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

Dr. C. Thomson Jacob, Dr. Signe Nybø, Dr. Stein Are Sæther
Ms. Maja Stade Aaronæs & Dr. Rupam Mandal

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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

PA	Protected Area
PBR	People's Biodiversity Register
SBB	State Biodiversity Board
SBSTTA	Subsidiary Body on Scientific Technical and Technological Advice
SDG	Sustainable Development Goal
SoER	State of Environment Report
SP	Strategic Plan
SS	Southern Sector
SSB	Spawning Stock Biomass
TEEB	The Economics of Ecosystems and Biodiversity
WII	Wildlife Institute of India
WHS	World Heritage Site
WSCG	Women Saving Credit Groups
UNESCO	United Nations Education Scientific and Cultural Organization
ZSI	Zoological Survey of India

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Dr. C. Thomson Jacob
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Foreword

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 90,000animal 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 biodiversty, 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 regularily 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 techical 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 apilot study in which the Nature Index tool was used to assessthe status of thebiodiversiy 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

Contents

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 plants[1] and more than 97,708 species of animals[2]. 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 Himalyas, 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 Ghats[4]). 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.

1. Singh, P and Dash, S.S. 2014. Plant Discoveries 2013. New Genera, Species and New Records. Botanical Survey of India, Kolkata. Botanicals Survey of India.
2. Animal Discoveries, 2018, Published by the Zoological Survey of India.
3 India's Fifth National Report to the Convention on Biological Biodiversity. Ministry of Environment and Forests, Government of India, 2014.
4 UNESCO website: http://whc.unesco.org/en/statesparties/in.
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

6 The Norwegian Nature Index - A Communication tool on Biodiversity. Signe Nybø, Erik Framstad, Bård Pedersen, Olav Skarpaas Norwegian Institute for Nature Research, Norway. Published during the 3rd Science for the Environment Conference Aarhus Denmark 1-2 October 2015. (see also http://www. naturindeks.no/).

7 The Norwegian Nature Index - A Communication tool on Biodiversity. Signe Nybø, Erik Framstad, Bård Pedersen, Olav Skarpaas Norwegian Institute for Nature Research, Norway. Published during the 3rd Science for the Environment Conference Aarhus Denmark 1-2 October 2015. (see also http://www. naturindeks.no/).

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.

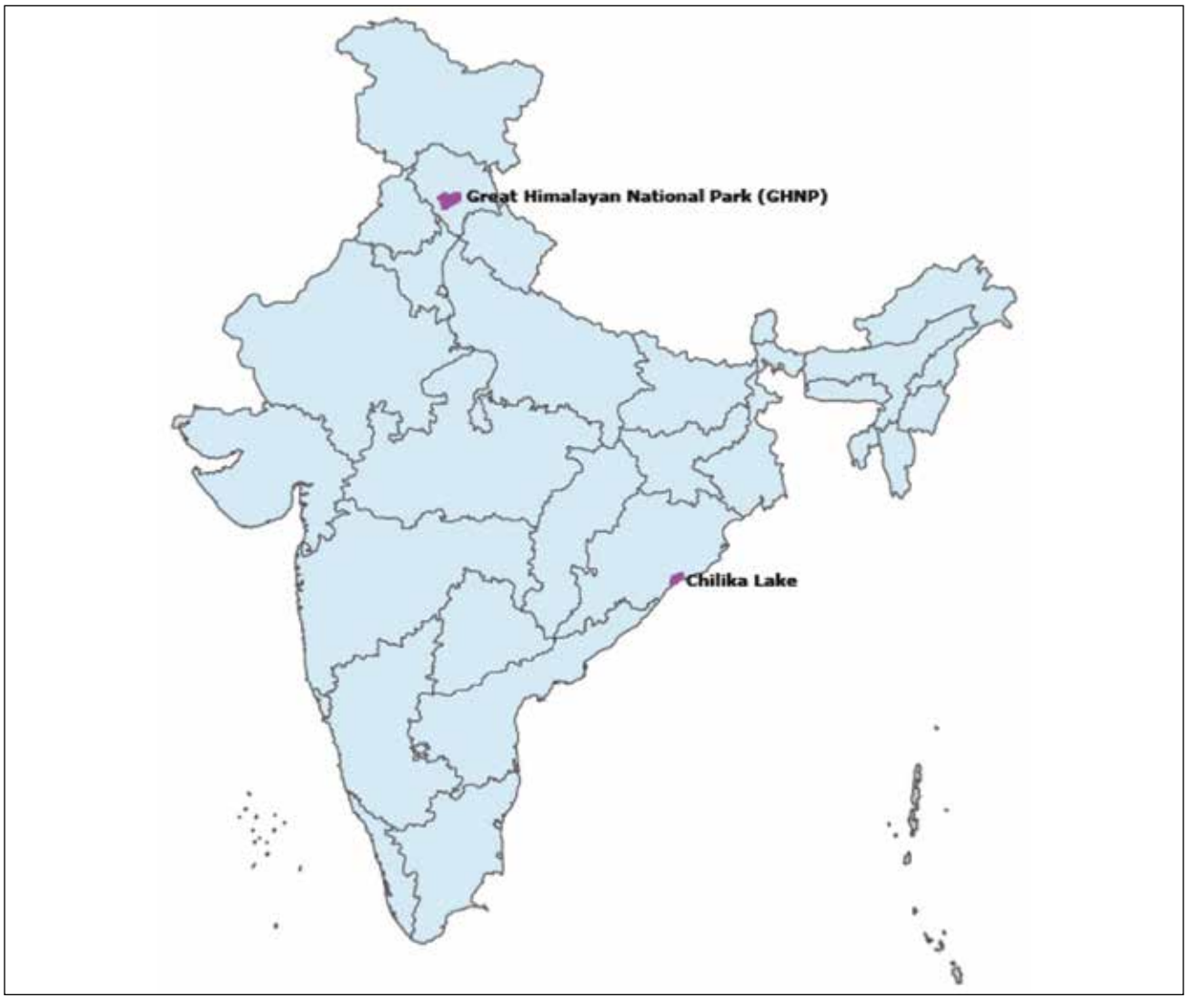


Figure 1: Location of two pilot sites

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[9].

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].

9. Web Resources: (www.nbaindia.org).
10. CEBPOL Project Proposal submitted to the Royal Norwegian Embassy on 27 June, 2011.
11. Web Resource: (www.nino.no/english/Home).

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[12]

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 though Women Saving Credit Groups (WSCGs)[13].

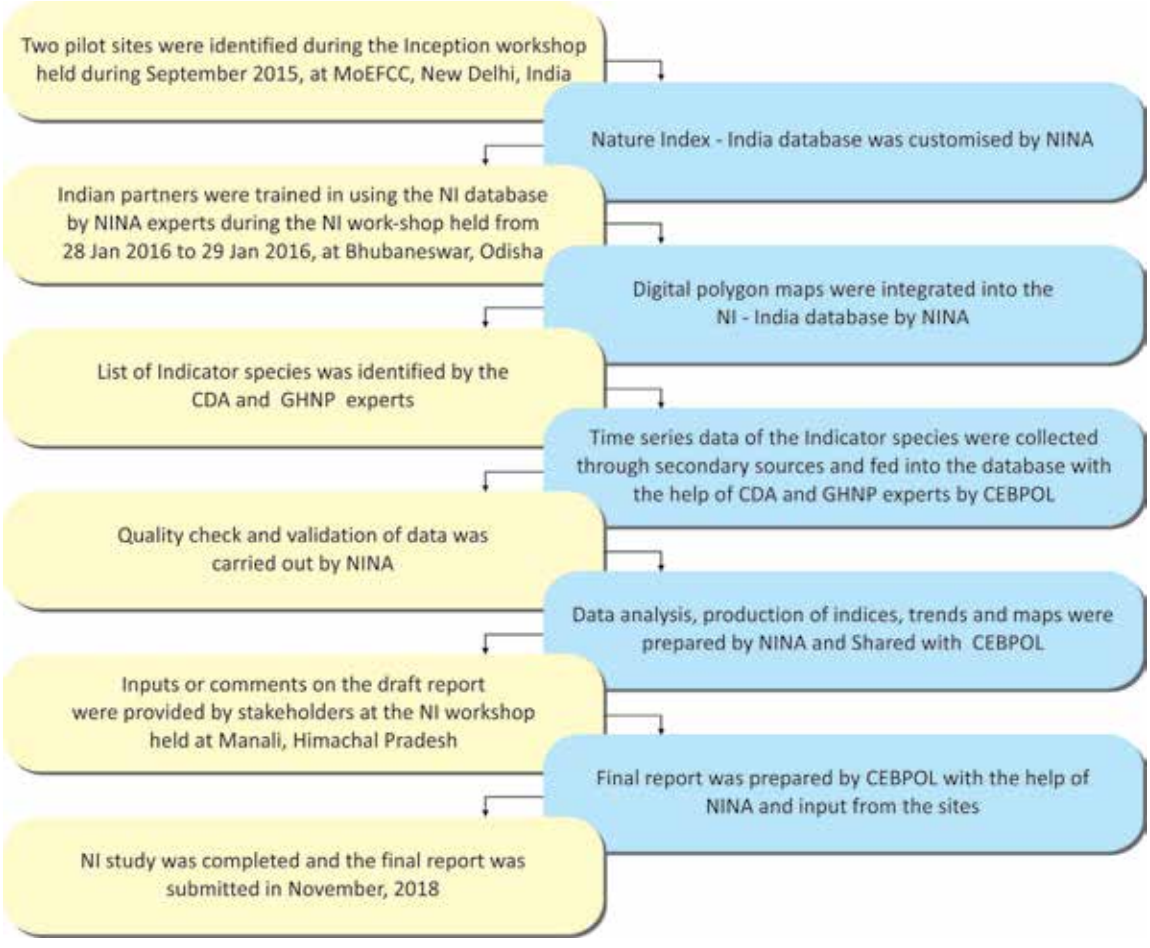
2.2. Process for the preparation of Nature Index

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.

12. Web Resources: www.chilika.com.

13. Great Himalayan National Park Official Website: http://www.greathimalayannationalpark.org/about-us/introduction-to-the-park.

Flowchart 1: Process for the preparation of Nature Index



2.3. Institutions and Experts Involved in the Preparation of Nature Index

Institution	Representatives/Designation	Roles and responsibilities
NBA	Dr. B. Meenakumari, Chairperson	• Provided necessary administrative support in finalising the NI India report
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)[14]

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

14 Pedersen, B. and Kvaløy, P. 2015. Manual for entering data to the Nature Index database. Version 2.1 - NINA Report 1139. 52 pp.

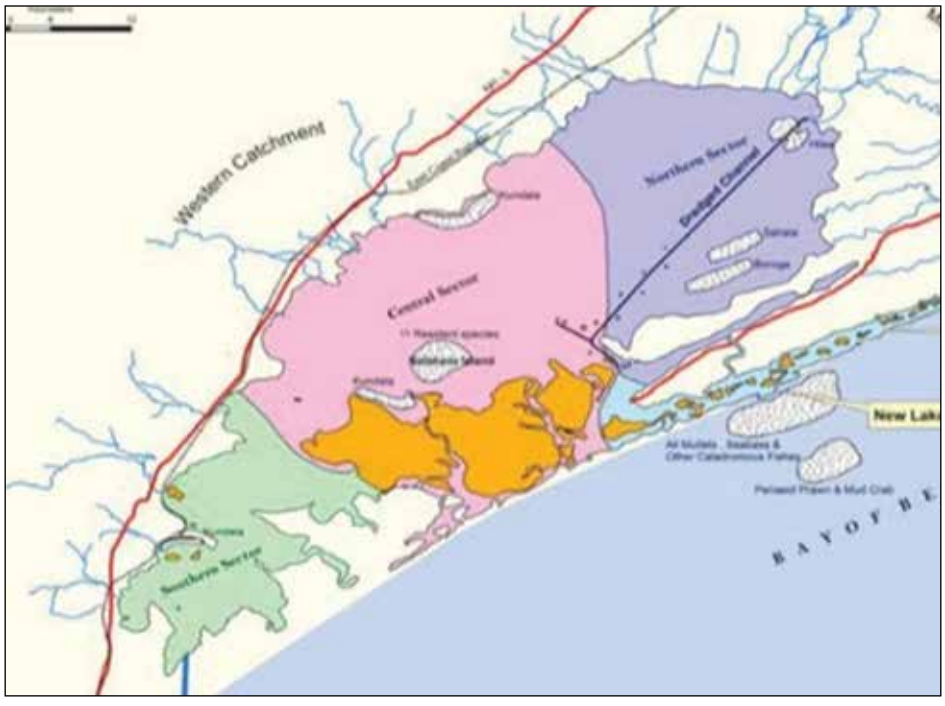


Figure 2: Chilika Lake and the demarcated sectors

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.

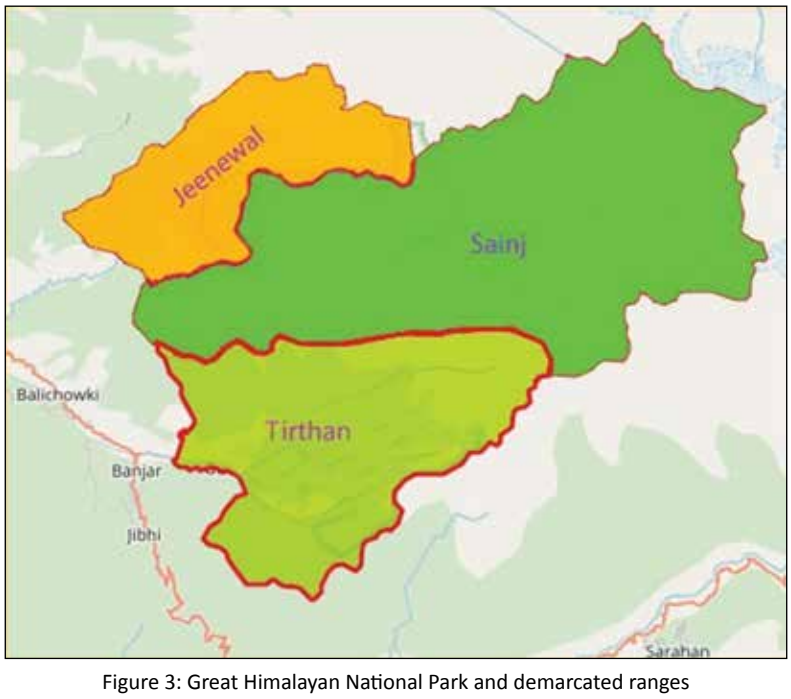


Figure 3: Great Himalayan National Park and demarcated ranges

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[15]

Criteria for selecting Indicators

- Measurable in nature
- Measurement must be linked to a specific, delimited area
- Possibility to estimate a Reference Value
- Ability to link to one or more major ecosystems
- Maintain a persistent population when the ecosystem is in its reference state
- Sufficient knowledge to be able to estimate trends in the indicators, preferably be a pop- ulation quality
- It must respond to changes in the environment.

Source: NINA

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 (19028'-19054'N and 85005'-85038'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.

15 Baard Pedersen, Signe Nyboe and Olav Skarpaas, 2013. Ecological framework for the Nature Index. NINA Minireport 442. A more rigorous approach to determination of reference values and selection of indicators.

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[16]. The highly productive lake ecosystem supports nearly 0.2 million fishermen and generates a revenue of more than INR 750 million annually[17]. 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[18].

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[19]. 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.

16 Surya K. Mohanty et al, 2015. Ichthyofaunal diversity of Chilika Lake, Odisha, India: an inventory, assessment of biodiversity status and comprehensive systematic checklist (1916-2014). Check list, the Journal of biodiversity data. Vol: 11(6); 1817.

17 Chilika newsletter, 2015, Volume - VIII. Published by Wetland International.

18 Arun pandit, A. Ekka, D.K. Biswas, L. Chakraborthy, S.K. Mohanty, Piyashi Debroy & B.K. Das, ICAR, Barrackpore, Kolkata. Published in the books of Abstracts, international symposium on culture based fisheries in inland open waters and satellite symposium.

19 Panda, S. et al, 2008. The Atlas of Chilika Published by the Chilika Development Authority, C-11/BJB Nagar, Bhubaneswar - 751014, India.

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 1: List of bird and fish indicator species from Chilika Lake

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

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[20].

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 2: List of bird and mammal indicator species from GHNP

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

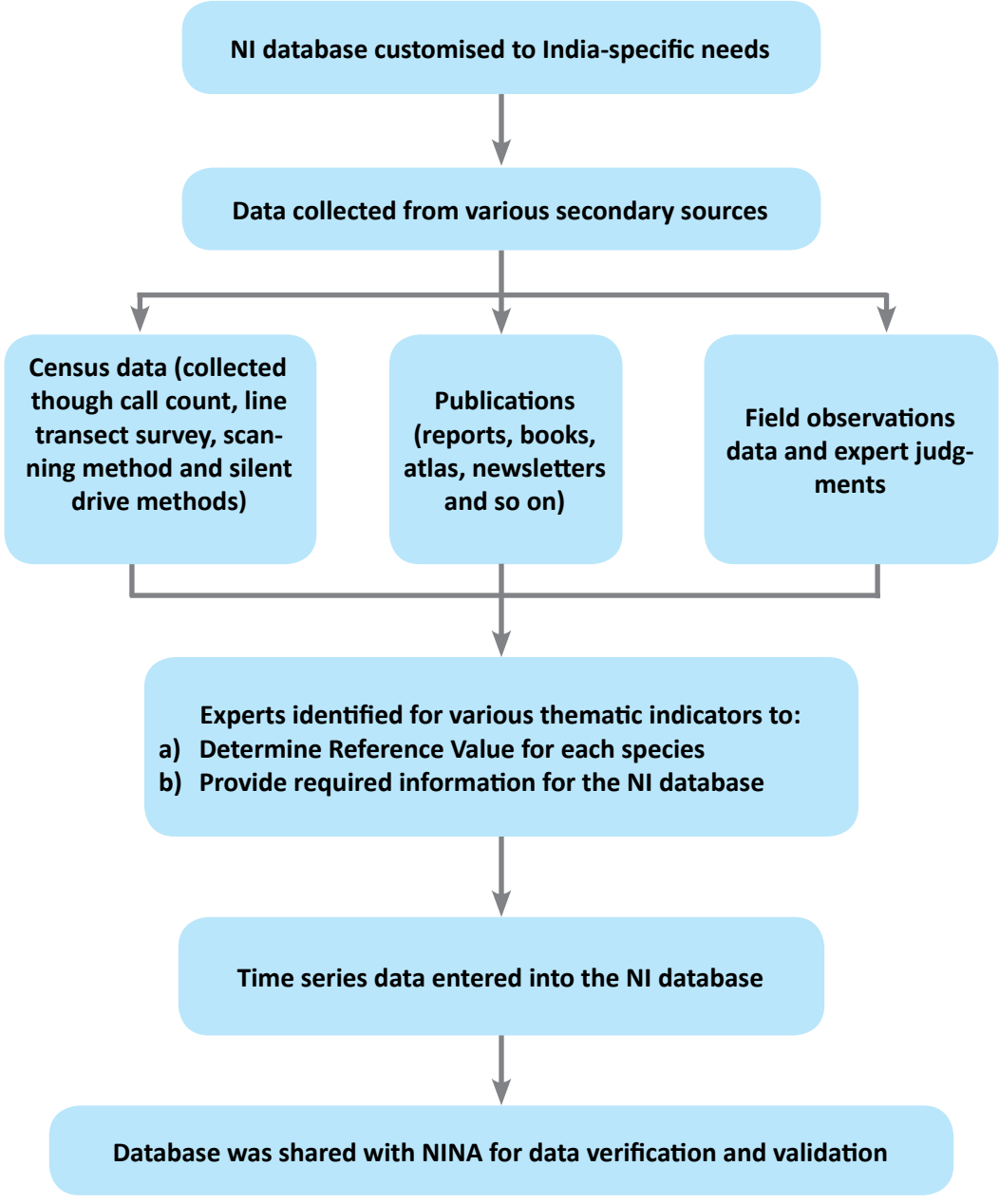
3.3. Data collection

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

20 Web source ; http://whc.unesco.org.

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



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).

