Hirakud Reservoir, Odisha

An Integrated Management Plan

Chilika
Development Authority

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The Chilika Development Authority is the nodal agency of State Government of Odisha entrusted with the conservation and sustainable management of Lake Chilika. It was created by the Forest and Environment Department, Government of Odisha vide Resolution No. 20389/ F&E dated 20.11.1991. The Authority is registered under the Orissa Societies Registration Act. Its Governing Body consists of the Chief Minister of Odisha as the Chairman and the Minister of Environment, Science and Technology as the working Chairman. The members are drawn from various state government departments, NGOs and technical experts besides elected representatives.

HIRAKUD RESERVOIR

An Integrated Management Plan

Wetlands International South Asia ♦ Chilika Development Authority

December 2015

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Communities living around the Hirakud Reservoir for providing their invaluable insights into various issues and integrated management needs

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ABBREVIATIONS

AFB	Adaptation Fund Board
amsl	Above Mean Sea Level
APHA	American Public Health Association
ATMA	Agriculture Technology Management Agency
AWC	Asian Waterbird Census
AWiFS	Advanced Wide Field Sensor
BALCO	Bharat Aluminium Company Limited
BOD	Biochemical Oxygen Demand
BRGF	Backward Regions Grant Fund
CAD	Command Area Development
CADWM	Command Area Development and Water Management
CAE	Commercial Agri Enterprises
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CAPART	Council for Advancement of People's Action and Rural Technology
CBD	Convention on Biological Diversity
CBOs	Community Based Organizations
CEPA	Communication, Education, Participation and Awareness
CIFRI	Central Inland Fisheries Research Institute
CIFT	Central Institute of Fisheries Technology
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health Environmental Engineering Organization
CPRs	Common Property Resources
CSOs	Civil Society Organizations
CSR	Corporate Social Responsibility
CWA	Constituency-Wise Allotment
CWC	Central Water Commission
CWINC	Central Waterways, Irrigation and Navigation Commission
CWRA	Central Wetlands Regulatory Authority
DDP	Desert Development Programme
DO	Dissolved Oxygen
DoA	Department of Agriculture
DoFE	Department of Forest and Environment
DoRD	Department of Rural Development
DoWR	Department of Water Resources
DPAP	Drought Prone Areas Programme
DP	District Panchayat
DPR	Detailed Project Report
DRDA	District Rural Development Agency
DRIP	Dam Rehabilitation and Improvement Project
DRSM	Dry Rubble Stone Masonary
DWDU	District Watershed Development Unit
EAPs	Externally Aided Projects
ENVIS	Environmental Information System
FAO	Food and Agriculture Organization of the United Nations
FARD	Fisheries and Animal Resources Department
FD	Fisheries Department
FDAs	Forest Development Agencies
FRL	Full Reservoir Level
GCF	Green Climate Fund
GDP	Gross Domestic Product
GIS	Geographic Information System
GoO	Government of Odisha
GPP	Gross Primary Productivity
HCSD	High Concentration Slurry Disposal
HH	Household
HRMC	Hirakud Reservoir Management Committee
IBAs	Important Bird Areas
ICAR	Indian Council of Agricultural Research
ILEC	International Lake Environment Committee Foundation
IMC	Indian Major Carps
INDC	Intended Nationally Determined Contribution
IPM	Integrated Pest Management

ISRO	Indian Space Research Organisation
IUCN	International Union for Conservation of Nature
IWDP	Integrated Wastelands Development Programme
IWMP	Integrated Watershed Management Programme
IWRM	Integrated Water Resources Management
JFM	Joint Forest Management
JMFCs	Joint Forest Management Committees
KVK	Krishi Vigyan Kendra
LDA	Loktak Development Authority
LISS	Linear Imaging Self-Scanner
LPG	Liquefied Petroleum Gas
LULC	Land Use Land Cover
MASS	Manav Adhikar Seva Samiti
MCL	Mahanadi Coalfields Limited
MCM	Million Cubic Metres
MDDL	Minimum Draw Down Level
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MLD	Million Litres per Day
MMA	Macro Management Agriculture
MMISO	Major and Medium Irrigation Sector Organization
MPN	Most Probable Number
MoEFCC	Ministry of Environment, Forest and Climate Change
MoUD	Ministry of Urban Development
MoWRRD	Ministry of Water Resources, River Development and Ganga Rejuvenation
MT	Metric Ton
MUY	Matshyajibi Unnayana Yojana
MW	Mega Watt
NABARD	National Bank for Agriculture and Rural Development
NAEB	National Afforestation and Eco-Development Board
NAP	National Afforestation Programme
NATMO	National Thematic and Mapping Organisation
NBSSLUP	National Bureau of Soil Survey and Land Use Planning
NDDP	Net District Domestic Product
NFDB	National Fish Development Board
NGOs	Non-Governmental Organizations
NH	National Highway
NIE	National Implementing Entity
NIH	National Institute of Hydrology
NLCP	National Lake Conservation Programme
NMPS	National Mission for Protein Supplements
NRAA	National Rainfed Area Authority
NRDWP	National Rural Drinking Water Programme
NRM	Natural Resource Management
NRSA	National Remote Sensing Agency
NRSC	National Remote Sensing Centre
NSC	National Steering Committee
NTFPs	Non-Timber Forest Products
NTPC	National Thermal Power Corporation
NTU	Nephelometric Turbidity Units
NWCP	National Wetland Conservation Plan
NWDPRA	National Watershed Development Project for Rain-fed Areas
OHPCL	Odisha Hydro Power Corporation Limited
OLIC	Odisha Lift Irrigation Corporation
OPCB	Odisha Pollution Control Board
OPDC	Odisha Pisciculture Development Corporation
ORSAC	Orissa Remote Sensing Application Center
OSPCB	Odisha State Pollution Control Board
OSRRA	Odisha State Rural Road Agency
OSWDA	Odisha State Wetland Development Authority
OUAT	Orissa University of Agriculture and Technology
OWDA	Odisha Wetland Development Authority
OWDM	Odisha Watershed Development Mission

PFCS	Primary Fishermen Cooperative Society
PIA	Project Implementing Agency
PIM	Participatory Irrigation Management
PMGSY	Pradhan Mantri Gram Sadak Yojana
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PRA	Participatory Rural Appraisal
RCSE-SU	Research Center for Sustainability and Environment, Shiga University
RD	Rural Development
RIDF	Rural Infrastructure Development Fund
RKVY	Rashtriya Krishi Vikas Yojana
RRR	Repair, Renovation and Restoration
RSP	Ravishankar Sagar Project
RVP	River Valley Project
SARC	Social Action for Rural Communities
SCA	Special Central Assistance
SEAC	State Level Expert Appraisal Committee
SEIAA	State Level Environment Impact Assessment Authority
SHGs	Self Help Groups
SPCB	State Pollution Control Board
SRI	System of Rice Intensification
SRTM DEM	Shuttle Radar Topography Mission Digital Elevation Model
STPs	Sewage Treatment Plants
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TS	Total Solids
TSC	Total Sanitation Campaign
TSS	Total Suspended Solids
UNFCCC	United Nations Framework Convention on Climate Change
UGs	User Groups
UTs	Union Territories
VSS	Vana Samrakshana Samities
WALMI	Water and Land Management Institute
WCs	Watershed Committees
WDF	Watershed Development Fund
WDT	Watershed Development Team
WIAMS	Wetland Inventory, Assessment and Monitoring System
WRIS	Water Resources Information System
WRTC	Wetland Research and Training Centre
WWF	World Wide Fund for Nature

1. Introduction

1.1 Background

Hirakud Reservoir, formed due to the damming of River Mahanadi at Sambalpur in 1957, is the largest and most significant water infrastructure of the State of Odisha. Spanning an area upto 700 km^2 when full, the Hirakud Reservoir provides water for generating ~ 300 MW hydropower through its two power houses at Burla and Chiplima; irrigating 462,100 ha culturable command area within Bargarh, Bolangir, Sambalpur and Subarnapur Districts; and securing 9,500 km^2 of Mahanadi Delta region from floods. Over 7,000 fisher households depend on the reservoir fisheries for livelihoods. The vast open waterbody attracts a sizeable population of ducks, geese and waders during winters, making it one of the major waterbird congregation areas in the state. The scenic surrounding of the reservoir alongwith historically and culturally significant landmarks marks its significance from cultural and recreation perspectives.

The multiple values of the Hirakud Reservoir have been adversely affected by rapid transformation of catchments and increasing demands for water in the downstream reaches. Silt is accumulating in the reservoir at rates much faster than planned for, reducing its water storage and flood moderation capacity. Expansion of agriculture within command, industries and urban settlement within the reservoir catchments, have accentuated water use conflicts. Decreasing fish catch, reduction in fish species diversity and increasing pollution has placed the livelihood of fishers under great stress. Biodiversity has been adversely impacted by habitat fragmentation and increasing anthropogenic stress on key habitats.

View of Hirakud Reservoir from Jawahar Minar

Realizing the multifaceted role of Hirakud in the overall economy and

ecological security of the state, the Odisha Wetland Development Authority (OWDA) recommended putting in place an integrated management framework for the reservoir. This management plan is a response to this decision, and marks the commitment of the Government of Odisha to set up effective management arrangements for conservation and sustainable management of the Hirakud Reservoir.

1.2 Management planning purpose and objectives

The overall purpose of management planning is to put in place effective management arrangements for securing full range of ecosystem services and biodiversity of Hirakud for ecological and economic security of stakeholders, particularly dependent communities. The management planning process addresses following specific objectives:

- Development of a baseline inventory of reservoir features and governing factors
- Assessment of status and trends in reservoir ecosystem components, processes and services, and risks of adverse change
- Participatory appraisal with communities dependence on reservoir resources to reflect their views, rights and capacities to support integrated management
- Evaluation of sectoral plans and management practices, and identification of interlinkages and coordination needs for integrated management
- Development of management planning framework for conservation and wise use of Hirakud Reservoir ensuring linkages with existing sectoral plans being implemented by various state government agencies
- Estimation of financial resources required for integrated management
- Development of an effective institutional mechanism with clear cut roles and responsibilities of participating institutions supported by appropriate policies and regulations
- Designing an effective monitoring and evaluation framework for sustainable management

1.3 Approach and method

The Ramsar Convention places reservoirs within the category of 'purpose-built' or 'human-made' water storage areas[1]. The complex interactions between fluviatile and lacustrine environments, and the swift changes in water levels, inflows and outflows distinguish reservoirs from natural lakes. Biotic communities and ecological productivity are known to exhibit complex responses to the obstruction of river flow, impoundment and drastic changes in water levels. Coexistence of hydrostatic and hydrodynamic conditions in reservoirs and associated river basin have significant management implications, key being inseparability of management issues across rivers and diverse wetland habitats, unpredictable behaviour and problems requiring longer timeframe for effective resolution.

Wetlands are managed to achieve wise use. Wise use of wetlands is defined in the Convention text as 'the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development'. Ecological character is 'the combination of ecosystem components, processes and benefits/ services that characterize the wetland at a given point in time'. Ecosystems approaches call for considering the complex relationship between various ecosystem elements and promote integrated management of land, water and living resources. Through emphasis on sustainable development, wise use calls for resource use patterns which can ensure that human dependence on wetlands can be maintained not only in the present, but also in the future. In the context of Hirakud, wise use entails maintenance of developmental benefits as well as ecological values of the reservoir considering its role in the

[1]Ramsar Classification of Wetland Type as approved by Recommendation 4.7 and amended by Resolutions VI.5 and VII.11 of the Conference of Contracting Parties.

wider Mahanadi River Basin landscape. In terms of ecosystem services, this requires achieving a balance between provisioning, cultural and regulating services, and ensuring maintenance of critical ecosystem components and processes that underpin ecosystem services and biodiversity.

The process of development and implementation of management plans for wetlands need to be accompanied with governance improvements at basin level. Such an approach underpins Integrated Lake Basin Management framework which calls for achieving 'sustainable management of lakes and reservoirs through gradual, continuous and holistic improvement of basin governance, including sustained efforts for integration of institutional responsibilities, policy directions, stakeholder participation, scientific and traditional knowledge, technological possibilities, and funding prospects and constraints (RCSE-SU and ILEC, 2014). Achieving close relationship between planning and governance is critical considering multiple stakeholder and sectoral interests which underlie and to a large extent structure wetland biodiversity and ecosystem service values, and the need to secure people's involvement and participation in basin scale management for considerably long periods of time.

From an initial emphasis on management for water supply or flood protection values, the ecological, socio-economic and cultural values of reservoirs are being increasingly recognized and factored in management planning. Conventional design life approaches for construction of reservoirs based on economic norms of comparing costs and benefits over short spans of time (usually 50 years) are being replaced by life cycle management approaches which take into account impacts of water infrastructure on sediment fluxes and ecological processes over larger and longer temporal and spatial scales (Kondolf et al., 2014). The List of Wetlands of International Importance[2] contains 216 sites listed as water storage areas or reservoirs, with 154 having integrated management plans in place. Listing of Hirakud as one of the priority wetlands for integrated management in the state is a reflection of such a policy shift.

Management of Hirakud thus far has been aimed at flood control and providing water for irrigation, hydropower and industrial use. A secondary objective is to secure fish production without compromising reservoir operations. The limitations of current management are apparent in loss of water holding capacity, declining water quality, deteriorating species habitats and resource use conflicts. Wise use of Hirakud reservoir entails putting in place management arrangements considering the full range of biological diversity and ecosystem service values, and in particular embedding reservoir management within the wider Mahanadi River Basin management. It entails planning and decision making that augments the current management focused on a limited set of developmental values to a wider set of biodiversity and ecosystem service values and drivers of change thereof. Integrated management planning is aimed at providing a programmatic framework for achieving wise use of wetlands through restoration of ecological character in a 'healthy state' and embedded within the environmental and socio-economic sustainability objectives pursued through the on-going developmental programming in the State of Odisha. The importance of securing appropriate governance structures to underpin such management is apparent.

The approach adopted for management planning of Hirakud is in line with the New Guidelines for Management Planning endorsed by the Eighth Meeting of Contracting Parties to the Ramsar Convention (Ramsar Convention Secretariat, 2007). The need to integrate site management plans into public developmental planning system at local, regional and national levels is emphasized in these guidelines. Further, in order to safeguard sites and their features, the guidelines recommend adoption of an adaptable management process

[2]Accessed on May 25, 2015

which allows wetland managers to respond to the legitimate interest of others, adapt to an ever-changing political climate, accommodate uncertain and variable resources, and survive the vagaries of the natural resources. Current management of Hirakud Reservoir needs significant upgradation to this effect, as adaptation has been limited to changing reservoir rules after prolonged periods, with consideration only to changes in the water holding capacity and water demands for human uses.

Management planning for Hirakud also draws upon the six governance pillars for Integrated Lake Basin Management (RCSE-SU and ILEC, 2014), namely:

- Institutions : development of effective organizations and governance frameworks
- Policies: setting broad directions and specific rules
- Participation: expanding circle of involvement
- Technology: possibilities and limitations
- Information: pursuing sources of knowledge and wisdom, and
- Finance: seeking for sustainable sources at appropriate level

The approach is also in line with the National Environment Policy (2006) of Government of India which recommends integration of conservation and wise use of wetlands into river basin management involving all relevant stakeholders, in particular local communities. The policy further recommends integration of wetland conservation into sectoral development plans for poverty alleviation and livelihood improvement, and link efforts for conservation and sustainable use of wetlands with all on-going rural infrastructure development and employment generation programmes. The National Water Policy (2012) and Odisha State Water Policy (2007) also espouse river basin scale planning, and integrated approaches in water resources management. Guidelines of MoEFCC's (Ministry of Environment, Forest and Climate Change) flagship programme for wetlands, NPCA (National Programme for Conservation of Aquatic Ecosystems) also recommend integration of wetland conservation in developmental programming by emphasizing convergence opportunities, stakeholder engagement and diagnostic evaluation approaches.

In line with available international and national guidelines and best practices, the management plan for Hirakud has been developed using a diagnostic approach. Status and trends in reservoir's hydrological, ecological and socio-economic features have been assessed to determine key factors limiting integrated management. An evaluation of institutional arrangements (including sectoral programmes, policy and regulatory frameworks and stakeholder arrangements) has been carried out to identify coordination opportunities. An integrated and hierarchical assessment, monitoring and evaluation system has been recommended to enable adaptive management. These analyses form the basis of an action plan, with well-defined objectives and outcomes, to achieve wise use.

The management plan has been prepared by a team of experts drawn from disciplines of hydrology, ecology, watershed management, sociology, and economics. Data on hydrological and ecological aspects was collected from various state government departments, agencies and research institutes. Detailed socio-economic surveys and participatory assessments were conducted in 40 villages located around the reservoir and its command areas to determine wetland livelihood interlinkages. Secondary literature was also collated to establish status and trends in wetland features. To the extent possible, all available data has been presented in the form of thematic maps.

1.4 Management plan structure

The management plan is presented in seven sections. Following Chapter 1, which sets up the management planning rationale and clarifies approach and methodology, Chapter 2 summarizes

the status and trends in hydrological, ecological, socio-economic and institutional features of the reservoir and their governing factors. A review of institutional arrangements and a proposal for integrated management are contained in Chapter 3. Description of Hirakud's ecological character and a complementing monitoring and evaluation framework are provided in Chapters 4 and 5. Detailed action plan, budget and resourcing opportunities are provided in Chapter 6 and 7 respectively.

Box 1 | A Brief History of Hirakud Reservoir Project

The history of Hirakud project dates back to 1850s when Sir Arthur Cotton, a British general and irrigation engineer, was asked to report on options to control floods which routinely ravaged Mahanadi Delta. In line with proposals for resolution of floods and irrigation challenges in Andhra Pradesh and Tamil Nadu, Cotton recommended construction of hydraulic structures across the Delta Rivers, namely the Mahanadi, Brahmani and Baitarni. The scheme was however not considered feasible. The 'Orissa Flood Enquiry Committee' constituted in 1928 and headed by Mr. Adams Williams, a well-known Chief Engineer of erstwhile Bengal, relooked into the problem and concluded that construction of flood control reservoirs on Mahanadi River and embankments in the delta region were impractical. Instead, the committee suggested opening some of the estuaries and cutting up the sand dunes to allow free passage of water into the sea. The committee also emphasized abandoning coastal canals, as they had failed to serve the purpose of irrigation and transport and were rather hindering the free flow of water. Later, in 1937 the enquiry was entrusted to Mr. M. Visveswaraya, an eminent engineer. After examining the 'Orissa Flood Enquiry Committee' report, Mr. Visveswaraya emphasized on the construction of multipurpose dams in the Mahanadi basin to address flood problems and that such a dam, if constructed, should have the capacity to withhold the flood water temporarily and release it gradually. In 1938, on his recommendations, the 'Orissa Flood Advisory Committee' was formed, which after exploring various options of flood control, suggested building a dam on Mahanadi.

The decision was given firm government endorsement at a conference held on November 8, 1945 at Cuttack under the chairmanship of Dr. B.R. Ambedkar, the then Labour Member of the Viceroy's Executive Council. The participants which included the representatives of Government of India, Government of Odisha, Central Provinces and Eastern States unanimously agreed upon the development of an integrated multi-purpose river valley project on the Mahanadi River for flood control, navigation, irrigation and power generation. In 1945 the Government of India commissioned Dr. A.N. Khosla who was the then Chairman of the Central Waterways, Irrigation and Navigation Commission (CWINC) to conduct detailed investigations. After extensively studying the matter and discussing with the local authorities, Dr. Khosla concluded that the construction of the reservoir was the only solution for the problems faced by the state of Odisha.

On March 15, 1946, Hawthorne Lewis, the then Governor of Odisha laid the foundation stone of the Hirakud Dam. The decision to build the dam in Hirakud witnessed large scale opposition from the local population, but was overshadowed by the nationalist drive for ensuring economic prosperity in the early post-independence era. The first batch of concrete was laid by the first Prime Minister of Independent India, Pandit Jawaharlal Nehru on April 12, 1948. The Hirakud project came to its completion in 1953, and was officially inaugurated by Pandit Nehru on January 13, 1957. The Dam became the first major post-independence multipurpose river valley project of India. Power generation along with supply for irrigation started progressively from 1956, and its full potential was achieved by 1966.

2. Description and Evaluation of Wetland Features

2.1 Wetland extent

The Hirakud Reservoir is located about 15 km upstream of Sambalpur Town at the confluence of River Mahanadi with River Ib. The Mahanadi River enters the reservoir from the westerly direction adjoining Village Panderi through a narrow gorge between two hillocks, Himgiri in the north and Barapahar in the south. Barapahar area to the east of the reservoir has been designated as Debrigarh Wildlife Sanctuary. River Ib flows into the reservoir from the north adjoining village Patrapalli (Map 2.1).

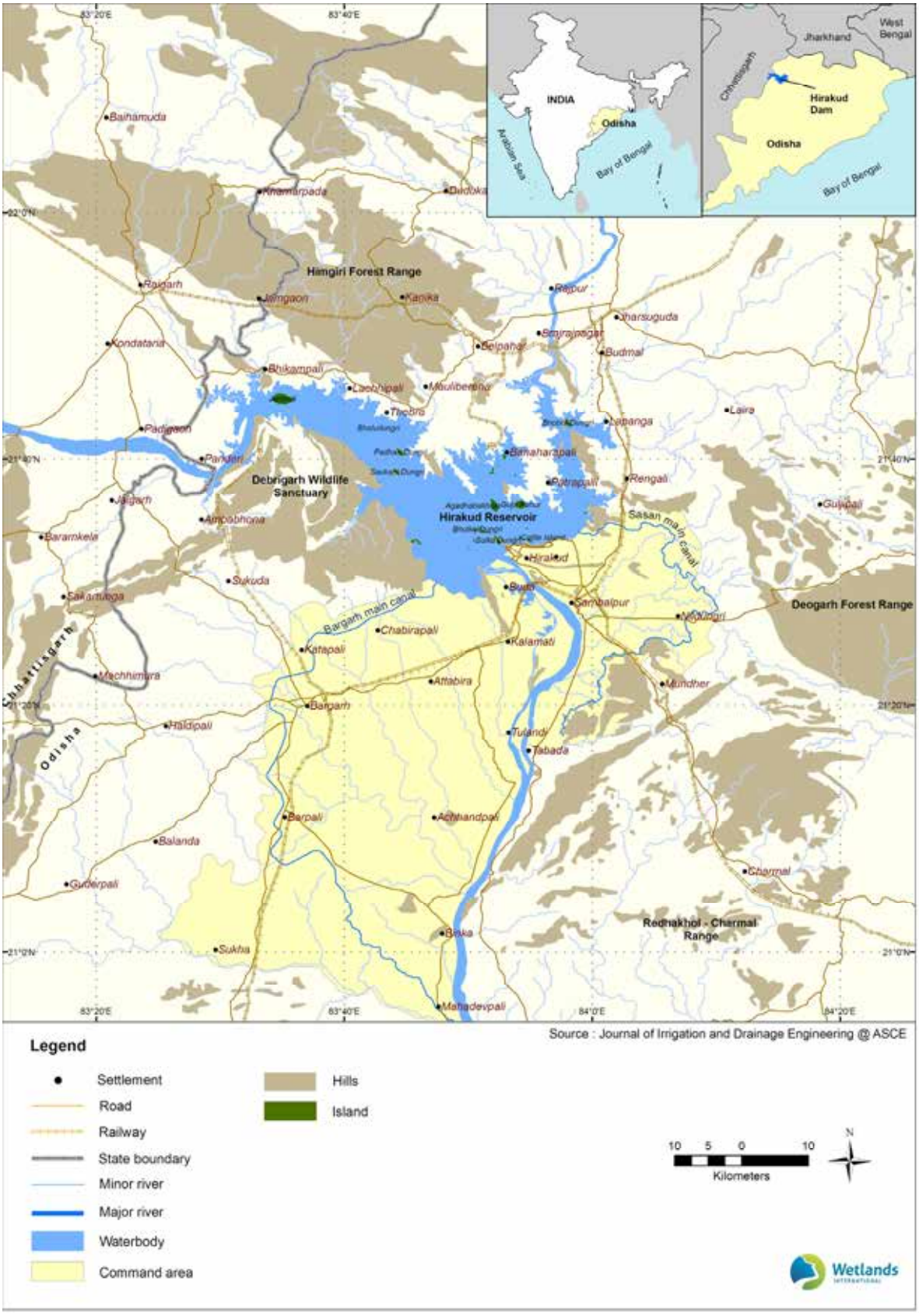
The Hirakud Dam has a full reservoir level (FRL) elevation of 192.02 m. The dam top, at an elevation of 195.68 m is further 3.66 m higher, allowing for flood moderation in case of extreme inflow surges. Dam operation during the months of monsoon is aimed at regulating flows at Naraj, the head of Mahanadi Delta, within a limit of 25,400 m^3/sec. The stored water is used for producing hydropower and meeting agricultural, industrial and municipal water needs during non-monsoon periods.

Hydropower is produced from two power houses. The Burla Power House is located at the base of the main dam section and has an installed capacity of 260 MW. The second power house located further south of the reservoir at Chiplima uses the tailrace of the Burla power station carried through a 25 km long conductor system. It has an installed capacity of 72 MW. Cumulatively, the two stations produce 740 MU[1] of hydropower annually.

Reservoir at Tamdei

Irrigation from the reservoir is provided through three canal systems namely Bargarh Main Canal, Sasan Main Canal and Sambalpur Distributary. These are linked to the gravity flow from the reservoir and regulated through head regulators.

[1] Average production for water year for the period 1996-97 to 2012-13 (Data Source: Odisha Hydro Power Corporation Limited)



Map 2.1 | Location of Hirakud Reservoir

The 88 km long Bargarh canal emanates from the right dyke of the reservoir and irrigates about 134,000 ha area in Bargarh and Sonepur Districts. The Sasan Canal is 22 km long and emanates from the right dyke irrigating 21,000 ha area within Sambalpur District. The Sambalpur distributary irrigates an area of 4,100 ha. In addition, the tailrace of power houses provides water for stabilizing irrigation in 167,000 ha of Mahanadi Delta Stage I and irrigating 136,000 ha of Delta Stage II.

Dam operations create a dynamic inundation regime in the reservoir. At FRL (192.02 m), an area of 689 km^2 is inundated. This gradually recedes in summer to 200 km^2 (close to its minimum draw down level (MDDL) of 179.83 m). The impacts of reservoir operation in a normal rainfall year are seen upto the confluence of River Mand with River Mahanadi. Along Ib River, water levels upto Brajnagar railway bridge, located upstream of the confluence of River Bheden with River Ib are known to vary with reservoir operations.

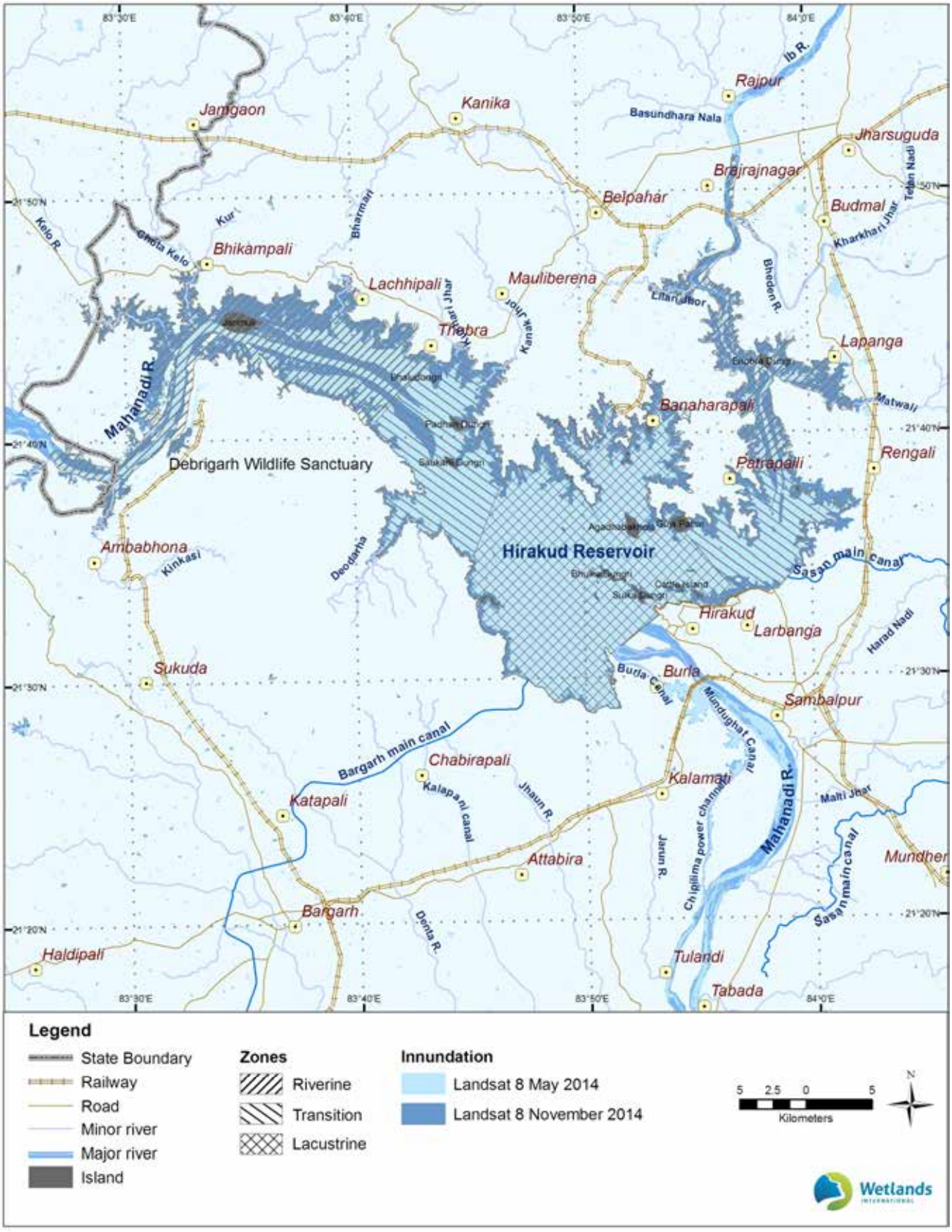
There are over 35 islands in the reservoir covering an area of 706 ha. Two of the largest islands, namely, Bhulka Dungri (68 ha) and Sulka Dungri (69 ha) are located close to the right dyke. Village Pandri marks the entry point of River Mahanadi into reservoir. All these islands are vegetated.

Hirakud, as in other large reservoirs, demonstrates a mix of riverine and lacustrine characteristics, largely influenced by topography, river inflows and dam operations. Ecologically the reservoir can be delineated into riverine, transitional and lacustrine zones (Map 2.2). The stretch of Mahanadi River between its confluence with River Mand and Bhaludungri Island is primarily riverine in character. The stretch has flowing water throughout the year, and the river channel discernible except during peak rainfall. A narrow floodplain has evolved all along this stretch. On the left, the river floodplains are over 3-4 kilometres wide, while the Barapahar constrains floodplain development on the right flanks. Water recedes in these areas after monsoon leading to creation of marshy conditions. By April, the floodplains completely dryout and are colonized by emergent macrophytes. Similar situation can be discerned in the River Ib stretch between the confluence of River Ib and Bheden adjoining Patrapalli village. The exposed floodplains are mostly used for cultivation of vegetables and short-duration paddy.

Shiva Temple in the Reservoir near Sapne village

The riverine zone is bordered by a narrow transition zone, shallow in depth and allowing colonization of submerged vegetation. The central area of impoundment, measuring around 270 km^2 maintains lacustrine conditions for most parts of the year, except during the period in which dam is operated.

The dynamic inundation results in significant temporal



Map 2.2 | Ecological zonation of Hirakud Reservoir

Table 2.1 | Seasonal changes in land use and land cover in Hirakud Reservoir

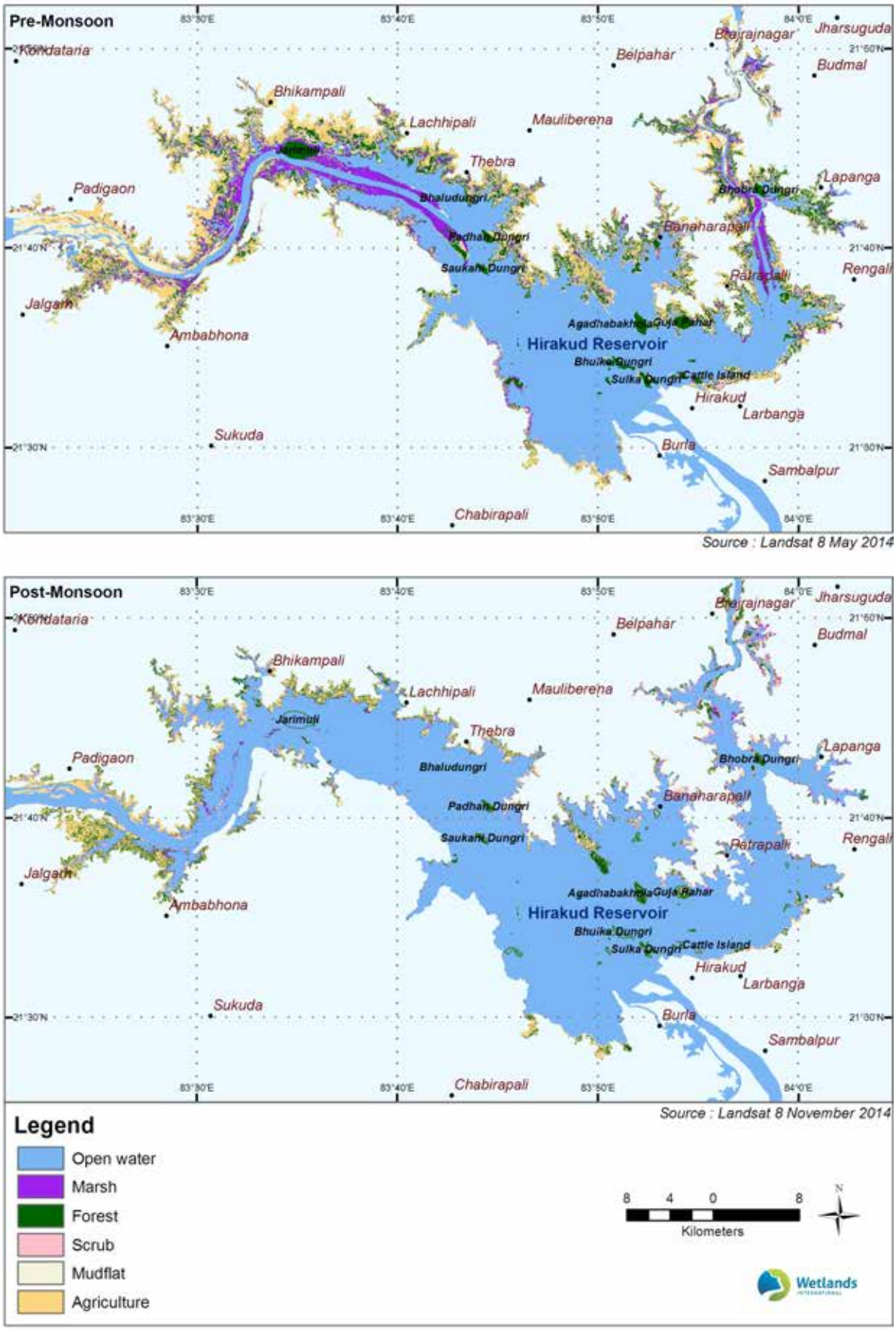
Category	Area (km^2)	
	Nov-14	May-14
Open Water	697.93	422.7
Marsh	16.2	66.8
Forest	20.1	20.1
Scrub	0	75.1
Mudflat	9.22	89
Agriculture	0	69.75
Total	**743.45**	**743.45**

changes in landuse and landcover. This is indicated in Table 2.1 derived from analysis of remote sensing imageries of November 2014 (corresponding to a reservoir water level of 192.02 m) and May 2014 map 2.3 (corresponding to a water level of 186 m).

For the purpose of management planning, the inundation area and the fringing marsh and mudflat habitats corresponding with the FRL have been considered as the wetland extent. This corresponds to an area of 745 km^2. The zone of influence of the reservoir includes the area under irrigation (the command area) and the Mahanadi Delta area (wherein much of the flood control objectives are targeted).

Such delineation provides a useful frame of reference for describing ecological processes, biodiversity characteristics and the community livelihood linkages of the reservoir within the Mahanadi River Basin landscape.

Confluence of Ib and Bheden River near Dantamura village



Map 2.3 | Seasonal changes in land use and land cover in Hirakud Reservoir

2.2 Wetland features

Hirakud Reservoir is a dynamic socio-ecological system, open to influences from a range of natural and human factors. This section of management plan contains description and analysis of status and trends in reservoir catchments, hydrological regimes, biodiversity and socioeconomic and livelihoods, with an aim to identify key issues that need to be taken into account while developing management strategies.

2.2.1 Catchment

The Hirakud Reservoir regulates inflows from 81,700 km^2 of the Mahanadi Basin area. Releases from the reservoir influence hydrological regimes in additional 58,000 km^2 of the downstream segments of the basin, particularly in 9,500 km^2 of Mahanadi Delta. For the purpose of management planning the upper segment of Mahanadi Basin has been considered as the direct catchment of Hirakud Reservoir and the downstream region as indirect catchments.

The description and analysis of reservoir catchments is based on historical and seasonal remote sensing data. Trends in land use and land cover over a period of 35 years have been assessed using Landsat MSS and ETM and IRS P6 AWiFS remote sensing images. Watersheds have been prioritized using SRTM Digital Elevation data, and soil erosion maps prepared by NBSSLUP (National Bureau of Soil Survey and Land Use Planning, Nagpur). Ancillary information on climate, geology and geomorphology and soils available from Survey of India toposheets, Geological Survey of India reports, soil maps of NBSSLUP and studies conducted by National Institute of Hydrology and others have been compiled and analysed to understand catchment characteristics relevant for Hirakud management.

Drainage

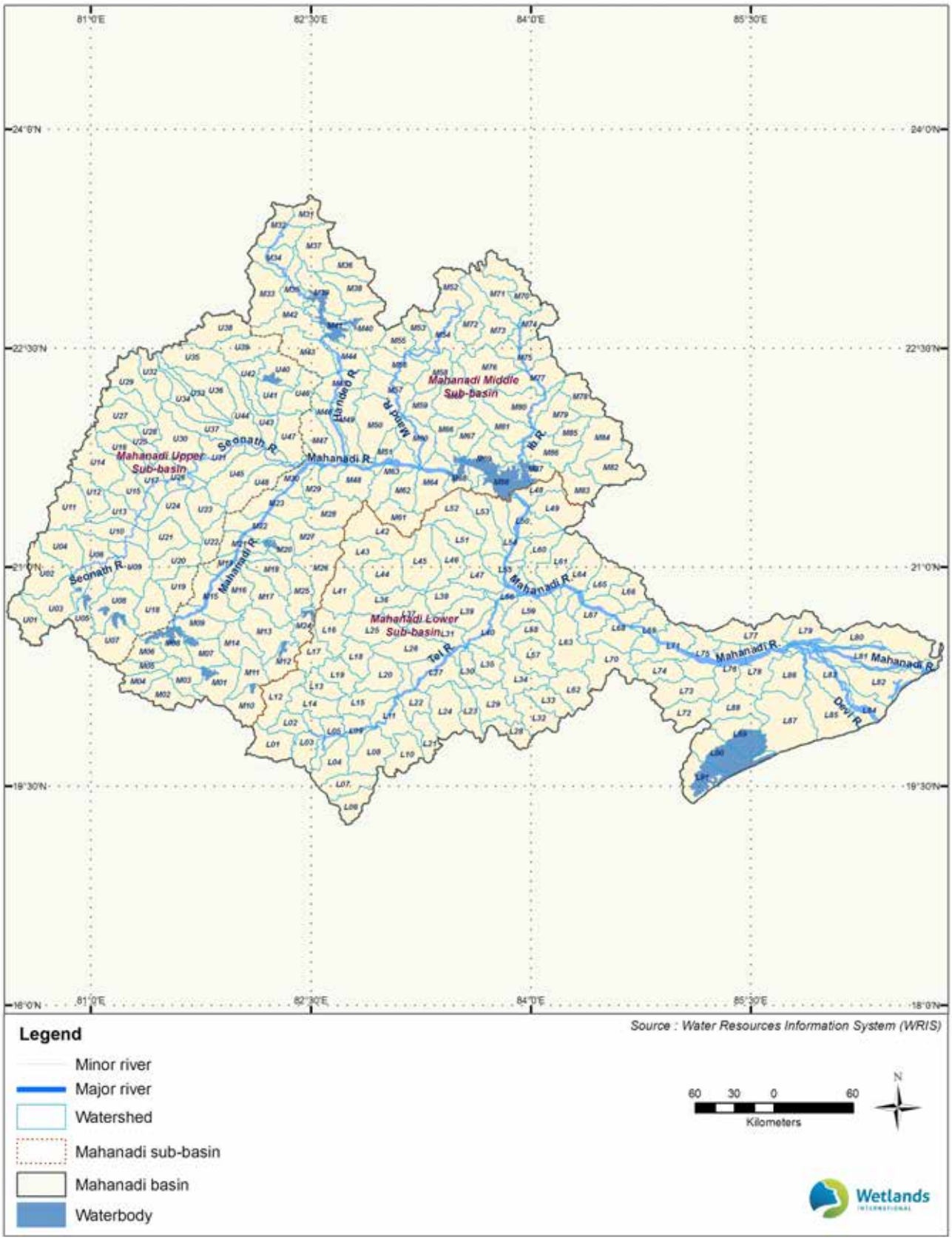
River Mahanadi, on which Hirakud Dam has been constructed, is the third largest Peninsular River of India having a basin[1] of 139, 652 km^2 spanning 80°28’ and 86°43’ east longitudes and 19°8’ and 23°32’ north latitudes . The River originates from a pool in the Sihawa hills, 6 km from Pharsiya Village in Dhamtari District of Chhattisgarh, and flows through a distance of 851 km across five states of central India. Mahanadi has 14 major tributaries, of which 12 join the river upstream of Hirakud and two downstream. Seonath, Tel and Ib are the significant tributaries of the Mahanadi, constituting 47% of the total catchment area. The drainage system upstream of Hirakud Reservoir is more extensive on the left bank of Mahanadi as compared to its right bank (Map 2.4). A major part of the river basin lies in Chhattisgarh and Odisha, with a small segment spread across the states of Maharashtra, Jharkhand and Madhya Pradesh. The basin is bound by the Central India hills in the north, Eastern Ghats in the south and east and the Maikala Range in the west. The Chiroli hills forms the watershed dividing the basin of River Wainganga from the basin of Mahanadi.

Based on drainage pattern, the Mahanadi Basin is classed in three sub-basins, namely the Upper Mahanadi, Middle Mahanadi and Lower Mahanadi (CWC and NRSC, 2014). The direct catchment of Hirakud comprises the upper and the middle sub-basins, comprising 63% of the total basin area. The area and number of watersheds are given in Table 2.2 and Map 2.4.

Table 2.2 | Area and number of watersheds in Mahanadi sub-basins

Sub-basin	Areas (km^2)	No. of watersheds
Upper Mahanadi	29,797	48
Middle Mahanadi	51,896	88
Lower Mahanadi	57,959	91

[1] The area cited in the report corresponds to the figures cited in the MoWR, 2014 report on Mahanadi River Basin. The area estimates for the basin as cited by various sources may differ.



Map 2.4 | Sub-basins and watersheds of Mahanadi River

The Mahanadi upper sub-basin is drained by Seonath and its tributaries, Arpa, Kurung, Maniari, Tandula and Kharkhara, joining Mahanadi River's left bank. The Seonath is the largest tributary of Mahanadi, rising in Village Kotgai in Durg District and draining three districts of Chhattisgarh namely Durg, Rajnandgaon and Bilaspur.

The middle sub-basin is drained by Pairi, Sukha, Jonk, Kanji, Lilar and Lath which join Mahanadi River on its right bank. Rivers Hasdeo, Mand, Ib, Kelo and Bhedan join River Mahanadi on its left bank. Ib is the third largest tributary of Mahanadi, rising in Village Pandrapat in Raigarh district of Chhattisgarh, and draining Raigarh and two districts of Odisha, namely Sundergarh and Sambalpur.

Mahanadi lower sub-basin covers southern and coastal parts of Odisha and is drained by Ong, Tel, and Hati Rivers. River Tel is the second largest tributary of Mahanadi River, rising in Village Jorigam of Koraput District of Odisha and draining four districts of Odisha namely Koraput, Kalahandi, Balangir and Phulbhani. Map 2.5 shows the river network of Mahanadi. The drainage network length and drainage areas of various tributaries of Mahanadi are given in Table 2.3.

Table 2.3 | Length and catchment areas of important tributaries of Mahanadi River

Tributary	Area (km^2)	Length (km)
Mahanadi *	49,785	851
Seonath	30,761	383
Jonk	3,673	196
Hasdeo	9,803	333
Mand	5,237	241
Ib	12,447	251
Ong	5,128	204
Tel	22,818	296
Total	**139,652**	**851**

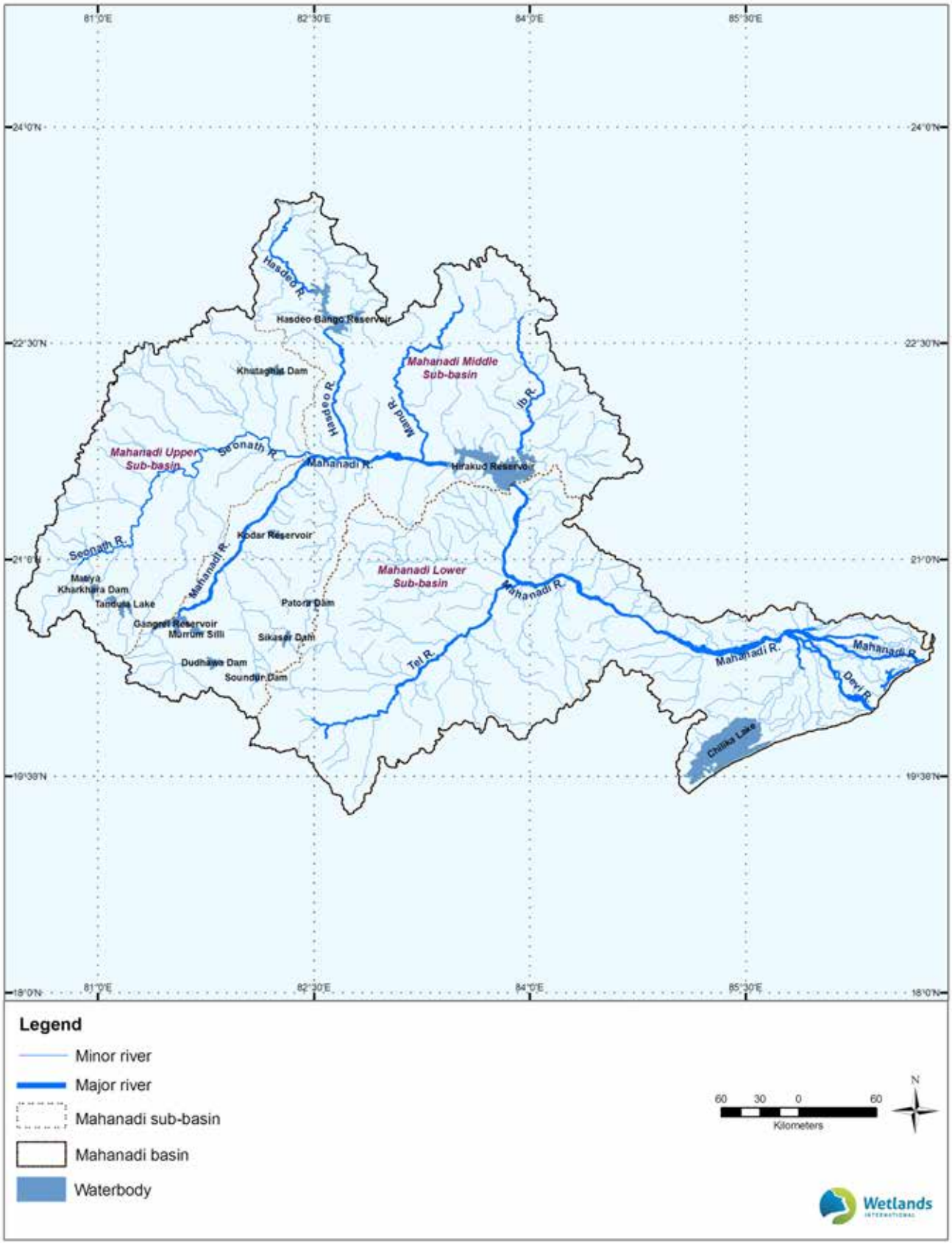
*Including Pairi R.

Climate settings

Sub-tropical climate prevails over the Mahanadi Basin. The average annual rainfall in the basin ranges between 1000 mm to 1400 mm with a mean of 1175 mm. The basin receives about 90% of its rainfall during the monsoon season. Generally, the southwest monsoon sets in by the middle of June and remains active till the end of September. The basin receives maximum precipitation in the month of August (Swain, 2014). The spatial variation in rainfall is moderate. Depressions in the Bay of Bengal frequently create cyclones, which bring about wide spread heavy rains resulting in floods mostly in the months of October and November.

Mahanadi River near Hirakud town

The temperature varies widely across the upper and the lower sub-basins. While the temperature remains moderate in the coastal region throughout the year, the average maximum temperature during April – May (recorded over a period



Map 2.5 | Mahanadi Basin Drainage network

of 100 years) remains over 40°C for the regions such as Jharsuguda, Raipur and Sambalpur in Odisha and many parts of Chhattisgarh.

Maximum temperature in May-June is known to be higher than 45°C. Highest day temperature recorded in the basin is 50.3°C in June 2003. Several blocks falling in 14 districts of the river basin are drought prone (Swain, 2014). Increasing trend in mean annual temperature of the range of 0.64°C /100 years have been reported for the Mahanadi basin (Singh et al., 2010). The basin has a correspondingly high rate of evapotranspiration varying from 152 cm in the east to 174 cm in the west.

Physiography

The Mahanadi River flows in NE-SW direction along tectonic division, known as the Mahanadi Graben. Mahanadi River is believed to have come into existence during the post Mio-Pliocene period when the Mio-Pliocene sea which was at Delang in Mahanadi deltaic terrain retreated to the present day coastal area (Mahalik, 2000). The Mahanadi River and the Mahanadi graben is sandwitched between the Eastern Ghats horsts and western Odisha graben crosscutting through the main physiographic divisions like the west Odisha upland, the central axial highland, east laterite peneplain and the coastal plains.

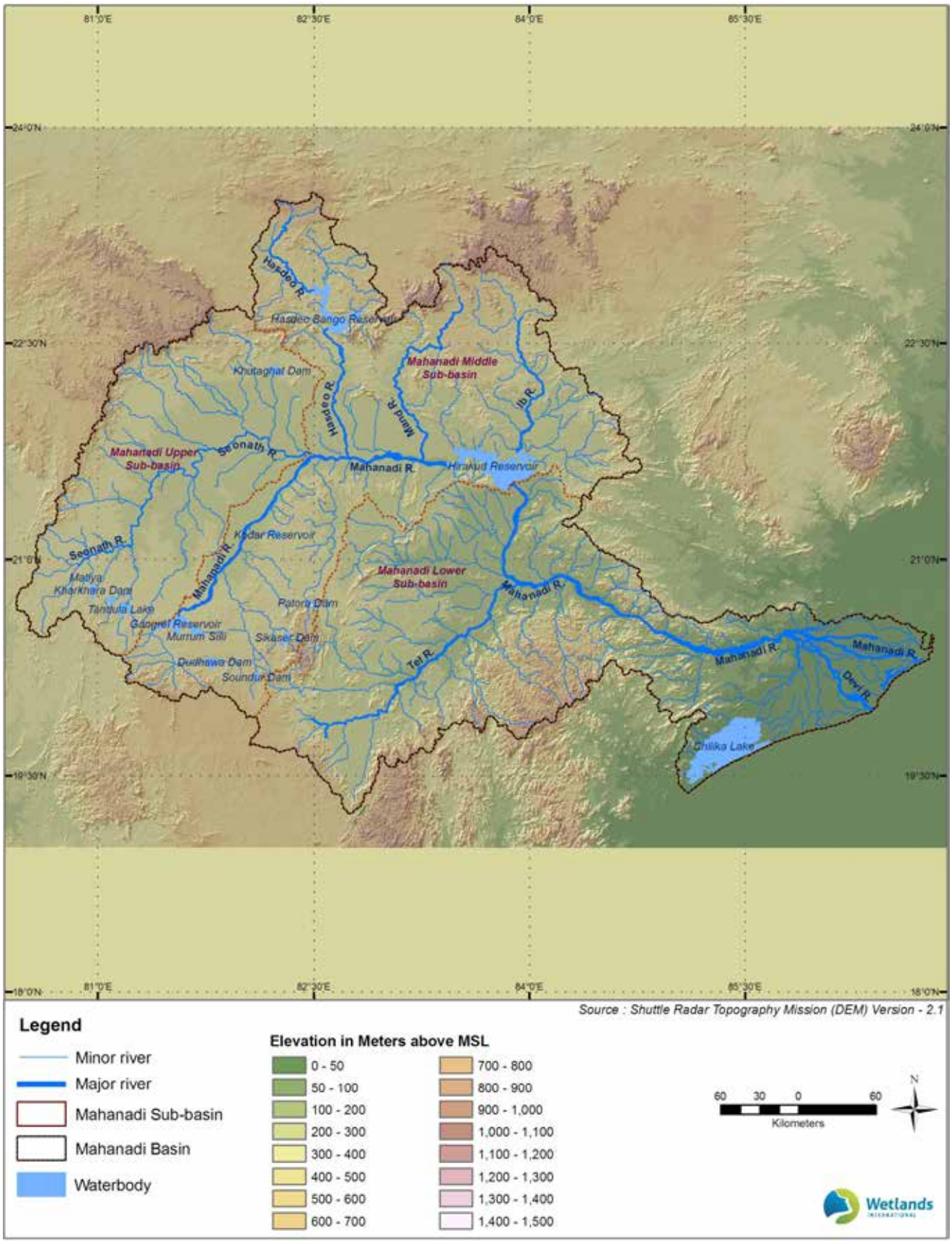
Mahanadi at Huma

Physiographically, the Mahanadi Basin can be divided into four regions, namely, the Northern Plateau, the Eastern Ghats, the Coastal Plains and the erosional plains of Central Table Land. The first two are hilly regions. The Coastal plain is the fertile delta area. The central table land is the central interior region of the basin, traversed by the river and its tributaries.

The catchment topography is uneven and marked by numerous plateaus, irregular high lands and peneplains. The maximum elevation of 1321 m is in the southern parts of basin, which are an extension of the Eastern Ghats in Odisha. The Mahanadi upper sub-basin has elevations ranging from 750 m to 1000 m in its northern parts. Pandrapat from where Ib originates is situated at an elevation of 762 m whereas Hasdeo River originates at 910 m from Sonhat in Koriya district of Chhattisgarh. Mand River rises at an elevation of about 686 m in Surguja district. The central flank of upper Mahanadi sub-basin is a plain area. The Seonath River rises at an elevation of 624 m amsl from Panabaras hill in this region.

The middle Mahanadi sub-basin has high hilly terrain in the north and east segments, falling in the Jashpur District and southern parts of Raipur District. Mahanadi River arises in this sub-basin at an elevation of 442 m. Elevation in the lower sub-basin varies from around 1000 m in Gandhamardhan and nearby hills to 10-50 m in the coastal plains of Cuttack and Puri districts. Elevation zones are depicted in Map 2.6.

Slope has major implications for management of Hirakud's catchment. The degree of slope governs runoff and erosive



Map 2.6 | Mahanadi River Basin – Elevation Profile

capacity and sets limits on land use. The slope features for the catchment have been derived from SRTM DEM data (version 2.1) and provide the basis for land use planning and soil conservation needs. As can be seen in Map 2.7, the basin is mostly level (68% of area), flanked by moderate hills on the margin. Catchment area with gentle to moderate slope constitutes 17% of total area. Over 3% of the catchment area has steep slopes >25 % (Map 2.7).

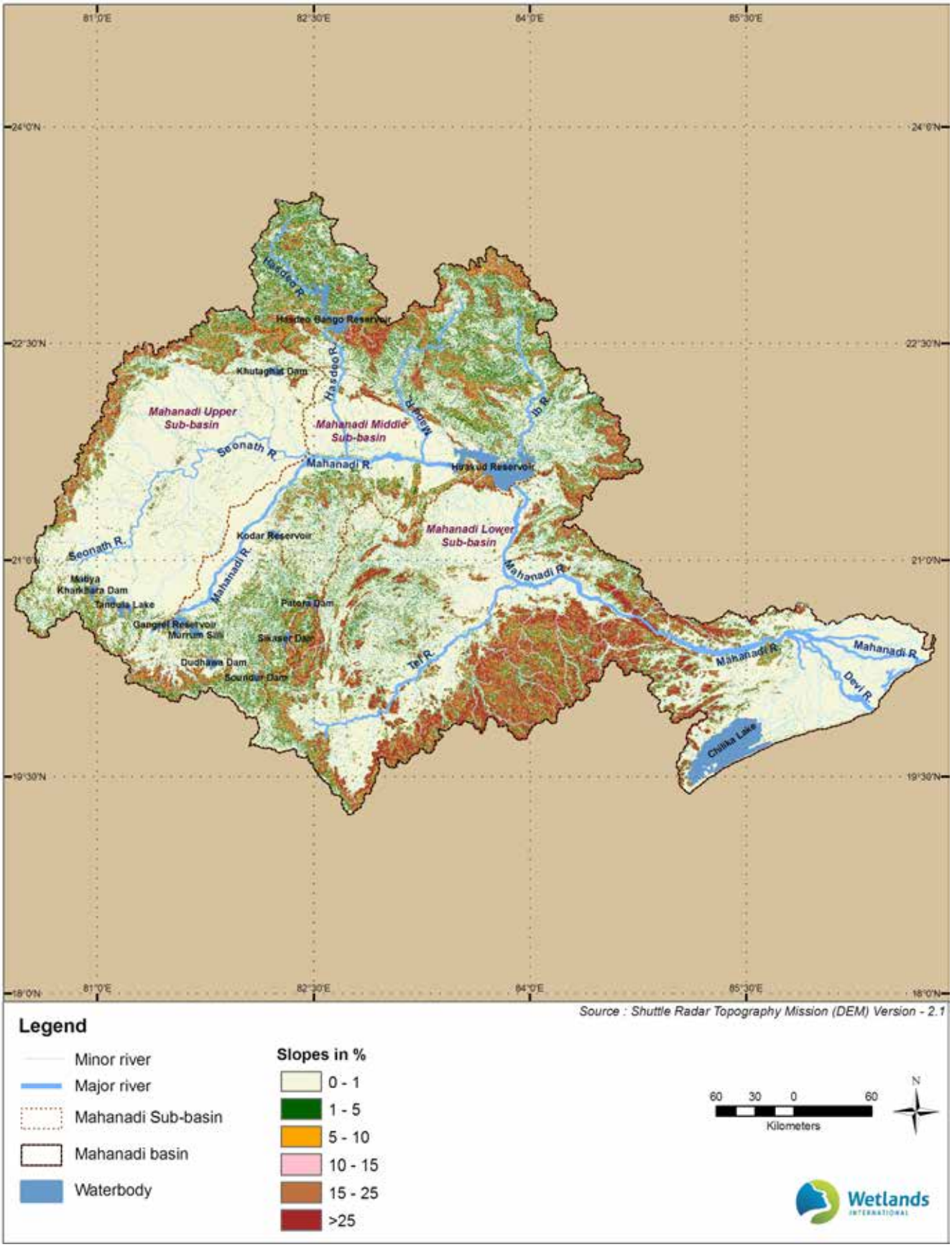
Geology and geomorphology

The Mahanadi drainage basin is underlain by rocks such as Archean crystallines comprising granites, gneisses and charnockites; Proterozoic arenaceous, argillaceous and calcareous rocks belonging to Chhattisgarh super group; Mesozoic coal bearing Gondwana sedimentaries to recent quaternary alluvium. Simultaneous congruent and incongruent weathering is the characteristic of the Mahanadi Basin. The upper Mahanadi sub-basin falls within one of the seven *Purana* basins in India, which are believed to have developed under a dominant extensional tectonic regime, and fed with eroded material from Archaean and Early Proterozoic continental crust of the Peninsular shield (Panigrahy and Raymahashay, 2005). In many parts of the basin, presence of crystalline formations and limestone bedrock has resulted in formations of ridges, and valleys due to the differential rates of weathering. Areas in the Seonath River Valley comprise mostly of limestone and shale with pockets of sandstone. Congruent dissolution of the stromatolitic limestone by Mahanadi River water has resulted in karst features. Granite and gneisses underlie the catchment's mantle in the Ib basin. The central valley zone of the basin is underlain by the coal bearing Gondwana rocks. The Talcher, Barakar and Kamathi series of rocks containing shales and sandstones occur in the Ib River valley and Sambalpur district in Odisha.

In the lower sub-basin, three distinct geomorphic divisions can be seen. The north Odisha highlands are underlain by rocks of Iron ore supergroup, whereas the south Odisha highlands underlain by rocks of Eastern Ghat group. Parts of Bolangir, Cuttack, Angul and Nayagarh districts of Odisha are underlain by Archean Khondalites which are named after Khond tribe of Odisha and have been used for carving famous temples of Konark and Jagannath Puri.

Industries in the catchment of Hirakud

The catchment is rich in iron-ores, bauxite, mica, dolomite, limestone and coal. The region holds the third largest reserve of coal in the country, and has a number of coal fields as the Jhilmili coalfields, Chirmiri, Hasdeo-Rampur coalfields, Mand-Raigarh coalfields and the Ib valley coalfields in the Jharsuguda District, Odisha. Sonhat and the Jhagra Khand coal fields are the extensions of the Sohagpur coal field in Son River valley. Bastar and Durg districts in Chhattisgarh are rich in Iron



Map 2.7 | Mahanadi River Basin – Slope Characteristics

ores while Durg, Raipur and Bilaspur districts are rich in limestone. Manganese ore is found in the Jharsuguda District and near Patnagarh in Bolangir District, Odisha. Bauxite is found in Kalahandi, Bolangir and Sambalpur districts of Odisha and in Jashpur District in Chhattisgarh. Graphite deposits are found in Nuapada, Bolangir, Kalahandi, Sambalpur districts.

The soils in the basin can be grouped broadly into six types based on the reconnaissance soil survey of the soil survey department of Chhattisgarh state in the command area of the Hasdeo Bango Project, pre-irrigation soil survey done by Odisha Soil Conservation Department in the ayacut of Ib project and the soil maps prepared by NATMO (National Thematic & Mapping Organisation).

