creeks (facilitates migration of fish juveniles), catchment area treatment, weed control, pollution control and community participation helps the Chilika lake to revive or rehabilitate with varied biodiversity wealth and has resulted increase in the population of residential and migratory bird population.

In GHNP, birds such as Koklass, Western tragopan, Monal and Cheer pheasant have showed high NI value in all the three ranges. However, the bird Kalij pheasant displayed a declining trend. For mammals, the Jeenewal and Tirthan ranges displayed a good population trend and in the Sainj range, the NI value declined. Mammals such as the Himalayan black bear, brown bear, gray langur and Rhesus macaque displayed a good population trend in the Jeenewal and Sainj ranges. The population of black bear, brown bear, common Leopard, Himalayan thar and Musk deer are declining in the Tirthan range.

A good NI value of birds and mammalians was noticed in the Jeenwal and Sainj ranges. This may be due to higher levels of protection imposed in the forest areas and also due to reduction of anthropogenic pressure in the form of collection of medicinal plants or fuel wood and grazing from national park area.

The results of NI can be used for policy-making and developing targeted action plans for better management of biodiversity. The bilateral collaborative initiative between India and Norway has increased the capacity of policy makers, biodiversity experts or scientists in using the NI tool for assessing or monitoring biodiversity in the wildlife-protected areas and ecologically fragile wetland ecosystems.

In Chilika and GHNP, the biodiversity data was scattered among different institutions and collating the time series data was a herculean task. However, this project has made the CDA and GHNP authorities to compile and collate the time series biodiversity data available for decision making.

Recommendations

- The NI policy tool can be used or adopted for assessing the biodiversity wealth of Protected Areas (PAs) in India.
- In order to facilitate data collating, an institution with access to biodiversity data and a network of data holders should be mandated with the coordinating role in expansion of NI beyond the pilot phase.
- The coordinating institution must be trained by NINA to use the NI tool and interpret data.
- In the sites where NI is implemented, the park managers, policy makers and conservers must be trained in using this tool to measure the health of an ecosystem.
- The results from NI may be used for making knowledge based policy recommendations.
1 Introduction

1.1 India’s Biodiversity wealth

India, a megadiverse country harbouring 7-8% of all recorded species in the world, which include 48,000 species of plants¹ and more than 97,708 species of animals². Being one of the 17 identified megadiverse countries, India has 10 biogeographic zones and is home for 8.6% of mammalian species, 13.7% avian species, 7.9% reptiles, 4.7% amphibians, 11.7% fishes and 11.8% plants in the world. In terms of endemism of vertebrate groups, India’s global ranking is tenth in birds (with 69 species), fifth in reptiles (156 species) and seventh in amphibians (110 species). India has more than 20,000 species of marine diversity, which includes 3,267 species of fish.³ of the 34 global biodiversity hotspots, 4 are situated in India, which include the Himalayas, the Western Ghats, the North- east and the Nicobar Islands. Nearly 39 sites are inscribed in the United Nations Education Scientific and Cultural Organization (UNESCO) as World Heritage sites, of which 7 are identified as natural sites (Great Himalayan National Park Conservation Area, Kaziranga National Park, Keoladeo National Park, Manas Wildlife Sanctuary, Nanda Devi and Valley of Flowers National Parks, Sundarbans National Park and Western Ghats⁴). So far, India has designated 771 Protected Areas (PAs) in the form of national parks, wildlife sanctuaries, conservation and community reserves. India also has 30 Marine Protected Areas (MPAs).⁵

1.2. Biodiversity Assessment in India

Biodiversity assessment is a means of collecting information on species present in a given area. Globally, many biodiversity assessment indexes are available. For example, Simson Index, Shannon Wiener Diversity Index, Berger-Parker Index, Agro-biodiversity Index and so on. In India, the biodiversity assessments of floral or faunal diversity are carried as a part of Environmental Impact Assessment (EIA) studies. An EIA study is a mandatory requirement under the Environmental Protection Act, 1986, in which the proponents are required to give details about threats to biodiversity, while undertaking developmental projects. Forest assessments are carried out in the PAs for assessing trees, shrubs, saplings, seedlings, climbers, herbs, grasses or sledges in terms of density, frequency and total basal area.

² Animal Discoveries, 2018, Published by the Zoological Survey of India.
⁵ National Wildlife Database cell, Wildlife Institute of India, 2017 (www.wiienvis.nic.in).
1.3. Nature Index

Nature Index (NI) is a policy tool that provides an overview of the state and trend of biodiversity. It provides authentic scientific data by involving relevant scientific institutions and statisticians. The results can be used for taking important policy decisions and guide the policy makers to take decisions for conserving and managing the natural resources.\(^6\) NI increases the understanding of the decision makers for taking appropriate policy measures towards halting the biodiversity loss.\(^7\) The NI tool provides an overall picture of the changes in biodiversity over a period of time and also provides details about the causative factors for taking corrective measures. This tool can be used for assessing the wealth of various ecosystems, such as forest, coastal and marine regions, wetlands and so on. The status of an indicator is calculated through a scaled value (0 to 1) where the value zero means that the species is extinct in the area of focus and the value 1 means that the status of the indicator is in a very good status. Then, NI is calculated as the average over many such indicators. This tool can be applied in both data-rich and data-deficient areas and can help policy makers and administrators to monitor the biodiversity status of the country. This scientific tool also helps in assessing the impact of climate change; monitoring the implementation of National Biodiversity Targets (NBTs) and Sustainable Development Goals (SDGs) and undertaking scientific studies for Inter-governmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES).

1.4. Nature Index in achieving National and Global Targets

Biodiversity plays a crucial role in the functioning of the ecosystems on which human beings depend for food, water, health, recreation and protection from natural disasters. The loss of biodiversity affects cultural and spiritual values that are integral to human well-being. The global mission of the Strategic Plan (SP) for biodiversity 2011-2020\(^8\) is to take effective and urgent action to halt the loss of biodiversity and ensure that ecosystems are resilient and continue to provide essential services by 2020, thereby securing the planet’s variety of life. The mission has brought out five strategic goals with 20 Aichi biodiversity targets and related indicators. The NI is a well-designed framework that can be used for reporting the status of biodiversity targets and for undertaking scientific studies as indicated below:

i) Population trends of utilised species and degradation of natural habitats

ii) Population trends of habitat dependent species in an ecosystem

iii) Population trends of target species and categorisation of the trends as endemic, endangered, rare and threatened

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8 Convention on Biological Diversity (Web resource www. cbd.int/sp/targets).
iv) Population trends of forest and agriculture dependent species
v) Trends in abundance of selected species
vi) Status and trend of species that provide ecosystem services
vii) Overall picture of the state of an ecosystem

1.5. Objective

The objective of the present study was to test the Norwegian NI methodology in the two identified pilot sites, namely Chilika Lake and Great Himalayan National Park (GHNP) in India (Fig.1) and assess the status of biodiversity in these sites.
2 Project organisation

2.1. Institutions involved

a) National Biodiversity Authority

National Biodiversity Authority (NBA) is an autonomous body established for the implementation of the Biological Diversity Act, 2002. As a statutory body, it regulates the activities related to access of biological resources and associated traditional knowledge and sharing of benefits arising from their use. NBA also performs an advisory role on matters related to conservation, sustainable use, access to biological resources and benefit sharing.10

b) Centre for Biodiversity Policy and Law

The Centre for Biodiversity Policy and Law (CEBPOL) is a bilateral collaborative programme established between India and Norway in 2013 to develop professional expertise in biodiversity policy and law and to develop capacity of stakeholders at various levels. This centre is focusing on biodiversity policies and laws that cater to the needs of national and international rule-making and their implementation on matters concerning biodiversity. Some of the thematic areas identified under this collaborative initiative include Mainstreaming Biodiversity, Nature Index, Access and Benefit-Sharing (ABS), Multilateral Environment Agreements (MEAs), Invasive Alien Species and Capacity building.10

c) Norwegian Institute for Nature Research

The Norwegian Institute for Nature Research (NINA) is Norway’s leading research institute on applied ecological research, which undertakes research activities in the field of biodiversity, ecosystem services, sustainable use of fish and game stocks, restoration ecology, and mapping and monitoring of biodiversity. It also facilitates the implementation of international conventions, decision-support systems and management regulations. To implement the NI pilot study in India, NINA was appointed as a research partner under the bilateral collaborative programme between India and Norway.11

d) Chilika Development Authority

Chilika Development Authority (CDA) was established in 1991 under the Department of Forest & Environment, Government of Odisha, with an objective of conserving the ecology of the Chilika lagoon. The following are some of the activities that CDA undertakes:

i) Protecting and conserving the genetic diversity of the lake
ii) Enhancing the economic condition of the community
iii) Undertaking eco restoration with measures for its sustainability and habitat improvement for birds
iv) Creating inventories and assessments of lagoon resources
v) Promoting eco-tourism
vi) Developing information system
vii) Managing macrophytes and invasive alien species

e) Great Himalayan National Park Authority

GHNP was constituted in 1984 and formally notified as a national park in 1999. The GHNP authority manages the GHNP Conservation area (1,171 sq. km), which includes National park area (754.4 sq. km), Sainj Wildlife Sanctuary (90 sq. km), Tirthan Wildlife Sanctuary (61 sq. km) and Eco-development Zone (265.6 sq. km). The GHNP area was included in the UNESCO’s World Heritage List. The GHNP authority is undertaking various community development measures through Biodiversity Conservation Society (BiodCS), Village-Level Forest Development Committees or Ward Development Committees, Community-Based Eco Tourism (CBET), direct labour engagement and patrolling activities with the help of local people. It provides alternate income generation to the local communities through Women Saving Credit Groups (WSCGs).

2.2. Process for the preparation of Nature Index

To initiate the NI pilot study, an inception meeting was organised during September 2015, at the MoEFCC office, New Delhi. During the meeting, two important sites for biodiversity importance were selected for testing the NI tool in India. The selected sites are Chilika Lake and GHNP. The process involved in the preparation of NI is illustrated in flowchart below.