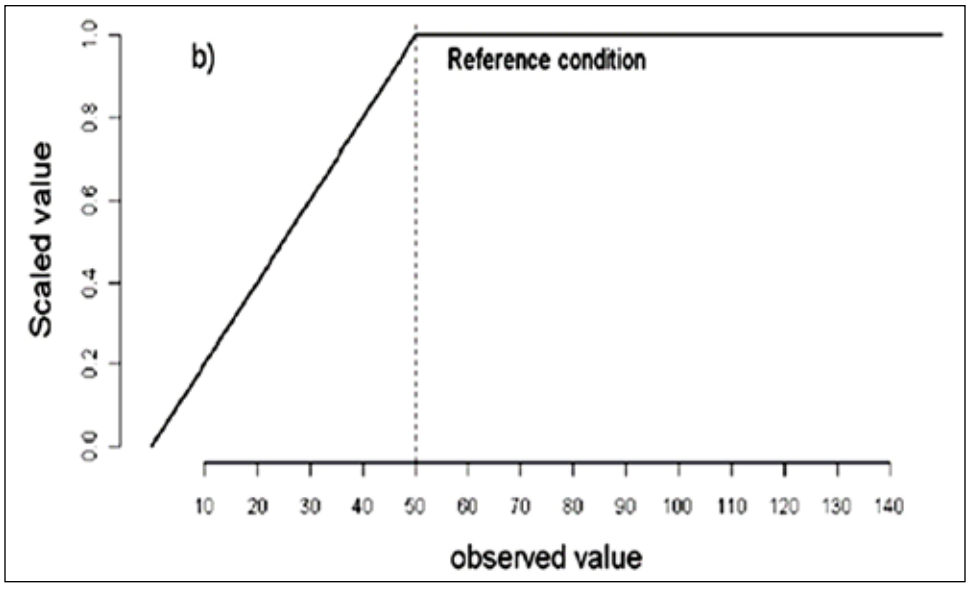


Figure 4: Scaling indicator values in relation to a Reference Value

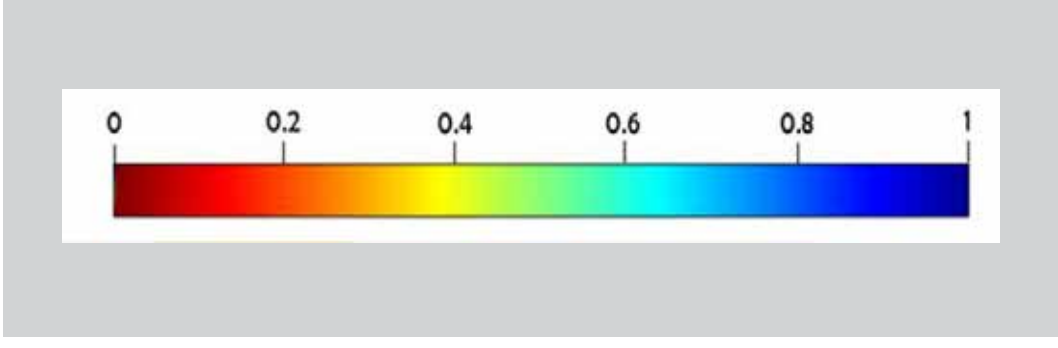


Figure 5: Scaled value expressed on a 0-1 scale

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 NIcalc 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.

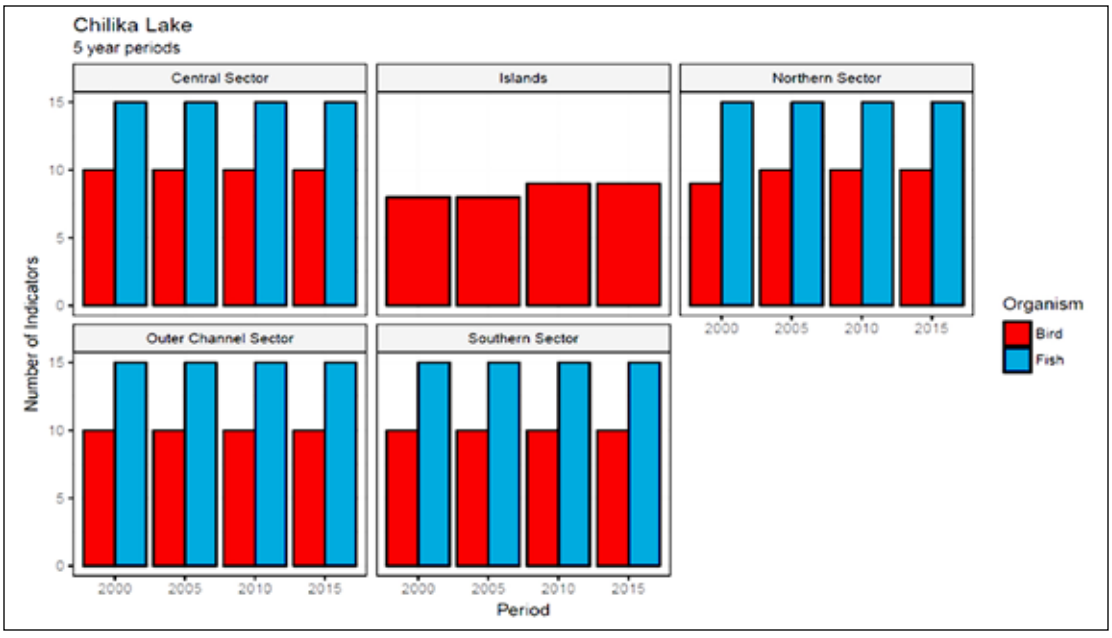


Figure 6: Number of indicators used to calculate Nature Index

4.1.1. Nature Index Value of Chilika Lake

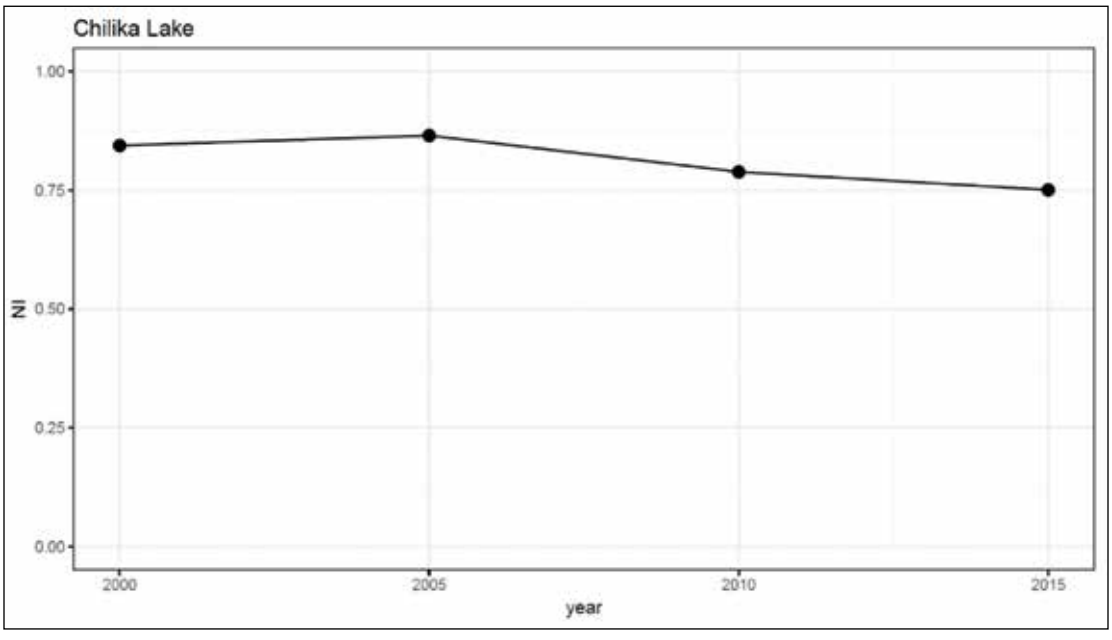


Figure 7: NI value for 5-year period in Chilika Lake

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.

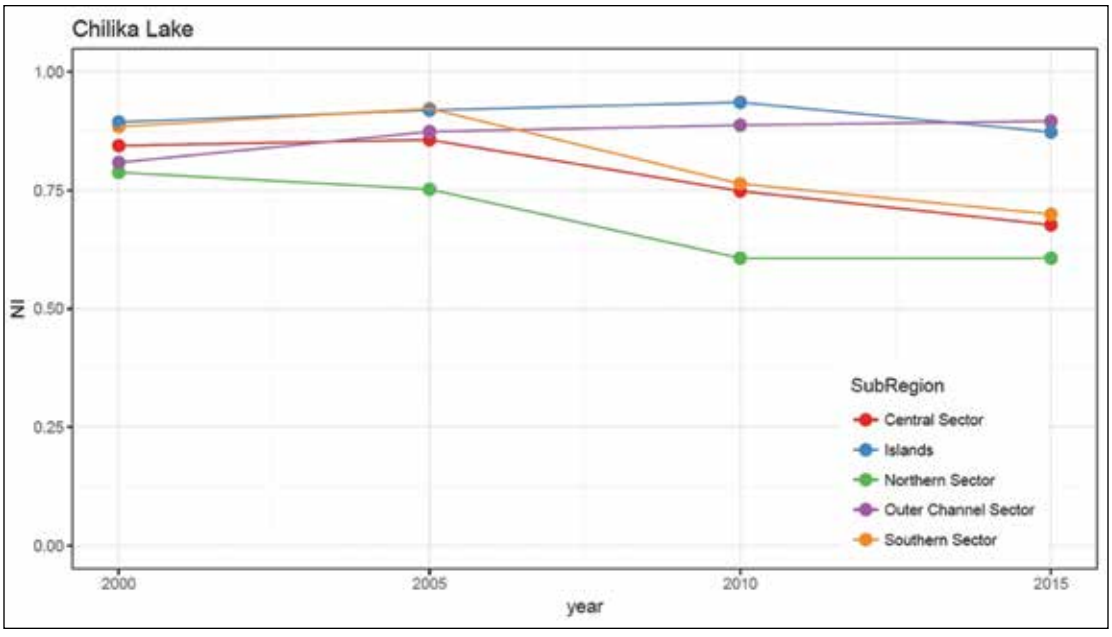


Figure 8: Nature Index value (5-year periods) for the five areas of Chilika Lake

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).

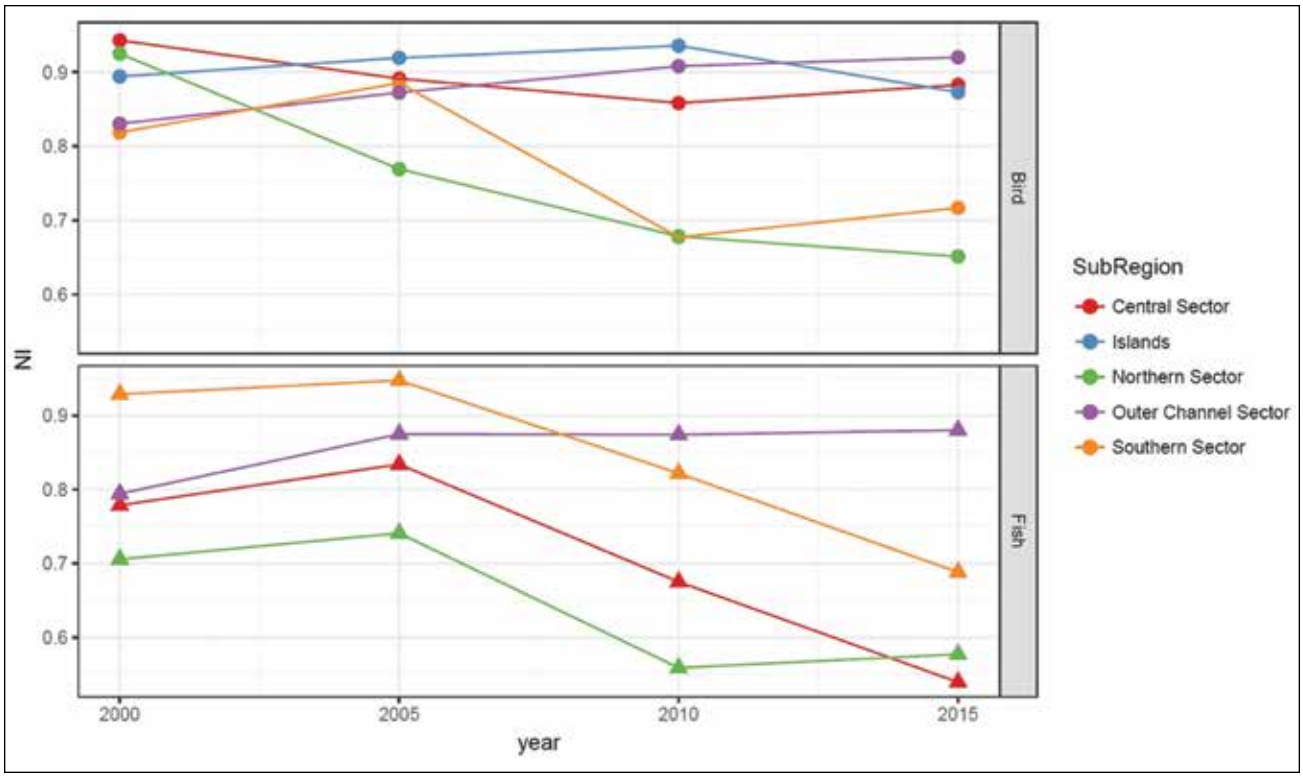


Figure 9: Thematic NI value (5-year periods) for the five areas of Chilika Lake

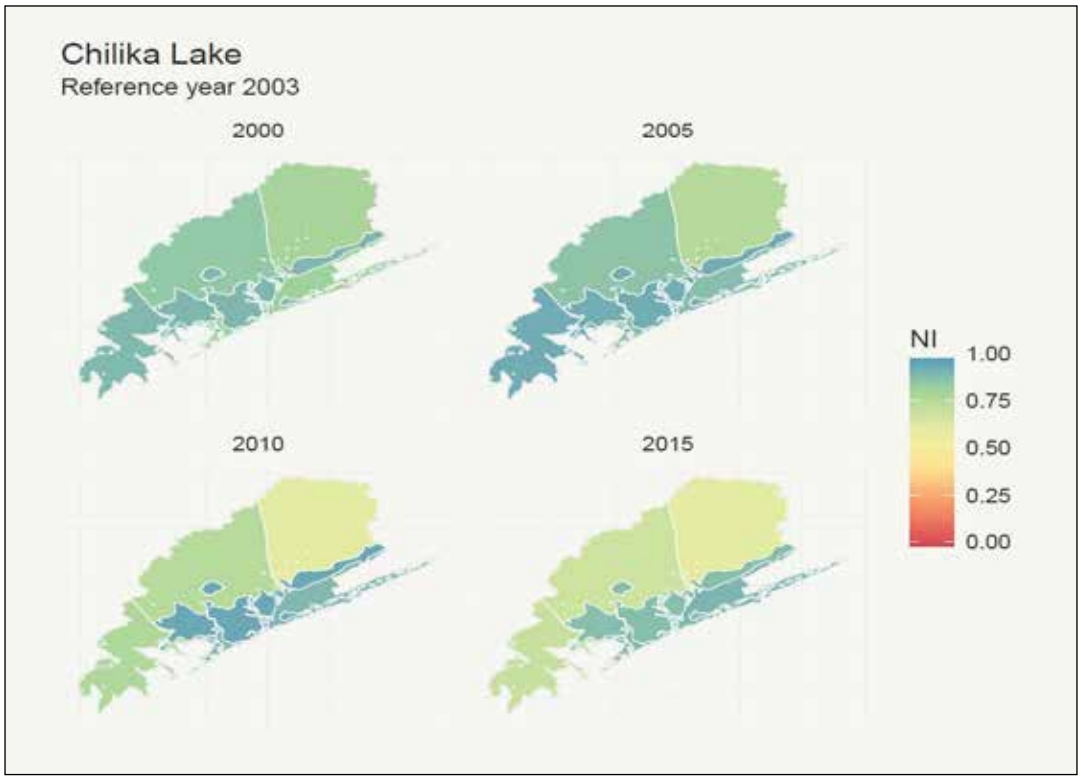


Figure10: Map of Nature Index values for the five areas of Chilika

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 ceplalus*)

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).