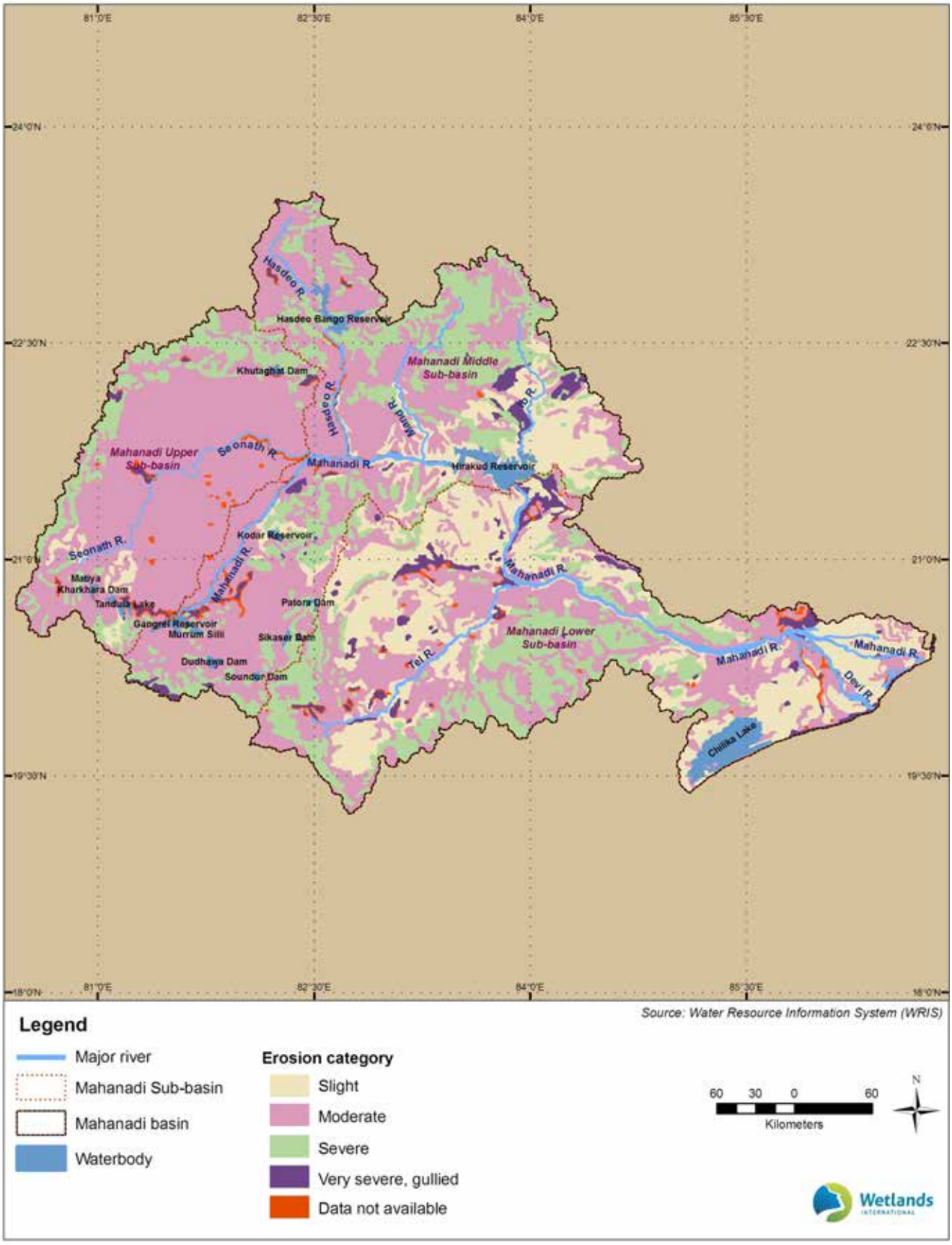
About 90 % of the Mahanadi Basin has moderately shallow to deep soil having depth greater than 50 cm. The upper sub-basin exhibits atypical weathering limited denudation regime in which the rate of removal of weathering products by erosion is greater than the rate of production. The limestone bedrock supports thin soil cover at a number of places in this region. As fresh bedrock material is continually being exposed to weathering solutions, such a regime has thin soil profiles and the solute concentrations in streams tend to be relatively high due to reactions between precipitation and fresh bedrock.

The incongruent weathering of silicate minerals is responsible for the formation of concretionary red soil and the organic rich black soil. Red soils are found in Surguja, Bilaspur, Raigarh, Bastar, parts of Rajnandgaon districts of Chhattisgarh. Black soils are distributed throughout Durg, Raipur and Rajnandgaon districts of Chhattisgarh, Sahadol of Madhya Pradesh, Nuapada, Kandhamal, Boudh, Sonepur, Bolangir, Bargarh and Sambalpur districts of Odisha. Mixed red and black soils are found in the banks of Mahanadi, its tributary Ong and its sub- tributary Jira, Jhaun etc. These soils have high Iron and Manganese content. Red and Yellow soils are found along the banks of the Mahanadi River upto the Hirakud Dam and along the banks of Ib and Mand Rivers. They have developed from Archean formation consisting of gneisses and granites of gondwana systems and have medium to fine texture, and poor water retentive capacity. Laterite soils are found in small patches in Raigarh, Durg, Raipur districts of Chhattisgarh and Bargarh district of Odisha. The deltaic alluvial soil is found in the coastal plains of the Mahanadi. The percentage of alluvial soil is low as compared to the other type of soils. Dhenkanal has old alluvium having higher content of clay. In Cuttack soils vary from clays to clay loams the latter found to a larger extent (CWC and NRSC, 2014).

Soil erosion map (Map 2.8) reveals that 63% of the catchment of Hirakud is under moderate erosion. 21,942 km^2 viz. 26 % areas are under severe to very severe erosion (Table 2.4). A number of watersheds in the catchment of Ib River viz. M78, M80, M77, M81, M79, are subject to very severe erosion and gully formation. Similarly, the watersheds around the origin of Mahanadi River as M02, M04,M01, M08 and the watersheds number U18, U08 around Tandula reservoir; M08 and

Table 2.4 | Slope and soil characteristics of the Mahanadi Basin

Sub-basins	Slope categories (km^2)			Soil erosion categories (km^2)		
	Gently to moderately sloping (1-5%)	Strongly sloping to moderately steep (5-15%)	Steep to very steep (>15%)	Moderate	Severe	Very Severe, Gullied
Upper sub-basin	2572	1661	1366	24149	5028	462
Middle sub-basin	11453	5434	4286	28769	14454	1999
Lower sub-basin	6848	5198	9321	23244	12411	2726



Map 2.8 | Mahanadi River Basin – Soil erosion

M09 around Ravishankar Sagar and M16 a watershed of Pairi River also falls under severe erosion class.

Land use and Land cover

Analysis of 2010 satellite data reveals agriculture and forests to be the major land use categories, accounting for 53% and 27% of the catchment of Hirakud. Waterbodies account for 2.6 % of the Hirakud catchment. The landscape is dotted by several barrages and their reservoirs, major being Hirakud, Hasdeo-Bango, Ravishankar Sagar, Tandula and Dudhwaha. Table 2.5 contains the LULC statistics for the area.

Forest extends to 30,995 km^2 basin area, of which 73% is in middle sub-basin and the rest in upper sub-basin. The basin overlays the Deccan bio-geographical region. Major forest types are Tropical Moist Deciduous and Tropical Dry Deciduous and are mostly Sal dominated. In the Seonath sub-basin as well as in Hasdeo sub-basin, the undulating terrain of the hill ranges have true Sal forests whereas the low-land areas are covered by a cluster of mixed Sal forests. The western and the central portions have teak forests as well. Plantations of Pine, Teak, Jatropa, *Acacia australiana*, Eucalyptus have been carried out under the afforestation program in forest land of the basin, particularly in the catchments of major rivers and around reservoirs. Tendu leaves are produced in many parts as Bilaspur and Raipur Districts of Chhattisgarh as well as parts of Odisha. *Anogeissus latifolia, Diospyros melanoxylon, Pterocarpus marsupium, Madhuca longifolia, Schleichera oleosa, Adina cordifolia, Ougeinia ogeinensis, Bombax ceiba, Buchnania lanzan, Butea monosperma, Dendrocalamus strictus, Terminalia arjuna, T. belerica, T. chebula, T. tomentosa, Albizzia lebbeck, Boswellia serrata, Dalbergia sissoo, Dillenia pentagyna, Eugenia jambolana, Lagerstroemia parviflora, Mangifera indica, Saccopetalum tomentosum* are other major tree species. The forests form an integral part of livelihoods of many tribal communities as Korwa, Birhor and others.

Hirakud catchment has 43, 798 km^2 under agriculture, of which 57% is in lower sub-basin and 43% in upper sub-basin. Rice, wheat, groundnut, linseed and sesame are the major crops. Rice crop is grown over the entire basin area while wheat is grown sparsely on the western side of the basin only. In Chhattisgarh, Rajnandgaon, Bilaspur, Durg, Kanker, Bastar and Dantewada are the main rice producing districts.

Industrial built up areas comprise 0.5% of the catchment chiefly comprising areas around Bhillai, Raipur, Durg and Ib valley (conservative estimate attributed to limitations of remote sensing data).

Table 2.5 | Land use and landcover change (1975 – 2010) *(Areas in km^2)*

	Upper sub-basin				Middle sub-basin			
	1975	**%**	**2010**	**%**	**1975**	**%**	**2010**	**%**
Open water	162	0.5	608	2.0	1143	2.2	1482	2.9
Very dense forest	1778	6.0	1287	4.3	6595	12.7	4214	8.1
Moderately dense forest	3200	10.7	2905	9.7	9605	18.5	8855	17.1
Open forest	1237	4.2	1128	3.8	5159	9.9	4148	8.0
Scrub	2017	6.8	3048	10.2	5082	9.8	5410	10.4
Agriculture	19551	65.6	18762	63.0	21701	41.8	25036	48.2
Barren	1262	4.2	804	2.7	1654	3.2	1256	2.4
Settlement	233	0.8	557	1.9	457	0.9	459	0.9
Tree groves	357	1.2	486	1.6	502	1.0	799	1.5
Industrial built up	0	0.0	213	0.7	0	0.0	237	0.5
Total	**29797**	**100.0**	**29797**	**100.0**	**51896**	**100.0**	**51896**	**100.0**

Major industries include the Iron and Steel industries including the Bhillai Steel Plant in Durg, the Jindal Steel and Power Limited and Monnet Ispat and Energy Ltd. near Raigarh; Aluminum industries such as BALCO in Korba and Hirakud; the Korba Super Thermal Power station; cement factories in Raipur and Sundargarh and paper mills near Cuttack. 1.2 % area of the catchment is under settlement which is closely interspersed with the industrial areas. The population around the river basin is 264 persons per km^2 (CWC and NRSC, 2014).

Over the past six decades since Hirakud's construction, the catchment has undergone significant changes. Coal mining which started way back in 1909 shortly after the expansion of Bengal-Nagpur railway, got a boost after the construction of Hirakud Reservoir and its Hydel Power Station that acted as a catalyst for the rapid establishment of industries and mining operations. The modern industries started establishing during the late 80s, post the nationalization of coal in 1975 and a national policy for the energy sector. Urbanisation followed in the footsteps of industrialisation.

A comparison with satellite data of 1975 reveals a loss of 5037 km^2 i.e. 6% of forest cover over the last 35 years. Similarly, 50% of the area was under agriculture. The open water expanse which was 1305 km^2 in 1975 has now increased considerably to 2090 km^2 primarily on account of construction of new reservoirs and expansion of irrigation. As irrigation facilities were made available in the upper reaches of the catchment forests, grazing lands and other wastelands have been converted for agriculture.

The transition matrix of land use land cover given in Table 2.6 reveals that a majority of the loss of forest cover is attributed to conversion for agriculture and degradation of dense forests to open forests and scrub lands. Decline in area under forest is accompanied by expansion of area under settlements and industrial built up area including mines which were observed to be negligible during 1975. Map 2.9 and Map 2.10 show the past and present land use and land cover patterns.

Rapid industrial development and extraction of mineral reserves without adequate ecological safeguards can significantly alter the quantity and seasonality of inflows as well as silt yield in the reservoir. Diversion of productive agricultural land accompanied by loss of forest cover and degraded condition of rivers adversely impacts the ability of Hirakud ecosystem to deliver ecosystem services.

Burla Power Station

Catchment prioritization for managing Hirakud

Maintaining ecological health of catchments is critical for Hirakud management. Catchment degradation process needs to be arrested or at least minimized viewing the adverse impacts it has on silt load in the reservoir. Various environmental characteristics such as slope, drainage density, forest cover, soil erosion and land use and land cover change

Table 2.6 Land use and land cover change matrix

CHANGE TO 2010	CHANGE FROM (1975)										
		Open Water	Very Dense Forest	Moderately Dense Forest	Open Forest	Tree groves	Scrub	Agriculture	Settlement	Barren	Industrial built up	Total
	Open Water	893	13	92	72	9	109	682	39	181	0	**2090**
	Very Dense Forest	8	3039	1912	321	7	113	93	0	6	0	**5500**
	Moderately dense forest	30	3786	5335	1240	36	721	575	4	32	0	**11759**
	Open forest	20	620	1838	1001	51	654	1037	3	51	0	**5276**
	Tree groves	5	89	256	240	364	243	10	4	74	0	**1285**
	Scrub	45	401	1342	1017	90	1293	3962	22	286	0	**8458**
	Agriculture	231	405	1922	2388	270	3778	33057	165	1582	0	**43798**
	Settlement	20	4	24	33	10	61	348	415	102	0	**1016**
	Barren	3	7	49	60	16	103	1224	25	573	0	**2061**
	Industrial built up	50	10	36	23	5	24	264	12	27	0	**450**
	Total	**1306**	**8372**	**12805**	**6396**	**859**	**7099**	**41252**	**689**	**2915**	**0**	**81693**

determine the environmental sensitivity of watersheds. Extensive area without vegetation cover, steep slopes coupled with high drainage density give rise to high run off with high erodibility.

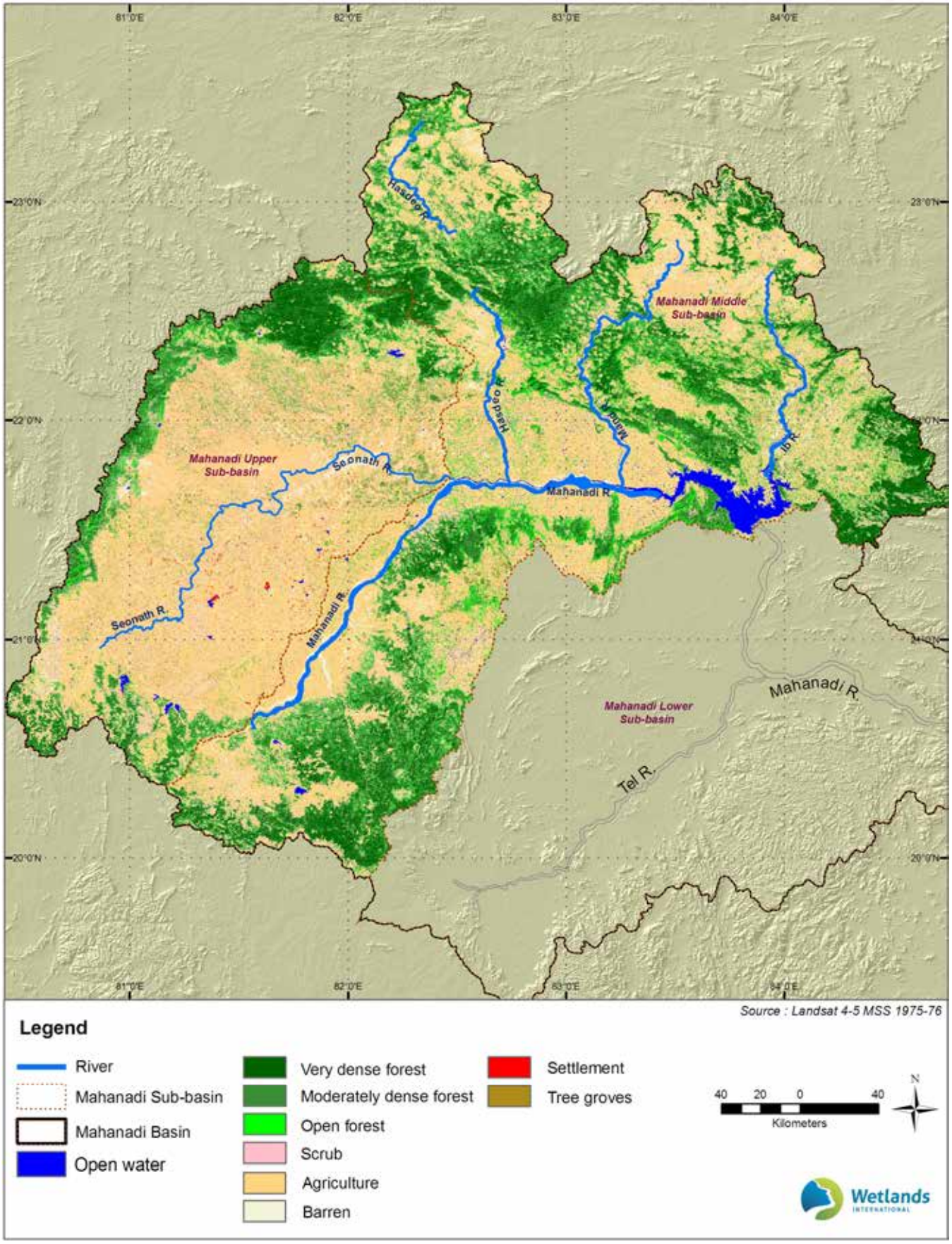
Environmental indicator based sensitivity analysis has been undertaken for catchment prioritization and treatment. Sensitivity of watersheds was calculated based on soil erosion, slope, drainage density and land use land cover change. Weightages were assigned to different categories of the indicators and GIS analysis was carried out to derive the scores for the individual watersheds. The watersheds have been classed based on sensitivity scores. Map 2.11 and table 2.7 show the environmental sensitiveness of the watersheds.

Extremely sensitive watersheds comprise of the watersheds of the upstream reaches of mainstream Mahanadi in Kanker Taluk. They owe their sensitivity to very high rates of erosion, moderate slopes but significant change in forest cover. Similarly, the watersheds falling in catchment of the Ib, Hasdeo and in Jashpur, Korba, and Raigarh districts are highly sensitive because of severe soil erosion and high drainage density. The watersheds of Bilaspur and Kawardha districts are extremely sensitive on account of high soil erosion, steep slopes and high drainage though afforestation programmes have been undertaken here.

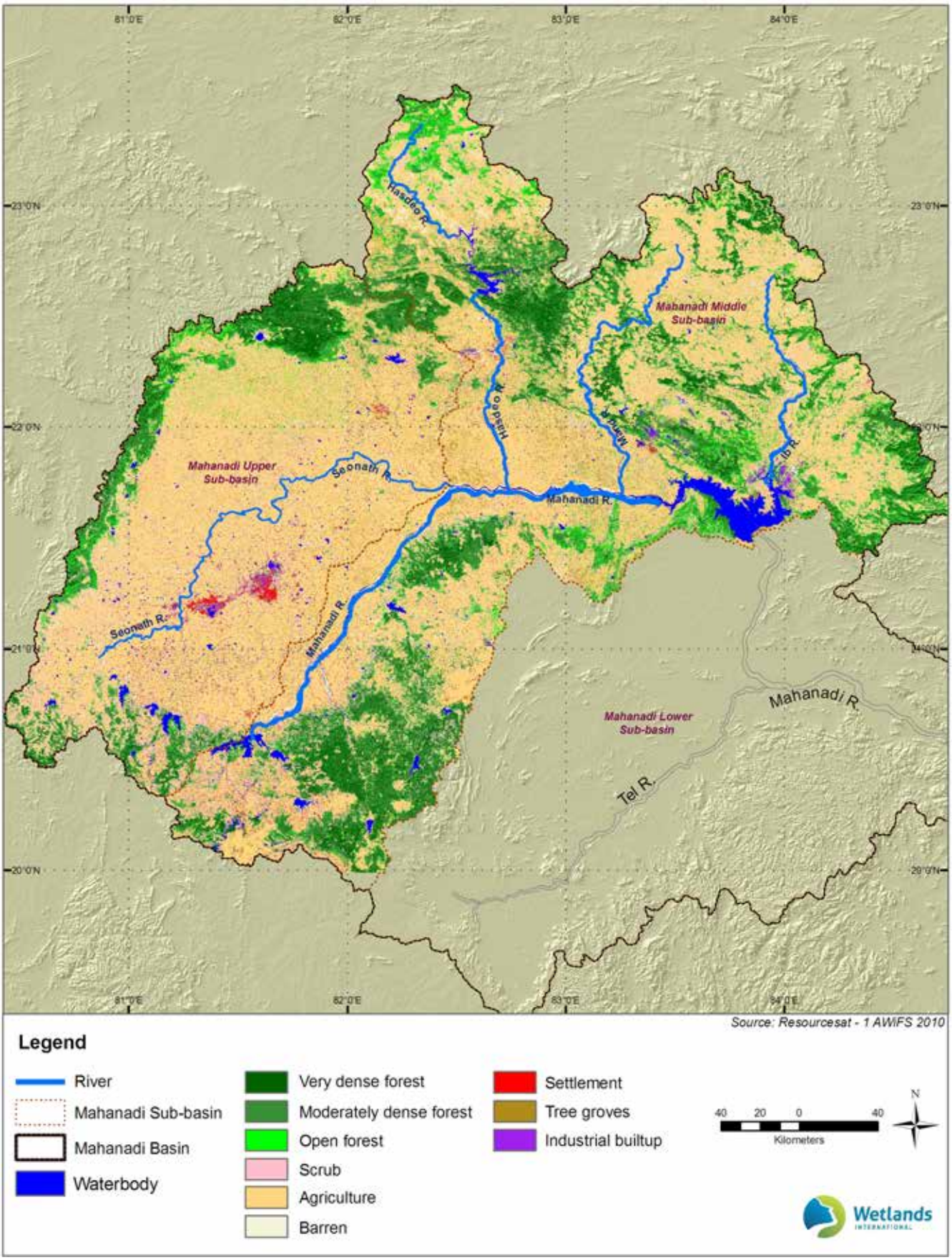
Table 2.7 | Prioritization of watersheds

	Priority class			
No of watersheds	**None or low**	**Moderate**	**High**	**Very high**
Upper sub-basin	33	2	10	3
Middle sub-basin	23	11	52	2

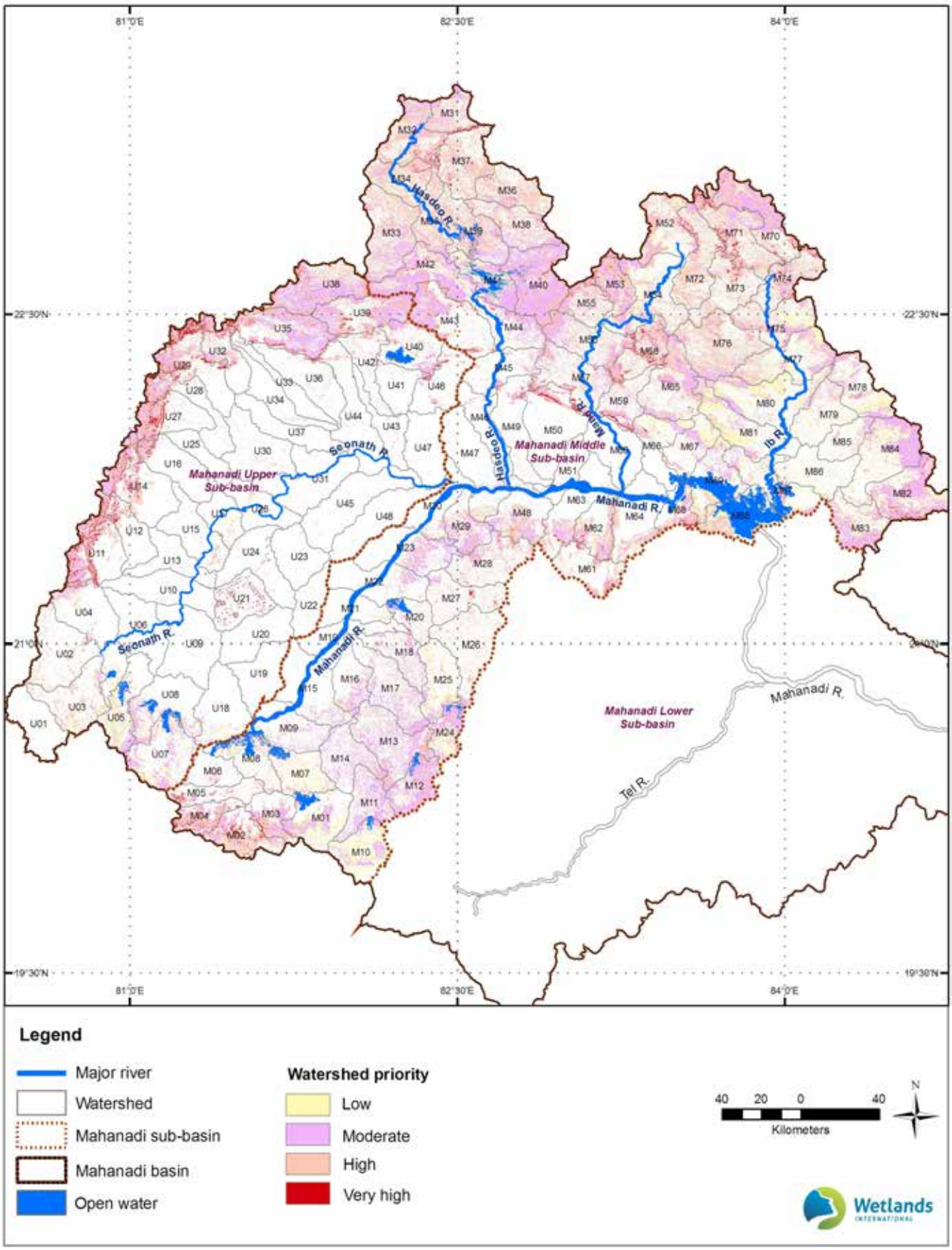
Soil erosion in the catchment of Hirakud



Map 2.9 | Land use and Land cover of Hirakud catchment (1975)



Map 2.10 | Land use and Land cover of Hirakud catchment (2010)



Map 2.11 | Watershed prioritization of Hirakud catchment

2.2.2 Hydrological regimes

This section of management plan presents an overview of the current state of hydrological regimes and key issues that limit achievement of integrated management objectives. The analysis is based on trend data for 30 years on water inflow, outflows and levels made available by the Department of Water Resources. Outcome of the three reservoir sedimentation studies (GoO 1980,1983,1986; NRSA, 2007) and 2007 report of the High Level Technical Committee to study various aspects of water usage for Hirakud Reservoir (GoO, 2007) have been also been analysed. Field assessments and stakeholder consultations were also conducted during monsoon and post monsoon periods of 2014. The findings are summarized in following sections.

Water inflows and outflows

Surface water inflow into Hirakud Reservoir is received from rivers (Mahanadi and Ib) and precipitation. During 1983-2013, the reservoir received 30,818.35 MCM inflows annually (Fig. 2.1a). Runoff received from the catchment contributes the majority component, with rainfall received on reservoir contributing only around 2% of the total inflows. Monsoon inflows (June-September) constitute 85.6% of the total.

Annual outflows for similar period, at 30,755.3 MCM, correspond with the inflows (Fig 2.1b). The design storage at the reservoir is 26.3% of the total inflows received into the reservoir (reduced further to 18.4% on account of siltation). Therefore, 62% of the inflow is allowed to flow downstream during monsoon months. Drawal for power and irrigation account for 29% and 7% of the total outflows respectively (Fig. 2.1c and 2.2). Nearly 2% of the total inflow is lost to evaporation. High inflow variability is experienced during monsoon months, with extreme flows in June and July months.

Seasonal and interannual variability of inflows creates a dynamic inundation regime. This has a significant influence on the biotic communities and landuse on the margins of the reservoir. The peak

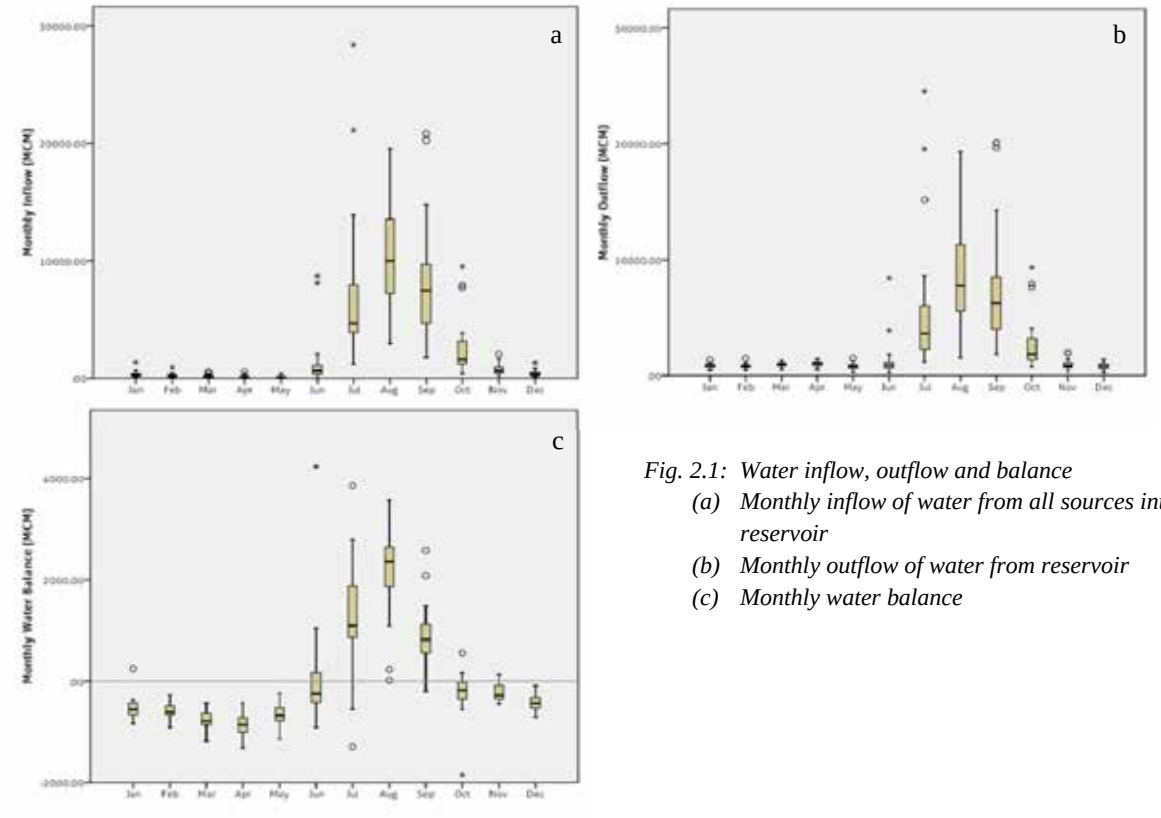


Fig. 2.1: Water inflow, outflow and balance
- *(a) Monthly inflow of water from all sources into reservoir*
- *(b) Monthly outflow of water from reservoir*
- *(c) Monthly water balance*

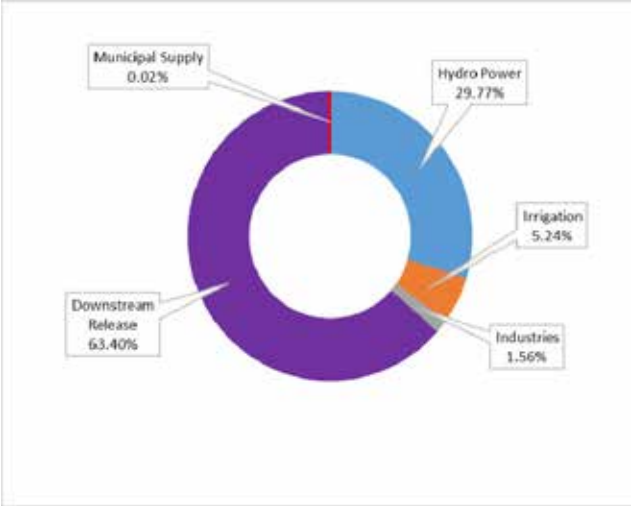


Fig. 2.2 | Water use by different sectors

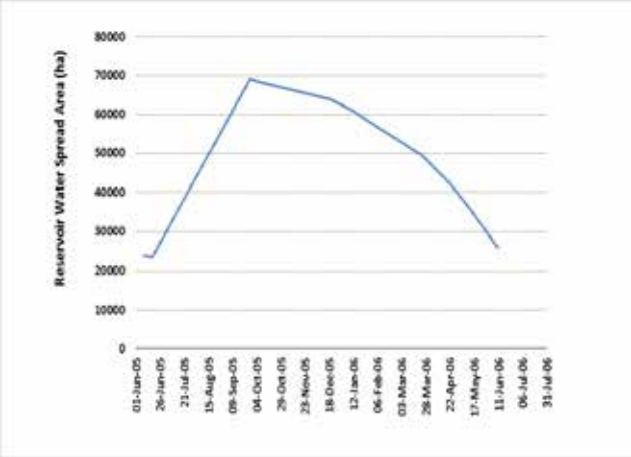


Fig. 2.3 | Water spread area in different months (2005-06)

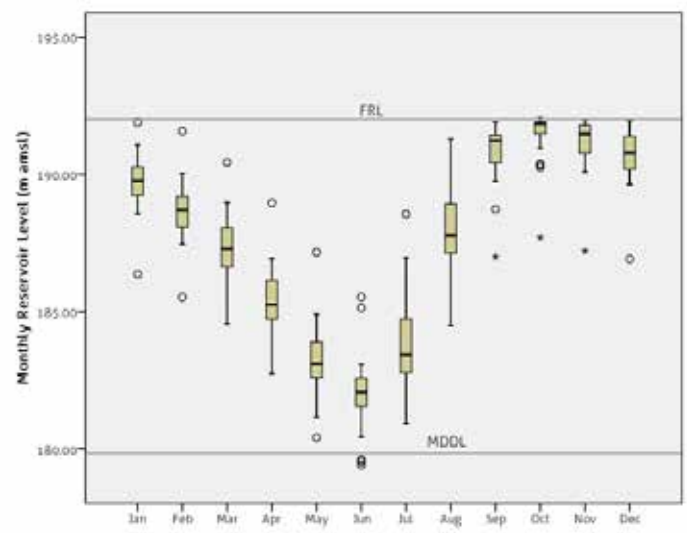


Fig. 2.4 | Fluctuations in reservoir levels

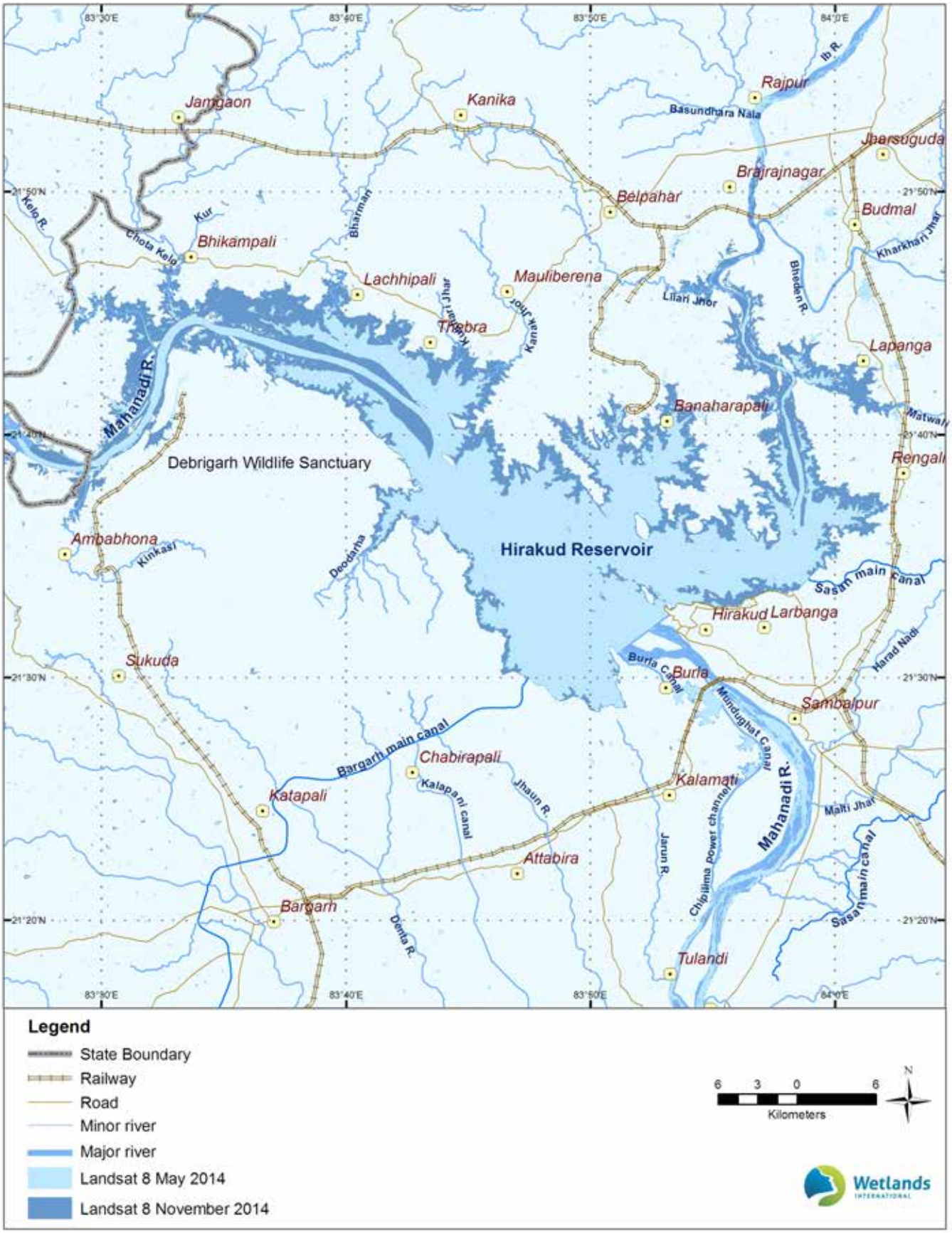
inundation of 68,900 ha achieved by September gradually reduces to 23,300 ha by June (Fig. 2.3 and Map 2.12). A major proportion of the shoreline, particularly around northern margins, gradually converts into wet marshes creating conducive conditions for colonization by macrophytes. Some dried up marsh areas are used for cultivation of vegetables and short duration crops.

The water levels in the reservoir are managed between a maximum of 192.02 m (FRL) and minimum of 179.83 m (MDDL). Fig 2.4 presents a picture of monthly fluctuations in water level, derived from records of the past 31 years (1983-2013). As per observations of the Technical Committee on Water Usage, filling of reservoir given a nearly six times higher runoff is not a constraint. Till 2007, reservoir did not fill up to its full capacity only in 6 years, with 2000-01 being an exceptionally dry year wherein the maximum levels moved up to only 188.07 m amsl. The probability of exceedance of average monthly water levels is presented in Fig 2.5.

Making water available for consumptive usages is contingent on stability of inflows. Available studies on Mahanadi Basin indicate gradual intensification of monsoons, and declining non-monsoon flows (Gosain et al., 2006; Ghosh and Mujumdar, 2006). In the last 40 years, a number of water resources development projects have been constructed upstream of Hirakud Reservoir. A major proportion of inflows is accounted for by managed releases from upstream reservoirs (Fig. 2.6 and Map 2.13), which is posing challenges for reservoir operations.

Sedimentation

Dams interrupt the continuity of sediment transport through river systems, leading to sediment accumulation in the reservoir as well as depriving downstream reaches of sediments required to support riparian ecosystems and maintain channel morphology. For reservoir operations, decreasing storage adversely impacts the ability of the water



Map 2.12 | Inundation pattern in Hirakud Reservoir

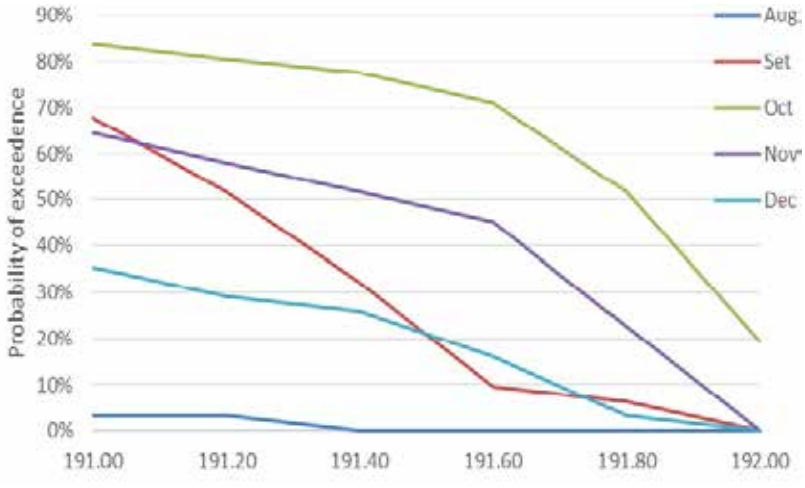


Fig. 2.5 | Probability of exceedance of average monthly levels

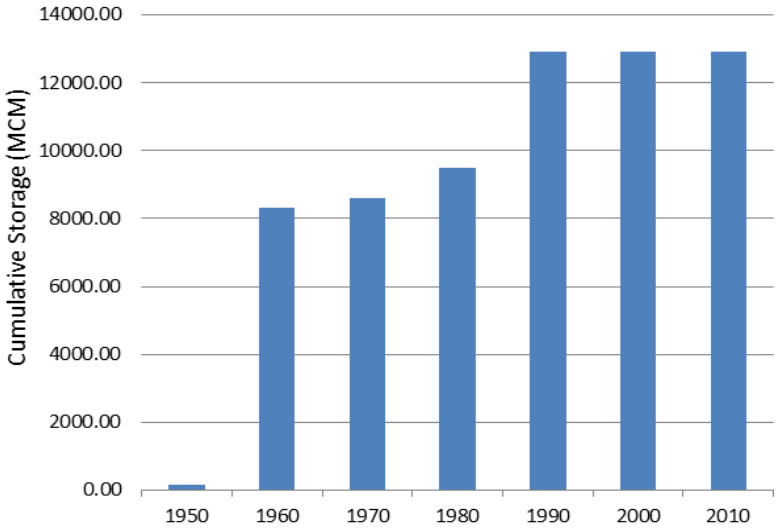


Fig. 2.6 | Cumulative storage in upper and middle Mahanadi Basin

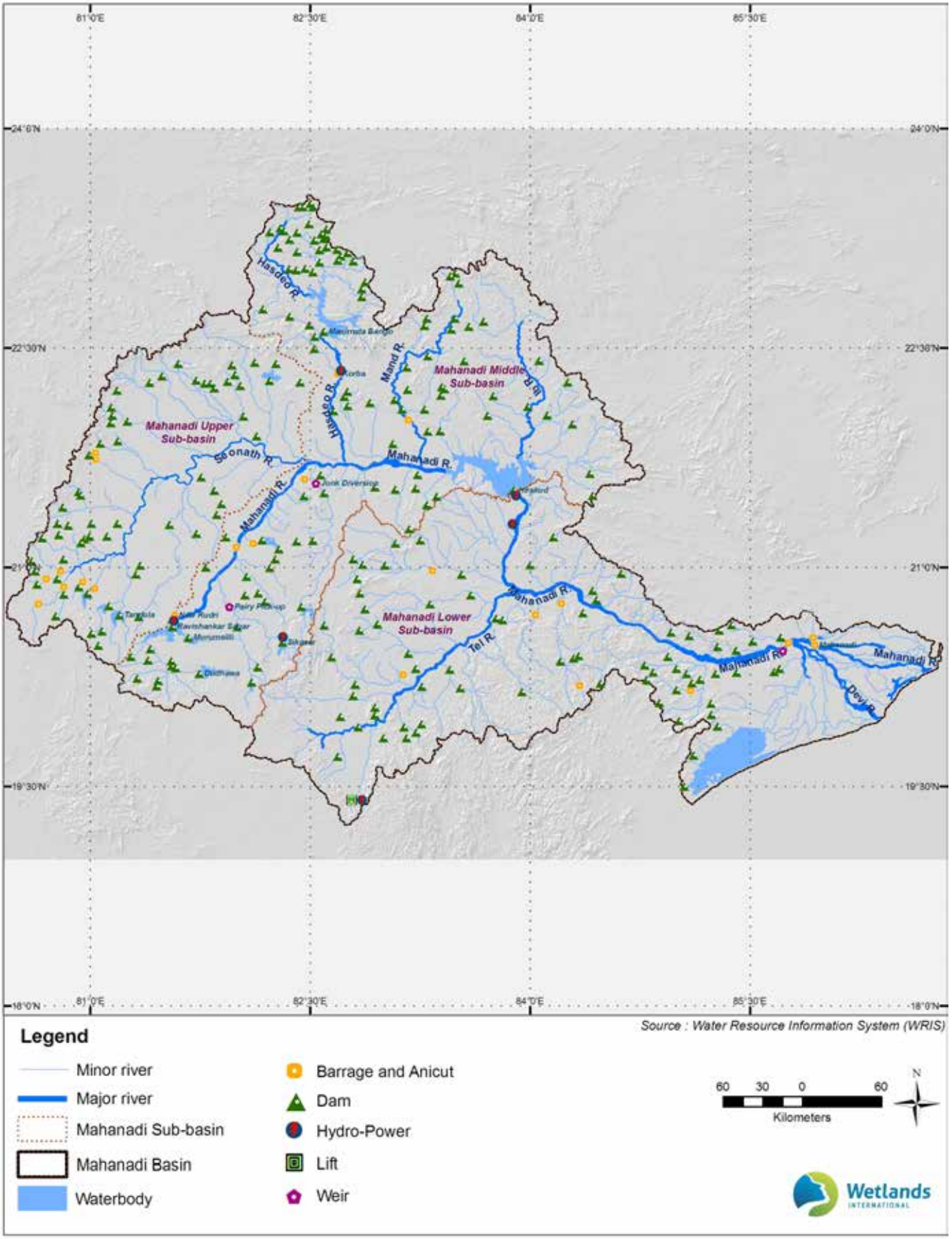
infrastructure to achieve its desired functions.

While considering sedimentation in reservoirs, it is useful to distinguish the role of coarse and fine sediments. Coarse sediments (gravel and sand) gives the form to riverbeds, and often creates ecologically significant habitats as riffles and pools. Fine grained sediment is a key constituent of floodplains and mudflats, and provides turbidity which helps transport nutrients and contaminants absorbed in clay material. Reduced supply of coarse sediment leads to channel incision, as can be seen in stretches downstream of Hirakud Reservoir. Reduced supply of fine sediments prevents building of floodplains and deltaic ecosystems, and altered nutrient conditions downstream. The location of sediment deposition in the reservoir is influenced by several factors as amount of sediment load, size distribution, fluctuations in stream discharge, reservoir shape, stream valley slope, and extent of catchment vegetation. As the river enters the reservoir, the dam infrastructure and increase in waterspread impede the flow and cause settling of the sediment. Progressively smaller sizes of materials are deposited in the higher contours creating a gentler slope towards the lower elevations.

At the time of design, the annual silt loading from Hirakud catchment was estimated to be 29.8 MCM, and it was projected that 8% of this silt would be deposited into the reservoir. With deep sluices constructed to remove coarse silt, it was estimated that the dead storage capacity of 1480 MCM would be sufficient. The silt accumulation was anticipated to range between 9.8 – 14.8 MCM, thereby the dead storage could function for over 100 years. Prevailing estimates from Grand Coulee Dam (USA) and Aswan Dam (Egypt) were used to arrive at these projections.

However, silt yields post commissioning of the dam were observed to be considerably higher (40 MCM) due to which the dead storage was increased to 2,260 MCM.

Sedimentation surveys were initiated right after Hirakud's commissioning. Surveys during 1947-51 indicated an annual silt yield of 36.47 MCM, of which 57% was deposited in the reservoir. The three cycles of hydrographic surveys concluded in 1979, 1982 and 1986, indicated annual silt



Map 2.13 | Hydraulic structures in Mahanadi Basin

deposition rate in the reservoir to be 54.25, 56.06, and 50.96 MCM respectively (GoO 1980, GoO 1983, GoO 1986).

In 2005-06, sedimentation survey of the reservoir was conducted using multi-date LISS III satellite data (NRSA, 2007). Water spread corresponding to each day of satellite overpass was estimated, and the derived reservoir capacity was compared with the original provision to compute the loss in storage due to sedimentation. A total loss of 2174.77 MCM (26.83%) was observed in gross reservoir capacity. The majority of the loss (1485.79 MCM, or 65.7%) was in the dead storage capacity (ibid).

The last sedimentation survey is still a decade old. The status of reservoir sedimentation at present has been projected using the sedimentation rates observed during 1986-2006 (Table 2.8). The analysis indicates that there is a likely loss of 30.21% of the reservoir capacity at the FRL. Of the total accumulation of 2,448 MCM of silt, 73% is settled within the dead storage elevation. Unless measures are put in place to manage silt inflow, the entire dead storage could be silted up within another 15 years. The impact of reservoir on sediment trapping is also apparent. Over 1973 – 2009, there has been as much as 67% reduction in river sediments reaching downstream (Gupta et al., 2012), leading to shrinkage in Mahanadi Delta.

Sediment quality has a significant influence on various ecosystem processes and life forms within aquatic ecosystems. Sedimentation surveys carried by the Department of Water Resources till date have mostly focused on the physical aspects, in particular sediment grain size. In 2007, CIFRI conducted assessment of sediment quality of the Mahanadi River, including stations upstream and downstream of the reservoir (Pathak et al., 2007). Data from the survey is summarized in Table 2.9.

The river sediment mainly comprises sand with minor proportions of silt and clay. The clay content is relatively higher in the upstream reaches. For most parts, the sediments tends to be neutral to slightly alkaline, except in select downstream areas wherein marginally acidic patches have been observed. The sediment is rich in nitrogen and phosphorus, but has low organic carbon content. Trapping of sediments, particularly fine sediments behind the reservoir is likely to reduce nutrient transport to the downstream river channels and wetlands of Mahanadi Delta, though a compensation from agricultural runoff is also likely to take place.

Table 2.8 | Changes in Hirakud Reservoir water holding capacity

Elevation (m amsl)	Original Provision (MCM)	Capacity in 2006 (MCM)	Capacity in 2014 (Projected)	% capacity loss
179.83 (MDDL)	2,262.11	776.32	483.28	78.64%
181.36	2,612.04	1,034.00	699.20	73.23%
182.83	3,290.01	1,573.19	1,277.78	61.16%
184.4	3,681.26	1,893.39	1,508.79	59.01%
185.98	4,547.42	2,644.37	2,313.27	49.13%
187.45	5,042.61	3,078.89	2,647.43	47.50%
189.1	6,124.40	4,075.31	3,742.96	38.88%
190.5	6,742.75	4,640.95	4,208.93	37.58%
192.02 (FRL)	8,104.99	5,930.22	5,656.43	30.21%

Table 2.9 | Sediment quality upstream and downstream of Hirakud Reservoir

	Physical composition			Chemical composition					
Stretch of Mahanadi	**Sand (%)**	**Silt (%)**	**Clay (%)**	**pH**	**Sp. Conductance (mS/cm)**	**Free $CaCO_3$ (%)**	**Organic Carbon (%)**	**Av. Phosphorus (mg/100g)**	**Av. Nitrogen (mg/100g)**
Upstream of reservoir (Chikli to Tamdei)	91.60-92 (91.8)	5- 5 (5.00)	3- 3.4 (3.2)	7.0-7.3 (7.1)	0.24 - 2.2 (1.26)	2.5-2.6 (2.5)	0.46 -1.22 (0.84)	1.08-1.1 (1.09)	5.3 -5.5 (5.4)
Downstream of reservoir (Durgapalli to Sambalpur)	96-97 (96.5)	2-2.5 (2.25)	1-1.5 (1.25)	6.7-7 (6.85)	0.061-0.089 (0.075)	1.0 -2.62 (1.81)	0.60- 0.69 (0.64)	0.82-1.3 (1.06)	6.7-7.4 (7.05)

Reservoir operations

To be able to deliver its functions, the water in the Hirakud Reservoir is required to be maintained to a level as low as possible before the monsoons so that flood water can be stored. Also, by the end of the monsoon, the dam needs to be filled to its capacity in order to provide water for various human uses during non-monsoon period.

Several committees have been constituted from time to time for recommending reservoir operation rule. The rule curve prescribed in the Reservoir Operation Manual of 1957 was amended in 1976 to address the needs of water allocation for agriculture. The 1957 recommendation was to maintain a level of 180.19 m at the beginning of monsoon (July 1) and achieve the FRL of 192.02 m by the end of season. The 1976 amendment put in an intermediate target of 185.92 m by August 10, and reaching 191.11 m by September 21 to ensure sufficient water availability for irrigation purposes.

In 1988, the rule curve was further amended on recommendations of committee constituted by Central Water Commission, which deemed necessary taking into account the impacts of reservoir sedimentation and variability in inflow patterns. The 1988 curve, which guides reservoir operations till date, recommends maintenance of reservoir levels between 179.83 and 181.36 m amsl during the beginning of monsoon (July 1 to August 1), and gradual filling up the reservoir by October 1 (Fig. 2.7). Above 190.5 m amsl, safety of dam is prime consideration.

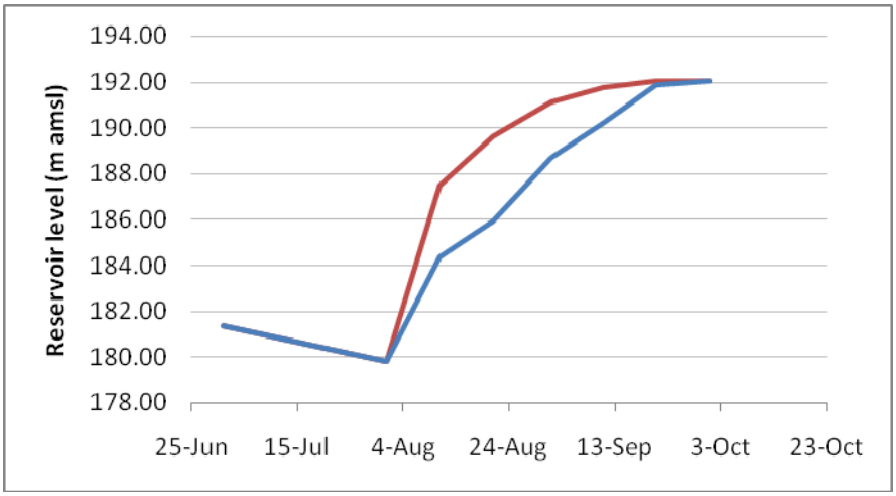


Fig. 2.7 | Hirakud Reservoir rule curve (1988)

For flood control, releases from Hirakud are so regulated such that the downstream release as well as runoff from downstream catchment remain within the safe limit of 28,300 m^3/sec at Naraj, which is at the apex of the Mahanadi Delta. The High–Level Technical Committee constituted for assessing water use in Hirakud observed that the frequency

of floods post Hirakud had come down to 3.3 events per 10 years, as against 8 events in 10 years observed during 1868-1946. However, the ability of reservoir to moderate high flood events has been subject to debate. There is a substantial downstream area not regulated by Hirakud and which can cause floods in the delta region. Moreso, releases from upstream reservoirs when the Hirakud is nearing full capacity can limit the effectiveness of flood control offered by the latter.

It is apparent that with increasing water regime variability, the process of reservoir operation rule setting will need to be more adaptive. As argued in the previous section, inflows are no longer natural, but include releases from upstream structures as a major component. Therefore, to achieve downstream flood protection, the rule curves of major structures need to be synchronized through use of better flow forecasting mechanism.

Water quality

There is no comprehensive system of water quality assessment in place for Hirakud. Assessments conducted at different points in time are the best available information for interpreting status and trends in water quality. Annual data from six stations of CPCB (two each within reservoir, upstream and downstream stretches) are available for 2007-2010 period (CPCB, 2007a, 2007b, 2008, 2009, 2010, 2011). Mishra et al. (1989) and Sugunan and Yadava (1992) provide insights into water quality status of the reservoir prevailing during 90s. Kar et al. (2010) have conducted sampling in reservoir downstream. Satpathy and Satpathy (2015) report reservoir water quality data for the period 2008-14. The action plan for abatement of pollution in Ib-Jharsuguda Valley prepared by Orissa Pollution Control Board (OPCB, 2010) present an overview of water quality in Ib-Jharsuguda Valley. In order to assess trends, the available data has been classified into five year periods along reservoir upstream, reservoir proper, and reservoir downstream stretches. Similarly, data from Ib Valley has been classified into upstream and reservoir confluence areas. It is however clarified that the data so presented is not based on systematic sampling and use of consistent methodology, and therefore is at best a broad generalization of the surface water quality status (Table 2.10 and 2.11).

Effluent discharge at Chaltikra drain connected to Ib River

The water quality reflects anthropogenic activities taking place within the respective stretches. The entire stretch is well-oxygenated and has low biological oxygen demand. In the reservoir upstream stretch, high level of nitrates may be associated with discharge of raw sewage into Mahanadi by Kelo River and adjoining drainages.

Table 2.10 | Seasonal variation in water quality of Hirakud Reservoir

Parameter	2005-2009								
	Pre-Monsoon			Monsoon			Post-Monsoon		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
Physical parameter									
Temperature (°C)	35	30	32.5	29	26	27.5	32	19	25.5
Turbidity (NTU)	18.1	5	11.55	855	116	485.5	32	0.9	16.45
TDS (mg/l)	161	104	132.5	106	72	89	108	87	97.5
TSS (mg/l)	142	10	76	376	120	248	31	10	20.5
Chemical parameter									
pH	7.8	7.4	7.6	8.3	7.1	7.7	8.2	7	7.6
Conductivity (mS/cm)	215	160	187.5	200	120	160	225	113	169
DO(mg/l)	8.1	7.1	7.6	7.8	6.2	7	10.3	7.1	8.7
Chloride (mg/l)	9	6	7.5	8.7	4	6.35	13.6	5	9.3
Total alkalinity (mg/l)	120	86	103	46	42	44	86	66	76
COD (mg/l)	8	7.6	7.8	13.6	9.6	11.6	10.3	4.1	7.2
BOD (mg/l)	1.2	0.9	1.05	2.5	0.7	1.6	1.2	0.2	0.7
Nitrate (mg/l)	3.2	0.2	1.7	1.1	0.2	0.65	0.6	0.2	0.4
Phosphate (mg/l)	0.1	0	0.05	0.2	0	0.1	0	0	0
Sulphate (mg/l)	9.1	7.7	8.4	13.3	9.9	11.6	12.8	5.4	9.1
Fluoride (mg/l)	1.4	0.1	0.75	0.5	0.1	0.3	1	0.2	0.6
Lead (mg/l)	0	0	0	7.8	7.8	7.8	10	6.2	8.1
Mercury (mg/l)	0	0	0	0	0	0	0.1	0.1	0.1
Biological parameter									
Faecal Coliform (MPN/100 ml)	7900	700	4300	2100	920	1510	1400	140	770
Total Coliform (MPN/100 ml)	24000	1400	12700	4300	1600	2950	2400	240	1320

Table 2.11: Trends in water quality in Hirakud and its upstream and downstream areas

	Mahanadi upstream					Hirakud Reservoir proper							Ib Valley			Reservoir downstream				
	Confluence with Mand		Riverine stretch between Mand confluence and Reservoir confluence			Transition zone		Lotic Zone					Reservoir Upstream	Reservoir confluence		Immediate downstream			Mahanadi River Downstream Stretch (Sambalpur-Huma)	
	2006-2010	2011-2015	1996-2000	2006-2010	2011-2015	1991 1995	20062010	1985-1990	1991-1995	2001-2005	2006-2010	2011-2015	2006-2010	2001-2005	2006-2010	2001-2005	2006-2010	2011-2015	2006-2010	2011-2015
Physical parameter																				
Temperature (°C)	25-34	24-33	27.3	23-35	24-32	-	26.9	21-30	-	21-29	26-32.2	24-32		24-29			17-39	22-34	18-38	20-30
Turbidity (NTU)						-		-	-					2-6.9		1-6.4	85-96.1			
Transparency (cm)			108.5	59		110	158	-	-											
TDS (mg/l)			2	1.13		-	96	-	-	161		98-112		88-134		98-132	73-285.8			
TSS (mg/l)				99		-		-	-								31.6-45.7			
TS (mg/l)																	283.1-331.6			
Chemical parameter																				
pH	7.5-8.7	7.5-8.5	8.1	7-8.4	7.4-7.4	8.2	8.1	7.3-8.5	8.2	7.1-8.2	7.6-8.3	7.4-8.3	6.7-8.4	6.5-8.1	6.9-8.4	6.8-8.4	6.7-9.3	7.2-8.3	6.9-9.1	7.5-8.4
Conductivity (mS/cm)	112-305	90-224	195	139-309	248-301		192	0.11-0.29		123-214	182-243	120-261		85-269		75-287	75-301	121-333	118-266	139-272
DO(mg/l)	6.4-7.6	6.7-8.0	8	6.4-7.6	7.1-7.4	9.6	8.45	6.8-12.0	8.6	6.9-9	6.2-8.4	7.8-8.6	6-9.3	5.6-9.4	6.9-9.2	4.5-10	4.4-10.2	5.3-9.6	5.9-9	6.3-9.1
Chloride (mg/l)						7.4		-	5.5			5.8-9.4					49.6-64.3			
Total alkalinity (mg/l)			87.2	89.7		39.6	84.7	60-88	39.6	120				84-120		80-104	27.1-66			
Free CO^2 (mg/l)			0.91	0.91			0.91	03- 08									0.63-1.83			
Total hardness (mg/l)			89.4	94.2		60	84.6	57.5-80.0	48								60-143.4			
Total Chloride (mg/l)			34.2	35.7		-	32.7	15-25	-					8-12						
COD (mg/l)						-		-	-	7.7	13.6			4-23.4		4-23.2	9.7-53.2			
BOD (mg/l)	0.2-2	1.1-1.3		0.8-3.1	0.9-1.6	-		-	-	0.4-0.7	0.9-2.5	0.8-2.0	0.3-2.4	4	0.4-2.2	0.1-1.4	0.4-37.5	0.6-3.3	0.6-3.0	1.0-2.9

	Mahanadi upstream					Hirakud Reservoir proper							Ib Valley			Reservoir downstream				
	Confluence with Mand		Riverine stretch between Mand confluence and Reservoir confluence			Transition zone		Lotic Zone					Reservoir Upstream	Reservoir confluence		Immediate downstream			Mahanadi River Downstream Stretch (Sambalpur-Huma)	
	2006-2010	2011-2015	1996-2000	2006-2010	2011-2015	1991 1995	20062010	1985-1990	1991-1995	2001-2005	2006-2010	2011-2015	2006-2010	2001-2005	2006-2010	2001-2005	2006-2010	2011-2015	2006-2010	2011-2015
Nutrient parameter																				
Nitrate (mg/l)	1-1.75	1.39-2.70		0.96-1.27	1.16-1.93	0.05		-	0.06	0.2-3.2		0.03-5.71		0.1-1.7		0.1-2.2	0.06-1.8	0.01-1.30	0.5-0.81	0.01-0.68
Phosphate (mg/l)						0.04			0.025							0-0.8				
Silicate (mg/l)						7		-	10											
Silica (mg/l)						-		10-20	-											
Inorganic salts																				
Calcium (mg/l)			20.13	21.1		52	19.16	-	40								16.1-16.6			
Magnesium (mg/l)			9.455	10.4		8	8.87	-	8											
Sulphite (mg/l)						-		0.37-1.12	-											
Sulphate (mg/l)						-		-	-								67.3-73.09			
Fluoride (mg/l)						-		-	-	1.4				0.3-0.8		0.2-1.1	0.59-0.75			
Cyanide (mg/l)						-		-	-								0.057-0.073			
Heavy metal																				
Arsenic (mg/l)						-		-	-								0.0029-0.0034			
Mercury (mg/l)						-		-	-								0.0011-0.0014			
Biological parameter																				
Faecal Coliform (MPN/100 ml)						-		-	-	450-7900	767-1125	330-1500		130-14000		490-24000	206-160000	310-92000	430-22000	140-13000
Total Coliform (MPN/100 ml)	05-2400	10-22		43-240	43-240	-		-	-	1300-24000	1510-2025	700-4300	940-3500	230-22000	130-1500	330-92000	467-1600000	700-160000	1300-43000	700-26000

Within the reservoir, higher levels of Chemical Oxygen Demand has been recorded, and the trend has been increasing over time. The reservoir also has high nitrate, total coliform and fecal coliform levels. These observations are correlated with higher COD and coliform levels recorded in the industrial cluster of Ib-Jharsuda. Water quality significantly deteriorates in the immediate downstream region. In this stretch, high level of COD, sulphite, fluoride and cyanide and mercury are recorded. The concentration of coliform in particular has been observed to increase by several times. Further downstream, observations are available only for a limited set of parameters, which indicate continued incidence of high coliform concentrations.

The Ib-Jharsuguda Valley has been identified as a critically polluted industrial cluster of the state (Map 2.14). Of the 50 major industries existing in the region, 17 have been classed as highly polluting. There is a high concentration of aluminium smelting, coal washeries and iron and steel sponge producing units in the region, with inadequate waste treatment facility. The region produces over 3,000 MT of fly ash annually, a significant proportion of which is washed into the reservoir. Drainages of Bheden, Ib and Khakhari bring in a high level of pollutants into the reservoir. The State Pollution Control Board in its 2010 assessment has indicated the possibility of an eight fold increase in fluoride bearing material into the reservoir (126,000 tons of fluoride bearing hazardous waste) (OPCB, 2010). Instances of widespread crop losses due to discharge of fluoride contaminated effluents have been reported from villages in Sambalpur, Jharsuguda, Bargarh and Sonepur districts.

