Kanwar Jheel

An Integrated Management Action Plan for Conservation and Wise Use

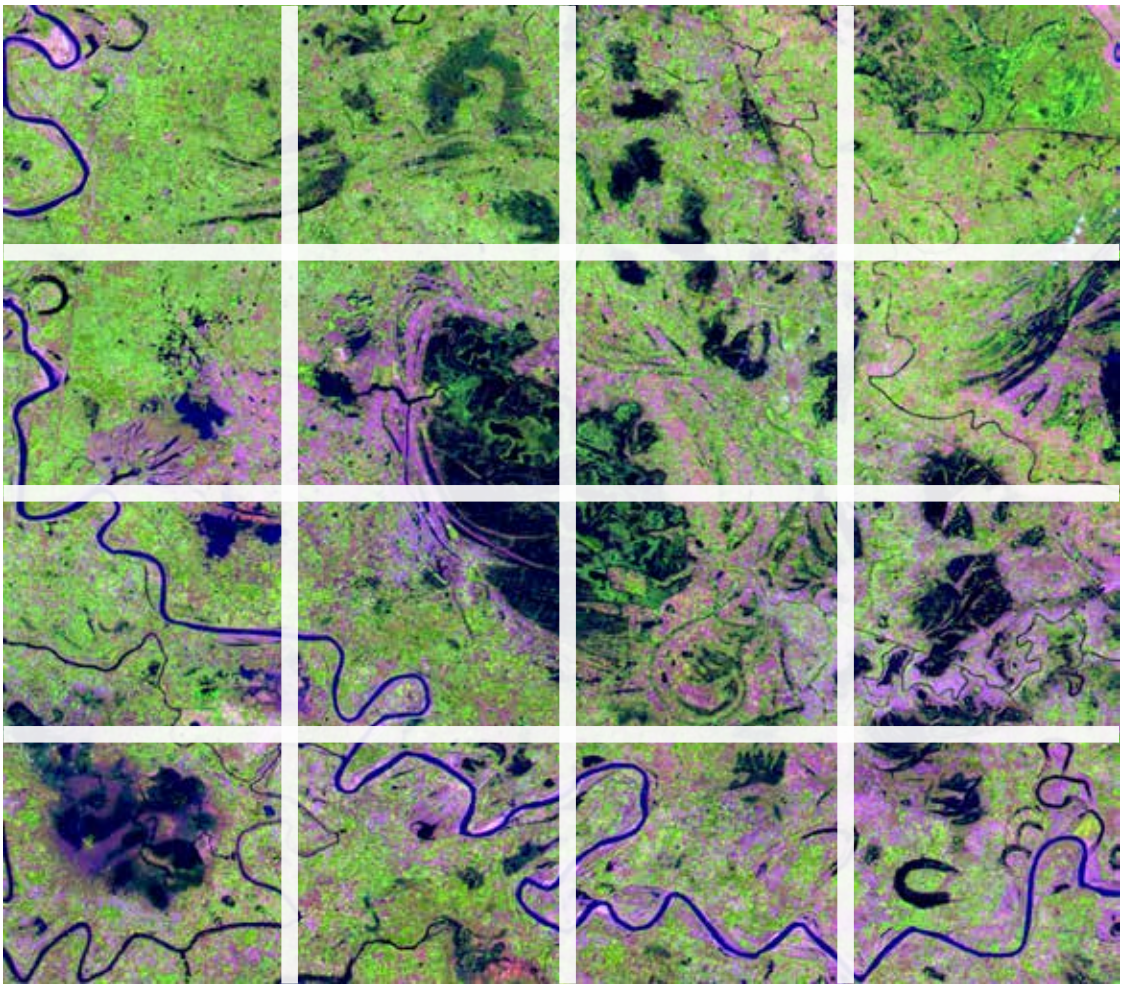
Wetlands INTERNATIONAL

Wetlands International South Asia

WISA is the South Asia Programme of Wetlands International, a global organization dedicated to conservation and wise use of wetlands, Its mission is to sustain and restore wetlands, their resources and biodiversity. WISA provides scientific and technical support to national governments, wetland authorities, non-governmental organizations, and the private sector for wetland management planning and implementation in South Asia region. It is registered as a non-governmental organization under the Societies Registration Act and steered by eminent conservation planners and wetland experts.

KANWAR

An Integrated Management Action Plan for Conservation and Wise Use



Wetlands International South Asia

February 2016

Project Team

Dr. Ritesh Kumar (Project Leader)

Dr. B. C. Jha (Consultant, Ecology)

Ms. Kalpana Ambastha (Lead, Remote Sensing & GIS Mapping)

Dr. Pranati Pattnaik (Lead, Fisheries)

Dr. Anita Chakraborty (Lead, Vegetation)

Mr. Satish Kumar (Lead, Livelihoods)

Mr. Kamal Dalakoti (Lead, Thematic Mapping)

Mr. Akoijam Yaiphaba Meetei (Lead, Waterbird)

Mr. Abhishek Kumar (Lead, Socioeconomic survey and community consultations)

Report prepared by **Wetlands International South Asia** for **Environment and Forest Department, Government of Bihar** under **Bihar Capacity Building Technical Assistance (BCB TA) Supported by DFID – World Bank Trust Fund**

Part financial assistance received from Partners for Resilience Project of Wetlands International under MFS II programme of Dutch Ministry of Foreign Affairs, The Netherlands

Report ID: 2015 – Kanwar – 02

World Bank Contract Reference: 7169448 of August 11, 2014

Suggested Citation

WISA, 2016. Kanwar Jheel - An Integrated Management Action Plan for Conservation and Wise Use. Technical Report submitted to the World Bank, New Delhi. Wetlands International South Asia, New Delhi, India.