Flowchart 1: Process for the preparation of Nature Index

Two pilot sites were identified during the Inception workshop held during September 2015, at MoEFCC, New Delhi, India

Indian partners were trained in using the NI database by NINA experts during the NI work-shop held from 28 Jan 2016 to 29 Jan 2016, at Bhubaneswar, Odisha

List of Indicator species was identified by the CDA and GHNP experts

Quality check and validation of data was carried out by NINA

Time series data of the Indicator species were collected through secondary sources and fed into the database with the help of CDA and GHNP experts by CEBPOL

Data analysis, production of indices, trends and maps were prepared by NINA and shared with CEBPOL

Inputs or comments on the draft report were provided by stakeholders at the NI workshop held at Manali, Himachal Pradesh

Final report was prepared by CEBPOL with the help of NINA and input from the sites

NI study was completed and the final report was submitted in November, 2018

Nature Index - India database was customised by NINA

Digital polygon maps were integrated into the NI - India database by NINA
### 2.3. Institutions and Experts Involved in the Preparation of Nature Index

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<thead>
<tr>
<th>Institution</th>
<th>Representatives/Designation</th>
<th>Roles and responsibilities</th>
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<tbody>
<tr>
<td>NBA</td>
<td>Dr. B. Meenakumari, Chairperson</td>
<td>• Provided necessary administrative support in finalising the NI India report</td>
</tr>
</tbody>
</table>
| NBA         | Mr. T. Rabikumar, Secretary | • Coordinated with the CEOs of CDA, GHNP and MoEFCC and NINA officials.  
• Provided administrative support for organising various technical discussions. |
| NINA, Norway | Dr. Signe Nybø, Research Director | • Developed NI India database and provided hands on training |
|             | Dr. Stein A. Sæther, Researcher   | • Provided capacity building training for Indian partners and CEBPOL team  
• Analysed and interpreted data  
• Helped with text production for report (Chapters 3.5 and 4.0)  
• Checked quality of data |
| CEBPOL      | Dr. C. Thomson Jacob, Consultant (Biodiversity Policy), CEBPOL | • Performed desk review and collected literature  
• Participated in all the technical discussions from the inception stage  
• Reviewed data and interpreted results  
• Coordinated with the Park Managers and NINA experts  
• Consolidated and finalised the NI India report |
| CEBPOL      | Dr. Suhas Nimbalkar, Programme Manager, CEBPOL (up to June 2016) | • Collected scientific data from CDA, GHNP and other stakeholders  
• Supported coordination |
| CEBPOL      | Dr. Rupam Mandal, Programme Manager (February 2017 onwards) | • Extended necessary support  
• Supported coordination |
| CEBPOL      | Mr. S. Singaram, IT Executive, CEBPOL | • Performed data entry into the NI India database in consultation with the site managers |
| GHNP        | Dr. M. Kirupashankar, District Forest Officer, HP | • Provided time series data and Reference Value of the indicator species of GHNP |
| CDA         | Dr. R.N. Samal, Scientific officer, CDA | • Provided time series data and Reference Value of the indicator species of Chilika Lake |
| CDA         | Mr. S.K. Mohanty, Fishery Consultant | • Helped in determining the Reference Value and provided expert judgement |
| BNHS        | Dr. Balachandran, Deputy Director, BNHS | • Provided expert advice on bird data of Chilika and GHNP |
3. Methodology

3.1. NI India Database

NINA has developed a web-based information system for recording, storing and presenting NI data. The system consists of SQL relational database connected to a web server. The database has various modules, such as indicator page, area and data. Within the indicator page, several sub-modules are available for updating information about the selected indicators. These include:

i) Indicator type (invertebrates/vertebrates)

ii) Type of organisms (mammals/reptiles/birds/fishes)

iii) Red list status (critically endangered/vulnerable/near threatened/least concern)

iv) Reference Value

v) Pressure factors (harvesting and exploitation, invasive species, acidification, eutrophication, pollution, climate change, land use, habitat destruction, distribution by human activities, human pressure and hydrological changes)

vi) Ecosystem affinity (freshwater, mountain, wetland, forest, traditionally cultivated land, brackish water, marine water and so on)

3.1.1. Polygon Map of Chilika and GHNP

A polygon map of Chilika lagoon was obtained from CDA, after being digitised from survey of India toposheets. In the polygon map, the Chilika lagoon was divided into the following 5 distinct ecological sectors based on salinity and depth (Fig.2).

i) Southern Sector (SS) - deeper zone with brackish water environment having least fluctuation of salinity

ii) Central Sector (CS) - brackish water environment

iii) Northern Sector (NS) - mostly freshwater environment

iv) Outer Channel Sector (OCS) - mostly marine influenced and freshwater influenced in monsoon due to unidirectional fresh water flow from the northern sector

v) Island - Nalabana, major bird congregation site

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Similarly, a polygon map was obtained from the GHNP authorities after being digitised from survey of India topo sheets. The GHNP area was divided into 3 regions, namely Jeenewal, Sainj and Tirthan ranges (Fig.3). These polygon maps of Chilika Lake and GHNP were integrated into the NI database by NINA.
3.2. Selection of sites and indicators

3.2.1. Criteria for selecting indicators

The biodiversity indicators can be defined as a natural variable related to any aspect of biodiversity for which a reference state can be established. Some of the criteria that can be used for selecting indicators are listed below.

a) Future taxonomic representative
b) Represents different ecological functions of the species (including common & rare species)
c) Key species
d) Sensitive to various kinds of pressures
e) Represents various habitat types and natural stages of succession within different major ecosystems
f) Not an alien species

The indicators can be selected from the main or native species groups, such as algae, fungi, plants, fishes, crustaceans, amphibians, birds, reptiles and mammals.

3.2.2. Chilika Lake

Chilika Lake is one of the largest brackish water lagoons in Asia and it is the first Ramsar site of India, located in Gamjam District, Orissa on the east coast (19°02’-19°05’N and 85°05’-85°03’E). It is an assemblage of marine, brackish and freshwater ecosystems and comprises 317 finfish species, in which 278 species are food fishes. Out of 317 species, 271 are migratory and 46 are resident species, indicating that the lake fishery is migratory species dependent. The unique and fragile ecosystem of Chilika Lake gradually began to lose its ecological integrity due to coastal processes, significant decrease in salinity regime and degraded drainage basin with associated anthropogenic impacts.

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Between 1950 and 2000, the lake fishery was in a continuing state of decline when the fisheries output reached its lowest point by the end of 1990s. The lake fishery suffered serious setbacks since the latter part of the 1980s with the salinity level sharply declined to 9.6 PSU compared to a level of more than 22.0 PSU in 1960. The recruitment corridors (outer Channel and Palur canal) also gradually silted up, adversely affecting the recruitment of fish and shellfish seed from the sea into the lake, while silted up river mouths in the Northern Sector of the lake also affected freshwater seed recruitment from riverine sources. In the aftermath of the gradual closure of the old lake mouth and Palur canal, the lake began transforming towards a freshwater ecosystem, causing substantial changes in the ichthyofaunal composition. The continuous degradation of the ecosystem, change in ecological characteristics, overall loss of biodiversity and decline in productivity adversely affected the livelihoods of local communities.

CDA has carried out a hydrological intervention by opening a new lake mouth during September 2000 along with the treatment of catchment and other restoration measures. Opening of the new lake mouth rapidly had a positive effect with spectacular enhancement in fisheries, overall ecology and biodiversity. The annual fish catch from the lake increased sevenfold as compared to the catch in the pre-restoration period. During the pre-restoration period (until 2000), a total of 23 species had been reported and during 2000-2003 (post restoration phase) a total of 43 species were recorded bringing the total to 276 species. The highly productive lake ecosystem supports nearly 0.2 million fishermen and generates a revenue of more than INR 750 million annually. Some of the rare and threatened animals that live in this lake includes Green sea turtle (endangered), Dugong dugon (vulnerable), Irrawaddy dolphin (vulnerable), Black buck (near threatened), spoon-billed sandpiper (critically endangered) and Fishing cat (endangered). The annual maximum sustainable yield of the lake is around 11, 376 MT.

Chilika is also one of the major water bird congregation areas within the Central Asia flyway. A total of 226 bird species were recorded, which include 20 species of ducks and geese, 48 species of waders, 17 species of gulls and terns, 14 species of birds of prey and 11 species of herons and egrets. Of these species, nearly 100 are migratory and migrates from the Caspian Sea, Baikal Lake, remote parts of Russia, Mongolia, Ladakh, Siberia, Iran, Iraq, Afghanistan and from the Himalayas. Chilika also provides habitat for near-threatened species, such as the River tern, Asian dowitcher, Spot-billed pelican, Oriental darter, Eurasian curlew, Eurasian spoonbill, Pallas’s fish eagle, Painted stork and Black tailed godwit. Nalabana Island located inside Chilika lagoon provides habitat for the avifauna and nursery ground for fish. It spreads over an area of 15.53 sq. km and the island is an abode of avifauna and important wintering ground for migratory birds. Nalabana continues to be a major congregation site, with a count ranging from 4,00,000 to 5,00,000 during the peak migratory season. The population of three species of ducks, namely Northern Pintail, Gadwall and Eurasian wigeon are over 1,00,000.

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17 Chilika newsletter, 2015, Volume - VIII. Published by Wetland International.
3.2.2.1. Indicators
For undertaking the NI study, Chilika Lake was divided into 5 sectors in the polygon map and 25 indicator species (15 species of fish and 10 species of birds) identified (Table 1).

<table>
<thead>
<tr>
<th>S.No</th>
<th>Scientific name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FISHES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><em>Mugil cephalus</em></td>
<td>Flat head mullet</td>
</tr>
<tr>
<td>2</td>
<td><em>Liza macrolepis</em></td>
<td>Large scale mullet</td>
</tr>
<tr>
<td>3</td>
<td><em>Lates calcarifer</em></td>
<td>Sea bass, Barramundi</td>
</tr>
<tr>
<td>4</td>
<td><em>Dasycieana albida</em></td>
<td>Bengal corvina</td>
</tr>
<tr>
<td>5</td>
<td><em>Eleutheronema tetradactylum</em></td>
<td>Four finger threadfin</td>
</tr>
<tr>
<td>6</td>
<td><em>Etoplus suratensis</em></td>
<td>Pearl spot</td>
</tr>
<tr>
<td>7</td>
<td><em>Tenuallsla ilisha</em></td>
<td>Hilsa shad</td>
</tr>
<tr>
<td>8</td>
<td><em>Plotosus canius</em></td>
<td>Grey eel-catfish</td>
</tr>
<tr>
<td>9</td>
<td><em>Strongylura strongylura</em></td>
<td>Spot tail needle fish</td>
</tr>
<tr>
<td>10</td>
<td><em>Nematalosa nasus</em></td>
<td>Bloch's gizzard shad</td>
</tr>
<tr>
<td>11</td>
<td><em>Gerres setifer</em></td>
<td>Small Bengal silver-biddy</td>
</tr>
<tr>
<td>12</td>
<td><em>Mystus gulio</em></td>
<td>Long whiskers catfish</td>
</tr>
<tr>
<td>13</td>
<td><em>Rhabdosargus sarba</em></td>
<td>Gold lined sea bream</td>
</tr>
<tr>
<td>14</td>
<td><em>Osteogeneiosus militaris</em></td>
<td>Soldier catfish</td>
</tr>
<tr>
<td>15</td>
<td><em>Channa striata</em></td>
<td>Striped snakehead</td>
</tr>
<tr>
<td><strong>BIRDS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td><em>Anas acuta</em></td>
<td>Northern pintail</td>
</tr>
<tr>
<td>17</td>
<td><em>Mareca penelope</em></td>
<td>Eurasian wigeon</td>
</tr>
<tr>
<td>18</td>
<td><em>Mareca strepera</em></td>
<td>Gadwall</td>
</tr>
<tr>
<td>19</td>
<td><em>Limos rosso</em></td>
<td>Black-tailed godwit</td>
</tr>
<tr>
<td>20</td>
<td><em>Larus brunnicephalus</em></td>
<td>Brown-headed gull</td>
</tr>
<tr>
<td>21</td>
<td><em>Fulica atra</em></td>
<td>Common coot</td>
</tr>
<tr>
<td>22</td>
<td><em>Anastomus oscitans</em></td>
<td>Asian open-bill</td>
</tr>
<tr>
<td>23</td>
<td><em>Porphyrio porphyria</em></td>
<td>Purple swamphen</td>
</tr>
<tr>
<td>24</td>
<td><em>Dendrocygna javanica</em></td>
<td>Lesser whistling-duck</td>
</tr>
<tr>
<td>25</td>
<td><em>Phalacrocorax niger</em></td>
<td>Little cormorant</td>
</tr>
</tbody>
</table>