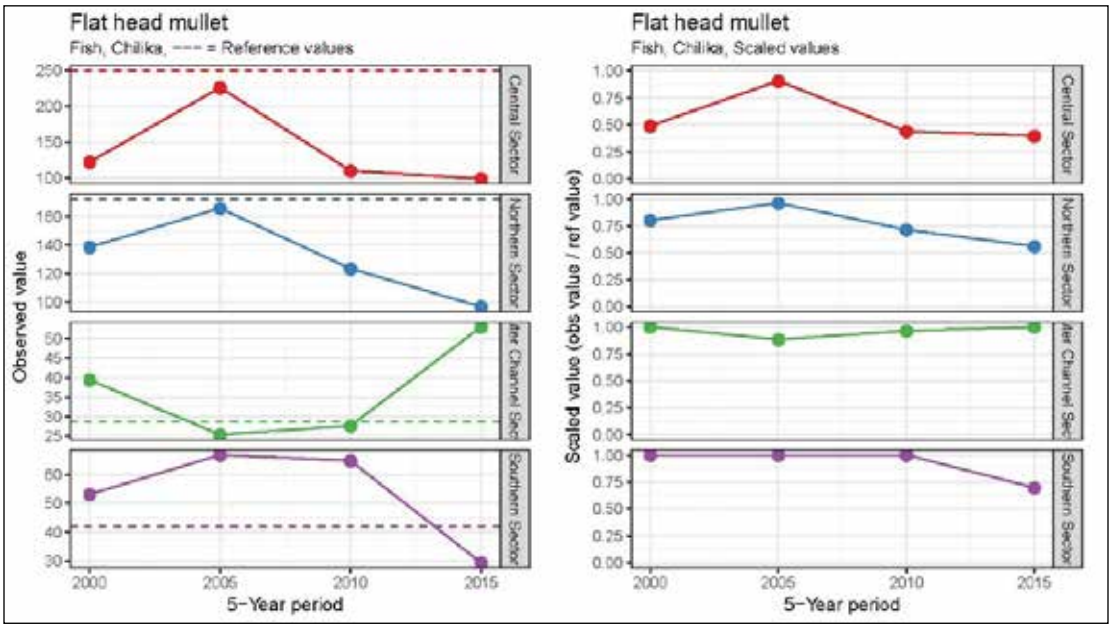


Figure 11: Observed and scaled value of Flat head mullet

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 (iliophagus 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).

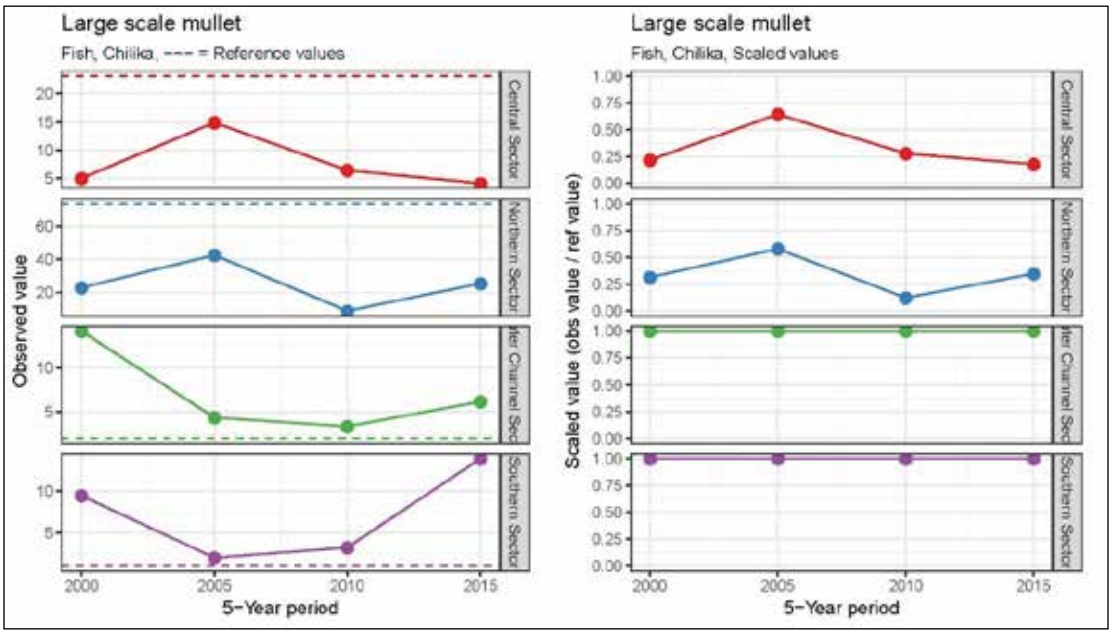


Figure 12: Observed and scaled value of large scale mullet

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.

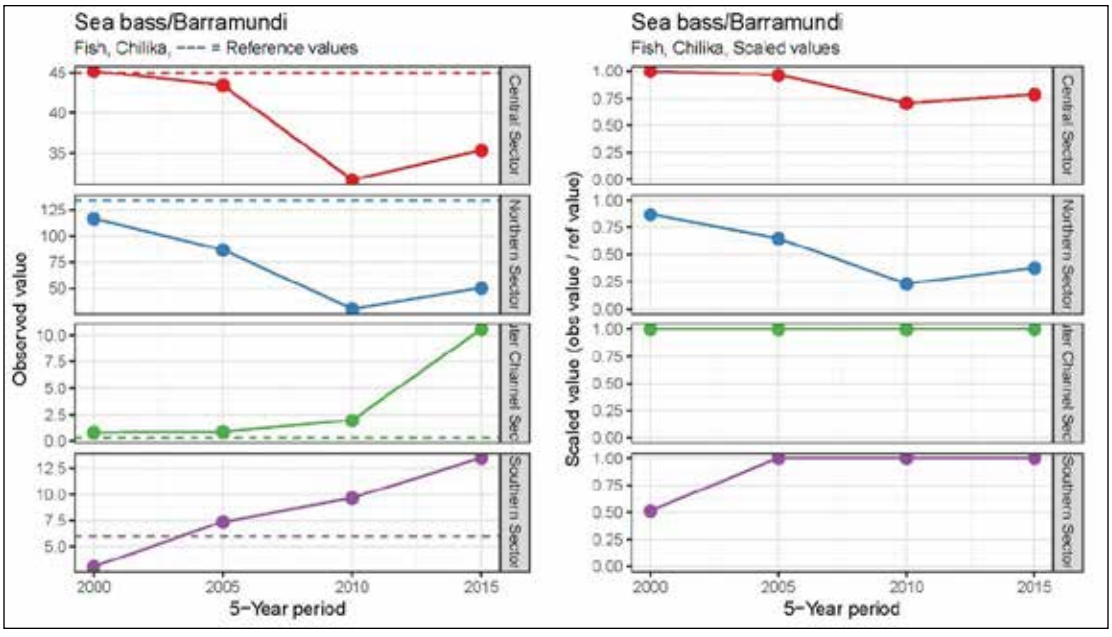


Figure 13: Observed and scaled value of Sea bass

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.

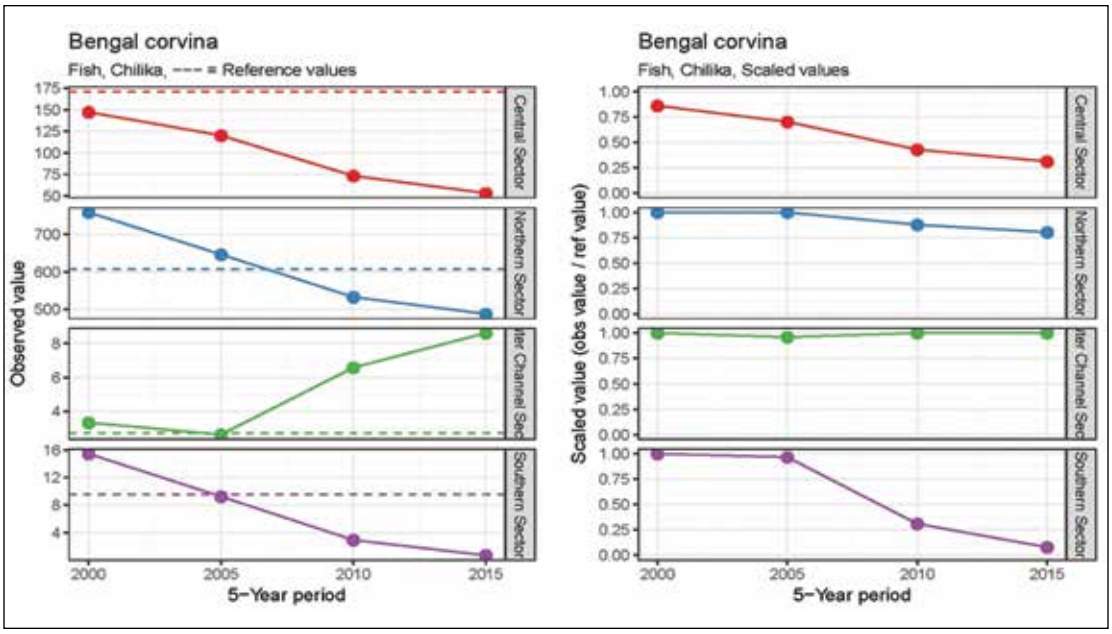


Figure 14: Observed and scaled value of Bengal corvine

5. Fourfinger Threadfin (*Eleutheronema tetradactylum*)

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

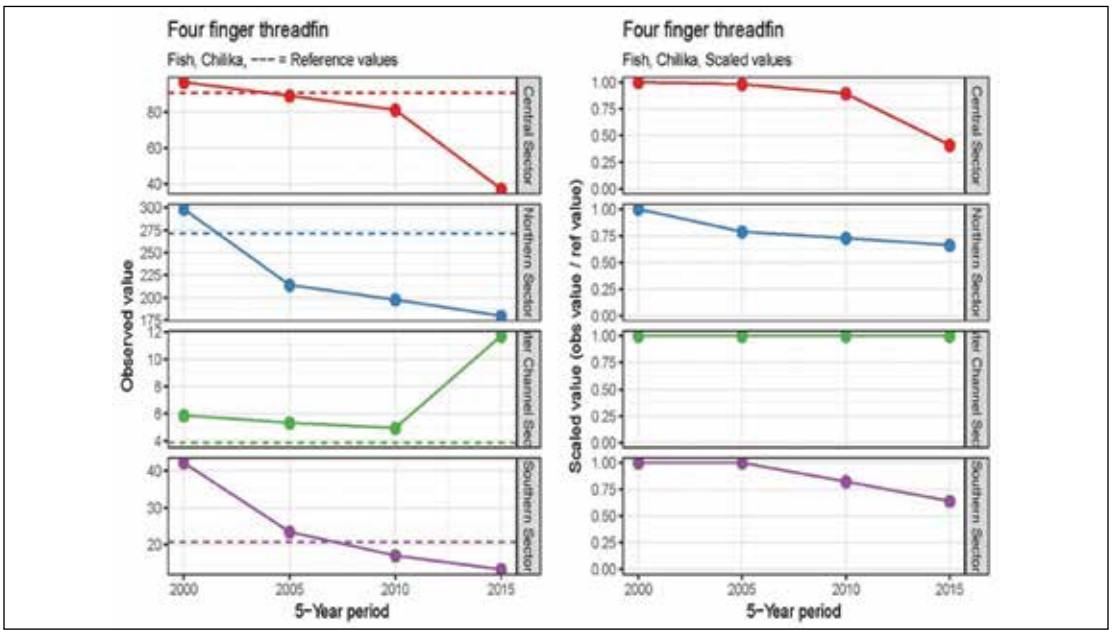


Figure 15: Observed and scaled value of four finger threadfin

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).

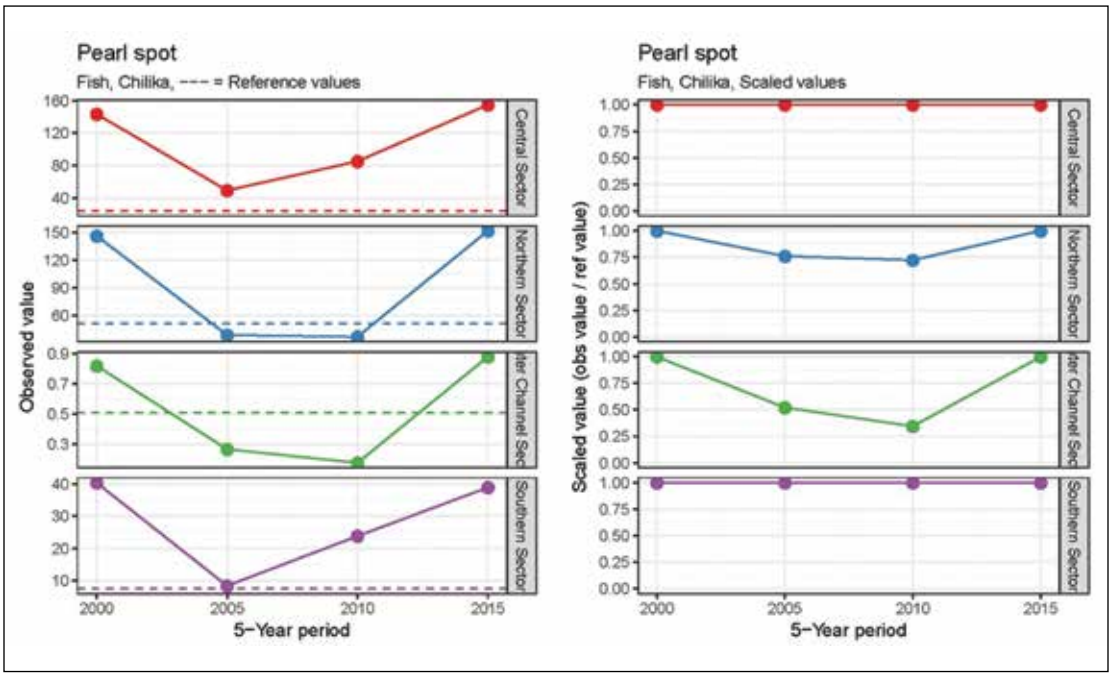


Figure 16: Observed and scaled value of Pearl spot

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).

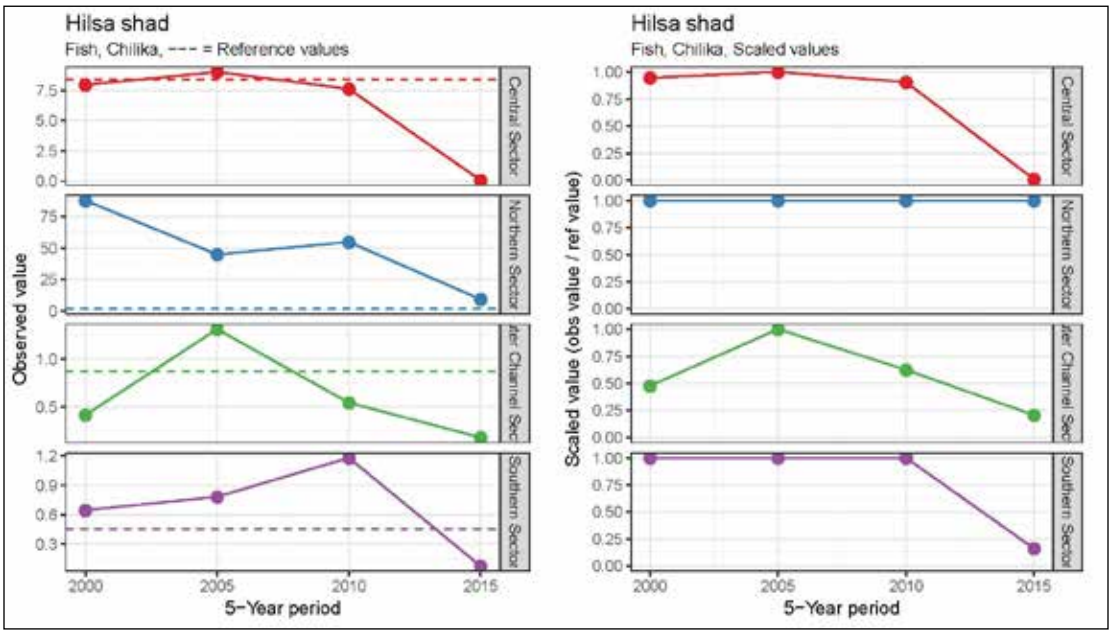


Figure 17: Observed and scaled value of Hilsa shad

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).

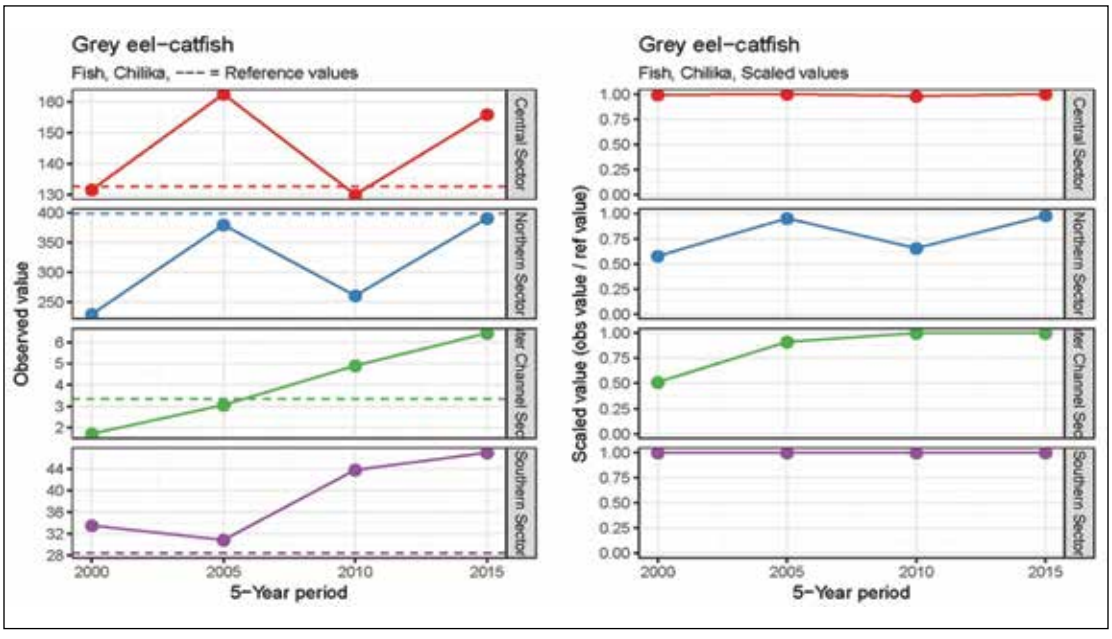


Figure 18: Observed and scaled value Grey eel catfish

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.