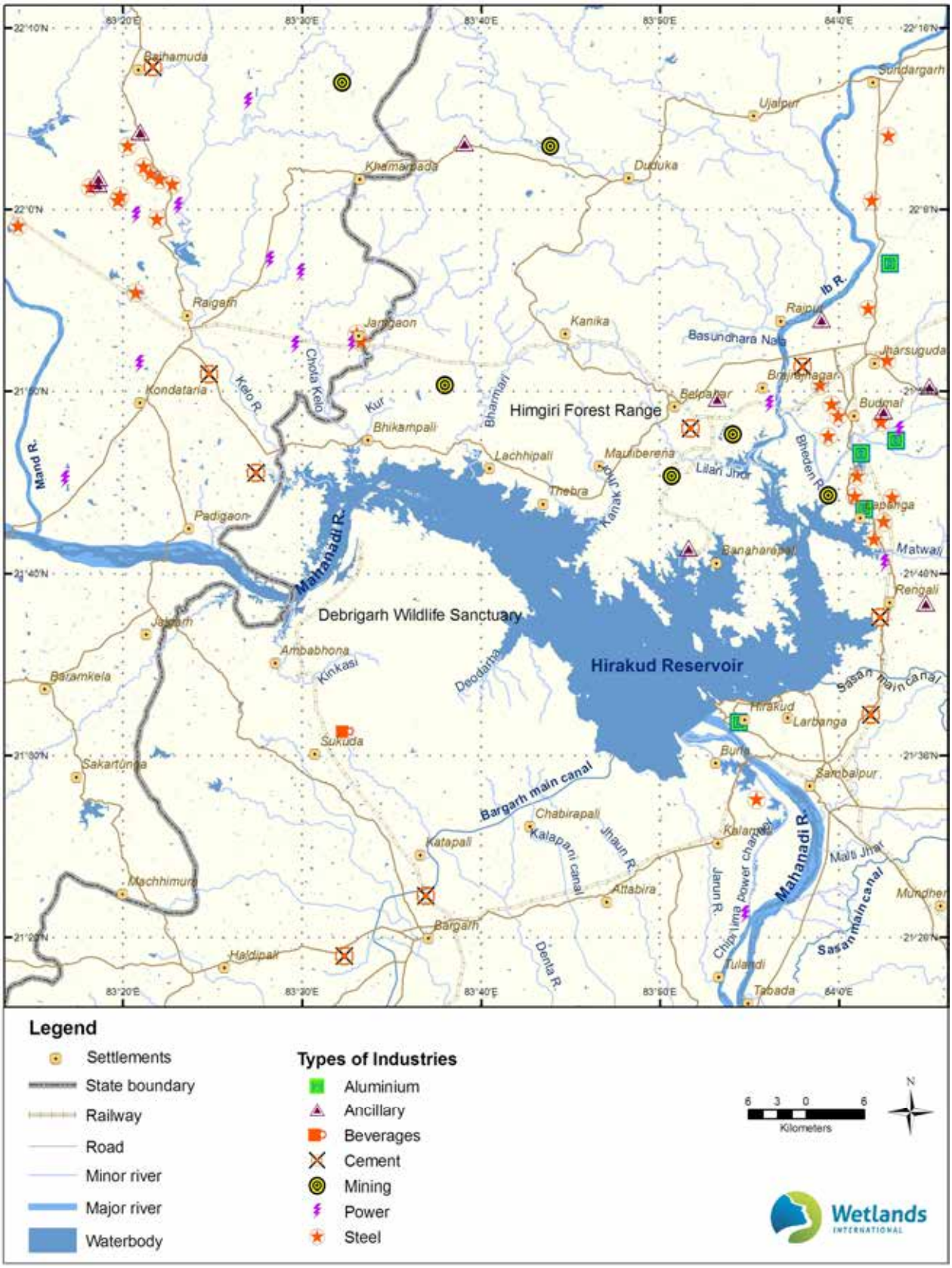
Water use

The reservoir storage built up during monsoon is used to meet water requirements for various sectors. Allocation for various uses is as per recommendations of the Hirakud Coordination Committee constituted under the Chairmanship of Commissioner-cum-Secretary, Department of Water Resources.

Hydropower | Water from the reservoir is used for hydropower generation through dam toe power house at Burla, set up with an installed capacity of 198 MW and expanded to 276 MW. A second power house at Chiplima with installed capacity of 72 MW uses the tailrace of the Burla power station. Power production from Chiplima has been considerably lower than the design capacity on account of poor inflow channel maintenance. Average withdrawal for power generation in non-monsoon period during the last 25 years is 9,554 MCM, of which 41% is availed during monsoon period (June to September) (GoO, 2007).

Irrigation | Hirakud Irrigation Project has a Culturable Command Area of 157,810 ha.

Bargarh main canal



Map 2.14 | Location of industries around Hirakud Reservoir

Over the last 25 years, annual withdrawal of water for irrigation during non-monsoon months (October to May) has been 1681 MCM. In addition, the tailrace of power houses provides water for irrigating 136,000 ha of Delta Stage II and stabilization of irrigation in 167,000 ha of Delta Stage I.

The overall water requirement and allocation for agriculture has increased. The extent of paddy cultivation during kharif projected to be 70% in the original project report reached to 98% by 2007.

Similarly, paddy cultivation during rabi has increased to 60% as compared to 33% envisaged during design period. The quantum of water withdrawn to irrigate per unit area is seen to be steadily on rise indicating reduction in efficiency of water use. Distribution of water to the tail end users has been an issue of concern.

Industrial use | The reservoir was envisaged to be a stimulus for economic development of the region, by ensuring access to stable flows for irrigation and industries. Development of agriculture, however, was much faster and industries caught up pace only since later 80s with establishment of thermal power based industries in the region. In 1990, the Department of Irrigation, Government of Orissa decided to utilize 390 MCM of water for industrial use. By 2010, water allocation to industries stood at nearly 500 MCM per annum.

Thermal power plants including captive power plants and other heavy industries are the major consumers of water accounting for nearly 80% of the total water allocated to industries from the reservoir. It is reasoned that industries generally have over 80% regenerated water for reuse by recycling. In actuality, about 90% of the total water consumed by industries such as iron and steel, thermal power and aluminium plant which operate under high temperature conditions, is expected to evaporate and only 10% returning as effluents from these industries. With the proposal for establishment of more industries in the region, industrial water demand from the reservoir is expected to increase further in the future.

Municipal supply | Towns like Brajaraj Nagar and Belpahar situated on reservoir periphery also draw their municipal water demand from the Hirakud Reservoir. Present use is about 7.4 MCM per annum, of which two thirds (67%) is drawn during non-monsoon period (GoO, 2007).

Discharge of effluent from Bhushan industry

Optimally meeting the stipulated water demands from the reservoir storage has been one of the important management objectives of the reservoir till date. To assess the current situation, a monthly water balance based on the available water inflow and outflow data is presented in Table 2.12. As can be seen, any further

allocation of water during the months of May and June would bring the reservoir close to its MDDL.

There was no allocation planned for industries in the reservoir design. Presently, water allocation to industries is compensated with reduced allocation to hydropower, and a compensation scheme under consideration. There is no consideration of the freshwater flow requirement for functioning of downstream ecosystems. Ecosystem services and biodiversity values of downstream wetlands as Lake Chilika and Bhitarkanika mangroves is critically linked to freshwater flows, availability of which to a large extent is governed by upstream hydraulic structures as Hirakud.

Key issues

The analyses of available information on hydrological regimes of Hirakud Reservoir indicate the following issues:

Siltation | The reservoir has been silting up at rates faster than envisaged. At current rates, it is likely that the entire dead storage would be filled up in another 15 years, reducing its capability to moderate water regimes and provide water for various developmental usages.

Water quality deterioration | The industrial cluster of Ib-Jharsuguda is adversely impacting water quality of the reservoir and its downstream stretches. As the reservoir also supports fisheries and agriculture, maintenance of water quality is required from human health concerns, as well as that of diverse wetland dependant biota.

No ecological considerations for environmental water requirements| Present system of reservoir operations only addresses human needs. Trade-offs between industrial water use and hydropower are apparent. No consideration is made for water requirements for maintaining downstream ecosystems.

Low water efficiency in agriculture | Water use per hectare of irrigated area has been increasing. There is considerable scope for improving water efficiency as a means of reducing water conflict.

Table 2.12 | Monthly water balance of Hirakud Reservoir

Month	Water level at month beginning	Storage at month beginning	Inflow	Water use and outflow	Net Storage	Water level at month end	Storage at closing
	m amsl	MCM	MCM	MCM	MCM	m amsl	MCM
Jan	189.75	4,501.49	291.70	828.50	(536.80)	188.78	3,964.69
Feb	188.78	3,964.69	220.75	795.24	(574.48)	187.66	3,390.20
Mar	187.66	3,390.20	164.49	937.76	(773.27)	185.96	2,616.93
Apr	185.96	2,616.93	138.67	1,003.93	(865.27)	183.65	1,751.66
May	183.65	1,751.66	91.68	773.07	(681.40)	181.23	1,070.26
Jun	181.23	1,070.26	1,198.67	1,197.23	1.43	181.23	1,071.70
Jul	181.23	1,071.70	6,654.00	5,408.26	1,245.74	185.22	2,317.43
Aug	185.22	2,317.43	10,557.01	8,345.74	2,211.28	189.80	4,528.71
Sep	189.80	4,528.71	7,975.69	7,114.96	860.73	191.22	5,389.44
Oct	191.22	5,389.44	2,451.96	2,656.12	(204.16)	190.90	5,185.28
Nov	190.90	5,185.28	712.32	915.24	(202.93)	190.57	4,982.35
Dec	190.57	4,982.35	361.41	777.21	(415.80)	189.75	4,566.55

2.2.3 Biodiversity

Reservoirs have been implicated for transformation of riverine biodiversity due to impediments caused to species migration and alteration of habitats. However, after passing through a cycle of trophic burst and depression, these structures are known to provide conducive environment for a range of species adapted to the altered conditions.

While riverine and lacustrine habitats coexist in a large reservoir as Hirakud, these large waterbodies also bear their own distinct habitat characteristics. Longitudinal gradient is developed beginning from the river entrance into the reservoir towards the dam structure. The riverine zone is relatively narrow and well-mixed, and although velocities tend to decrease, advective forces are still sufficient to transport significant quantities of fine suspended particles, such as silts, clays and organic particles. Light penetration is minimal limiting primary production. An aerobic environment is maintained as the zone is shallow and well-mixed. Significant sedimentation occurs through transition zone with a subsequent increase in light penetration. The lacustrine zone is characteristic of deep lake system. Light penetration in margin is sufficient to promote primary production with protection from nutrient limitation.

The lotic sector of reservoir provides conducive habitat for riverine communities, while the lentic sector harbours communities adapted to still water conditions. During peak monsoon months, the entire reservoir progresses towards lotic environment, gradually switching to lentic conditions during non-monsoon months. Alternate wetting and drying of the margins of the riverine stretches and long littoral zones allows for higher nutrient enrichment and providing habitats for macrophytes to colonize. In comparison, the deeper lacustrine parts allow planktons and nektons to colonize. An interplay of these habitats sustain the biodiversity values in a reservoir ecosystem. Beyond reservoir waterspread, considerable species exchange also takes place with upstream and downstream habitats, signifying their role in maintaining biodiversity in the wider landscape.

Hirakud Reservoir is yet to be systematically investigated for the richness of species and habitats. Nor has the role of the reservoir been assessed in maintaining species populations in upstream and downstream stretches. Much of the pre-impoundment surveys focused on icthyofauna (Day, 1889; Hora and Law, 1941; Job et al., 1955). Limited research on planktons was carried during the late 80s (Dash et al., 1993). An overview of the fish and planktonic diversity is provided in Sugunan and Yadava (1992). In 2007, CIFRI published a study on ecological status and productivity dynamics of entire Mahanadi River, including stations immediate upstream and downstream of the reservoir (Pathak et al., 2007). Asian Waterbird Census programme carried since 1993 (also

Vetiveria zizanioides stands near Chikli

used to collate trends as reported in Nair et al., 2014) provide insights into the significance of reservoir as waterbird habitat.

For groups as Periphyton, Macrophyte, Zooplankton, Mollusc, Insects, Amphibians and Reptiles, available information pertains to the river, and thus are only of indicative purpose (Table 2.13).

This section of the management plan builds on the available literature and field surveys to present an overview of the floristic and faunistic diversity in the reservoir, and key issues that constrain maintenance of these values. Wherever relevant, the IUCN Red List of Threatened Species version 2015.3 has been used to assess conservation status.

Flora

Information on floral communities present in Hirakud and Mahanadi River is limited to phytoplankton and macrophytes. Phytoplanktons and aquatic vegetation are key constituents of the grazing food chain. Widely varying inundation regimes and silt accumulation in the shorelines create conductive environments for these species. Assessments of phytoplanktons is however nearly three decades old, and that of the rest dated by a decade.

Phytoplankton | Phytoplankton population of the reservoir is represented by Cyanophyceae (12 species), Chlorophyceae (11 species), Euglenophyceae (2 species) and Bacillariopyceae (14 species) (Dash et al., 1993) (Annex I). The River Mahanadi is reported to have a much higher richness as indicated by occurrence of 29 Bacillariopyceae, 27 Chlorophyceae, 12 Myxophyceae, 11 Desmidiaceae 2 Dinophyceae species.

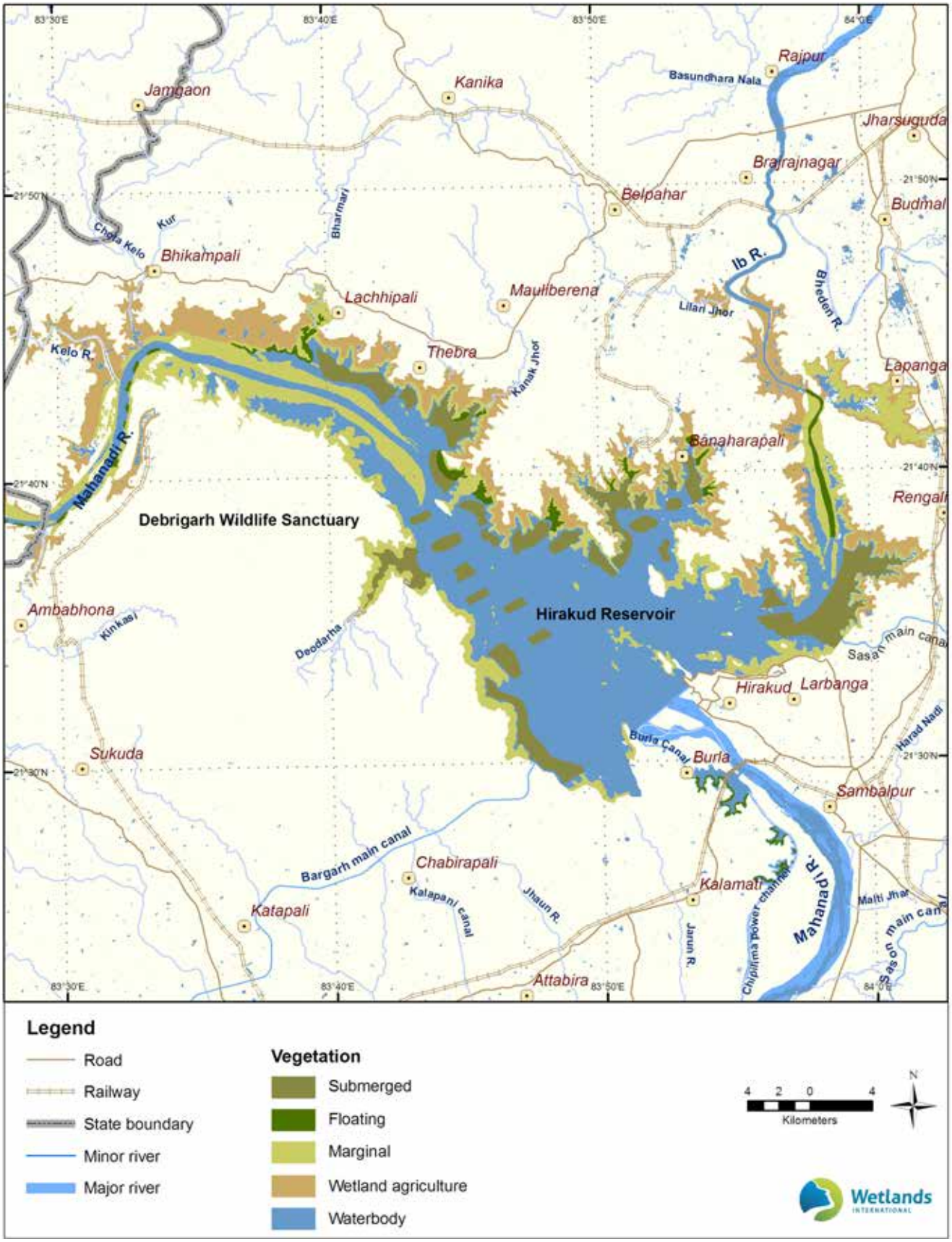
Assessment by Dash et al., 1993, shows a wide range of planktonic density from 2,590/l – 42,474/l in the reservoir. The Gross Primary Productivity (GPP) is estimated in the range of 1.7 g C/m3/day in the summers to 2.7 g C/m3/day in the winters.

Macrophytes | Map 2.15 shows the distribution of macrophytes in the reservoir. Submerged aquatic vegetation is present all along the Mahanadi-Mand confluence till the downstream reaches. *Najas* sp. *Hydrilla* sp., *Vallisneria spiralis* are the key

Table 2.13 | Conservation status of flora and fauna in Hirakud Reservoir and Mahanadi River

Biodiversity	Group	No. of Species	Source	Status						
				CR	EN	VU	NT	LC	DD	NE
Flora	Phytoplankton	39	Dash et al., 1993							39
	Periphyton	36	Pathak et al., 2007							36
	Macrophytes	34	Pathak et al., 2007					22		12
Fauna	Zooplankton	45	Pathak et al., 2007							45
	Molluscs	35	Pathak et al., 2007							35
	Insects	25	Pathak et al., 2007							25
	Pisces	54	CIFT (ca 1995) and Sugunan, 1995		1		6		39	8
	Amphibians	10	Dash and Mahanta, 1993					10		
	Reptiles	7	Rufford Foundation for Nature Conservation, 2005	1	1	2		3		
	Aves	130	AWC Records and Nair et al., 2014		2	8	10	109		1

CR-Critically Endangered; EN-Endangered; VU-Vulnerable; NT-Near Threatened; DD-Data Deficient; LC- Least Concern; NE-Not Evaluated



Map 2.15 | Macrophyte in Hirakud

submerged species. Reservoir margins are colonized by emergents as *Cyperus* sp. and *Polygonum* sp.

Assessment of distribution of macrophytes in the reservoir are yet to be carried out. The Mahanadi River has 34 species belonging to 21 families. Of these, 18 are emergent, 13 free floating and 3 submerged species (Annex III). Their biomass was found to range between 0.1 kg m^2 to 30.4 kg m^2 (Pathak et al., 2007).

Macrophytes tend to accumulate significant amount of nutrients, and thereby tend to colonize patches with high nutrient availability. Such an environment is present at the confluence of Rivers Ib and Bheden, wherein extensive patches of floating (*Eichhornia* sp. and *Salvania* sp.) and submerged (*Ceratophyllum demersum, Hydrilla verticillata* and *Vallisneria spiralis*) macrophytes can be seen. This stretch receives industrial effluent and city sewage all along the year. Such dense growth creates problems for navigation and fishing, and creates impediments for movement of brooders and carp juveniles.

Excessive growth of emergent in Mahanadi River at Chikli (the confluence point of river with the reservoir) had been observed to impede breeding grounds of carps. Shading caused at the surface also adversely affects establishment of benthic organisms.

The shallow segment of reservoir adjoining Lakhanpur has dense stands of *Khas* grass (*Vetiveria zizanioides*) which is extracted commercially for making door mats and air cooler coolants. Forest Department charges revenue for permitting harvest of Khas grass, although the exact amount could not be established during survey. A stretch of the reservoir adjoining Rengali block is used for retting Sunn hemp (*Crotalaria juncea*). Since retting process is known to release inorganic nitrogen and sulphides into waterbodies, its impact needs to be carefully evaluated.

Fauna

Zooplankton | Available information on zooplankton pertain to the entire Mahanadi River, and are not specific to the reservoir. CIFRI, based on the 2007 survey have indicated presence of 45 species in the Mahanadi River. These are constituted of Copepoda (2 species), Cladocera (11 species), Ostracoda (1 species), Rotifera (22 species) and Protozoa (9 species) (Annex IV). Data from Tamdei indicates higher diversity of rotifers as compared to copepods. This may be correlated with high level of nutrients recorded in the reservoir waters.

Submerged vegetation - Potamogeton sp. in Hirakud Reservoir at Lacchipali, Sahasbhaga Village

Planktons play an important role in the food chain of fish species. In particular, zooplankton constitutes an important source of food for fish fries and adults of carps. Creating conducive environments for growth of phytoplanktons at Ib-Bheden confluence and Chikli which are reported by the fisher communities as major fish breeding grounds, is likely to enhance fish catch.

Reservoir fish being sold at Burla

Macrobenthos | The Mahanadi River is inhabited by 35 species of macrobenthos, represented by Gastropoda and Bivalvia (Annex V), predominated by the former. Their density was observed to range between 6 individuals per m^2 to 2217 individuals per m^2 (average ≈ 390 individuals per m^2). Species abundance was recorded to be maximum at *Tamdei*, with low values in the downstream stretches. The 2007 estimates of CIFRI indicate increase in density during post-monsoon while gradually decreases during the monsoon. Colonization of emergents near Tamdei is likely to have adverse impacts of the macrobenthos niches in the reservoir. The macro-zoo-benthos provide a vital link in the shift of energy to the upper consumer level including fishes and plays a vital role in the production processes. Gradual establishment of thick stands of emergent vegetation and low water depth at fringes of the reservoir is not conducive for colonization of these bottom dwellers. Establishment of benthic communities is also limited by reservoir operations.

Fish | Icthyofauna of the Hirakud reservoir and its parent rivers (Mahanadi and Ib) comprises both plain and sub-mountainous forms with sizable representation of carps and catfishes.

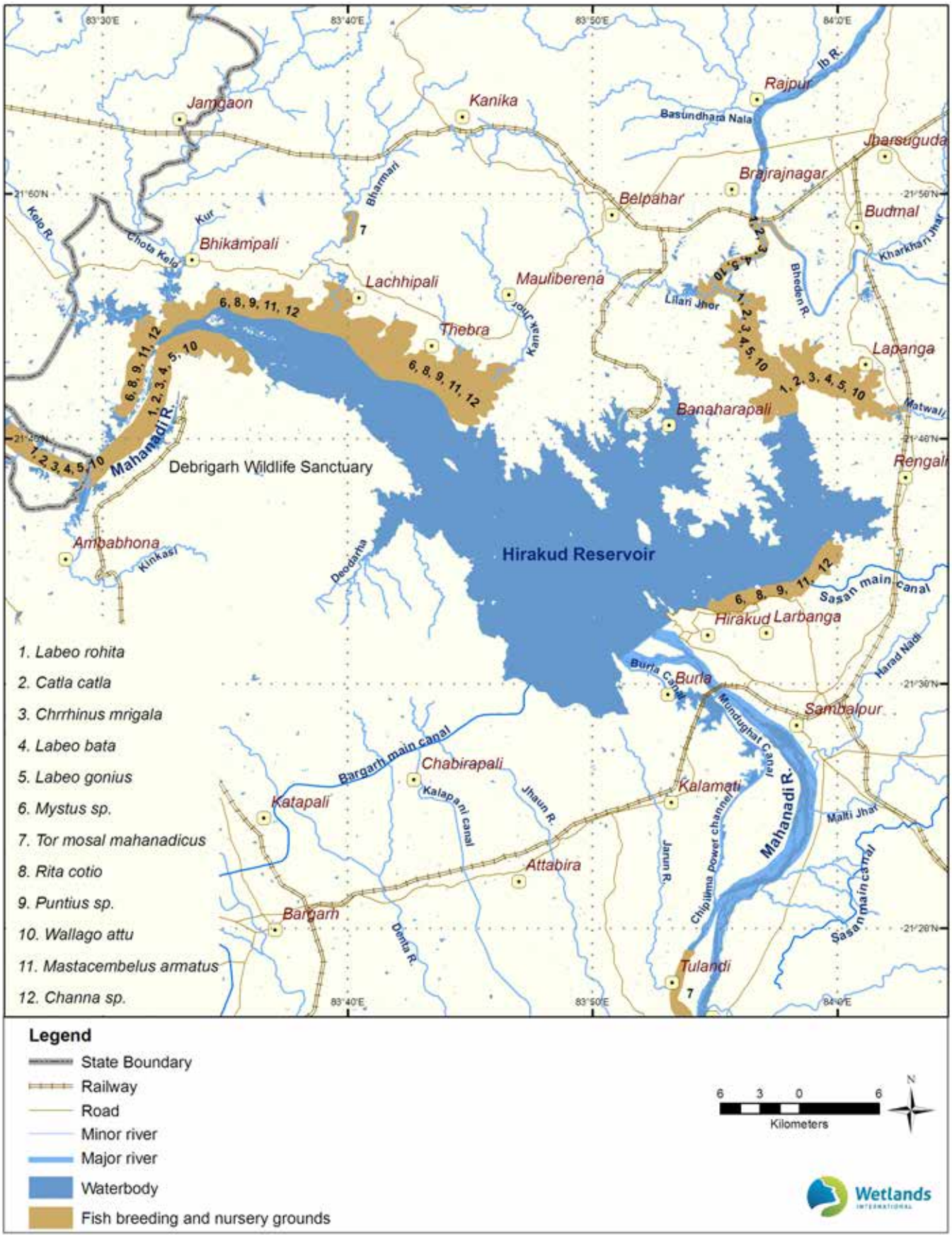
Available information on commercial fisheries of the Hirakud is based on an assessment carried out in 90s by CIFT, Burla. The list of 40 species[1] is dominated by carps (16 species) and catfishes (11 species). The remaining is constituted of 3 air breathing, 1 featherback, 1 mullet, 1 freshwater prawn and 7 miscellaneous species. Sugunan (1995) also present a list of 40 commercial fisheries from a similar period, however the two lists differ by 25 species. In addition, during the present surveys, the fishers indicated that commercial catches since last 5 years have significant presence of *Oreochromis niloticus* (an exotic) and *Pangasius sutchi* (an exotic catfish).

Since both these assessments pertain to similar periods, putting the two together gives a list of 52 exclusive species. Adding to the two recently observed ones takes the list to 54 species (Annex VI). Icthyofauna is dominated by carps (20 species) and catfishes (17 species). Seven species are of high conservation significance (*Pangasius sutchi* being classed as endangered and 6 others[2] near threatened). Map 2.16 indicates the most likely nursery and breeding grounds of major fish species found in the reservoir.

Pre-impoundment fish diversity of Mahanadi River was reported to be as high as 183 species (Job et al., 1955). *Tor mosal mahanadicus, Tor tor* and

[1] The list shared by the Department, based on CIFT survey of the 90s contains 43 species. However, when matched with FishBase records, 3 species could not be confirmed, while for 1, the biological name can be tracked based on the given local name. For management planning thereby the list has been refined to include only 40 species.

[2] [*Tor tor, Wallago attu, Bagarius bagarius, Ailia coila, Ompok bimaculatus, Ompok pabda*]



Map 2.16 | Fish breeding and nursery ground

Indo-Gangetic major carps (IMC) were reported to be common. Day (1889) reported presence of 146 fish species in Mahanadi River, however, much of the sampling was done in Cuttack. Impoundment of Mahanadi River has impeded upstream migration as well as led to conversion of fish breeding grounds, ultimately reducing species richness. The impact was more severe on certain species as *Tor mosal mahanadicus, Notopterus chitala, Mystus aor, Mystus seenghala, Tenualosa ilisha*, and fresh water prawns *Macrobrachium malcolmsonii*. These are no longer known to breed in the reservoir.

The presence of sizeable number of catfish species in the reservoir has been attributed to lack of stocking during the reservoir establishment period (Sugunan, 1995). This allowed the hardy, bottom feeding species to colonize, albeit at a cost to fish productivity. Rivers Mand and Kelo are also known to be rich in catfish species (Tamboli and Jha, 2012).

Tor mosal mahanadicus is an endangered mahseer species with high food as well as game value. Once reported to be abundant in catch throughout the year, (40 mm – 100 mm in size; 100 g – 5000 g) Mahseer is now almost absent from the reservoir (Badapanda, 1996). The population in the river thrives mainly due to community protection offered to the species at Huma temple, Marwarighat of Sambalpur town, and Koilighugar in Belpahar (Box 2).

Deep pockets near Chiplima – Basking sites for reptiles

Aquatic Insects | Aquatic insects constitute a major part of food for aquatic insectivores. The amphibious adaptation of this group thus serves as a vital link for exporting the aquatic biomass to the riparian habitat and vice versa, while also reducing the organic matter and nutrient in the systems (Jackson and Resh, 1989).

Assessment by CIFRI, 2007 confirms the presence of 25 aquatic insect species in the River Mahanadi (Annex VII). Hemiptera (11 species) and Odonata (6 species) dominate the group, the rest constituted by Diptera (4 species), Ephimeroptera (2 species), Placoptera and Trichoptera (1 species each). Dominance of species of order Hemiptera is an indicator of stressed environment. River stretch at Sambalpur was observed to have very high density of Hemipterans during monsoon, which may be attributed to discharge of raw sewage.

Amphibians | Amphibians are key indicators of aquatic ecosystem health (Welsh and Ollivier, 1998, Sheridan and Olson, 2003). Their behavioural ecology and adaptation (for growth, survival and colonization) represent complex biological phenomenon in the habitats. It also helps to determine the stress on the environment and succession processes (adaptation of few species from aquatic to terrestrial mode of life and their microhabitat selections).

No inventorization of amphibians inhabiting the reservoir or the Mahanadi River has been attempted to

Box-2: Mahseer

Mahseers of the genus Tor are large cyprinids endemic to Asia. The genus is popular for cultural, economic, recreational and conservation values, and is listed amongst 20 mega fishes of the world. Due to their large sizes (length upto 3 meter and weight upto 40 kg), Mahseers are also called the *'Tiger of the Water'*.

Mahseer was first reported in India in the year 1984 from the Indrayani River in Maharashtra. The species inhabits hill streams with rocky and stony substrate. Of 47 Mahseer species existing globally, India is home to 13 species and 3 sub-species.

Tor mosal mahanadicus, a sub-species of *Tor mosal (*copper mahseer) is endemic to River Mahanadi. When compared with the latter, *Tor mosal mahanadicus* has head in proportion with body width, longer eyes and greenish yellow colour (as compared with golden yellow of *Tor mosal*). Gonadal development usually take place when male species attains >370 mm and female >480 mm in length. The fecundity was estimated at 10,300/kg body weight. The gravid female has two mature and immature ova released in two phases. The first mature sets are released during the late monsoon (August-September) and the second during winters (November-January). The young fry feeds on insect, their larvae and molluscs but the adult are omnivorous and feed on phytoplankton, macrophyte (tender parts of *Vallisneria* sp. and *Chara* sp.), insect and their larvae and mollusc.

Within Mahanadi, Mahseer is usually found in the river stretch between Sambalpur and Boudh. In the period till seventies, their distribution was much wider. In Hirakud Reservoir alone, nearly 2000 kg of this fish was caught in 1977. Construction of Hirakud Dam has distinctly impacted their upstream migration, limiting its distribution to certain pockets. Protection accorded by the local communities to species populations adjoining Huma, Koilighugher, water fall near Belpahar, and Marwarighat in Sambalpur play a key role in sustaining their populations in Mahanadi River.

The National Commission on Agriculture highlighted the need for Mahseer conservation in India way back in 1976, although no major steps were taken. The Government of Odisha declared Mahseer as its state fish in 2012. Recently WWF-India convened a national workshop in 2013 to outline a strategy for Mahseer conservation. Tata Electrical Group has been supporting a Mahseer conservation initiative (primarily artificial breeding) in Pune since 1970.

The Wildlife (Protection) Act 1972 offers very limited scope for protection of this endangered species. While fishes are included as 'wildlife', they are not considered within the list of 'wild animals'.
(Based on Kulkarni and Ogale, 1979; Menon, 1992; Badapanda, 1996; WWF, 2013)

Mahseer shoals at Huma

Shallow margin of reservoir at Pitapalli village

date. Dash and Mahanta (1993) indicate presence of 10 amphibian species in Sambalpur district (Annex VIII), of which only one (*Euphlyctis ehrenbergii*) is truly aquatic, and two (*Fejervarya limnocharis* and *Hoplobatrachus tigerinus*) known to colonize the aquatic margins.

Reptiles | Three species (*Gavialis gangeticus* - Critically endangered, *Crocodylus palustris* and *Crocodylus porosus*) of crocodilians have been reported from River Mahanadi (Annex IX). Extensive sand bank (on Mahanadi River) along Majhipara, Binkei, Baramul and Atthamalik downstream are natural nesting and hatchling sites of these species. Muggers have been found dominant in Satkoshia Gorge area, while gharials reported from Majhipara- Binkei to basks and nests around. They are usually known to prefer the sandy banks over rocky riverbank.

Waterways connecting Binkei and Kankei is potential threat to crocodile habitats. Reports on death of hatchling in the nesting sites have been alarmingly increasing from the nesting sites of Majhipara.

Four species of turtles (*Chitra indica* Endangered; *Nilssonia gangetica* Vulnarable, *Lissemys punctata* and *Pangshura tentoria*) are resident in Mahanadi River (Rufford Foundation for Nature Conservation, 2005). Their population is sizeable between Athamalik to Naraj. Turtles are also frequently reported from reservoir fish catch. A small population of soft shell turtles is also reported from the power channel at Chiplima.

Birds | Each winter, Hirakud reservoir teems with large population of migrating waterbirds. Asian Waterbird Census, a voluntary mid-winter waterbird count programme, is being conducted in the reservoir since 1993, giving a good insight into the significance of Hirakud as a waterbird habitat. The list of waterbirds, compiled from the census records yields 89 exclusive species. However, a recent analysis Nair et al. (2014) list 112 species. Collating the two datasets yields a list of 130 exclusive species, (Annex X) of which 115 are waterbirds (of which 45 species are winter migrants). Of these, 20 species are of high conservation significance (2 endangered, 8 vulnerable and 10 near-threatened species). The total population of waterbirds regularly exceeds 20,000. For 10 species, the recorded population is equivalent or more than 1% biogeographic population threshold.

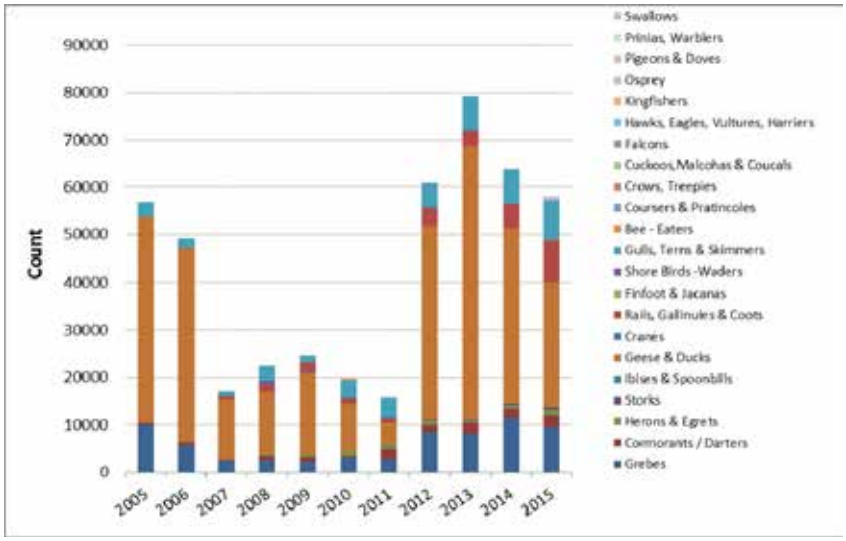


Fig. 2.8 | Annual abundance (2005-2015) of birds in Hirakud Reservoir

The number of birds has averaged 58,095 during 2005-15, with peak counts going upto 79,138 in 2013 (Fig. 2.8). There are nine major congregation

areas in the reservoir (Map 2.17). Fluctuation in counts is largely due to varying coverage in different years. The counts are largely on the lower side as the riverine stretches of the reservoir along Mahanadi River are yet to be comprehensively assessed.

The reservoir and its islands provide three categories of breeding habitat i.e. shoreline and islands for ground-nesting birds; trees along the margin of the wetlands for colonial heronries and marsh and reed bed for marsh birds. Six species were observed to breed in the shoreline and islands[3]. Heronries of egrets, herons, storks, ibises and cormorants have been observed from the village woodlots (Nair et al., 2014). The dense reed beds of *Typha angustifolia* and *Arundo donax* along the margins (near Govindpur) supports the breeding nests of purple herons (*Adrea purpurea*), whistling ducks (*Dendrocygna javanica*), common coots *(Fulica atra*) etc. Beside this, the Debrigarh Sanctuary hosts a range of resident (*Asarcornis scutulata*, *Dendrocygna javanica etc*.) and migratory birds (*Anser indicus*, *Anser anser etc.)* (Box 3).

There have been instances of bird trapping and poaching in the past, especially from Jarimuli Island area, which has been largely curtailed due to the regular patrolling and watch and ward by Forest Department staff. There is a distinct need to put in place systematic efforts for conservation of waterbird diversity through involvement of local communities.

Key issues

Review of available information on biodiversity indicates the following key issues:

Limited knowledge on biodiversity values of the reservoir: Available information on biodiversity values of reservoir is very limited. Given the rapid development around the region, it is important to develop comprehensive baselines so that any adverse change can be prevented.

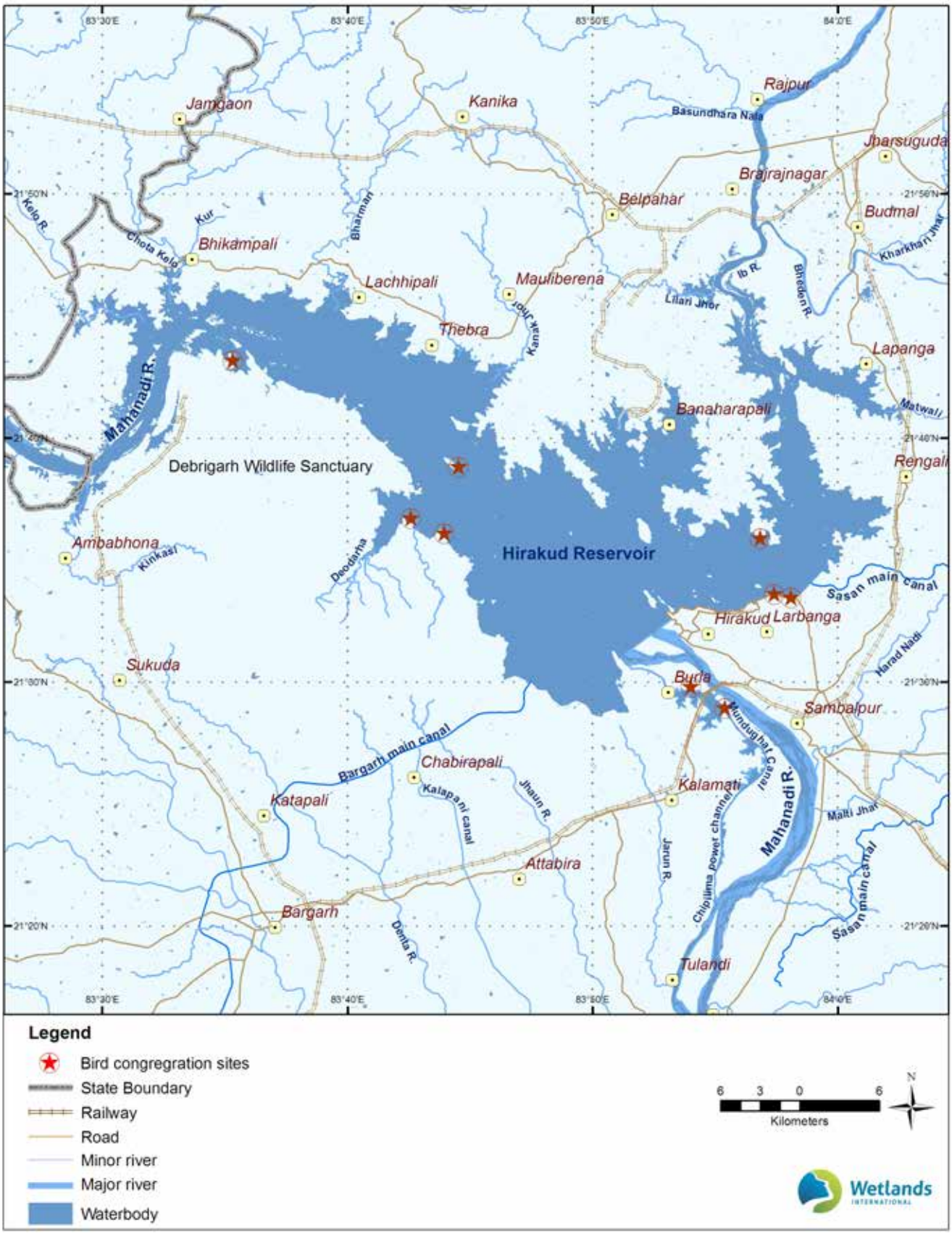
Increasing anthropogenic pressure on key habitats: The riverine stretches of the reservoir are facing increasing land use intensification. This is likely to stress breeding and nesting grounds of fishes. Use of small mesh size nets for fisheries is detrimental for reservoir biota. Continued pollution loading is also likely to replace sensitive species with more hardy ones.

Biodiversity conservation not being used as an opportunity for incentivizing resource stewardship: The rich biodiversity values of the reservoir provide tremendous potential for promoting a community based management. The local communities can be incentivized to benefit from a healthy ecosystem. Such opportunities are however weakly recognized in present management.

Reservoir operations does not integrate requirement of downstream ecosystems: Water regime management at present is only designed to address human needs. Water requirement for downstream ecosystems is not integrated in rule curve setting. Biodiversity and ecosystem processes consideration are not included in Reservoir Rule Curve setting. With intensifying human uses, water allocation for biodiversity and maintenance of ecosystem functions is being increasingly constrained.

Koilighugar stretch of Mahanadi conserved for Mahseer by local communities

[3] *Himantopus himantopus; Glareola maldivarum; Glareola lactea, Charadrius dubius, Sterna albifrons, Vanellus indicus*



Map 2.17 | Bird congregation site

Box-3: Debrigarh Wildlife Sanctuary

Debrigarh Wildlife Sanctuary is located in Barapahar hills of Bargarh District, Odisha. It comprises Lohara and Debrigarh Reserved Forests. The sanctuary was notified in 1985 by the State Government (Govt. Notification No. 2409/FFAH Dtd. 08.02.1985), with an area of 353.81 km^2, of which 79.80 km^2 is the core area. The sanctuary is under the administrative control of Hirakud Wildlife Division.

Debrigarh Wildlife Sanctuary is known for its natural beauty and pristine wilderness. The dry deciduous forests along the margin (one-third of its boundary being bound by the reservoir) harbour a rich diversity of floral and faunal species. Mixed vegetation of *Pterocarpus marsupium* (Bija), *Shorea robusta* (Sal), *Dalbergia sissoo* (Sissoo), *Madhuca longifolia* (Mahua), *Anogeissus latifolia* (Dhaura) dominate the forest while scattered patches of *Dendrocalamus strictus* (Salia bamboo) are sparsely distributed. The bank of the reservoir around the sanctuary forms a continuous patch of grasslands and reeds. The sanctuary is home to *Tetracerus quadricornis* (Four horned antelope), *Bos gaurus* (Indian Gaur), *Panthera tigris* tigris (Tiger), *Panthera pardus* (leopard), *Melursus ursinus* (Sloth bear), *Axis axis* (Chital), *Rusa unicolor* (Sambar), *Boselaphus tragocamelus* (Nilgai). Beside this, the sanctuary also hosts a range of resident (*Asarcornis scutulata, Dendrocygna javanica* etc.) and migratory birds (*Anser indicus, Anser anser* etc.), reptiles (*Crocodylus palustris*), soft shell turtle (*Nilssonia gangetica*). Notably, freedom fighter, Sri Veer Surendra Sai and his team members took refuge into these forests waging Gorilla war against the British. The tract lies in the Chhatisgarh-Dandakaranya region of Deccan Peninsula which is of ancient origin.

The sanctuary receives about 50,000 tourists each year. There are two entry points, Dhadrokusum in the south and Lakhanpur in the north. Six trails have been marked within the forest for tourists. Six eco-cottages were constructed in 2007-8 to provide accommodation to the visiting tourists within the sanctuary, and are managed by local communities. The Debrigarh Eco-tourism and Eco-development Society was formed and registered (under Registration of Society Act of 1860) to administer the eco-tourism activity. However, the society is presently defunct and does not engage in management of tourist facilities. An ecotourism plan for Debrigarh is in the offing for realizing the benefits of ecotourism to its full potential.

Entrance of Wildlife Sanctuary

2.2.4 Reservoir Fisheries

Hirakud Reservoir constitutes an important inland fisheries resource of the state. Reservoirs, on an overall, can play a significant role in enhancing fish productivity thereby overall nutritional security, provided managed on scientific principles. At the same time, such large ecosystems also pose significant management challenges. Stocking based culture fishery, practiced successfully in several small and medium reservoirs, has been found to be of limited impact in large reservoirs due to uncertainties associated with capture of stocked fish. Therefore, a 'stock enhancement' based management, aimed at building breeding populations to augment auto-stocking, can be ideal to support sustainable fish catch on a regular basis (Yadava and Sugunan, 2009). Beyond stocking, such management involves enhancement of species, environment and fishing practices for improving well-being of fisher communities.

In existence for nearly half a century now, Hirakud has emerged from an initial phase of trophic burst and subsequent depression to enter into a stable production environment. Extensive water-spread, reasonably high water depth, abundance of nutrients, availability of lotic and lentic habitats and high food availability create conducive environmental conditions for fisheries in Hirakud. The upstream riverine habitats provide breeding and migration pathways for carp species whereas the shallow zones are used as nesting grounds for catfishes and Murrells. Alternate drying and wetting of margins adds to the overall nutrient availability in ambient waters.

Over the years, the Department of Fisheries has made considerable effort and investments in establishing a cooperative based fisheries management around the reservoir. Interventions for building the required capacity and infrastructure have also been attempted. Yet, the current state of fisheries in the reservoir remains constrained by low productivity, weak infrastructure and a crumbling co-operative structure. Crucial opportunities for stock management during the initial years of impoundment have been lost, resulting into greater dominance of minnows, low value fish, ushering a longer food chain and an inefficient conversion of primary production into desired fish flesh. Reservoir siltation, pollution loading and increased encroachment of the shorelines further stress the overall environment.

Small canoes being used for fishing in the reservoir

Management of reservoir fisheries has also been constrained by lack of robust monitoring and assessment mechanisms. CIFRI conducted an analysis of the available baseline information in 1992 for identification of strategies for fisheries development (Sugunan and Yadava, 1992, also published as a chapter in Sugunan, 1995). Subsequently, as a part of

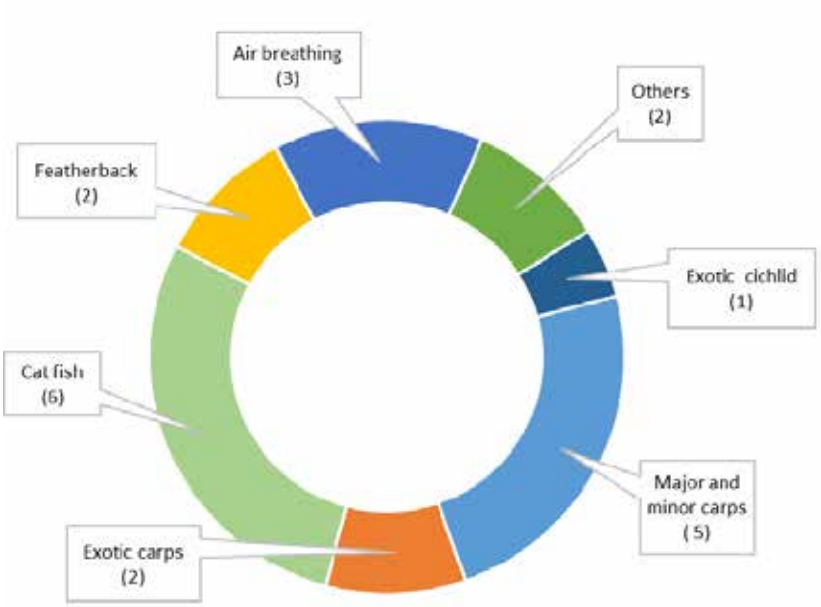


Fig. 2.9 | Major groups of economically important fishes from the reservoir

its rapid survey of 1995-96 on ecological status and production dynamics of River Mahanadi, CIFRI included two stations within reservoir (Chikli and Tamdei) and two immediate downstream (Durgapalli and Sambalpur) wherein data on a limited set of biotic and abiotic variables, and fish and fisheries was collected (Pathak et al., 2007). These studies provide an insight into the situation of reservoir fisheries prevailing till the 1995. No assessment of reservoir fisheries health seems to have taken place since then. The Odisha State Fisheries and Animal Resources Department (FARD) has continued to collect and publish details of fish catch as a part of District Annual Reviews and other departmental reports. A comprehensive review of present status of reservoir fisheries is however alluding.

This section of the management plan presents an analysis of the status and trends in reservoir fisheries. The analysis is based on review of the existing reports, data and statistics made available by FARD. To complement the above sources, primary surveys were carried out in 40 villages to estimate the number of fishers, their fishing practices, assess their socioeconomic status and rights and capacities for integrated management.

Data was also collected from the 5 Primary Fishermen Cooperatives Societies, which are the key community institutions in this sector. The surveys were carried during January – March 2015.

Fish and fisheries

Indian reservoirs are known to harbour about 60 species (Yadava and Sugunan, 2009), of which about 40 species contribute to commercial fisheries.
Of these, 21 species contribute to reservoir fishery (Annex XI and Fig. 2.9). This list is predominated by carp and catfish (constituting 52% of the species). The prevailing average prices of these fishes in the markets of Burla and Sambalpur are presented in Table 2.14.

It may be pertinent to reassess the species contributing to commercial fishery at the present, as the species structure are known to vary over a period of time. Evidences from the current survey indicate increasing dominance of minnow species, and a gradual decline of major carp and economically important catfish.

Fish catch

Data on fish catch from the Hirakud Reservoir are available since 1958 (Fig 2.10). As per records, the annual catch remained below 50 MT till 1967 and below 100 MT till 1969. The catch gradually increased to nearly 200 MT till 1976, reaching an all-time high of 827 MT in 1980. During 1983-1992, the catch hovered between 230 and 360 MT, reaching minor peak of around 400 MT in 1993-94. Since then, the catch has consistently declined, barring a few years, to 154 MT in 2004. However, from 2010 onwards, the catch has been reported to steadily increase from 1,140 MT to nearly 4,800 MT in 2013 (Fig 2.11).

Table 2.14 | Price major group of fishes (Rs./Kg.)

Sl. No.	Group of fish	Name of Species	Prices of table size fish (Rs./Kg.)
1	Major carps	*Catla catla, Labeo rohita, Cirrhinus mrigala*	125-250
2	Minor carps	*Labeo gonius, Labeo bata, Labeo fimbriatus etc*	125-200
3	Live fishes	*Channa striata, Channa marulius, Channa punctate etc*	60-80
4	Cat fish	*Wallago attu, Ompok bimaculatus, Sperata seenghala, etc*	200-600
6	Feather back	*Notopterus notopterus, Chitala chitala*	200-300
5	Shell fish	*Macrobrachium malcolmsonii*	750-1000
6	Weed/ other fishes	*Chanda nama, Puntius sophore, Xenentodon cancila, Rhinomugil corsula etc*	100-150

Fig. 2.10 | Fish catch from the Hirakud Reservoir (1959-2009)

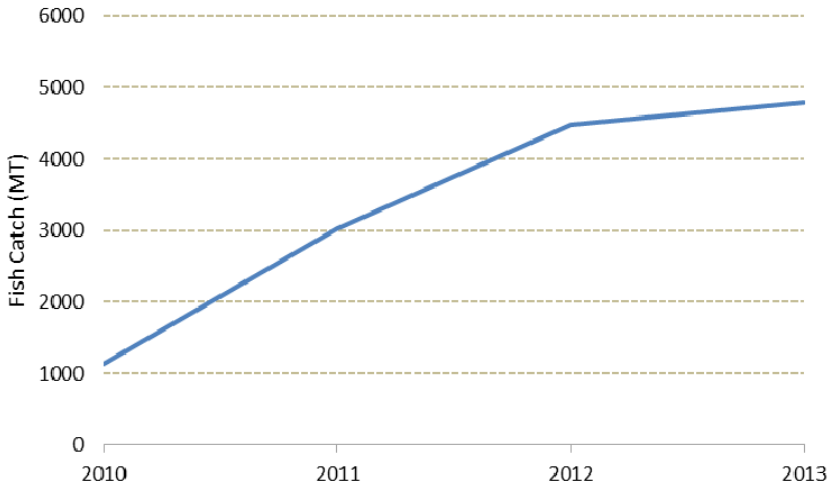


Fig. 2.11 | Fish catch from the Hirakud Reservoir (2010-2013)

The increase of fish catch during the period between 70s and 90s is attributed to increase in number of fishers (Sugunan, 1995). The near exponential increase in catch since 2010 is attributed by the Department to stocking programmes supported by National Fish Development Board (NFDB).

Data on fish catch is an important component for management planning thereby its robustness is of prime concern. The catch statistics are presently computed from the records of the fishery cooperatives. Interview with their key functionaries indicated that no standard protocol is followed for catch estimation. The catch brought by the fishers to the landing centres are segregated into major groups (carps, minnows, catfishes, air breathers, and prawns and miscellaneous) and total weights recorded. The catch statistics are likely to be lower estimates as not all catch is aggregated and traded thorough these cooperatives. Diffused landing centres also leads to poor catch estimates.

A fisher with less catch dominated with catfishes and minnows in winters

The substantial increase in catch reported since 2010 does not seem ecologically feasible, as the stocking programme was initiated in the very year, and it is likely to take some time before catch actually tends to surface. In order to address this ambiguity, an attempt to quantify the current catch was made based on survey data from 158 fisher households. The total annual catch estimated from the survey stands out to be 460 MT for 2014. This is higher than the estimates provided for the years preceding the stocking programme, yet is a fraction of the catch presently reported by the Department. Detailed statistics derived from the survey are presented in Annex XII.

To assess reservoir fishery productivity, trends in catch per hectare and catch per fisher over the period 1968-2009 were derived (Fig. 2.12). The total fishing area has been taken to be 43,512 ha[1]. Data on number of fishers for distinct years (reported in Sugunan and Yadava, 1992 and for 2014 estimated from the current survey) have been made continuous by fitting linear trendline. The analysis indicates low productivity of the reservoir (hovering between 5-8 kg per ha for most of the period), far below the national average of 33 kg per ha. The current productivity at 10.6 kg per ha[2] is very low for a large fisheries resource as Hirakud. The statistics however are of indicative nature due to issues related with data quality.

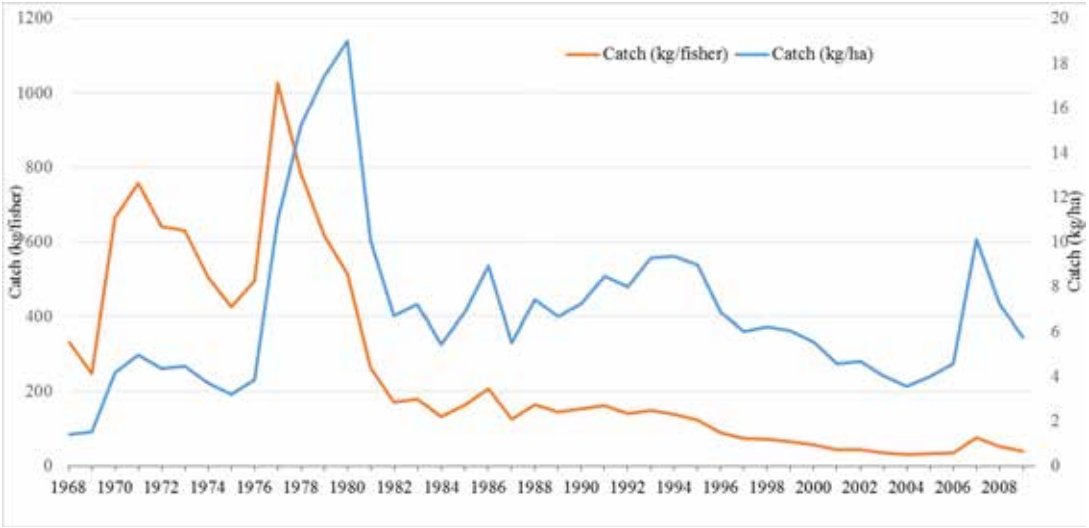


Fig. 2.12 | Productivity of Hirakud Reservoir fisheries

[1] This is the area leased out to the fisher cooperatives. Also refer to section on fisher cooperatives on the revision in leased area and related issues.

[2] Reservoir fish productivity when computed based on the statistics provided by the State Department of Fisheries stands out to be 110 kg per ha.

While fishing is done round the year, there is a considerable dip during June 15 - August 31, wherein a fishing ban is stipulated to allow establishment of breeding stocks. An individual fisher fishes for 160 days in a year. Catches during the months of June, July and September are highest. During monsoon, the catches of carps are the highest, whereas the catch of catfishes peak during summers.

There is no system in place for recording species specific catch. As per the data collected from survey, of the current catch, 40% is constituted by carps, 27% by catfishes and 33% by minnows. Studies on catch composition for 1978-79 (available for 26 species) indicated that carps and catfishes constituted 42% and 43% of the catch respectively, with the rest being minnows. Apparently, the proportion of carps in the catch has remained constant over the years, whereas catfishes are being gradually replaced by minnows. Noticeably, the 1995 assessment also indicated an increasing proportion of minnows and omnivorous or multiple breeder fishes and declining proportion of catfishes.

During the survey, several location specific changes were reported in catch composition. The riverine stretches of the reservoir, namely Mahanadi and Ib, which used to be active breeding and spawning grounds of major carps, have gradually suffered a decline. Within catfishes, the proportion of prized varieties as *Wallagu attu* and *Ompok* sp. has declined. Freshwater prawns used to be abundant around Muhammadpur have also dwindled extensively. While it is difficult to identify the causative factors for these changes in absence of systematic species wise catch data, extensive siltation in the margins, increasing upstream water regulation and pollution from Ib-Jharsuguda Valley may be key contributing factors for these shifts.

Available data indicates that from a production perspective, the reservoir food chain continues to be elongated, resulting in inefficient conversion of available energy in terms of desired fish catch.

Stocking

Stocking plays an important role is sustaining reservoir fisheries. It helps in building up of stocks of fast growing species in an ecosystem by colonizing at diverse niches. It is however important that species stocked ultimately get naturalized in the system through auto-stocking to meet the long term objective of obtaining a sustainable yield. Management involving persistent stocking tends to significantly raise input costs as well as requires maintaining adequate quantities of stocking material putting significant demands on limited resources. The national guidelines for fisheries management in medium and large reservoirs of India (Yadava and Sugunan, 2009) recommend several measures for ensuring effective stocking of reservoirs. Reservoirs are known to develop into a phase of trophic burst during initial years of impoundment, owing to the high levels of nutrients derived from submerged organic material. This period is recommended for stocking as it enables establishment of stocked species earlier in the

Government hatchery at Bomaloi

system, thereby benefitting from shortened food chain, and high availability of food. Lapses in doing so leads to gradual lengthening of food chain and a poorer conversion of available primary energy into fish flesh. It is also important that the species stocked are selected with due consideration to their biophysical and physiological requirements, particularly habitat conditions, such that it gains a comparative advantage in food availability. Management of reservoirs often do not take into account the habitat requirement of fisheries creating impediments in natural breeding rhythms ultimately leading to failure of stocked fish in reservoirs (Jhingran and Natarajan, 1969).

Stocking was introduced in Hirakud as a small scale effort since 1985, after nearly three decades of impoundment. Apparently, the opportunity of capitalizing from the initial trophic burst conditions was not put to use, and information on species structure indicate that by this time, minnows constituted a significant proportion of the catch. Stocks were procured by the Fisheries Department from local private hatcheries. During the period 1988-91, a total of 4.26 million fingerlings of Indian Major Carps were stocked at a very low density of 47 fingerlings per ha (Sugunan, 1995). It was believed that large reservoirs as Hirakud were auto-stocked naturally and thereby no serious measure was taken in this direction till recently.

Cage culture at sector II of Hirakud Reservoir

The fish stocking infrastructure created in the form of large government hatcheries at Chiplima and Bomaloi and smaller hatcheries at Pipalmunda and Jarimuli were meant mainly to support stocking of smaller reservoirs of the state. However, the near consistent decline in fish catch since 1995 forced the Department to relook into the restocking options.

The Odisha State Reservoir Fisheries Policy was introduced in 2004 with an objective of augmenting fish production from the reservoirs, providing livelihoods to dependent communities, and putting in place systematic management. A systematic fish stocking programme in the reservoir was initiated in 2010-11 with the support of National Fisheries Development Board (NFDB). As per records, the reservoir was stocked with 9.1 million advanced fingerlings during 2010-11, which increased to 10.4 million during 2013-14. The Department intends to continue this programme for atleast another five years till a sustained increase in catch is established.

The NFDB has also prescribed guidelines for implementing the stocking programme. Key elements of the guidelines include:

- Use of fingerlings of 80mm size of Indian Major Carps for stocking purposes
    - No direct purchase of fingerlings, instead procurement of fries and *in-situ* or *ex-situ* rearing for stocking of reservoir
    - Avoiding long distance transport of fingerlings
    - Development of an action plan for stocking operations and stocking only during daytime
    - Constitution of a Monitoring and Evaluation Committee to oversee stocking programme
    - Community participation for ensuring transparency, accountability and reliability of the programme

Advanced fingerlings (of nearly 91 mm and above) of major carps are sourced from OPDC (Odisha Pisciculture Development Corporation) fish seed farm at Burla, three operational hatcheries (Chiplima, Bomlei and Pipalmunda) and private hatcheries. Stocking is done in all sectors during post monsoon period (November-December). The Department has also reported a commensurate increase in fish catch ever since stocking programmes have been introduced.

Stocking programme in the reservoir had a delayed start. The current stocking programme also needs considerable improvement. It is implemented in an almost mechanical fashion with no monitoring prior to the release of stocks, no post monitoring of the stock condition, and maintenance of no-fishing activity to enable stocks to establish and breed. Interviews with PFCS functionaries indicated high rate of mortality (over 40%), though no records of stocking success exist.

In 2012, cage culture of *Pangasius sutchi* (Thai mangur) has been initiated in the deeper pockets of the reservoir (at Sapne Village, Sector II fishing zone, under Mohammadpur PFCS). Finance and technical support for the initiative is being provided by the NFDB. The results so far have been encouraging.

A fisher returning after laying nets in the reservoir at Katarbhaga Village

Crafts and gears

Reservoirs due to presence of underwater obstacles are not conducive for use of active gears, and the choice is limited to use of passive gears like simple gill nets. Gills nets are the predominant fishing gear used in Hirakud reservoir. In certain pockets, drag nets, cast nets and stakenets are also used. Use of small mesh sizes is rampant. Data from the survey indicated that none of the 274 nets had mesh size in line with the recommendations of the State Reservoir Policy (2004). Within the sample, 55% of the nets had mesh sizes below 5 mm and 42% with sizes between 5-10 mm. Gill nets are set in the night and hauled in the morning.

Siltation along the shorelines is creating conducive conditions for use of dragnets in several pockets (particularly along Tamdei and Lakhanpur). In pockets along Tamdei-Chikli and Thebra-Lacchipalli, fishers also resort to dredging in order to make operation of dragnets convenient.

Fishers use dugout canoes, small plank boats and large boats for fishing. Of the 4,800 boats in use at present, a majority (90%) are small plank boats (locally called kishti) which can carry maximum two persons at a time. During monsoons, only large boats (upto 7 m long and 1.5 m wide) with a capacity to carry upto 12 persons is used. Such boats are however in limited numbers (about 130). Boats are mostly procured from Talcher (Angul) and markets in Chhattisgarh. There is very limited mechanization of the fleet at present. Attempts made by CIFT during 90s to introduce mechanical trawling have not yielded positive results.