3.2.3 Great Himalayan National Park
The GHNP conservation area is located within the globally significant Western Himalayan Temperate Forests eco-region and protects part of Conservation International’s Himalaya biodiversity hot spot. It is also a part of the Birdlife International’s Western Himalaya Endemic Bird Area. GHNP supports rich biodiversity across different ecosystems, including alpine, sub-alpine, temperate and sub-tropical zones and is home for
832 vascular plant species, 192 species of lichens, 12 species of liverworts and 25 species of mosses. Nearly 58% of its angiosperms are endemic to the Western Himalayas and this park also protects 31 species of mammals, 209 birds, 9 amphibians, 12 reptiles and 125 insects. It provides habitat for four globally threatened mammals, three globally threatened birds and a large number of medicinal plants. It also protects important habitat and endangered species, such as Western tragopan and Musk deer\(^2\).

### 3.2.3. Indicators
The GHNP was divided into 3 ranges in the polygon map and 14 indicator species were identified, which includes 5 species of birds and 9 species of mammals (Table 2).

<table>
<thead>
<tr>
<th>S. No</th>
<th>Scientific name</th>
<th>English name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BIRDS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Lophura leucomelanos</td>
<td>Kalij pheasant</td>
</tr>
<tr>
<td>2</td>
<td>Pucrasia macrolopha</td>
<td>Koklass pheasant</td>
</tr>
<tr>
<td>3</td>
<td>Tragopan melanocephalus</td>
<td>Western Tragopan</td>
</tr>
<tr>
<td>4</td>
<td>Lophophorus impejanus</td>
<td>Himalayan monal</td>
</tr>
<tr>
<td>5</td>
<td>Catreus wallichii</td>
<td>Cheer pheasant</td>
</tr>
<tr>
<td><strong>MAMMALS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Ursus thibetanus</td>
<td>Himalayan black bear</td>
</tr>
<tr>
<td>7</td>
<td>Ursus arctos</td>
<td>Himalayan brown bear</td>
</tr>
<tr>
<td>8</td>
<td>Semnopithecus entellus</td>
<td>Gray langur</td>
</tr>
<tr>
<td>9</td>
<td>Panthera pardus</td>
<td>Common leopard</td>
</tr>
<tr>
<td>10</td>
<td>Rhesus macaque</td>
<td>Monkey</td>
</tr>
<tr>
<td>11</td>
<td>Naemorhedus goral</td>
<td>Himalayan goral</td>
</tr>
<tr>
<td>12</td>
<td>Capricornis thar</td>
<td>Himalayan serow</td>
</tr>
<tr>
<td>13</td>
<td>Hemitragus jemlahicus</td>
<td>Himalayan thar</td>
</tr>
<tr>
<td>14</td>
<td>Moschus leucogaster</td>
<td>Musk deer</td>
</tr>
</tbody>
</table>

### 3.3. Data collection
During the implementation phase of the project, NINA customised the NI database to suit India’s specific needs for the two identified pilot sites. After that, the online database operational procedure was shared with CEBPOL, CDA and GHNP officials for entering time series data into the database. In Chilika Lake, secondary data for fish and bird species were collected from CDA. The fish catch data of Chilika was estimated by CDA by following a statistical sampling method called Systematic Sampling, which was approved by the National Nodal

Agency (ICAR-CIFRI) for the collection of Inland fishery statistics and also the methodology was published in an international Journal. Similarly, data for birds and mammals were collected from GHNP authorities. Information pertaining to the indicators were fed into the NI-India online database by CEBPOL, GHNP and CDA officials. After that, the updated version of the database was shared with the NINA experts for further analysis. The process of data collection for the preparation of NI is depicted in flowchart 2.

Flowchart 2: Process involved in data collection

NI database customised to India-specific needs

Data collected from various secondary sources

- Census data (collected through call count, line transect survey, scanning method and silent drive methods)
- Publications (reports, books, atlas, newsletters and so on)
- Field observations data and expert judgments

Experts identified for various thematic indicators to:
  a) Determine Reference Value for each species
  b) Provide required information for the NI database

Time series data entered into the NI database

Database was shared with NINA for data verification and validation
3.4. Determination of Reference Values

The Reference Value of an indicator is used to scale the values of an indicator, so that they can be synthesised into a final index. The Reference Value indicates the state of biodiversity in an area or a habitat. The value 0 indicates large deviations from the reference state. For example, the extinction of this species within the particular area (Fig.4). The status of an ecosystem or sector was calculated by weighted average of the values of all the indicators. The status of biodiversity can be visualised using colour coding. For example, red shows a very poor state and the blue a very good state. Orange, yellow and green signify gradual improvements towards blue (Fig.5).

![Figure 4: Scaling indicator values in relation to a Reference Value](image)

![Figure 5: Scaled value expressed on a 0-1 scale](image)
In Chilka Lake and GHNP, the Reference Value for the indicators were determined with the help of experts (expert judgement or opinion). While determining the Reference Value, some of the scientific data or factors that were taken into consideration includes:

a) Census data
b) Published reports and annual reports
c) Monitored data
d) Anthropogenic pressure factors
e) Natural calamities (flood and fire), snow fall
f) Habitat richness (food or shelter)
g) Climatic conditions
h) Breeding or reproductive behaviour-generation interval
i) Carrying capacity

For Chilka Lake, the year 2003 was used as a reference year, assuming that 2003 was a year of good ecological status. In the GHNP, different Reference values were identified for each indicator species with the help of experts. While determining the reference values, factors such as extent of area, potential habitat, census data, direct/indirect sighting, anthropogenic pressure, weed infestation, natural calamities (flood, fire, snow fall) were taken into consideration.

3.5. Data Analysis using R-Script

The NI values were calculated using R-scripts that use functions from the R-package Ncalc developed for the Norwegian NI. Much of this concerns estimating uncertainty of the NI. These scripts read data from the database and finds the appropriate statistical distribution for the uncertainty information for each indicator and uncertainty information for each Reference Value. The scripts then:

a) Draw random samples for each indicator
b) Scale the sampled values to the Reference Values using a defined scaling model (Fig.4)
c) Calculate weights based on the area
d) Calculate a sampled index value for a specified number of times (For e.g. 1000).

The median of these sampled index values can then be used as the NI value, and the 2.5th and 97.5th quantiles as a 95 percent confidence interval. However, if there is no information about the uncertainty of indicator values, no confidence interval for the NI can be calculated. If only some indicators have such information about uncertainty, the confidence interval for the NI will be biased. Since this was the case here, the NI values reported below were calculated as the mean of the scaled indicator values, without any confidence intervals (see also http://brage.bibsys.no/xmlui/bitstream/handle/11250/2374610/3/1226.pdf)

\[ NI_{jkt} = \sum_{i=1}^{n} S_{ikt} W_{ijk} \]

S - Scaled indicator values
W - Indicator weight
K - Spatial Units
J - Major Habitats
T - Time
4. Results

The data of the indicator species were collected from various secondary sources and the Reference Value for the indicator species were determined with the help of experts. The indicators were scaled in such a way that they measure deviation from a Reference State, which is specified as an ecologically sustainable state for the indicator. NI is an average of the scaled values, and values range between 1 (Reference State) and 0 (very poor state). For calculating the NI value, the time series data were fed into the NI-India database and the NI values were calculated using R-scripts. The analysis of the indicator values were carried out with the help of NINA and the status of each indicator species is described in this section.

4.1. Chilika Lake

In Chilika Lake, data was available for all the indicators from the year 2000 to 2015, for every 5 year period (Fig.6) and exhibits the number of indicators used for calculating the NI value. The time series data of the indicator species were collected from various secondary sources from the year 2001 to 2015 and the year 2003 data was taken as a Reference Value against which all other year values were compared.

Note: This is a pragmatic solution and not generally recommended within the NI framework, because the year may not represent the same state for all parts of the ecosystem and it also may not represent a very good state.

In Chilika, the data for all the species were aggregated into 5-year periods using the mean of the available yearly data for each 5-year period. In the Island region, only the bird count was taken into consideration while calculating the NI value. Apart from that, data was available for all the indicator species in all sectors for every 5-year period.
4.1.1. Nature Index Value of Chilika Lake

Figure 7 indicates the fact that the overall NI value of the Chilika Lake (above 0.75) was good. This in turn indicates that the biodiversity status of the lake was good from the year 2000 to 2015. The highest value was recorded during the year 2005, which may be due to the restoration activities carried out from 2000 to 2003. It was also reported by the ZSI that six species have reappeared after the restoration phase of the Chilika Lake.
The sectoral NI values calculated in all the 5 sectors (CS, Island, NS, OCS and SS) were compared with each other to understand the area wise deviation of the NI values. It was observed that the NI values of OCS and Island were good and varied between 0.75 to 1.00. The NI values of SS, CS and NS fluctuated (above 0.50 and below 0.75) during the year 2015 and there was a decline in the population after the year 2010 in all these sectors as indicated in Fig.8. The maximum NI was recorded in the OCS region, because this sector provides habitat for fresh water and brackish water species, and migratory routes for marine and freshwater species. The Nalabana Island provides habitat for different types of migratory and resident bird species, and excellent breeding and feeding habitat for the birds to nourish, hence the NI value of the Island was good.