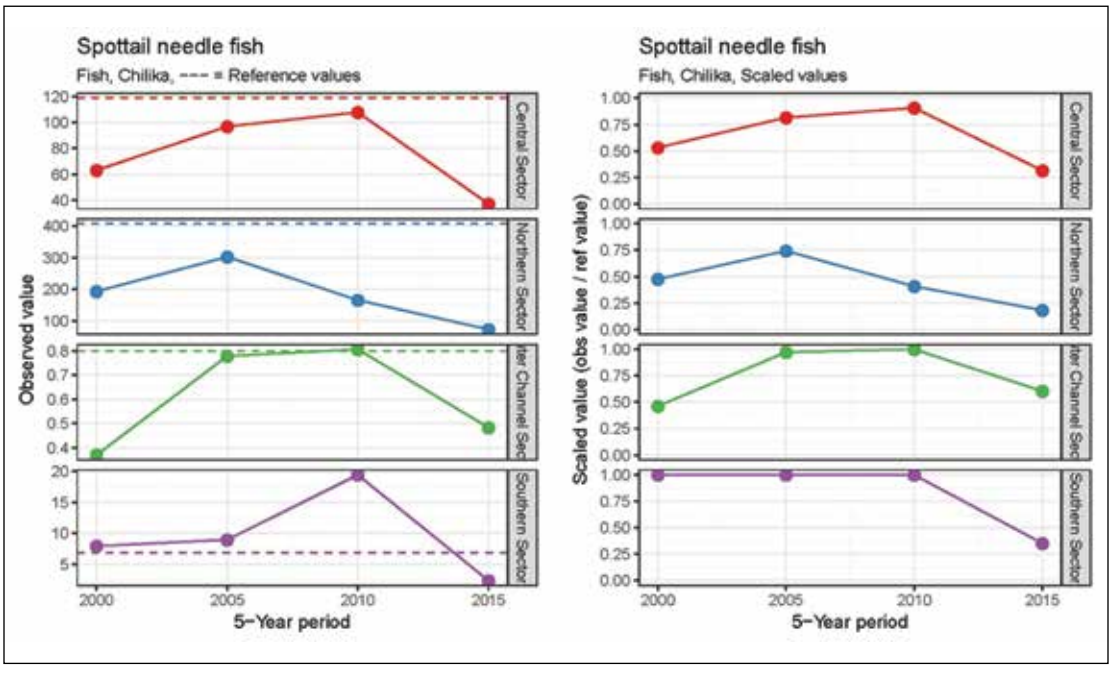


Figure 19: Observed and scaled value of Spot tail needle fish

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).

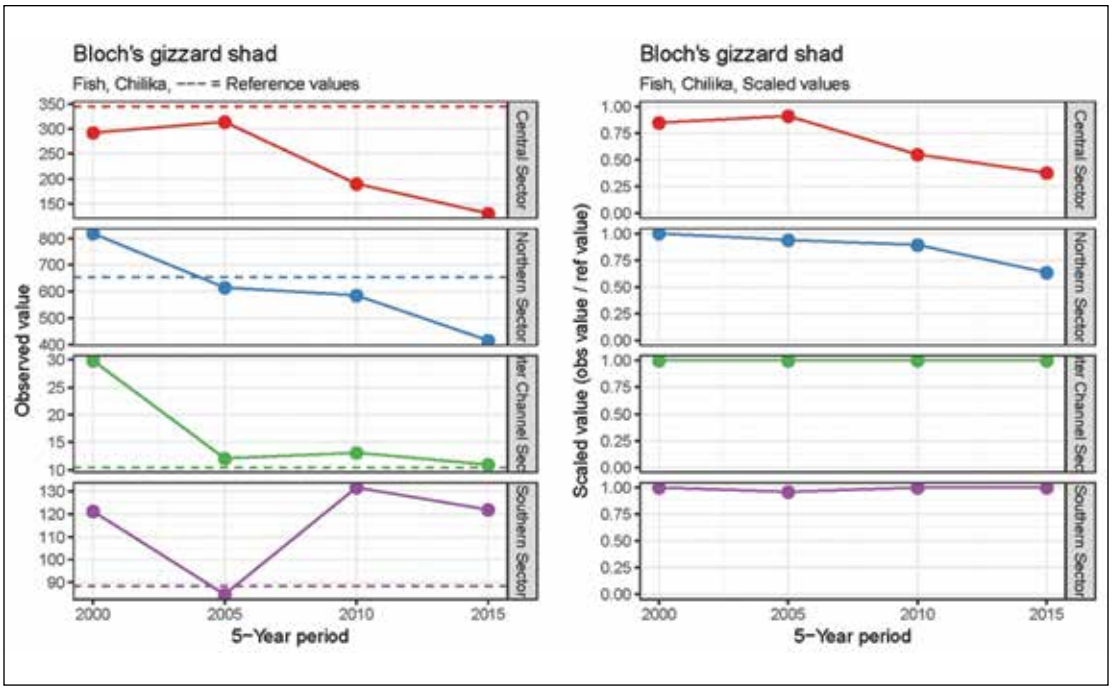


Figure 20: Observed and scaled value of Bloch's gizzard shad

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).

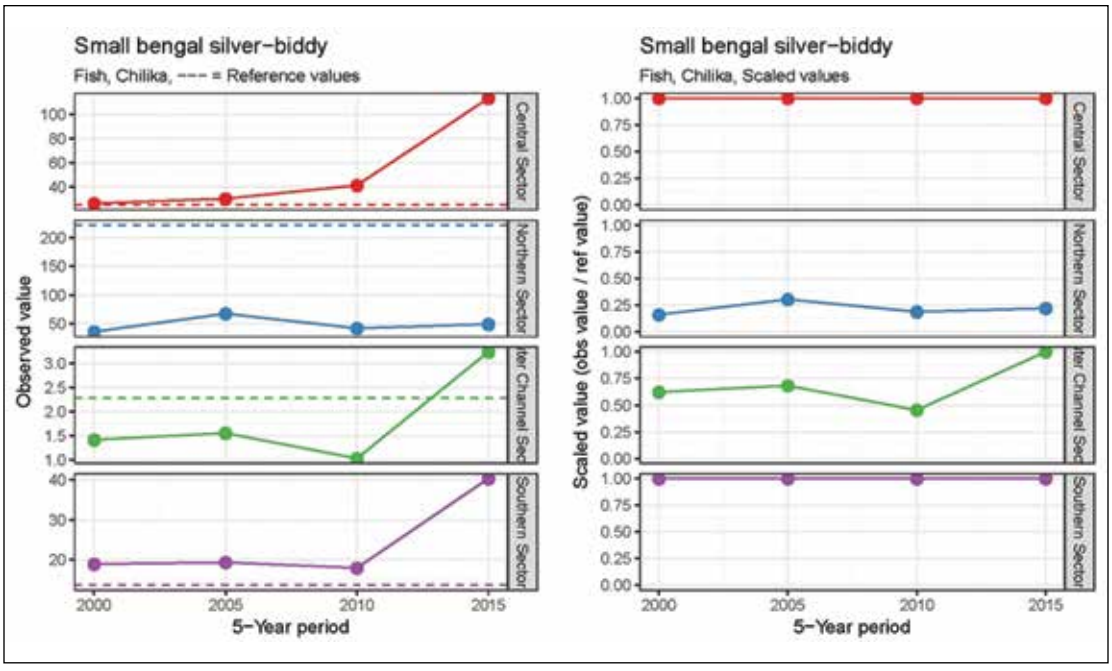


Figure 21: observed and scaled value of small Bengal silver

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).

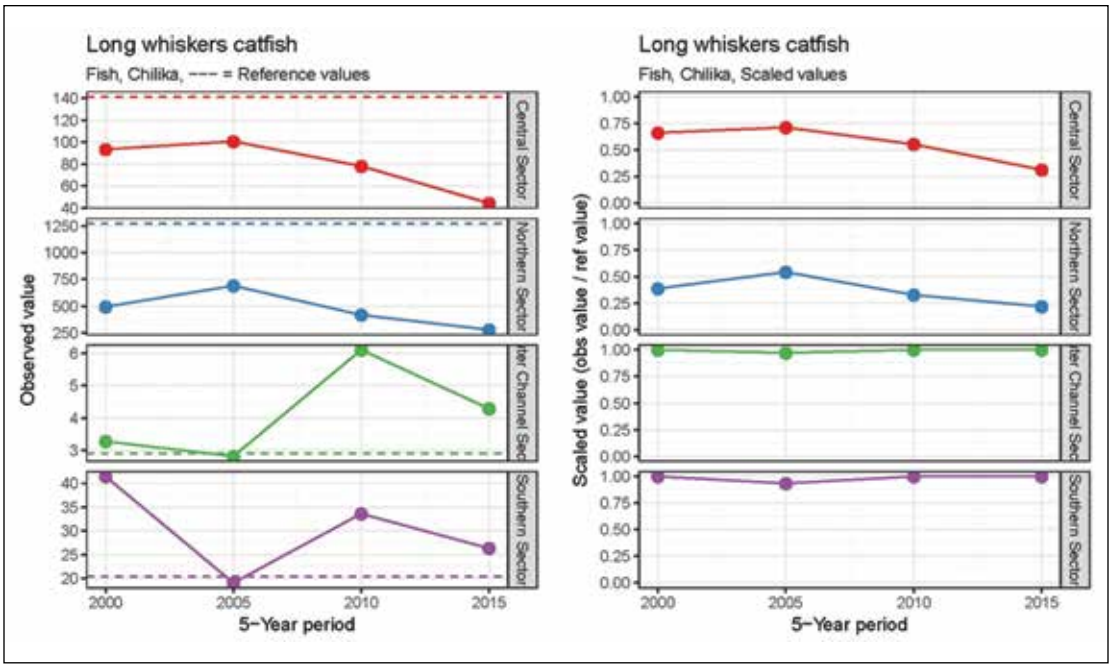


Figure 22: Observed and scaled value of Long whiskers catfish

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).

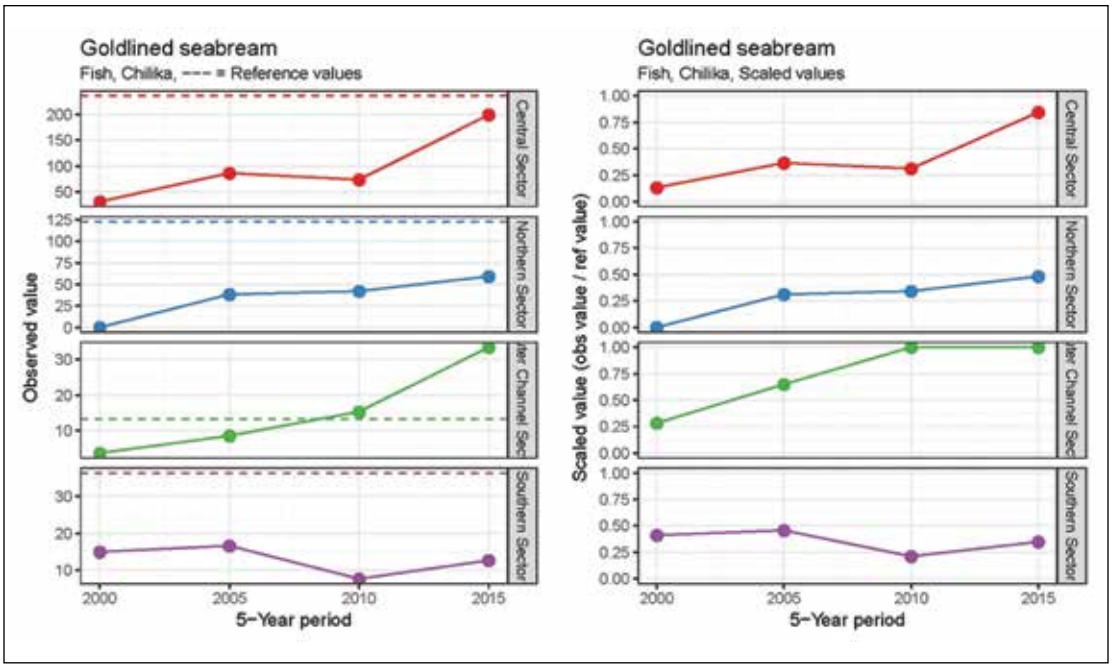


Figure 23: Observed and scaled value of Goldlined seabream

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.

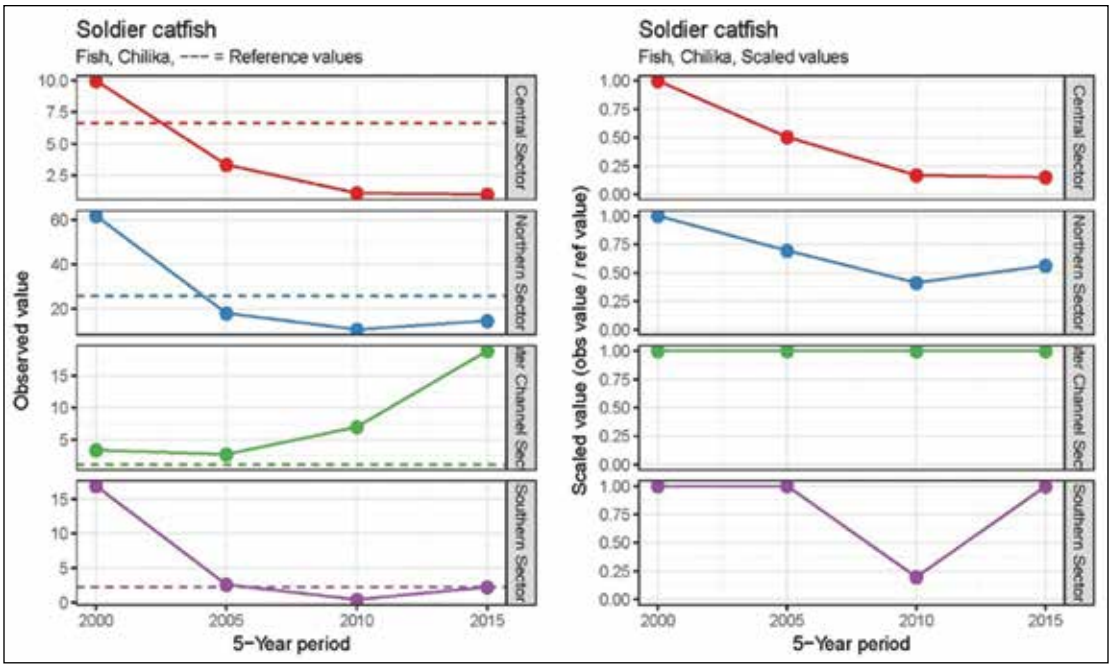
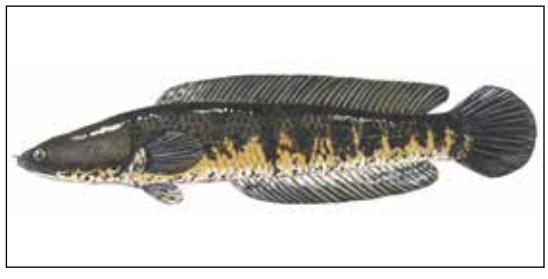


Figure 24: Observed and scaled value of Soldier catfish

15. Stripped Snake head (*Channa striata*)



Striped 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 from 0.75 to 0) (Fig.25). The IUCN red list status for this fish is Least Concern (LC).

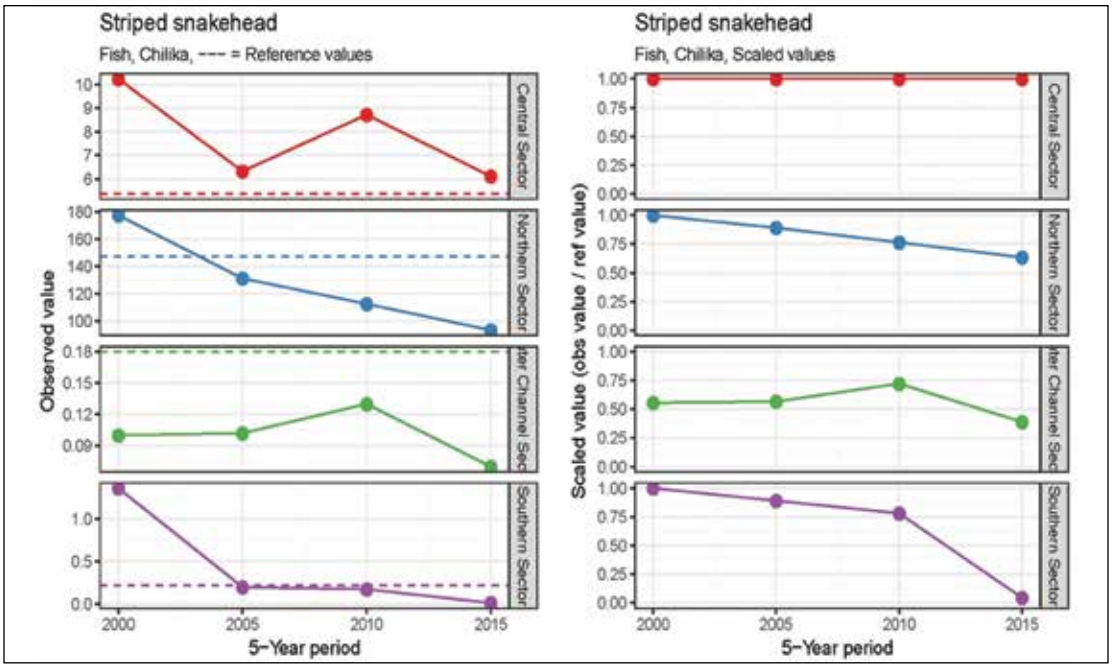


Figure 25: Observed and scaled value of Stripped snake head

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 (Sujawal), Punjab (Harike), 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, Srilanka 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

21 Ali, S. & S.D. Ripley (1987): Compact Handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. 2nd edn. Oxford University Press, Delhi. Manakadan, R., J.C. Daniel & N. Bhopale (2011): Birds of the Indian Subconti- nent: A field guide. BNHS, Mumbai & OUP, New Delhi. PP40.