Fig. 2.13 indicates patterns of change in use of fishing gears during 2001-15. The 2001 data pertains to survey in 2 villages on the eastern margins of the reservoir. A mix of gill net, dragnets and shore siene

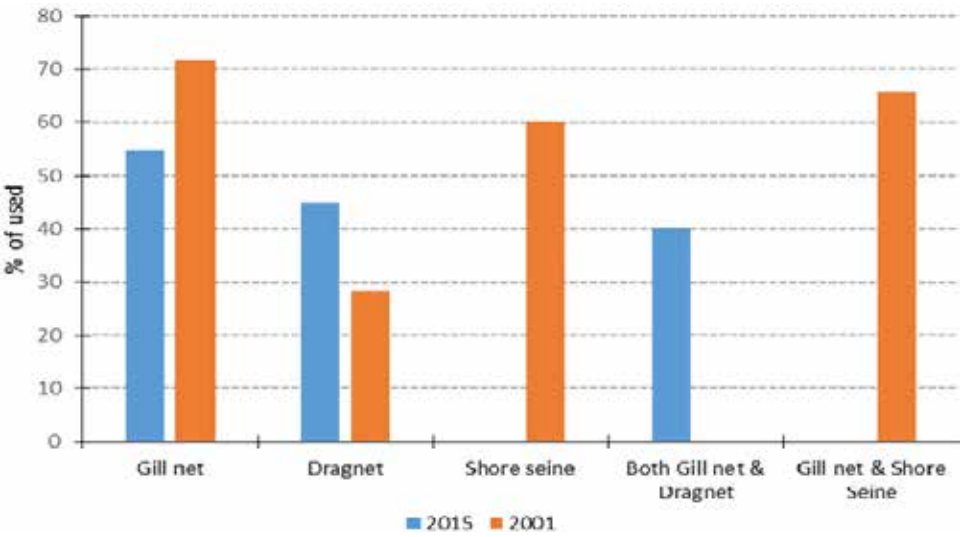


Fig. 2.13 | Pattern of changes in use of fishing gear in reservoir

were reported. Data from 2014 survey indicated that sienes are no longer popular fishing gear, which may be due to declining catfish population.

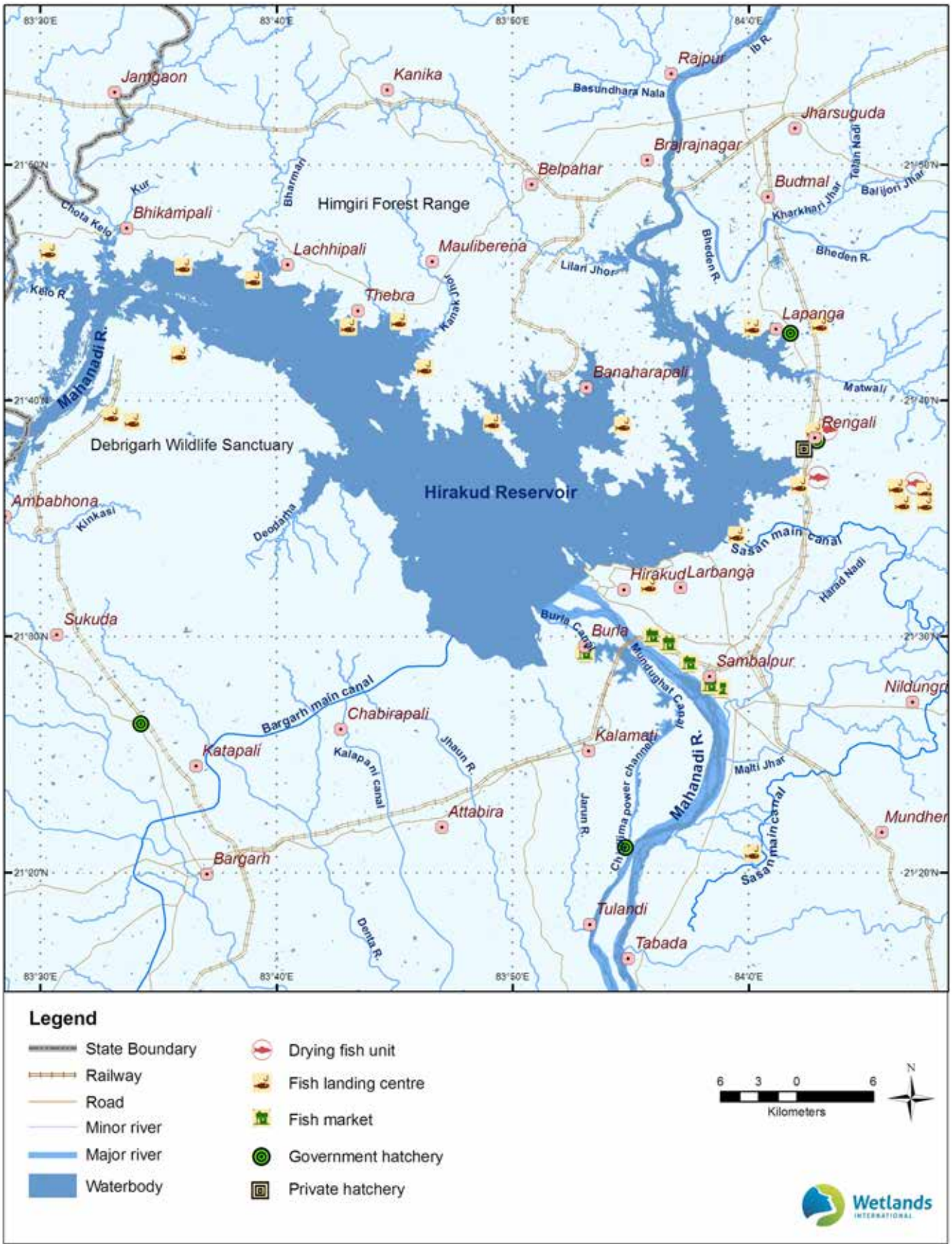
Prevalence of low mesh sizes and narrow range of gears in the face of low productivity and increasing fisher population will continue creating stressed conditions for the reservoir fisheries. Improvisations in crafts and gears are required to ensure sustainable harvest and good economic returns from the enterprise to the dependant fishers. Investment is also required in creating local boat building and repairing yards.

Post-harvest and marketing

The fish catch of the reservoir is traded through a number of diffuse market chains. The FARD has tried to establish a formal market chain with PFCS as intermediary. However, over a period of time, this chain has come to be controlled by private traders which exploit the existing inefficiencies to garner a substantial share of profits.

There are no physically identified landing centres around Hirakud as construction of any permanent infrastructure is prohibited in the reservoir. Rather, there are 34 locations at which the fishers enter the reservoir (termed as landing centres by the Department of Fisheries). The cooperatives depute vendors at each of these locations, who buy the fish after segregation in broad categories (for most species, the prices paid by the vendors are half to one-third of the prevailing prices at Sambalpur market). The vendor is also responsible for collecting a levy for each kilogram of fish, which is used to cover operational expenses of the cooperative. The charges range from Rs. 2 to Rs. 5 per kilogram of fish, and is deducted from the payment to the fisher. The vendors usually sell the catch, at a small margin to the society appointed traders. The vendors and the traders pack the catch in ice-boxes for sale at the larger markets, located in the five blocks. At three locations (Belpahar, Rengali and Birenbadh), a part of the catch is also transported to neighbouring states (primarily West Bengal, Jharkhand and Chhattisgarh) (Map 2.18).

Fish market at Goal bazar, Sambalpur



Map. 2.18 | Landing infrastructure and hatchery around Hirakud Reservoir

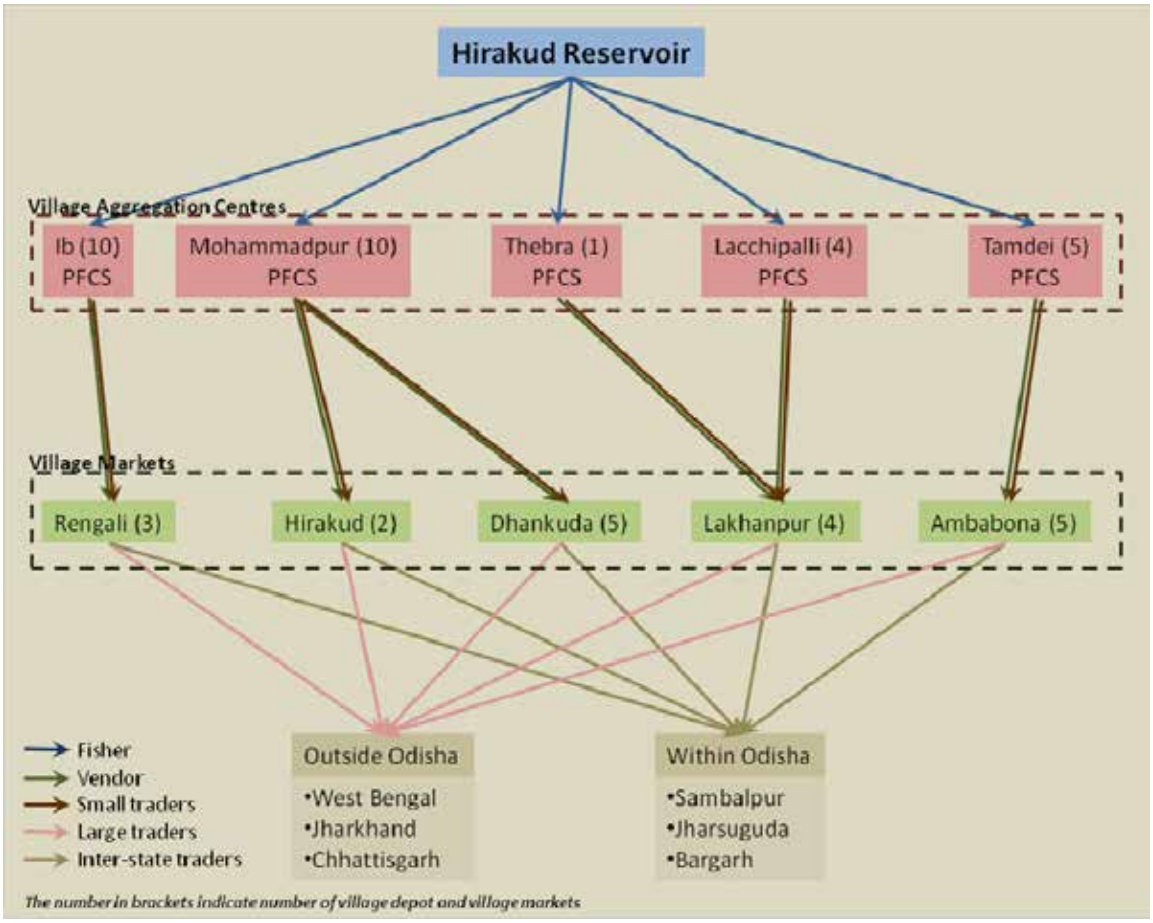


Fig. 2.14 | Prevailing market chain for Hirakud fish

Fishers, however, mostly tend to bypass this chain (thereby not paying any levy to the cooperatives, and also not being impacted by the price differential between vendor and the trader). Instead, they sell their catch to private traders which operate through informal collection centres in almost all major fishing villages. Presently, 30 such aggregation centres are operational. The prevalent market chain for Hirakud fisheries is presented in Fig.2.14. The informal collection centres are mentioned as village depots in the market chain.

The private traders have over a period of time exploited inefficiencies in the market chain, key being, lack of access to formal credit to the fishers and no reimbursement for the elected society members to handle the catch. The private traders provide credit directly to the fishers, entering into an informal agreement of buying their entire catch at predetermined prices. These prices are marginally higher than those paid by the cooperatives, still substantially lower than those prevailing in larger markets as Sambalpur. The influence of these private traders is such that they are termed as 'mafia', and are known to influence the elections and appointment of members of cooperatives.

The designated catch collection centres of the cooperatives have therefore fallen into disuse, and are dilapidated. The availability of ice is also a constraining factor, as there are only two factories (Burla and Sambalpur). There are some small units at Sambalpur but the production overall is much less than demand. Presently, a majority share of the ice manufactured in these factories is sold to the private traders, further strengthening their control in the trade.

The present market chain does not bring equitable returns to the fishers. Substantial gains are to be made if the market chains are reworked to the benefit of the fishers, which will also pave way for implementing responsible fisheries in the reservoir.

Fisher cooperatives and their management

The fishing rights of Hirakud were transferred to State Fisheries Department in 1960. The Department leases these rights to PFCS.

The department has classified the reservoir fishing area into six sectors. Till 2004, the department leased 43,512 ha of the total fishing area of 61,124 ha, the rest being around the dam infrastructure not leased due to security purposes. In 2004, the areas were reassessed using GIS, and leases given on the basis of average inundation area. The total area leased to the cooperatives was thus reduced to 23,484 ha.

The lease values are defined as per provisions laid under State Reservoir Fisheries Policy, 2004. The society pays a lease amount of Rs.20 per ha of leased area, of which Rs.10 is transferred by the Department of Fisheries to the Department of Water Resources as royalty. The Department issues leases on a five year cycle. In 2013-14, the Department received Rs.0.46 million as lease value. The annual lease amount per registered member comes to around Rs. 136, which is less than 0.5% of the average annual household incomes of the fishers. Yet, with limited capitalization within the societies, paying lease amount on time is a challenge for most of the societies. Considerable confrontation amongst societies exists on the leased areas as these are not demarcated clearly.

Lease of each of the sectors is given to single cooperative society. Accordingly, there are five PFCSs operational in Hirakud. The Ib, Tamdei and Thebra Cooperative Societies were constituted in 1963-64. The society at Muhammadpur and Lacchipalli were constituted in 1970 and 1979 respectively. These have been formed as per the provisions under Orissa Cooperative Society Act 1962, and are meant to be governed by their individual rules and bylaws. Each Society has four office bearers (President, Vice President, Treasurer and Secretary) and seven elected board members. Of the five cooperatives, only two (Ib and Mohammadpur) are effective, and the rest being gradually rendered dysfunctional. Most often, the mafia influences the society elections, making sure that elected members hold no influence and the society does not create impediments in operation of market chain operated by private traders. Table 2.15 summarizes key features of the 5 cooperative societies.

Tamdei Primary Fishermen Cooperative Society office

Over the years, the membership of the cooperative societies has virtually stagnated. The number of registered members was reported to be 3,030 in

Table 2.15 | Institutional details of the PFCS

Co-operative Name	Fishing Sector	Year of establishment	Fishing area (ha)	No. of Villages	No of registered fishers		Amount of lease in Rs. (Lease value + royalty)	Share capital (Rs.)	Amount charged from members for handling catch (Rs./Kg)	Depots (village common) used for disposal of catch at present	Active vendor	Active trader	Ongoing program and schemes (form of assistance in Rs/No. of beneficiary) for 2013-2014							Major constraints
													National					State		
					Men	Women							NMPS	NFDB fund in lakh for Stocking in reservoir (Fund in Rs. allotted)	RKVY	ATMA (no. of beneficiary trained)	MGNREGA	MUY		
																		Boat + Nets (no. of beneficiary)	Bicycle + ice box (no. of beneficiary)	Scholarship
Ib PFCS	I	1963	4331	39	628	15	86620	9500	2	10	50	10		24.6	Training on nursery management	Training on farm operation and management (25)		6	4	35	Lack of fund
Mohammadpur PFCS	II	1970	7868	87	833	33	157360	43000	2	10	30	12	Training on operation of cage culture	29.14	Training on nursery management		Excavation of community Pond (1 nos)	57			Lack of fund
Thebra PFCS	IV	1964	6516	25	748	8	130320		4	4	12	7		27.84		Training on farm management					Lack of fund; dormant board member; unauthorized fishing, low membership enrolment
Lachhipali PFCS	V	1979	1906	11	428	21	38120	43560	5	4	12			10.36							Lack of fund; dormant board member; unauthorized fishing, low membership enrolment
Tamdei PFCS	VI	1964	2963	31	713	22	59260		4	15	2	15				Fishing technique in reservoir (260)		42		5	Lack of fund; dormant board member, unauthorized fishing

NMPS = National Missions for Protein Supplements; RKVY = Rashtriya Krishi Vikas Yojana; ATMA = Agriculture Technology Management Agency; MGNREGA = Mahatama Gandhi National Rural Employment Guarantee Act; MUY = Matshyajibi Unnayana Yojana

1995, and after nearly two decades has increased to only 3,449 members in 2014. Consultations indicated that nearly half of the fishers do not enrol into PFCS. There is no mechanism in place to debar a non-registered fisher from fishing in the reservoir.

Considerable confrontation amongst societies exists on the leased areas, as these are not demarcated clearly. More recently, it is being envisaged to restructure fish rights on the basis of blocks, and to increase the number of cooperative to 10. Four of the five new cooperatives are proposed to be constituted that the fish caught is procured on spot from the reservoir and transported to nearest markets. The traders also exploit the economic vulnerability of the fishers by providing credit for nets and boats and even domestic requirements, by negotiating an iniquitous terms of trade. It is estimated that nearly 50% of the present catch from the reservoir is traded by the informal sector.

The societies were constituted with government share and subsidies. It was envisaged that a steady flow of revenues from the members in the form of a levy on catch would make the society financially viable. It was also expected that the societies will function as key intermediary between the government and the individual fisher to enable delivery of various welfare schemes, (for example subsidies on procurement of boats and nets, insurances, housing, employment and food guarantee programmes). However, over a period of time the revenues have declined, limiting their ability to handle the member's catch. In 1995, the available capital per member was Rs. 124 (75% being government funding). As per data collected in 2014, the share capital is Rs. 49 per member.

The status of the fishers remains amongst the lowest of all the communities living around their reservoir. The fisher households have lower access to infrastructure (84% having kutcha houses, 35% without toilets, 5% with drainage, over 35% not having access to electricity, only 4% having access to drinking water supply). Expenditure on food and transport constitutes over 60% of household expenses, and over 75% meeting their credit requirement from informal sources. Most of the households feel that the overall environmental condition around the reservoir has degenerated since the 1990s, adversely impacting fisheries and creating conflict with powerful private traders or the mafias. In such circumstance, there is question on the efficiency of the cooperative in terms of their ability to access benefits from on-going developmental schemes, or secure fishing rights.

Presently, of the total fisher households, 47% supplement their incomes by working as wage labourers and 34% through farming. The private traders have been exploiting this vulnerability to gain access to larger share of trade, without vying for legal access to fishing rights and creating unfair terms of trade. Fishers, on the other hand have diversified occupations to augment the meagre incomes derived from fisheries. As per data from household surveys, only 30% of the annual income of fisher households is derived from sale of fish catch, the rest through engagement as wage labour for in the industries and working as farm labour.

Community consultation in Sahasbhaga Village, Lakhanpur

There is an urgent need to review the fishery cooperative to ensure that fishers remain as stewards of wetland resources, and benefit equitably from the enterprise. These institutions would need to be revamped to bring back the trust of the community, and spearhead integrated management.

Key issues

The 1992 assessment of Hirakud Reservoir Fisheries concluded that its low productivity was an outcome of irrational management in its formative years. Unfortunately, the recommendations made over two decades ago for sustainable development of reservoir fisheries have been addressed only marginally at best, and the issues identified therein continue to linger. The review of fisheries of Hirakud as contained in the previous sections indicate the following issues:

Lack of systematic database to support integrated management: Current monitoring systems are limited to maintaining catch data. Systematic data collection protocols are yet to be evolved and rigorously implemented. Data on several key elements required for integrated management, as the ecological productivity, species wise catch from different landing centres, species and size composition of the catch, and distribution of effort are not available. Specific assessments on migratory pathways, habitat quality, impact of anthropogenic disturbances as pollution need to be undertaken to supplement the information base.

Low fish productivity: The reservoir, in absence of any proactive species management in the initial impoundment years, has progressed to a low productivity phase. Any attempt towards changing fish stock is likely to be ecologically difficult and economically unviable. However, it is important that a mix of stocking based interventions, coupled with active conservation of riverine breeding and spawning grounds is continued. These interventions will need to be supported with design and implementation of a long term stocking and harvesting policy for the reservoir, clearly articulating stocking density, schedule, gear selection and mesh size regulation.

Improvisation of post-harvest infrastructure: Existing infrastructure for managing post-harvest is at best dismal and needs considerable improvement. There is a need to ensure effective cold chain so that the fish can be traded win markets offering best prices.

Weak cooperative structure: Efforts made till date for institution of a cooperative based fisheries management have failed to live up to their desired objectives. Weak capitalization, resources and capacities have limited their role in securing equitable outcome for the fishers. Private traders have filled the gap building on the inefficiencies into the system, exploiting the vulnerability of the fishers, whereas also ensuring that the cooperatives fail rapidly. The societies need to be reinvigorated with efforts made at capacity development, better capitalization, and role in overall fisheries management.

Sundrying of small fishes in Tamdei Village

2.2.5 Socio-economics and Livelihoods

Dams and their reservoirs are socio-politically contested landscapes, owing to their impact on livelihoods systems, and in particular changes induced in human-environment relationships. Hirakud Reservoir is placed in a similar situation. Its conceptualization was marked with series of community protests. However in the last half century, Hirakud has become a significant driver of economic development in the region. This section of the management plan analyses the interrelationship between reservoir functioning and livelihood systems so that the pathways of wetland wise-use lead to maintenance of ecosystem services accrued to wetland communities.

The Mahanadi Basin in Odisha, with as many as 38,285 villages and 34 urban centres and an average population density of 264 persons per km^2, is the sixth most densely populated river basin in the country (Jena, 2008; CWC and NRSC, 2014). This is also an important landscape within which much of the Central India's economic activity thrives. The rich mineral resources of the upper and middle Mahanadi Sub-basin, due to its favourable geological setup has resulted in a concentration of mining, steel and cement industries, which has significant influence on livelihood systems. Industries in the upper sub-basin extract water from the tributaries of the Mahanadi River, whereas industries in the middle basin rely on the Hirakud Reservoir itself to meet their water and electricity needs. The livelihood system of the lower Mahanadi Sub-basin, can be indirectly attributed to the existence of the reservoir wherein a highly dense (i.e. 53% of the population of the entire basin) and flood prone landscape has been modified to ensure the sustainability of diverse livelihood options, such as floodplain agriculture and riverine & coastal fisheries, with lower risks of damage from disasters due to the reservoir's flood buffering services.

As per the Odisha Economic Survey 2014-15 the basin districts in Odisha (Jharsuguda, Angul and Sambalpur) have respectively emerged as the first, third and fifth most economically productive districts based on their percentage share of Net District Domestic Product (NDDP). The Mahanadi River which flows through these districts coupled with its rich mineral wealth can be attributed for this rapid economic development.

Despite its high significance for livelihoods, limited analysis of reservoir functioning from a socio-economic perspective is available. Existing socio-economic data of the communities living within the reservoir basin are limited to the Census of India and Economic Survey of Odisha data, wherein interlinkages with the reservoir are not addressed. Furthermore, a number of studies and papers on Hirakud have been published over the years, but much of the discourse is focused on the displacement of local communities and conflicts that have

Mahanadi River at Lacchipalli

arisen within the reservoir basin, rather than on the existing livelihood dependency on the reservoir and linkages with its management.

For the purpose of management planning for Hirakud Reservoir, a socio-economic survey of communities living around the reservoir was conducted. Primary data was collected through a sample survey of 10% of the total households residing in 40 villages in and around the reservoir. Through stratified random sampling, a total of 402 households were interviewed using a socio-economic survey questionnaire. Data was collected to reflect household level demographic profile, economic profile, resource use, ecosystem services and perception towards management planning. Participatory appraisals were also conducted in 10% of the villages to assess community rights and capacity for integrated management.

Profile of communities living around the reservoir

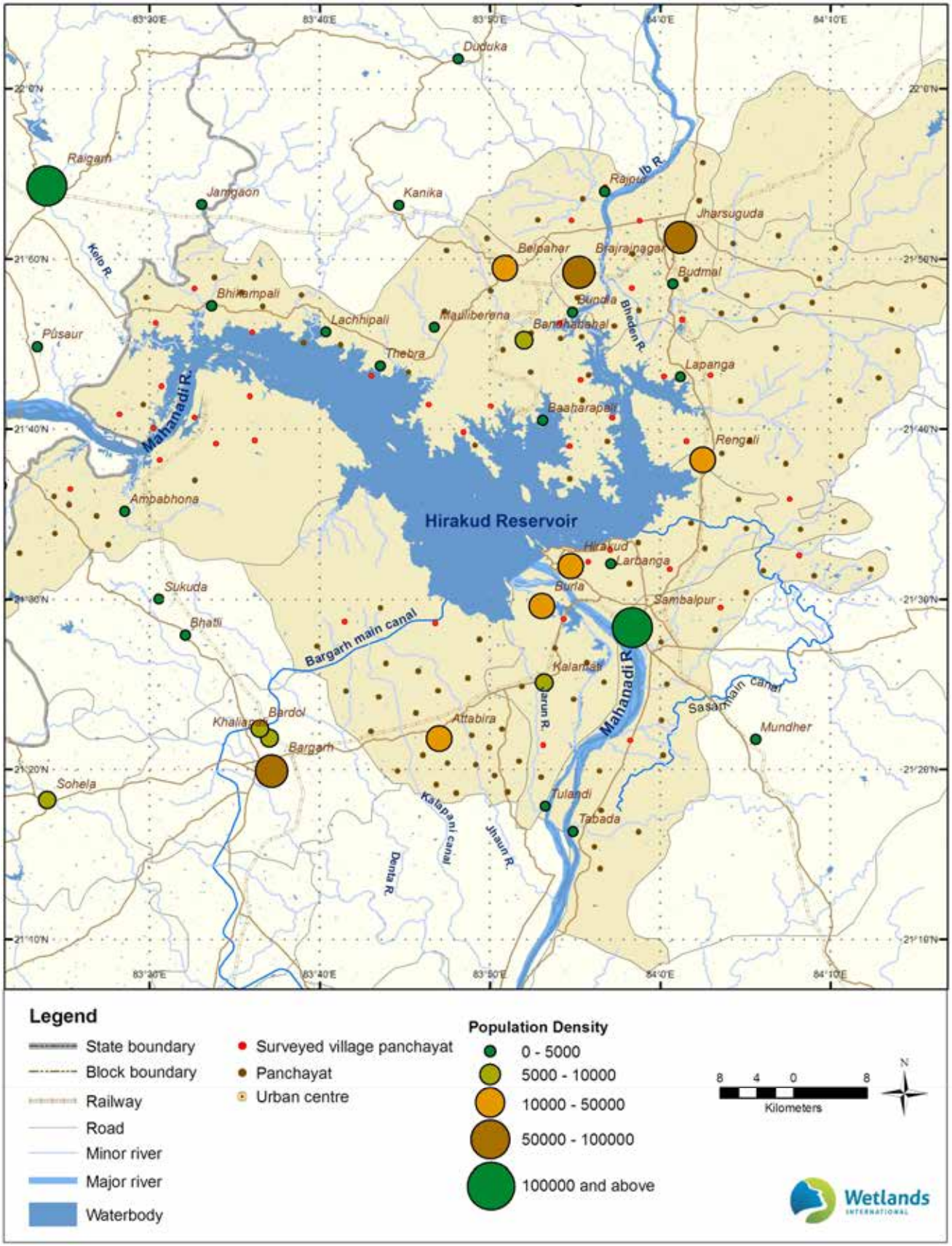
A total of 118 revenue villages (across seven blocks of the three districts of Sambalpur, Bargah and Jharsuguda) comprising of 26,111 households (Annex XIII) adjoin the reservoir (Map 2.19). As per the 2011 census the total population of these villages is 0.11 million, of which 53% belong to Schedule Castes and Schedule Tribes. Jharsuguda, Rengali, Dhankauda, Maneswar and Attabira Blocks have a higher concentration of population. Development of 7 major townships (Belpahar, Brajrajnagar, Jharsuguda, Ib Thermal, Hirakud, Sambalpur and Burla), infrastructure, amenities and industries are likely the key determinants for population concentration.

The villages of Lakhanpur Block and Ambabhona Block are mainly concentrated along the Hirakud reservoir and Mahanadi River. Limited economic opportunities and infrastructural facilities determined by the terrain result in low population density in these locations. The main concentration of the schedule tribe households is found in the villages located near the forest reserves of Debrigarh Sanctuary and Hemgir Forest Range – on the west and north of the reservoir.

Fisheries and agriculture are the main primary occupations around the reservoir and each account for 40% of the working population. Wetland agriculture and industrial labour are the main alternate livelihood options (Table 2.16).

Table 2.16 | Occupation profile of communities living in and around Hirakud Reservoir

		% of total HH	Primary and Secondary Occupation						
			Agriculture	Fisher	Fish vendor	Livestock farming	Service	Agricultural labour	Wage Labour
Agriculture Farmer	Large	7%	**100%**	0%	0%	2%	17%	10%	18%
	Small	21%	**100%**	0%	0%	6%	9%	10%	46%
	Marginal	11%	**100%**	0%	0%	0%	3%	4%	73%
Fisheries	Fisher	39%	34%	**100%**	0%	1%	4%	16%	31%
	Fish vendor	1%	17%	17%	**100%**	0%	50%	0%	67%
Livestock farming		2%	50%	39%	0%	**100%**	6%	0%	6%
Service		7%	46%	46%	0%	0%	**100%**	0%	21%
Labourer	Non agriculture	9%	40%	13%	2%	0%	1%	0%	**100%**
	Agriculture	2%	10%	0%	0%	0%	0%	**100%**	47%



Map 2.19 | Village panchayat around Hirakud Reservoir

Variability in the resource availability and infrastructural development around the reservoir have led to distinct spatial patterns of livelihoods. Over half (53%) of communities living around the riverine stretch and Debrigarh Sanctuary engage in fisheries as their primary occupation. A mere 15% engage in wetland agriculture during the dry season.

Similarly, the concentration of industries near the Ib River have led communities living to the north-east and east of the reservoir to engage in fisheries and industrial labour as their main occupations. Communities living in the command area, between the Sasan and Bargarh Canals mainly engage in agriculture as their primary occupation due to the availability of irrigation, followed by fisheries (both reservoir and riverine).

Fisheries is presently the main livelihood option of the community living around the reservoir. Communities from adjoining areas, even as far as Chhattisgarh have settled near the reservoir boundary for this purpose. The proportion of households depending on reservoir fisheries has increased from 27% in 1960 to 47% at present.

Wetland agriculture albeit minimal during the initial days of the reservoir has grown in its extent. Easily available subsidized seeds, fertile soil, limited requirements for skill and investments and assured returns from short duration crops (such as vegetables and water retaining fruits) have resulted in 34% of the fishers engaging in wetland agriculture as their secondary occupation.

Further, in the last three decades rapid industrial development that has emerged to the east of the reservoir (east of the Ib River), has begun altering the occupation structure. Industrial wage labour is emerging as a significant contributor of primary and secondary occupations of the communities living around the reservoir. Although initially communities engaged in industrial wage labour only during the lean activity months, recent trends are revealing that 9% of the working population is engaged in industrial wage labour all through the year, as a primary occupation.

Migration to adjacent urban and industrial centres to engage in secondary occupations is a common practise. Communities living near the Mahanadi River (both near the Debrigarh Sanctuary and in Lakhanpur) migrate to Raigarh in Chhattisgarh; communities from Lakhanpur near the Ib River migrate to the mining town of Belpahar; communities from Rengali and Dhankauda work in the adjacent industries; and communities, from Maneswar and Attabira migrate to Sambalpur town for wage labour.

The communities' economic status reflects in their income levels, as well as, their ownership and access to assets and amenities. The average per capita income of the communities living around the reservoir is Rs.15, 991 as against the State's average of Rs. 28,384 (GoO, 2015). The average per capita income of all communities is below the state's average. Large farmer households (whose average landholding is 7.20 acres) earn 84%, fisher households earn 61%, industrial wage labour households earn 58% and marginal farmer households (whose average landholding is 2.69 acres) earn 37% of the State's average per capita income (Fig. 2.15).

Income generated through reservoir services account for a proportion of the communities' total income across all occupation groups (Fig. 2.16). Agriculture as a livelihood system is most benefitted from reservoir services. 66% of the income of big agricultural farmers is derived from wetland agriculture. Notably, only 28% of fishers' total income is contributed by reservoir services (i.e. fisheries), while the remaining is earned through secondary livelihood sources.

Food accounts for the majority of household expenditure. An average of 55% of the annual income of households is spent on food. Only 12% of household expenses are reinvested in livelihoods. Only a marginal proportion of household expenses is spent on education (6%) and health (10%) Table 2.17.

Amongst agricultural farmers, all own agricultural land and 58% own livestock. Nearly half (46.5%)

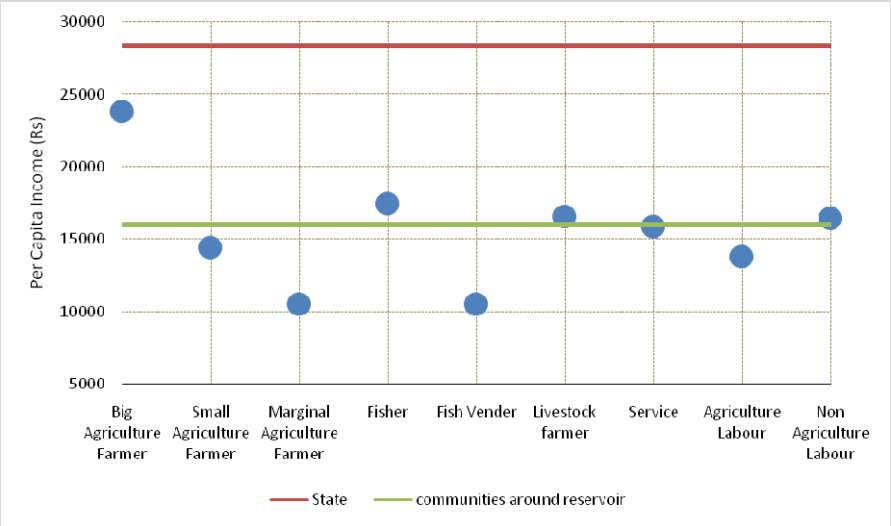


Fig. 2.15 | Per capita income of different stakeholders

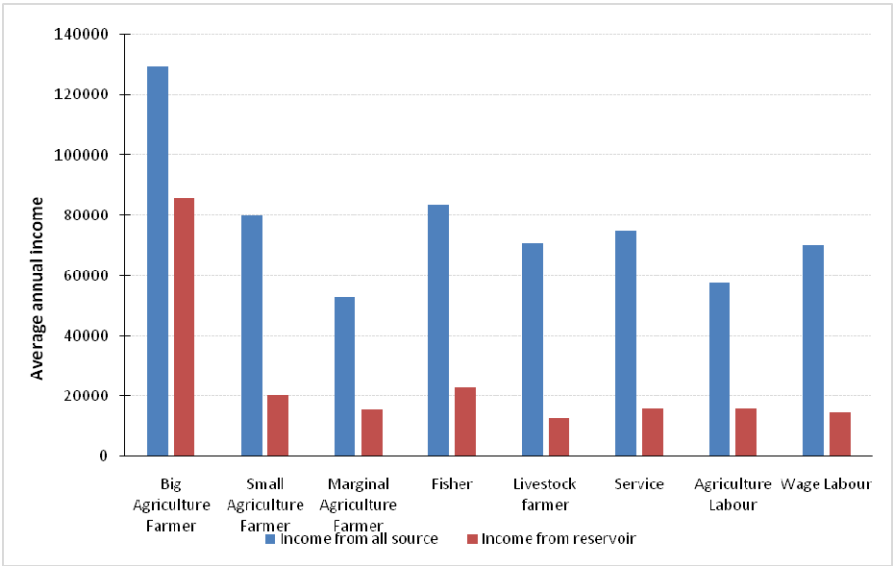


Fig. 2.16 | Contribution of reservoir to communities' average annual income

households engage in occupations other than agriculture. Amongst the fisher communities, 92% of the households own boats and all own nets. Poultry, bullock carts, tillers, irrigation pumps, tractors and traps are the other main occupational assets/implements owned by these communities.

Due to the regular need for maintenance of occupational implements, high input costs of production and low income levels, there is a high level of indebtedness amongst the communities. The survey revealed that 66% of the households take loans to meet their occupational needs and 30% to meet their household needs. Inadequate uptake of formal credit and banking facilities have led to local money lenders and land owners being the main source of credit of communities living around the reservoir.

Access to water and sanitation facilities is low. Only 8% of the households have access to their own source of drinking water (be it through piped water supply, wells and/or handpumps) as against the State average of 22.4%; 8% households have drainage facilities and 15% have their own toilets against the State average of 22%.

Participation in community level institutions is generally low, except in the case of those community institutions that enhance livelihood opportunities. Only 5% of the communities are members of the village panchayat which results in their limited decision making powers and access to on-going developmental schemes. As against this, 60% of the fisher households are members of one of the five Primary Fisher Cooperative Society (PFCS) even though the PFCS's are dysfunctional; and 27% of the farmer households are members of agricultural cooperatives. Membership to Self-Help Groups (SHGs) is also relatively high i.e. 53%, especially amongst livestock farmers.

Table 2.17 | Asset holding of stakeholders

Livelihood assets		Unit	Stakeholder Category								
			Agriculture Farmer			Fisher	Fish Vender	Livestock farmer	Service	Agriculture Labour	Industrial Labour
			Large	Small	Marginal						
Education											
Adult literacy		% adult in household	95%	91%	89%	90%	95%	86%	96%	82%	95%
Adult literacy (female)		% adult female in household	34%	37%	35%	36%	42%	32%	37%	29%	37%
Quality of housing											
Pucca houses		% household	28%	4%	7%	5%	0%	0%	7%	11%	8%
Semi-Pucca		% household	38%	18%	14%	12%	0%	29%	11%	11%	14%
Kutcha		% household	34%	79%	79%	84%	100%	71%	82%	78%	78%
Drainage		% household	23%	6%	18%	5%	0%	0%	13%	0%	4%
Toilets		% household	39%	24%	14%	7%	0%	14%	11%	0%	24%
Electricity		% household	85%	85%	82%	65%	100%	83%	76%	86%	69%
	>8 hrs	% household	81%	49%	62%	47%	67%	100%	62%	83%	58%
	<8 hrs	% household	19%	51%	38%	53%	33%	0%	38%	17%	42%
Drinking water	Piped water	% household	7%	14%	4%	4%	20%	0%	11%	0%	3%
	Well	% household	10%	2%	7%	2%	20%	0%	7%	0%	14%
	Handpump	% household	13%	10%	11%	14%	20%	0%	4%	22%	5%
Energy for cooking	LPG	% household	31%	9%	11%	5%	0%	0%	10%	0%	15%
	Fuelwood	% household	100%	100%	97%	99%	100%	100%	96%	100%	100%
	Cowdung cake	% household	0%	19%	33%	2%	0%	0%	0%	0%	15%
	Kerosene	% household	0%	14%	0%	0%	0%	0%	0%	0%	0%
	Coal	% household	0%	23%	18%	0%	0%	20%	11%	50%	17%

Livelihood assets		Unit	Stakeholder Category								
			Agriculture Farmer			Fisher	Fish Vender	Livestock farmer	Service	Agriculture Labour	Industrial Labour
			Large	Small	Marginal						
Agriculture land & livestock	Own Agriculture land	% household	100%	100%	100%	28%	20%	57%	61%	56%	57%
	Landholding	Average , acre	7.20	4.51	2.69	2.51	1.58	253%	193%	251%	180%
	Own Livestock	% household	75%	55%	80%	42%	100%	50%	0%	80%	36%
	Own Poultry	% household	9%	11%	0%	7%	0%	17%	11%	21%	0%
Occupational Impliment	Bullock cart	% household	15%	14%	10%	5%	0%	0%	6%	15%	9%
	Tiller	% household	53%	11%	18%	3%	0%	0%	16%	27%	8%
	Irrigation pump	% household	8%	11%	11%	0%	0%	0%	11%	17%	9%
	Tractor	% household	33%	13%	0%	0%	0%	0%	0%	8%	0%
	Boats	% household	8%	0%	10%	92%	0%	67%	50%	33%	47%
	Nets	% household	8%	4%	25%	100%	100%	67%	50%	47%	56%
	Traps	% household	0%	0%	0%	2%	0%	0%	0%	21%	0%
			0%	0%	0%	0%	0%	0%	0%	0%	0%
Annual Income		Average (Rs.)	119028	78954	54111	83605	60700	70857	75107	63750	70271
		SD	79869	63894	22829	60970	12387	22289	43500	22334	27802
Proportion of expenditure on											
Food		% of monthly Expenditure	57%	58%	62%	54%	65%	63%	62%	59%	57%
Education		% of monthly Expenditure	5%	9%	6%	6%	5%	7%	7%	5%	5%
Health		% of monthly Expenditure	7%	7%	7%	6%	7%	8%	7%	9%	8%
Transport		% of monthly Expenditure	14%	7%	7%	10%	8%	8%	7%	8%	7%
Repair and maintenance of house		% of monthly Expenditure	7%	8%	7%	8%	6%	6%	7%	9%	10%

Livelihood assets		Unit	Stakeholder Category								
			Agriculture Farmer			Fisher	Fish Vender	Livestock farmer	Service	Agriculture Labour	Industrial Labour
			Large	Small	Marginal						
Main livelihood activity (fisheries, agriculture, etc.)		% of monthly Expenditure	11%	11%	11%	16%	9%	8%	10%	9%	12%
Indebted		% household	43%	30%	22%	21%	20%	43%	36%	33%	43%
Purpose											
	Occupational needs	% of indebted household	92%	80%	80%	67%	0%	33%	80%	67%	94%
	Household needs	% of indebted household	8%	20%	20%	30%	100%	33%	20%	33%	6%
	Education	% of indebted household	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Medicines/hospitals	% of indebted household	0%	0%	0%	0%	0%	0%	0%	0%	0%
Main source of credit											
	Local money lender	% of indebted household	0%	30%	42%	48%	0%	0%	50%	100%	0%
	Land owner	% of indebted household	0%	10%	8%	14%	100%	50%	33%	0%	18%
	SHGs	% of indebted household	0%	20%	0%	14%	0%	0%	17%	0%	9%
	Other_Bank	% of indebted household	100%	40%	50%	24%	0%	50%	0%	0%	73%
Outstanding Credit		Average (Rs.)	51333	20455	12550	16619	50000	45000	0	8000	17545
		SD	33625	12084	9167	16479	0	7071	0	0	12461
Membership to institution											
Village panchayat		% household	0%	1%	0%	2%	20%	0%	7%	0%	0%
Village committees		% household	13%	8%	9%	4%	0%	14%	0%	0%	14%
Youth club		% household	3%	1%	2%	2%	0%	0%	11%	11%	3%
Disaster management committees		% household	0%	0%	0%	0%	0%	0%	0%	0%	0%

Livelihood assets	Unit	Stakeholder Category								
		Agriculture Farmer			Fisher	Fish Vender	Livestock farmer	Service	Agriculture Labour	Industrial Labour
		Large	Small	Marginal						
Agricultural cooperatives	% household	20%	23%	26%	1%	20%	14%	11%	0%	8%
Fish cooperatives	% household	3%	2%	4%	65%	20%	71%	25%	22%	24%
Other co-op societies	% household	23%	16%	2%	2%	0%	0%	7%	22%	11%
Pani panchayat/Water associations	% household	0%	0%	0%	0%	0%	0%	0%	0%	0%
Van Sanrakshan Samities	% household	0%	0%	0%	2%	0%	0%	4%	0%	0%
NGOs	% household	0%	0%	2%	2%	0%	0%	4%	0%	0%
SHGs	% household	17%	23%	11%	31%	0%	57%	25%	22%	35%
Women groups/ Mahila mandals	% household	0%	0%	2%	1%	0%	0%	0%	0%	3%

The farmers have also organized themselves to form an association called 'Budhi Anchal Sangram Parishad' (literally meaning *Submerged Area Struggle Council*) to ensure the legal right of displaced farmers on Hirakud Farm land.

Reservoir livelihood interlinkages

Strong interlinkages can be drawn between community livelihoods and the reservoir inundation regimes, especially in regard to its provisioning and regulating services which determine the bundle of services available to the communities and the seasonal resource use pattern.

Livelihood systems, as reservoir fisheries thrive from March to November and wetland agriculture from October to July. Communities gain access to reservoir services, as drinking water from November to June; fuelwood from January to April; and fodder from November to April. During the monsoon months, from June to September, the primary service of the reservoir is flood protection. As such this is the stress period in terms of livelihood systems for the communities living around the reservoir. Reservoir fisheries is also banned during these months, and fishers who engage in reservoir fisheries do so illegally.

Cultural services of the reservoir are available for most part of the year between March to April and July to January. (Fig. 2.17)

The topography around the reservoir also plays a significant role in determining the livelihood opportunities available as well as the services provided by the reservoir. The region between the Mahanadi and Ib Rivers which is mainly hilly, is characterized by a predominance of farmers and fishers who practise farming between the RL630 and RL632 contours. In recent years, increased drying of reservoir fringes has prompted cultivation of floodplains.

The region between the Ib and Mahanadi Rivers (across Jharsuguda and Sambalpur Districts) and Mahanadi River and Debrigarh Sanctuary (across Sambalpur and Bargarh districts) are mainly plains, wherein agriculture, industries and urban centres dominate. The provisioning services of the reservoir for this region is that of supporting fisheries, irrigation, industries and as a basic amenity. Further, given the hilly terrain and sanctuary status of Debrigarh, the reservoir services are mainly characterized by the water availability for fisheries all around the year, as well as the newly and fast emerging livelihood

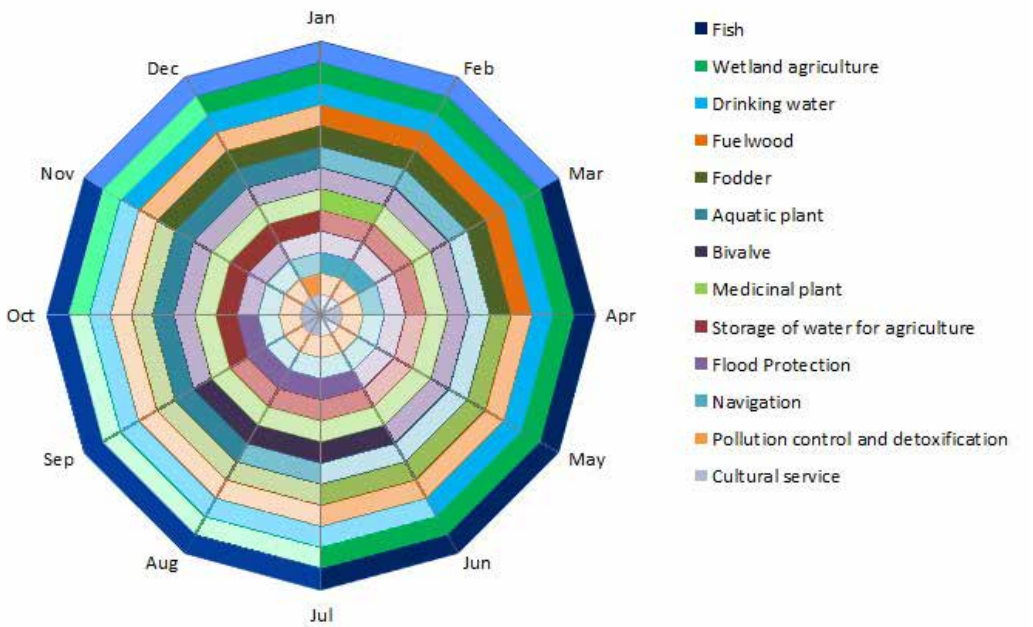


Fig 2.17 | Seasonality of resource use in Hirakud Reservoir

opportunity of tourism for which available infrastructure is being capitalised on.

Wetland Agriculture

Every year 69.75 km^2 of the reservoir is exposed due to variable inundation regime, providing communities living around the reservoir direct opportunities for wetland agriculture. A total of 205 households engage in wetland agriculture, of which 105 households belong to the farmer community and 53 households to fishers.

Wetland agriculture is undertaken mainly along the Mahanadi River channel and smaller portions of the Ib River are also cultivated (Map 2.20).

The most productive months for wetland agriculture are from December to June, when short duration (i.e. 90 day gestation) Rabi and Zaid crops are cultivated. Paddy (Rabi Crop), Brinjal, Tomato, Cabbage, Cauliflower and Spinach (Zaid Crops) are the main crops to be grown. Vegetable cultivation is dominant in Loising, Hansamura, Katapali, Lapanga, Nishan Bhanga, Dantamura and Tamdei villages located to the north and north-east of the reservoir.

There are no tenurial rights on this land, ad areas are demarcated based on mutual agreements between all those practicing wetland agriculture, with regards to who will cultivate which area of the reservoir.

Reservoir Fisheries

With the formation of the Hirakud Reservoir, communities living within the reservoir basin have adapted their fishing practices to engage in reservoir fisheries as against riverine fisheries which they practised in the past. As per survey, 6,700 fisher households from the adjoining 118 villages engage in reservoir fisheries as their primary occupation. Notably, 92% of the fishers are from the schedule castes (55%) and schedule tribes (37%), with *'Kewat'* (sub caste '*Beahera'* and *'Mirdha'*) being the dominant caste. (Kumar, 2014)

A concentration of fishers belonging to the schedule tribes is found to the south west and north of the reservoir, which coincides with Debrigarh Sanctuary and Hemgiri Forest Range. Despite fishing being the main source of income, especially in the Debrigarh Sanctuary area, wherein 53% of the households engage in fisheries as a primary occupation, there is limited availability of basic amenities and infrastructure required for fishing.

In 1960, the State Fisheries Department was designated as the custodian of fishing rights for the reservoir. Since then, a total of five Primary Fisher Co-operative Societies (PFCSs) have emerged with a total membership of 3,512 fisher households which is approximately 50% of the total fisher households. Each of these PFCS's sub-let

Short term paddy being cultivated in reservoir fringes

Map 2.20 | Agriculture extent around Hirakud Reservoir

Fishers in Hirakud Reservoir

a pre-determined section of the reservoir, by paying a lease amount to the State Fisheries Department, which allows its members to fish within a designated portion of the reservoir (Section 2.2.4 gives a detailed account of the functioning of PFCSs).

In the past three decades, fishers have preferred to pursue alternate livelihood options. 34% of fisher households engage in wetland agriculture and 31% in industrial wage labour, especially those living near the Ib River. This can be attributed to the limited functioning of PFCS's because of which fishers are losing their confidence in PFCS's being able to ensure and secure their livelihoods, as well as, the minimal input costs and high returns from engaging in wetland agriculture and industrial wage labour.

During the lean season (normally during the monsoon months when fishing is banned in the reservoir) fishers living near the Debrigarh Sanctuary and Hemgir Forest Range collect non-timber forest products (NTFPs) to sell in the local market as a means to supplement their income. Fishers living to the south of the reservoir seek employment in Sambalpur town during these months.

Tourism

Sambalpur, Deogarh, Bargarh and Jharsuguda, due to their rich historical and cultural heritage and natural attractions have emerged as tourist hotspots of international importance in the State. The Hirakud Reservoir, located right in the midst of this setting, is also listed as a key tourist destination by the Tourism Department of Odisha. It is said that *"Hirakud"* literally meaning "*Diamond* (Hira) *Island* (Kud)" was Sambalpur's traditional reserve for extracting diamonds from the sands of Mahanadi River (Odisha Tourism, 2015).

Having the distinction of being the longest earthen dam in the world, Hirakud attracts 2.70% of the tourist inflow into the state, majority being domestic tourists (Fig. 2.18). A 21km drive along the reservoir's dyke affords a spectacular view of the reservoir. Further, two observatory towers – Jawahar Minar on the south-west corner and Gandhi Minar on the north-east corner – offer tourists an aerial view of the entire reservoir. The vast expanse of water acts as an ideal refuge for migratory waterbirds in winter, which further adds to its tourist value.

It is not Hirakud alone but its associated tourist complex that has become the backbone of the tourism industry in this region. However, post 2014 the tourist inflow has witnessed a slight decrease due to the strict regulations that are being enforced in the aftermath of a boat tragedy in which 31 lives were lost.

The Debrigarh Sanctuary on the west of the reservoir is one of the main wildlife destinations of

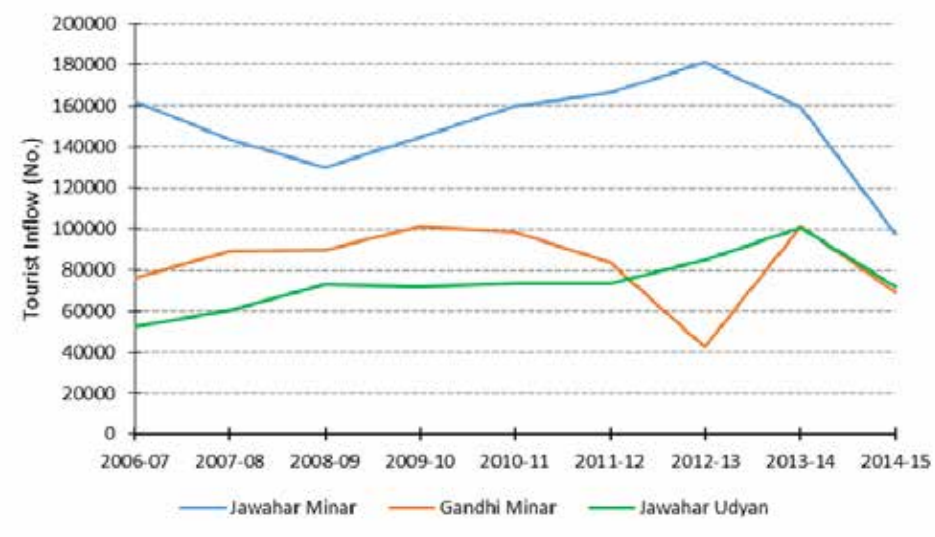


Fig. 2.18 | Tourist inflow in Hirakud Reservoir

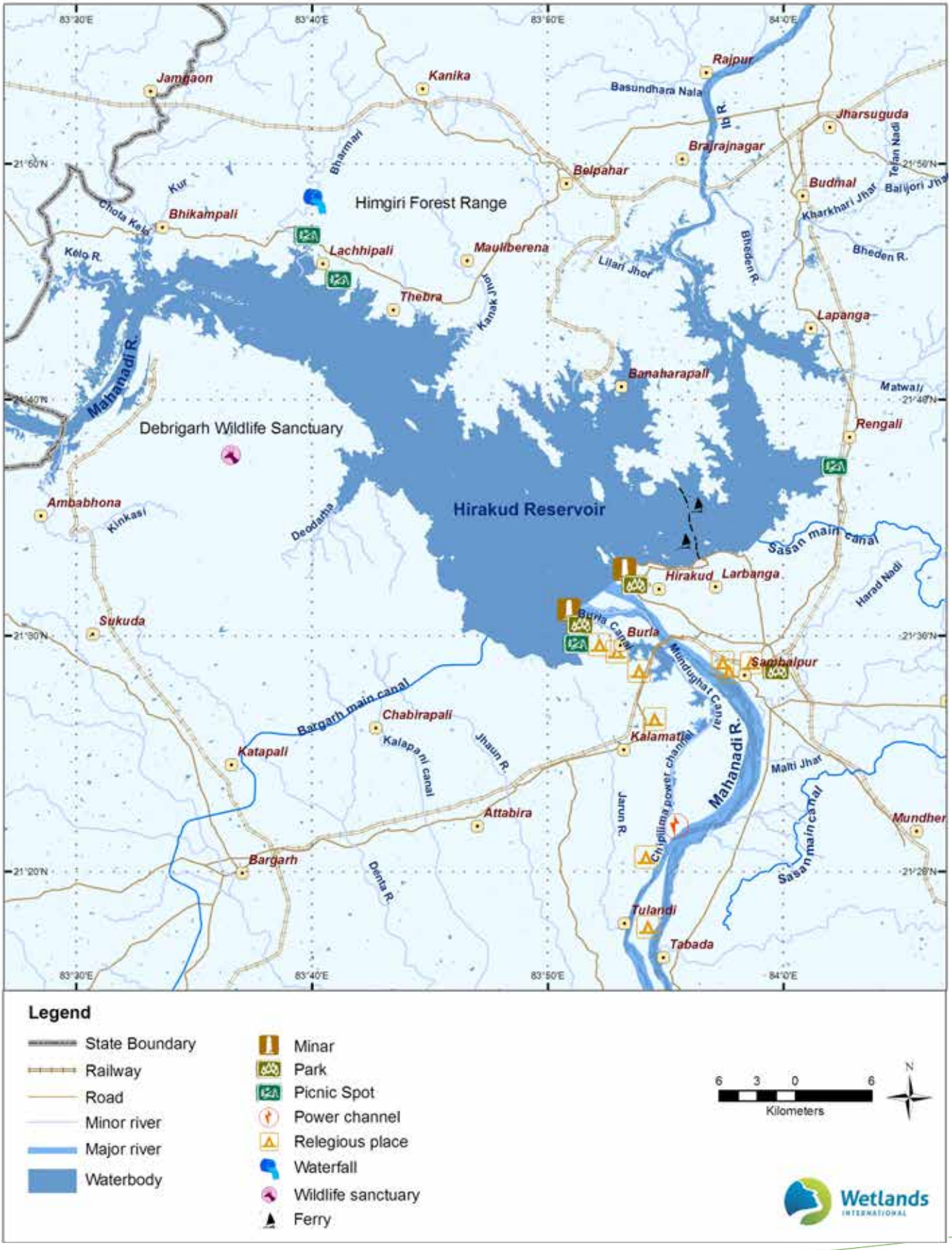
the State. The Hydro-Electric plant of Hirakud, located at Chiplima, to the south of the reservoir, with its natural waterfall of 24.4mts is another important destination. The area holds a strong place in the religious sentiments of local fishers, as the temple of their deity "Ghantlei" or Ghanteswari is located here. The uniqueness is in the variety of the shapes and sizes of bells found at this temple.

"Huma" the famous Shiva temple located 21 kms south of Sambalpur is one of the spots of religious significance. Built in the 17th century by the Chouhan rulers, the temple leans to the west at approximately a 75 degree angle. Every year during 'Shivratri' a week long fair in honour of Lord Bimaleshwar (one of the avatars of Shiva) is organized around the temple. Of ecological significance, the 'Mahseer' is found in abundance in the part of the Mahanadi River that flows adjacent to the temple. These fish are known especially for eating food from the hands of visitors, and as such are protected by the local community. The river at this point resembles a large natural aquarium, especially during the winter months (Odisha Tourism, 2015).

Two other religiously significant spots near the reservoir are the Chandi Mandir (at Brajrajnagar on the banks of the Ib River) and the Koilghughar Waterfall (at Lakhanpur). There is a shivalingam known as 'Maheshwarnath' inside the waterfall and is only visible during the day when sunrays are reflected by it. Like the Huma Temple, a fair is organized at Koilighughar every year on the occasion of 'Shivaratri'.

Koilighughar waterfall

A web of railways (the East Coast Railway route of the Indian Railways) and national highways (NH 6 and NH 42) connect each of the tourist sites to each other as well as to all major metros and prominent cities across the country. (Map 2.21)



Map 2.21 | Tourist spots in and around Hirakud Reservoir

Sasan canal: lifeline of command area agriculture

Command Area Agriculture

Communities living in the command area of the reservoir primarily drive livelihoods based on agricultural practices. In fact one of the main objectives for developing the Hirakud Reservoir was to provide irrigation to the rain-fed regions of Sambalpur, Bargarh and Jharsuguda districts, in order to propel the growth of the agriculture sector.

Approximately 300,000 farmers spread over an area measuring 462,100 ha across eight districts in the downstream command area depend on irrigation provided by the reservoir (Mahapatra and Panda, 2008). Crops are cultivated bi-annually, during two principal cropping seasons – Rabi and Khariff. During the Rabi Season paddy, vegetables, oilseed and sugarcane are cultivated for period of 130 days, from December to May. Paddy is the main crop during the Khariff Season, from July to December.

During the inception of the reservoir, the command area fell mainly within the boundaries of the erstwhile united Sambalpur district (which went on to be split into four of the current districts – Sambalpur, Bargarh, Jharsuguda and Deogarh in 1993 and 1994). The command area is clearly divided into two sections – the upstream i.e. north of the reservoir between the Mahanadi River and the Ib River and the downstream i.e. south of the reservoir from the Sasan Canal to the Bargarh Canal. While irrigation for the downstream command area was ensured through three main channels – Sasan Canal, Bargarh Canal and Sambalpur Distributary – irrigation for the upstream failed due to the unfeasibility of the lift irrigation project initially planned.

Lower levels of inundation as per the originally demarcated reservoir boundary (at inception) led the Government to initiate farming along the northern boundary of the reservoir, in an area measuring approximately 4000 ha in place of the 'Hirakud Farm'. The objective was to produce hybrid seeds of maize, wheat and vegetables to cater to the increased demand for seeds in the command area during the 4th Five Year Plan (Senapati and Mahanti, 1971).

In the 1960's an 'Agriculture District Programme' was initiated by the Government of Odisha in collaboration with the Ford Foundation to give further impetus to the sector and community blocks were set-up for focused agricultural development. A total of 9 community blocks were set up in the erstwhile Sambalpur District – given that the district had a little less than 300,000 acres of cultivable area for which irrigation was assured through the Hirakud Reservoir.

In 1970 as a part of a community driven agitation against the Government's decision to lease 'Hirakud Farm' to a Russian seed production company, farmer's displaced by the formation of the reservoir (who had not received compensation)

and were a part of the community blocks already cultivating in the area, encroached upon the land. (Choudhury et al., 2012)

Community Perception on Integrated Management Needs

Communities living within the immediate vicinity of the reservoir perceive the services provided by Hirakud to be of critical value to their lives and livelihoods. The key ecosystem services provided by the reservoir (as per community perceptions) are as a source of fish, fuelwood and navigation, as well as a habitat for Mahseer and waterbirds. The community has also attributed significant value to the flood buffering service provided by the reservoir to downstream areas (Fig. 2.19).

The degradation of Hirakud is widely recognised as a threat to the livelihoods of the communities. 99% of the respondents have attributed degradation of the reservoir to the following issues (with a rank more than 0.7) namely siltation, wetland encroachment for agriculture, reduced outflow, destruction of breeding grounds and over harvesting of resources (Fig. 2.20).

Controlling sediment load, curtailing encroachment on reservoir land for agriculture, communication & awareness generation, and constituting a dedicated institution for management of the reservoir, have been identified as the key solutions (Fig. 2.21).

Communities also believed that the primary management objectives of the reservoir development authority should be focused on securing water availability and securing integrated livelihoods and biodiversity conservation (Fig. 2.22).