4.1.2. Thematic Index Value
The thematic Index exhibits the status of fish and bird population in Chilika Lake. In Chilika Lake, the maximum bird population was recorded in OCS, CS and Nalabana Island (NI value was above 0.8). Moderate values were recorded in SS (above 0.7) and NS (above 0.6) from 2010 to 2015 and there was a decline in bird population from the year 2005 onwards. For fish diversity, the OCS recorded the maximum value of above 0.8 during the year 2015. In the other sectors, the NI values fluctuated (SS >0.9 to <0.7; NS >0.7 to <0.6; CS >0.7 to <0.6) between 2000 to 2015 (Fig.9).
Figure 9: Thematic NI value (5-year periods) for the five areas of Chilika Lake

Figure 10: Map of Nature Index values for the five areas of Chilika
The status of NI can also be visualised through the colour coded maps depicted in Fig. 10. The colour-coded map indicates the fact that the NI value is declining in the NS and it is also showing a declining trend in SS and CS (the colour changes from green to yellow). The contributory factors for the decline in the NI value may include:

a) By-catch of juveniles and usage of destructive fishing gears
b) Illegal prawn Gheries
c) Blockage of Palur canal by barrier nets round the year
d) Dense growth of macrophytes, which causes deterioration of water quality
e) Increased population of motorised boats

4.1.3. Fish

1. Flat head mullet (*Mugil cephalus*)

Flat head mullet is commonly called as Khainga and it is one of the high-value commercially important herbivore fishes found in brackish water. It is a demersal (inhabits the bottom area of the water body) catadromous species which migrates to the sea for breeding during September to January. It grows to a maximum size of 712 mm and forms more than 3% in the commercial catch. It has iliophagus feeding habits and mainly feeds on slime algae and detritus. The NI value of Flat head mullet was maximum and above the Reference Value range in OCS. In SC, the NI value was above the Reference Value until 2010 and the value slightly declined to <0.75 (2010 to 2015). In NS and CS there was a moderate decline in the mullet population from the year 2005 to 2015. The reason for the depletion of the mullet population may be due to brood stock capture during seaward migration, destructive fishing practices and bycatch by the local fishing community (Fig. 11). The IUCN red list status for this fish is Least Concern (LC).

![Flat head mullet](image)

*Figure 11: Observed and scaled value of Flat head mullet*
2. **Large scale mullet** (*Liza macrolepis*)

Large scale mullet is an ecologically significant herbivorous or detrivorous, demersal fish, which feeds on detritus. It remains in the lake from juvenile to adulthood stages for feeding. After that it migrates to the sea for spawning.

This is one of the highly prized or high-value fishes of mullet group, which grows to a maximum size of 480 mm and contributes 0.8% of the commercial catch. It shows catadromous breeding behaviour, basically found in brackish water habitats and mainly feeds on detritus and algae (iliophagous feeding habits). It is a high-fecund brackish water fish. The large scale mullet population was maximum in OCS and SS (above the Reference Value). It was reported that there was a decline in the NI value of large scale mullet in the CS and NS, which may be due to the overexploitation of fishery resources by the local communities (Fig.12). The IUCN red list status for this fish is Least Concern (LC).

![Figure 12: Observed and scaled value of large scale mullet](image)

3. **Sea bass or Barramundi** (*Lates calcarifer*)

The decrease in Sea bass population in NS may be due to the fluctuation of salinity, overfishing of brood stock and decrease in forage species. During the summer season, the brooders congregate near Muggermukh and migrate to the sea mouth region for spawning.

![Image of Sea bass](image)
Sea bass (Bhekti) is a demersal, catadromous and carnivore species. It lives both in marine and brackish water ecosystems and grows to large sizes (23 kg recorded in Chilika). It is a high-value fish, which contributes more than 1% in commercial catch. It breeds in the coastal water during June and July. The juvenile enters into estuaries, lagoons and brackish water for feeding and during summer the brooders congregate near Muggermukh and migrate to the sea mouth region for spawning. It feeds mostly on small fishes and prawn (more than 90%). Bhekti exhibits protandrous hermaphrodite characteristics. The mature Bhekti functions as male for one or more spawning seasons before it undergoes sex reversal. The NI value was recorded maximum in OCS, SS (above the Reference value) and CS regions (above 0.75) and showed a good population trend during the study period. There was a decline in NS where a minimum value of <0.25 was recorded during 2010 and a slight increase was noticed (>0.25) during the year 2015 (Fig.13).

4. Bengal corvina (*Daysciaena albida*)

Bengal corvina (Borogo) is a brackish water fish that breeds in lakes (Northern sector) and feeds on small fishes, prawns, amphipods, isopods and stomatopods. It contributes 6% of the commercial catch and grows to a very large size of 800 mm in Chilika.

It is a high-value fish species, which contributes nearly 5% of the commercial catch and helps in maintaining the balance in the food chain. It was noticed that there was a drastic reduction in the population in the CS and SS regions from the year 2000 onwards. A minimum value of <0.25 was recorded in SS and CS (>0.25) during 2015 (Fig.14). This may be due to overfishing, particularly juveniles and decrease in spawning stock biomass (SSB) in CS and SS.
5. Fourfinger Threadfin (*Eleutheronema tetradiactylum*)

Fourfinger threadfin fish (Sahala) is a high-value threadfin species, which contributes more than 2.7% of the commercial catch. It breeds in the sea and lake, performing inter sea-lake movements. It grows to a large size of 1000 mm in the lake. It is amphidromous, neritic (lives in shallow part of the ocean) and largely feeds on prawns, fish and plankton. There are indications of recruitment twice a year (February to April and August to
September) and it breeds both inside the sea as well as in the lake and prefers sea-lake movement. This species is susceptible for easy capture during their breeding seasons. In the OCS region, the NI value was above the Reference Value. In NS and SS, the NI value was moderate (above 0.50). In CS the value declined from 1.0 to below 0.50 between 2010 to 2015 (Fig.15). The decrease in value may be due to bycatch and overexploitation.

6. Pearl spot (*Etroplus suratensis*)

Pearl Spot (Kundala) is an indigenous brackish benthopelagic fish found in peninsular India. It is a high-value resident cichlid species in the lake, which breeds in the lake throughout the year (two peak periods are: December-February and April-May). The fish starts maturing to a length of above 105 mm and grows to the maximum size of 305 mm in the lake. This is an important aquaculture species cultured both in brackish and fresh water. This species is commercially important and contributes more than 1% of the total landing in Chilka. Pearl spot is an herbivorous species, which feeds on weeds (48%), algae (12%), detritus (34%), gastropods (4%) and other miscellaneous matters (2%).

It was recorded that the pearl spot population was above the Reference Value in CS and SS, from the year 2000 to 2015. In NS and OCS, there was a decline in the NI value from the year 2000 to 2010 but the value gradually increased to a maximum of 1.0 during the year 2015 (Fig.16). Pearl spot showed a healthy population status in all the four sectors, as it can survive and grow well in both fresh water and brackishwater. The IUCN red list status for this fish is Least Concern (LC).

![Figure 16: Observed and scaled value of Pearl spot](image)
7. Hilsa shad (*Tenualosa ilisha*)

Hilsa shad (Ilishi) is an anadromous fish which occurs mostly in NS (freshwater zone). It emigrates from the sea to the lake mainly for breeding in the freshwater zone during monsoon months and emigrates during winter for feeding. It is a high-value fish, which currently exhibits a declining trend forming an average of 0.5% of composition of the commercial landing. It grows to a maximum size of 515 mm in the lake. The annual landing has declined in the lake most likely due to habitat damage by weed infestation in the river mouth zone, siltation at the spawning ground and deeper migratory channel in the northern sector, intensive destructive fishing activities in the outer channel sector and overfishing. It is also observed that there is a marked decline in the coastal population of the fish which may have caused the decline of Hilsa fishes in the lake.

Hilsa population was above the Reference Value in the NS, but there was a drastic decline in population in all the other sectors (CS, OCS and SS) from the year 2005 onwards. The scaled value may not reflect the actual status in this sector, because of the low Reference value. All these sectors have reached the minimum NI value of 0.25 during the year 2015, due to over exploitation by the local fishers. The brood stocks are captured in seine nets and a high mortality rate of 70-84% was recorded in these sectors (Fig.17). The decline in the population and catch of this very important commercial fish species is a serious concern. The IUCN red list status for this fish is Least Concern (LC).

![Figure 17: Observed and scaled value of Hilsa shad](image)
8. Grey eel-catfish (*Plotosus canius*)

Grey eel-catfish (Kaunda) is a resident species in Chilika, which is dominantly available in the northern and central sectors of the lake. It breeds in the bottom muddy substratum. It is primarily a carnivore, which feeds largely on shrimps, molluscs, and so on. The Grey eel grows to a maximum size of 1060 mm. NS is the favourite breeding site for this species due to the availability of soft mud bed. Mostly it breeds during May to September, July being the peak month. The efficient fishing gear of the species is hook and line, therefore the population density is well maintained. The NI value of the Grey eel was good in all the sectors from the year 2000 to 2015 (Fig.18).

![Figure 18: Observed and scaled value Grey eel catfish](image)

9. Spot tail needle fish (*Strongylura strongylura*)

Spot tail needle fish (Gania) is considered as a resident species in Chilika, which breeds in the lake throughout the year. It is a high-value fish forming about 2.5% of the commercial catch and it feeds on small clupeoid fishes. It is a pelagic neritic fish and the juvenile of this species emigrate from the marine waters to the fresh water and completes its life cycle in Chilika Lake. It is also one of the commercially important finfish species, which fetches lucrative prices for the local fishermen.
Spot tail needle fish breeds in CS at Nalabana and also in NS area near Tuanali during June and July. The population status of the needle fish was good until 2010 in all the sectors. There was a decline in the population from the year 2010 to 2015, when a minimum value of <0.25 was recorded in NS. In SS and CS, the NI value was above 0.25 (Fig.19). The decreasing trend is noticed due to the increase in market demand, hence overfishing is prevalent by the local fishing communities.

![Figure 19: Observed and scaled value of Spot tail needle fish](image)

10. **Bloch gizzard shad (Nem atalosa nasus)**

Bloch’s gizzard shad (Balangi) is a brackish, freshwater pelagic-neritic and anadromous clupeoid fish. It is a commercially viable species in Chilika with an average annual landing of 943 tonnes, contributing to nearly 8% of the commercial catch. Balangi enters from the marine water and completes its life cycle in Chilika lake. The matured marine stock immigrates into the lake for breeding from January to June and prefers sandy areas for breeding.