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.

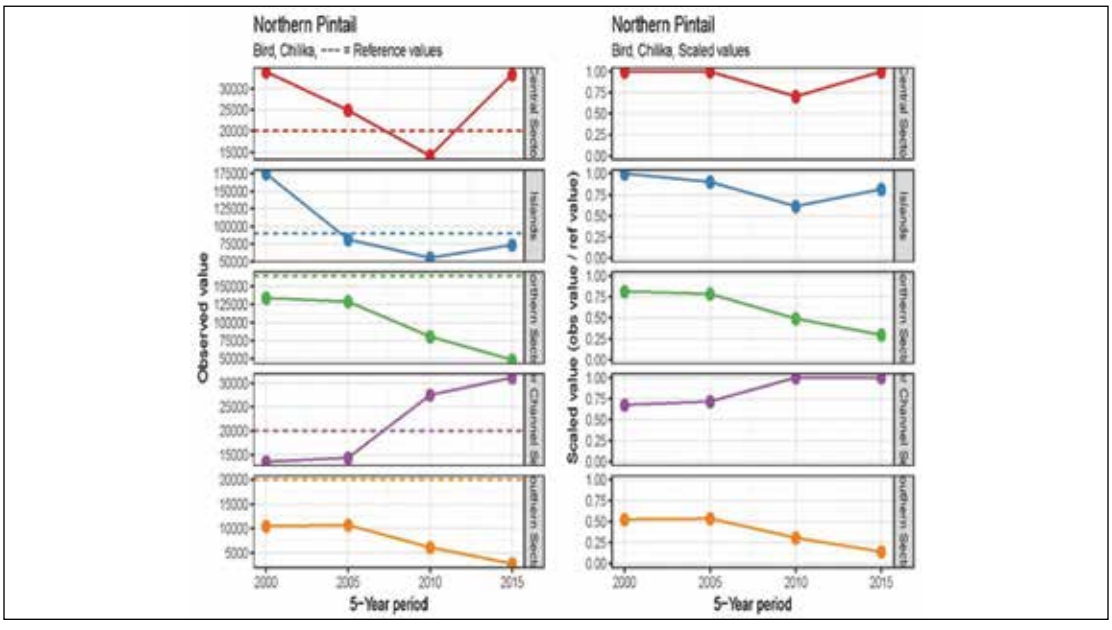


Figure 26: Observed and scaled value of Northern Pintail

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[22]. 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[23].

22 Del Hoyo, J.,A. Elliott, J.Sargatal, D.A. Christie & E.de Juana (Eds)(2017): Handbook of the birds of the World Alive. Lynx Edicions, Barcelona. (Sourced from http://www.hbw.com/ node/53521 2017).

23 Salim Ali, The Book of Indian Birds, 13th Edition revised, 2002. Published by Bombay Natural History Society, Oxford University Press.

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.

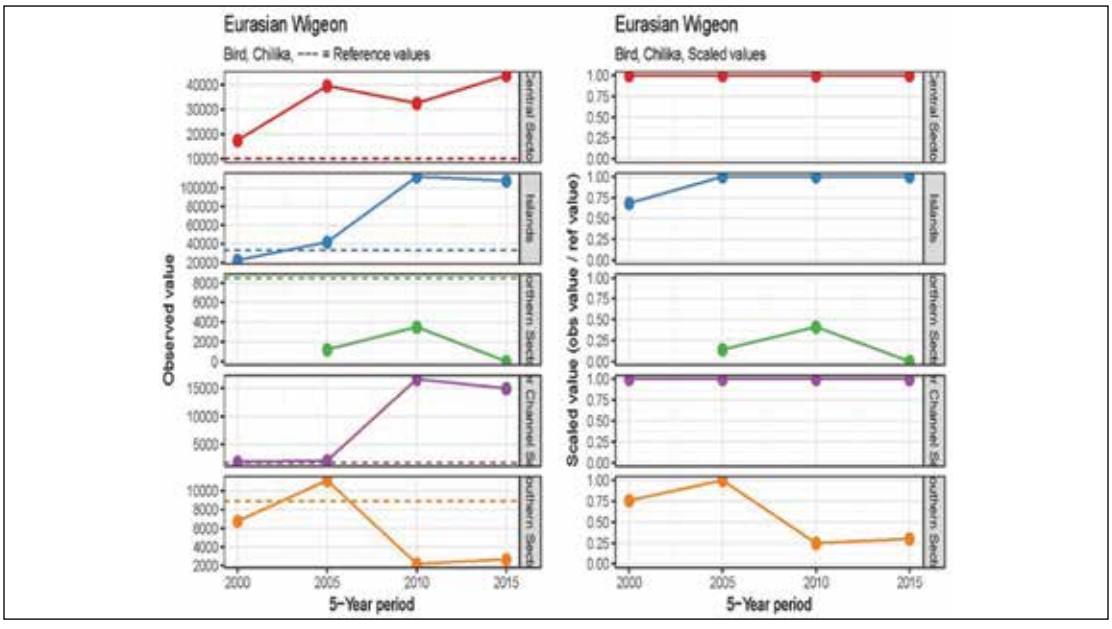


Figure 27: Observed and scaled value of Eurasian wigeon

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[24]. 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[25]. 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

24 Del Hoyo, J.,A. Elliott, J.Sargatal, D.A. Christie & E.de Juana (Eds)(2017): Handbook of the birds of the Wprld Alive. Lynx Edicions, Barcelona. (Sourced from http://www.hbw.com/ node/53521 2017).

25 Ali, S.& S.D. Ripley (1987): Compact Handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. 2nd edn. Oxford University Press, Delhi. Manakadan, R., J.C. Daniel & N. Bhopale (2011): Birds of the Indian Subconti- nent: A field guide. BNHS, Mumbai & OUP, New Delhi. PP40.

(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.

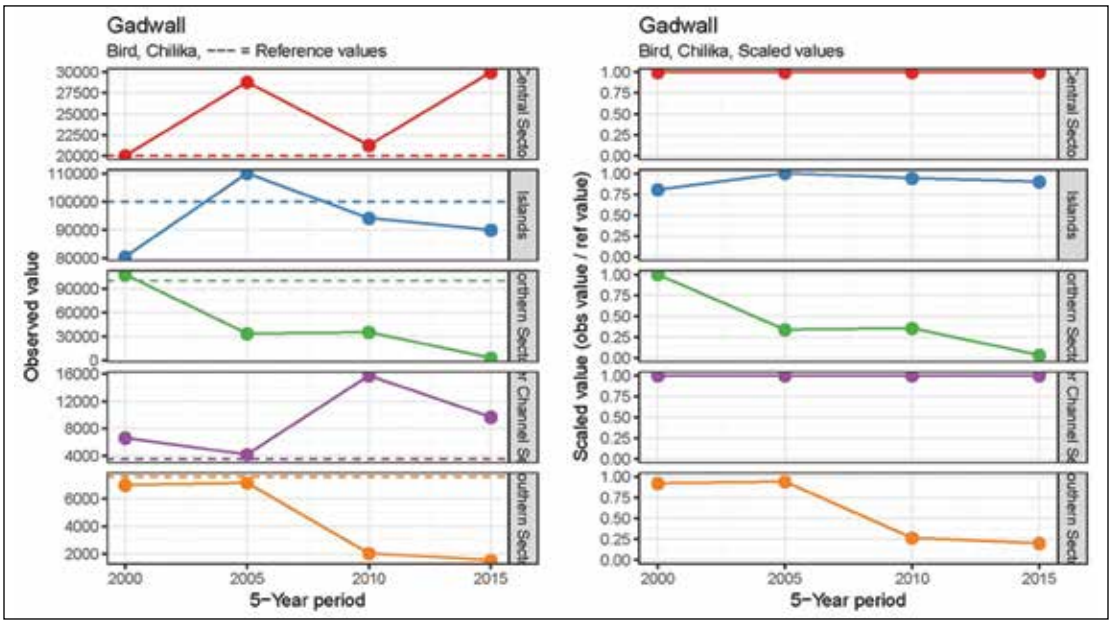


Figure 28: Observed and scaled value of Godwall

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[26]. 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.

26 Ali, S.& S.D. Ripley (1987): Compact Handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. 2nd edn. Oxford University Press, Delhi. Manakadan, R., J.C. Daniel & N. Bhopale (2011): Birds of the Indian Subconti- nent: A field guide. BNHS, Mumbai & OUP, New Delhi. PP40.

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.

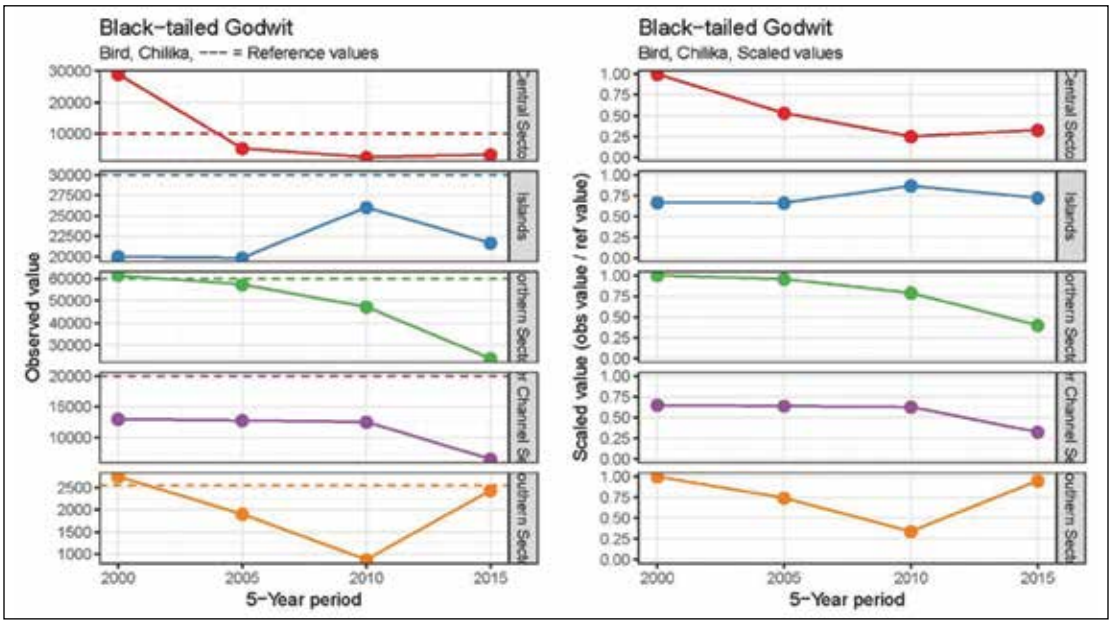


Figure 29: Observed and scaled value of Black-tailed Godwit

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, Srilanka 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.

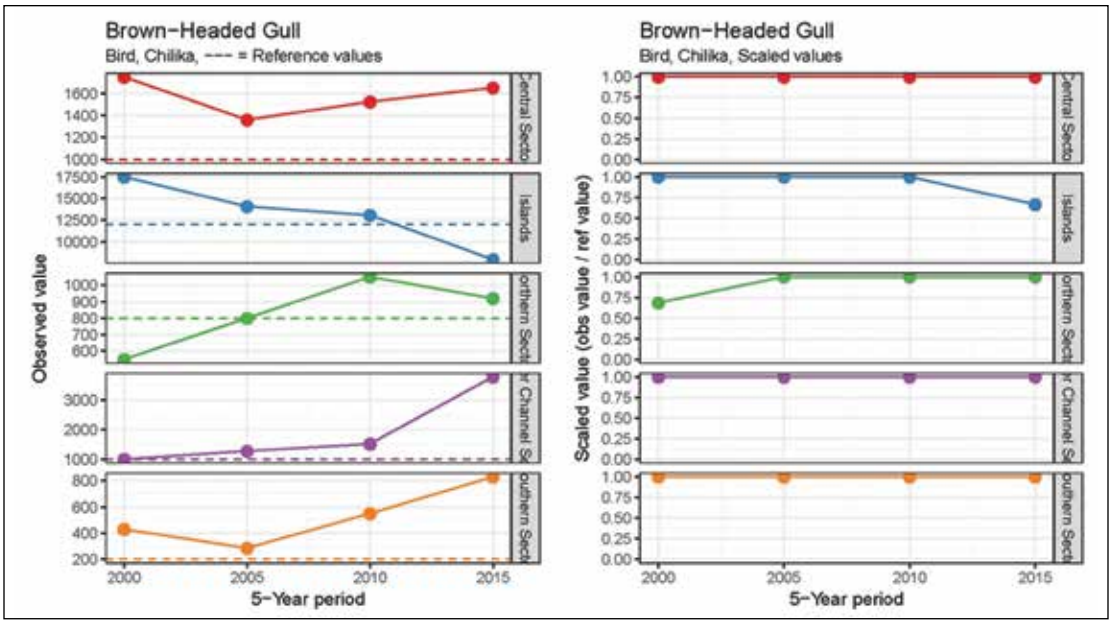


Figure 30: Observed and scaled value of Brown headed gull

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 a 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.

27 Del Hoyo, J.,A. Elliott, J.Sargatal, D.A. Christie & E.de Juana (Eds)(2017): Handbook of the birds of the Wprld Alive. Lynx Edicions, Barcelona. (Sourced from http://www.hbw.com/ node/53521 2017).

28 Ali, S.& S.D. Ripley (1987): Compact Handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. 2nd edn. Oxford University Press, Delhi. Manakadan, R., J.C. Daniel & N. Bhopale (2011): Birds of the Indian Subconti- nent: A field guide. BNHS, Mumbai & OUP, New Delhi. PP40.

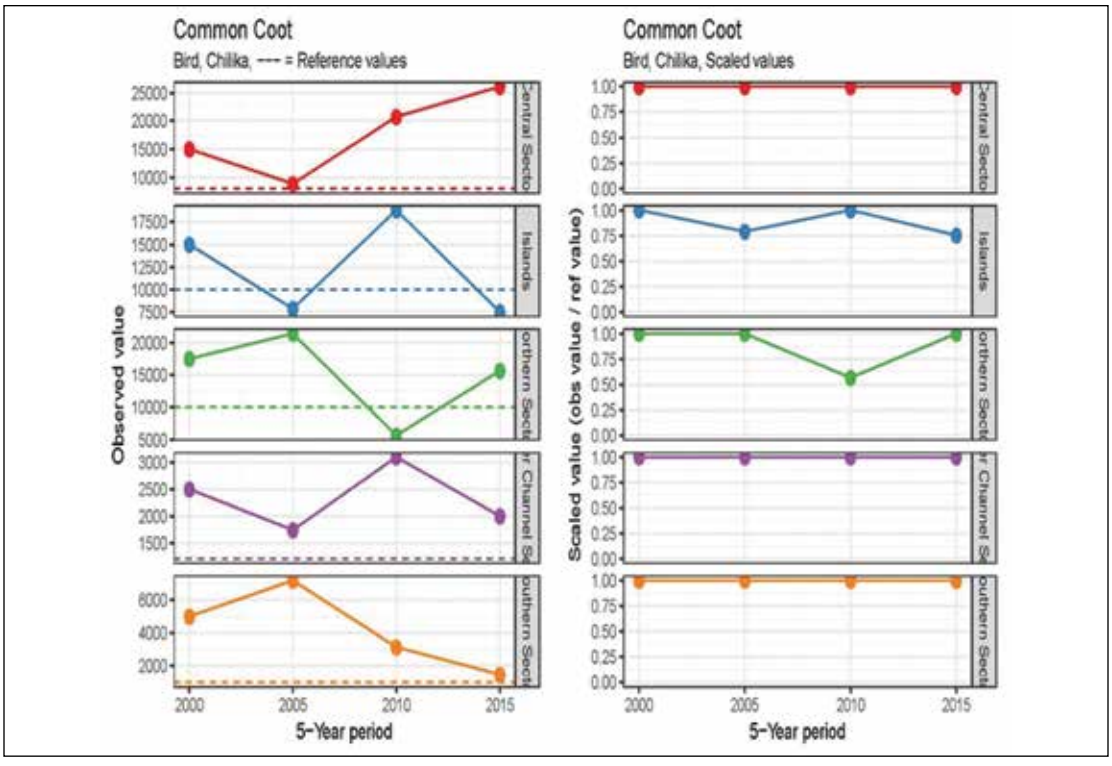


Figure 31: Observed and scaled value of Common coot

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 Srilanka. 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).

29 Ali, S.& S.D. Ripley (1987): Compact Handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. 2nd edn. Oxford University Press, Delhi. Manakadan, R., J.C. Daniel & N. Bhopale (2011): Birds of the Indian Subconti- nent: A field guide. BNHS, Mumbai & OUP, New Delhi. PP40.

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.

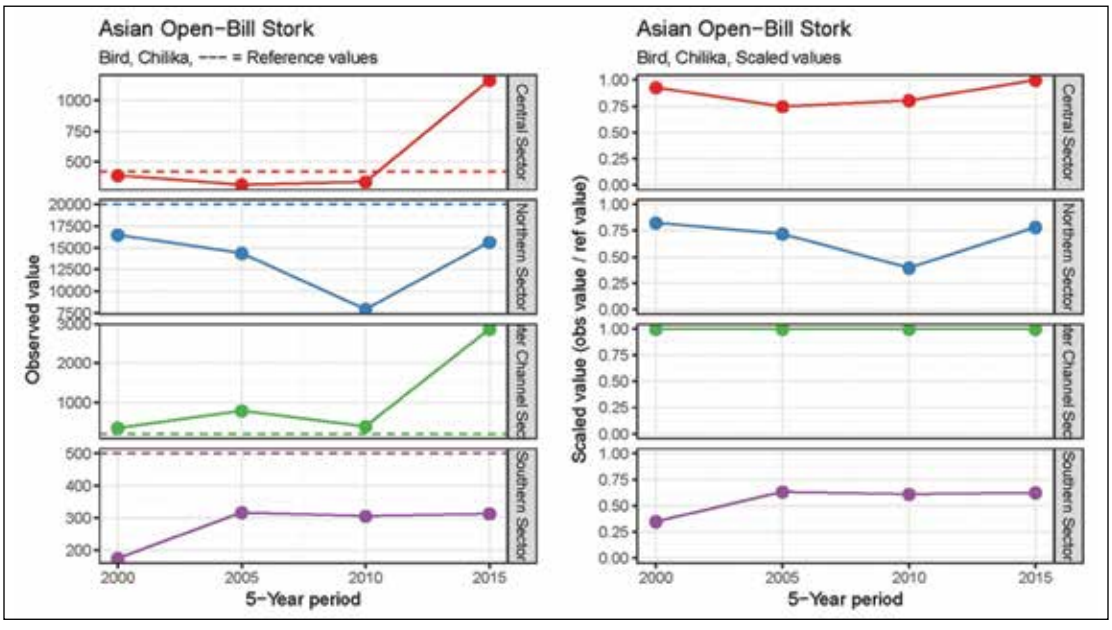


Figure 32: Observed and scaled value of Asian open-bill stork

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.