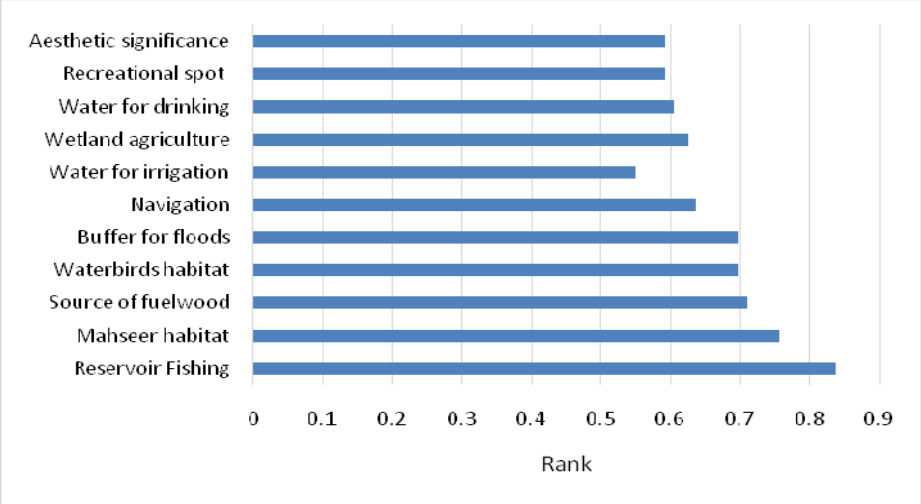


Fig.2.19 | Community perception of ecosystem services from Hirakud Reservoir

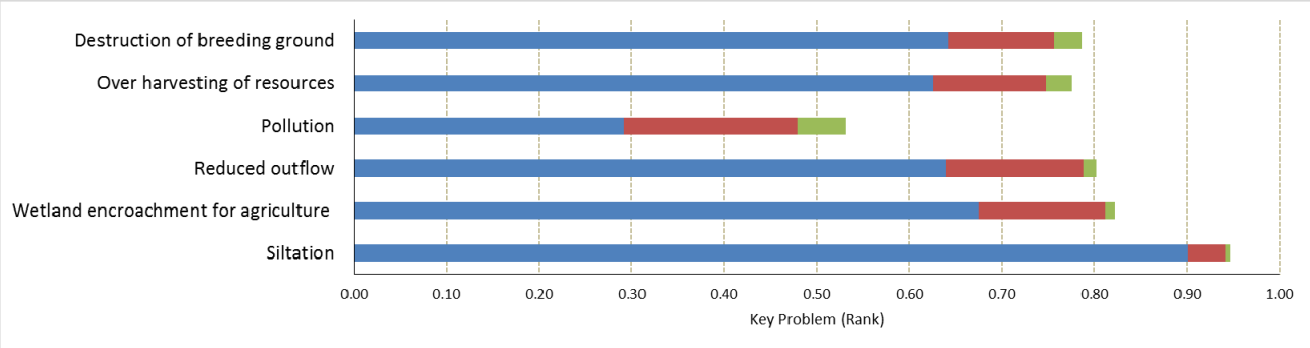


Fig. 2.20 | Key issues leading to the degradation of Hirakud Reservoir

Vulnerability Contexts

Low productivity of traditional livelihoods

Agricultural productivity, especially to the north and west of the reservoir is one of the main challenges of the communities. Fly ash from adjacent

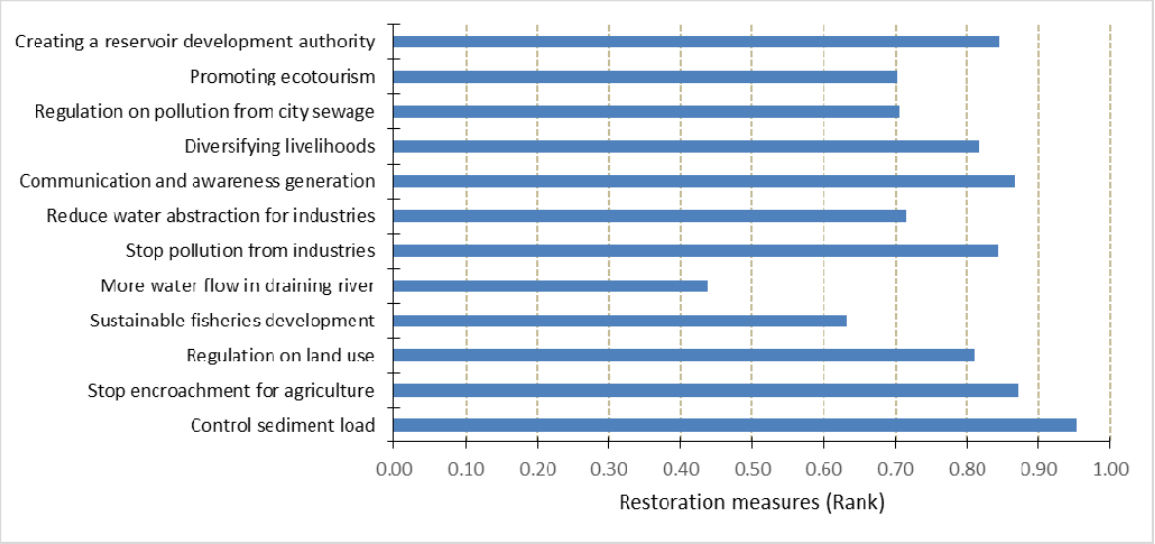


Fig. 2.21 | Key restoration measures identified

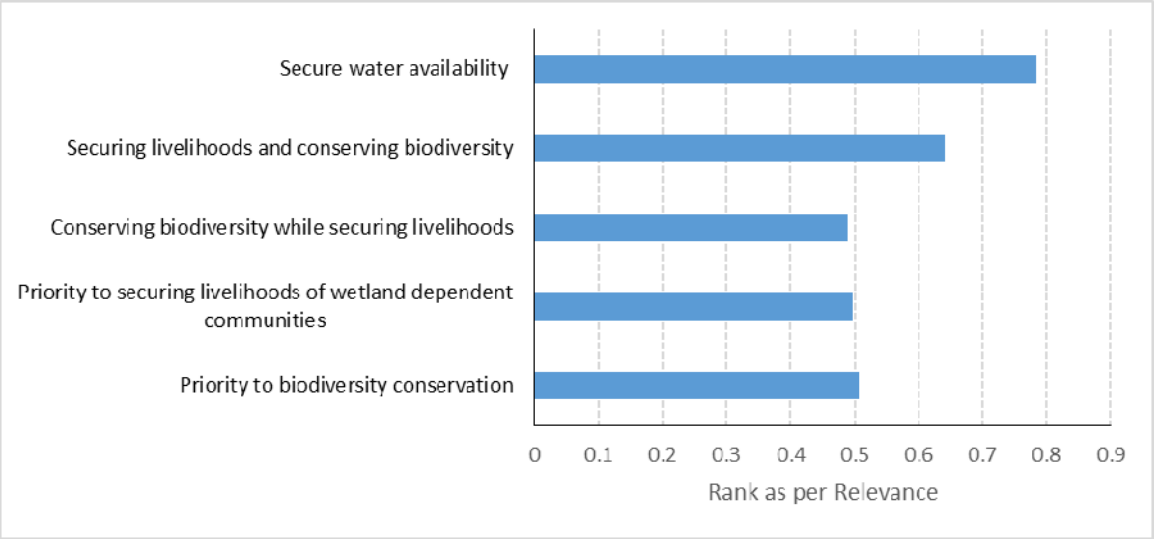


Fig. 2.22 | Key management objectives for reservoir conservation

power plants near the Ib River and lack of irrigation facilities in the Debrigarh Sanctuary area have led to low productivity of the crops being cultivated in these regions. A decrease in the income of fisheries has also been witnessed. As a result, the working population of the communities living in and around the reservoir are more inclined to engage in industrial labour as their primary livelihood as against their traditional occupations of agriculture and/or fishing as not only are the incomes higher but are also evenly distributed throughout the year. While this may be seen as development of communities in general, the main point of concern is that the command area of the reservoir is one of the main grain and vegetable producing regions in Odisha and a change in occupation structures could have larger ramifications on the food security of the state as a whole. Furthermore this would hamper the communities' perception towards the relative

importance of the reservoir and the need to conserve and manage its original ecological character.

Resource use conflicts

With the emergence of a dense industrial belt along the Ib River, a conflict of interest has arisen between the indigenous communities of the Hirakud reservoir and industries along the Ib, especially with regard to water allocation & extraction, and discharge of untreated industrial effluents into the reservoir and irrigation canals.

Crops are damaged due to the release of highly contaminated water for irrigation; agricultural fields in Lapanga and Nishan Bhanga have permanently been converted to barren land because of large quantities of effluent discharge by the Hindalco and Bhushan Steel plants; and fish catch and quality has significantly been effected as well.

Farmers have also reported that deposition of large quantities of fly ash, produced by the Ib Thermal power plant on agricultural fields has led to reductions in crop productivity.

The conflict escalated manifold between 2005 and 2008 when the Sasan Canal was damaged due to unplanned encroachments made by industries on the reservoir, such that government intervention became essential to reach a resolution.

In 2005 the Bhusan Steel plant constructed its private concrete embankment along the reservoir enabling water extraction for its production processes. The embankment obstructed the inflow of water from the Ib River into the reservoir, such that virtually no water was flowing from the Ib into the reservoir. A subsequent removal of the embankment led to a heavy load of silt (that had piled up) to flow into the Sasan Canal, which endured damage at several locations due to its limited capacity. The Sasan was inoperative for a period of two years for repairs (under Acceleration Irrigation Benefit Programme) during which farmers dependent on it for irrigation suffered a loss of livelihoods and were forced to engage in wage labour.

On October 26, 2006, more than 30,000 farmers formed a human chain around the reservoir to draw the attention of the government to the volume of water extracted by industries which was impacting their livelihoods. On March 7, 2008 representatives of the Eastern Orissa Farmer Association – 'Samanmaya Samithi' – met representatives from the Department of Water Resources. A sum of 200 crores rupees was sanctioned for augmenting the Sasan Canal and an order was issued by the office of the Chief Minister expressly detailing that water would not be supplied to industries from the Sasan Canal. Despite this, many industries continue to extract water illegally from the Sasan Canal at Parmanpur by using tankers. As a result, farmers at the tail end continue to struggle to

Fly ash dumping yard at Sapnae Village

meet the irrigation requirements of their crops.

The Odisha State Pollution Control Board (OSPCB) issued show cause notices to industries around the reservoir who were flouting the quality norms as per the Air and Water Pollution Acts, in July, 2009. However, the impact seems to be limited. As immediately after the 2011 floods, crop loss due to fluoride contamination and instances of farmers suffering from skin diseases were reported in 35 villages of Sambalpur, Jharsuguda, Bargarh and Sonepur district. A farmer agitation led the district administration to once again ask for an investigation and report on the issue from the State Pollution Control Board (SPCB) (Choudhury et al., 2012). However, instances of crop contamination continue to be reported (Guru, 2013).

Conflict between displaced community and dam authority for land right

Farmers living in and around the reservoir, especially upstream farmers cultivating crops in the erstwhile Hirakud Farm land, are yet to settle the land right and ownership disputes that have arisen with the government. These farmers belong to the communities that were displaced due to the development of the reservoir. While the farmers encroached upon the land to cultivate their crops and share an understanding with one another including fishers, as to who will cultivate which plot of land, they cannot claim any legal rights on the land. Through the consistent efforts of the 'Budhi Anchal Sangram Parishad' the issue of land rights faced by displaced farmers has been recognised as an area of concern.

In 2011, the State Government declared that a comprehensive survey would be undertaken to identify the villages that were originally located between the RL630 and RL632 contours, such that appropriate compensation can be ensured for those farmers. (Choudhury et al., 2012)

Adverse impact on community health due to deteriorating water quality

Untreated industrial effluent discharge and agricultural run-off (heavily laden with fertilizer and pesticide content) from upstream agricultural fields have contaminated the water in the reservoir. Communities living in and around who rely on the reservoir water for their daily household and occupational needs, especially fishers, are feeling the effects of the contaminated water. Skin diseases are common amongst fishers due to the long hours they spend in the reservoir. Diarrhoea and other stomach related diseases are the common ailments of the communities living in and around the reservoir.

Heavy smog around the reservoir

Unsustainable agriculture practices

A study conducted by the Manav Adhikar Seva Samiti (MASS) in 2006 citing reductions in the water being released by the Hirakud Development Authority for irrigation where only 8 cusecs of water was being released as against the 11 cusecs originally

proposed - further revealed that farmers are engaging in unsustainable agricultural practices (Manav Adhikar Seva Samiti, 2006; Nayak, 2011). At the inception of the reservoir (1947) it was proposed that the agricultural cultivation in the command areas would be undertaken such that 70% of the land would be allocated to paddy cultivation (during the Kharif Season), 10% to sugarcane, 5% to cotton and 15% to other crops. However, in actuality farmers are cultivating paddy (the most water intensive crop) in 95% of the land (during both kharif and rabi seasons) and other crops in only 5% of the land (Nayak, 2011).

Further, resource intensive methods of cultivation wherein large volumes of water are being wasted and excessive use of pesticides, insecticides and fertilisers (which as a part of agricultural run-off is contaminating the reservoir, especially from upstream agricultural fields) have been observed.

Issue of community involvement in reservoir management

Since the formation of the reservoir, communities dependent on it have not been involved in its management. The primary concern of the communities is to extract wetland resources and ensure their rights, rather than ensuring sustainable use and management of the wetland itself. This can be witnessed in the lack of community participation in biodiversity conservation; adoption of unsustainable fishing techniques; and demand driven land use land cover changes (disregarding the resultant impacts on the reservoir).

Discharge of industrial effluent

3. Institutional Arrangements

Wetland functioning, their biodiversity and ecosystem services values are linked with institutional settings and governance systems. Institutions encompass all formal and informal interactions among stakeholders and social structures that determine decision making, power relationships and sharing of responsibilities. Various institutions come together collectively to form governance systems, that include interactions between different centres of power in the society at different scales. Most importantly, institutions and governance influence the direct and indirect drivers of change in a wetland ecosystem. The degree of fit of institutions and governance systems with functioning of Hirakud at basin scale is one of the key determinants of wise use.

Institutional requirements for conservation and sustainable management of Hirakud is defined by the ability to ensure integration of site management within broad scale environmental and developmental programming (at river basin scale), and enabling stakeholder participation. Relevant institutional and governance settings are thereby linked with sectoral programming taking place within the basin of Hirakud.

This section of the management plans contains an analysis of institutional arrangements in the context of integrated management of Hirakud Reservoir. Existing institutional and governance settings are discussed in the first section, wherein sectoral policy and programming details have been analyzed. Convergence opportunities for sustainable management of Hirakud with existing environmental and development sector programmes are discussed in the second section. The third section draws lessons from crafting institutions and governance systems for wetland management, at national scale as well as within states. A proposal for institutional arrangement for integrated management of Hirakud is discussed in the fourth section.

View of Dam Dyke

3.1 Existing institutional and governance settings

Within the existing setup, there is no single institution mandated for managing the Hirakud Reservoir. Instead policies, regulatory framework and programmes spread across several agencies cumulatively influence reservoir functioning.

Key agencies

Being a purpose made water infrastructure, the Department of Water Resources is primarily mandated for reservoir maintenance, operations and water allocation. Rights for reservoir fisheries are vested with the Department of Fisheries. Protected areas located around the reservoir are being managed by the Hirakud Wildlife Division. The Odisha State Pollution Control Board has been entrusted the task of enforcing various environmental laws and regulations to abate pollution. The Department of Agriculture and the Department of Forests have afforestation and watershed management programmes within the direct catchments of the reservoir. Besides the public sector agencies, there are a number of private sector community institutions with programmes related to Hirakud, though relatively small. A brief discussion of the sectoral programmes relevant for management of Hirakud is in the following paragraphs and details provided in Annex XIV.

Water resources development | The Department of Water Resources (DoWR) is the nodal agency for planning, developing and managing the State's water resources. To achieve these objectives, the department is responsible for formulating water policies and plans, undertaking execution, operation and maintenance of irrigation projects; flood control and drainage development; command area development and allocation of water for various uses. Notably, the major programmatic focus of the department is on water resources development, with issues related to conservation and water quality being addressed by the Department of Environment and the State Pollution Control Board.

The department manages Hirakud and other water infrastructure to meet various water resources requirements of the state. Affairs related to Hirakud Reservoir are mainly dealt within the Major and Medium Irrigation Sector Organization (MMISO)[1] of the DoWR functioning under an Engineer-in-Chief, (Water Resources). Within MMISO, different functions related to management of Hirakud are delivered through the following:

- **Hirakud Coordination Committee** constituted under the Chairmanship of the Commissioner cum Secretary, DoWR decides on sectoral allocation of water from Hirakud Reservoir during non-monsoon period.
- **Dam Safety Organization** (headquartered in Bhubaneswar) functional since 1981 is the nodal agency for monitoring and planning for structural safety of all large dams in the state, including Hirakud. An Interstate Dam Safety Committee (with members from Odisha, Jharkhand and Chhattisgarh) has also been constituted for ensuring Mahanadi Basin-wide safety and covers Hirakud Dam.
- **The Office of Chief Engineer, Upper Mahanadi Basin** is responsible for operating the Hirakud Dam during the monsoon season as per the prescribed rule curve. It also implements water allocation decisions of the Hirakud Coordination Committee.

The Department is also implementing, since 2012, The World Bank funded Dam Rehabilitation and Improvement Project (DRIP*)* aimed at improving the safety and operational performance of

[1] The Department of Water Resources is presently organized into seven constituent organizations. These are: 1) Major and Medium Irrigation, 2) Minor Irrigation, 3) Odisha Lift Irrigation Corporation Limited,4) Ground Water Survey and Investigation, 5) Command Area Development and Water Management, 6) Odisha Construction Corporation Limited, and 7) Water and Land Management Institute.

distressed dams. Hirakud is included as one of the five dams[2] wherein infrastructure reinforcement for improved safety is being undertaken. The hydrological information system of the state is being significantly upgraded under the World Bank funded Hydrology Project. Phase I of the project included establishment of 56 river gauge stations, equipped with rain gauges and nine Full Climatic Stations as part of basin-wise hydrological information system network across Odisha. Besides, a reservoir sedimentation survey of Hirakud reservoir to compute the silt deposit is in progress with the use of an integrated bathymetry system. As part of research and development studies, model development for DSS-Planning in Mahanadi Basin is in progress.

Hydropower operations | Hydropower operations have been placed under the Odisha Hydro Power Corporation Limited (OHPCL). OHPCL is a power utility set up by Government of Odisha with an objective of maintaining and augmenting the state's hydropower generation capacity on the principles of economic profitability as well as ecological security. The agency manages the Hirakud Power System comprising of the Burla and Chiplima Power Stations.

Reservoir fisheries | Right to reservoir fisheries is vested with the Fisheries and Animal Resources Department, Government of Odisha. The Fisheries Department has leased fishing rights in the reservoir to five fisher cooperative societies. As discussed at length in Section 2.2.4, efforts made till date for institution of cooperative based fisheries around Hirakud have failed to live up to their desired objectives. Weak capitalization, resources and capacities have limited their role in securing equitable outcomes for the fishers. The Department has also initiated, with support of NFDB, a systematic restocking programme, however the effects are yet to materialize in terms of increase in catch levels.

Irrigation within reservoir command area | Management of irrigation infrastructure is as per the laid out policies for Participatory Irrigation Management (PIM), and with involvement of village level community collectives known as Pani Panchayats. A Directorate of Command Area Development and Participatory Irrigation Management (CAD and PIM) has been established within the Department of Water Resources during 2007-08 to provide necessary support to operationalize the PIM concept in the State. Irrigation infrastructure within the drainage area was developed under the centrally sponsored Command Area Development and Water Management (CADWM) programme.

Catchment conservation | Programmes for catchment conservation are spread across the district administration and state departments of Forests and Agriculture. Catchment programmes in the immediate forested areas of Hirakud is overseen by the office of the Regional Chief Conservator of Forests, Sambalpur Circle having jurisdiction over four territorial divisions (Sambalpur, Jharsuguda, Rairakhol and Bargarh) and two wildlife divisions (Hirakud and Bamra).

Forest department undertakes soil and forest conservation activities under several state and central plan and non-plan schemes. Major forestry programmes in Odisha are centrally sponsored projects such as Increasing Green Cover in the State; Green India Mission; 13th Finance Commission Grants; and the National Afforestation Programme (NAP) Scheme being operated by National Afforestation and Eco-Development Board (NAEB). State plans such as the Intensive Protection of Critically Endangered Area being implemented in 37 territorial divisions; and Odisha Community Forest Protection and Participatory Management in JFM mode are also being implemented.

The leading watershed agencies are the **State Watershed Management Agency** in Chhattisgarh and the **Odisha Watershed Development**

[2] Other four being Kalo, Nesa, Banksal and Sanmachakundana

Mission (OWDM)[3] in Odisha responsible for drawing the perspective and strategic plan for watershed development for the entire river basin and states, sanctioning watershed projects and overseeing their implementation.

The Integrated Watershed Management Programme (IWMP) [4] of the Department of Land Resources, Ministry of Rural Development, Government of India is an ongoing seven year program (2009 to 2016), covering wastelands and rainfed agricultural lands in the states of Chhattisgarh and Odisha. Prior to IWMP, measures for integrated soil and water resource conservation in the Hirakud catchment were components of the River Valley Project (RVP), a centrally sponsored scheme for soil conservation. To enhance productivity and better manage natural resources schemes such as Drought Prone Area Program (DPAP), Integrated Wasteland Development Program (IWDP), National Watershed Development Project for Rain-fed Areas (NWDPRA) have been implemented during different plan periods. The NWDPRA, RVP scheme have been subsumed under the Macro Management Agriculture (MMA) scheme of Department of Agriculture and Cooperation from November, 2000.[5]

The watershed development processes are synergized with employment generating programmes such as the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Backward Regions Grant Fund (BRGF), National Horticulture Mission, Tribal Welfare Schemes, and Artificial Ground Water Recharging scheme to provide coordination and facilitate the mobilization of additional financial resources.

Implementation of IWMP is supported through a network of organizations. In Chhattisgarh and Odisha, the State Level Nodal Agency responsible for implementing IWMP has forged partnerships with several agencies.[6]

The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) launched in July 2015 is an effort to achieve convergence of the ongoing schemes being implemented by various ministries. The scheme aims to reduce the dependence of the agriculture sector on the monsoons by expanding cultivable area under assured irrigation and enhanced adoption of sustainable water conservation practices. The state agriculture department is the nodal agency for implementation of PMKSY projects, while an inter-ministerial National Steering Committee (NSC) has been set up for periodic reviews. Further, the World Bank assisted Neeranchal Project which supports the preparation of integrated science-based,

[3] OWDM was created in 2000-2001 as a registered society under the Administrative Department of Agriculture responsible to plan, monitor, supervise and implement all watershed programmes in a coordinated manner in Odisha State.

[4] Modified programme of erstwhile Drought Prone Areas (DPAP), Desert Development Programme (DDP) and Integrated Wastelands Development Programme (IWDP) of the Department of Land Resources, consolidated for optimum use of resources, sustainable outcomes and integrated planning. The programme is being implemented as per Common Guidelines for Watershed Development Projects 2008.

[5] In Chhattisgarh, as on date, 263 projects with a treatment area of 11.97 lakh ha and cost of 1497.98 crores is being covered under IWMP. At present, the OWDM is implementing watershed management activities in an area of 17.0 lakh hectares with a cost of 2191.52 crores under the IWMP and its components as IWDP, DPAP,EAS (W/S), ACA (W/S) and WORLP.

[6] In Odisha the watershed programmes are being implemented with the support from agencies such as the Agriculture Finance Corporation; Central Institute for Fresh Water Aquaculture; Institute on Management of Agriculture Extension; International Potato Center; Orissa Remote Sensing Application Center (ORSAC); Orissa University of Agriculture and Technology (OUAT); Regional Center of Central Tuber Crops Research Institute (ICAR), Bhubaneswar; State Institute Of Rural Development; Water And Land Management Institute (WALMI), Cuttack; Water Technology Center For Eastern Region (ICAR), Bhubaneswar; and several NGOs. Similarly, in Chhattisgarh, IWMP is supported by Regional Remote Sensing Centre, ISRO, Nagpur; Chhattisgarh Council of Science and Technology, Raipur; Bankers Institute of Rural Development; Central Soil and Water Conservation Research and Training Institute; Society for Elimination of Rural Poverty; Water and Land Management Institute, Indira Gandhi Agricultural University Raipur; and National Bank for Agriculture and Rural Development for providing technical know-how and skill development.

participatory watershed plans with greater focus on water management, will be implemented in Jashpur and Kanker districts in Chhattisgarh.

Soil conservation | The Directorate of Soil Conservation, Department of Agriculture implements both plan and non-plan schemes for soil conservation such as the soil conservation component of central NWDPRA, RVP in MNREGA and the state plan schemes. The Soil Conservation Office, Hirakud Division, Burla has under its jurisdiction the districts of Sambalpur, Bargarh, Jharsuguda and Deogarh comprising five Soil Conservation Sub-Divisions.

Management of protected areas around Hirakud | The protected areas around Hirakud such as Debrigarh Wildlife Sanctuary is under the administrative control of the Hirakud Wildlife Division, Department of Forest and Environment (DoFE). The sanctuary is managed as per working plans of the department. The department has formed the Debrigarh Eco-tourism and Eco-development Society to manage the ecotourism infrastructure within the sanctuary and enable community participation in management. However, the society is presently defunct. An ecotourism plan for Debrigarh is in the offing for realizing cultural and recreational benefits to the fullest potential.

The Wildlife Division also coordinates the mid-winter annual waterbird census programmes, under the Asian Waterbird Census (AWC) programme of Wetlands International. The waterbird population estimates derived from the census form a part of the global Waterbird Population Estimates database.

Wetland management| The DoFE is also the nodal agency for managing the wetlands in Odisha. Programmes for wetland management are delivered through the following key agencies:

- **Odisha Wetland Development Authority** (OWDA), an autonomous body registered under the Societies Registration Act 1860, is an autonomous regulatory, planning and policy making body for protection, conservation, restoration, regeneration and integrated development of all the wetlands of the state. The society is steered by a Governing Body with the Chief Minister as the chairman, and secretaries of concerned departments as members. The Society has prioritized 15 wetlands, including Hirakud for integrated management. A core budget outlay has also been created under the state budget for supporting field interventions.

- **Chilika Development Authority**, an agency of the Government of Odisha, functioning under the aegis of DoFE, is charged with conservation and sustainable management of Lake Chilika. The Authority has led a successful ecological restoration initiative which has rejuvenated the Ramsar Site, and has been awarded the prestigious Ramsar Wetland Conservation Award in 2002. The Authority has also established a state of the art Wetland Research and Training Center for wetland monitoring. The experiences from management of Lake Chilika and the monitoring and assessment infrastructure can be used strategically to support the integrated management of Hirakud.

Rural development and livelihoods | Rural Works and Rural Water Supply and Sanitation are under the ambit of the Department of Rural Development (DoRD) in Odisha. The department implements the rural connectivity programme, maintenance and upkeep of public buildings in rural areas, rural drinking water supply and sanitation programmes and provides emergency support services during natural calamities.

Centrally sponsored schemes for rural development focusing on road/bridge construction, are funded through Rural Infrastructure Development Fund (RIDF), the Pradhan Mantri Gram Sadak Yojana (PMGSY) and Constituency-Wise Allotment (CWA).

Rural water supply is among the subjects entrusted to Panchayats by the States. The central government has been supplementing the efforts of the state government in the sector through the centrally sponsored National Rural Drinking Water Programme (NRDWP). The NRDWP focuses on addressing the issues of the rural drinking water sector by ensuring coverage, sustainability and water quality.

Rural sanitation is addressed through the centrally sponsored Swachha Bharat Abhiyana, previously known as the Total Sanitation Campaign (TSC). The programme aims at improving individual household and community sanitation facilities, solid/liquid waste management, and supports capacity building with Central and State Government funding on a 80:20 sharing basis.

Improvement of physical and natural capital in the villages around Hirakud is supported through the Mahatma Gandhi National Rural Employment Guarantee Scheme. The Indira Awaas Yojana provides housing support to marginalized communities.

For the successful implementation of community-based demand driven programmes such as the Swaccha Bharat Abhiyana, Odisha State Water and Sanitation Mission, a registered society under the aegis of DoRD, has been established. Similarly, the Odisha State Rural Road Agency (OSRRA) has been formed to look after successful implementation of road construction works under PMGSY. These schemes are being implemented as per the guidelines issued by respective union ministries.

These schemes have limited coverage in and around Hirakud. The grass root Palli Sabha and Gram Sabha are elite dominated and controlled by upper castes with limited representation of marginalized communities. There is a need for focused programmes similar to the Special Central Assistance (SCA) under the Revised Long Term Action Plan for Koraput, Bolangir and Kalahandi (KBK) districts.

Community institutions | There are a number of civil society organizations which serve to represent the views and perspectives of communities with the concerned state government agencies. 'Water Initiatives Odisha' is a rights based organization, which has been actively raising concerns on various facets of water management in the state, including that of Hirakud.

'Hirakud Budi Anchal Sangram Samiti' has been raising the issues of displaced communities with the government. 'Krushak Sangha' represents issues of farmers with regards to the reservoir operations.

Nongovernment organization 'Eklavya' works on waterbird conservation issues. Similarly, Sambalpur based 'Social Action for Rural Communities (SARC)' works on capacity development and microcredit programmes for reservoir fishers and farmers. 'Ajaka' works on livelihood issues and women empowerment.

Private Sector and PSU Engagement | Most of the industrial units in the Ib-Jharsuguda valley have Corporate Social Responsibility (CSR) programmes aimed at improving the social welfare of the communities living around the region.

Bhushan Steel and Vedanta have supported plantations in Jharsuguda valley. Bhushan Steel has also augmented the waste management infrastructure of the local municipality. Vedanta has undertaken programmes to improve livelihoods and provide microcredit to farmers and local CBOs. Mahanadi Coalfields Limited is supporting the DoWR to construct a ropeway between the two minarets across the dam. National Thermal Power Corporation (NTPC) has also supported plantation programmes in the region.

Private sector and PSU investments are yet to be meaningfully targeted at conservation of Hirakud and/or ensuring sustainable livelihoods of wetland dependent communities.

Policy and regulatory environment

As with programming, there is no single policy at the state level pertaining to management of the Hirakud Reservoir. Several sectoral policies, vision documents and regulatory frameworks are relevant for the management of Hirakud Reservoir. These are discussed as under (details in Annex XV):

Water resources: The National Water Policy, 2012 provides an overarching policy framework for water resources management at the national scale. The policy advocates for efficient use of water resources, equitable access to water and its fair pricing, for various uses arrived at through independent assessment by a statutory water regulatory authority, set up by each State. The policy also emphasizes on holistic and balanced development of catchments and the command areas, planning, development and management of water resources such as Hirakud based on the concepts of Integrated Water Resources Management (IWRM) wherein river basin are considered as a single unit of planning. The policy also recommends the creation of a National Water Informatics Center.

The broad principles and priorities for water resources and their management in the state are contained in the Odisha State Water Policy, 2007. The policy outlines river basins and sub-basins as the basic planning units and accords an order of priority for allocation of water (from high to low priority) for drinking water and human use; ecology; irrigation, agriculture and related activities including fisheries; hydropower; industries, including agro-industries; and navigation and other uses as tourism.

The current policy builds on its forerunner which underscored the need for a coordinated approach to the state's water resources development. A Water Resources Board, formed under chairmanship of Chief Secretary, Government of Odisha, is the apex body responsible for implementing the state's water policy, prioritize the development of water resources, earmark water for allocations to various sectors, environmental management of water resources and to ensure interdepartmental co-ordination. At the time of writing of this report, the DoWR is considering revising the state water policy in keeping with the elements of the new national policy.

The state government has put in place a policy and regulatory framework to ensure the participation of farmers in management of irrigation systems. The Odisha Pani Panchayat Act, 2002 and the Orissa Pani Panchayat Rules, 2003 provide legal backing for the setting up and managing Water User Associations for management of irrigation projects.

Forestry and Watershed Management: The overall policy framework for conservation and management of the forested areas is contained in the National Forest Policy, 1988. The policy aims at increasing forest and tree cover in the country through massive afforestation and social forestry programmes, especially on all denuded, degraded and unproductive lands. The policy also envisions a minimum of one-third of the total land area of the country under forest or tree cover, wherein two-thirds of the hilly regions are to be maintained under forest cover.

The Policy and the subsequent government resolution on participatory forest management – Joint Forest Management Resolution, 1990 - emphasize the need for people's participation in natural forest management. A two-tier arrangement namely the Forest Development Agencies (FDAs) and Joint Forest Management Committees (JMFCs) colloquially called the Vana Samrakshana Samities (VSS) support the department in protecting and managing village fringe forests.

The Indian Forest Act, 1927 is the core law relating to forests, the transit of forest-produce and the duty leviable on timber and other forest-produce. It provides the states with the power to

constitute any forest-land or waste-land which is the property of Government as reserve/protected forests and specifies penalties and procedures therein.

These acts are further strengthened by the Forest (Conservation) Act, 1980 that places a restriction on the de-reservation of forests or use of forest land for non-forest purpose. As per the Act, diversion of forest land for any non-forest purpose should be subject to ecological, environmental and social examination and such projects should provide funds for prior compensatory afforestation and development of social infrastructure in the area.[7] Guidelines were formulated in 2009 by the Ministry of Environment, Forest and Climate Change, Government of India for establishing CAMPAs in the States/UTs and putting in place a funding mechanism for utilizing funds received towards Compensatory Afforestation in lieu of Net Present Value. The National CAMPA Advisory Council with Minister of Environment and Forests as the Chairperson was constituted following the Hono'ble Supreme Court's order dated 10.07.09 (I.A. no. 2143 in W.P. (C) No. 202/ 1995).

The Odisha Forest Act, 1972 is a unified approach of the two Forest Acts applicable in Odisha i.e. the Indian Forest Act, 1927 and the Madras Forest Act, 1882. The Odisha Act draws from other Acts to incorporate additional clauses for management and regulation related to forests which are the joint property of the Government and other stakeholders. The Act prohibits cutting of fruit-bearing trees standing on private property other than the Government's.

The Orissa Communal Forest and Private Lands (Prohibition of Alienation) Act, 1948 provides legal protection to community lands.

The Government of Odisha has outlined Vision 2020 for the forestry sector building on the principles of sustainability, ensuring secured provision of ecosystem services, protection of customary rights and usages, and lowered regulatory burden and transaction costs. The Government of Chhattisgarh notified its State Forest Policy in 2001, with emphasis on community control and management, and a shift in focus from major to minor forest products and from crown to multi-tier forestry.

The Common Guidelines for Watershed Development Projects, 2008 were framed to guide the development of Rainfed/Dryland Farming Systems, by the National Rainfed Area Authority (NRAA). The guidelines form the basis for executing watershed schemes of different Ministries including externally aided projects (EAPs). Delegation of authority of sanction of projects to States; dedicated institutions; financial assistance by the centre; treatment of micro-watersheds on cluster basis; capacity building of stakeholders; monitoring and evaluation; improved livelihood capital; and productivity enhancement are the key features of the common guidelines.

Environment: National Environment Policy, 2006 provides the overarching framework for conservation and judicious use of our nation's natural resources. Conservation of wetlands, and their integration in river basin and coastal zone management is identified as a priority action within the national policy, and is relevant for management of Hirakud.

The Wetland (Conservation and Management) Rules, 2010 framed under the provisions of the

[7] The Compensatory Afforestation Fund Management and Planning Authority (CAMPA) Odisha was constituted vide Notification No. 13995/F&E dated 14.08.2009. Since 1980 up to December 2007, 336 numbers of project proposals under different Sectors have been approved by the MoEFCC, Government of India in the Odisha state involving diversion of 34,692 ha of forest land. Compensatory afforestation in lieu of forest areas diverted for non-forestry purpose has been undertaken over an area of 33,472 ha of forest land and non-forest land till 1st Jan. 2008 as per the provisions of the Forest (Conservation) Act, 1980. Principal funds available with the states as on March 2013 were 212,173 million rupees. 2,058 million rupees were allotted to Odisha in 2012-13. 40,930 million rupees were available for allocation to Odisha state CAMPA as on 31.03.14.

Environmental Protection Act, 1986 provide the regulatory framework for wetlands notified for the purpose in the said Rules.

There is a highly evolved regulatory framework for environment conservation, both at the national as well as the state level. Odisha is a forerunner in environmental conservation and has adopted the Orissa River Pollution Prevention Act in 1953. The adoption of the Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981 by the state's Legislative Assembly led to the creation of a Orissa State Prevention and Control of Pollution Board which has been re-designated as the Orissa State Pollution Control Board, OSPCB).

The OSPCB is the key agency for enforcing advising, monitoring, researching and raising public awareness. With the enactment of the Environment (Protection) Act, 1986 the OSPCB has been assigned the responsibility of enforcing a number of key regulations and notifications[8]. The Board issues directives to industries to adopt clean technologies, install adequate emission control measures and set up effluent treatment plants. The Board has identified Ib-Jharsuguda as a critically polluted industrial cluster and developed an action plan for pollution abatement for the cluster in 2010. The Board also monitors water quality status through a network of stations.

[8] Hazardous Waste (Management & Handling) Rules, 1989 amended in 2000; Manufacture, use, import, Export, Storage of Hazardous Microorganism, Genetically Engineered Organisms or Cells Rules, 1989; Manufacture, Storage and Import of Hazardous Chemical Rules, 1989,amended in 2000; Environment Audit Notification, 1993; EIA (27.01.1994) and Notification for conducting public hearing (10.04.1997) prior to the issue of NOC (Consent to establish a statutory requirement under EP Act and rules); Coastal Regulation Zone Notification, 1991; Chemical Accidents (Emergency Planning, Preparedness & Response) Rules, 1996; Biomedical Waste (Management & Handling) Rules, 1998; Municipal Solid Wastes (Management & Handling) Rules, 2000; Recycled Plastics Manufactures and Usage Rules, 1998 amended in 1999; Notification on Flyash (14th September 1999); The Noise Pollution (Regulation and Control Rules, 2000; Ozone Depleting Substance (Regulation) Rules, 2000; Batteries (Management & Handling) Rules, 2001

In 2006, the Government of Odisha, as per directions of the MoEFCC, has constituted a State Level Environment Impact Assessment Authority (SEIAA) and State level Expert Appraisal Committee (SEAC) for enforcement of the MoEFCC's 2006 notification on Environment Impact Assessment. The Authority can recommend clearances for Category B projects.

Under the provisions of the Biological Diversity Act, 2002, the state government has notified the Odisha Biological Diversity Rules, 2012 and constituted the State Biodiversity Board responsible for enforcing its provisions. The Board has an advisory as well as a regulatory role in matters concerning conservation of biodiversity, sustainable use of its components, and fair and equitable sharing of benefits arising out of the use of biological resources and knowledge. Being in its inception period, the Board is yet to develop a programme for conservation of biodiversity for the state.

Fisheries: The Indian Fisheries Act, 1897 prohibits destructive fishing practices and protection of fish in selected waters and prescribes penalties and imprisonment for defaulting.

The Vision 2020 for fisheries management and development in the state, aims at being "a leader in the country in sustainable fisheries and aquaculture and improving food, livelihood security and socio-economic status of fishers." The state's ten year perspective plan for the fisheries sector (2010 – 20) identifies action plans for inland and marine fisheries, brackishwater aquaculture, infrastructure development, fisher welfare, and capacity building. The plan envisages to increase fish productivity from large reservoirs from 0.51 – 5.3 kg /ha to 30 kg/ha.

The State Reservoir Fishery Policy, 2004 and Odisha Fisheries Policy, 2015 aim at augmenting fish production from reservoirs by introducing systematic management strategies for conservation and sustained fish production. The policy also

seeks to attract investment from the private sector and stimulate entrepreneurship in reservoir fisheries. The policy's operational strategy includes leasing out fishing rights to Primary Fisherman Cooperative Societies on 5 year cycle with a lease value of Rs. 200 per hectare[9] of which Rs.140 is deposited with the Fish Farmers Development Agency for procurement of fish seed and stocking the reservoir.

Conservation measures recommended in the policy include prohibitory activities as ban on catching brood stock of economically important species; capture and sale of Indian Major Carps below 250 mm; use of gill nets below 100 mm stretched mesh size; use of explosives, poisons, and toxins; erection of fixed gears in watercourses draining into the reservoir; unauthorized fishing; discharge of untreated sewage; and introduction of exotic species (except with permission of the Fisheries Department). An officer of the rank of Fisheries Extension Officer / Inspector of Fisheries has been empowered to enforce the provisions.

Tourism: Odisha Tourism Policy, 2013 aims to promote sustainable tourism as a means of inclusive economic growth in Odisha. It provides fiscal incentives such as concession on stamp duty and capital investment subsidy as well as non-fiscal incentives as land bank for tourism projects. The institutional arrangement for promoting tourism comprises the State tourism promotion council, a tourism advisory committee, a district and a local tourism promotion council as prescribed by the policy.

The policy is well aligned with the National Tourism Policy, 2002, which emphasizes on seven "S" as key elements – Swagat (Welcome), Soochna (Information), Suvidha (Facilitation), Suraksha (Safety), Sahyog (Cooperation), Samrachana (Infrastructure development), and Safai (Cleanliness).

[9] For medium and major reservoirs. In case of minor reservoirs (of area 10 to 1,000 ha), the lease value charged is Rs. 300 per hectare.

The potential for Hirakud as a eco-tourism destination is yet to be fully realized. Limited recreational tourism avenues have been created in the form two minarets and gardens. Development of Sambalpur- Hirakud- Dhama- Pradhanpat- Khandadhar- Vedvyas-Pitamahal- Khinda- Deogarh circuit was an identified project under the 11th plan, but is yet to be acted upon.

Cultural festivals as *Lokamahotsav* Sambalpur are promoted and sponsored by the Department of Tourism. Work is underway for a erection of 800-metre ropeway between *Jawahar Udyan* and *Gandhi Minar* of Hirakud being executed by the Odisha Construction Corporation with funding from the Mahanadi Coalfields Limited (MCL).

Climate change: The Department of Forest and Environment is also the nodal agency for issues related to climate change. The Orissa Climate Change Action Plan 2010-2015 is a cross-cutting plan identifying priorities and action across 12 sectors (agriculture, coasts and disasters, energy, fisheries and animal resources, forestry, health, industry, mining, transport, urban planning, water resources and cross-cutting).

Wetland conservation has been identified as an action under urban planning, water resources, and coasts and disaster sectors. Within the plan, there are 123 mitigation actions which have a direct and indirect bearing on the ways Hirakud functions, and developmental activities, particularly industrial development is structured in its basin.

India, in its submission of Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) has submitted proposals for sustainable lifestyles, cleaner economic development, reduction in emission intensity of Gross Domestic Product (GDP), increasing share of non-fossil fuel based electricity, enhancing carbon sinks, adaptation, mobilizing finance and technology transfer and capacity building. The INDC commits to reduce the emission's intensity

by 33-35 % between 2005 and 2030, and create an additional carbon sink of 2.5 to 3 billion tonnes by increasing the tree cover besides prioritizing efforts to build resilience to climate change impacts. Ecosystem based adaptation is considered as a pathway for adaptation.

Green Climate Fund (GCF) is the financial commitment of the UNFCCC for supporting projects, programmes, policies and other activities in developing countries. The GCF was operationalised in India in 2015. The funds are proposed to be made available to organisations that make development investment decisions. The National Bank for Agriculture and Rural Development (NABARD) is accredited as the first National Implementing Entity (NIE) of the GCF. Three projects with an outlay of US $ 5.0 million have been approved by Adaptation Fund Board (AFB) which administers the GCF.

Gaps

Despite a highly evolved policy and regulatory framework, and a gamut of programmes, the reservoir continues to be threatened, thus indicating the insufficiency in addressing integrated management. Following gaps are indicated based on the review:

Sectoral approaches: Existing policies and programmes are designed to meet sectoral objectives. Their impacts on other sectors are often not taken into account. For example, the water allocation plan takes into account a limited set of objectives related to human water requirements but does not take into account the ecological requirements. Programmes for management of Debrigarh Sanctuary are limited to the land area, without taking into account the interlinkages with aquatic habitats of the reservoir. Policies and programmes for industrial development do not take into account implications on water availability for other sectors, or water quality of the reservoir and impacts on biota.

Insufficient prioritization of Hirakud in sectoral programming: In several circumstances, while the objectives of schemes are aligned with management of Hirakud, site selection criteria adopted tend to exclude the reservoir basin. For example, the criteria for selection and prioritization of watershed development projects under IWMP weigh heavily on socioeconomic parameters, putting the less populated yet severely degraded catchments of Hirakud at a disadvantage. Programmes of the Department of Tourism do not consider the Hirakud Reservoir within the network of tourism development sites.

Weak enforcement of regulatory mechanisms: The ecological status of the reservoir is impacted by weak enforcement of existing regulations. There is rampant violation of the mesh size regulation (prescribed in the Reservoir Fisheries Policy). Similarly, downstream of the reservoir, poor water quality has been observed due to discharge of industrial as well as domestic effluents.

Inadequate allocation of financial and human resources: Several schemes have failed to create a positive impact on the reservoir due to inadequate allocation of financial and human resources. This is especially true for the projects of the fisheries sector, wherein critical intervention periods have been lost and the interventions being made at present for improving fishing infrastructure are not of effective scale.

3.2 Convergence opportunities with sectoral programming

The ongoing developmental programmes present opportunities for addressing threats on various wetland features, and contribute to integrated management. These are as follows:

- Enhancing vegetative cover in the catchment under ongoing afforestation (Department of Forests and Environment) and watershed management programmes (Department of

Agriculture) in order to reduce sedimentation of the reservoir;
- Strengthening enforcement of OSPCB pollution standards in Ib-Jharsuguda Valley to improve the water quality of the reservoir;
- Enhancing fish seed production for reservoir fisheries under schemes of the Directorate of Fisheries;
- Strengthening community managed reservoir fisheries by upscaling implementation of the Directorate of Fisheries programmes for strengthening capacities of fisher cooperatives;
- Including water requirements for downstream ecosystems within the reservoir operations planning process of the Department of Water Resources;
- Improving water efficiency and promoting sustainable agro-practices in reservoir command areas through schemes of the Department of Agriculture; and,
- Integrating wetland based ecotourism within the initiatives of Department of Tourism.

3.3 Institutional arrangements for wetland management: lessons learnt

Efforts for developing institutional arrangements for conservation and sustainable management of wetlands within India are in place since the last three decades. This section provides an overview of these efforts and provides a background for developing an institutional architecture for management of Hirakud Reservoir

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National scenario | Wetland management draws strength from a rich legacy of environmental conservation embedded in various national policies, legislations and regulatory frameworks. The Indian Constitution encapsulates this spirit, in Article 51-A (g) stating that "it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures."

Within the federal structure, wetland conservation and sustainable management is placed within the mandate of the MoEFCC. Wetlands were initially conserved for their biodiversity values alone, wherein several landscapes as Keoladeo-Ghana, Harike, Kaziranga and Manas were declared as wildlife sanctuaries and national parks (IUCN Category II protected area).

With India becoming a party to the Ramsar Convention in 1982, and the MoEFCC being established in 1985, a national programing framework for wetlands was institutionalized. The Ministry established the National Wetland Conservation Plan (NWCP),1986 to provide the overarching policy framework and financial assistance to state governments for implementing site management plans. In 2001, the National Lake Conservation Programme (NLCP) was developed to address pollution in urban and semi-urban environments through interception, diversion and treatment of pollution load entering lakes. As of December 2013, the network of sites of national and international significance include 170 wetlands.

The policy architecture for wetlands is defined within the broader national environment policy. The National Conservation Strategy and Policy Statement on Environment and Development,1992 identified pollution and over-exploitation of wetlands as an area of concern. Conservation of wetlands was highlighted as a strategy for sustainable use of land and water resources as well as biodiversity conservation.

Subsequently, the revised National Environment Policy, 2006 laid down specific policy elements wherein wetlands have been identified as 'freshwater resources'. Recommended policy actions include integration in developmental planning, management based on wise use approaches, promotion of ecotourism and implementation of a regulatory framework. Integration of wetlands in river basin management has been identified as a strategy for management of river systems.

In 2010, in line with recommended policy actions, a regulatory framework for wetlands was introduced by the Ministry in the form of Wetland (Conservation and Management) Rules, 2010 under the provisions of the Environment (Protection) Act, 1986. The Rules stipulate prohibition and regulation of a range of developmental activities within a wetland notified under its provision by state governments. The rules, at the time of writing this report, are being revised to promote a more decentralized regulation of wetlands considering specific ecological character and ecosystem services.

A Central Wetlands Regulatory Authority (CWRA) has been constituted for the purpose of enforcing the rules, to evaluate proposals for wetland notification submitted by state governments and setting thresholds for activities to be regulated.

Wetlands are also addressed in sectoral policies for water and climate change. The National Water Policy, 2012 provides an important policy framework for linking wetlands to water resources management. The policy recommends adoption of a basin wide approach for water resources management, and identifies conservation of river corridors, water bodies and associated ecosystems as an important action area. The Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWRRD) has several programmes that contribute to wetland conservation. The MoWRRD has also been coordinating the implementation of pilot scheme for "National Project for Repair, Renovation and Restoration (RRR) of Water Bodies directly linked to Agriculture" since January, 2005. The scheme supports restoration and augmentation of the storage capacity of water bodies, including recovery and extension of their lost irrigation potential. In 2013, the Ministry of Urban Development (MoUD) issued an advisory on conservation and restoration of waterbodies in urban areas, clearly identifying the financial provisions under schemes of the MoUD and MoWRRD for urban wetlands (MoUD, 2013).

Provisions of the Indian Forest Act, 1927 and The Indian Wildlife (Protection) Act, 1972 define the regulatory framework for wetlands located within forests and designated protected areas. Similarly, the Coastal Regulation Zone (Notification) amended in 2011 provides the regulatory framework for coastal wetlands. Coral reefs, mangroves, mud flats and salt marshes are included within ecologically sensitive areas and accorded highest conservation significance. The Indian Fisheries Act, 1897, The Water (Prevention and Control of Pollution) Act, 1974, The Environment (Protection) Act, 1976 and The Biological Diversity Act, 2002 provide substantive elements of legal and regulatory framework for Indian wetlands. The Coastal Aquaculture Act, 2005 prohibits conversion of natural coastal wetlands as mangroves, salt pans, estuaries and lagoons for aquaculture.

In line with the CBD Strategic Plan 2011-2020, India has formulated 12 National Biodiversity Targets. Wetlands find direct reference under Target 3 (Strategies for reducing rate of degradation, fragmentation and loss of natural habitats are finalized and actions put in place by 2020), Target 6 (Ecologically representative areas on land and in inland waters, as well as coastal and marine zones, especially those of particular importance for species, biodiversity and ecosystem services, are conserved effectively and equitably) and Target 8 (By 2020, ecosystem services, especially those related to water, human health and livelihoods and well-being are enumerated and measures to safeguard them are identified).

Scenario in States | Several state governments (such as West Bengal, Odisha, Kerala, Manipur, Assam) have enacted their own legislations pertaining to wetlands. The Government of Manipur notified the Manipur Loktak Lake (Protection) Act, 2006 and Manipur Loktak Lake (Protection) Rules, 2008 which define a core zone and buffer zone, and stipulate specific activities that can be permitted within these designated areas. Similarly, the East Kolkata Wetlands

(Conservation and Management) Act, 2006 recognizes use of sewage as one of the core ecological characteristics of the East Kolkata Wetlands. In Kerala, the Conservation of Paddy Land and Wetland Act, 2008 bans conversion of wetlands. In 2015, the state governments of Karnataka and Rajasthan have enacted legislations for conservation of wetlands.

Given the need to bring multiple departments and stakeholders together to implement management plans, different state governments have considered constituting dedicated wetland authorities. The Loktak Development Authority (LDA) constituted in 1986 was one of the first wetland development authorities set up in the country. The Authority was formed to manage the rapid degradation of Loktak Lake due to species invasion, shrinkage in area and reduction in water holding capacity, after the commissioning of Loktak Hydro-electric Project in 1983.

In 1992, the Government of Odisha constituted the Chilika Development Authority to address the threats to Chilika Lake, as increasing silt load, declining fisheries and expansion of shrimp aquaculture.

In 1997, the Government of Jammu and Kashmir constituted the Lakes and Waterways Development Authority under the aegis of the Housing and Urban Development Department for restoration of Dal and Nigeen Lakes.

Within the decade of 2000, separate wetland authorities were created for waterbodies of Madhya Pradesh, lakes within Bengaluru City and East Kolkata Wetland. The Lake Conservation Authority of Madhya Pradesh initially focused on Bhoj Wetlands but was mandated with the conservation of all waterbodies of the state in 2004. Odisha and Bihar state governments each constituted a state level wetland authority in 2012 and 2014 respectively.

The management interventions described so far have been the core of network scale programming initiatives for Indian wetlands, based on a prioritization of ecosystem services and biodiversity values. Successes as reflected in ecological restoration of Chilika, and its transformation from a Ramsar Site enlisted within Montreux Record to receiving the Ramsar Wetland Conservation Award and Evian Special Prize in 2002, are indicative of the significance attached to conservation of wetlands in the country. Efforts are also being made to improve the information base on wetlands, and increase awareness on societal benefits provided by these ecosystems.

The following are the key lessons and experiences with reference to establishing a wetland management institution:

- **Distinct institution for wetland management:** The cross sectoral and multi-stakeholder needs for wetland management can be best served by designating a separate institution responsible for ensuring cross sectoral coordination and balancing interests of stakeholders while ensuring ecological integrity of the wetland system.

- **Strategic planning and coordination function**: Wetland authorities need to function as strategic planning and coordinating bodies maintaining an overview of the overall ecological state and trends and the drivers and pressures on a wetland ecosystem within the wider landscapes as river basins and coastal zones. The capacity to implement interventions for ecological restoration is available within the respective departments, however, the wetland authorities need to provide integrated plans, evaluate implementation effectiveness and suggest mid-course corrections of activity pathways.

- **Capacity and financing:** The success of wetland authorities is closely related to the availability of adequate human and financial resources to design and implement wetland management plans. Infrastructure for wetland

monitoring and evaluation forms a critical part of this capacity.

- **Adaptable management:** Wetland management institutions need to be adaptable to work in changing ecological and socio-political landscapes. The success of management is linked to the ability to modify management based on a continuous evaluation of the dynamic changes in the external environment.

- **Participation and awareness:** The governance structure of wetland authorities should reflect the diversity of stakeholders influencing the state of wetlands. A mix of political, technical, administrative and civil society representation in the governing body enables better coordination and ensures sanctity to the management processes. The institutional mechanisms responsible for wetland management also need to create an enabling environment by enhancing awareness on wetland ecosystem services and processes.

- **Regulatory regimes:** Wetlands are open systems and as such are exposed to a range of pressures stemming from unsustainable use. In several circumstances, application of state acts and regulations provide a means to regulate these processes to ensure the ecological integrity of wetlands. However, for wetlands which are intensively used for livelihoods and placed within a context of rapid urbanization and industrialization, wetland authorities need to be empowered with suitable regulation to ensure conservation and wise use.

3.4 Proposed institutional framework for managing Hirakud Reservoir

Though built primarily to meet the human requirements of water, Hirakud Reservoir is associated with a range of ecosystem services values, cutting across a range of stakeholders. The current institutional arrangements fails to support an integrated management approach for the reservoir, thus leading to sub-optimal performance and stakeholder conflicts.

As critical infrastructure of the water sector, the Department of Water Resources needs to be at the helm of management of the Hirakud Reservoir. However, mechanisms are required to ensure that dam operations address a range of stakeholder concerns, including those of the upstream and downstream ecosystems. Similarly, sectoral programmes taking place in the reservoir basin need to be coordinated in a manner that adverse impacts on ecological character are prevented and wise use ascertained.

To meet the aforementioned requirements, it is proposed to constitute a 'Hirakud Reservoir Management Committee' under the aegis of the Department of Water Resources, with Chief Secretary, Government of Odisha as the Chairperson. The Committee will have following functions:

- Putting in place an integrated policy framework for management, considering the full range of ecosystem service values and stakeholder linkages;
- Coordinating programmes across sectors and stakeholders for integrated management;
- Reviewing and approving all technical matters pertaining to management of Hirakud Reservoir;
- Ensuring regulation and control of all activities detrimental to the maintenance of ecosystem service values;
- Ensuring compliance with existing national and state level regulatory frameworks;
- Mainstreaming ecosystem services values in developmental programming;
- Resolving trans-boundary and trans-catchment and multi-stakeholder conflicts;
- Developing and maintaining a wetland inventory, assessment and monitoring system, based on scientific guidelines, to assess and

respond to changes in wetland components, processes and services;
- Supporting multidisciplinary research to support integrated and adaptive management; and,
- Developing and implementing a communication and outreach strategy for Hirakud.

The following are proposed to be members of the Committee:

- Engineer in Chief, Water Resources
- Member Secretary, Odisha Wetland Development Authority
- Director, Department of Forest and Environment
- Divisional Forest Officer (Hirakud Division)
- Director, Fisheries
- Director, Agriculture
- Director, Tourism
- Representative (Wetlands Division), MoEFCC
- Collector, Sambalpur
- Representative, Primary Fishermen Cooperative Society
- Representative, Civil Society
- Subject matter expert(s)

The committee should meet atleast twice a year, and review the status of the reservoir and implementation of the management plan. Monitoring of the reservoir, as per the programme outlined in Chapter 5, is proposed to be done by a sub-center of the Wetland Research and Training Center of the Chilika Development Authority, given their existing capacity and infrastructure.

4. Ecological Character Description

The primary objective of management planning is to outline a strategy for achieving wetland wise use, described in Ramsar Convention text as 'maintenance of ecological character, achieved through implementation of ecosystem approaches, within the context of sustainable development'. Ecological character is 'the combination of ecosystem components[1], processes[2] and services[3] that characterize the wetland at any given point in time.' Changes to ecological character of wetlands outside natural variation may signal that uses of the site are unsustainable, and may lead to the breakdown of its ecological, biological and hydrological functioning (Ramsar Convention 1996, Resolution VI.1). Assessing and responding to risks of human induced adverse change in ecological character is therefore fundamental to achieving wise use of wetland site.

A view of Debrigarh Sanctuary adjoining the reservoir

The objective of maintaining ecological character of Hirakud requires identification and retaining essential ecological functions which underpin the site's ecosystem services and biodiversity. Implicit within this recommendation is the need to identify key features of Hirakud's ecological character, maintaining which would constitute wise use. The extent to which ecological character is maintained and adverse human-induced changes prevented is reflected in these key features.

[1] The living (biotic) and non-living (abiotic) constituents of wetland ecosystem. These include: Geomorphic setting (landscape, catchment, river basin); Climate (precipitation , wind, temperature, evaporation, humidity); Physical setting (area, boundaries, topography, shape, bathymetry, habitat type and connectivity); Water regime (inflow, outflow, balance, surface – groundwater interactions, inundation regime, tidal regime, quality); Wetland Soil (texture, chemical and biological properties); and Biota (Plant and animal communities)

[2] Processes that occur between organisms and within and between populations and communities, including interactions with non-living environment, that result in existing ecosystem state and bring about changes in ecosystems over time. These include: Physical processes (water stratification, mixing, sedimentation, erosion); Energy – nutrient dynamics (primary production, nutrient cycling, carbon cycling, decomposition, oxidation – reduction); Processes that maintain animal and plant population (recruitment, migration); and Species interaction (Competition, predation, succession, herbivory)

[3] Benefits obtained by humans from ecosystems, categorized as: Provisioning (fisheries, use of aquatic vegetation for economic propose, wetland agriculture, biochemical products); Regulating (maintenance of hydrological regimes) and Cultural (recreation and tourism, spiritual, scientific and educational value). Supporting services have been included in definition of ecosystem processes.

The Ramsar Convention's Guidelines for ecological character description are contained in Ramsar Resolution X.15. The national framework and guidance for ecological character description developed by Government of Australia is also a useful reference for this purpose (Department of Environment, Water, Heritage and the Arts, Government of Australia, 2008). However, both frameworks underemphasize social and livelihood interlinkages in wetlands. Hirakud reservoir can be best characterized as a nested socio-ecological system, wherein its ecological character stands influenced and modified by the way livelihood systems are linked to wetland resources, choices and trade-offs they make and governance systems that influence their behaviour. The social construct of the ecological character provides insights into the ways ecological character connects with livelihood capitals, institutions and finally human- wellbeing. Therefore, for the purpose of management planning of Hirakud Reservoir, the ecological character description framework has been modified to include livelihood capitals of wetland dependent communities.

The current section of the management plan includes identification of key ecological character elements, status and trends in ecological character, analysis of risks of human induced adverse changes in ecological character. The analysis also includes identification of knowledge gaps that need to be addressed so as to improve integration of wetland functioning in sectoral programming.

4.1 Key features

Key ecological character features of Hirakud stem from its primary purpose of construction, which is to provide flood control in Mahanadi Delta during monsoon, and store water for meeting various human uses during the non-monsoon season. However, as an ecosystem, Hirakud is bestowed with a range of additional ecosystem services and biodiversity values, maintenance and enhancement of which constitute the site's wise use. Available information on ecological, hydrological, socioeconomic and institutional features of Hirakud (collated and discussed in Chapters 2 and 3 of the management plan) allude to the following:

Water source for developmental usages. The reservoir is a source of water for producing ~ 300 MW of hydropower and irrigating 436,000 ha of cultural command area.

Flood control. By regulating riverine flows from 83,400 km^2 of River Mahanadi Basin, Hirakud Reservoir moderates floods in the Mahanadi Delta, the ecological and socio-economic hub of the east coast of India.

Supports productive fisheries. The reservoir is inhabited by 21 fish species of economic importance, presently yielding a catch of ~ 480 MT of fish annually, which is the mainstay of livelihoods of 7,000 fisher households.

Important habitat for migratory waterbirds in the Central Asian Flyway region. The reservoir provides habitat to 115 waterbird species, of which 45 are winter migrants of the Central Asian Flyway. The site regularly holds over 20,000 waterbirds, qualifying to be designated as a Wetland of International Importance. For atleast 10 species, the population recorded at the site during past five years is more than 1% of their known global population.

Biological diversity habitat. The gradient of habitats ranging from riverine to lacustrine, while moving towards the dam, enables the reservoir to support a range of floral and faunal species, including several of high conservation significance. For example, of the known 54 species of fish from the reservoir, 1 has been classed as being endangered and 6 near threatened. Similarly, of the over 130 bird species recorded at this site, 20 species are of high conservation significance.

Role in maintaining biodiversity habitats in Mahanadi Delta. The habitats of Mahanadi Mahseer *Tor mosal mahanadicus* (between

Sambalpur and Boudh), muggers and gharial (between Satkosia Gorge and Majhipara-Binkei) and turtles (between Athmalik and Naraj) are hydrological connected with the Mahanadi River flows, influenced by Hirakud Reservoir operations. Flows from the reservoir influence salinity gradients in coastal wetlands as Chilika and Bhitarkanika as well.

Cultural and recreational values. The reservoir supports abundant tourism, and forms an integral part of the high touristic value sites located around Sambalpur. Over 30,000 tourists visit the reservoir annually for recreational purposes.

Representativeness. Hirakud is representative of large multipurpose human- made wetlands resulting from impoundment of rivers. Much of the conservation and management efforts to date in India has been placed on natural wetlands. Management of Hirakud will serve as a demonstration for nearly 50 such large hydraulic structures in the country to meet a wider set of developmental as well as ecological objectives.

The following ecosystem components and processes underpin these biodiversity and ecosystem service values:

Water holding capacity which defines the quantum of water that can be stored for meeting various human uses during non-monsoon periods, and the extent to which flood moderation can be achieved.

Variable inundation regime leading to cyclical wetting and drying of the reservoir fringes which creates habitat for breeding of fish, improves availability of nutrients in water, and regulates growth of macrophytes.

Hydrological connectivity and exchange of species and matter with riverine environment in upstream and downstream stretches.

Physico-chemical quality of water which has an important influence on structure of biota, and health of communities living in and around the reservoir.

Catchment land use and land cover which influence the extent of soil erosion and sedimentation in the reservoir.

Well established plankton and benthic communities providing support to productive fisheries.

Macrophyte communities along the shoreline and islands which provide breeding habitats for waterbirds, as well as regulating water quality in the reservoir.

Functioning community institutions that influence the extent to which communities gain livelihood benefits from reservoir and have incentives for participating in management.

4.2 Status and trends

Available information of ecological, hydrological, socioeconomic and institutional features of Hirakud have been collated and synthesized to assess the status and trends in reservoir's ecological character. Information on ecological components indicates declining inundation and reduction in storage capacity. The water quality of the reservoir is tending towards being eutrophic. The data available on ecosystem processes and biota is patchy but indicative of moderate productivity which enables supporting habitats of a number of aquatic species. Migration of fish from the river, and waterbirds within Central Asian Flyway underpin maintenance of populations. While the reservoir was primarily constructed to meet water requirements in non-monsoon season, a set of provisioning services (fisheries, aquatic vegetation, wetland agriculture) and cultural services have also gained importance from management perspective. Table 4.2 presents an overview of status and trends in ecological character of Hirakud.