The mean length of the species varies between 135-175 mm and it feeds on decayed organic matter or detritus and large amounts of benthic foraminifera along with mud (65%). The NI value was good in OCS, SS (above the Reference Value) and NS (>0.50 in the year 2015) and there was a decline in the Bloch’s gizzard shad population in CS from the year 2005 onwards and it reached a minimum value of <0.50 during the year 2015 (Fig.20). The IUCN red list status for this fish is Least Concern (LC).
11. Small Bengal Silver-biddy  
(*Gerres setifer*)

The small Bengal silver-biddy (*Jagili*) live both in the marine and brackish water regions. It is a benthopelagic, amphidromous fish that has a high commercial value and contributes 1.1% (approximately 129 tonnes) of the total catch. The peak breeding season of Jagili is June and it breeds mostly in the sandy bottom area. The fish feeds on crustaceans (42%), molluscs (31%), algae (6%), decayed organic matter (13%) and miscellaneous matter (8%). The overall mean length of the fish is 110 mm. The population status of Small Bengal Silver-biddy was above the Reference Value in the CS and SS regions from 2000 to 2015. In OCS, there was a decline in the population (<0.50) during 2010 and it gradually increased to the maximum index value of 0.1. In NS, the value was constantly low from the year 2000 onwards (<0.25) and showed a very poor population density, which may be due to overfishing in the freshwater region by the local community (Fig.21).
12. Long Whiskers Catfish (Kantia) 
*Mystus gulio*

Long whiskers catfish (Kantia) live both in brackish as well as fresh water. It is an anadromous fish endemic to Chilika lake and one of the high-value commercial fish being caught in the lake throughout the year. It grows to a size of 131 mm. The average annual landing was 594.22 tonnes (4.98%) and its favourable habitat is mud and clay substrates. It feeds on amphipods (31%), prawns (13%), algae (13%), detritus (8%), higher plant matter (5%), fish (5%), mysids (4%), gastropods (4%), isopods (3%), insects (2%) and miscellaneous (12%). This catfish completes its life cycle within the lake and breeds from June to November, August being the peak breeding period. The Nalabana bird sanctuary situated in the CS is known to be the important spawning ground of this species. Maximum NI values (above the Reference Value) were recorded in OCS and SS regions. There was a decline in catfish population in CS and NS from the year 2005 onwards and it recorded a minimum value of <0.50 in CS and <0.25 in NS during the year 2015 (Fig.22). The IUCN red list status for this fish is Least Concern (LC).
13. Goldlined sea bream *(Rhabdosargus sarba)*

Goldlined seabream (*Rhabdosargus sarba*, locally called as Dhala Khuranta) lives both in brackish and sea water regions. The juveniles emigrate from the sea to Chilika Lake and it remains in the lake for feeding and growing until it attains adulthood.

The average annual landing is estimated as 164.35 tonnes and contributes 1.38% of the total catch in Chilika. It feeds on algae (31%), molluscs (20%), crustaceans (17%), organic detritus (12%), larger aquatic plants (11%) and miscellaneous matter (11%). The mature adults congregate at the lake mouth near OCS just before spawning and migrates to the sea for spawning. The NI value was high in the OCS (above the Reference Value) and CS (>0.75) regions. In OCS, it has drastically increased from 0.25 to 1.0 from the year 2000 to 2015, which may be due to increase of inward migration of spawning population. The NI value was moderate in NS (0.50) and was below 0.50 in SS during 2015. (Fig.23).
14. **Soldier Catfish (Osteogeneiosus militaris)**

Soldier catfish (Sunga) is an endemic species to Chilika, which breeds in NS and CS from January to June. The Nalabana bird sanctuary area in CS is a major spawning ground for this species. It largely feeds on prawns, crustaceans, fishes, bivalves and decayed organic matters. It is commercially viable and the production is 47 tonnes per year. The NI value was high in OCS (above the Reference Value from 2000 to 2015) and SS (1.0 during 2015). In NS, a moderate population of >0.50 was recorded during 2015 and in CS, the value drastically declined from a maximum value of 1.0 to a minimum value of <0.25 from the year 2000 to 2015 (Fig.24). The low fecundity characteristic of the species coupled with overfishing may be the reason for their decline.
15. Stripped Snake head (*Channa striata*)

Stripped Snakehead (Seula) is mostly confined to NS (Freshwater zone). The shoal of young fry, swarm around the male parent, which guards them below the surface water. It largely feeds on fish, small frogs (tadpoles), insects and crustaceans. Since the species mainly feeds on small fishes, it reduces the forage fish population in the lake.

Its presence in the lake affects the abundance of many commercially important species since, their young ones are consumed by this species. The average annual landing of this species fluctuates from 63 to 286 tonnes. Although this fish originates from freshwater, it has adapted to Chilika conditions and has become a resident species of the lake. In CS, the NI value was above the Reference Value and in NS it gradually declined from 1.0 (during 2000) to >0.50 (2015) showing a moderate population density. In OCS (<0.50) and SS (<0.25) regions, the population declined considerably from the year 2010 to 2015 onwards (in OCS from 0.75 to >0.50 and in SS from 0.75 to 0) (Fig.25). The IUCN red list status for this fish is Least Concern (LC).
4.1.4 Birds

1. Northern pintail (*Anas acuta*)

The Northern Pintail is distributed in most of the Nearctic and Palaearctic regions. During winter it travels to the northern part of South America, Africa and South and East Asia. The distribution was also recorded in Russia (Lake Chany and Caspian Sea), Kazakhstan (Lake Tengiz), Pakistan (Suajwal), Punjab (Harke), Assam (Dibrugarh), Rajasthan (Bharatpur), Bihar (Manjhaul), Madhya Pradesh (Karera), Odisha (Lake Chilika), and Tamil Nadu (Point Calimere). It frequents reedy jheels, brackish lagoons and estuaries in India, Sri Lanka and Maldives\(^{21}\). The male has long pointed pin like feathers projecting well beyond the tail and is largely vegetarian. The NI value of the Northern Pintail was high in the CS, OCS (above the Reference Value) and Nalabana island (>0.75) regions during the year 2015 and showed a good population status during the study period. The value had considerably declined in NS (<0.50) and SS (<0.25) from the year 2005 onwards and attained minimum values during the year 2015 (Fig.26). The observed value of Northern Pintail was high in the Nalabana Island and NS. In NS and SS, the NI value declined due to the

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disturbance (obstructing the movement) caused by the expansion of fishnet by the fisherman. A high Reference Value was observed in NS, due to the occurrence of shallow marshes during their arrival time, whereas the water levels were high in all the other sectors. As the population declined during the subsequent lined. The highest value of Northern Pintail was reported in NS, due to the availability of roosting and feeding habitat. It was noticed that all these roosting sites were disturbed due to the increase tourism and boat movement for fishing.

2. **Eurasian wigeon (Mareca penelope)**

The Eurasian Wigeon breeds in Iceland and northern Britain moves across northern Europe and north Asia to the Pacific coast. In winter, the birds move to central and southern Europe, South Asia, north and Central Africa, and reach North America. It frequents reedy marshes in Pakistan, northeast India, Bangladesh and moves southwards to Tamil Nadu and Sri Lanka. The distribution range of Eurasian wigeon was recorded in Pakistan (Lake Manchar), Punjab (Harike), Rajasthan (Bharatpur), Assam (Kaziranga), Madhya Pradesh (Karera) and Odisha (Chilika). Eurasian Wigeon is found in shallow grassy Jheels and marsh areas. It is a mixed surface feeder, which is largely vegetarian. Apart from up-ending in shallow water for food, it is often seen walking in marshes, grazing on grass shoots and aquatic weeds. It is a swift powerful flyer and it flies with a peculiar rustling sound of wings.

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The NI value was higher than the Reference Value in the CS, OCS and Island regions. Whereas in the NS and SS regions, the NI values declined considerably during 2015. A minimum value (0 in NS) and (0.25 in SS) displays a very poor status (Fig. 27). The observed value was high in the Island and CS regions, due to the availability of extensive thickets of Potamogeton pectinatus (Pond weed). The decrease in population of Eurasian Wigeon was noticed in NS and SS was due to the disturbance (obstructing the movement) caused by the expansion of fishnet in NS and SS by the fishermen.

Figure 27: Observed and scaled value of Eurasian wigeon

3. **Gadwall (Mareca strepera)**

Gadwall is a winter visitor and one of the most common and locally abundant migratory wild birds. Gadwall breeds in most of North America and north and Central Eurasia between 40°N and 60°N. During winter it moves towards south to Central America, South-central and Southeast Eurasia and North Africa between 20°N and 60°N. During winter, it commonly migrates to the Indian subcontinent, and is mostly found in reedy marshes in the mainland, rare in southern India and vagrant in Sri Lanka. The birds start arriving in October, reaches its peak in October and November and leave by mid-March to April. The distribution ranges are Russia (Lake Chany and Omsk), Kazakhstan (Lake Tenghiz), Kyrgyzstan

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(Issyk Kul), Pakistan (Lake Manchar), Punjab (Harike), Rajasthan (Bharatpur) and Odisha (Lake Chilika). It is a mixed surface feeder and largely vegetarian. In both CS and OCS, the NI value exceeded the Reference Value, and in the Island region the NI value was above 0.75. A high NI value of Gadwall was recorded in the CS and OCS sectors, due to the prolific growth of *Potamogeton pectinatus* (Pond weed).

The NI value in NS profusely declined from 1.00 to 0 and in SS, it varied from 0.9 to 0.25 from the year 2000 to 2015 (Fig.28) indicating a poor NI value. This may be due to frequent visits of fishing boats and other anthropogenic pressures.

![Figure 28: Observed and scaled value of Godwall](image)

4. **Black – tailed Godwit (*Limosa limosa*)**

Black tailed Godwit breeds in Western and Central Europe and migrates to Russia and moves up to the upper Yenisey river. During winters it migrates to Mediterranean and sub-Saharan Africa and also it visits Indian subcontinent such as Andaman and Nicobar Islands, Lakshadweep, Srilanka and Maldives. Godwit is found in the seacoast, sparingly on large rivers and Jheels and frequently harbours in coastal villages. It eats insects, grubs, slugs and shoots of various crops. It breeds in colonies in Ladakh and in bogs in Tibet. It lives in the tidal mud flats and marshy areas of both freshwater and brackish water regions. It is often seen in large closely-packed flocks and in association with other waders.

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The observed value of Godwit was high in NS and Nalabana Island, due to the availability of shallow marshes and mudflats in the NS and Island regions. The NI value was high in the SS (1.0) and Island (<0.75) regions and in CS, OCS and NS regions, the NI value declined (below 0.5) during 2015, due to anthropogenic pressure and extensive ecotourism related activities (Fig.29). The high numbers generally recorded for this species in NS is due to the availability of paddy fields in the adjoining areas, where it frequents to feed both on the benthic fauna and paddy grains. A declining trend was noticed in NS similar to that of Northern pintail. Godwit also feeds on adjacent paddy fields and congregate in the shallow marshes for feeding and roosting.