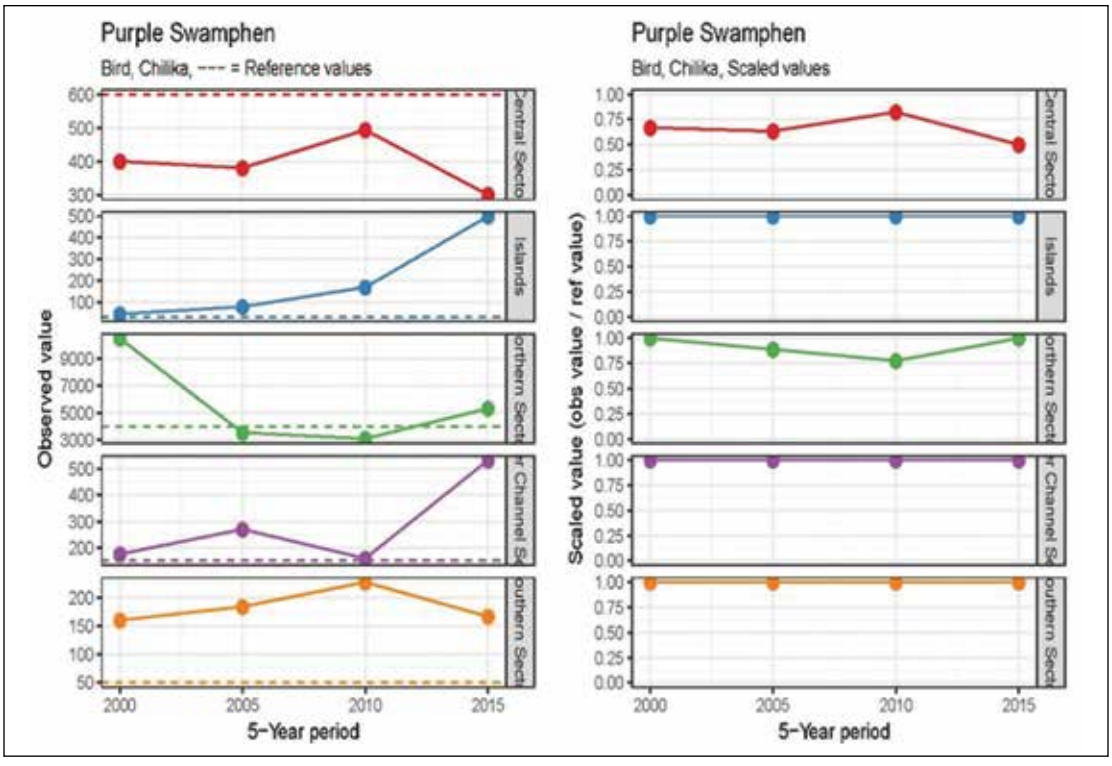


Figure 33: Observed and scaled value of Purple Swamphen

9. Lesser whistling duck (*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.

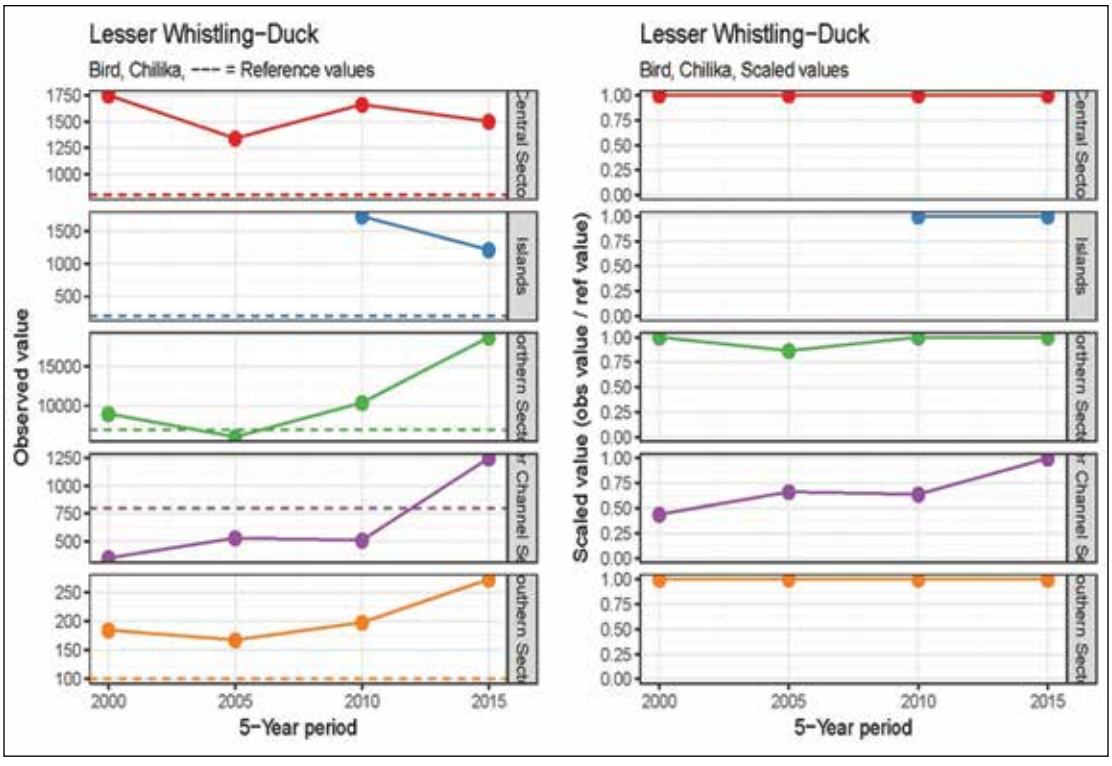


Figure 34: Observed and scaled value of Whistling duck

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.

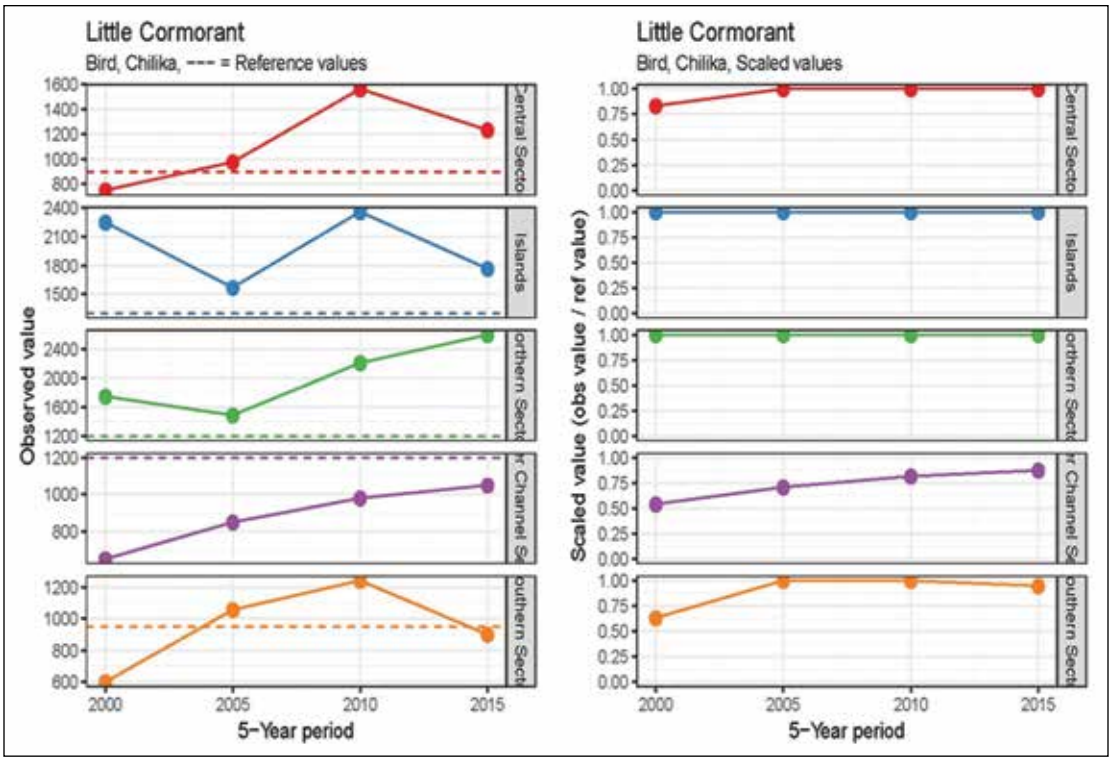


Figure 35: Observed and scaled value of Little cormorant

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.

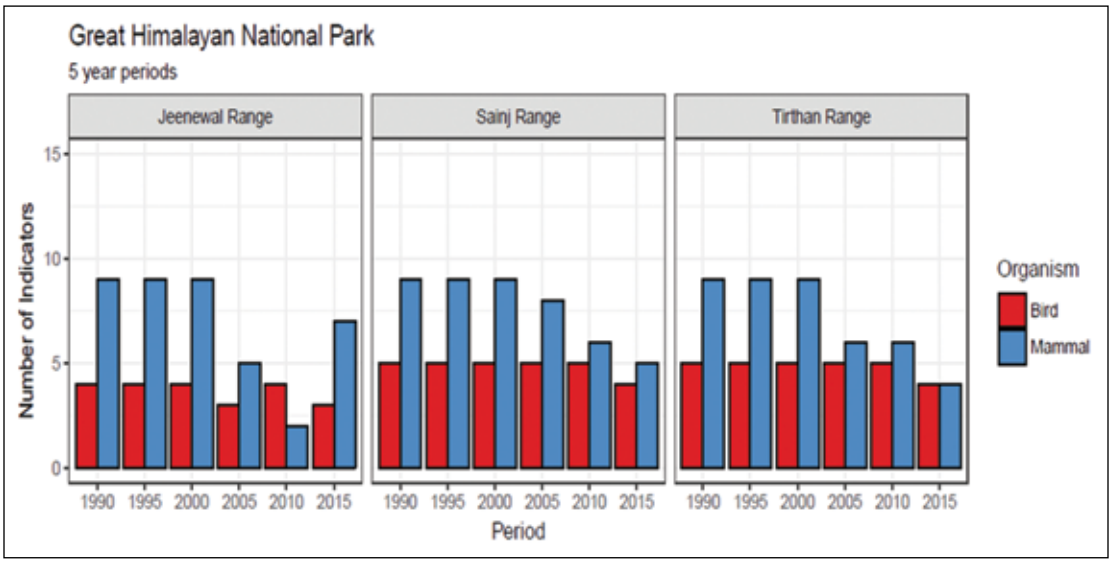


Figure 36: Number of indicators used to calculate the NI for GHNP (Birds/Mammals)

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).

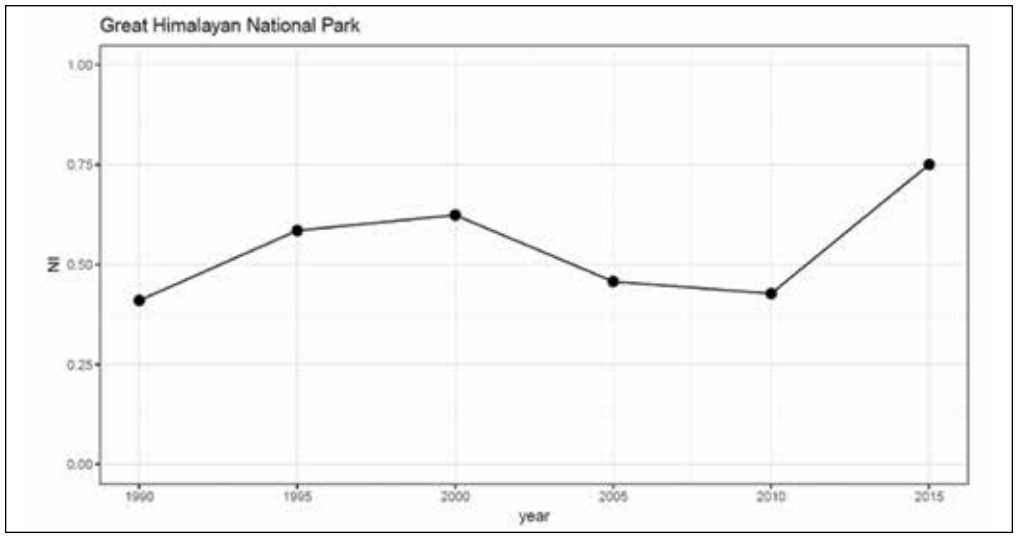


Figure 37: Nature Index values for 5-year periods in GHNP

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).

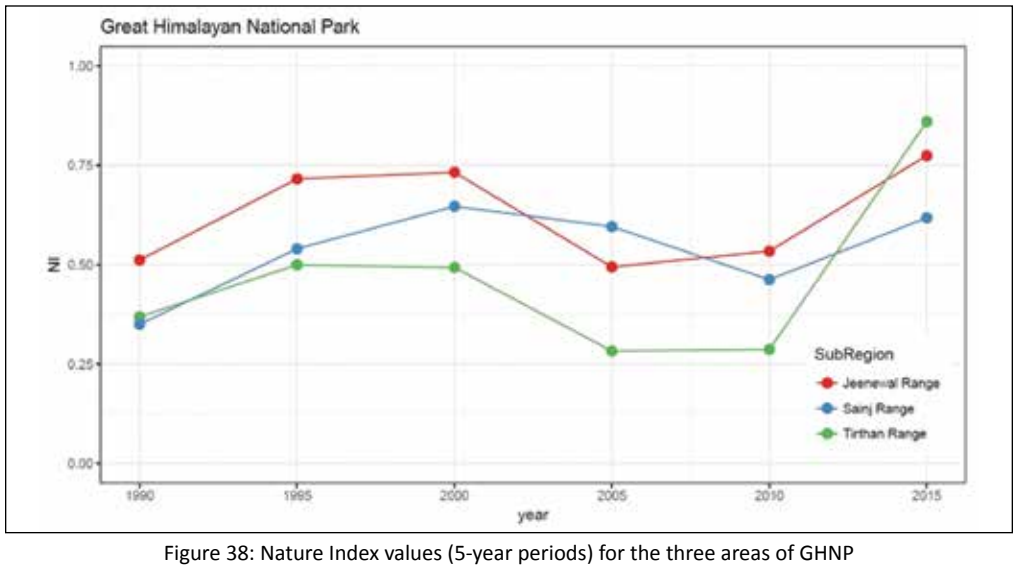


Figure 38: Nature Index values (5-year periods) for the three areas of GHNP

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).

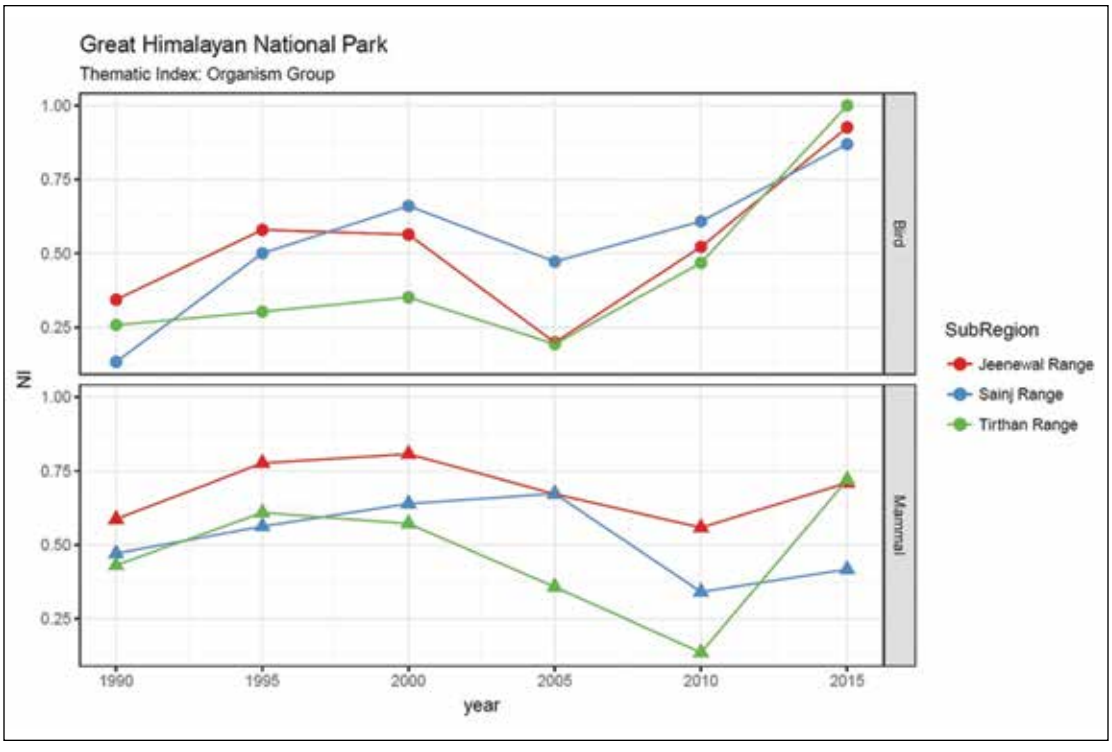


Figure 39: Thematic Nature Index value of GHNP for every five years

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.