Table 4.1 | Status and trends in components, processes and services

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
1. Physical Form					
a) Area	Wetland regime extents to 74,345 ha which includes peak inundation area of 69, 793 ha (achieved at 192.02 m amsl elevation), and the rest under marshes, mudflats and islands.	2014: LANDSAT 8 OLI Satellite Data	The inundation area has reduced from 72,731 ha to 69,793 ha during 1957 – 2014. While the total wetland area has not changed, a substantial area on the margins has attained marsh like characteristics.	1980: First Sedimentation Survey – GoO, 1980 2007: Satellite based Reservoir Sedimentation Survey – NRSA, 2007	Comprehensive wetland delineation is required using inundation, soil and vegetation characteristics.
b) Bathymetry	Water levels in the reservoir ranges between MDDL 179.83 m amsl and FRL of 192.02 m amsl. At its deepest point, the reservoir is over 12 m deep, with average depth being 5.87 m. Water holding capacity of the reservoir in 2014 has been projected to be 5656 MCM.	2014: Sedimentation projected from reservoir capacity surveys of 1980 (GoO, 1980), 1986 (GoO, 1986) and 2006 (NRSA, 2007)	Significant reductions in the storage capacity of the reservoir have been recorded. At FRL, the water holding capacity has reduced from 8105 MCM to 5656 MCM during 1957 – 2014. Of the total accumulation, 73% of silt is settled in reservoir dead storage.	2014: Sedimentation projected from reservoir capacity surveys of 1980 (GoO, 1980), 1986 (GoO, 1986) and 2006 (NRSA, 2007)	A detailed bathymetric survey of the reservoir needs to be undertaken to assess the current rates of water holding capacity loss.
c) Shape	The reservoir is triangular in shape.	2014: LANDSAT 8 OLI Satellite Data	No discernible trends.		
2. Wetland Soils					
a) Texture	Observed density, texture and size of deposited particles data are inadequate. In the reservoir upstream, sand, silt and clay are in the proportion of 91.8:5:3.2. In the reservoir downstream, the proportion of sand increases to the ratio 96.5:2.25:1.25.	1995-96: Pathak et al., 2007	No information.	--	A detailed analysis of physical, biological and chemical properties of wetland soils needs to be undertaken.
b) Chemical properties	Chemical properties of wetland soils not assessed. In the reservoir upstream and downstream stretches the sediments tends to be neutral to slightly alkaline except in certain	1995-96: Pathak et al., 2007	No information.	--	

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
	downstream patches where marginal acidity has been observed. The sediment is rich in nitrogen and phosphorus but, has low organic carbon content.				
c) Biological properties	Not assessed.	--	No information.	--	
3. Physico-chemical characteristics of water					
a) Nutrients					
Nitrate (mg/l)	Ranges between 0.03-5.71 mg/l.	2015: Satpathy and Satpathy, 2015	The nitrate content in the reservoir has tended to increase from 0.06 mg/l during 1991-95 to a maximum of 5.71 mg/l in 2014.	1992: Sugunan and Yadava, 1992 2007 -10: CPCB 2015: Satpathy and Satpathy, 2015	A comprehensive water quality assessment program using representative sites within the reservoir and upstream and downstream stretches need to be put in place.
Phosphate (mg/l)	Ranges between 0-0.1 mg/l.	2005-09: CPCB online database	Concentration of phosphate is tended to increase towards mesotrophic and eutrophic states.	1993: Dash et al., 1993	
Silicate (mg/l)	No observation		No information.	1993: Dash et al., 1993	
b) Conductivity (µS/cm)	Ranges between 120-261 µS/cm.	2015: Satpathy and Satpathy, 2015	Has tended to increase in the reservoir (from 0.11- 0.29 µS/cm to 120-261 during 1985-90 to 2015.	1989: Mishra et al., 1989 1992: Sugunan and Yadava, 1992 2007 -10: CPCB 2010: Kar et al., 2010 2015: Satpathy and Satpathy, 2015	
c) Cations and Anions					
Calcium (mg/l)	No observation.		Calcium levels during 1991-95 were recorded at 40mg/l.	1992: Sugunan and Yadava, 1992	
Magnesium (mg/l)	No observation.		Magnesium levels during 1991-95 were recorded at 8mg/l.	1992: Sugunan and Yadava, 1992	
Sulphate (mg/l)	Ranges between a post monsoon minimum of 5.4 mg/l during post monsoon to a maximum of 13.3 mg/l during monsoon.	2005-09: CPCB online database			
Chloride (mg/l)	Ranges between a post monsoon minimum of 5 mg/l to a post monsoon maximum of 13.6 mg/l.	2005-09: CPCB online database	Chloride levels during 1991-95 were recorded at 5.5mg/l.	1992: Sugunan and Yadava, 1992	

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
Fluoride (mg/l)	Ranges between a monsoon minimum of 0.1 mg/l during pre-monsoon to1 mg/l post monsoon.	2005-09: CPCB online database	Fluoride levels during 2001-05 were recorded at 1.4mg/l.	2007 -10: CPCB	
Sulphite (mg/l)	No observation.		No information.		
d) Temperature (°C)	Surface water temperature range from post monsoon minimum of 19°C to a pre monsoon maximum of 35°C.	2005-09: CPCB online database	No discernible change in surface water temperature.	1989: Mishra et al., 1989 1992: Sugunan and Yadava, 1992 2007 -10: CPCB 2010: Kar et al., 2010 2015: Satpathy and Satpathy, 2015	
e) Dissolved Oxygen (mg/l)	Reservoir is well oxygenated with dissolved oxygen ranging between 7.8-8.6.	2015: Satpathy and Satpathy, 2015	No discernible change in dissolved oxygen.	1989: Mishra et al., 1989 1992: Sugunan and Yadava, 1992 2007 -10: CPCB 2010: Kar et al., 2010 2015: Satpathy and Satpathy, 2015	
f) pH	Tends to be neutral to slightly alkaline. 7.4-8.3 However, marginally acidic patches have been observed in Ib-Jharsuguda Valley and immediate downstream of the reservoir.	2015: Satpathy and Satpathy, 2015	No discernible change in the pH of the reservoir water. Acidic patches reported in Ib-Jharsuguda Valley and immediate downstream of the reservoir.	1989: Mishra et al., 1989 1992: Sugunan and Yadava, 1992 2007 -10: CPCB 2010: Kar et al., 2010 2015: Satpathy and Satpathy, 2015	
g Nutrient cycling	No observation.				
h) Turbidity (NTU)	Highly turbid during monsoon (maximum 855 which reduces to 5 during pre-monsoon).	2005-09: CPCB online database	No information.		
i) Biological Oxygen Demand (mg/l)	Ranges between monsoon maximum of 2.5 mg/l to post monsoon minimum of 0.2 mg/l indicative of low to moderate level of microbial metabolism of organic compounds.	2015: Satpathy and Satpathy, 2015	Within reservoir, BOD levels have typically tended to be around 2 mg/l. However, within Ib-Jharsuguda Valley, values upto 4 mg/l have been recorded. Similarly, in reservoir downstream stretches values tending to above 3 mg/l have been recorded.	2007 -10: CPCB 2015: Satpathy and Satpathy, 2015	

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
j) Chemical Oxygen demand (mg/l)	Ranges between a monsoon maximum of 13.6 mg/l to a post monsoon minimum of 4.1 mg/l.		COD values reaching upto 20 mg/l have been reported from Ib-Jharsuguda Valley and upto 50 mg/l from reservoir downstream.	2007 -10: CPCB	
k) Total coliform (MPN/100ml)	Within reservoir total coliform range between a pre-monsoon maximum of 24,000 MPN/100ml to a post monsoon minimum of 240 MPN/100ml.	2005-09: CPCB online database	Within reservoir coliforms have tended to increase. The values, however, have tended to increase to exorbitant levels in immediate downstream of the reservoir.	2007 -10: CPCB 2010: Kar et al., 2010 2015: Satpathy and Satpathy, 2015	
l) Faecal Coliform (MPN/100 ml)	Within reservoir faecal coliform range between a pre-monsoon maximum of 2,100 MPN/100ml to a post monsoon minimum of 140 MPN/100ml.	2005-09: CPCB online database	Faecal Coliform levels have continued to remain high in the reservoir and Ib-Jharsuguda Valley. However, the values tend to explode in immediate downstream of the reservoir.	2007 -10: CPCB 2010: Kar et al., 2010 2015: Satpathy and Satpathy, 2015	
m) Trace element (mg/l)					
Cyanide	No observation.		No information.		
Lead	No observation		No information.		
Arsenic	No observation		No information.		
Mercury	No observation		No information.		
4. Biota					
a) Micro-organism	No assessment.		No assessment.		
b) Cryptogam					
Phytoplankton	39 species represented by Cyanophyceae (12 species), Chlorophyceae (11 species), Euglenophyceae (2 species) and Bacillariopyceae (14 species).	1993: Dash et al., 1993	No assessment.		Spatial and temporal distribution of phytoplankton needs to be assessed particularly with reference to reservoir fisheries.
Periphyton	No assessment for Hirakud Reservoir. Overall 36 species reported from Mahanadi River (Annex II).	1995-96: Pathak et al., 2007	No assessment.		

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
c) Phanerogams					
Macrophytes	Submerged aquatic vegetation is present all along the Mahanadi-Mand confluence till the downstream reaches. *Najas* sp., *Hydrilla* sp., *Vallisneria spiralis* are the key submerged species. Reservoir margins are colonized by emergents as *Cyperus* sp. and *Polygonum* sp. Complete inventory of macrophytes in Hirakud yet to be carried out. 34 species have been reported in Mahanadi River.	2014: Field assessment	Excessive growth of emergent in Mahanadi River at Chikli (the confluence point of river with the reservoir) had been observed to impede breeding grounds of carps.		An assessment of spatial and temporal trends in distribution of macrophytes needs to be carried out with reference to primary productivity, water quality and species habitats particularly for waterbirds.
Terrestrial vegetation	Margin of reservoir along Debrigarh Sanctuary has dry deciduous forests. The vegetation comprises *Pterocarpus marsupium* (Bija), *Shorea robusta* (Sal), *Dalbergia sissoo* (Sissoo), *Madhuca longifolia* (Mahua), *Anogeissus latifolia* (Dhaura), and *Dendrocalamus strictus* (Salia bamboo). Most of the islands are vegetated although very little is known about their floral species distribution. Cattle Island located near Kumarbandh has local varieties of *Butea monosperma* (Palash); *Delonix regia* (Gulmohar); *Ficus* sp. (Banyan); *Phoenix* sp. (Khajur); *Shorea robusta* (Sal); *Terminalia arjuna* (Arjun); *Anacardium occidentale*	2014: Field assessment	No information.		Systematic assessment of distribution of terrestrial vegetation and its relationship with ecosystem processes and species habitats particularly for waterbirds needs to be undertaken.

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
	(Kaju); *Mangifera* sp. (Aam); *Tamarindus* sp. (Imli) etc.				
d) Invertebrate fauna					
Zooplankton	No assessment for Hirakud. 45 species reported from Mahanadi River.	1995-96: Pathak et al., 2007			Systematic inventory of faunal species, habitats and relationship with key ecosystem component and processes needs to be undertaken. Priority may be accorded to assessment of status and trends in fish and waterbird species with specific reference to their breeding and migration behavior, habitat utilization and threats.
Aquatic macro-invertebrates	No assessment for Hirakud. 35 species reported from Mahanadi River.	1995-96: Pathak et al., 2007			
Aquatic Insect	No assessment for Hirakud. 25 species reported from Mahanadi River.	1995-96: Pathak et al., 2007			
e) Vertebrate fauna					
Fish	Partial assessments indicate presence of 54 species of which 21 species contribute to commercial catch. Carps and cat fishes form over 60% of species richness.	2014: State Fishery Department	Pre impoundment survey of Mahanadi River indicates presence of over 180 species. The presence of sizeable number of catfish species in the reservoir has been attributed to lack of stocking during the reservoir establishment period. This allowed the hardy, bottom feeding species to colonize, albeit at a cost to fish productivity. Rivers Mand and Kelo are also known to be rich in catfish species. *Tor mosal mahanadicus* is an endangered mahseer species with high food as well as game value. Once reported to be abundant in catch throughout the year is now almost absent from the reservoir.	1995: Sugunan, 1995 2012: Tamboli and Jha, 2012 1995: Badapanda,1996	
Amphibians	No data from Hirakud. 10 species reported from Mahanadi River.	1993: Dash and Mahanta, 1993	No information.		
Reptiles	Reservoir is the key water source to crocodilian and turtle habitats in the downstream stretches of	2005: Rufford Foundation for Nature Conservation, 2005			

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
	Mahanadi River. Comprehensive assessment yet to be carried out.				
Waterbirds	Each winter Hirakud Reservoir teams with large number of migrating waterbirds. Reservoir is a habitat for 130 bird species of which 115 are waterbirds. Of these, 20 species are of high conservation significance (2 endangered, 8 vulnerable and 10 near-threatened species). The number of birds has averaged 58,095 during 2005-15, with peak counts going upto 79,138 in 2013. There are nine major congregation areas in the reservoir.	2014: Nair et al., 2014	Despite increasing anthropogenic pressure on the reservoir, it is still one of the largest congregation sites of waterbirds in the state after Chilika.		
f) Mammals	No observation				
5. Climate					
a) Precipitation	The average annual rainfall for Hirakud has been recorded as 1386.32 mm, with July and August being the months in which maximum rainfall is recorded.	2009-13: CRIS,IMD	Climate modelling done for Mahanadi River basin indicates intensifying monsoons and declining non-monsoon rainfall.	2006: Gosain et al., 2006 2006: Ghosh and Mujumdar, 2006	Reservoir operations need to be assessed with respect to outcomes of climate scenarios, and feasibility of achieving flood control and water allocation for various human uses.
b) Air Temperature	The average annual temperature ranges from 12°C (in December & January) to 40°C (in May & June).	1969-2004: CWC Report, IMD	Trends in the mean annual temperature have shown an increase in the range by 0.64°C /100 years in the Mahanadi River basin.	2010: Singh et al., 2010	Impact of changes in air temperature on basin hydrology and reservoir operations need to be assessed.
c) Evaporation	High rates of evapotranspiration varying from 1520 mm in the east to 1740 mm in the west are recorded for the reservoir.	IMD	Evapotranspiration is predicted to increase	2003: Taha and Nanda, 2003 2006: Gosain et al., 2006	
d) Wind	No observation				

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
e) Humidity	The climate is mainly 'Humid' with the highest relative humidity varying between 68-87% (during July-August) and lowest between 9-45% (during April-May).	2014: CWC and NRSC, 2014			
6. Geomorphology					
a) Topography	The reservoir catchment extends to 83,400 km^2 delineated into 136 watersheds. Over 80% of the catchment is a flat valley with elevations ranging between 200-250 m amsl and slopes between 0-5%. The valley is surrounded by hills having elevations between 800-1,200 m amsl and slopes increasing from 5-15% and beyond.	2014: DEM version 2, WISA			
b) Connectivity to surface waters	The surface water inflow into the Hirakud Reservoir is received from Mahanadi River, the Ib River and precipitation. Downstream the reservoir flows govern the hydrology of Mahanadi Delta, in particular freshwater inflows into wetlands as Chilika and Bhitarkanika.		In the last 40 years, a number of water resources development projects have been constructed upstream of Hirakud Reservoir. A major proportion of inflows are accounted for by managed releases from upstream reservoirs, which is posing challenges for reservoir operations.		
c) Water sources	Surface water inflow from the Mahanadi River, Ib River and precipitation are the main water sources of the reservoir.				
d) Soils	Dominant soil sub-groups are Aeric Haplaquests, Typic Ustochrepts in the northern periphery of Hirakud. Ultic and Typic Haplustalfs dominate in forested areas surrounding Hirakud.	1999: Maps produced by NBSSLUP in cooperation with the Department of soil Conservation, Orissa and associated data			

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
e) Erosion	63% of the catchment of Hirakud is moderately eroded, 23% is severely eroded and 3% is very severely eroded and gullied.	2014: CWC	Over the past six decades, there has been a 6% decline in area under forest which is concomitant with the expansion of area under settlements and industrial built up area including mines which were observed to be negligible during 1975-76 but now comprise 0.5 % of the catchment. These land use changes have implication for erosion which needs to be quantified.		The rate of soil erosion in the catchment from the perspective of resultant sedimentation in the reservoir needs to be recorded at regular intervals for reservoir management purposes.
7. Hydrology					
a) Water balance	The reservoir receives 30,818 MCM of inflows 98% of which is from the rivers and the rest from direct precipitation. A similar amount flows out of which 62% is accounted for monsoon releases and 2 % lost to evaporation. Drawal for hydropower, irrigation, industries and municipal supply account for the rest of the outflows.	2013: Department of Water Resources, GoO	The inflows received at present are majorly constituted of managed releases from upstream hydraulic structures. This impacts flood moderation capacity of the reservoir. Moreover, with declining water holding capacity, the extent to which water can be made available for developmental needs during non-monsoon period stands compromised. A trade-off is already evident between water supply for hydropower and industrial use.	1983-2013: Department of Water Resources, GoO	Scenario based modelling of water use integrating climate uncertainty needs to be carried out to support water allocation decisions. Ecological requirements of water particularly for downstream ecosystem needs to be integrated in water use assessment.
b) Groundwater infiltration and seepage	No observation				
c) Surface -groundwater interactions	No observation				Role of surface groundwater interactions both within and downstream of the reservoir needs to be assessed and integrated in water resources planning and decision making.

Ecological Components	Status	Data assessment year and source	Trends	Data assessment year and source	Data gaps for management
d) Inundation regime	Seasonal and inter-annual variability of inflows creates a dynamic inundation regime. This has a significant influence on the biotic communities and land-use on the margins of the reservoir. The peak inundation of 68,900 ha achieved by September gradually reduces to 23,300 ha by June. A major proportion of the shoreline, particularly around northern margins, thereby gradually converts into wet marshes creating conducive conditions for colonization by macrophytes. Some dried up marsh areas are used for cultivation of vegetables and short duration crops.	2013: Department of Water Resources, GoO	The peak inundation area has reduced from 72,731 ha to 69,793 ha during 1957 – 2014. A substantial area on the margins has attained marsh like characteristics.	1980: First Sedimentation Survey – GoO, 1980 2007: Satellite based Reservoir Sedimentation Survey – NRSA, 2007 2014: LANDSAT 8 OLI Satellite Data	High resolution satellite data based analysis is required of the spatial and temporal changes in land use around the reservoir.
8. Energy - nutrient dynamics					
a) Primary production	1.7 g C/m^3/day (summer)-2.7 g C/m^3/day (winter)	1986: Dash et al., 1993	No information.		Primary production studies need to be carried out at regular intervals with reference to fisheries and other aquatic life.
b) Nutrient cycling	No observation.		No information.		
c) Carbon cycling	No observation.		No information.		
d) Decomposition	No observation.		No information.		
e) Oxidation -reduction	No observation.		No information.		

Ecological processes			Data assessment year and source	Trend	Data assessment year and source	Data gaps for management
1. Process that maintain animal and plant population						
a)	Fish recruitment and migration	The confluence zones of Mahanadi, Ib and Bheden are breeding and spawning grounds for the carps. Vegetation along the margins along the north-western margins are breeding grounds for minnows and murrels. *Tor mosal mahanadicus* is known to breed in the 23 km narrow stretch of Mahanadi River between Athamallik to Narasinghpur.	2014: Field assessment	The riverine stretches of the reservoir, namely Mahanadi and Ib, which used to be active breeding and spawning grounds of major carps, have gradually suffered a decline. Within catfishes, the proportion of prized varieties as *Wallagu attu* and *Ompok* sp. has declined. Freshwater prawns used to be abundant around Muhammadpur have also dwindled extensively. Impoundment of Mahanadi River has impeded upstream migration as well as led to conversion of fish breeding grounds, ultimately reducing species richness. The impact was more severe on certain species as *Tor mosal mahanadicus*, *Notopterus chitala*, *Mystus aor*, *Mystus seenghala*, *Tenualosa ilisha*, and fresh water prawns *Macrobrachium malcolmsonii*. These are no longer known to breed in the reservoir.		Fish breeding and spawning grounds, and migratory pathways need to be systematically identified and assessed for sustainable management of fisheries.
b)	Waterbird migration	Of the 115 waterbird species known to use Hirakud as habitat, 45 species are winter migrants. The total population of waterbirds regularly exceeds 20,000. For 10 species, the recorded population is equivalent or more than 1% biogeographic population threshold. The dense reed beds of *Typha angustifolia* and *Arundo donax*	2005-15: Asian Waterbird Census Nair et al., 2014	Waterbird population estimates are available since 1993, however, the coverage is uneven. The data is not of adequate quality to discern trends. There have been instances of bird trapping and poaching in the past, especially from Jarimuli Island area, which has been largely curtailed due to the regular patrolling and watch and ward by staff of Forest Department.	2005-15: Asian Waterbird Census Nair et al., 2014	Systematic waterbird monitoring and habitat assessment need to be put in place to ensure maintenance of waterbird population.

Ecological processes		Data assessment year and source	Trend	Data assessment year and source	Data gaps for management
	along the margins (near Govindpur) supports the breeding nests of purple herons (*Adrea purpurea*), whistling ducks (*Dendrocygna javanica*), and common coots (*Fulica atra*). The reservoir and its islands provide three categories of breeding habitat i.e. shoreline and islands for ground-nesting birds; trees along the margin of the wetlands for colonial heronries and marsh and reed bed for marsh birds.				
2. Species interaction					
a) Competition	No observation.		No information.		
b) Predation	No observation.		No information.		
c) Succession	No observation.		No information.		
d) Herbivory	No observation.		No information.		
3 Physical processes					
a) Stratification	No observation.				
b) Mixing	No observation.				
c) Sedimentation	50.96 MCM per year	1986: GoO 1983, GoO 1986	Surveys during 1947-51 indicated an annual silt yield of 36.47 MCM, of which 57% was deposited in the reservoir. The three cycles of hydrographic surveys concluded in 1979, 1982 and 1986, indicated annual silt deposition rate to be 54.25, 56.06, and 50.96 MCM respectively. It is likely that 30.21% of the reservoir capacity at FRL has been lost. Of the total accumulation of 2,448 MCM of silt 73% is settled within the dead	1986: GoO 1980, GoO 1983, GoO 1986	Sedimentation surveys need to be updated.

Ecological processes		Data assessment year and source	Trend	Data assessment year and source	Data gaps for management
			storage.		
d) Erosion	Direct estimates for Hirakud catchment are not available. During 1975-2014, 6% of area under forest has declined.		Based on environmental sensitivity analysis of the watersheds, 5 and 63 watersheds have been classed as very high and high priority for management.		Erosion studies of the catchment will help establishing a relationship between land use change and sedimentation.

Ecosystem services		Data assessment year and source	Trend	Data assessment year and source	Data gaps for management
1 Provisioning Services					
a) Water for irrigation	The reservoir provides 1,680 MCM of water to irrigate a culturable command area of 157,810 ha. The tailrace of power houses provide water for irrigating 1,36,000 ha of Delta Stage II and stabilization of irrigation in 1,67,000 ha of Delta Stage I.	Department of Water Resources, GoO	The overall water requirement and allocation for agriculture has increased. The extent of paddy cultivation during kharif projected to be 70% in the original project report reached to 98% by 2007. Similarly, paddy cultivation during rabi has increased to 60% as compared to 33% envisaged during design period. The quantum of water withdrawn to irrigate per unit area is seen to be steadily on rise indicating reduction in efficiency of water use. Distribution of water to the tail end users has been an issue of concern. Agriculture around Sambalpur has also been impacted due to discharge of fluoride contaminated effluents.	Department of Water Resources, GoO	

Ecosystem services			Data assessment year and source	Trend	Data assessment year and source	Data gaps for management
b)	Water for hydropower	The reservoir provides 9,554 MCM (59% during non-monsoon period) for hydropower generation through power houses at Burla and Chiplima with installed capacities of 276 MW and 72 MW respectively.		Production from Chiplima has been lower than design capacity due to poor inflow channel maintenance.		
c)	Fisheries	Reservoir harbours 21 species of economic importance providing an annual catch of 460 MT and supporting livelihoods of 7,000 fisher households.	2014: Field assessment	In absence of any proactive species management in the initial impoundment years, Hirakud has progressed to a low productive phase. Prevalence of low mesh sizes and narrow range of gears in the phase of low productivity and increasing fisher population create stress condition for reservoir fishery. Weak capitalization, limited resources and capacities have marginalized fisher cooperatives thereby reducing the role of fisher communities in benefit sharing. The status of fishers remains amongst the lowest of all communities living around the reservoir.	1970 -1990, 1995-2010, 2012-2013 & 2011-2013: State Fisheries Department	Catch estimates based on a standardized methodology needs to be calculated annually. Data on species and their physiology also needs to be maintained to record species change.
d)	Water for industrial use	Nearly 500 MCM of water are allocated to industries located in Ib-Jharsuguda Valley.		Water allocation to industries is compensated with reduced allocation to hydropower. The industrial cluster of Ib-Jharsuguda is adversely impacting water quality of the reservoir and its downstream stretches.		

Ecosystem services			Data assessment year and source	Trend	Data assessment year and source	Data gaps for management
e)	Aquatic vegetation for household and economic use	The shallow segment of reservoir adjoining Lakhanpur has dense stands of Khas grass (*Vetiveria zizanioides*) which is extracted commercially for making door mats and air cooler coolants. Communities living around the reservoir also harvest aquatic plants for use as fodder and fuelwood, however, extent of harvest is unknown.	2014: Field assessment			
f)	Wetland Agriculture	Nearly 6,700 ha wetland area is used for agriculture in the post monsoon season, providing livelihoods to 8,700 households. Short duration crops (90 days gestation) such as paddy and vegetables are cultivated in the rabi and zaid seasons.	2014: Field assessment	Wetland Agriculture is being increasingly taken up by communities given the low inputs and higher yields. Approximately 36% fishers have adopted wetland agriculture as their secondary occupation.	2014: Field assessment	
g)	Navigation	4 to 6 passenger boats (upto 25 passengers capacity) ply between Durgapali (Sambalpur) to foothills of Belpahar (Jharsuguda). This is the shortest navigational route connecting southern and northern segments of the reservoir.		A boat tragedy of 2014 in which over 30 people died has raised safety concerns on inland navigation in Hirakud.		
2	**Regulating Services**					
a)	Flood moderation	Hirakud Dam is operated during monsoon months to secure 9,500 km^2 from floods.		The frequency of floods post Hirakud has come down to 3.3 events per 10 years as against 8 events in 10 years as observed during 1868 to 1946. However, the ability of reservoir to moderate high flood events has	GoO, 2007	

Ecosystem services			Data assessment year and source	Trend	Data assessment year and source	Data gaps for management
				been subject to debate. There is a substantialdownstream area not regulated by Hirakud and which can cause floods in the delta region. Moreso, releases from upstream reservoirs when the Hirakud is nearing full capacity can limit the effectiveness of flood control offered by the latter.		
3	**Cultural services**					
a)	Recreation and tourism	Hirakud and its associated tourist complex attract 10.64% of the total tourist inflow in western Odisha. The main tourist spots within the reservoir include Jawahar Minar, Gandhi Minar, Jawahar Udyan and Debrigarh Sanctuary.	2015: Main Dam Division, Burla	Total tourist inflow in various sites of reservoir increased from 0.29 million to 0.36 million from 2006 to 2014. However due to restrictions on reservoir tourism post a boat tragedy, the tourist inflow has reduced slightly.	2015, Main Dam Division, Burla	The associated recreation and tourist destination need to be assessed to incorporate in Tourism Master Plan.
b)	Spiritual	Chiplima, Koilighughar, Ghanteswari and Huma Temples are the main religious centres around the Hirakud Reservoir. Approximately 0.40 million pilgrims visit from various parts of India on the occasion of Shivratri and Navratri annually.	2013: GoO, 2013			
c)	Scientific and educational	The reservoir and its catchment provide significant scope for undertaking scientific studies, especially on biodiversity and limnology.				

4.3 Risk of adverse change

The risk of adverse change in ecological character have been assessed by mapping the major threats, their likely impact (on ecological character) and effectiveness of current institutional arrangements in stemming the adverse impacts. Knowledge gaps have also been identified, which are addressed in the form of a monitoring plan for Hirakud. The analysis is presented in Table 4.2. The analysis indicates that the threats on hydrological regimes are likely to impair, in short to medium term, the effectiveness of Hirakud in meeting the various human water demands. Intensification of land use in the reservoir margins and unsustainable fishing techniques have adverse implication for reservoir biodiversity and productivity. The current institutional arrangements need to be modified to reduce the risk of adverse change in ecological character. On an overall, the degree of risk of adverse change is moderate at present, but can transform into high if necessary changes in management are not ensured.

Table 4.2 | Analysis of risks to ecological character of Hirakud

Major threats to ecological character	Likely impact on key ecological character elements	Effectiveness of current management arrangements	Knowledge gaps
Reservoir siltation The reservoir has been silting up at rates faster than envisaged. In the last 5 decades, the reservoir storage capacity (at FRL) and peak inundation area have declined by 30% and 5% respectively. Reduced vegetative cover in the catchment (6% decline in forest cover during 1975-2010) is a significant contributor to reservoir siltation.	Siltation leads to reduced water storage capacity, and thereby ability to meet water requirements for various human needs. Over medium to long term, reduced depth on account of siltation may also lead to altered zonation and changes in community structure.	Prioritization of watersheds does not take into account the relationship of Hirakud catchment land use and reservoir siltation.	Degree of sensitivity of reservoir siltation to changes in land use and land cover in upper and middle Hirakud Basin.
Upstream Regulation of river flows Since Hirakud's construction, a number of major, medium and minor water resources projects have come up in the upper catchment leading to the changed inflow pattern at the dam site.	Flow moderation capacity of Hirakud is compromised as the operational regimes of hydraulic structures are not synchronised. Changes in downstream releases are also likely to adversely impact biodiversity habitats within Mahanadi Delta.	Decision making regarding water allocation is focused mainly on human uses, and is done with participation of a narrow range of stakeholders.	Water requirements for maintaining species habitats and ecosystem functioning of wetlands located in Mahanadi Delta
Pollution The industrial cluster of Ib-Jharsuguda is adversely impacting water quality of the reservoir and its downstream stretches. Discharge of untreated effluents from industries into the reservoir and irrigation canals has emerged as a serious threat to the communities and their livelihoods.	Adverse change in water quality will lead to alteration in ecological communities, and predominance of more hardy species over species sensitive to pollution. Increased incidence of water borne diseases and increased morbidity is also implicated for the communities living around the reservoir and using water and aquatic species for human uses.	Weak enforcement of existing water quality regulations has led to increased pollution in the reservoir and its downstream stretches. Ecological condition of the Hirakud Reservoir is not taken into account in the planning for pollution control in Ib-Jharsuguda industrial cluster.	Systematic monitoring of physical, chemical and biological components of water quality within the reservoir and upstream and downstream stretches
Unsustainable fishing techniques Prevalence of small mesh sizes and narrow range of gears in the face of low productivity and increasing fisher population has created a stress condition for reservoir fisheries. Harvesting of fish juveniles is one of the major factors reducing productivity	Further reduction in the productivity of the reservoir	Weak enforcement of fisheries policy has led to continued prevalence of unsustainable fishing techniques in the reservoir. The Primary Fishermen Cooperative Societies have failed to secure adequate incentives for resources stewardship to fishers.	Systematic assessment of fish catch, catch per unit effort and sustainable yield.
Increasing anthropogenic pressure on key species habitats	Changes in landuse in the reservoir margins will adversely impact	There is no management arrangement in place to prevent	Impact of land use changes on species

Major threats to ecological character	Likely impact on key ecological character elements	Effectiveness of current management arrangements	Knowledge gaps
The riverine stretches of the reservoir which act as breeding and spawning grounds of fish are increasingly subject to land use intensification.	ecological communities having life cycles linked to these habitats (fish, amphibians, macrophytes and birds).	alternation of land use in the intermittently inundated reservoir margins.	populations and habitats
Resource use conflict With increasing water use and declining storage capacity, there is a conflict in water use for agriculture and irrigation. Similarly, in reservoir fisheries, weak primary community institutions have led to predominance of middle men and private traders. Tenural conflicts over land rights on the reservoir fringes has also increased.	Increase in conflicts adversely impacts the livelihood capitals of dependent communities, and adversely alters their incentives to participate in wetland management.	There are very limited mechanisms of integrating needs, capacities and aspiration of communities in reservoir management.	Pathways of conflict resolution.
Climate Change There is an increasing variability in rainfall particularly increase in intensity of monsoon and decline in non-monsoon rainfall. Climate projections also indicate reduction in stream flow.	Changes in inflow patterns would alter inundation regime and stress ecological communities.	Climate change planning for the state does not take into account the role of Hirakud in adaptation to changing climate	Impacts of climate change on water allocation planning and decision making

5. Monitoring Plan

Management of Hirakud is aimed at maintaining its ecological character, and in doing so, retaining those essential ecological and hydrological functions which ultimately enable the wetland to provide its provisioning, regulating and cultural services. Having a system to describe, monitor and detect changes in ecological character is therefore critical to support decision making for wise use of the Hirakud Reservoir. Equally important is to be able to assess effectiveness of management in terms of ability to develop and implement an integrated planning, management and evaluation system to secure wise use of the wetland.
The present system for monitoring Hirakud Reservoir is highly fragmented and disjointed. A few government agencies and departments (for example the state government departments of water resources, agriculture, fisheries and animal resources, tourism; and agencies as Pollution Control Board) collect information on specific parameters of interest. There is no system at present for systematic collection of data on various wetland features and collating the same to support management. This severely limits the possibility of objectively defining the status and trends of various wetland features, and identification of related drivers and pressures.

In absence of institutional arrangements for integrated management of Hirakud Reservoir, each sectoral programmes is monitored independently and consolidated at the level of department or agency. The monitoring is largely based on physical and financial targets, and are rarely linked with a specific results. There are no mechanisms in place to assess the cumulative impacts of sectoral programmes on the status of the reservoir or various wetland features.

The current section of the management plan describes a monitoring framework for Hirakud Reservoir to support integrated management for wetland wise use. The section detail monitoring purpose and strategy and associated resource requirement. The monitoring plan is proposed to be applied both at the scale of wetland ecosystem, as well as institutional arrangements supporting management. Thus a section outlining strategy and framework for assessing management effectiveness is also included. The cost implications of the monitoring plan are factored in the Chapter 6 (management planning framework) and Chapter 7 (budget and financing).

5.1 Monitoring objective

Developing a monitoring plan for Hirakud requires addressing the following inter-related requirements of wetland inventory and wetland assessment. It is imperative therefore to put in place an integrated Wetland Inventory, Assessment and Monitoring System (WIAMS) to address the overall information needs for wetland management, and to provide a robust decision support system for the same. The ambit of monitoring is also envisaged to include assessment of management effectiveness.

The follow are the specific objectives for establishing WIAMS:

- Developing up-to-date and scientifically valid information on status and trends of wetland features and influencing factors
- Establishing a baseline for measuring change in ecosystem components, processes and services
- Informing decision makers and stakeholders on the status and trends in biodiversity, ecological functioning and ecosystem services of the wetland
- Supporting compliance to national and state legal requirements and regulatory regimes
- Determining impacts of developmental projects on ecosystem components, processes and services

- Identifying risks to ecological character and support development of response strategies
- Assessing effectiveness of wetland management

5.2 Monitoring strategy

Monitoring strategy responds to the following information needs for effectively managing Hirakud, considering the developmental activities within the immediate catchments, as well as its role in wider landscape:

- inventory - to establish the ecological character baseline
- assessment – to establish status, trends and threats to wetland using inventory information
- monitoring – to assess changes in status and trends, including reduction in existing threats or appearance of new threats, or even changes in management effectiveness

As these information pertain to various spatial scales, the overall information requirements can be classified at three hierarchical levels:

- Hirakud Reservoir site
- Hirakud catchment (the area directly draining into the reservoir and the zone of direct influence)
- Mahanadi River Basin

A hierarchical classification of inventory, assessment and monitoring needs for Hirakud is presented in Table 4.1. The information needs for inventory are derived from the core datasets needed to establish a baseline on ecological character[1] for Hirakud, and contain all the essential ecosystem components, processes and services, as well as management related parameters that characterize the site. At the basin scale, the information requirement is related to geo-morphological and climatological setup, as well as basin wide management arrangements, particularly those related to land and water resources. As the catchment is the zone of direct influence on the reservoir, information needs include land and water management practices which have direct influence on the wetland status of the reservoir; including assessing the habitat connectivity and water, sediment, energy and nutrient flux which influence its ecological character. Finally, at the site scale, the information requirements pertain to important ecosystem component, processes and services, which are applicable to the site condition. At all levels, information on institutional arrangements and management practices is included so as to enable creation of a baseline on sectoral programmes, and the linked stakeholders, which are likely / have an impact on the wetland state.

Information needs related to assessment are aimed at deriving the status, trends and existing or likely threats to wetland system. At the site scale, the focus is on deriving ecological character change and ecosystem services valuations and tradeoffs. Specific assessments related to fish migration and waterbird habitats have also been identified based on the review of wetland features contained in previous chapters. At the catchment scale, the focus is on deriving the environmental flows which influence the vulnerability of ecological character change, based on deriving limits of acceptable change for the ecological character feature of interest, thereby maintaining the ecological integrity of the reservoir, maintenance of biodiversity and ecosystem services. At the Mahanadi River basin, the assessments are aimed at determining the climate induced risks to ecological character, ultimately aimed at developing a suitable response strategy for risk reduction and management. While not explicitly mentioned, strategic environmental assessments can be commissioned for any developmental project that has / likely to have negative impact on the wetlands.

[1] Derived from the core inventory fields required for ecological character description as per Ramsar Convention Resolution X.15: Describing the ecological character of wetlands, and data needs and formats for core inventory: harmonized scientific and technical guidance. These fields have been further integrated into guidance related to information requirement for describing Ramsar site at the time of designation and subsequent updates (Ramsar Convention Resolution XI.8 and XI.8 annex 1)

Information needs for monitoring Hirakud Reservoir have been derived from assessment of ecological character carried out for development of the management plan. Four cluster of needs have been identified: a) land use and land cover change, to assess the dynamics of land use within the catchment; b) hydrological regimes, to assess the flux of water, sediments and nutrients; c) ecological components and processes, to assess the biodiversity, habitat quality and resource productivity; and d) socioeconomics and livelihoods to assess the trends in ecosystem services – livelihoods interlinkages.

These monitoring information adequately address the needs of Wetland (Conservation and Management) Rules, 2010 of the Ministry of Environment, Forests and Climate Change[2] which will become applicable if Hirakud is proposed for designation under the said rules by the state government[3]. A list of wetland features, indicators and corresponding methodology and data collection frequency is provided as Table 5.2.

The monitoring and assessment needs are envisaged to be addressed by a dedicated monitoring programme and specific research and assessment projects. Inventory, being based on collated information on identified wetland features and management practices, will be developed based on the monitoring and assessment information, as well as secondary sources.

Inventory, assessment and monitoring form an integral part of wetland management, and thereby core activity of the nodal agency entrusted with the task of ensuring conservation and wise use of Hirakud. The management plan proposes establishment of a Hirakud Management Committee under the aegis of the Department of Water Resources Authority for Hirakud, which, amongst other functions, will also be responsible for putting in place management to respond to any adverse change in ecological character. For the committee to be able to discharge these functions appropriately, a wetland monitoring unit is proposed be constituted within the Department of Water Resources with adequate human and technical resources. Given the established expertise and infrastructure within Wetland Research and Training Center of Chilika Development Authority on management of wetlands, it is proposed to establish a sub-center of WRTC at Sambalpur to discharge the monitoring functions.

Linkages also need to be developed so that data from the existing monitoring networks of different agencies (for example, river flow and flood extent information from Central Water Commission and Department of Water Resources; groundwater quality and quantity from Central Ground Water Board; select surface water quality parameters from Odisha State Pollution Control Board) can be accessed and shared. The current infrastructure of State Fisheries Department can be used for monitoring fish diversity, catch and effort on the basis of agreed sampling procedures. Similarly, provision for participation of NGOs and civil society in monitoring programme should also be built, especially for socioeconomics and livelihoods aspects and biodiversity monitoring (for example, waterbird census being implemented by NGOs under the aegis of Asian Waterbird Census and Important Bird Area Programmes).

[2] The Wetland (Conservation and Management) Rules, 2010 prohibit any change in wetland to non-wetland usages, reclamation, discharge of untreated wastes and construction of permanent nature; and regulate withdrawal and impoundment of water as well as activities which interfere with the normal runoff.

[3] All wetlands located below an altitude of 2,500 m amsl and having an area of 500 ha or above fall under the purview of the Wetland (Conservation and Management) Rules, 2010.

Table 5.1 | Inventory, assessment and monitoring needs for managing Hirakud Reservoir

	Information Purpose		
Information Scale	**Inventory**	**Assessment**	**Monitoring**
Mahanadi River Basin	**Geology and Geomorphology** (Soils, elevation, slope, drainage pattern) **Climate** (Precipitation, Temperature) **Land use and land cover** **Water regimes** (river flows, upstream abstraction)	**Climate risk and vulnerability** (changes in river flows and implications for reservoir)	**River basin management planning** (water regulating structures and water allocation/discharge plans along the river basin)
Hirakud Catchment	**Climate** (Precipitation, temperature, wind, humidity, evaporation) **Land use, land cover and management practices** **Physical setting** (area, boundary, connectivity) **Water regime** (riverine flows, inflow -outflow balance, surface-groundwater interactions, inundation regimes, quality, regulation, abstraction) **Sediment regime** (inflow, outflow, balance, distribution and transport) **Sectoral programmes and institutional arrangements** for management of land and water resources and biodiversity conservation	**Ecological character risk and vulnerability** (limits of acceptable change for critical ecosystem components, processes and services; sensitivity and adaptive capacity of critical components; risks of adverse change in ecological character)	**Land use and land cover change and impacts on reservoir hydrodynamics (water availability and allocation amongst sectors)** **Pollution Status in Ib-Jharsuguda Valley** and impacts on reservoir water quality and biota **Water sue efficiency** in agriculture within reservoir command area
Hirakud Reservoir	**Physical setting** (area, boundary, topography, shape, bathymetry, habitat type and connectivity) **Climate** (precipitation, wind, temperature, humidity) **Water regime** (inflow, outflow, balance, surface-groundwater interactions, inundation regimes, quality) **Sediment regime** (inflow, outflow, balance, distribution and transport) **Wetland soils** (texture, chemical and biological properties) **Biota** (plant and animal communities, conservation status) **Energy and nutrient dynamics** (primary productivity, nutrient cycling, carbon cycling, decomposition, oxidation-reduction) **Species interaction** (invasion, competition, predation, succession, herbivory) **Processes that maintain animal and plant population** (recruitment, migration) **Ecosystem services, stakeholders and trade-offs** (Provisioning – reservoir fisheries, aquatic vegetation for human uses, water for various human uses, navigation; Regulating – Flood moderation; Cultural – tourism and recreational values) **Institutional arrangements** (governance, formal and informal rights and ownership, application of acts and regulations)	**Ecological character change** (change in ecosystem components, processes and services – can also be derived based on assessment of indicators related to ecosystems, habitat, species and / or management) **Land use land cover change in reservoir fringes** **Ecological status of fish breeding grounds and migration pathways** **Waterbird habitat assessment**	**Impacts of land use land cover change in reservoir fringes** on fish and waterbird habitats **Response of Reservoir fish productivity** to stocking, conservation of breeding grounds and migratory pathways, and improved functioning of fisher cooperatives

Table 5.2 Monitoring and assessment parameters and indicators

Parameter	Indicator	Priority	Monitoring Method	Monitoring Frequency
Land Use and Land Cover				
Land use and land cover change within Hirakud catchment	% area under various land use and cover classes (agriculture, forest cover, settlements, wetlands)	High	GIS and Remote Sensing Radar sensed data	Once in 5 years
Hydrological regime				
Water and sediment flux	Water inflow	High	Monitoring at guaging stations	Annual
	Water outflow	High		Annual
	Sediment inflow	High		Annual
	Sediment outflow	High		Annual
Water holding capacity	Bathymetry	High	Bathymetric surveys	Once in 5 years
Inundation Regime	Seasonal fluctuation in waterspread area	High	Remote sensing	Once in 5 years
Surface Water quality	Temperature	Medium	Standard procedures of APHA	Monthly
	pH	High		Monthly
	Dissolved Oxygen	High		Monthly
	Specific Conductance	High		Monthly
	Nutrients and Nutrient Cycling (Nitrate, Phosphate, Silicate)	High		Monthly
	Cations and Anions (Calcium, Magnesium, Sulphate, Chloride, Fluoride, Sulphite)	High		Monthly
	Chemical Oxygen Demand	High		Monthly
	Transparency	Medium		Monthly
	Heavy metals (Arsenic, Mercury)	High		Monthly
	Biological oxygen demand	Medium	Standard procedures of APHA	Monthly
	Total Coliform	Medium		Annual
	Faecal coliform	Medium		Annual
Sediment quality	Texture	Low	Standard procedures of APHA	Annual
	pH	High		Annual
	Organic carbon	High		Annual
	Available nitrogen	High		Annual
	Available phosphorus	High		Annual
	Available calcium carbonate	Medium		Annual
Ground water quality	Water level	High	Methodology approved by Groundwater Estimation Committee (1997)	Annual
	Conductivity	Medium		Annual
	Total hardness	Medium		Annual
	Chloride	Medium		Annual
	Fluoride	High		Annual
	Arsenic	High		Annual

	Iron	High		Annual
Water abstraction	Water abstracted for irrigation	High	Survey	Once in 5 years
	Water abstracted for hydro-power generation	High		
	Water abstracted by industries	High		
Ecosystem Processes and Biodiversity				
Flora	Phytoplankton (diversity and abundance)	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Periphyton	Medium		Seasonal
	Macrophytes (diversity and abundance	High		Seasonal
	Species invasion	High	Habitat Sampling and Remote sensing (using high resolution data)	Once in 2 years
	Primary production	High	Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
Fauna	Zooplankton (diversity and abundance)	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Aquatic macro-invertebartes	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Aquatic Insects	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Fish diversity	High	Taxonomic studies	Once in 5 years
	Amphibians	High	Taxonomic studies	Once in 5 years
	Reptiles	High	Taxonomic studies	Once in 5 years
	Fish catch and effort (number of fishing days, boats and types of gears)	High	Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Monthly
	Recruitment (no. of juveniles)	High	Sampling and Taxonomic studies as per Standard procedures in Central Inland Fisheries	Seasonal

				Research Institute Bulletin No. 10	
		Fish breeding, spawning and migration pattern	High	Specific assessments and tagging experiments	Once in 5 years
		Water Bird population and diversity	High	Census and Taxonomic studies	Annual
		Water Bird migration pattern	High	Species specific ringing and banding studies	Once in 5 years
		Avian disease	Medium	Surveillance	Annual
		Habitat quality of bird congregation sites: - Number of nests or egg - Type of vegetation - Water level - Abundance of macrobenthos	Medium	Assessment of bird habitat quality and Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10 (for macrobenthos)	Annual
Socioeconomics and livelihoods					
	Community dependence on wetland ecosystem services	Fish catch	High	Socioeconomic survey	Monthly
		Performance of PFCS (Capitalization, infrastructure, catch processed, membership)	High		Annual
		% contribution of fisheries and tourism to income and employment	High		Bi-annual
		Number of tourists visiting wetland and direct and indirect spending	High		
	Livelihood status of wetland dependent communities	Physical capital, financial capital, social capital, human capital indicators of livelihood systems	Medium		
		Number of reported instances of conflicts	Medium		

5.3 Assessing management effectiveness

For wise use of Hirakud to be ensured, it is pertinent that periodic management effectiveness assessments are conducted. Such an assessment should enable evaluation of the degree to which institutional arrangements result in reduced risk of adverse change in ecological character, timely recognition of new risks, and mainstreaming full range of wetland values in wider developmental programming. The assessment should include, *inter alia*, following elements:

- Degree of (formal or informal) protection to the site
- Enforcement of existing regulation
- Clarity of management objectives
- Boundary delineation
- Availability and acceptance of management plan, including stakeholder endorsement
- Degree of management interface in research programmes
- Active management of biodiversity habitats
- Maintenance of integrated wetland inventory, assessment and monitoring systems

- Allocation of human resources to management
- Implementation and effectiveness of communication, education and awareness programmes
- Integration of landscape considerations in reservoir management
- Incorporation of upstream and downstream habitat connectivity in reservoir operations
- Inter-agency and intersectoral cooperation in reservoir management
- Stakeholder involvement, particularly local communities, in reservoir management

It is recommended that the aforementioned aspects are firmed-up and included in a management effectiveness assessment evaluation system. Evaluation should be carried out annually, and reported to the Hirakud Management Committee for their information and action as may be required for enhancing management effectiveness.

5.4 Infrastructure and human resources requirements

Implementing the monitoring strategy as outlined in the previous sections requires the following physical and human infrastructure support:

- Remote Sensing and GIS unit with advanced capabilities of remote sensing image processing, preparation of maps and development and maintenance of spatial datasets
- Ecological monitoring laboratory with capabilities for analysis of chemical, physical and biological properties of water and soil
- Database system for storing and retrieving monitoring and assessment data. The monitoring data would be stored alongwith metadata, as per the quality control procedures suggested in the following sections.
- Network of hydro-meteorological and water quality stations for hydro-biological monitoring

Deployment of the aforementioned resources can be done in a cost effective manner by applying the lessons and expertise of the existing infrastructure created by the state government for management of Lake Chilika. The Wetland Research and Training Center of the Chilika Development Authority has the necessary infrastructure and experience to conduct ecological monitoring. It is therefore recommended that a sub-center of WRTC may be created at Sambalpur for coordinating ecological monitoring.

Need based training programmes should be conducted to upgrade skills of the concerned state government departments and agencies.

5.5 Reporting

Reporting constitutes an important element of wetland monitoring programme. The intended user group, format, style and peer review requirement need to be set in the initial phases of set up of the monitoring programme.

Periodic reports, for example as a part of the annual report of the Hirakud Wetland Committee should aim to provide a summary overview of the outcomes of monitoring.

Special publications, for example wetland atlases constituting thematic maps on various parameters are intended to inform stakeholders on wetland status and trends.

Outcomes of specific assessments, for example ecological character status and trends, economic valuation, environmental flows etc. could be made available in the form of technical report series, with an extended summary for general readership. As the monitoring programs get sophisticated over a period of time, real time monitoring options through use of satellite based data communication techniques can be explored.

5.6 Quality control

Quality control in monitoring systems is required to ensure the scientific validity of sampling, laboratory analysis, data analysis and reporting. They also play a critical role in preventing introduction of random and systematic errors in data collection, analysis and reporting.

It is recommended that a Quality Management and Assurance Plan is developed for the monitoring programme. The plan should determine, *inter alia*:

Specification of objectives for sampling programme

Data quality objectives: maximum amount of uncertainty that can be tolerated to ensure that the data is fit for intended use

Sampling programme design: Statistical robustness of sampling frame; means to ensure that samples are representative of environment; sample recording; procedures for minimizing environmental impact

Documentation: Procedures for field sample record keeping and methods documentation

Sample processing validity (especially for water quality and biological components)

Data quality control methods: processes for quality control samples, duplicates and replicates,

Performance audit procedures, including data and systems audit

5.7 Review and adaptation

A periodic review of the monitoring programme is required to determine the extent to which the objectives, particularly support to management is achieved, and monitoring system remains relevant for the wetland state (particularly in the light of new and emerging threats). The review process should also aim at increasing the sophistication of the monitoring system to be able to assess complex landscape scale processes affecting the ecological character of wetland and related management.

Review process should include documentation on the way wetland inventory, assessment and monitoring information is being used to support management planning and policy goals. Review should also include identification of appropriate mechanisms to ensure that wetland monitoring is continued in the event of a funding shortfall.

6. Management Action Plan

6.1 Goal and purpose

The goal of integrated management of Hirakud is to secure wise use of the reservoir. This entails maintenance of developmental benefits as well as ecological values considering the role of Hirakud Reservoir in Mahanadi River Basin landscape.

The purpose of integrated management is to put in place effective governance arrangements for securing full range of ecosystem services and biodiversity of Hirakud Reservoir.

6.2 Management strategy

The management strategy for securing wise use of Hirakud Reservoir focuses on complementary planning and governance improvements for mainstreaming biodiversity and ecosystem services within Mahanadi River Basin scale developmental programming. Following are the key elements of the management strategy:

Hirakud Reservoir Management Committee as nodal agency for integrated management
Integrated management of Hirakud Reservoir requires an institutional arrangement to enable coordination of programmes across sectors and stakeholders to ensure that the developmental benefits as well as ecological values can be maintained now and in future. Such an architecture is proposed in the form of 'Hirakud Reservoir Management Committee' constituted under the aegis of Department of Water Resources, Government of Odisha. The Committee shall coordinate implementation of sectoral plans, maintain an overview of status and trends in reservoir's ecological character, and ensure stakeholder engagement in management.

Reducing reservoir siltation rate
The ability of Hirakud Reservoir to moderate floods and provide water for various human uses in non-monsoon period is closely linked with maintenance of water holding capacity. The extent to which Hirakud Dam has impeded sediment transport through Mahanadi River is apparent in terms of loss of reservoir storage and sediment starvation in downstream reaches and in the delta region. Sustainable sediment management options therefore should form an important part of management strategy to sustain reservoir capacity and minimize environmental impacts. Systematic and comprehensive treatment of catchment areas is envisaged to reduce sediment production. This will need to be complemented with interventions for minimizing sediment deposition and recovering storage volume.

Improving water allocation efficiency
Water allocation from Hirakud Reservoir needs to address human uses as well as ecological requirements considering interactions within a diverse lentic and lotic environments. This can be enabled through involvement of wider group of stakeholders in setting reservoir operations rule curve. Enhancing efficiency of water use in agriculture through improved water delivery, modern water-saving farming techniques, crop diversification, and conjunctive use of both surface and groundwater would enable increasing agricultural productivity with reduced water use. Similarly, water allocation to industries need to be optimized by improving water recycling and increased use of water saving processes. Environmental flows assessment shall be used to assess water regime requirements for downstream ecosystems.

Habitat management to secure biodiversity values
Reservoir management shall seek to maintain key species habitats. Fish breeding and spawning grounds and migration pathways connecting reservoir to riverine stretches will be maintained.

River floodplains and in particular riparian vegetation will be maintained to provide habitats for waterbirds and fishes. Local communities will be made aware and mobilized to accord protection to species habitats. Existing environmental regulations need to be more effectively enforced to abate pollution in Ib-Jharsuguda Valley. The needs of downstream ecosystems will also be factored in reservoir operations. The overall information base on biodiversity values of the reservoir will be enhanced through comprehensive surveys and species research studies. Management will also aim to establish community managed conservation reserves at strategic locations within reservoir and its downstream stretches for securing viable populations of migratory waterbirds and endemic fish species, Mahseer. Effective linkages will be made between conservation planning for the Debrigarh Wildlife Sanctuary and Hirakud Reservoir.

Improving livelihood benefits

Fish production, the most direct tangible benefit from the reservoir shall be enhanced through scientific management of stocking, implementing mesh size regulations and enforcing no-fishing periods in fish breeding seasons. Strengthening of PFCS will ensure that the fishers gain equitable benefit from fisheries enterprise. Systematic development of ecotourism will also enable communities to benefit from a healthy ecosystem. Access to safe water, sanitation and disaster risk reduction infrastructure will be improved towards enhancing well-being of reservoir communities.

Integrated wetland inventory, assessment and monitoring system to support adaptive management

Monitoring and evaluation is critical to assess changes in ecological character of Hirakud Reservoir. Management planning would therefore strive to put in place an integrated wetland inventory, assessment and monitoring system to support establishment of ecological and socioeconomic information baseline, assessing efficiency of management interventions and determining impacts of sectoral programmes on Reservoir environs. An important part of the strategy would be to involve stakeholders, particularly local communities and civil society organizations in wetland monitoring. The Hirakud Reservoir Management Committee shall also work towards creating a network of specialist organizations to support assessments and independent review of quality and outcomes of inventory, assessment and monitoring efforts.

Capacity development

A major factor limiting integrated management of Hirakud Reservoir is lack of effective capacity amongst concerned state government departments, stakeholders and local communities. The management plan therefore emphasizes on building capacity on integrated wetland management, particularly recognizing biodiversity and ecosystem services values and governing factors, underlying lentic-lotic interactions and integrating these in planning, decision making and implementation at all levels.

6.3 Management components, objectives and performance indicators

Management of Hirakud Reservoir is proposed to be organized in seven components. The components on catchment conservation, water management and habitat management are aimed to secure ecosystem processes and habitat conditions that underpin various ecosystem services and biodiversity values of the reservoir. Components on sustainable fisheries and agriculture development are aimed at optimizing developmental and livelihoods benefits. The cross cutting components on institutional development and communication, education, participation and awareness would secure the institutional and governance arrangements to complement management. Specific objectives and performance indicators envisaged under these components are as follows:

Component 1: Institutional development

Objectives

- Establish institutional mechanism for cross-sectoral coordination and multi-stakeholder engagement
- Operationalize decision support systems for adaptable management of Hirakud Reservoir

Performance indicators

- Hirakud Reservoir Management Committee (HRMC) is able to establish stakeholder engagement in reservoir management, and integrate management actions with ongoing developmental programming
- Wetland inventory, assessment and monitoring system is able to effectively inform decision makers on existing and emerging risks of adverse change in ecological character
- Built capacity is used by key state government agencies and stakeholders to support integrated management of Hirakud Reservoir

Component 2: Catchment Conservation

Objectives

- Reduce silt loading in reservoir from direct catchment of Hirakud Reservoir

Performance indicators

- Vegetative cover enhanced to 33% of reservoir catchment
- Siltation in reservoir reduced by 20% (from present annual rates of ~50 MCM to ~ 40 MCM)

Component 3: Water Management

Objectives

- Water regime sustains full range of ecosystem services and biodiversity values of reservoir
- Increased productive life of the reservoir

Performance indicators

- Reservoir operations rules takes into account human needs as well as ecological water requirements
- Water quality of the reservoir and its downstream reaches is suited for key aquatic habitats
- Reduction in water stress in reservoir and its command areas
- Alternate sediment management practices assessed and applied for sustaining reservoir capacity

Component 4: Habitat Management

Objectives

- Viable population of key species and habitats is maintained in Hirakud Reservoir
- Hirakud Reservoir continues to support over 20,000 waterbirds each year

Performance indicators

- Community engagement in maintenance of habitats of waterbirds and Mahseer
- Improved status of breeding, spawning grounds and migratory pathways of fish
- Viable populations of Mahseer in Mahanadi River
- Population trends of waterbirds in Hirakud Reservoir remain positive

Component 5: Sustainable Fisheries Development

Objectives

- Sustainable enhancement of fish yield to atleast 30 tons / hectare
- Strengthening community managed reservoir fisheries
- Enhanced well-being of reservoir fishers as an incentive for ‘responsible fishing’

Performance indicators

- Annual fish catch from reservoir maintained below sustainable yield levels

- PFCS meet atleast 80% of credit requirements of member fishers
- Atleast 90% of fishers are members of PFCS and are benefited in terms of better prices and increased access to credit and other infrastructural support
- Significant decline in unsustainable fishing practices in the reservoir

Component 6: Sustainable Agriculture Development

Objectives

- Increased water use efficiency in agriculture in command area agriculture

Performance indicators

- Atleast 20% reduction in water demand from agriculture
- Reduction in dependence on surface water irrigation through conjunctive use of surface and groundwater
- Atleast 20% increase in returns to farmers through use of sustainable agriculture techniques

Component 7: Communication, Education, Participation and Awareness

Objectives

- Enhance stakeholder engagement in planning, decision making and implementation of reservoir management plan
- Views, rights and capacities of stakeholders, particularly reservoir dependent communities are taken into account in reservoir management
- Create positive economic incentives for local communities through participation in sustainable management of the reservoir

Performance indicators

- Awareness within stakeholders, particularly local communities and biodiversity and ecosystem services values of the Hirakud Reservoir and needs of integrated management
- Increased integration of sectoral programmes with integrated management
- Ecotourism managed within carrying capacity of the Hirakud Reservoir leads to additional income generation for wetland dependent communities
- Extent of integration of community rights, views and capacities in reservoir management

6.4 Action plan

Component 1: Institutional Development

1.1 Constitution of Hirakud Reservoir Management Committee

It is proposed to constitute Hirakud Reservoir Management Committee (HRMC) as the nodal policy making, planning and regulatory agency for Hirakud Reservoir. The Committee will provide an effective arrangement for cross-sectoral coordination and multi-stakeholder engagement in reservoir management.

Specific activities to be undertaken include the following:

- Finalization of Terms of Reference of the Committee
- Notification of Committee
- Work allocation as per the approved Terms of Reference
- Conducting business as per the terms of reference, including periodic review meetings, commissioning specific studies and stakeholder outreach.

1.2 Establishing Integrated Inventory, Assessment and Monitoring System

An integrated inventory, assessment and monitoring system is proposed to be put in place to address the information needs of reservoir management, and to provide a robust decision support system. Specific objectives and a detailed framework have been outlined in Chapter 3. The following activities are proposed:

1.2.1 Establishment of WRTC Sambalpur sub-center

A sub-center of Wetland Research and Training Center (WRTC) of Chilika Development Authority is proposed to be established to coordinate wetland surveillance, assessment and monitoring programme. The sub-center can be housed within the Office of Chief Engineer and Basin Manager, Upper Mahanadi Basin located at Burla. The sub-center can be initially staffed with scientists on deputation from the Wetland Research and Training Center, Department of Water Resources and State Pollution Control Board. The sub-center will be responsible for:

- Conducting regular surveillance and monitoring programme
- Maintaining field stations established to monitor hydrological regimes, water quality and related ecological aspects
- Maintaining systematic database on various biophysical and social aspects of reservoir
- Conducting specific assessments to support wetland management

1.2.2 Development of a database management system

A database system for storing, retrieving and analysing the reservoir inventory, assessment and monitoring outputs is proposed to be set up in a GIS environment. This will include: a) development of data quality management and assurance plan including specification of data collection objectives, data quality objectives, sampling programme design, data and metadata documentation procedure, data quality control methods and performance audit procedures; and b) development of GIS based database management system. The database system will be maintained by the WRTC Hirakud sub-center.

1.2.3 Reservoir surveillance and monitoring

Wetland monitoring and inventory protocols for land use and land cover, hydrological regimes, ecosystem processes, biodiversity and socioeconomics and livelihoods as proposed in Section 5.2 will be implemented.

1.2.4 Assessment studies

The following assessment studies, as indicated in Section 5.1 are proposed to be commissioned to support reservoir management:

- **Waterbird habitat and health** to assess habitat preferences, precise requirements and ecology of key waterbird species; strategies for maintaining viable populations for resident and migratory bird species; and assess risks and potential of transmission of avian diseases to other birds and animals
- **Fish breeding and migration behaviour** to assess interaction between riverine and reservoir environments, presence and status of breeding grounds; strategies for improving habitat conditions
- **Ecological character risk and vulnerability** to determine the limits of acceptable change for critical ecosystem components, processes and services; sensitivity and adaptive capacity; and risk of adverse change
- **Ecosystem services valuation** to assess the contribution made by ecosystem services to local livelihoods, and regional food and water security; thresholds and required conditions for delivery of ecosystem services; conservation – development tradeoffs and strategies for incentivizing ecosystem services stewardship
- **Climate risk and vulnerability** to assess perception of climate risks based on sensitivity and adaptive capacity of critical ecological character elements; climate scenarios with respect to ecological character; implications of changes in hydrological regimes on reservoir water allocation planning; risk management options

1.3 Capacity development

Capacity development interventions are aimed at enabling state government agencies and

stakeholders concerned and entrusted with reservoir management obtaining, strengthening and maintaining capabilities for integrated wetland management. This is to be achieved through:

- Capacity development needs assessment
- Building knowledge through structured training courses, workshops, field application, and exchange programmes
- Exchange programmes to understand possibilities and implications of sectoral programming in relationship with reservoir functioning
- Develop coaching and mentoring processes for key state government agencies
- Implement mechanism of networking site managers with national and international networks for learning and sharing best practices and lessons learnt
- Assess effectiveness and adaptation of capacity development interventions

Component 2: Catchment Conservation

Management component on catchment conservation is aimed at reducing sediment inflow from the upstream, so as to enhance reservoir's longevity. Available information on watershed characteristics and land use changes has been used to prioritize catchments (Section 2.2.1).