Figure 29: Observed and scaled value of Black-tailed Godwit

5. Brown-Headed Gull  
(Larus brunnicephalus Jerdon)

The Brown-headed Gull is distributed in western and eastern sea coast of India and inland waters. It is also found in Bangladesh, Pakistan, Sri Lanka and Myanmar. It feeds on insects, grubs, slugs and shoots of various crops and breeds in colonies in Ladakh, and in Tibet, in bogs around Rhamtso, Manasarovar, Rakhas Tal and other lakes. This species feeds or scavenges on dead and discarded fishes. It feeds mostly on open waters and roosts on exposed mud flats. In the CS, NS, OCS and SS regions, the NI value of the Brown-headed Gull population was higher than the Reference Value, similarly the Island region also showed a good population status (<0.75). Overall, the population status of the Brown-headed Gull was good in all the sites throughout the study period (Fig.30). There was a slight decline in the value in the Nalabana Island. This may be due to the shrinkage of mud flat in Nalabana Island, which is a favoured site for its roosting.
6. Common coot (Fulica atra)

The Common coot occurs in the Indian subcontinent, breeds in Europe, North Africa, Azores and Canary Islands. During winter it migrates to the northeast Africa, Southeast Asia and the Philippines\(^27\). In the Indian subcontinent, it is either a resident or an abundant winter migrant, frequenting large jheels, lakes, and reservoirs in the mainland, Andamans, Sri Lanka and Maldives. It breeds erratically throughout the plains of the mainland and up to 2,500 m in the Himalayas\(^28\). The distribution ranges of Common coot are Kazakhstan (lake Alalol, Lake Sasykkol and Lake Balkhash), Punjab (Harike) and the entire Indian subcontinent.

Common Coot is found in rush-bordered irrigation tanks and marshy lands and it migrates from central and western Asia. It feeds on grass and paddy shoots, aquatic weeds, insects, molluscs and so on. In the CS, OCS, NS and SS regions, the NI values were above the Reference Value, except in the Island ecosystem (>0.50). Overall, the population status was good in all the sectors (Fig.31). Among all the sectors, the Island and NS were favourite habitats of this species. Though the population is declining in the island, there was an increase in population during 2010. In the NS region, the decline was recorded during 2010, which may be due to the spread of fishing net.

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7. **Asian Openbill Stork**  
*(Anastomus oscitans)*

The Asian openbill, which belongs to the stork family, Ciconiidae, is available, from India and Sri Lanka to Thailand and Indochina. In the Indian subcontinent, it is resident and locally migratory, and it is recorded throughout Pakistan, India, Nepal and Sri Lanka. Some birds shift locally with water conditions, while some perform migratory movement\(^{29}\). They are large wading birds, which make long-distance movements in response to the weather and food availability.

It is relatively small and its usual foraging habitats are inland wetlands and tidal flats, agricultural landscapes, crop fields, irrigation canals, and seasonal marshes. It feeds on large molluscs, water snakes, frogs and large insects. The NI value of Asian openbill was above the Reference Value in OCS (continuously from 2000 to 2015) and CS (during 2015). In NS (>0.75) and SS (>0.50), it had a moderate population status (Figure 32).

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The observed value was very high in NS when compared with other sectors. Being a resident bird, it mostly feeds on snails, frogs and larger insects and appears in the shallow marshes. The population density was high in CS, NS and OCS and a moderate population was recorded in SS during the year 2015.

8. **Purple swamphen**

*Porphyrio porphyria*

The Purple swamphen is distributed throughout the plains of the Indian Union, Bangladesh, Pakistan, Myanmar and Srilanka and it lives in swamps and margins of Jheels. It eats shoots, vegetable matters, insects and molluscs. The Purple swamphen population status was good in NS, OCS, NS, and SS (NI values were above the Reference Value). In the CS region, the value was below 0.5 and showed a declining trend (Fig. 33). This species was mostly recorded in NS, due to the availability of shallow marshes with both floating and emergent vegetation and grassland habitat. As the Nalabana Island lacked these vegetation, the observation value was low when compared with NS. However, due to the invasion of grass species in Nalabana, the population has gone up to more than 20 times from the year 2010 to 2015.
9. Lesser whistling duck
\textit{(Dendrocygna javanica)}

Lesser whistling duck is found in vegetation covered tanks and is available throughout India, Bangladesh, Pakistan, Nepal, Sri Lanka and Andaman and Nicobar Islands. It walks well on marshland and often grazes like goose. It is a good diver and perches freely on trees. Lesser whistling duck is vegetarian and eats on shoots, grains, small fishes and snails.

The NI value of the lesser whistling duck was good in all the sectors from the year 2000 to 2015. In island, the data was available only from the year 2010 to 2015 (Fig.34). The species was never recorded at Nalabana Island till 2010. After 2010, due to the proliferation of grass in the Island, this species started visiting mostly for roosting. The observed value was good in NS when compared with other sectors.
10. Little Cormorant
*(Phalacrocorax niger)*

The little cormorant is a sea bird, which is distributed throughout India. It is found in inland water bodies, brackish lagoons and tidal creeks and lives exclusively on a fish diet. The NI value of cormorant population was high in all the five sectors. The little cormorant population showed good congregation in CS, NS, SS and Island regions (values were above the Reference Value) during the study period and in the OCS region it fluctuated between 0.50 and above 0.75 (from 2000 to 2015) (Fig.35). Little cormorant being a generalist species, which exclusively feeds on fishes, it did not show much fluctuation, though a slight increasing trend was observed in NS and OCS.
4.2 Great Himalayan National Park

The frequency of distribution of the scaled indicator value of birds and mammals from the year 1990 to 2015 is given in Fig.36.
4.2.1 NI Value of GHNP

The overall NI value of GHNP indicates that during the year 1990, the NI value was <0.5, and it gradually increased to above 0.5 from the year 1995 to 2000. Further, it declined (<0.5) from 2005 to 2010 and the NI value drastically increased to about 0.75 during the year 2015. The overall NI value of the GHNP shows that the biodiversity status was good during the year 2015 (Fig.37).

The region wise index value shows that in Jeenewal range, the NI value was fluctuating between >0.50 to >0.75 from the year 1990 to 2015. In Sainj and Tirthan, the index value was less in 1990 (<0.50), subsequently the value had increased (during 1995 to 2000), further he value declined (during 2000 to 2010). The increasing trend of the NI value was recorded during 2010 to 2015 in all the ranges and the maximum value of >0.75 was recorded in Jeenewal and Tirthan ranges and in Sainj the value was >0.50 during the year 2015 (Fig.38).
4.2.2 Thematic Index value

The NI value was calculated separately for birds and mammals to compare changes in NI value between these two groups of organisms. The overall Index value of the bird population was >0.75 during the year 2015 in all the three ranges and the NI showed a good status. During 1990, the NI value was <0.50 in all the three ranges, but there was a decline in bird population status during the year 2005 and subsequently the population rate increased (Fig.39).

In the mammalian population, the Jeenewal range showed a good status from 1990 to 2015 and the values fluctuated (>0.5 to <0.75). In the Sainj and Tirthan ranges, there was a decline in the NI value during 2010 and after that, there was a remarkable increase in Tirthan (<0.75) and Sainj. Overall, the NI value was good in the Jeenewal and Tirthan ranges and the value was low in the Sainj range (<0.5) (Fig.39). The colour-coded map substantiates the results provided in Fig.40.
Figure 40: Map of the thematic index value of GHNP for every five-year period

Note: Bluish colour shows the best state while the red colour shows the bad state of the thematic index

4.2.3 Birds

1. Kalij Pheasant  
   *(Lophura leucomelanos)*

The Kalij pheasant (*Lophura leucomelanos*) is found in western Himalayas to western Nepal. The male appears like chicken and has black-and-white plumage, red face and white crest.

The female is brown and has a red patch on the face. Its habitat includes bamboo thickets and shrubs near cultivation and water sources, pure ban and Kharshu oak forests, and mixed cedar and blue pine. Primarily, they roost in ban oak forests and can be seen at dusk and dawn near the villages in GHNP’s ecozone. The population density of this bird was measured through a call count method. The NI value of the Kalij bird was below 0.25 in all the 3 ranges (Jeenewal, Sainj and Tirthan) studied. In Sainj, a maximum value of 0.75 was recorded during the year 2000 and it further declined (Fig.41).
2. **Koklass Pheasant**  
*(Pucrasia macrolopha)*

The Koklas are elusive, medium-sized birds, limited to high-altitude forests across India to central Nepal, and north-eastern Tibet to northern and eastern China. They live below GHNP’s tree line. The male and female have distinct, elongated tails, which are tipped with pale feathers. They tend to lurk under bushes and can be identified by its loud dawn-chorus calls during autumn and the breeding season. They live in pairs or small family groups throughout the year and nest on the ground. They spend the nights roosting in trees or under rock overhangs. The population density was estimated through call count method and a maximum value (higher than the Reference Value) was recorded in Jeenewal and Sainj and Tirthan ranges. The density of the population considerably increased from the year 2010 (Fig.42).

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30 Web source: https://www.greathimalayannationalpark.org/koklass/
3. **Western Tragopan**  
*Tragopan melanocephalus*

Western tragopan, the State bird of Himachal Pradesh, is the rarest of all living pheasants. They are endemic to northwest Himalaya, and a narrow range from Hazara in north Pakistan. Owing to its beautiful plumage and large size, it is locally known as ‘jujurana’ or ‘king of birds’. The upper part of GHNP’s forest zone has the world’s largest recognised population of western tragopan. They prefer ringal (dwarf) bushes as habitat and bamboo available beneath dense forests. They primarily feed on leaves, shoots and seeds, and also consume insects and other invertebrates. Similar to other pheasants, they roost in trees, singly or in pairs\(^3\)\(^1\). The population density is measured using call count method and it was considered as vulnerable under the IUCN classification. The NI value of Western Tranopan was higher than the Reference Value in all the three ranges during the year 2015 and there was a drastic increase in their population from the year 2005 onwards (Fig. 43).

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\(^3\)\(^1\) Web Source: https://www.greathimalayannationalpark.org/western-tragopan/
4. Himalayan monal 
(*Lophophorus impejanus*)

Himalayan Monal population is abundant in the GHNP forest’s temperate upper zone. The zone comprises oak and conifer forests and is interspersed with open grassy slopes, cliffs and alpine meadows. The birds are concentrated mostly between 2,700m and 3,700m. They display altitudinal migration, descending as low as 2,000 m during winter. They also show tolerance to snow and has been seen digging through snow-fall for roots, tubers and invertebrates. They can be seen in pairs during the breeding season (April to August) and they form large coveys or flocks for communal roosting in the winter (Figure 44). The male was previously heavily-hunted for its crest feathers\(^{32}\). The population of this species was estimated through call count method, and it was found that there was an increase in Monal population in all the ranges during the year 2015. In Tirthan, the value drastically increased from <0.25 to 1.0. In Jeenewal, the maximum value recorded was >0.75 and in Sainj range, it was 0.50.