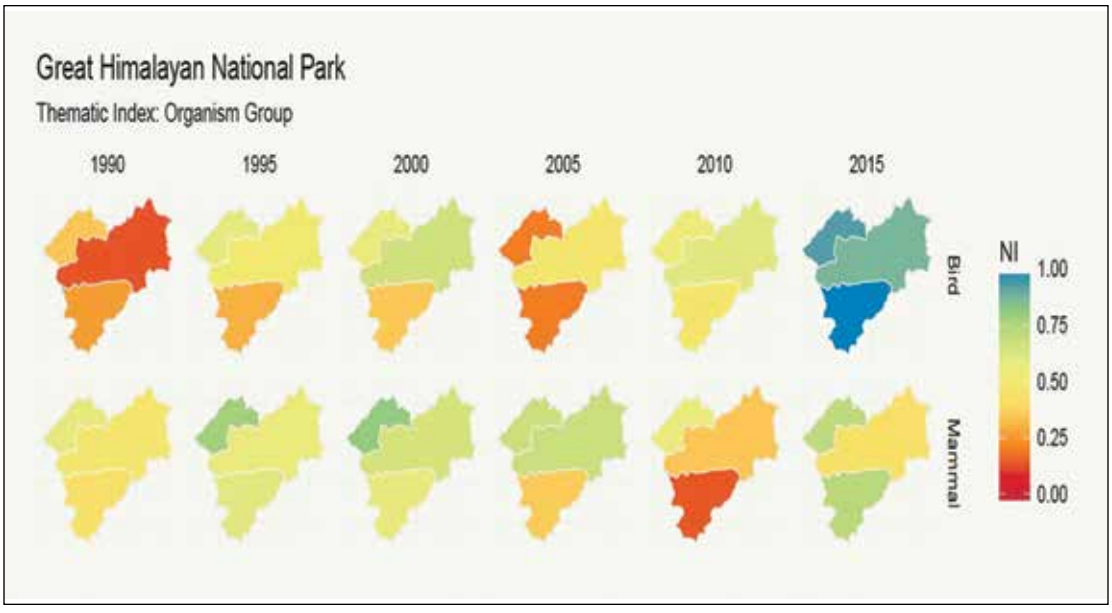


Figure 40: Map of the thematic index value of GHNP for every five-year period

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[30]. 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).

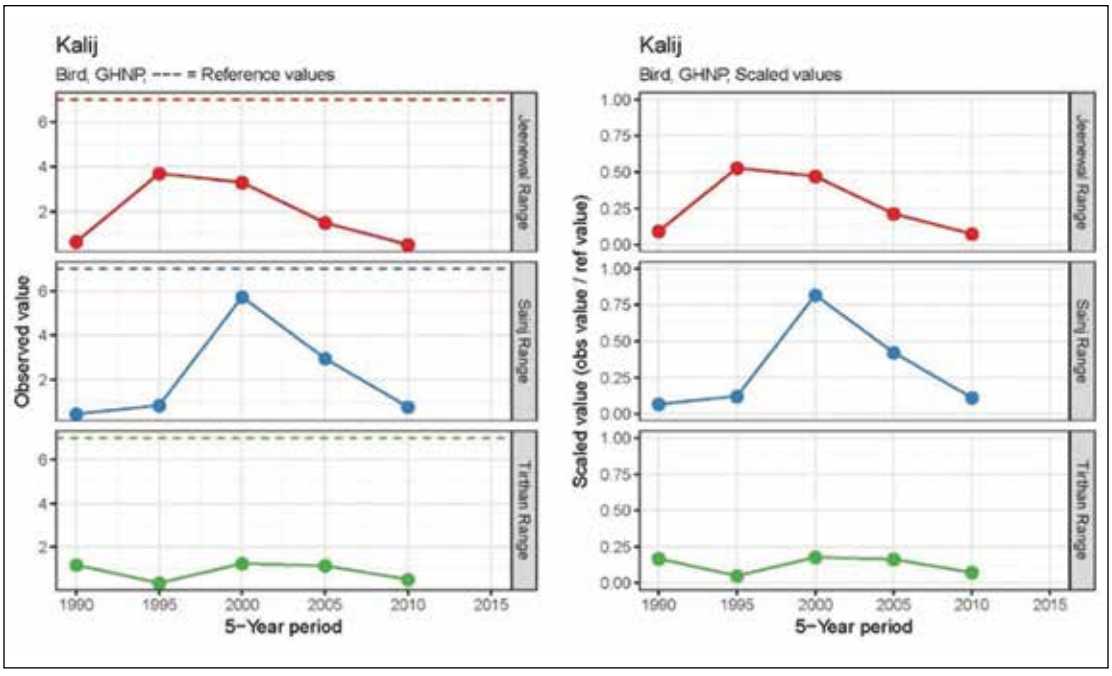


Figure 41: Observed and scaled value of Kalij

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[30]. 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).

30 Web source: https://www.greathimalayannationalpark.org/koklass/

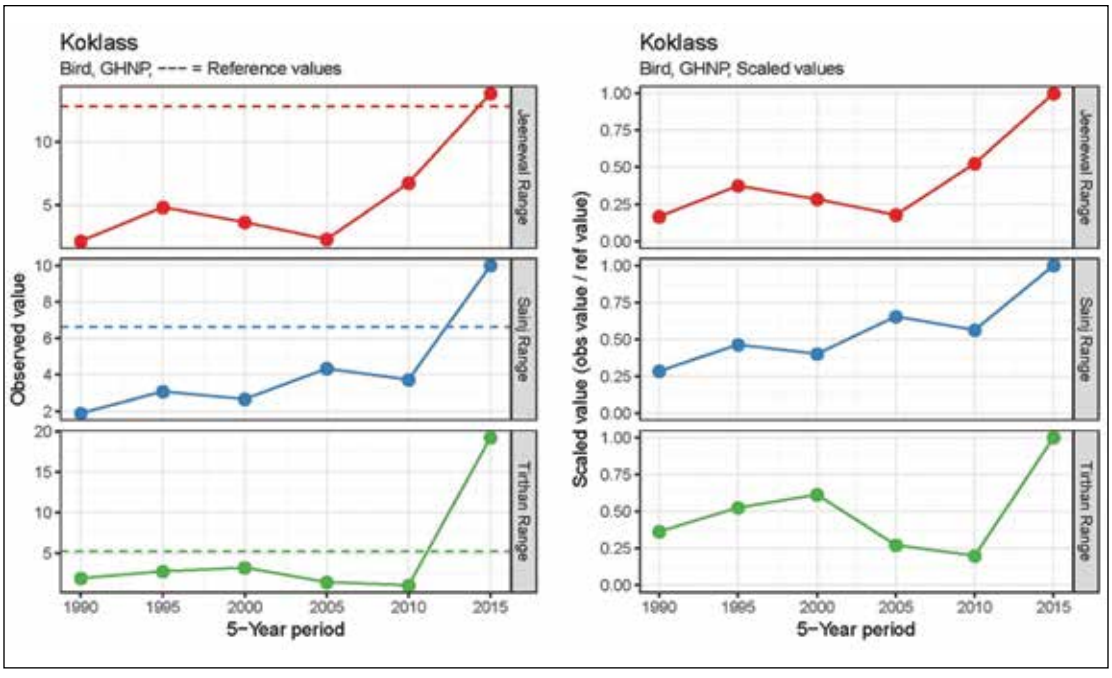


Figure 42: Observed and scaled value of Koklass

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[31]. 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).

31 Web Source: https://www.greathimalayannationalpark.org/western-tragopan/

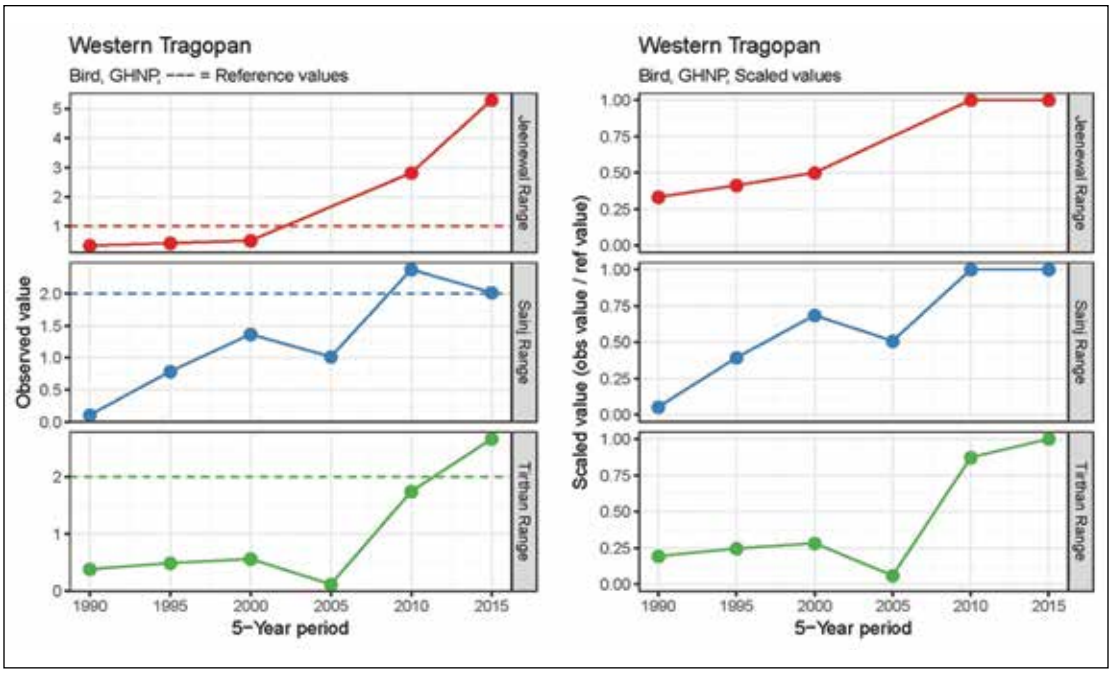


Figure 43: Observed and scaled value of Western Tragopan

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/

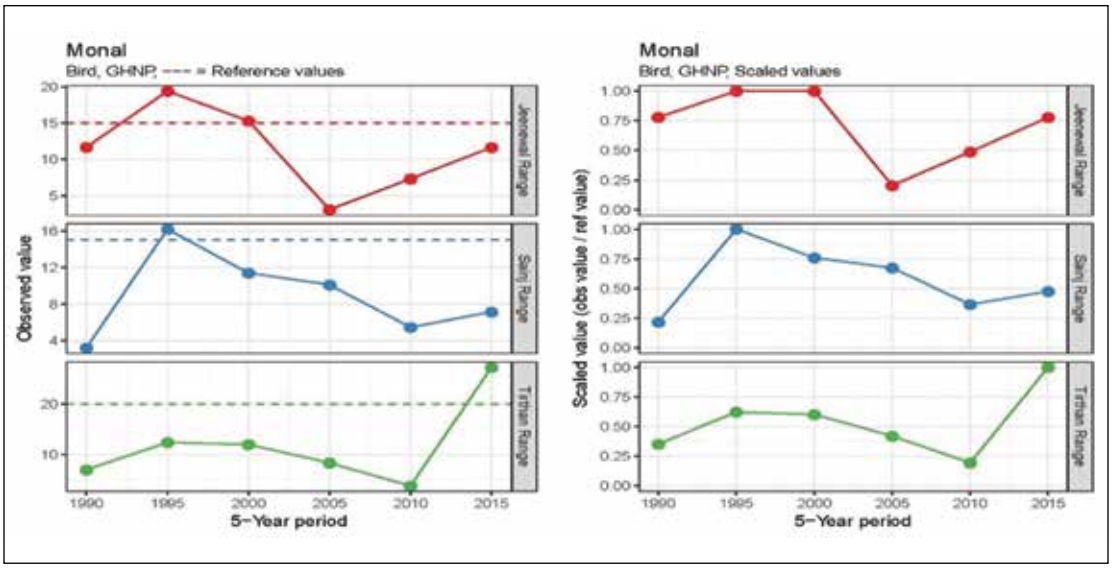


Figure 44: Observed and scaled value of Monal

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[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.

33 ibid

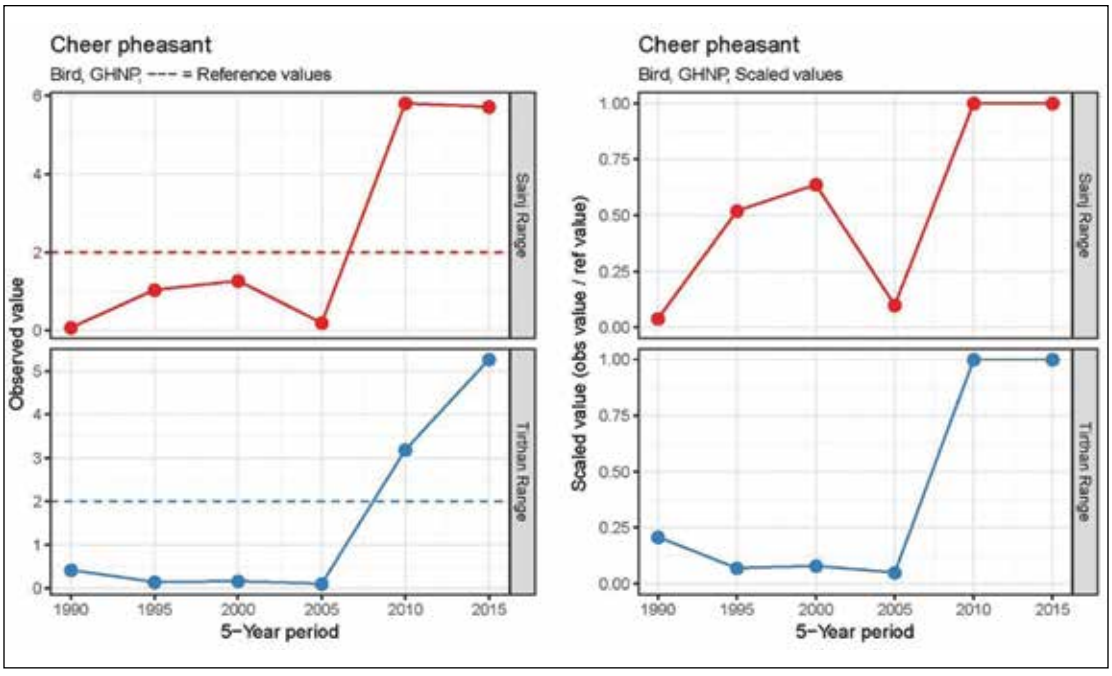


Figure 45: Observed and scaled value of Cheer pheasant

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).

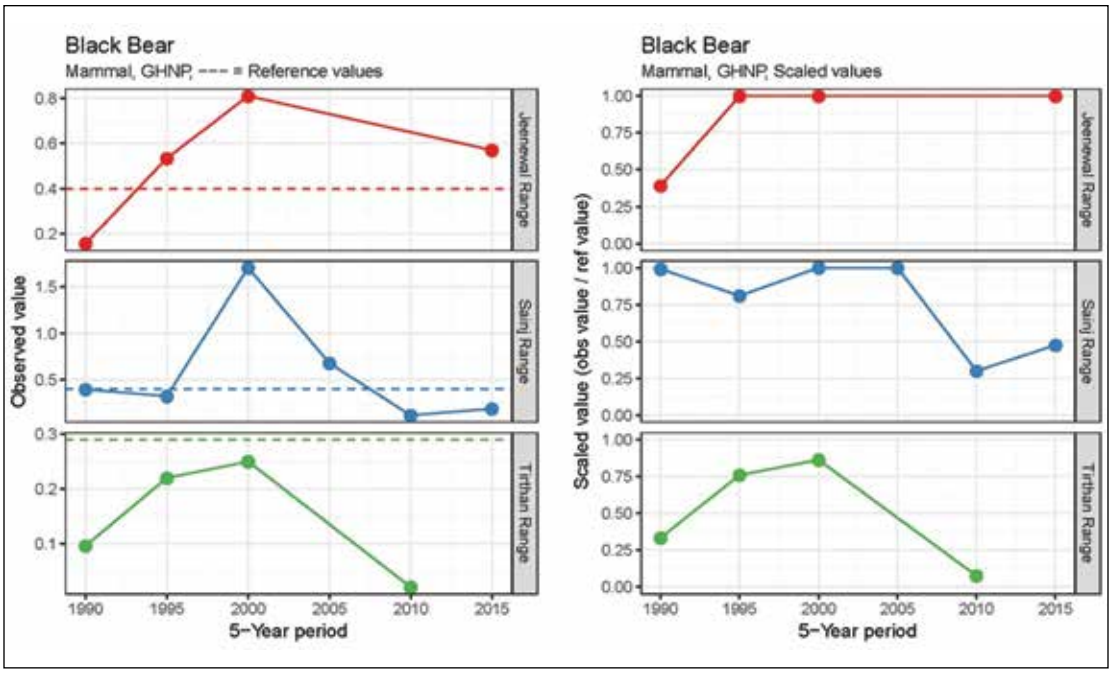


Figure 46: Observed and scaled value of Black bear

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).