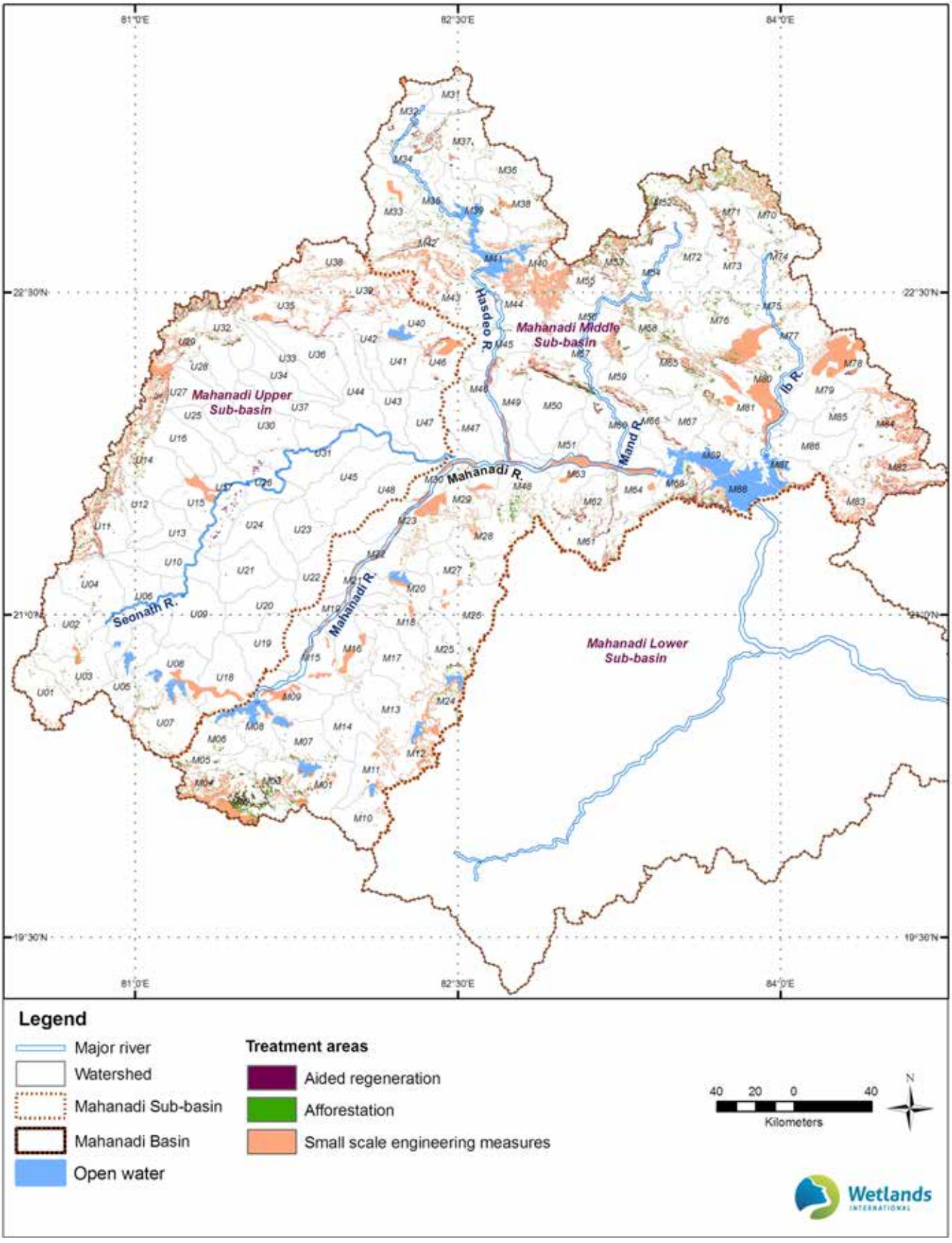
Keeping in view that land use should follow their respective land capabilities, vegetative and small scale engineering measures are proposed to be sued for control of soil erosion, landslides and arrest flow of silt from critical watersheds. The area earmarked for various treatment measures have been mapped at 1: 50,000 scale (Map 6.1). The estimates for afforestation and regeneration given in this action plan have been derived based on practices in watershed conservation assuming partial saturation of watersheds.

It is proposed to implement catchment conservation interventions as per the Common Guidelines for Implementation of Watershed Development Projects 2008, framed by the Government of India. Key features of the guidelines are:

- Village reckoned as a unit of planning and implementation
- Dedicated implementing agencies at various levels supported by multi-disciplinary professional teams
- Productivity enhancement and livelihoods to be given priority along with conservation measures
- Cluster approach with interventions covering geo-hydrological units
- Multi-tier approach, with water sources to be treated with forestry approaches, intermediate slopes treated with watershed management interventions and valley areas with watershed development synergized with labour intensive and employment generating interventions.

Implementation of interventions will be based on a community centred approach involving the watershed committee, the Gram Sabha and JFM (Joint Forest Management) Committees at the village level. JFM/Watershed Committee will be created or strengthened where already existing in the treatment areas. At the district level the implementation will be through the district IWMP (Integrated Watershed Management Planning) institutions such as the District Watershed Development Unit that will link with relevant organizations and offices to impart training to community groups on catchment conservation measures.

Watershed development projects are to be sequenced in three phases, namely (a) preparatory, (ii) works and (iii) consolidation and withdrawal phase. Budget allocation as prescribed by common guidelines would be in a phased manner with around 10 % for entry point activities, 75 % for watershed related activities and 5% for consolidation and withdrawal. The preparatory



Map 6.1: Watersheds prioritized for catchment conservation

phase aims to institute appropriate mechanisms for adoption of participatory approach and empowerment of local institutions such as Watershed Committee, Self-Help Groups, and User Groups which are part of the institutional framework under IWMP.

Major funding for implementation is to be leveraged under the ongoing IWMP programmes. Wherever, possible the Project Implementation Agency or the District level agencies shall explore and encourage availing the credit facility provided by banks and financial institutions and harmonise resources of different schemes and programmes. The following funds need to be created for implementation:

- Watershed Development Fund - People's contribution towards the Watershed Development Fund (WDF) shall be a minimum 10% of the cost of NRM works executed on private lands only.
- Revolving funds for SHGs not exceeding Rs 1 lakh.

Specific activities are detailed below:

2.1 Village level micro-planning and preparation of DPR

For on-site implementation a detailed micro-watershed level planning at 1: 1000 scale has to be carried out after PRA exercise by the Watershed Development Team with active participation of the Watershed Committee. This micro-plan will identify locations for small scale engineering measures and activities to be carried out, selection of beneficiaries and work-sites and design and costing of all works. The overall responsibility for the preparation of DPR would lie with the Project Implementing Agency (PIA). After approval by the Gram Sabha, the PIA shall submit the DPR for approval to the DWDU/DRDA/DP. The DPR will also work out detailed resource-use agreements (for surface water, groundwater and common/forest land usufructs) among User Group members in a participatory manner based on principles of equity and sustainability. Specific actions include:

- **Initiating the development of Village level institutions** such as Watershed Committees (WCs), Self- Help Groups (SHGs) and User Groups (UGs) and Capacity Building of different stakeholders on institutional and work related aspects.

- **Entry point activities** to establish credibility of the Watershed Development Team (WDT) and create a rapport with the village community. These include trainings on:

    - Nursery management and plantation activities
    - Contour trenching, construction of check dam, percolation tanks etc.
    - Agroforestry measures and conservation agronomy practices as cultivation of–soil binding crops as legumes and use of cover crops, contour farming, land preparation, crop mulching, mixed and intercropping, imparted through local Krishi Vigyan Kendras and local agriculture institutions
    - Horticultural practices
    - Use of smokeless hearths

2.2 Ridge area treatment through vegetative measures

The Land use and land cover analyses reveal that there has been a loss of 6 % forest cover over the past four decades. This has resulted in considerable silt loading in the reservoir. In order to alleviate this problem it is proposed to undertake extensive forestry measures to restore the health of the catchment area through regeneration of vegetative cover in forest and common land, afforestation, staggered trenching, contour and graded bunding, bench terracing etc. It is targeted to enhance the vegetative cover from 27% to 33 % in the entire catchment area of Hirakud. Specific actions include the following:

- **Afforestation using native species -** A total of 10,600 ha of area under bare steep slopes in 13 watersheds have been identified for treatment by afforestation in the districts of Jharsuguda, Bargarh, Sambalpur, Sundargarh that form the immediate catchment of Hirakud (Table 6.1). On similar lines, 74,639 ha of the catchment lying within Chhattisgarh need to be taken for afforestation through various government schemes (Table 6.2). Native soil binding and economically important species would be used for afforestation in consultation with local communities through PRA exercise. The present MAP provides a budget estimate of 20 % of this area i.e. 15,000 ha.

- **Aided regeneration -** A total of 12,774 ha of non-forested land above >25% slope in 13 watersheds has been identified for treatment by aided regeneration in the first phase (Table 6.1). In the second phase 43,711 ha lying in Chhattisgarh lying mostly in Jashpur, Korba, Bilaspur, Koriya,Surguja, Kawardha districts can be taken for aided regeneration (Table 6.2).

2.3 Drainage line treatment with a combination of vegetative and engineering structures, such as earthen checks, brushwood checks, loose boulder checks, gabion structures. Check dams, gabion structures, spurs are some of the techniques that could be used to arrest surface run off and reduce reservoir sedimentation. Stream bank erosion would be controlled through drainage line treatment, particularly of the first, second and third order streams in watersheds listed in Table 6.3. Specific actions to be taken are as under:

- **Construction of check dams:** 10,000 DRSM, 3000 Gabion check dams and 2,500 concrete check dams on first, second and third order drainage and shallow rivers and streams will be constructed to arrest flow of silt and prevent bank erosion in very severely gullied hilly regions and stream banks. The concreate dams will also serve as a water harvesting structure and provide irrigation benefits to nearby farmlands.

- **Landslide control structures:** 1000 landslide control structures are proposed to be constructed to control landslides. Areas presently under quarrying and intensive erosion shall be given a high priority under the activity.

- **Stream bank erosion control measures:** Streambank protection spurs, 2000 in number along streamlines would be constructed in areas prone to severe soil erosion and landslides.

2.4 Improving groundwater recharge through water harvesting structures – Water harvesting structures shall be constructed for enhancement of moisture regimes in the watersheds. This includes construction of low-cost farm ponds, nalla bunds, percolation tanks and other measures. Major activity planned in this head construction of 1000 percolation tanks primarily meant to provide irrigation benefits in rainfed areas.

2.5 Promotion of alternate fuelwood sources

Development of village woodlots - Village commons, panchayat lands and group lands are ideal for raising woodlots to meet the energy requirements of the village and to reduce dependence on the forests for firewood. Small timber, fuel wood and fodder species could be raised for the bonafide uses of the beneficiaries. Identification of land and beneficiaries for the programme is proposed to be carried out by the village panchayats, which will stipulate clear cut rules for management of these lands and sharing of the usufruct.2500 ha has been proposed to be developed as village woodlots around Hirakud.

Table 6.1: Areas to be treated through forestry measures in Jharsuguda, Bargarh, Sambalpur, Sundargarh districts

Watershed ID	Total area(ha)	Afforestation area(ha)	Aided regeneration area(ha)
M68	31398	1323	1131
M69	62356	582	775
M77	80211	689	158
M78	61034	377	626
M80	93511	2161	906
M81	76672	1599	701
M82	78841	814	3475
M83	54702	432	760
M84	92574	718	1701
M85	36604	94	58
M86	62936	96	12
M87	67750	418	381
M88	66257	1301	2091
Total	**864,845**	**10,604**	**12,774**

Table 6.2: Areas to be treated through forestry measures in Chhattisgarh

Watershed ID	Total area (ha)	Afforestation area(ha)	Aided regeneration area(ha)
M04	53605	1485	809
M58	68790	2411	891
M02	62375	5544	3117
M03	78259	2461	1468
M05	78097	892	458
M12	42066	413	189
M24	72054	895	234
M26	86463	463	306
M27	91706	378	223
M28	92694	925	257
M31	70248	142	266
M32	75939	1212	1360
M33	73458	1222	514
M34	35141	801	437
M35	46784	1092	134
M36	68475	491	369
M37	88799	935	813
M38	66115	817	322
M39	47130	2001	164
M40	75594	1790	635
M42	54295	1506	675
M43	40226	828	359

Watershed ID	Total area (ha)	Afforestation area(ha)	Aided regeneration area(ha)
M44	43992	500	171
M48	43085	2083	211
M52	95016	4318	2470
M53	80321	2421	1641
M54	62356	1792	1159
M55	69736	1123	1079
M56	70632	592	397
M57	74856	1169	1102
M59	52418	662	919
M61	34583	1168	1300
M62	39776	1095	897
M63	58626	497	479
M65	85569	3026	1011
M70	87982	5022	1560
M71	57293	3044	1901
M72	84308	1752	1063
M73	48974	663	514
M74	57933	911	614
M75	53665	1017	318
M76	77477	1811	302
U08	60456	814	345
U12	44071	652	675
U14	49567	1913	1181
U28	55426	338	462
U32	47130	1187	246
U35	80745	257	246
U38	79580	383	685
U39	70761	379	688
U40	60354	379	318
U11	75939	1662	2271
U27	58626	869	1414
U29	80158	2437	2072
Total	**3,509,724**	**74,639**	**43,711**

Table 6.3: Area to be treated under drainage line treatment measures

Immediate catchments		Chhattisgarh	
Watershed ID	Area(ha)	Watershed ID	Area(ha)
M68	3817	M04	13909
M69	4740	M58	8473
M77	18848	M02	22940
M78	23718	M03	7840
M80	25262	M05	2234
M81	18932	M12	11797

Immediate catchments		Chhattisgarh	
Watershed ID	Area(ha)	Watershed ID	Area(ha)
M82	25255	M13	5670
M83	11287	M17	2276
M84	17926	M18	1998
M85	520	M20	3794
M86	456	M24	6669
M87	5399	M26	2389
M88	7718	M27	2006
		M28	3725
		M29	4184
		M31	1422
		M32	5736
		M33	6389
		M34	2225
		M35	1450
		M36	1278
		M37	3177
		M38	3874
		M39	2444
		M40	29766
		M42	15398
		M43	9202
		M44	4666
		M48	4729
		M52	9771
		M53	11593
		M54	7003
		M55	6983
		M56	11039
		M57	6763
		M59	4108
		M61	4968
		M62	4255
		M63	10665
		M65	9535
		M70	21404
		M71	11581
		M72	5031
		M73	2478
		M74	3087
		M75	3604
		M76	6127
		U08	9423
		U12	4228
		U14	10538
		U28	8650
		U32	6917

Immediate catchments		Chhattisgarh	
Watershed ID	Area(ha)	Watershed ID	Area(ha)
		U35	251
		U38	251
		U39	13745
		U40	8375
		U42	1183
		U11	16149
		U27	10684
		U29	12619
Total	**163,878**		**434,668**

- **Promotion of smokeless hearths -** Smokeless hearths reduce pressure on forests through efficient use of fuelwood and help in improving the environment in areas adjoining forest lands. The hearths are also known to reduce smoke and therefore significantly enhance the domestic cooking environment. Models designed by CAPART can be suitably modified as per the local conditions and training provided to the user groups for construction and maintenance of these hearths. The Action Plan aims for inclusion of the respective village panchayats in implementation of the programme. A total of 3,000 numbers of smokeless hearths shall be installed in the 118 villages around Hirakud. Training will be provided to community groups for installation and maintenance of these hearths.

2.6 Pasture development - Grazing pressures in forest areas to be reduced through regeneration of degraded grasslands in areas adjoining forests through a system of rotational closed grazing and plantation of grass seeds. Conservation based management of grasslands through techniques such as balancing numbers with grazing capacity of the grasslands, controlled grazing by fencing, area closure, cut and carry will help to preserve soil and vegetation and improve grassland productivity. Introduction of better forage species can be done by seeding using seeds of native species or by plantation of sods. Grass species such as *Dichanthium annulatum*, *Panicum antidotale*, *Sehima nervosum*, *Cenchrus ciliaris*, and *Chrysopogon fulvus* and legumes such as *Dolichos lab lab*, *D. axillaris*, *Stylosanthes humilis*, *Phaseolus atropurpureaus* are suitable for the area. Cutting of undesired species and shrubs at regular intervals would be done. An area of 5,000 ha is targeted under this activity

2.7 Sustainable land use practices

It is targeted to promote sustainable resource use practices in 21,000 ha which constitutes around 2 % of the area in 13 watersheds surrounding Hirakud. Specific interventions are as follows:

- **Promotion of agro forestry models -** 20,000 ha of the immediate catchment of Hirakud is proposed to be taken up for agroforestry plantations integrating tree and agricultural crops in various temporal/ spatial combinations such as such as bund plantations. Species suitable for the area such as trees as *Hardwickia binata*, *Acacia tortilis*, *Acacia auriculiformis*, *Albizzia amara*, *Glyricida maculata*, *Moringa oleifera*; shrubs as *Sesbania grandiflora*, *Leucaena latisiliqua* can be promoted in the region. Planting in narrow hedge with weeding and pruning, operations, controlled grazing, border row plantation, bund plantations would be promoted

- **Improved management of homesteads**
  Enrichment of homesteads for production of useful biomass is an important strategy to reduce the dependence of the communities on forest resources. This could be achieved through introduction of three storey vegetation above ground including useful fruit trees, shrubs, climbers and herbs (including a select having medicinal value) particularly in the plains where soil and moisture conditions are favourable. Packages of assorted seeds could be provided to the households along with technical inputs on raising their nurseries and maintenance of crops. The other alternative could be encouraging the households to grow native species, with adequate emphasis on utilizing the below as well as above ground products. It is proposed to cover 2,500 households for homesteads living within and / or adjoining the forest areas having dependence on forest biomass for livelihoods under this activity. Selection of the beneficiary households would be done through the village panchayats.

- **Promotion of sustainable horticulture practices**
  Horticultural crops are proposed to be cultivated in land capability falling in class V to VII particularly in denuded, sloping wastelands where it would prove to be profitable and economical as well. It is envisaged to demonstrate sustainable horticulture practices in 1000 ha, wherein in-situ moisture conservation techniques such as mulching would be followed by laying V shaped ditches along the contour with planting of fruit trees on the hill sides.

2.8 Consolidation and Withdrawal

The final phase will involve review of catchment conservation measures undertaken and will include:

- Documentation of successful experiences as well as lessons learnt for future use.
- Mechanisms for management of developed natural resources
  - Improving the sustainability of various interventions under the project;
  - Formal allocation of users right over Common Property Resources (CPRs);
  - Collection of user charges for CPRs;
  - Repair, maintenance and protection of CPRs;
  - Sustainable utilization of developed natural resources;
  - Involvement of gram panchayat / corresponding institutions (as a governance body) in addressing the above aspects.
- Replication and up scaling of successful experiences related to above aspects through revolving fund under the project as well as credit and technical support from external institutions;
- Mechanisms for participatory planning, implementation and monitoring of activities
- Federations could be formed at the level of a cluster of villages in order to support economic activities at scale. Local-level institutions are expected to reach maturity and exit protocols become operative for the PIA.

Component 3: Water Management

Interventions under water management component would include four areas, namely upgradation of reservoir operation rules, maintenance of water infrastructure, feasibility assessment of sediment management options and water quality improvement.

3.1 Upgradation of reservoir operations rule

Upgradation of reservoir operations rule is envisaged to be a key instrument for achieving adaptive management, and factoring in lentic-lotic interactions. The reservoir operations rule upgradation will take into account: a) revised storage capacity of the reservoir; b) implications of upstream flow regulations; c) requirement of

downstream ecosystems; d) compatibility of various sectoral water usages; e) sedimentation management options; f) stakeholder needs and g) climate variability.

Following process is proposed to be followed:

- Constitution of a technical committee
- Formulation and finalization of terms of reference
- Assessment of current reservoir operations rule in the context of terms of reference
- Assessment of water requirements for maintaining ecosystem processes and biodiversity habitats
- Assessment of ecosystem water requirements for downstream wetlands and aquatic habitats (e.g. Mahseer habitats)
- Assessment of implication of existing and proposed water resources development infrastructure in upstream and downstream reaches
- Incorporation of immediate climate change scenarios on water and sediment fluxes
- Propose a revised reservoir operations rule along with adaptation measures as appropriate.

3.2 Maintenance of irrigation and power supply channels

Provisions are made for ensuring periodic structural and operational stability of dam infrastructure, including main dam, dykes, and irrigation canals. The World Bank funded Dam Rehabilitation and Improvement Project (DRIP) will address this aspect of management plan.

3.3 Feasibility assessment for sediment management options

Managing sediments of Hirakud Reservoir in order to preserve reservoir capacity is urgently required to prolong reservoir life and benefit downstream reaches by mitigating sediment starvation that results from sediment trapping. Sediment management techniques in reservoirs can be broadly classed into three: a) Reducing sediment yield from watersheds; b) Minimizing sediment deposition by routing sediments around or through storages; and c) increase, recover of reallocate storage volume through hydraulic and mechanical excavation[1]. Activities under the component on Catchment Conservation address one of strategy options for sediment management, and are not likely to bring about comprehensive solution to the problem of rapid loss of reservoir capacity. Options to minimize sediment deposition or recovering storage volume will also need to be explored for application, post feasibility assessment.

Under the ambit of management planning, it is envisaged to commission an assessment of reservoir sediment management options for Hirakud, including feasibility for application. The study should be conducted through involvement of expert agencies, and recommendations assessed by a technical committee constituted by Department of Water Resources. Implementation of options can be as per recommendations of the technical committee.

3.4 Water quality improvement

In order to address pollution stress on the reservoir operations, actions proposed include enforcement of environment quality regulations in Ib-Jharsuguda Valley, upgradation of waste management infrastructure in urban settlements and comprehensive sanitation coverage in villages around the reservoir.

3.4.1 Enforcement of environmental quality regulations in Ib-Jharsuguda Valley

Pollution from Ib-Jharsuguda Valley is a significant stressor on Hirakud's aquatic environment. It is proposed to address pollution threats from this industrial cluster by comprehensive implementation and enforcement of the recommendations of the 2010 Action Plan

[1] For a cross continent review of sediment management strategies in reservoirs and regulated rivers, refer Kondolf et al. (2014).

of OSPCB to abate pollution in this industrial cluster. Following recommendations have been made under the plan for control of water pollution:

Thermal Power Plants

- All lean slurry disposal system to be converted to (High Concentration Slurry Disposal) HCSD or mine void filling
- All thermal power plants shall adopt zero discharge

Coal Mines

- Creation of reservoir for storage of mine drainage water and runoff which can be used for industrial purpose
- Making provision for supply of drinking water in the peripheral villages of coal mining area
- Back filling of the mine voids and restoration of the mined out area.

Iron & Steel and Ferro & Alloys sector

- All steel plants and sponge iron plants have to develop collection and treatment facility for mineral char and coal pile runoff during monsoon

Common Infrastructure and Services

- Construction of water storage reservoirs to collect the mine water from the underground mines
- Establishment of on-line monitoring station for water quality monitoring of River Mahanadi and online data transmission facility with SPCB and CPCB. The parameters shall also include Fluoride, Cadmium and TOC
- Monitoring of Pb, Cr, Cd and Fluoride concentrations in groundwater

3.4.2 Upgradation of existing waste management infrastructure in urban settlements

The reservoir, in its upstream, is fringed by two major urban centers (Brajrajnagar and Jharsuguda) having a total population of 178,133 as per 2011 census (39,547 households), projected to increase by 2025 to 242,874. This is likely to lead to sewage generation of 29 MLD, which in absence of any treatment facilities, is ultimately discharged in the reservoir.

It is therefore proposed to install two sewage treatment facilities of 15 MLD each at these two townships to reduce stress on water quality of the reservoir. A DPR for the same needs to be prepared. All infrastructure shall be made compliant with Manual of Sewerage and Sewage Treatment of CPHEEO (Central Public Health Environmental Engineering Organization).

The Sewage Treatment Plants (STPs) would be operated and managed by the municipalities of Brajrajnagar and Jharsuguda. Management plan would cover installation of plant, and operation and maintenance for five years, after which the continued functioning would be the responsibility of local bodies.

3.4.3 Comprehensive coverage of safe sanitation

Poor access to safe sanitation and drinking water facilities in communities living around the reservoir creates adverse impact on water quality, as well as on community health. As per socioeconomic assessments carried during the process of management plan formulation, of the 26,111 households living around the reservoir, only 15% have access to safe sanitation facilities, whereas a marginally higher proportion (23%) has access to safe drinking water facilities.

It is proposed to provide comprehensive coverage of safe sanitation in all 118 villages located around the reservoir. Implementation will be dovetailed with the ‘Swacch Bharat Mission’ and as per the guidelines of the sub-mission ‘Swacch Bharat Mission (Gramin)’. The scheme is built around community led and community saturation approaches focusing on collective behaviour change, and if implemented as per proposed design, will bring along positive changes in ecological status of the reservoir as well as health of the rural communities.

Specific activities, in line with the guidelines include the following:

- Updation of baseline survey to assess the status of sanitation and hygiene practices
- Orientation of key personnel and preparation of district plans
- Implementation of Information, Education and Communication programmes aimed at bringing behavioural change
- Building capacity of stakeholders and sanitation workers in promoting behavioural change, construction and maintenance of toilets and solid and liquid waste management
- Construction of individual household toilets, including a sanitary substructure, a super structure and hand wash unit for cleaning and handwashing
- Increasing local availability of sanitation material

As provided in the guidelines, the programme would provide a support of Rs. 12,000 for each household toilet unit to all household units below poverty line, and others restricted to scheduled castes and tribes, small and marginal farmers, landless labourers, physically handicapped and women headed households. Households above poverty line not falling in above categories will be motivated and triggered to take up construction of the household toilets on their own.

Component 4: Habitat Management

Interventions for water management, particularly those for upgrading reservoir management rule, sediment management and improved water quality will have positive impacts on the reservoir habitat. Complementing these interventions, the component on habitat management focuses on Mahseer and waterbird community, both of which are indicators of ecological health.

4.1 Mahseer conservation

Actions to be taken for conservation of Mahseer would include habitat identification and assessment, community mobilization, establishment of community reserves and monitoring.

4.1.1 Habitat identification and assessment

Mahseer is presently found to be distributed in Mahanadi River stretch between Sambalpur and Boudh. It is proposed to carry a systematic habitat identification and assessment based on:

- Population size surveys
- Habitat survey
- Analysis of feeding and breeding behaviour
- Migration patterns through tagging experiments
- Evaluation of threats at major congregation sites

4.1.2 Community mobilisation and awareness generation

At key locations as Huma, existing community efforts for conservation of Mahseer will be strengthened by mobilization and awareness generation interventions. Specific actions include:

- Sensitization workshops for community groups, school and college students, NGOs and CBOs
- Mahseer conservation campaigns
- Establishing do's and don'ts for habitats
- Establishment of community led surveillance programmes

4.1.3 Establishment of the community reserve

It is proposed to designate river stretch at Huma as community conservation reserve to secure viable populations of Mahseer in Mahanadi River. Steps to be taken include the following:

- Feasibility assessment
- Stakeholder consultations for development of management plan specifying prohibited and restricted activities in the reserve, and institutional arrangements for enforcement
- Notification as community reserve

- Implementation of habitat management plan, including enforcement of regulations

4.1.4 Monitoring and evaluation

Periodic monitoring of population status, habitat quality and threats is proposed to ensure maintenance of Mahseer habitats in River Mahanadi.

4.2 Waterbird conservation

Interventions for waterbird conservation include population monitoring, maintenance of habitats and establishment of community reserve adjoining Jarimuli village.

4.2.1 Waterbird population monitoring

Regular monitoring of waterbird population following standard protocols as the Asian Waterbird Census at all the major congregation sites within and around Hirakud Reservoir shall be undertaken in a coordinated manner so as to understand comprehensively the significance of the wetlands for waterbirds (both resident and migratory) and to plan and monitor habitat management strategies and actions. Thus, adopting a holistic approach for assessment and mapping of the reservoir and its floodplains as potential waterbirds congregation site is essential. Waterbird population shall be monitored through:

- **Annual Census:** Current census operations cover only parts of the reservoir, with inadequate information on habitat quality. Much of the coverage is in south-eastern and south-western parts of the reservoir, while the rich marsh beds in the north have been inadequately covered. It is therefore proposed to conduct comprehensive mid-winter counts each year, in coordination with the Hirakud Wildlife Division, and as per protocols recommended under AWC. Census programmes will include training of prospective census participants and local waterbird enthusiasts.
- **Habitat identification and mapping:** Key waterbird habitats are proposed to be mapped using GPS and on a GIS platform to enable surveillance and monitoring. Specific attention may be given to:
    - Open water areas as feeding areas for diving species, such as pochards, grebes and coots, and as open roosting areas for other flocking waterbird species
    - Reed beds and channels for feeding and roosting migratory ducks and geese
    - Reed beds and open marsh vegetation for nesting species
    - Trees along the wetland edge and on islands in the wetlands for tree nesting species
    - Patches of wet grassland and open ground for grazing ducks and geese, and shorebirds
- **Breeding waterbird investigation:** An intensive programme to determine the distribution and breeding concentrations of all waterbird species (reed bed, marsh and tree nesting) should be undertaken to determine the current baseline population of breeding birds. Studies of the habitat preferences, precise requirements, ecology of key waterbird species and determination of current threats will be required to enable planning and execution of measures to manage and improve existing habitats, to identify potential breeding areas and restore degraded areas to increase breeding habitats and address increased prey requirements. A long term comprehensive waterbird migration study should be established for long-distance and seasonal migratory species. To understand local, national and international movements of birds, the application of metal leg rings/bands, colour bands, flags and neck collars should be undertaken on selected waterbird species.

- **Waterbird health:** Knowledge of the health of resident and migratory species that inhabit the wetland is critical to understand the risk and potential threat of transmission of avifauna diseases. Thus, specific studies need to be undertaken to establish the baseline of common diseases affecting the bird population. Establishment of a wild bird disease unit capable of undertaking year round and long-term surveillance and monitoring of breeding and migratory waterbirds is required. Such surveillance activities need to be conducted in collaboration with local and international expertise.

4.2.2 Maintenance of habitats

Following interventions are proposed for maintenance of waterbird habitats in Hirakud Reservoir:

- **Management of riparian vegetation:** Management of riparian vegetation particularly in riverine stretches by preventing spread of permanent agriculture and colonization by invasives.
- **Community mobilization for habitat protection:** Sensitization workshops are proposed to be organized for local NGOs, CBOs, students and local residents on the need of waterbird conservation. Bird Protection Committees should be formed after adequate training for controlling poaching and protection of bird nests and habitats.

4.2.3 Establishment of new community reserve

It is proposed to establish a community reserve in the reservoir area adjoining Jarimuli village to provide protection to waterbird habitats. Actions to be taken include:

- Feasibility assessment
- Stakeholder consultations for development of management plan specifying prohibited and restricted activities in the reserve, and institutional arrangements for enforcement
- Notification as community reserve
- Implementation of habitat management plan, including enforcement of regulations

Management should also aim at designation of Hirakud Reservoir as a site within Important Bird Areas (IBAs) network.

Component 5: Sustainable Fisheries Development

Interventions for sustainable development of Hirakud reservoir fisheries will include: a) stock management; b) strengthening PFCS; and c) promotion of cage culture. These will be supplemented by measures for environmental management (primarily through components on water management and biodiversity conservation), improving information base and governance (through component on institutional development). Implementation of these intervention are proposed to be dovetailed with ongoing schemes of the FARD. Details of first three are provided below, with the rest included in respective sections.

5.1 Stock management

Sustainable development of reservoir fisheries would endeavor putting in place systematic stock management practices, including stocking, upgradation of stocking sources, and monitoring.

5.1.1 Stocking

- **Process Standardization:** It is envisaged to develop a standard protocol for stocking operations in the Hirakud Reservoir. This would include setting specifications for: a) species to be used for stocking; b) stocking rate; c) sourcing stocking material; and d) pre and post monitoring requirements. Process standardization is recommended to be done in consultation with NFDB, CIFRI, FARD and PFCS representatives.
- **Training:** Representatives of FARD and PFCS are proposed to be trained in stocking techniques as per the standardized protocol.

- **Stocking operations:** Periodic stocking should be done in the reservoir as per the agreed stocking protocol, with material sourced as advised.
- **Monitoring:** Systematic pre and post stocking is proposed to be conducted to assess survival and breeding patterns, and the extent to which auto-stocking is enabled.

5.1.2 Upgradation and operationalization of existing fish hatcheries

To enhance availability of stocking material, it is proposed to upgrade and operationalize the existing hatchery at Jarimuli Village (in Bargarh District) to produce 2 lakh fingerlings/cycle. This will augment existing hatcheries at Bomaloi, Chiplima and Pipalmunda. Steps to be taken include:

- Re-establishing operational procedures including management arrangements, operation and maintenance schedules, and financial viability. It is proposed that management of hatchery is placed with Tamdei Fisher Cooperative with handholding and supervision of FARD.
- Infrastructure renovation including brood and breeder tanks, water supply, sewerage, and feed stocks.
- Training to PFCS on hatchery management and fish seed production, disease identification and their management, and marketing.
- Hatchery operations as per agreed schedule and management arrangements

5.2 Strengthening Primary Fisher Cooperative Societies

PFCS constitute the key element of community managed fisheries in Hirakud Reservoir. It is proposed to take following actions for strengthening of these institutions to enable their functioning as stewards of fisheries resources:

5.2.1 Training: Training in phases is proposed to be conducted for all 5 PFCS (and any new cooperatives to be constituted by the Department) on various aspects of sustainable fisheries development, including modern techniques of sustainable yield enhancement.

5.2.2 Infrastructure development: Available infrastructure of the PFCS is proposed to be upgraded with:

- Renovation of office spaces
- Provision of ice boxes to member fishers
- Provision of fish processing platforms
- c) Holding tanks for live fishes

Support to the cooperatives is to be provided in the form of revolving credit of Rs. 10 lakh / society. In addition, the following common infrastructure is also proposed to be developed:

- Ice plant at Sambalpur with a production capacity of 10 tonnes per day
- Boat building and repairing yard at Lakhanpur

5.3 Promoting of cage culture

Culture of *Pangasius sutchi* by the FARD with NFDB support has so far been successful in Hirakud Reservoir. It is proposed to extend the current production system, with upgraded risk management protocols, to an additional unit having two batteries of 24 cages. Specific activities are as follows:

- **Site and beneficiary selection**: Site selection is to be done with due consideration of water level fluctuation; adequate water circulation; availability of sheltered, weed free, shallow bays; and operational accessibility. Site and beneficiary selection should be carried out in consultation with NFDB experts and PFCS representatives.

- **Training**: The target PFCS should be trained in use of cage culture technology, harvest and post-harvest management, dos and donts, and fish marketing. Training on the cage installation, species selection, stock maintenance and feeding operation and harvest needed to be imparted to the beneficiaries.
- **Cage installation**: Cage should be installed as per expert recommendations, adopting necessary precautionary measures.
- **Monitoring:** Periodic monitoring of the cage by the PFCS should be carried out to assess the overall growth, prevalence of disease, structural stability of cages, water quality and other aspects. Monitoring should be under the guidance of FARD experts. Records should be maintained at all stages to ensure comprehensive evaluation of the culture process.
- **Feasibility assessment of alternate species and production systems for culture fisheries:** A feasibility assessment of introduction of other species (as Common, Chinese or Gangetic Major Carps) and alternate production technology (pen culture) may be commissioned by the FARD for future integration in fisheries development of Hirakud Reservoir.

Component 6: Sustainable Agriculture Development

The management component on sustainable agriculture development is aimed at increasing water use efficiency in reservoir command areas to reduce water stress as well as improve crop productivity. Interventions are proposed in two broad areas, namely promotion of sustainable agro-practices and promotion of agro and allied enterprises.

6.1. Promote sustainable agro practices

Measures proposed include crop diversification, management of nutrient and irrigation and strengthening of farmers' clubs.

6.1.1 Crop diversification

Measures for crop diversification are aimed at reducing area under water intensive, long duration crops so as to ensure adequate water availability in the tail regions of the command area. This can be achieved in convergence with the National Food Security Mission which provides an assistance of Rs. 7,500/ha for cluster demonstration on intercropping techniques. Besides, farmers can avail upto Rs. 50,000 per ha. (i.e. 75% of the expenditure on planting material/seeds and input costs) for intercropping under the Department of Agriculture's Scheme entitled "Establishment of New Garden (Area Expansion)". Key activities include demonstration of technology through progressive farmers, and replication through outreach and technical accompaniment. Specific activities are as follows:

- **Cluster demonstration**
  Intercropping will be taken up initially at demonstration scale in five clusters in reservoir command area wherein cultivation of legumes, maize, oilseeds, millets, and others with technical support of Krishi Vigyan Kendra's (KVK). Implementation will be done in following steps:

  - Community mobilization through awareness camps and technical workshop with farmers in clusters of 20 villages each
  - Selection of 5 clusters of 100 ha each based on assessment of technical feasibility and farmers' willingness to participate
  - Training beneficiary farmers on intercropping technique, crop management, pre and post-harvest practices and establishing market linkages
  - Field application of inter-cropping practices with capital, technical and financial inputs organized through the local KVK.

- Monitoring and evaluation in the form of a comparative study of mono-cropping and diversified cropping input and output indicators shall be undertaken to establish the incremental benefit of engaging in crop diversification.
- Outcome dissemination to all the farmers club in 118 villages surrounding the reservoir, and villages located in the reservoir command area.

- **Replication and upscaling**
  Replication and upscaling will be enabled through the following activities
:
  - Training imparted to farmers willing to undertake crop diversification through the local KVKs via regular training programmes and re-fresher courses on methods of cultivation, pre and post-harvest practices and market linkages.
  - Access to subsidized inputs through schemes of the government and on-going support to facilitate field level implementation of crop diversification shall be extended through local KVKs.
  - Monitoring and evaluation of on-going field implementation shall be undertaken regularly to ensure successful implementation of crop diversification practices, as well as to identifying emerging trends for adapted crop diversification practices, as climate change.

6.1.2 Nutrient Management

In order to improve soil fertility, manage soil health and reduce inflow of agricultural run-off into the reservoir from the catchment, integrated pest management practices (IPM) (through the use of bio-fertilizers and pesticides and organic manure created through vermi-compost) shall be adopted.

Activities for nutrient management shall be implemented under the “Organic Farming” and “Pesticides/Bio-Pesticides” Schemes of the Department of Agriculture. The Organic Farming Scheme, provides farmers with subsidies upto 50% of the cost limited to Rs. 10,000 per ha (for a maximum area of 4 ha. per beneficiary), spread over a period of 3 years involving an assistance of Rs. 4000/- in first year and Rs. 3000/- each in second and third year. Farmers can also access subsidies on vermicompost units wherein 50% of cost of a permanent vermibed with the dimensions of 30’ x 8’ x 2.5’ (with a total cost of Rs. 60,000) and a HDPE vermibed with dimensions of 96 cft (12’ x 4’ x 2’) (with a total cost of Rs.10,000) shall be reimbursed on a pro-rata basis.The Pesticides and Bio-Pesticides Scheme provides farmers with subsidies on 50% of the cost of pesticides/bio-pesticides, limited to Rs.500 per ha.

The key activities to ensure nutrient management are as follows:

- **Training and outreach:** Farmers will be made aware of the benefits of adopting IPM practices; and shall be trained on the use of IPM practices by KVKs.
- **Site and beneficiary selection:** Uptake of IPM practices shall be promoted amongst all 118 villages surrounding the reservoir. Vermi-composting shall be promoted in 73 of the catchment area villages.
- **Access to inputs and implementation support:** Access to subsidized bio fertilizers and pesticides will be facilitated
- **Monitoring and evaluation** of on-going field implementation shall be undertaken regularly to ensure successful implementation of nutrient management practices and adaptation as required to emerging threats, as emergence of new varieties of pests and disease.

6.1.3. Irrigation Management

Micro irrigation practices and modern irrigation techniques (such as adoption of SRI techniques, and use of drip & sprinkler irrigation systems) shall be promoted amongst the farmers engaged in agriculture in the reservoir command area.

Activities shall be implemented under the "Micro Irrigation" Scheme of the Department of Agriculture wherein general farmers can access 80% and small/marginal farmers can access 90% subsidies on the cost of DRIP or Sprinkler irrigation units. The subsidy will be made available in the proportion of 40: 40: 20 (Central: State : Beneficiary) for general farmers and 50: 40: 10 for small/marginal farmers.

The key activities to ensure irrigation management include:

- **Training and outreach:** Farmers will be made aware of the benefits of adopting SRI and sprinkler & drip irrigation techniques; and shall be trained on applying the techniques by KVKs.

- **Site and beneficiary selection:** Uptake of SRI techniques shall be promoted in 7800 ha i.e. 30% of the total agricultural land, in two pockets of Lakhanpur block – the first upstream of Mahanadi River and the second upstream of Ib River. Drip & sprinkler irrigation shall be promoted in 6250 ha i.e. 25% of the agricultural land between Bheden River and Sasan Canal of Rengali and Jharsuguda blocks. The panchayats wherein drip and sprinkler irrigation shall be promoted is listed in Table 6.4.

Table 6.4 | Panchayats identified for promotion of Drip and Sprinkler Irrigation

Panchayat	Block
Khinda	Rengali
Lapanga	Rengali
Nishanbhanga	Rengali
Rengali	Rengali
Hirma	Jharsuguda
Malda	Jharsuguda
Patrapali	Jharsuguda

- **Access to inputs and implementation support:** Access to subsidized inputs and incentives for adopting SRI and drip & sprinkler technologies shall be facilitated.

- **Monitoring and evaluation** of on-going field implementation shall be undertaken regularly to ensure successful implementation of irrigation management practices and adaptation as required to emerging threats, as changes in precipitation patterns, etc.

6.1.4 Strengthening Farmer Clubs

Community level institutions as farmer clubs shall serve as the grass root level institution responsible for ensuring adoption of sustainable agro practices, dissemination and outreach of best practices, transfer of technology and investment in agriculture.

- **Training and outreach:** Farmers around the reservoir shall be made aware of the benefits of organising themselves into farmer clubs and a total of 118 farmer clubs shall be formed (i.e. one per village). Training will be imparted on the functioning of farmer clubs, sustainable agro practices, financial management (including banking and credit processes), collaborating with technical institutions for inputs, accessing subsidies and incentives, and market linkages.
- **Infrastructure Development** in the form of seed/grain banks per farmer club i.e. 118, shall be extended to facilitate the storage of seeds and grains.

6.2. Promote agro and allied micro-enterprises

Micro-enterprise development based on agro and allied sectors shall widen the livelihood options of farmers and ensure sustainable use of wetland resources. A total of 35 SHGs engaged in puffed rice production and poultry units shall be formed.

Activities to promote agro and allied micro-enterprises shall be implemented under the "Capital Investment Subsidy for Commercial Agri Enterprises (CAE)" Scheme of the Department of Agriculture and the "Ajeevika" Scheme of the Department of Rural Development. The CAE Scheme provides 40% (to general category) and 50% (to SC/ST/Women/Graduates of Agriculture

and allies disciplines) subsidies on the fixed capital costs (excluding the cost of land) subject to a limit of Rs.50 lakhs for setting up commercial agri enterprises. The Ajeevika Scheme provides SHGs 50% subsidy, if total investment is less than 1.25 lakhs. There is no monetary ceiling on subsidies for irrigation projects. Central and State Government financing ratio is 75:25. Expenses can be incurred for training, infrastructure, revolving fund assistance and subsidy for economic activities under this scheme. Following activities are proposed:

- Training: SHG members shall be imparted training on operations and management of SHGs as per the Societies Act, technology (for puffed rice production or poultry management as the case maybe), financial management (including banking and credit processes) and market linkages.
- Seed fund: All 35 SHGs shall be supported by raising a proportionate of the seed fund.
- Access to inputs and implementation support: Access to subsidized inputs and on-going implementation support shall be extended to the SHGs to facilitate
- Monitoring and evaluation: Monitoring and evaluation of the functioning of SHGs shall be undertaken regularly to ensure social equity and economic viability in functioning of SHGs.

Component 7: Communication, Education, Participation and Awareness

The CEPA (Communication, Education, Participation and Awareness) is aimed at enabling stakeholders, particularly dependent communities in taking actions for wise use of Hirakud Reservoir. The action components are designed to enable stakeholders to understand and appreciate the full range of value of Hirakud Reservoir so that they become advocates for wise use, and may act to be engaged in relevant policy formulation, planning and management. Implementation of the component will also be strengthened through actions under component on institutional strengthening which will secure participation and capacity development of stakeholder for effective participation in integrated management. Key target groups to be involved are as follows:

- State government departments and agencies having programmes relevant for integrated management
- State government departments and agencies having activities within Mahanadi Basin, or influencing Mahanadi Basin
- Communities living around the reservoir and its' command area
- Industrial units operating in Ib-Jharsuguda Valley
- Civil Society Organizations (CSOs) operating in areas around Hirakud Reservoir
- Community Based Organizations (as Panchayat, Farmer Clubs, Fisher Cooperatives)
- Learning institutions in the region, as local schools and colleges
- Tour operators

In addition to activities proposed under institutional development, ecotourism and awareness generation are proposed.

7.1 Ecotourism development

- Development of comprehensive ecotourism development plan with detailed zoning of Hirakud Reservoir taking into account habitat diversity, ecological requirements of wetland biota and cultural values
- Development of key sites for bird watching providing facilities for observing birds at various spots
- Developing board walks to take closer view of marshes and associated habitats
- Development of a wetland interpretation center at Sambalpur as the nodal unit for communication, education and public participation programmes
- Training to local communities to act as field guides for tourists

7.2 Awareness campaigns

Awareness programmes are proposed to be organized with key partners to inform them about wetland values and the need for integrated management, build community support, and promote stewardship approach and attitudes towards Hirakud Reservoir. Wherever possible and relevant, media is proposed to be engaged to inform decision-makers, key wetland resource users and broader society on values of Hirakud Reservoir and associated wetlands of Mahanadi Basin. Key activities envisaged include:

- Awareness campaigns for school children and college students
- Media workshops
- Organization of World Wetland Day, World Environment Day and other events
- Publishing Hirakud Reservoir Health Report Card (a communication tool to make stakeholders aware of ecological status of Hirakud Reservoir. This is being used by Chilika Development Authority)
- Publications
- Audio-visuals (posters, movies)

It is proposed to assess effectiveness of awareness programmes periodically, by developing an awareness baseline at the beginning of management plan implementation, and assessment every two years.

6.5 Implementation arrangements

Implementation of management plan is proposed to be coordinated by the Hirakud Reservoir Management Committee. The Committee would adopt annual action plans based on the overarching management plan, and would ensure implementation coordination through various state government departments and agencies. Periodic monitoring and evaluation would assist the Committee in assessing the impact of management plan of ecological status of the reservoir and livelihoods of dependent communities. Following departments are proposed as nodal agencies for implementation of component actions:
Component 1: Institutional Development – Odisha Wetland Development Authority and Chilika Development Authority

Component 2: Catchment Conservation – Forest Department and Department of Agriculture

Component 3: Water Management – Department of Water Resources and Odisha Pollution Control Board

Component 4: Habitat Management – Hirakud Wildlife Division and Odisha State Biodiversity Board

Component 5: Sustainable Fisheries Development – Fisheries Department

Component 6: Sustainable Agriculture Development – Agriculture Department

Component 7: Communication, Education, Participation and Awareness – Odisha State Wetland Authority, Department of Tourism

6.6 Prioritization and phasing

Management plan implementation will first and foremost endeavor to establish necessary institutional mechanism (Hirakud Reservoir Management Committee) to coordinate implementation of sectoral programmes, and set up inventory, assessment and monitoring system to be able to comprehensively assess the status of the reservoir and overall management effectiveness. Within the catchment component, microplanning is proposed to be initiated at appropriate village cluster scales. Similarly, under water management component, the process for updation of reservoir operation rules and alternate sediment management strategy are proposed to be initiated. Under Habitat management component, demarcation of habitats is proposed to be undertaken. Components on sustainable fisheries and agriculture would aim at mobilization and capacity development of PFCS and Farmer Clubs.

During the second, third and fourth years, implementation of all envisaged physical interventions shall be completed, following appropriate guidelines, and as per agreed institutional arrangements. The last year shall mostly focus on consolidating the outcomes and to review overall management effectiveness, so as to set course for the following five years.

6.7 Review

The Integrated Inventory, Assessment and Review system proposed to be established under the Hirakud Reservoir Management Committee will provide regular updates on the overall impacts of management plan implementation on the ecological status of the reservoir and livelihoods of the dependent communities. The Committee will meet periodically to assess trends in key ecological character elements as a guide to adaptive management. Management effectiveness assessment will also provide information on the extent to which desired management objectives are being met. In addition, it is proposed to conduct a third party evaluation of management plan implementation at the end of the third and the fifth year.

7. Budget and Financing

7.1 Component wise budget

Implementation of the management action plan as outlined in Chapter 6 entails a budget of Rs. 7,153.36 million for a period of five years. Of this, 90.5% funds are earmarked for catchment conservation (72.9%) and water management (17.6%). Components on sustainable agriculture development and fisheries development have been allocated 3.4% and 1.4% of the resources respectively. Habitat management will benefit from implementation of all components and therefore has been separately allocated 0.6% of the total budget. Components on institutional development and CEPA have been allocated 2.1% and 1.9% respectively. Component wise details of funds requirement is presented in Table 7.1. Detailed activity budget is provided in Table 7.2.

Table 7.1| Component wise budget required for management plan implementation (Rs. Lakh)

Component	Total	Year 1	Year 2	Year 3	Year 4	Year 5
Institutional Development	1,605.00	400.00	330.00	350.00	255.00	270.00
Catchment Conservation	52,044.84	30,133.08	12,947.92	6,781.28	616.28	1,566.28
Water Management	12,575.78	2,214.40	1,556.40	7,324.18	740.40	740.40
Habitat Management	515.00	80.00	142.50	147.50	102.50	42.50
Sustainable Fisheries Development	1,000.00	185.00	277.50	317.50	160.00	60.00
Sustainable Agriculture Development	2,438.01	64.72	648.80	641.41	541.54	541.54
Communication, Education, Participation and Awareness	1,355.00	637.50	437.50	80.00	80.00	120.00
Grand Total	**71,533.62**	**33,714.70**	**16,340.62**	**15,641.87**	**2,495.72**	**3,340.72**

Table 7.2 | Detailed activity budget

Components and Activities			Rate (Rs.)	Unit	Targets		Year 1		Year 2		Year 3		Year 4		Year 5	
					Physical (2015 - 20)	Financial (2015 - 20) (Rs. Lakh)	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial
1	**Institutional Development**					**1,605.00**		**400.00**		**330.00**		**350.00**		**255.00**		**270.00**
1.1	**Constitution of Hirakud Reservoir Management Committee**					**10.00**		**10.00**								
1.2	**Establishing Integrated Inventory, Assessment and Monitoring System**					**1,470.00**		**365.00**		**305.00**		**325.00**		**230.00**		**245.00**
	1.2.1	Establishment of WRTC Sambalpur sub-center		1 unit with satellite stations		1,000.00		200.00		200.00		200.00		200.00		200.00
	1.2.2	Development of a database management system				50.00		50.00								
	1.2.3	Reservoir surveillance and monitoring				120.00		30.00		30.00		30.00		30.00		
	1.2.4	Assessment studies				200.00		75.00		75.00		50.00		-		-
		Waterbirds habitat and health				50.00		25.00		25.00						
		Fish breeding and migration behaviour				50.00				25.00		25.00				
		Ecological character risk and vulnerability				25.00		25.00								
		Ecosystem services valuation				25.00						25.00				
		Climate risk and vulnerability				50.00		25.00		25.00						
	1.2.5	Review				100.00		10.00				45.00				45.00
		Management effectiveness assessment				50.00		10.00				20.00				20.00
		Third party evaluation				50.00						25.00				25.00
1.3	**Capacity development**					**125.00**		**25.00**		**25.00**		**25.00**		**25.00**		**25.00**
2	**Catchment Conservation**					**52,044.84**		**30,133.08**		**12,947.92**		**6,781.28**		**616.28**		**1,566.28**
2.1	**Village level micro-planning and preparation of DPR**					**2,000.00**		**2,000.00**								
	2.1.1	Initiating the development of Village level institutions														
	2.1.2	Entry point activities														
2.2	**Ridge Area treatment through vegetative measures**					**30,684.84**		**21,233.08**		**6,622.92**		**1,696.28**		**566.28**		**566.28**
	2.2.1	Afforestation using native species				15,994.84		8,803.08		5,492.92		566.28		566.28		566.28
		Nursery Raising	19,000	per ha	25740	4,890.60	25,740.00	4,890.60								
		Advance work	11,000	per ha	25740	2,831.40	25,740.00	2,831.40								
		Plantation	8,000	per ha	25740	2,059.20			25,740.00	2,059.20						
		Soil and moisture conservation (contour trenching)	11,000	per ha	25740	2,831.40			25,740.00	2,831.40						
		Transportation	400	per ha	25740	102.96			25,740.00	102.96						
		Maintenance	2,000	per ha	25740	1,544.40					25,740.00	514.80	25,740.00	514.80	25,740.00	514.80
		Overheads(up to 10% of above)	5,500			1,426.00		772.20		499.36		51.48		51.48		51.48
		Awareness generation (up to 5% of sub total)	1,200			308.88		308.88								
	2.2.2	Aided regeneration				14,690.00		12,430.00		1,130.00		1,130.00				
		Aided regeneration operation	22,000	per ha	56500	12,430.00	56,500.00	12,430.00								
		Maintenance	2,000	per ha	56500	2,260.00			56,500.00	1,130.00	56,500.00	1,130.00				
2.3	**Drainage line treatment**					**10,000.00**		**3,850.00**		**3,050.00**		**3,050.00**		**50.00**		
	2.3.1	Construction of check dams														
		DRSM	5,000	per structure	10000	500.00	3,000.00	150.00	3,000.00	150.00	3,000.00	150.00	1,000.00	50.00		
		Gabion checks	50,000	per structure	3000	1,500.00	1,000.00	500.00	1,000.00	500.00	1,000.00	500.00				
		Stop dams	650,000	per structure	1000	6,500.00	400.00	2,600.00	300.00	1,950.00	300.00	1,950.00				
	2.3.2	Landslide control structures	50,000	per structure	1000	500.00	400.00	200.00	300.00	150.00	300.00	150.00				
	2.3.3	Stream bank erosion control measures	50,000	per structure	2000	1,000.00	800.00	400.00	600.00	300.00	600.00	300.00				

Components and Activities			Rate (Rs.)	Unit	Targets		Year 1		Year 2		Year 3		Year 4		Year 5	
					Physical (2015 - 20)	Financial (2015 - 20) (Rs. Lakh)	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial
2.4	**Improving groundwater recharge through water harvesting structures**		**140,000**	**per structure**	**2000**	**2,800.00**	**1,000.00**	**1,400.00**	**500.00**	**700.00**	**500.00**	**700.00**				
2.5	**Promotion of alternate fuelwood**					**360.00**		**150.00**		**150.00**		**60.00**				
	2.5.1	Development of village woodlots	12,000	per ha	2500	300.00	1,000.00	120.00	1,000.00	120.00	500.00	60.00				
	2.5.2	Promotion of smokeless hearths	2,000	per unit	3000	60.00	1,500.00	30.00	1,500.00	30.00						
2.6	**Pasture development**		**15,000**	**per ha**	**5000**	**750.00**	**2,000.00**	**300.00**	**1,500.00**	**225.00**	**1,500.00**	**225.00**				
2.7	**Sustainable land use practices including in-situ soil and moisture conservation**					**4,450.00**		**1,200.00**		**2,200.00**		**1,050.00**				
	2.7.1	Promotion of agro forestry models	20,000	per ha	20000	4,000.00	5,000.00	1,000.00	10,000.00	2,000.00	5,000.00	1,000.00				
	2.7.2	Improved management of homesteads	10,000	per HH	2500	250.00	1,000.00	100.00	1,000.00	100.00	500.00	50.00				
	2.7.3	Promotion of sustainable horticulture practices	20,000	per ha	1000	200.00	500.00	100.00	500.00	100.00						
2.8	**Consolidation and Withdrawal**					**1,000.00**										**1,000.00**
3	**Water Management**					**12,575.78**		**2,214.40**		**1,556.40**		**7,324.18**		**740.40**		**740.40**
3.1	**Upgradation of reservoir operations rule**					**50.00**		**50.00**								
3.2	**Maintenance of irrigation and power supply channels**					**1,000.00**		**200.00**		**200.00**		**200.00**		**200.00**		**200.00**
3.3	**Feasibility assessment for sediment management options**					**200.00**		**200.00**								
3.4	**Water quality improvement**					**11,325.78**		**1,764.40**		**1,356.40**		**7,124.18**		**540.40**		**540.40**
	3.4.1	Enforcement of environmental quality regulations in Ib-Jharsuguda Valley				50.00		10.00		10.00		10.00		10.00		10.00
	3.4.2	Upgradation of existing waste management infrastructure in urban settlements (2 STPs of 15 MLD each)				8,623.78		1,224.00		816.00		6,583.78				
		Infrastructure														
		Civil works (Rs./MLD)	4,080,000	per MLD	30	1,224.00	30.00	1,224.00								
		Engineering and Manufacturing works	2,720,000	per MLD	30	816.00			30.00	816.00						
		Operation and Maintenance	21,945,920	per MLD	30	6,583.78					30.00	6,583.78				
	3.4.3	Comprehensive coverage of safe sanitation (in 118 villages)	12,000	per HH	22100	2,652.00	4,420	530.40	4,420.00	530.40	4,420.00	530.40	4,420.00	530.40	4,420.00	530.40
4	**Habitat Management**					**515.00**		**80.00**		**142.50**		**147.50**		**102.50**		**42.50**
4.1	**Mahseer Conservation**					**225.00**		**55.00**		**67.50**		**47.50**		**37.50**		**17.50**
	4.1.1	Habitat identification and assessment				100.00		50.00		50.00						
	4.1.2	Community mobilization and awareness				25.00		5.00		5.00		5.00		5.00		5.00
	4.1.3	Establishment of community reserves				50.00						30.00		20.00		
	4.1.4	Monitoring and evaluation				50.00				12.50		12.50		12.50		12.50
4.2	**Waterbirds Conservation**					**290.00**		**25.00**		**75.00**		**100.00**		**65.00**		**25.00**
	4.2.1	Waterbirds population monitoring				175.00		10.00		60.00		65.00		30.00		10.00
		Annual Census				25.00		5.00		5.00		5.00		5.00		5.00
		Habitat identification and mapping				25.00				15.00		10.00				
		Breeding waterbirds investigation				50.00				25.00		25.00				
		Studies on habitat improvement				50.00				10.00		20.00		20.00		
		Waterbirds health				25.00		5.00		5.00		5.00		5.00		5.00
	4.2.2	Maintenance of habitat				75.00		15.00		15.00		15.00		15.00		15.00
		Management of riparian vegetation				25.00		5.00		5.00		5.00		5.00		5.00
		Community mobilization for habitat protection				50.00		10.00		10.00		10.00		10.00		10.00

Components and Activities			Rate (Rs.)	Unit	Targets		Year 1		Year 2		Year 3		Year 4		Year 5	
					Physical (2015 - 20)	Financial (2015 - 20) (Rs. Lakh)	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial
	4.2.3	Establishment of new community reserves				40.00						20.00		20.00		
5	**Sustainable Fisheries Development**					**1,000.00**		**185.00**		**277.50**		**317.50**		**160.00**		**60.00**
5.1	**Stock Management**					**510.00**		**85.00**		**182.50**		**172.50**		**50.00**		**20.00**
	5.1.1	Stocking				250.00		70.00		67.50		57.50		42.50		12.50
		Process Standardization				50.00		50.00								
		Training				50.00		20.00		20.00		10.00				
		Stocking operations				100.00				35.00		35.00		30.00		
		Monitoring				50.00				12.50		12.50		12.50		12.50
	5.1.2	Upgradation and operationalization of existing fish hatcheries				260.00		15.00		115.00		115.00		7.50		7.50
		Re-establish operational procedures				5.00		5.00								
		Infrastructure renovation				200.00				100.00		100.00				
		Training to PFCS on hatchery management (20 members/PFCS for 5 PFCS	5,000.00	per member	200.00	10.00	200.00	10.00								
		Follow up support				45.00				15.00		15.00		7.50		7.50
5.2	**Strengthening Primary Fisher Cooperative Societie**					**270.00**		**70.00**		**75.00**		**75.00**		**25.00**		**25.00**
	5.2.1	Training	25,000.00		80.00	20.00		20.00								
	5.2.2	Infrastructure developmen	5,000,000.00	per PFCS	5.00	250.00		50.00		75.00		75.00		25.00		25.00
5.3	**Promoting of cage culture**					**220.00**		**30.00**		**20.00**		**70.00**		**85.00**		**15.00**
		Site and beneficiary selection				10.00		10.00								
		Training				20.00		20.00								
		Cage installation				100.00				20.00		40.00		40.00		
		Monitoring				30.00								15.00		15.00
		Feasibility assessment of alternate species and production systems for culture fisherie				60.00						30.00		30.00		
6	**Sustainable Agriculture Development**					**2,438.01**		**64.72**		**648.80**		**641.41**		**541.54**		**541.54**
6.1	**Promoting sustainable agro-practices**					**2,395.36**		**49.78**		**635.29**		**634.31**		**537.99**		**537.99**
	6.1.1	Crop Diversification				99.30		32.08		29.72		37.50		-		-
	i.	Community Mobilization				25.00		25.00								
	ii.	Training of farmers on diversify crop cultivation	10,000	per village	118	11.80	70.80	7.08	47.20	4.72						
	iii	Field demonstration of inter cropping practices	12,500	per ha	500	62.50			200.00	25.00	300.00	37.50				
	6.1.2.	Nutrient Management				49.70		5.90		26.28		17.52		-		-
	i.	Training of farmers club on IPM practices and vermi - composting	5,000	per farmer club	118	5.90	118.00	5.90								
	ii.	Community base vermi compost unit	60,000	per village	73	43.80			43.80	26.28	29.20	17.52				
	6.1.3	Irrigation Management				2,157.86		5.90		537.99		537.99		537.99		537.99
	i.	Training of framer club on SRI, drip and sprinkler irrigation	5,000	per farmer club	118	5.90	118.00	5.90								
	ii.	Cluster demonstration on SRI technique	8,070	per ha	7,800	629.46			1,950.00	157.37	1,950.00	157.37	1,950.00	157.37	1,950.00	157.37
	iii.	Provide input subsidies on field demonstration site	7,500	per ha	7,800	585.00			1,950.00	146.25	1,950.00	146.25	1,950.00	146.25	1,950.00	146.25
	iv.	Drip and sprinkler irrigation	15,000	per ha	6,250	937.50			1,562.50	234.38	1,562.50	234.38	1,562.50	234.38	1,562.50	234.38
	6.1.4.	Strengthening Farmer Clubs				88.50		5.90		41.30		41.30		-		-
	i.	Training of farmer club on functioning, financial management & collaborating with	5,000	per club	118	5.90	118.00	5.90								
	ii.	Training of farmer club on subsidies & incentives and market linkages	5,000	per club	118	5.90			59.00	2.95	59.00	2.95				
	iii.	Seed/Grain bank	65,000	per unit	118	76.70			59.00	38.35	59.00	38.35				
6.2	**Promote agro and allied micro enterprises**					**42.65**		**14.94**		**13.51**		**7.10**		**3.55**		**3.55**
	i.	Puffed rice	355,000	per unit	10	35.50	3.00	10.65	3.00	10.65	2.00	7.10	1.00	3.55	1.00	3.55
	ii.	Poultry Development(Banraj Chicks)	28,600	per SHG	25	7.15	15.00	4.29	10.00	2.86						
7	**Communication, Education, Participation and Awareness**					**1,355.00**		**637.50**		**437.50**		**80.00**		**80.00**		**120.00**
7.1	**Ecotourism Development**					**875.00**		**587.50**		**287.50**						
	7.1.1	Ecotourism master plan						100.00								

Components and Activities			Rate (Rs.)	Unit	Targets		Year 1		Year 2		Year 3		Year 4		Year 5	
					Physical (2015 - 20)	Financial (2015 - 20) (Rs. Lakh)	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial	Physical	Financial
	7.1.2	Development of recreational facilities				125.00		62.50		62.50						
	i.	Angling Spots	2,500,000	per unit	1	25.00		12.50		12.50						
	ii.	Thematic Gardens at the entrance of Debrigarh Sanctuary	10,000,000	per unit	1	100.00		50.00		50.00						
	7.1.3	Development of visitor education facilities				750.00		525.00		225.00		20.00		20.00		20.00
	i.	At Sambalpur	15,000	per sqm	5000	750.00		525.00		225.00		20.00		20.00		20.00
7.2	Awareness and outreach					480.00		50.00		150.00		80.00		80.00		120.00
	7.2.1	Awareness campaigns				50.00		10.00		10.00		10.00		10.00		10.00
	7.2.2	Media workshops				50.00		10.00		10.00		10.00		10.00		10.00
	7.2.3	World Wetlands Day and other events				100.00		20.00		20.00		20.00		20.00		20.00
	7.2.4	Hirakud Reservoir Ecosystem Health Report Card				120.00				50.00		10.00		10.00		50.00
	7.2.5	Publications				50.00		10.00		10.00		10.00		10.00		10.00
	7.2.6	Audio-visuals				110.00				50.00		20.00		20.00		20.00
	Grand Total					**71,533.62**		**33,714.70**		**16,340.62**		**15,641.87**		**2,495.72**		**3,340.72**

7.2 Financing opportunities

The management plan has been budgeted on the principle of convergence, taking into cognizance resources available within existing sectoral developmental programming within public as well as private sector. A bifurcation of total funds required for management plan implementation, into available public and private sector funding is presented in Table 7.3. As per the analysis, of the total budget of 7,153.36 million, Rs. 57,45.77 million (80%) can be generated through resources already available under ongoing schemes of central and state government. The rest of the resources, Rs. 1,397.58 million would need to be supplemented through a mix of private and public sources, or with international funding.