\(^{32}\) Websource: https://www.greathimalayannationalpark.org/western-tragopan/
5. Cheer pheasant (*Catreus wallichii*)

Cheer pheasants are distributed in the highlands and scrublands of the Himalaya, in India, Nepal, Kashmir and Pakistan, mainly above 1,800 m, and up to 3,000 m in summer. Both genders appear brown with long, pointed tails, red faces and small crests. They live in small groups within GHNP on the steep, grassy slopes, which are scattered with trees. They can be sighted near Gati Pat in Jeenewal Valley and on the boundary of the park, close to the villages in Tirthan Valley. The population density for per sq.km was measured using the call count method\textsuperscript{33}. The NI value of cheer pheasant was higher than the Reference Value in Tirthan and Sainj Ranges, from the year 2010-2015 and this species was classified as vulnerable under the IUCN classification (Fig.45). The population count drastically increased from the year 2005 onwards.

\textsuperscript{33} ibid
4.2.4 Mammals

1. Himalayan black bear  
   (Ursus thibetanus)

Himalayan (Asiatic black bear) or Moon bear has a glossy black chest, and is much shorter than the other black bear of India. It is arboreal, which ascends trees to feed on fruits or honey or to escape.

This species is found throughout Himalayas from Jammu & Kashmir to Arunachal Pradesh and in hilly regions of other north-eastern states and it prefers heavily forested broadleaved and coniferous forests as habitat. The population count of this species was measured using line transect survey method and IUCN has categorised this species as vulnerable. In Jeenewal range, the Black bear population was above the Reference Value from the year 1995 onwards and there was a drastic reduction of population in Sainj range (<0.50) and in Tirthan range (<0.25) during 2010. After that, there was a slight increase (>0.50) in population in Sainj range till 2015 (Fig.46).
2. Himalayan Brown Bear (*Ursus arctos*)

Himalayan brown bear is the world’s largest terrestrial carnivore has a thick reddish brown coat. This bear is seen in the Western Himalayan states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand (3000-5000 m). It is habituated in alpine scrubs and meadows above the tree line. Brown bear population was estimated using a line transect survey method and it was noticed that the population status of brown bear was above the Reference Value in Sainj range from the year 2005 onwards. In Jeenewal range, a maximum value of >0.75 was recorded during 2000 and in Tirthan, it showed a declining trend and a minimum value of >0.50 was recorded during 2000 (Fig.47).
3. **Gray Langur**  
*Semnopithecus entellus*

Gray langur species stretches from the Himalayas in the north to Sri Lanka in the south. They habituate in deserts, tropical habitats like tropical rainforests and temperate habitats like coniferous forests, deciduous habitats and mountains habitats. The Gray Langur population is estimated through transect survey.

In Jeenewal range, the NI value was above the reference value from the year 2000 to 2015 also the Sainj range showed an increasing trend up to 2005. In Tirthan, it fluctuated from >0.50 (1990) to 0.25 (2010) and a maximum value of >0.75 was recorded during the years 2005 and 2015 (Fig 48).
Figure 48: Observed and scaled value of Gray langur

4. **Common leopard (Panthera pardus)**

Common leopard has a clear yellow coat marked with black rosettes, they manage to coexist with tigers by hunting smaller prey and hauling carcasses up trees. It is found in deciduous and evergreen forests, scrub jungle, open country and fringes of human habitation. The population of this leopard is measured using line transect survey method and IUCN has categorised this species as near threatened. The common leopard population was high in Jeenewal range (higher than the Reference Value) throughout the study period (1990 to 2015). In Sainj, it was <0.50 (during 2015) and in Tirthan range, it showed a minimum value of <0.25 (during 2010) (Fig.49).
5. **Monkey (Rhesus macaque)**

Rhesus macaque is a medium sized monkey with brown to grey fur and it has an opposable thumbs on their forelimbs and hind limbs which aid them in climbing. They are highly territorial and aggressively defend their home ranges from non-kin groups. In terms of feeding habits, these macaques are generalists. Although they primarily feed on fruits, they also consume succulent leaves, wild fruits and berries in forests, insects, lizards and eggs. The population status of the Rhesus monkey was estimated through transect survey method and it was found that the NI value was above the Reference Value in all the three ranges (Fig. 50).
6. Himalayan Goral 
*(Naemorhedus goral)*

Himalayan goral is a small brown goat antelope and it is distributed in Northern India, river Satluj along the Himalayas to Arunachal Pradesh, north of river Brahmaputra and found in steep grassy mountain slopes with low tree cover and moderate shrubs interspersed with cliffs. It uses forest cover, open gullies, cliffs and rocky areas for escape (400-4000 m). The population status of goral was estimated through a Transect survey method and IUCN has categorised this species as near threatened.

It was observed that the NI value of Goral declined in Jeenewal and Sainj ranges (<0.25) and a maximum value of >0.75 was recorded in Tirthan range during 2015 (Fig.51).
7. Himalayan Serow (*Capricornis thar*)

Himalayan Serow appears like a goat antelope and it is widely seen in the southern slopes of Himalayas from Jammu & Kashmir, Arunachal Pradesh, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Tripura and Nagaland. It is found in the forested gorges, broadleaved valleys, and subalpine scrubs with dense cover and boulder strewn hills (300-3000 m). The population of the serow was measured using transect survey method and IUCN has categorised this species as near threatened. In Tirthan and Jeenewal, the NI value was above the Reference Value from 1990 to 2000. In Sainj range, it was < 0.50 during the study period from 1990 to 2000 (Fig.52).
8. Himalayan Thar (*Hemitragus jemlahicus*)

The Himalayan Thar is a large even-toed ungulate native to the Himalayas in southern Tibet, northern Pakistan, northern India and Nepal. It is listed as near threatened species and the population is declining due to hunting and habitat loss. It is fragmentally distributed in western and central Himalayas from Jammu & Kashmir to Sikkim. It lives in temperate and subalpine forests, precipitous terrain with grass cover and mostly seen in slopes with oak and bamboo forests. In is mostly seen in Greater Himalayas forested slopes. Himalayan thar population was estimated using scanning method and the NI value was good in the Jeenewal range (<0.75) during 2015 and there was a decline in Himalayan thar population in Sainj and Tirthan ranges though out the study period (value was below 0.25) (Fig.53).

9. Musk deer (*Rhododendron campanulatum*)

The Himalayan Musk deer is a shy brownish yellow mountain ruminant. It communicates though olfaction and deer scent is marked by defecation and secretion of caudal, musk and inter digital glands. Musk deer is widely distributed in the Himalayan region from central Kashmir up to Sikkim. It resides in Subalpine oak, rhododendron forests, high elevation coniferous forest in the Western Himalayas and in Sikkim. The population count was measured through silent drive count method and the IUCN has categorised this as an endangered species. The Musk deer population drastically reduced in all the three ranges from the year 2000 to 2015. A minimum value of <0.25 was recorded in Jeenewal (during 2015) and Tirthan (2010) ranges. In Sainj, the NI value was 0.25 (declined) during the study period (Fig.54).
Figure 54: Observed and scaled value of Musk deer
5 Discussion

5.1 Interpretation of results in Chilika Lake

Chilika Lake being an assemblage of marine, brackish and freshwater ecosystems, it harbours fish species belonging to these regimes, thereby enhancing ichthyofaunal diversity and contributing to the commercial landings. The distribution of plant and animal species is influenced by the salinity gradients and also due to tidal prism. The lake fishery largely depends on effective function of obstruction-free outer channel and Palur canal. Since these two connecting channels with the sea are the main sea-ward migratory routes for catadromous breeding populations and recruitment routes for juveniles of many commercially important fishes and shellfishes; any obstruction in these two channels will lead to fluctuation in fishery.

Chilika Lake had experienced reduced connectivity to the sea until 2000 owing to increased sedimentation. The degraded catchments choked the connectivity of the lagoon with the Bay of Bengal and resulted in a decline in fish resources. This impacted the livelihoods of the fishermen who depend on the lake for sustenance. After the post restoration phase, it was noticed that there was a drastic increase in biodiversity status, fishery wealth and the overall ecology of Chilika. It was reported that 6 species of fish, 4 species of prawn, 7 species of crab and 2 species of Indian spiny lobster have reappeared and there was an increase in Irrawaddy dolphin population from 89 to 160 individuals. The annual catch of fish was also increased from 1747 tonnes in 2000 to 14228 tonnes in 2012. The rejuvenation has resulted in the decrease of waterweed *Eichhornia crassipes* (water hyacinth) and expanded sea grass meadows from 25 km.square in 2000 to 87 km.square in 2004.

The thematic NI value shows that the NI value of fish of OCS was high when compared with other sectors. It was noticed that SS, NS and CS showed a declining trend from the year 2005. The declined NI value may be due to the capture of immature and juvenile finfishes in absence of enforcement of regulatory measures. The decline in spawning stocks, usage of small and zero mesh size nets, illegal prawn Gheries, dense growth of macrophytes and increased population of motorised boats contribute immensely to the decline in fish population in Chilika lake. The analysis also revealed that the pearl spot and grey eel-catfish show a high NI value in all the sectors. These two species are resident species and they are well adapted to live both in brackish as well as freshwater habitat, hence the population density of pearl spot and grey eel cat-fish was high in Chilika. It was observed that the Hilsa Shad has good NI value in NS when compared with other sectors, which may be due to the anadromous migration of this species towards fresh water (NS is confluence with

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34 India’s Fifth National Report to the CBD, 2014.
35 Chilika Newsletter, February 2015, Volume VIII. Published by Wetland International South Asia.
many rivers and the salinity is low) region for spawning during their life cycle. Also the Hilsa population decline in other sectors may be attributed to siltation and decreased depth in the deeper anadromous migratory routes and heavy weed infestation.

Chilika Lake is well-known for its migratory water birds. The congregation of massive number of migratory ducks during winter and nesting of resident species are the two major features of this wetland. In Chilika a diverse group of bird species have been recorded and it was reported that nearly 700,000 to 9,50,000 birds utilise this lake annually (Balachandran et al, 2006). The NI value of the bird population was high in OCS, CS and Island regions. The Nalabana Island is a bird sanctuary and is the core area for birds located in CS. In this area, the observed values for several species exceeded over 50,000. A high observed or reference value was recorded in the Nalabana Island, due to the availability of shallowness, natural drawdown, high vegetation density and mudflats with extensive shorelines.