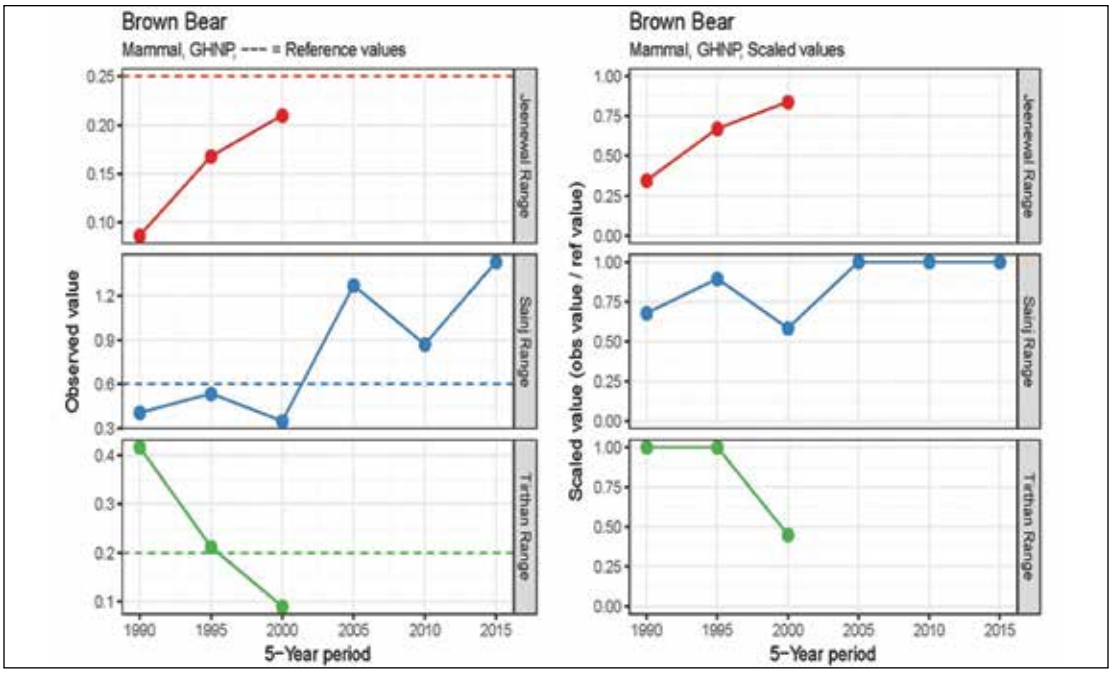


Figure 47: Observed and scaled value of Brown bear

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).

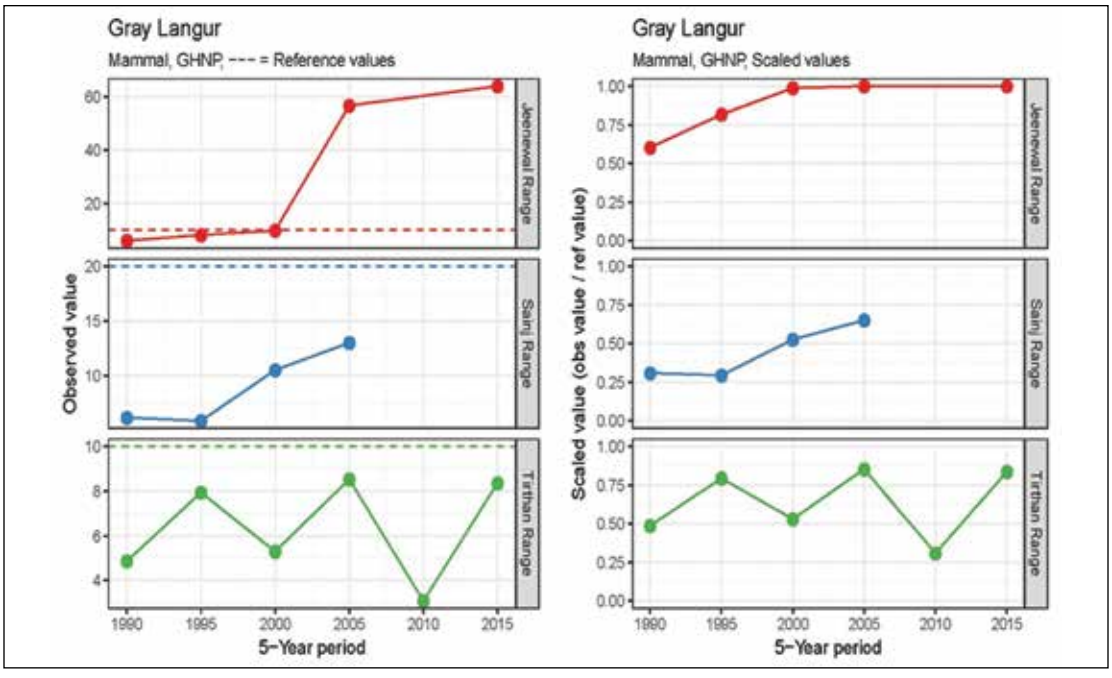


Figure 48: Observed and scaled value of Gray langur

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).

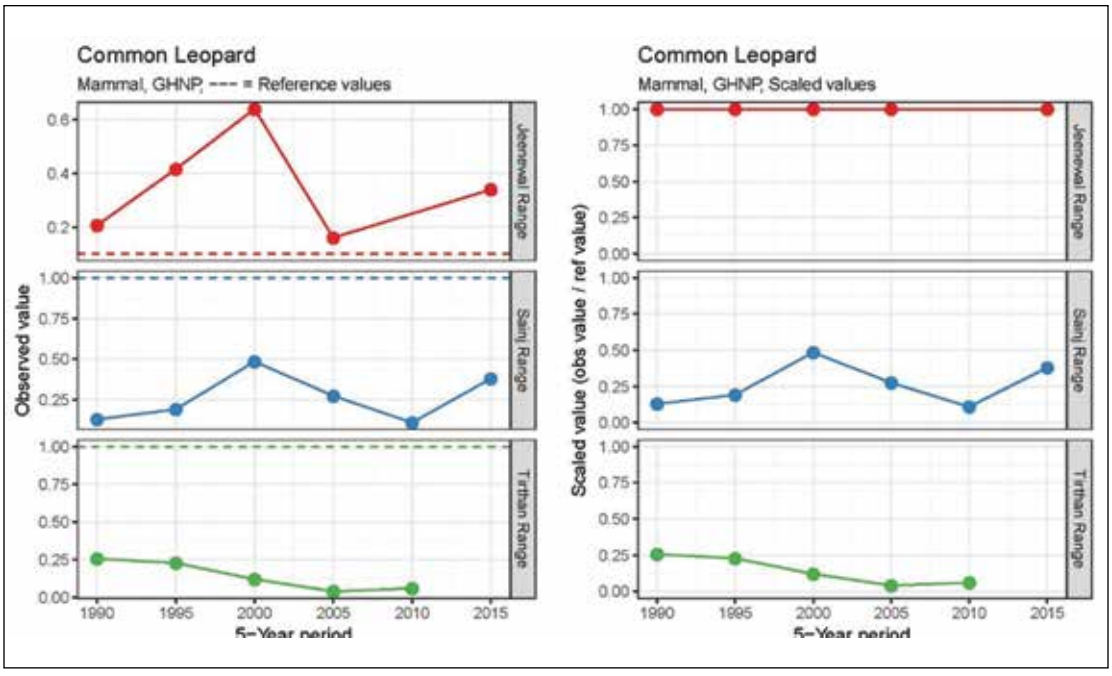


Figure 49: Observed and scaled value of Common Leopard

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).

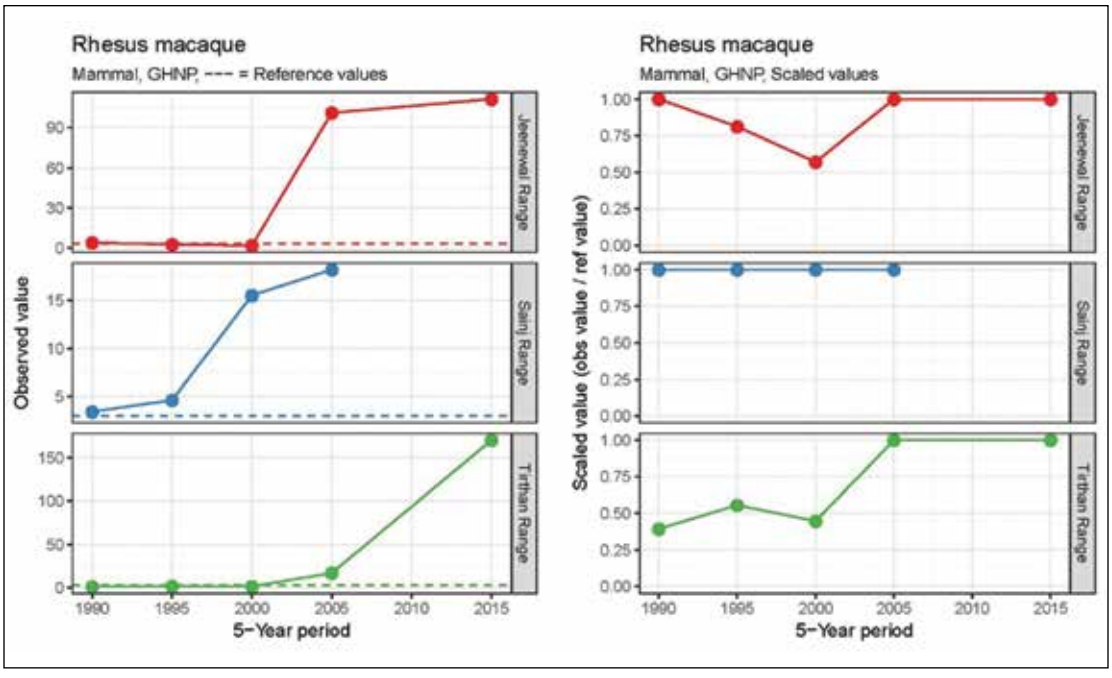


Figure 50: Observed and scaled value of Rhesus macaque

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).

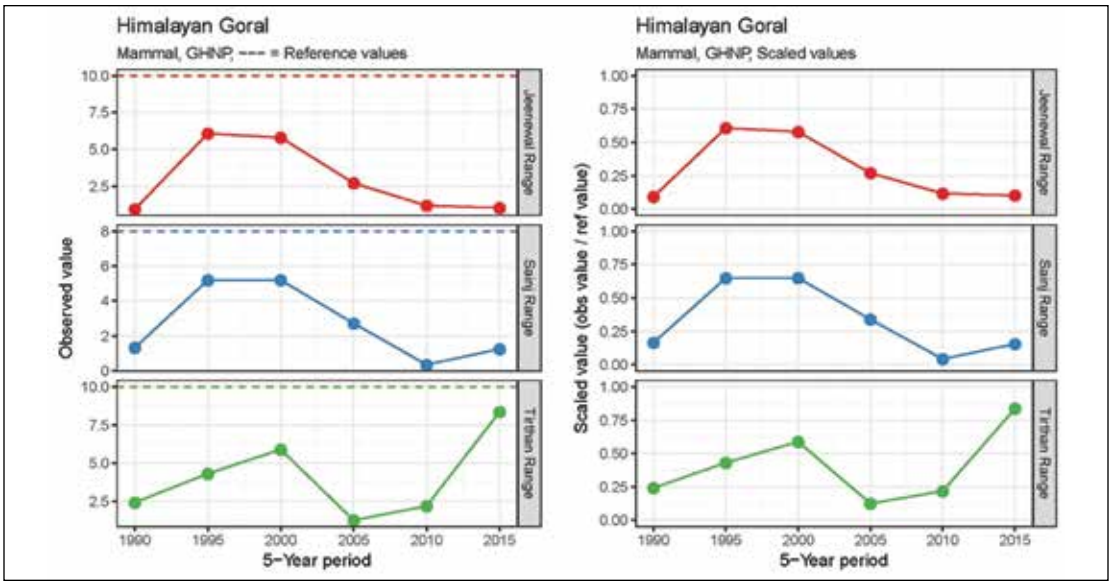


Figure 51: Observed and scaled value of Himalayan Goral

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).

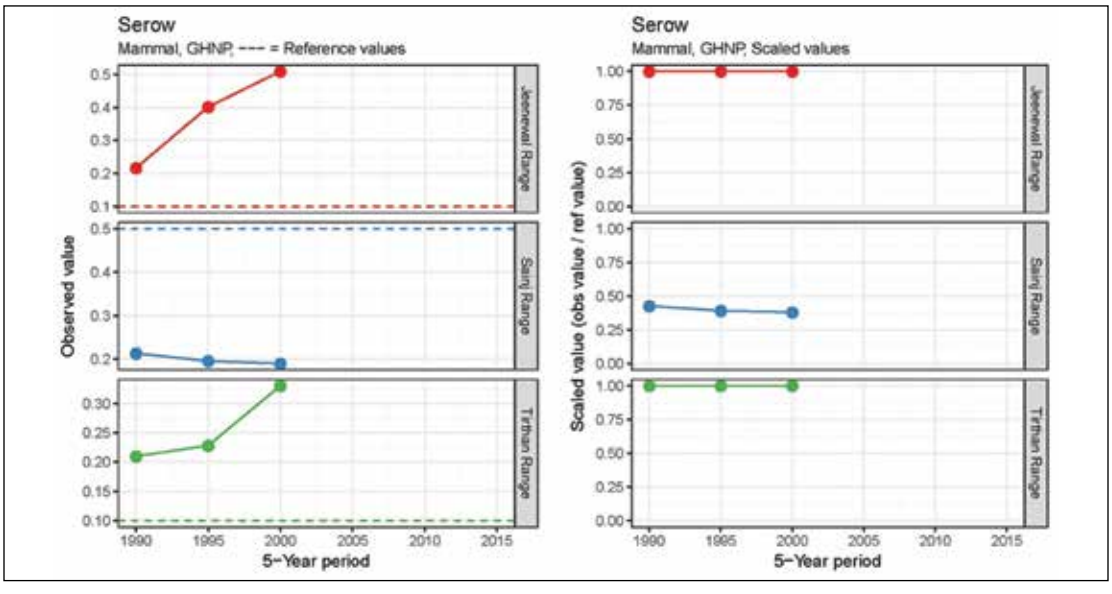


Figure 52: Observed and scaled value of Serow

8. Himalayan Thar (*Hemitragus jemlahicus*)

The Himalayan Thar is a large even-toed ungulate native to the Hima- layas 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).

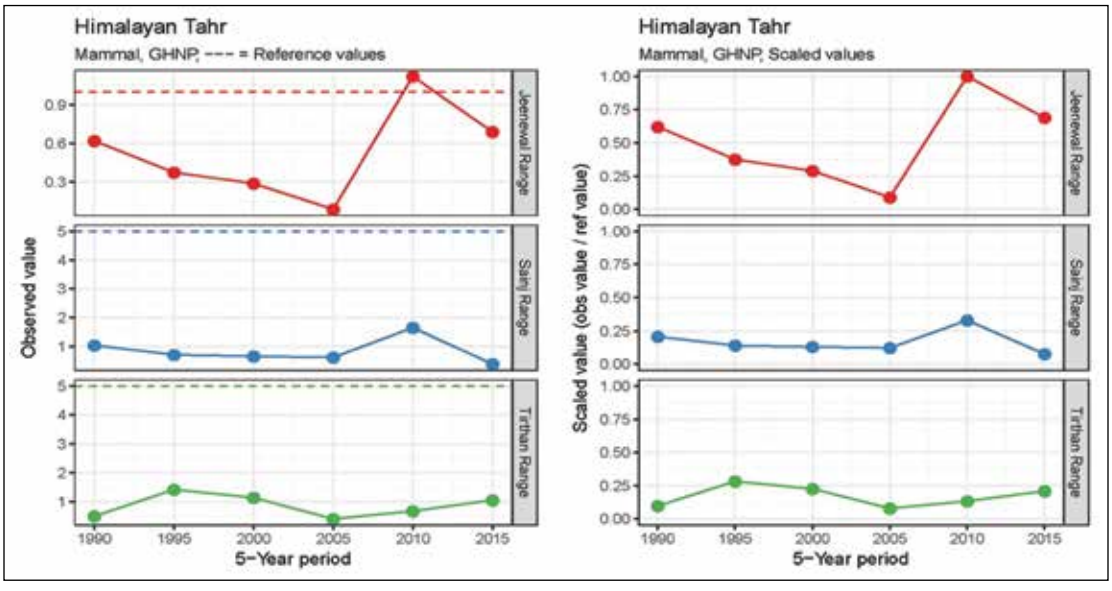


Figure 53: Observed and scaled value of Himalayan thar

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).

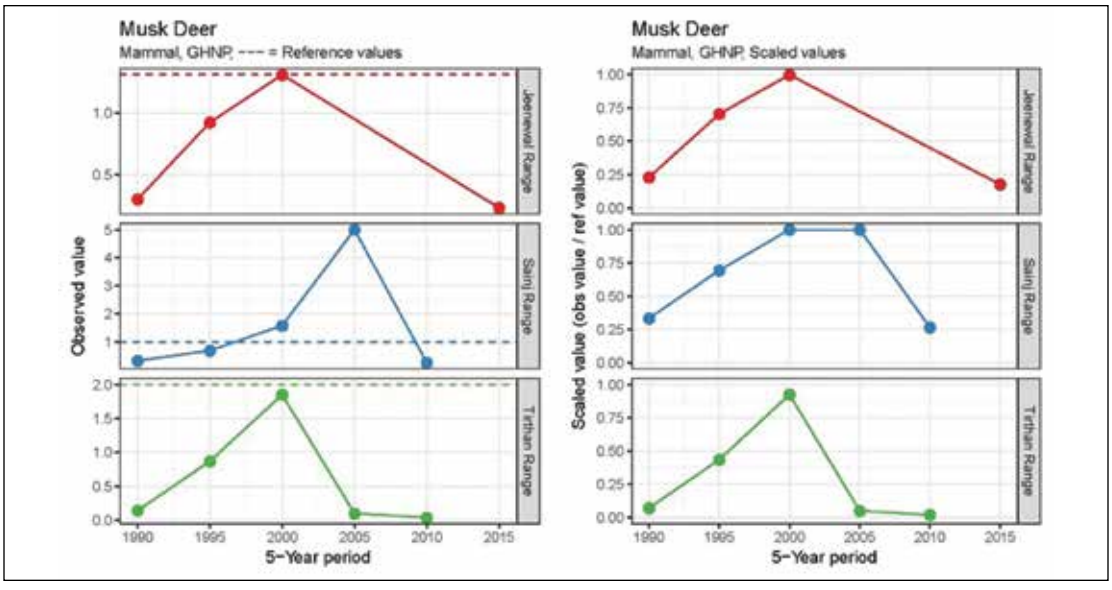


Figure 54: Observed and scaled value of Musk deer

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 chocked 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[34]. 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[35] 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[36]. 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

34 India's Fifth National Report to the CBD, 2014.

35 Chilika Newsletter, February 2015, Volume VIII. Published by Wetland International South Asia.

36 ICAR-CIFRI report on Post Restoration Assessment of Ecology and Fisheries Diversity of Chilika Lake, 2017. Prepared under the ICAR-CIFRI/CDA-ICZMP Consultancy Research Project.

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 ex- ample, 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; criterias 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).

NOTE

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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