Table 7.3| Convergence funding possibilities for management of Hirakud Reservoir (Rs. Lakh)

Management Plan Components			Budget		Convergence Scheme	Concerned Department/ Agency/Organization	Convergence Budget
1	**Institutional Development**			**1,605.00**			
	1.1	Constitution of Hirakud Reservoir Management Committee	10.00				
	1.2	Establishing Integrated Inventory, Assessment and Monitoring System	1,470.00				
	1.3	Capacity development	125.00				
2	**Catchment Conservation**			**52,044.84**	Integrated Watershed Development Programme		52,044.84
	2.1	Village level micro-planning and preparation of DPR	2,000.00				
	2.2	Ridge Area treatment through vegetative measures	30,684.84				
	2.3	Drainage line treatment	10,000.00				
	2.4	Improving groundwater recharge through water harvesting structures	2,800.00				
	2.5	Promotion of alternate fuelwood	360.00				
	2.6	Pasture development	750.00				
	2.7	Sustainable land use practices including in-situ soil and moisture conservation	4,450.00				
	2.8	Consolidation and Withdrawal	1,000.00				
3	**Water Management**			**12,575.78**			
	3.1	Upgradation of reservoir operations rule	50.00				
	3.2	Maintenance of irrigation and power supply channels	1,000.00		DRIP	DoWR	1,000.00

	3.3	Feasibility assessment for sediment management options	200.00				
	3.4	Water quality improvement	11,325.78		Swacch Bharat Mission	RD	2,652.00
4	**Habitat Management**			**515.00**			
	4.1	Mahseer Conservation	225.00		CSR	MCL/Vedanta /others	200.00
	4.2	Waterbirds Conservation	290.00		CSR	MCL/Vedanta /others	200.00
5	**Sustainable Fisheries Development**			**1,000.00**			
	5.1	Stock Management	510.00				
	5.2	Strengthening Primary Fisher Cooperative Societies	270.00		Matsyajeebi Unnayan Yojana	FD	80.00
	5.3	Promoting of cage culture	220.00		Cage Culture	NFDB	85.00
6	**Sustainable Agriculture Development**			**2,438.01**			
	6.1	Promoting sustainable agro-practices	2,395.36		Establishment of New Garden (Area Expansion) ;Micro-irrigation; Organic Farming; Pesticides / Biopesticides	DoA; OLIC	853.25
	6.2	Promote agro and allied micro enterprises	42.65		Capital investment subsidy for commercial agri-enterprises; Ajeevika	DoA; RD	42.65
7	**Communication, Education, Participation and Awareness**			**1,355.00**			
	7.1	Ecotourism Development	875.00		CSR	MCL/Vedanta /Others	100.00
	7.2	Awareness and outreach	480.00		CSR		200.00
	Grand Total			**71,533.62**			**57,457.74**

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Annexes

Annex I

Phytoplankton recorded in Hirakud Reservoir
(Source: Dash et al., 1993)

Bacillariophyceae

Amphipleuraceae

1 *Frustulia* sp.

Bacillariaceae

2 *Nitzschia* sp.

Catenulaceae

3 *Amphora* sp.

Cymbellaceae

4 *Cymbella* sp.

Naviculaceae

5 *Navicula* sp.

6 *Gyrosigma* sp.

Fragilariaceae

7 *Fragilaria* sp.

Hydrodictyaceae

8 *Pediastrum* sp.

Melosiraceae

9 *Melosira* sp.

10 *Melosira ambiguna*

Stephanodiscaceae

11 *Cyclotella* sp.

Surirellaceae

12 *Surirella* sp.

Tabellariaceae

13 *Diatoma elongata*

Ulnariaceae

14 *Synendra ulna*

Chlorophyceae

Chlamydomonadaceae

15 *Chlamydomonas globosa*

Chlorellaceae

16 *Chlorella vulgaris*

17 *Actinastrum* sp.

Coccomyxaceae

18 *Dispora cuneiformis*

Scenedesmaceae

19 *Scenedesmus* sp.

Selenastraceae

20 *Ankistrodesmus falcatus*

21 *Kirchneriella* sp.

Trebouxiophyceae

22 *Crucigenia* sp.

Volvocaceae

23 *Pandorina* sp.

24 *Eudorina* sp.

Zygnemataceae

25 *Spirogyra* sp.

Cyanophyceae

Chroococcaceae

26 *Microcystis* sp.

27 *Merismopedia glauca* (Ehr.) Naegeli

28 *Synechococcus* sp.

Nostocaceae

29 *Anaebaena orientalis*

30 *Anaebaena* sp.

31 *Nostoc* sp.

Oscillatoriaceae

32 *Oscillatoria amoena* Gomont

33 *Oscillatoria orientalis*

34 *Oscillatoria simplicissima*

35 *Phormidium* sp.

36 *Arthrospira* sp.

37 *Spirulina* sp.

Euglenophyceae

Euglenaceae

38 *Euglena* sp.

Phacaceae

39 *Phacus* sp.

Annex II

Periphyton recorded in Mahanadi River
(Source: Pathak et al., 2007)

Amphipleuraceae
1 *Frustulia* sp.

Catenulaceae
2 *Amphora* sp.

Chaetophoraceae
3 *Uronema* sp.
4 *Draparnaldiopsis* sp.
5 *Chaetophora* sp.

Chlamydomonadaceae
6 *Protococcus* sp.

Cladophoraceae
7 *Cladophora* sp.

Cocconeidaceae
8 *Cocconeis* sp.

Cymbellaceae
9 *Cymbella* sp.

Desmidiaceae
10 *Cosmarium* sp.
11 *Staurastrum* sp.
12 *Desmidium* sp.

Diploneidaceae
13 *Diploneis* sp.

Gloeotilaceae
14 *Binuclearia sp.*

Mastogloiaceae
15 *Mastogloia* sp.

Melosiraceae
16 *Melosira* sp.

Mesotaeniaceae
17 *Spirotaenia* sp.

Microsporaceae
18 *Microspora* sp.

Nostocaceae
19 *Anabaena sp.*

Oedogoniaceae
20 *Oedogonium* sp.

Oscillatoriaceae
21 *Oscillatoria sp.*

Pinnulariaceae
22 *Pinnularia* sp.

Pithophoraceae
23 *Basicladia* sp.

Prasiolaceae
24 *Hormidium* sp.

Rhopalodiaceae
25 *Rhopalodia* sp.

Selenastraceae
26 *Kirchneriella* sp.

Stauroneidaceae
27 *Stauroneis* sp.

Surirellaceae
28 *Surirella* sp.

Tabellariaceae
29 *Diatoma* sp.
30 *Asterionella* sp.
31 *Meridion* sp.
32 *Tabellaria* sp.

Treubariaceae
33 *Treubaria* sp.

Tribonemataceae
34 *Tribonema* sp.

Ulotrichaceae
35 *Ulothrix* sp.

Zygnemataceae
36 *Zygnema* sp.

Annex III

Macrophytes recorded in Mahanadi River
(Source: Pathak et al., 2007)

Acanthaceae

1 *Asteracantha longifolia* (L.) Nees

Alismataceae

2 *Sagittaria sagittifolia* L.

Amaranthaceae

3 *Alternanthera sessilis* (L.) R.Br. ex DC.

Amaryllidaceae

4 *Crinum defixum* Ker Gawl.

Araceae

5 *Pistia stratiotes* L.

6 *Colocasia esculenta* (L.) Schott

Cannaceae

7 *Canna glauca* L.

Compositae

8 *Enydra fluctuans* Lour.

Convolvulaceae

9 *Ipomoea aquatica* Forssk.

10 *Ipomoea indica* (J. Burman) Merr.

Gramineae

11 *Brachiaria cruciformis* Griseb.

12 *Coix lacryma-jobi* L.

13 *Cynodon dactylon* (L.) Pers.

14 *Oryza sativa* L.

15 *Saccharum spontaneum* L.

Hydrocharitaceae

16 *Najas indica* (Willd.) Cham.

17 *Ottelia alismoides* (L.) Pers.

18 *Vallisneria spiralis* L.

Lemnaceae

19 *Lemna perpusilla* Torr.

20 *Wolffia arrhiza* (L.) Horkel ex Wimm.

21 *Spirodela polyrhiza* (L.) Schleid.

Lythraceae

22 *Trapa bispinosa* Roxb.

Marsileaceae

23 *Marsilea quadrifolia* L.

Nelumbonaceae

24 *Nelumbo nucifera* Gaertn.

25 *Nelumbo pentapetala* (Walter) Willd.

Nymphaeaceae

26 *Euryale ferox* Salisb.

27 *Nymphaea stellata*

Onagraceae

28 *Jussiaea repens* L.

Pontederiaceae

29 *Eichhornia crassipes* (Mart.) Solms

Salviniaceae

30 *Azolla pinnata* R.Br.

31 *Salvinia molesta* Mitch.

Scrophulariaceae

32 *Bacopa monnieri* (L.) Wettst.

Typhaceae

33 *Typha elephantina* Roxb.

Umbelliferae

34 *Centella asiatica* (L.) Urb.

Zooplankton recorded in Mahanadi River
(Source: Pathak et al., 2007)

Cladocera

Bosminidae

1 *Bosmina* sp.

Centropagidae

2 *Limnocalanus* sp.

Chydoridae

3 *Alona* sp.

4 *Alonella* sp.

5 *Chydorus* sp.

6 *Leydigia* sp.

Daphniidae

7 *Ceriodaphnia* sp.

8 *Daphnia* sp.

Moinidae

9 *Moina* sp.

Sididae

10 *Diaphanosoma* sp.

11 *Sida* sp.

Copepoda

Cyclopidae

12 *Cyclops* sp.

Diaptomidae

13 *Diaptomus* sp.

Ostracoda

Cypridiidae

14 *Cypris* sp.

Protozoa

Centropyxidae

15 *Centropyxis* sp.

Colpodidae

16 *Colpoda* sp.

Difflugiidae

17 *Difflugia* sp.

Euglyphidae

18 *Euglypha* sp.

19 *Trinema* sp.

Oxytrichidae

20 *Oxytricha* sp.

Plagiopyxidae

21 *Bullinularia* sp.

Spirostomidae

22 *Blepharisma* sp.

23 *Spirostomum* sp.

Rotifera

Asplanchnidae

24 *Asplanchna* sp.

Brachionidae

25 *Brachionus* sp.

26 *Keratella* sp.

27 *Notholca* sp.

Conochilidae

28 *Conochilus* sp.

Euchlanidae

29 *Diplois* sp.

Gastropodidae

30 *Ascomorpha* sp.

31 *Chromogaster* sp.

32 *Gastropus* sp.

Lecanidae

33 *Lecane* sp.

34 *Monostyla* sp.

Lepadellidae

35 *Colurella* sp.

Mytilinidae

36 *Lophocharis* sp.

37 *Mytilina* sp.

Philodinidae

38 *Rotaria* sp.

Synchaetidae

39 *Polyarthra* sp.

40 *Synchaeta* sp.

Testudinellidae

41 *Pompholyx* sp.

42 *Testudinella* sp.

Trichocercidae

43 *Trichocerca* sp.

Trochosphaeridae

44 *Filinia* sp.

45 *Horaella* sp.

Molluscs recorded in Mahanadi River
(Source: Pathak et al., 2007)

Gastropoda

Amnicolidae

1 *Amnicola* sp.

Ampullariidae

2 *Pila* sp.

Assimineidae

3 *Assiminea* sp.

Cochliopidae

4 *Littoridina* sp.

Cypraeidae

5 *Cypraea* sp.

Hydrobiidae

6 *Tryonia* sp.

Littorinidae

7 *Littorina* sp.

Lymnaeidae

8 *Lymnaea* sp.

Melongenidae

9 *Pugilina* sp.

Muricidae

10 *Murex* sp.

Nassariidae

11 *Nassarius* sp.

Neritidae

12 *Nerita* sp.

Planorbidae

13 *Gyraulus* sp.

14 *Indoplanorbis* sp.

Pleuroceridae

15 *Goniobasis* sp.

16 *Pleurocera* sp.

Potamididae

17 *Cerithidea* sp.

18 *Telescopium* sp.

Thiaridae

19 *Melanoides* sp.

20 *Tarebia* sp.

21 *Thiara* sp.

Viviparidae

22 *Bellamya* sp.

23 *Campeloma* sp.

24 *Viviparus* sp.

Bivalvia

Cyrenidae

25 *Corbicula* sp.

Donacidae

26 *Donax* sp.

Pharidae

27 *Siliqua* sp.

Sphaeriidae

28 *Musculium* sp.

29 *Pisidium* sp.

30 *Sphaerium* sp.

Unionidae

31 *Anodonta* sp.

32 *Lamellidens* sp.

33 *Ligumia* sp.

34 *Parreysia* sp.

Veneridae

35 *Meretrix* sp.

Fish species recorded in Hirakud Reservoir
(Source: CIFT (ca 1995) and Sugunan 1995)

Ambassidae

1 *Chanda nama* Hamilton, 1822

Bagridae

2 *Sperata seenghala* (Sykes, 1839)
3 *Sperata aor* (Hamilton, 1822)
4 *Mystus gulio* (Hamilton, 1822)
5 *Rita chrysea* Day, 1877
6 *Mystus tengra* (Hamilton, 1822)
7 *Mystus cavasius* (Hamilton, 1822)

Belonidae

8 *Xenentodon cancila* (Hamilton, 1822)

Channidae

9 *Channa striata* (Bloch, 1793)
10 *Channa marulius* (Hamilton, 1822)
11 *Channa punctata* (Bloch, 1793)
12 *Channa gachua* (Hamilton 1822)

Cichlidae

13 *Oreochromis niloticus* (Linnaeus, 1758)

Clariidae

14 *Clarias batrachus* (Linnaeus, 1758)

Clupeidae

15 *Gudusia chapra* (Hamilton, 1822)

Cyprinidae

16 *Catla catla* (Hamilton, 1822)
17 *Labeo fimbriatus* (Bloch, 1795)
18 *Labeo calbasu* (Hamilton, 1822)
19 *Labeo rohita* (Hamilton, 1822)
20 *Labeo gonius* (Hamilton, 1822)
21 *Labeo bata* (Hamilton, 1822)
22 *Cirrhinus mrigala* (Hamilton, 1822)
23 *Cirrhina reba* (Hamilton, 1822)
24 *Tor tor* (Hamilton, 1822)
25 *Systomus sarana* (Hamilton, 1822)
26 *Osteobrama cotio cunma* (Day, 1888)
27 *Salmophasia bacaila* (Hamilton, 1822)
28 *Puntius sophore* (Hamilton, 1822)
29 *Puntius ticto* (Hamilton, 1822)
30 *Puntius chola* (Hamilton, 1822)
31 *Puntius dorsalis* (Jerdon, 1849)
32 *Esomus danrica* (Hamilton, 1822)
33 *Rasbora daniconius* (Hamilton, 1822)
34 *Amblypharyngodon mola* (Hamilton, 1822)
35 *Tor mosal mahanadicus* (non David, 1953)

Gobiidae

36 *Glossogobius giuris* (Hamilton, 1822)

Heteropneustidae

37 *Heteropneustes fossilis* (Bloch, 1794)

Mastacembelidae

38 *Mastacembelus armatus* (Lacepède, 1800)
39 *Mastacembelus pancalus* (Hamilton, 1822)

Mugilidae

40 *Rhinomugil corsula* (Hamilton, 1822)

Nandidae

41 *Nandus nandus* (Hamilton, 1822)

Notopteridae

42 *Notopterus notopterus* (Pallas, 1769)
43 *Notopterus chitala* (Hamilton 1822)

Palaemonidae

44 *Macrobrachium malcolmsonii* Johnson, 1973

Pangasiidae

45 *Pangasius pangasius* (Hamilton, 1822)
46 *Pangasius sutchi* Fowler, 1937

Schilbeidae

47 *Silonia silondia* (Hamilton, 1822)
48 *Eutropiichthys vacha* (Hamilton, 1822)
49 *Ailia coila* (Hamilton, 1822)

Sciaenidae

50 *Otolithoides pama* (Hamilton, 1822)

Siluridae

51 *Wallago attu* (Bloch & Schneider, 1801)
52 *Ompok bimaculatus* (Bloch, 1794)
53 *Ompok pabda* (Hamilton, 1822)

Sisoridae

54 *Bagarius bagarius* (Hamilton, 1822)

Insects recorded in Mahanadi River
(Source: Pathak et al., 2007)

Diptera

Ceratopogonidae

1 *Probezzia* sp.

Chaoboridae

2 *Chaoborus* sp.

Chironomidae

3 *Chironomus* sp.

Simuliidae

4 *Simulium* sp.

Ephimeroptera

Baetidae

5 *Cloeon* sp.

Caenidae

6 *Caenis* sp.

Hemiptera

Corixidae

7 *Corixa hieroglyphica*

Gelastocoridae

8 *Gelastocoris bufo*

Gerridae

9 *Gerris spinolae*

Nepidae

10 *Nepa* sp.

11 *Ranatra filiformis*

12 *Laccotrephes maculatus*

Notonectidae

13 *Notonecta* sp.

14 *Anisops* sp.

Pleidae

15 *Plea* sp.

Belostomatidae

16 *Belostoma* sp.

17 *Lethocerus indicus*

Odonata

Gomphidae

18 *Aphylla* sp.

19 *Gomphus* sp.

20 *Hagenius* sp.

Lestidae

21 *Lestes* sp.

Sarcophagidae

22 *Agria* sp.

Aeshnidae

23 *Anax* sp.

Placoptera

Perlodidae

24 *Isogenus* sp.

Trichoptera

Hydropsychidae

25 *Hydropsyche* sp.

Annex VIII

Amphibians recorded in Sambalpur District
(Source: Dash and Mahanta, 1993)

Bufonidae

1 *Duttaphrynus melanostictus* (Schneider, 1799)

2 *Duttaphrynus stomaticus* (Lütken, 1864)

Dicroglossidae

3 *Sphaerotheca breviceps* (Schneider, 1799)

4 *Fejervarya limnocharis* (Gravenhorst, 1829)

5 *Hoplobatrachus tigerinus* (Daudin, 1802)

6 *Euphlyctis ehrenbergii* (Peters, 1863)

Microhylidae

7 *Microhyla ornata* (Duméril & Bibron, 1841)

8 *Ramanella variegata* (Stoliczka, 1872)

9 *Uperodon systoma* (Schneider, 1799)

Rhacophoridae

10 *Polypedates maculatus* (Gray, 1830)

Annex IX

Reptiles recorded from Mahanadi River Downstream
(Source: Rufford Foundation for Nature Conservation, 2005)

Crocodylidae

1 *Crocodylus palustris* Lesson, 1831

2 *Crocodylus porosus* Schneider, 1801

Gavialidae

3 *Gavialis gangeticus* (Gmelin in Linnaeus, 1789)

Geoemydidae

4 *Pangshura tentoria* (Gray, 1834)

Trionychidae

5 *Nilssonia gangetica* (Cuvier, 1825)

6 *Lissemys punctata* (Lacépède, 1788)

7 *Chitra indica* (Gray, 1830)

Annex X

Bird species recorded at Hirakud Reservoir
(Source: AWC Records and Nair et al., 2014)

Sl. No.	Species	Common Name	Family	IUCN Status	Population Trend
1	*Milvus migrans* (Boddaert, 1783)	Black Kite	Accipitridae	LC	Unknown
2	*Haliastur indus* (Boddaert, 1783)	Brahminy Kite	Accipitridae	LC	Decreasing
3	*Circus melanoleucos* (Pennant, 1769)	Pied Harrier	Accipitridae	LC	Decreasing
4	*Circus aeruginosus* (Linnaeus, 1758)	Western Marsh-Harrier	Accipitridae	LC	Increasing
5	*Haliaeetus leucogaster* (Gmelin, 1788)	White-bellied Sea-eagle	Accipitridae	LC	Decreasing
6	*Clanga clanga* (Pallas, 1811)	Greater Spotted Eagle	Accipitridae	VU	Decreasing
7	*Clanga hastata* (Lesson, 1831)	Indian Spotted Eagle	Accipitridae	VU	Decreasing
8	*Haliaeetus leucoryphus* (Pallas, 1771)	Pallas's Fish-Eagle	Accipitridae	VU	Decreasing
9	*Circus macrourus* (Gmelin, 1770)	Pallid Harrier	Accipitridae	NT	Decreasing
10	*Alcedo atthis* (Linnaeus, 1758)	Common Kingfisher	Alcedinidae	LC	Unknown
11	*Ceryle rudis* (Linnaeus, 1758)	Pied Kingfisher	Alcedinidae	LC	Unknown
12	*Halcyon smyrnensis* (Linnaeus, 1758)	White-throated Kingfisher	Alcedinidae	LC	Increasing
13	*Pelargopsis capensis* (Linnaeus, 1766)	Stork-billed Kingfisher	Alcedinidae	LC	Decreasing
14	*Anser indicus* (Latham, 1790)	Bar-headed Goose	Anatidae	LC	Decreasing
15	*Sarkidiornis melanotos* (Pennant, 1769)	Comb Duck	Anatidae	LC	Decreasing
16	*Aythya ferina* (Linnaeus, 1758)	Common Pochard	Anatidae	LC	Decreasing
17	*Tadorna tadorna* (Linnaeus, 1758)	Common Shelduck	Anatidae	LC	Increasing
18	*Anas crecca* Linnaeus, 1758	Common Teal	Anatidae	LC	Unknown
19	*Nettapus coromandelianus* (Gmelin, 1789)	Cotton Pygmy-goose	Anatidae	LC	Stable
20	*Mareca penelope* (Linnaeus, 1758)	Eurasian Wigeon	Anatidae	LC	Decreasing
21	*Aythya nyroca* (Güldenstädt, 1770)	Ferruginous Duck	Anatidae	NT	Decreasing
22	*Dendrocygna bicolor* (Vieillot, 1816)	Fulvous Whistling-duck	Anatidae	LC	Decreasing
23	*Mareca strepera* (Linnaeus, 1758)	Gadwall	Anatidae	LC	Unknown
24	*Spatula querquedula* (Linnaeus, 1758)	Garganey	Anatidae	LC	Decreasing
25	*Anser anser* (Linnaeus, 1758)	Greylag Goose	Anatidae	LC	Increasing
26	*Dendrocygna javanica* (Horsfield, 1821)	Lesser Whistling-duck	Anatidae	LC	Decreasing
27	*Anas platyrhynchos* Linnaeus, 1758	Mallard	Anatidae	LC	Decreasing
28	*Marmaronetta angustirostris* (Ménétriés, 1832)	Marbled Teal	Anatidae	VU	Decreasing
29	*Anas acuta* Linnaeus, 1758	Northern Pintail	Anatidae	LC	Decreasing
30	*Spatula clypeata* (Linnaeus, 1758)	Northern Shoveler	Anatidae	LC	Decreasing
31	*Netta rufina* (Pallas, 1773)	Red-crested Pochard	Anatidae	LC	Unknown

Sl. No.	Species	Common Name	Family	IUCN Status	Population Trend
32	*Tadorna ferruginea* (Pallas, 1764)	Ruddy Shelduck	Anatidae	LC	Unknown
33	*Aythya fuligula* (Linnaeus, 1758)	Tufted Duck	Anatidae	LC	Stable
34	*Anas poecilorhyncha* Forster, 1781	Indian Spot-billed Duck	Anatidae	LC	Decreasing
35	*Asarcornis scutulata* (S. Müller, 1842)	White-winged Duck	Anatidae	EN	Decreasing
36	*Anhinga melanogaster* Pennant, 1769	Oriental Darter	Anhingidae	NT	Decreasing
37	*Ixobrychus flavicollis* (Latham, 1790)	Black Bittern	Ardeidae	LC	Decreasing
38	*Nycticorax nycticorax* (Linnaeus, 1758)	Black-crowned Night-Heron	Ardeidae	LC	Decreasing
39	*Bubulcus ibis* (Linnaeus, 1758)	Cattle Egret	Ardeidae	LC	Increasing
40	*Casmerodius albus* (Linnaeus, 1758)	Great Egret	Ardeidae	LC	Unknown
41	*Ardea cinerea* Linnaeus, 1758	Grey Heron	Ardeidae	LC	Unknown
42	*Ardeola grayii* (Sykes, 1832)	Indian Pond-heron	Ardeidae	LC	Unknown
43	*Ardea intermedia* Wagler, 1829	Intermediate Egret	Ardeidae	LC	Decreasing
44	*Egretta garzetta* (Linnaeus, 1766)	Little Egret	Ardeidae	LC	Increasing
45	*Ardea purpurea* Linnaeus, 1766	Purple Heron	Ardeidae	LC	Decreasing
46	*Ixobrychus cinnamomeus* (Gmelin, 1789)	Cinnamon Bittern	Ardeidae	LC	Stable
47	*Botaurus stellaris* (Linnaeus, 1758)	Great Bittern	Ardeidae	LC	Decreasing
48	*Ixobrychus sinensis* (Gmelin, 1789)	Yellow Bittern	Ardeidae	LC	Unknown
49	*Charadrius alexandrinus* Linnaeus, 1758	Kentish Plover	Charadriidae	LC	Decreasing
50	*Vanellus indicus* (Boddaert, 1783)	Red-wattled Lapwing	Charadriidae	LC	Unknown
51	*Vanellus malarbaricus* (Boddaert, 1783)	Yellow-wattled Lapwing	Charadriidae	LC	Stable
52	*Pluvialis squatarola* (Linnaeus, 1758)	Grey Plover	Charadriidae	LC	Decreasing
53	*Charadrius dubius* Scopoli, 1786	Little Ringed Plover	Charadriidae	LC	Stable
54	*Pluvialis fulva* (Gmelin, 1789)	Pacific Golden Plover	Charadriidae	LC	Decreasing
55	*Vanellus duvaucelii* (Lesson, 1826)	River Lapwing	Charadriidae	NT	Unknown
56	*Anastomus oscitans* (Boddaert, 1783)	Asian Openbill	Ciconiidae	LC	Unknown
57	*Ciconia ciconia* (Linnaeus, 1758)	White Stork	Ciconiidae	LC	Increasing
58	*Ciconia episcopus* (Boddaert, 1783)	Woolly-necked Stork	Ciconiidae	VU	Decreasing
59	*Leptoptilos javanicus* (Horsfield, 1821)	Lesser Adjutant	Ciconiidae	VU	Decreasing
60	*Mycteria leucocephala* (Pennant, 1769)	Painted Stork	Ciconiidae	NT	Decreasing
61	*Cisticola juncidis* (Rafinesque, 1810)	Zitting Cisticola	Cisticolidae	LC	Increasing
62	*Columba livia* Gmelin, 1789	Rock Pigeon	Columbidae	LC	Decreasing
63	*Corvus levaillantii* Lesson, 1831	Jungle Crow	Corvidae	LC	Stable
64	*Centropus sinensis* (Stephens, 1815)	Greater Coucal	Cuculidae	LC	Stable
65	*Falco ruficollis* Swainson, 1837	Red-necked Falcon	Falconidae	LC	Decreasing
66	*Falco peregrinus* Tunstall, 1771	Peregrine falcon	Falconidae	LC	Stable
67	*Glareola maldivarum* Forster, 1795	Oriental Pratincole	Glareolidae	LC	Decreasing

Sl. No.	Species	Common Name	Family	IUCN Status	Population Trend
68	*Glareola lactea* Temminck, 1820	Small Pratincole	Glareolidae	LC	Unknown
69	*Grus nigricollis* Przevalski, 1876	Black-necked Crane	Gruidae	VU	Decreasing
70	*Grus grus* (Linnaeus, 1758)	Common Crane	Gruidae	LC	Unknown
71	*Hirundo rustica* Linnaeus, 1758	Barn Swallow	Hirundinidae	LC	Decreasing
72	*Riparia chinensis* (J. E. Gray, 1830)	Grey-throated Sand Martin	Hirundinidae	NE	
73	*Hirundo daurica* Linnaeus, 1771	Red-rumped Swallow	Hirundinidae	LC	Stable
74	*Hirundo fluvicola* Blyth, 1855	Streak-throated Swallow	Hirundinidae	LC	Increasing
75	*Hirundo smithii* Leach, 1818	Wire-tailed Swallow	Hirundinidae	LC	Increasing
76	*Metopidius indicus* (Latham, 1790)	Bronze-winged Jacana	Jacanidae	LC	Unknown
77	*Hydrophasianus chirurgus* (Scopoli, 1786)	Pheasant-tailed Jacana	Jacanidae	LC	Decreasing
78	*Larus ridibundus* Linnaeus, 1766	Black-headed Gull	Laridae	LC	Decreasing
79	*Larus brunnicephalus* Jerdon, 1840	Brown-headed Gull	Laridae	LC	Stable
80	*Larus cachinnans* Pallas, 1811	Caspian/Heuglin's Gull	Laridae	LC	Stable
81	*Larus marinus* Linnaeus, 1758	Greater Black-backed Gull	Laridae	LC	Increasing
82	*Gelochelidon nilotica* (Gmelin, 1789)	Gull-billed Tern	Laridae	LC	Decreasing
83	*Larus fuscus* Linnaeus, 1758	Lesser Black-backed Gull	Laridae	LC	Increasing
84	*Hydrocoloeus minutus* Pallas, 1776	Little Gull	Laridae	LC	Increasing
85	*Sternula albifrons* (Pallas, 1764)	Little Tern	Laridae	LC	Decreasing
86	*Larus ichthyaetus* Pallas, 1773	Pallas's Gull	Laridae	LC	Decreasing
87	*Sterna aurantia* Gray, 1831	River Tern	Laridae	NT	Decreasing
88	*Chlidonias hybrida* (Pallas, 1811)	Whiskered Tern	Laridae	LC	Stable
89	*Sterna acuticauda* Gray, 1832	Black-bellied Tern	Laridae	EN	Decreasing
90	*Rynchops albicollis* Swainson, 1838	Indian Skimmer	Laridae	VU	Decreasing
91	*Merops orientalis* Latham, 1802	Little Green Bee-eater	Meropidae	LC	Increasing
92	*Motacilla citreola* Pallas, 1776	Citrine Wagtail	Motacillidae	LC	Stable
93	*Motacilla cinerea* Tunstall, 1771	Grey Wagtail	Motacillidae	LC	Stable
94	*Anthus rufulus* Vieillot, 1818	Paddyfield Pipit	Motacillidae	LC	Stable
95	*Motacilla alba* Linnaeus, 1758	White Wagtail	Motacillidae	LC	Stable
96	*Motacilla madaraspatensis* Gmelin, 1789	White-browed Wagtail	Motacillidae	LC	Stable
97	*Motacilla flava* Linnaeus, 1758	Yellow Wagtail	Motacillidae	LC	Decreasing
98	*Pandion haliaetus* (Linnaeus, 1758)	Osprey	Pandionidae	LC	Increasing
99	*Pelecanus philippensis* Gmelin, 1789	Spot-billed Pelican	Pelecanidae	NT	Decreasing
100	*Phalacrocorax carbo* (Linnaeus, 1758)	Great Cormorant	Phalacrocoracidae	LC	Increasing
101	*Phalacrocorax fuscicollis* Stephens, 1826	Indian Cormorant	Phalacrocoracidae	LC	Unknown
102	*Microcarbo niger* (Vieillot, 1817)	Little Cormorant	Phalacrocoracidae	LC	Unknown
103	*Podiceps cristatus* (Linnaeus, 1758)	Great Crested Grebe	Podicipedidae	LC	Unknown

Sl. No.	Species	Common Name	Family	IUCN Status	Population Trend
104	*Tachybaptus ruficollis* (Pallas, 1764)	Little Grebe	Podicipedidae	LC	Decreasing
105	*Podiceps nigricollis* Brehm, 1831	Black-necked Grebe	Podicipedidae	LC	Unknown
106	*Fulica atra* Linnaeus, 1758	Common Coot	Rallidae	LC	Decreasing
107	*Gallinula chloropus* (Linnaeus, 1758)	Common Moorhen	Rallidae	LC	Stable
108	*Porphyrio porphyrio* (Linnaeus, 1758)	Purple Swamphen	Rallidae	LC	Unknown
109	*Amaurornis phoenicurus* (Pennant, 1769)	White-breasted Waterhen	Rallidae	LC	Unknown
110	*Zapornia pusilla* (Pallas, 1776)	Baillon's Crake	Rallidae	LC	Unknown
111	*Zapornia fusca* (Linnaeus, 1766)	Ruddy-breasted Crake	Rallidae	LC	Decreasing
112	*Gallicrex cinerea* (Gmelin, 1789)	Watercock	Rallidae	LC	Decreasing
113	*Himantopus himantopus* (Linnaeus, 1758)	Black-winged Stilt	Recurvirostridae	LC	Increasing
114	*Rostratula benghalensis* (Linnaeus, 1758)	Greater Painted-snipe	Rostratulidae	LC	Decreasing
115	*Tringa nebularia* (Gunnerus, 1767)	Common Greenshank	Scolopacidae	LC	Stable
116	*Actitis hypoleucos* Linnaeus, 1758	Common Sandpiper	Scolopacidae	LC	Decreasing
117	*Calidris minuta* (Leisler, 1812)	Little Stint	Scolopacidae	LC	Decreasing
118	*Tringa stagnatilis* (Bechstein, 1803)	Marsh Sandpiper	Scolopacidae	LC	Decreasing
119	*Tringa glareola* Linnaeus, 1758	Wood Sandpiper	Scolopacidae	LC	Stable
120	*Limosa limosa* (Linnaeus, 1758)	Black-tailed Godwit	Scolopacidae	NT	Decreasing
121	*Tringa totanus* (Linnaeus, 1758)	Common Redshank	Scolopacidae	LC	Unknown
122	*Gallinago gallinago* (Linnaeus, 1758)	Common Snipe	Scolopacidae	LC	Decreasing
123	*Calidris ferruginea* (Pontoppidan, 1763)	Curlew Sandpiper	Scolopacidae	LC	Increasing
124	*Numenius arquata* (Linnaeus, 1758)	Eurasian Curlew	Scolopacidae	NT	Decreasing
125	*Tringa ochropus* Linnaeus, 1758	Green Sandpiper	Scolopacidae	LC	Stable
126	*Calidris temminckii* (Leisler, 1812)	Temminck’s Stint	Scolopacidae	LC	Unknown
127	*Ketupa zeylonensis* (Gmelin, 1788)	Brown Fish-Owl	Strigidae	LC	Decreasing
128	*Threskiornis melanocephalus* (Latham, 1790)	Black-headed Ibis	Threskiornithidae	NT	Decreasing
129	*Pseudibis papillosa* (Temminck, 1824)	Red-naped Ibis	Threskiornithidae	LC	Decreasing
130	*Plegadis falcinellus* (Linnaeus, 1766)	Glossy Ibis	Threskiornithidae	LC	Decreasing

Annex XI

Commercially important fish species in Hirakud Reservoir

Bagridae

1 *Mystus tengra* (Hamilton, 1822)

2 *Sperata aor* (Hamilton, 1822)

Belonidae

3 *Xenentodon cancila* (Hamilton, 1822)

Channidae

4 *Channa striata* (Bloch, 1793)

5 *Channa marulius* (Hamilton, 1822)

6 *Channa punctata* (Bloch, 1793)

Cichlidae

7 *Oreochromis niloticus* (Linnaeus, 1758)

Clariidae

8 *Clarias batrachus* (Linnaeus, 1758)

Cyprinidae

9 *Labeo rohita* (Hamilton, 1822)

10 *Catla catla* (Hamilton, 1822)

11 *Cirrhinus mrigala* (Hamilton, 1822)

12 *Labeo gonius* (Hamilton, 1822)

13 *Labeo bata* (Hamilton, 1822)

14 *Cyprinus carpio* Linnaeus, 1758

15 *Ctenopharyngodon idella* (Valenciennes, 1844)

16 *Salmophasia bacaila* (Hamilton, 1822)

Notopteridae

17 *Notopterus notopterus* (Pallas, 1769)

18 *Notopterus chitala* (Hamilton 1822)

Pangasiidae

19 *Pangasius pangasius* (Hamilton, 1822)

20 *Pangasius sutchi* Fowler, 1937

Siluridae

21 *Wallago attu* (Bloch & Schneider, 1801)

Annex XII

Estimation of fish catch from Hirakud Reservoir

Description	Values
Total population (Census, 2011)	112240
Total Household (Census, 2011)	26111
Working population (Census, 2011)	56820
Main working population (Census, 2011)	34759
Marginal working population (Census, 2011)	22061
Main working population/HH	1.31
Marginal working population/HH	2.17
Total No. of HH surveyed	400
Number of fisher household surveyed	158
Number of fisher HH (with land)	45
Number of fisher HH (share cropper)	12
Number of other HH (wage labour)	12
Active fisher HH (excluding fisher HH with land + fisher HH of share cropper and fisher HH as wage labour)	89
% of active fisher HH (Total HH surveyed/Active Fisherman)	22.25
No. of total fisher HH (% of active fisher HH x Total HH)	5810
Total fisher (Total fisher HH x Main working population/HH)	7611

Annex XIII

List of Villages around Hirakud Reservoir

District	Block	Panchayat	Village	Number of household	Population
Bargarh	Ambabhona	Banjipali	Arjunda	884	3475
			Banjipali	257	1214
			Behera	451	1859
			Bugbugi	106	465
			Dechuan	54	237
			Kusmuda	205	948
		Dunguri	Badmal	321	1325
			Sauntamal	335	1470
		Kapasira	Antradi	236	988
		Lakhanpur	Banjhipali (K)	169	810
			Babebira	216	805
		Ruchida	Bara	182	863
			Beherapali	340	1268
			Bilaigad	127	541
			Khijupali	115	507
			Narangapur	111	439
			Ruchida	485	2413
		Uttam	Bungapali	233	1016
			Chandipali	175	659
			Gobindpur	570	2419
			Jarimuli	88	457
			Khola	175	790
			Kurumkel	77	384
			Launsara	512	1828
			Lelehar	109	522
			Lether	159	743
			Paruabhadi	86	420
			Ramkhol	62	340
			Rengali	492	2192
			Tamdei	11	58
			Udhepali	138	588
			Uttam	193	895
	Attabira	Silat	Silat	383	1523
			Nuabatimunda	141	575
Jharsuguda	Lakhanpur	Badimal	Baddarha	216	1095
			Badimal	254	1037

District	Block	Panchayat	Village	Number of household	Population
			Guchhapali	132	611
			Kanjijharan	56	219
			Kusmel	152	734
		Baghmunda	Baghmunda	596	2565
			Singharpur	206	964
		Bhaunrkhol	Bhaunrkhol	269	1191
			Kholjamkani	21	73
		Dalgaon	Badimal	107	432
			Basupali	135	496
			Dalgaon	433	1959
			Dudulsingha	231	864
			Gudiali	192	697
			Negipali	225	1024
			Solpali	41	178
		Jamgaon	Jamgaon	452	1713
			Lachhipali	119	478
			Telen	64	278
		Kadamdihi	Bhaurachaka	120	523
			Belijharan	72	322
			Dudugaon	110	454
			Govindpur	134	555
			Kadamdihi	145	690
			Kutrapali	108	478
			Parsian	194	871
		Kandheikela	Sukhasodha	172	782
		Kumbharbandh	Bhatli	21	91
			Kumbharbandh	433	1791
			Rengali	237	983
			Sahajbahal	312	1285
		Palsada	Jharupada	220	899
			Mahasingh	137	529
			Nachenmura	130	547
			Palsada	389	1690
			Panchpudugia	57	239
			Renkuli	85	351
		Pandri	Balanda	111	544
			Benkmura	72	322
			Pandri	413	1869
		Pipilikani	Batlaga	109	443

District	Block	Panchayat	Village	Number of household	Population
			Bhejikud	110	416
			Pipilikani	524	2247
			Sartang	92	343
		Pithinda	Amapali	193	809
			Gudum	132	611
			Nandapali	48	215
			Pithinda	629	2469
		Rampela	Barpali	255	1020
			Rampela	686	2973
		Remenda	Bhutia	136	577
			Remda	664	2857
		Remta	Chikhili	272	1194
			Kiritmal	160	709
			Mohadi	187	913
			Remta	354	1593
			Saradha	127	624
		Samarbaga	Chuikhanch	37	161
			Debdarha	44	171
			Duanmunda	111	469
			Jhargaon(a)	92	385
			Kudabaga	127	598
			Kuremal	164	687
			Samarbaga	191	784
		Sunari	Barihapali	147	736
			Beheramal	196	830
			Kutripali	153	691
			Patrapali	375	1539
			Sunari	311	1247
		Tilia	Ramela	424	1898
			Singhaipali	167	703
			Tilia	409	1734
			Barangamal	73	270
	Kirimira	Goudpanpali	Kadobahal	168	703
Sambalpur	Dhankauda	Gadmunda	Gadmunda	971	4344
			Larbanga	323	1393
		Talab	Baramunda	55	215
			Bhalu Kunda	148	619
			Jamadarpali	369	1943
			Jogipali	164	691

District	Block	Panchayat	Village	Number of household	Population
			Madhupur	100	395
			Pandaripali	142	634
			Talab	64	298
			Tihura	137	630
Total				**26111**	**112240**

Annex XIV

Sectoral policies and regulatory frameworks relevant for management of Hirakud Reservoir

Key ecological character element that is (likely to be) influenced by sector policy environment			**Existing policies, guidelines, plans for the sector having relevance for Hirakud management**		**Existing regulatory framework (Acts and Rules) for the sector having relevance for Hirakud management**		**Opportunities for sectoral policy supporting Integrated Management of Hirakud**	**Gaps that need to be addressed for sectoral policy to support integrated management of Hirakud**
Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
Watershed Management								
Land cover, Water sources to rivers, Erosion	Sedimentation				Indian Forest Act, 1927		The act provides for reservation and protection of forest areas in the catchment of Hirakud	
			National Forest Policy (1988)				The policy recommends one third of Hirakud catchment to be under forest cover (two third in hill areas); The policy restricts projects on steep slopes, catchment of rivers, lakes, and reservoirs and other ecologically sensitive areas. The policy also requires the mining and quarrying beneficiaries to repair and re-vegetate the area in accordance with established forestry practices and establishments of green belts in urban/industrial areas	Applicable only to areas notified as forests under Indian Forest Act, 1927 (or land covered by trees)
					Forest Conservation Act(1980), Supreme Court Orders with regard to creation of CAMPA		Restricts the state governments from dereserving a forest, or assign any forest land for non-forest purpose, or grant lease to any private person or authority without the prior approval of the Central Government.	
					Forest Conservation Rules, 2003			

Key ecological character element that is (likely to be) influenced by sector policy environment			Existing policies, guidelines, plans for the sector having relevance for Hirakud management		Existing regulatory framework (Acts and Rules) for the sector having relevance for Hirakud management		Opportunities for sectoral policy supporting Integrated Management of Hirakud	Gaps that need to be addressed for sectoral policy to support integrated management of Hirakud
Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
							Various agencies have deposited amounts when forests were used for non-forest purpose	
					JFM resolution 2011		The resolution applies to participatory forest management of the community forest resource	
			The Common Guidelines for Watershed Development Projects, 2008				The guidelines provide a robust institutional framework to undertake watershed management activities in Hirakud catchment	Interventions are meant to enhance land productivity and augmenting livelihoods in a rainfed agrarian landscape. The guidelines can be made more inclusive to focus on integrated catchment conservation and with respect to mode of engagement with sectoral nodal agencies
Water Resources Management								
			National Water Policy (2012)				As the policy advocates Integrated Water Resources Management (IWRM) taking river basin / sub-basin as a unit should be made be made the main principle for planning, development and management of water resources around Hirakud. Water Pricing to ensure its efficient use and reward conservation. Evolution of a Water Framework Law.	
				State Water Policy (2007)			In line with the policy recommendations a hydrological information system can be developed for Hirakud. As recommended by the policy a master plan for flood control and management	Revision of State Water Policy based on the National Water Policy (2012) Need for revision of State Water Plan

Key ecological character element that is (likely to be) influenced by sector policy environment			Existing policies, guidelines, plans for the sector having relevance for Hirakud management		Existing regulatory framework (Acts and Rules) for the sector having relevance for Hirakud management		Opportunities for sectoral policy supporting Integrated Management of Hirakud	Gaps that need to be addressed for sectoral policy to support integrated management of Hirakud
Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
							for each flood prone area of the Mahanadi basin can be prepared to guide future investments Polluters Pay Policy be strictly applied to meet the expenses of maintaining water quality. Concerted efforts be made for proper management of watersheds as a non-structural measure of flood control and drought mitigation. A regulatory authority can be set for fixation of water rates in order to achieve full cost recovery of the O&M charges.	
				Strategic Environmental Policy for Water Resources Planning and Development in Orissa (2001)			Effective integration of environment considerations in the development and implementation of the Integrated River Basin Plan and operationalize the principles of sound environment planning in the water sector.	
					The River Boards Act, 1956		A River Board can be established for Mahanadi as per the provisions of the act which will serve to better management of water resource across the river basin	At present, no River Board has been established between the states of Odisha and Chhattisgarh.
					Inter-state Water Disputes Act (1956)			

Key ecological character element that is (likely to be) influenced by sector policy environment			Existing policies, guidelines, plans for the sector having relevance for Hirakud management		Existing regulatory framework (Acts and Rules) for the sector having relevance for Hirakud management		Opportunities for sectoral policy supporting Integrated Management of Hirakud	Gaps that need to be addressed for sectoral policy to support integrated management of Hirakud
Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
					The Water (Prevention and Control of Pollution) Act, 1974		The main instrument that provides for the prevention and control of water pollution, and for the maintaining or restoring of wholesomeness of water in the country.	
					The Water (Prevention and Control of Pollution) Cess Act 1977		Heavy cess can be imposed on polluters in order to prevent and control of water pollution in the upstream and downstream and in the reservoir	
						Orissa Irrigation Act (1959) Orissa Irrigation Rules (1961)	An Act to consolidate and amend the laws relating to irrigation, assessment and levy of water rate and cess in force in different parts of the State of Odisha and to provide for the regulation of use of water from Government source.	
						Orissa Pani Panchayat Act (2002) Orissa Pani Panchayat Rules (2003)	An act to provide for Farmers' participation in the management of irrigation systems and for matters connected therewith or incidental thereto.	
Wetland Management								
					Wetland (Conservation and Management) Rules, 2010 (under EPA, 1986)			

Key ecological character element that is (likely to be) influenced by sector policy environment			Existing policies, guidelines, plans for the sector having relevance for Hirakud management		Existing regulatory framework (Acts and Rules) for the sector having relevance for Hirakud management		Opportunities for sectoral policy supporting Integrated Management of Hirakud	Gaps that need to be addressed for sectoral policy to support integrated management of Hirakud
Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
Environment Conservation								
Present state of environment (abiotic and biotic well be maintained in their respective niches)			National Environment Policy, 2006					Adoption and implementation at Hirakud and its associated biotope level
			National Conservation Strategy and Policy Statement on Environment Development (1992)					
					The Environment (Protection) Act, 1986		The polluters are bound to prevent and mitigate environmental pollution	
					The Wildlife (Protection) Act, 1972			Act does not explicitly draw attention to the fish under the definition of ‘wild animal’ which is defined as including amphibians, birds, mammals and reptiles and their young, and in the case of birds and reptiles, their eggs. The only specific reference to protected fish species is restricted to Part II a of Schedule I which includes the marine species like whale shark, shark and ray, sea horse and giant grouper.

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Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
					Biological Diversity Act, 2002		The act provides a framework to create information and documentation system for biological resources and associated traditional knowledge	
Fishery Development								
				Orissa State Reservoir Fisheries Policy 2012				Inland Fisheries Policy need to be amended
					The Indian Fisheries Act, 1897			
				Perspective Plan of the Fisheries sector in Orissa for ten years (2010-11 to 2019-20)				
						The Orissa Marine Fishing Regulation Act 1981 (Orissa Act 10 of 1982)		
						The Game and Fish Protection Regulation Act 12 of 1914		

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Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
Tourism Development								
		Recreation and Tourism	National Tourism Policy (2002)				1. Integrated approach of Hirakud and associated tourism complex can be designated as one of the eco tourism site under the objective of tourism development master plan	1.Lack of participation of water resource department in state Tourism Promotion Council and tourism advisory Committee at policy level 2. Some regulation must be incorporate for tourist safety and securities
				Odisha Tourism Policy (2013)				
Industrial Development								
		Overall help in generation secondary livelihood and decline in resource stress	National Mineral Policy, 2008	Orissa Industrial Policy (2001)	Industries (Development and Regulation) Act, 1951		Integrated monitoring framework need to be introduced to serve the purpose of Industrial development vis-vis natural resource restoration and landscape conservation	The draft Orissa Industrial Policy does not encourages any regulation of the conservation of environment
					The Mines and Minerals (Development and Regulation) Act, 1957			Consideration of ecological factors during the exploration of mineral is over ruled
					Mineral Concession Rules, 1960 (MCR)			

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Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
					Dumping and Disposal of Fly Ash discharged from coal of lignite based thermal power plants on land, Rules, 1999			
					Environment (Siting for industrial Project) Rules, 1999			
Rural Development and Livelihoods								
		Human well-being	Pradhan Mantri Gram Sadak Yojana guidelines				Increase road connectivity to improver infrastructure facility for trading	Minimum eligibility criteria for non revenue village around Hirakud need to be revised
			National Rural Drinking Water Guideline (2013)				Need to focus on piped water supply rather than hand pump	
			Guideline for Swachh Bharat Mission (2014)				Increase safe sanitation coverage around Hirakud Reservoir	
			National policy on Disaster management (2009)				Contingency plan that includes an advance early warning system should be develop to warn and help in mass evacuation during critical situation	
			National Policy on Rehabilitation & Resettlement (2007)					

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Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
				State Disaster Management Policy (2005)			Comprehensive district disaster management action plan associated with Hirakud can be develop as preparedness measure	
				Orissa Resettlement and Rehabilitation Policy (2006)			State R & R policy has given specific attention and priorities to vulnerable section of community(women, Widow, Physically challenged and tribes) for compensation and assistance for capacity building for promotion of alternate livelihood option	1. Land acquisition act 1894 was placed during construction of Hirakud dam. According to which displaced person were only paid full compensation for land and properties. they were free to resettle themselves in place of their choice. But most of the family settled in 21 non revenue village in the periphery of reservoir and yet to be compensate 2.Limited coverage of Rehabilitation package for displaced community
					The National Rural Employment Guarantee Act 2005	MNREGA Rule (2010)	Community participation toward conservation programme of Hirakud can be better address under MNREGA	
Agriculture Development								
		Livelihoods	National Policy for Farmers(2007)				Easy access to institutional credit to all tribal farmer and adequate provision of Kisan credit cards for them	Lack of Integration of different policies aligned with different agriculture plan

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Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
				Odisha Agriculture Policy (2012)			1. Encourage organic farming 2. Integrated watershed development programme 3. Promote participatory irrigation management through pani panchayat system	
Urban development								
		Will impact the well being of the stakeholder depended on the reservoir and associated water bodies	National Urban Sanitation Policy		Municipal solid waste (Management and handling) Rules, 2000	The Odisha Municipal Corporation (Amendment) Act, 2008		
			National Urban Transport Policy			The Odisha Development Authorities Act, 1982		
			National Mission on Sustainable Habitat			Odisha Water Supply & Sewerage Board (OWSSB) Act-1992		
						The Odisha State Housing Board Act, 1968		

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Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
						Rule: Odisha Municipal Accounting Manual		
						Regulations: BDA (Planning and Standard) Regulations 2008		
Climate Change								
		Reduce vulnerability		Odisha Climate Change Action Plan (2010 - 2015)			Key Priority area set under OCCAP 1. Flood mapping, flood forecasting and downscale climate change projection in downstream of Hirakud 2.Fly ash utilization from power plant 3. Vaccination of livestock against contagious disease 4. Increase reforestation / afforestation activities in degraded forest areas. 5. Assess GHG profile of major industrial cluster 6. Conduct heat -island study fro Talcher and Jharsuguda area 7. River health monitoring and eco systems environmental flow demand studies 8. Raising awareness raising with Pani Panchayat through Framer Training programme and creating agro - climatic stations	

Key ecological character element that is (likely to be) influenced by sector policy environment			Existing policies, guidelines, plans for the sector having relevance for Hirakud management		Existing regulatory framework (Acts and Rules) for the sector having relevance for Hirakud management		Opportunities for sectoral policy supporting Integrated Management of Hirakud	Gaps that need to be addressed for sectoral policy to support integrated management of Hirakud
Component	**Processes**	**Services**	**National**	**State**	**National**	**State**		
		Reduce vulnerability	National Action Plan on Climate Change (2008)				Action identified for conservation of wetlands 1. Environmental appraisal and impact assessment of developmental projects on wetlands 2. Mapping of catchments and surveying and assessing land use pattern with emphasis on drainage, vegetation cover, siltation, encroachment, human settlements and human activities and their impact on catchments and waterbodies 3. Creating awareness among people on importance of wetland ecosystems 4. Formulating and implementation a regulatory regime to ensure wise use of wetlands at the national, the state and district levels 5. Enhance community participation in JFM for increase in forest cover	

Annex XV

Sectoral investment schemes and programmes relevant for management of Hirakud Reservoir

Key ecological character element that is (likely to be) infleucned by sector policy environment			**Schemes/Programmes in operation having releavance for management of Hirakud**		**Nodal implementaing agencies**		**Opportunities for sectoral programing providing support for Intergrated Management of Hirakud**	**Gaps within sectoral programmes that need to be addressed for integrated management of Hirakud**
Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
Watershed Management								
Land cover, Water sources, Erosion	Sedimentation			Joint Forest Management Programme		Forest and Environment Department, GoO (through Vana Surakshya Samities, Eco-development committees)	The programme can be used for protection of peripheral reserve forests through community participation and promotion of sustainable land used practices in the catchment	JFM institutions need to be strengthened by empowering the local communities with adequate power and responsibilities, needs to work closely with the Panchayati Raj Institutions for decentralized forest governance
			Compensatory afforestations programmes		National Compensatory Afforestation Fund Management and Planning Authority (CAMPA) Advisory Council	State CAMPA	Its forest and wildlife components promote forest cover and biodiversity conservation around Hirakud	Efficiency of fund utilisation under the programme can be increased
			13 th Finance commission grants			Forest and Environment Department, GoO	Maintaininga nd extending green cover in the catchment	
			Odisha Forestry Sector Development Project			Odisha Forestry Sector Development Society (with funding from Japan International Cooperation Agency)	Can be extended to Hirakud	Hirakud districts not covered

Key ecological character element that is (likely to be) infleucned by sector policy environment			Schemes/Programmes in operation having releavance for management of Hirakud		Nodal implementaing agencies		Opportunities for sectoral programing providing support for Intergrated Management of Hirakud	Gaps within sectoral programmes that need to be addressed for integrated management of Hirakud
Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
			Integrated Watershed Management Programme		Department of Land Resources, Ministry of Rural Development, GoI (with support of the National Rainfed Area Authority (NRAA), Ministry of Agriculture , GoI)	State Watershed Management Agency, Department of Panchayat and Rural Development, Chhattisgarh; Odisha Watershed Development Mission, Department of Agriculture,Odisha	IWMP provides a platform for implementing watershed conservation in Hirakud .	IWMP interventions do not adequately reach to the upper catchments. There is need for better inter-sectoral coordination to create synergies through convergence of sectoral programmes particlularly through more active involvement of forest department
			Macro Management Agriculture including the NWDPRA and RVP components		Ministry of Agriculture,GoI	Department of Agriculture, Odisha	Promotes soil conservation in Hirakud and prevent catchment deterioration	Suffers from poor implementation
				Mahatma Gandhi National Rural Employment Generation Scheme			Can be used for land treatment works related to water conservation and harvesting, and flood control especially earthworks and afforestation through community participation	
			Pradhan Mantri Krishi Sinchai Yojana		Ministry of Agriculture , GoI		This new government scheme can be used to augment watershed conservation parctices further	
Water Resources Management								
			Rural Infrastructure Development Fund - RIDF (under implementation)			Finance Department. GoO		

Key ecological character element that is (likely to be) infleucned by sector policy environment			Schemes/Programmes in operation having releavance for management of Hirakud		Nodal implementaing agencies		Opportunities for sectoral programing providing support for Intergrated Management of Hirakud	Gaps within sectoral programmes that need to be addressed for integrated management of Hirakud
Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
			Hydrology Project (Phase III proposed)			Department of Water Resources (GoO)		
			Dam Rehabilitation and Improvement Project (DRIP)			Department of Water Resources (GoO)		
				Mega Lift IrrigationProgramme (under implementation)		Department of Water Resources (GoO)		
				Hirakud Command Area Development Work (under implementation)		Orissa Lift Irrigation Corporation Ltd.		
Wetland Management								
			National Plan for Conservation of Aquatic Ecosystems			Odisha Wetland Development Authority		Hirakud not covered
			13 th finance commission awards			Odisha Wetland Development Authority		
Environment Conservation								
				Orissa State Vanaspati Van Society	Ministry of Forests, Environment and Climate Change	District Wildlife Division	Sectots of Badarma, Barapahar and Sundargar Forest range area can be adopted for cultivation and preservation of medicinal seedlings and other activities of the forest	Despite of fact that the mentioned range is rich in medicinal plants no effort for sustainable cultivation and germplasm management had yet been initiated
			Medicinal Plants Programme			State Medicinal Plants Board	Protection of rare, endangered and threatened species and its germplasm	

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Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
				Conservation and protection of wildlife and its habitats	Ministry of Forests and Environment	District Wildlife Division	Conservation of Mahseer and its habitat nitches can be initiated under te program	State Fishery Department, Regional Resource Centre had yet not been involved in integrated management of Hirakud at the Debrigarh sanctury site
Fishery Development								
Increased fish diversity	More energy can be transforme d in harvestable nectons	The harvest from the reservoir, its upstream downstrea m water can be largely enhanced	Development of Inland Fisheries and Aquaculture through Fish Farmers Development Agency (FFDA); National Fisheries Development Board (NFDB); National Mission for Protein Suppliment (NMPS); Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS); Matshyajibi Unnayana Yojana (MUY)	Development of Inland Fisheries and Aquaculture through Promotion of intensive aquaculture and fresh water fish seed hatchery	Department of Animal Husbandary, Diary and Fisheries	Orissan State Fishery Department	Scientific management for enhanced seed production need to be taken	Capacity need to be enhanced
				Development of Inland Fisheries and Aquaculture through dedicated electric feeder to aquaculture cluster				Need to be adopted in associted waterboides of three district of Bargarh,Jharsuguda and Sambalpur

Key ecological character element that is (likely to be) infleucned by sector policy environment			Schemes/Programmes in operation having releavance for management of Hirakud		Nodal implementaing agencies		Opportunities for sectoral programing providing support for Intergrated Management of Hirakud	Gaps within sectoral programmes that need to be addressed for integrated management of Hirakud
Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
				Development of Inland Fisheries and Aquaculture through inclusion of Farm Machineries of Allied Sector				
				Development of Inland Fisheries and Aquaculture through inclusion of new Commercial Agri Enterprises				
				Welfare of Fishermen through Biju Krushak Kalyan Yojana				Need introduction at the Hirakud and its associated waterbodies PFCS Level
				Welfare of Fishermen through Empowering fishermen through mobile advisory services and Establishment of toll free call centre for fisheries extension service and Assistance to fishermen for dwelling houses				Need introduction at the Hirakud and its associated waterbodies PFCS Level
				Welfare of Fishermen through Matshya Credit Card				Need introduction at the Hirakud PFCS Level

Key ecological character element that is (likely to be) infleucned by sector policy environment			Schemes/Programmes in operation having releavance for management of Hirakud		Nodal implementaing agencies		Opportunities for sectoral programing providing support for Intergrated Management of Hirakud	Gaps within sectoral programmes that need to be addressed for integrated management of Hirakud
Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
				On-going subsidy Schemes through Interest subvention on credit support to fish farmers: a) Short term loan and b) Long Term loan for fisheries development			Integration of more Nationalised Bank in the process	Coverage need to increased
Tourism Development								
				Eco guide training programme		Tourism Department	Special training programme on ecotourism can be developed for Hirakud and its associated tourism spots	Limited participation of candidate during training programme
Industrial Development								
Threat to the existing biodiverity can be regulated		Threat to harvestable commodity can be declined		Compensatory Afforestation	Ministry of Environment and Forest	State	Private industries can be encouraged in the plantation and their regenaration work	
				Pollution control	Central Pollution Control Board	The State Pollution Control Board	State Fisheries Department can be encouraged to conduct joint venture in periodic water sampling (with special impahasis on hazarrdous industial effulent) in the River draining in and out of the reservoir.	Regional Environmental Management Plan does not incorporate Hirakud Reservoir as station for Air quality monitoring; Water quality monitoring only cover one point at Hirakud reservoir
							Awareness Programmes on Environment & Pollution Control can be promoted to the reservoir managers	No traing yet had been given to the concerned personnel

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Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
Rural Development and Livelihoods								
				Odisha tribal empowerment & livelihood programme plus (OELP Plus): Sustainable livelihood opportunity for tribal		Odisha Tribal Empowerment & Livelihood Programme, ST & SC Development Department, Government of Odisha	Programme can be used to build capacities and facilitate alternate livelihood option based on the need of poor tribal HHs around Hirakud	Districts around Hirakud are excluded from implementation of these scheme
			Indira Awaas Yojana		Department of Rural Development		Housing support for SC/ST, minorities and physically disabled	Limited Coverage
			Swacch Bharat Abhiyan		Department of Drinking Water and Sanitation		The programme provides oppurtunity to provide safe sanitation coverage through its individual components and improved solid/liquid waste management	Limited Coverage
			Pradhan Mantri Gram Sadak Yojana			Ministry of Rural development, Government of India	100% government funded scheme with Central and State government contribution being 60:40.	Limited Coverage
			Mahatma Gandhi National Rural Employment Guarantee Scheme		Department of Rural Development	Ministry of Rural development, Government of India	The programme can provide assured employmnet to communities in Hirakud catchmnet and promote sustainable resource management practices to bring improved social and natural capital	

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Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
			Ajeevika		Department of Rural Development		Livelihood promotion scheme providing capital support to individual and SHG projects	
			Rashtriya Swasth Bima Yojana				Scheme provide health insurance coverage to Below Poverty Line (BPL) families	
			Pradhan Mantri Jan-Dhan Yojana		Department of Financial Services, Ministry of Finance		Ensures financial access, namely Banking/Savings, Remittance, Credit, Insurance and Pension in an affordable manner.	
			Pradhan Mantri Suraksha Bima Yojana		Department of Financial Services, Ministry of Finance		Total accidental coverage (sum-insured) under the scheme is Rs. 2 Lakh	
			Pradhan Mantri Jeevan Jyoti Bima Yojana		Department of Financial Services, Ministry of Finance		Provides death coverage benefits(sum-insured) of Rs. 2 Lakh	
			Integrated Child Development Services		Department of Women and Child Welfare		Services available under the scheme: Supplementary Nutrition, Immunization, Health Check-up, Referral Services and Pre-School Education	
Agriculture Development								
		Improve livelihood		Jalanidhi : Harnessing ground and surface water for agriculture		Directorate of Agriculture & Food Production, Department of Agriculture	Financial assistance (subsidies) up to Rs. 50000 for lift irrigation from river, stream, minor canal in tail region of command area	Availability of water in minor channel of command area need to be assessed

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Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
		Improve livelihood		Jeebika – Orissa Rural Livelihood Programme: (ORLP)		The Odisha watershed Development Mission (OWDM), under the Department of Agriculture	The scheme has been implemented to provide an additional livelihood component to the people of the watershed area of ongoing watershed projects under the IWDP and the Drought Prone Area Programme (DPAP)	Scheme should be implemented after detail assessment of land right issues
		Improve livelihood		Biju Krushak Vikas Yojana		Directorate of Agriculture & Food Production, Department of Agriculture	Financial assistance 80% Government funding (can be increased to 90% in Tribal Sub-Plan Areas and KBK districts) and 20% Pani Panchayat's/Water User Association's contribution (in cash or in terms of labour or land)	
Urban development								
			Jawaharlal Nehru National Urban Renewal Mission					Required adoptation at district level
			Urban Infrastructure Development scheme for Small and Medium Towns					
			Jawaharlal Nehru National Urban Renewal Mission PMIS					
			Capacity Building for Urban Local Bodies					

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Component	**Processes**	**Services**	**National (CSS)**	**State**	**National**	**State**		
			Pooled Finance Development Scheme	Orissa State Pooled Finance Development Scheme	Ministry of Urban Development	Municipal Corporation		The SWM implementatation on cluster basis has already been initiated in the Jharsuguda, Brajrajnagar and Belpahar while the big town along the Bargarh District
				Project e-Municipality Programme	Ministry of Urban Development	Municipal Corporation		Required adoptation at district level
Climate Change								
			Green Climate Fund and the National Adaptation Fund on Climate Change (NAFCC)		National Bank for Agriculture and Rural Development (NABARD)			
				Fly ash utilisation	Fly Ash Resource Centre, OSPCB		Fly Ash Resource Centre, notification recommneds use of 100 per cent fly ash through building and road construction	

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