The population trend arrived through NI analysis was more appropriate for the Nalabana Island when compared with other sectors. This is because the Nalabana Island is a very small sector with high density of birds and the estimation was more authentic than other sectors (extended up to 100 sq.km). NS has shallow marshes (For e.g., Mangalajodi) and CS and SS have deeper water bodies with less micro habitats. Hence, the bird density was relatively low in CS and SS despite the larger areas. The NI value of the Island can be taken as a representative trend for the whole of Chilika Lake. After Nalabana, the OCS region represents good bird population due to the availability of shallow depth, mud flats and this region provides excellent feeding ground for birds. Some of the initiatives taken by the CDA, namely protection of migratory waterfowl from poaching, eviction of the Illegal prawn gharries, maintenance and dredging of the feeder channel and creeks (facilitates for migration of fish juveniles), catchment area treatment, weed control, pollution control and community participation helps the Chilika lake to revive or rehabilitate with varied biodiversity wealth and this has resulted increase in the population of residential and migratory bird population.

5.2 Interpretation of Results in Great Himalayan National Park

The Great Himalayan National Park is a habitat for numerous flora and more than 375 fauna species. The pilot study has reported that there is an increase in the density of the birds during the study period from 1990 to 2015. The overall Index value of the bird population was high in all the three ranges.

For mammals, the Jeenewal and Tirthan ranges showed a good population trend but in Sainj range, the NI value declined. Mammals such as Himalayan Black bear, Brown bear, Gray Langur and Rhesus macaque showed a good population trend in the Teenwal and Sainj ranges. The population of black bear, brown bear, common Leopard, Himalayan Thar and Musk deer are declining in the Tirthan range. A good NI value of birds and mammalians were noticed in Jeenwal and Sainj ranges, which may be due to the higher level of protection imposed in the forest areas and also due to reduction of anthropogenic pressure in the form of collection of medicinal plants or fuel wood and grazing from national park area. After the notification, the Government has declared 756 km.square area of forest as national park in 1999 and the park officials have taken some management measures towards conserving the biodiversity of the park, which includes:
a) Restriction to the local communities from entering inside the park area for grazing and collection of medicinal plant in the notified areas

b) Formation of Biodiversity Conservation Society

c) Village level Forest Development Committees or Ward Development Committees

d) Community Based Eco-tourism (CBET)

e) Patrolling activities with the help of local people

f) Provided alternative Income generation activities such as, vermicomposting; Pine needle basket or artefact making; smokeless charcoal making; and training on bakery making and sewing, knitting and tailoring through Women Saving Credit Groups (WSCG)

g) Deployment of camera traps in the park area for monitoring of wild animals. The protective measures also resulted in overt expression of agitation against the creation of park. This has resulted in intentional kindling of fire in the forest areas and unregulated grazing of sheep and goats in areas even though it is not a customary practice, which has resulted in decrease in the NI value of the mammalian population during the year 2010.
6 Lessons learned

1. One of the lessons learned from the pilot study is that before undertaking a NI study, it is important to carry out a feasibility study to check the following.
   a) Availability of time series data for the selected indicators (during the pilot study the list of indicator species selected were modified and the new set of indicators were selected based on data availability)
   b) Availability of dedicated manpower (For example, in Chilika Lake we had rich source of data and experts, but in GHNP we had poor sources of time series data and lack of manpower to synthesis data. This resulted in delay in finalizing the NI report). The lessons learned are based on the following observations:

   • The final outcomes with respect to trend and state analysis of biodiversity was less comprehensive than intended and also the delay of the project was related to this issue.
   • The biodiversity data were scattered among different institutions and collating the time series data can thus be a herculean task. However, this project made the CDA and the GHNP authorities compile and collate the time series biodiversity data available for decision making.

2. The availability and collation of data from the pilot sites was challenging (For example, during the NI workshop, Irrawaddy Dolphin – one of the critically endangered species of Chilika lake was identified as an indicator species, but due to the non-availability of the time series data, this species was replaced with another species. This challenge will probably be even higher for other potential sites.

3. It is possible to use monitoring data, models or expert judgements as input into the database. For the current study, only monitoring data have been used (For example, in Chilika, secondary data were collected from various fish landing centres and in GHNP, census data were collected from various records). In the NI-framework, the scientists providing expert judgements also shall give an estimate of how certain they are of their judgement. If this study is scaled up to the newer locations, the expert opinions may be used to a greater extent and it is important that the experts are trained on how these judgements are to be considered.

4. Defining the Reference Value of an indicator is challenging, because it requires good biological understanding of the pilot site and historical data. The reference state should be a situation where the state of biodiversity is optimal or good (NI value = 1). Historical data, models, expert opinions or other sources must be used to define the reference state. In the pilot project, we defined the reference state as the year that we knew the ecological status was as good as possible. This is an adjustment of the NI-method to make it more easily understood and communicated. This adjustment means the results are
more suitable for comparison of biodiversity trends within an area, than to compare across areas. The interpretation of the NI changes from condition relative to a (theoretical) good state to condition relative to a certain year. However, the main problem of using a particular year as the reference state is that not all indicators may be in a similar good state in this year. Some indicators had higher values in the study period than the reference year. This observation indicates that the reference year, for instance of Chilika lake, probably should have been set at another year after the channel is open. Due to the selection of 2003 year data as a reference value or year, the scaled values in these cases will be 1 no matter how much higher the value is than the Reference Value.

5. It is felt that adequate training and capacity building is required for determining the Reference Value; criteria for selecting indicators; data analysis; interpretation of results, and so on.

- The number of communication steps between NINA and the experts providing the data made it challenging to have a dialogue about the data needed and the interpretation of the data entered.
- All the above mentioned challenges have resulted in the pilot study taking longer than planned (approximately 15 months) to finalise. The development of NI for all the PAs will be a highly demanding task. The experience from the pilot is that even for areas where data availability is above average, developing the NI is a challenging and time consuming task.
- The park managers and policy makers have found that the NI-policy tool can be useful in assessing the biodiversity wealth of the protected areas in India and can help in halting the loss of biodiversity. This model can be replicated in other protected areas with the technical assistance and support from NINA.
7 Recommendations

- The NI tool help us to synthesise and communicate the state of biodiversity and the impact of anthropogenic pressure on biodiversity. The NI database can be regularly updated every year, but every 5 years can be chosen to analyse trends in loss or increase in biodiversity. It can be a tool for communication of scientific data though visual clarity (maps and graphs), which ultimately may be used to make decisions on conservation and management of biological resources. Currently, there is no other database internationally available to store, synthesise the time series biodiversity data showing trends over time (monitoring data, models, expert judgments) for any ecosystem (marine, freshwater and terrestrial).

- An Integrated Biodiversity Information System (IBIS) can be developed by bringing all the biodiversity related database (national, state and local) under one umbrella, namely agro biodiversity, fisheries, forestry, medicinal plants, insects and microbes. The database available with national bureaus, such as Zoological Survey of India (ZSI), Botanical Survey of India (BSI), Environmental Information System (ENVIS), National Centre for Sustainable Coastal Management (NCSCM) and People’s Biodiversity Registers (PBRs) available with BMCs and State Biodiversity Boards (SBBs) can be better utilised. The integrated database will help us to develop a national level biodiversity information system, in turn, this will help us to monitor the bioresources available at the local, state and national levels. The database development and mapping exercise will help us in processing or approving the ABS applications. The national level biodiversity information system will bring India to the global forefront and help in gaining insight into the Indian biodiversity, and thus enable targeted actions for conserving the biodiversity.

- In order to facilitate data collation, an institution with access to biodiversity data and with a network of data holders should be mandated with the coordinating role. NINA may train a research institution in India to be able to use the NI database and analyse results on biodiversity status and trends (statistical analysis – R programme). For somebody trained in advanced statistics and ecology, the NI concept is easy to implement.

- Hence, it is recommended that an Indian scientific institution to be in charge of the complete project (coordinating data flow, training experts in the ecological framework and analysing results) must be identified and NINA can provide support to this institution.

- A full-time dedicated ecologist should be hired for statistical analysis and to interpret the NI results. This person should be able to give advice regarding the study sites on a daily basis, for example, on experience in indicator selection, how to standardise data or expert judgement, methodology and so on. Also, the person must carry out the statistical NI-analysis on the final dataset.
• Expert judgement is currently being used in different assessments, for example, the red list. NINA considers that expert judgements on trends of species within a study area can be used to a larger extent in later projects. This option may increase data availability for the NI. The use of expert judgements will require training or a course on how to implement this.

• This policy tool can be used for assessing the biodiversity wealth of the Protected Areas (PAs). Hence, the park managers, policy makers, conservers need to be trained in using this tool for assessing the biodiversity wealth of the designated PAs.

• While selecting the species indicator, it is suggested to include both common and threatened species and also equal representation can be given for plants and animal species.

• To make success with the NI, the results must be disseminated in a simple language to the managers, conservers, policy makers, researchers, politicians and so on through various awareness programmes and by preparing adequate capacity building materials.

7.1 Potential uses of Nature Index in India

• Nature Index can be useful in the management of national parks, sanctuaries and biodiversity hotspots in India. The PA managers can use this tool to monitor the status of wildlife biodiversity in the PAs.

• The SBBs can use this tool at the block/district level to monitor the status of biodiversity for policy support. The NI-tool can also be used for notifying species which are on the verge of extinction or likely to become extinct in the near future as a threatened species and prohibit or regulate collection of those species. The NI assessment study will provide useful information for the states in taking appropriate rehabilitative measures for conserving the threatened species.

• The NI methodology and database is very well suited to gather data and assess the state of biodiversity in India. The data generated under the study can be used for the preparation of State of Environment reports, state and Climate Change action plans, TEEB Study, undertaking IPBES studies etc.

• As India has pledged under several International agreements, the NI study can be used for monitoring the progress of the various global and national biodiversity targets (For example, Aichi, NBAP and SDG goals).
About CEBPOL

Government of India in collaboration with the Norwegian Government has established “Centre for Biodiversity Policy and Law (CEBPOL)” at the National Biodiversity Authority (NBA), an autonomous and statutory body of the Ministry of Environment Forest and Climate Change towards strengthening of expertise in Biodiversity Policy and Law in India. This programme is executed by the NBA in collaboration with Norwegian Environment Agency through the Royal Norwegian Embassy, New Delhi, India.

The Centre aims to provide advice and support to the Government of India and Norway on Biodiversity Policy and Law related issues including complex negotiations on Access and Benefit Sharing and Traditional knowledge as well as governance issues relating to biodiversity at the National and International level. The Centre proposes to help NBA in the effective implementation of International agreements on conservation, sustainable use and the associated access and benefit sharing components of it.

CEBPOL is set up as a specialized Centre of Excellence in Biodiversity Policy and Law to network, organize and consolidate expertise on issues of Biodiversity Policy and Law in India and Norway. The Centre, located at NBA, would function as an independent think tank on Biodiversity Policy and Law. In addition, CEBPOL aims to contribute to the effective implementation of the Biological Diversity Act 2002 and Rules 2004.

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