Disclaimer

Photograph credits: WISA Photo Library

Cover: Fisher using box trap to catch fish in Kanwar; Inside Cover: IRS P6 LISS III image of Kanwar and associated wetlands, October 20, 2008 (Source: bhuvan-noeda@nrsc.gov.in)

Back Cover: Waterbirds in Kanwar

Printed by: Systems Vision (systemsvision@gmail.com)

Acknowledgement

Wetlands International South Asia expresses sincere appreciation for the support received from:

Mr. Shashi Shekhar (Special Secretary, Ministry of Environment, Forests and Climate Change, Government of India) for valuable guidance on management planning process and cross-sectoral management structure

Mr. V. K. Singh (Secretary, Department of Environment and Forests, Government of Bihar) for reviewing the action plan and guiding departmental inputs

Mr. D. K. Singh (Secretary, Department of Water Resources, Government of Bihar) for guidance on restoration of hydrological regimes

Mr. B.A.Khan (Principal Chief Conservator of Forests, Government of Bihar) for extensive support throughout the assignment

Mr. B.N. Jha (Former Principal Chief Conservator of Forests, Government of Bihar) for advice on institutional arrangements

Mr. D.K.Shukla (Chief Wildlife Warden and Additional Principal Chief Conservator of Forests, Government of Bihar) for advice on biodiversity conservation

Mr. Bharat Jyoti (Director, Department of Ecology and Environment, Government of Bihar) for continuous support on management plan review and departmental inputs

World Bank Team: Mr. Pyush Dogra (Task lead), **Dr. Anupam Joshi, Mr. Harinath, Mr. Gaurav Joshi** and **Dr. Tapas Paul** for financial support and technical guidance

Wetlands International South Asia Board: Dr. A.K. Kundra (President), **Mr. S.K. Pande** (Vice President) and **Dr. Ajit K. Pattnaik** (Chief Executive, Chilika Development Authority and Treasurer, WISA Society) for overall guidance and recommendations on institutional arrangements

Mr. Prabhat K. Gupta (Conservator of Forests, Muzaffarpur Circle); **Mr. A.K.Ojha** (DFO, Begusarai) devoted special attention to project implementation and provided several field insights into conservation of Kanwar; **Mr. Sudhir Karn** (Advisor, Environment and Forest Department, Government of Bihar) coordinated data acquisition from various line departments. **Mr. Nishat Ahmed** (Director, Fisheries), **Mr. Rakesh Kumar** (Member Secretary, Bihar State Pollution Control Board), **Dr. Dipankar Saha** (Regional Director, Central Ground Water Board, Patna), **Mr. Sudhir Kumar Sahu** (Chief Engineer, Central Water Commission) and **Mr. Sunil Kumar Singh** (Executive Engineer, Water Resources Department) provided access to data on various aspects of Kanwar wetlands.

Mr. Arvind Mishra (Mandar Nature Club, Bhagalpur) for sharing waterbird census data and providing valuable insights into managing Kanwar as waterbird habitat.

Mr. Ali Hussain (an ardent birdwatcher from Manjhaul) and **Mr. Vakil Sahni** (President, Manjhaul Fishermen Cooperative Society) for sharing historical information on Kanwar and wetland status and trends

Communities of villages around Kanwar for participating in the rural appraisals, surveys and several rounds of discussions.

The work is dedicated to **Late Dr. C.L.Trisal (Founder Director, WISA)** who played an instrumental role in introducing scientific rigor to wetland management planning. WISA team continues to draw strength from his veritable insights on managing wetlands in a societal context.

Contents

Tables, Figures and Maps

Table

Figures

Maps

Acronyms

APHA	American Public Health Association
BOD	Biochemical Oxygen Demand
BNHS	Bombay Natural History Society
BWDA	Bihar Wetland Development Authority
CBO	Community Based Organization
CGWB	Central Ground Water Board
CIFRI	Central Inland Fisheries Research Institute
CPCB	Central Pollution Control Board
Cr	Crore
CRZ	Coastal Regulation Zone
CWRA	Central Wetlands Regulatory Authority
DFID	Department for International Development (UK)
DO	Dissolved Oxygen
FMIS	Flood Management Information System
FMISC	Flood Management Information System Cell
g	Gram
GIS	Geographic Information System
GPS	Geographic Positi oning System
GoB	Government of Bihar
GOI	Government of India
Ha	Hectare
HH	Household
IBA	Important Bird Areas
IMC	Indian Major Carps
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
KMA	Kanwar Management Authority
Km	Kilometre
km^2	Square Kilometre
Kg	Kilogram
kg/m^2	kilogram/square metre
KVK	Krishi Vigyan Kendra
LDA	Loktak Development Authority
LPG	Liquefied Petroleum Gas
MCM	Million Cubic Meters
M	Metre
m amsl	Metres above mean sea level
mg/l	Milligram per litre
ml	Millilitre
MoEFCC	Ministry of Environment, Forests and Climate Change
MoUD	Ministry of Urban Development
MoWRRD	Ministry of Water Resources, River Development and Ganga Rejuvenation
MT	Metric Tons
NABARD	National Bank for Agriculture and Rural Development
NGO	Non-Governmental Organization
NLCP	National Lake Conservation Plan
NPCA	National Plan on Conservation of Aquatic Eco-systems
NRSC	National Remote Sensing Center
NWCP	National Wetland Conservation Programme
PPM	Parts Per Million
PRA	Participatory Rural Appraisal
RRR	Repair, Renovation & Restoration
Rs.	Indian Rupees
SHG	Self Help Group
SRI	System of Rice Intensification
TA	Technical Assistance
UNESCO	United Nations Educational, Scientific and Cultural Organisation
US$	United States Dollar
UT	Union Territory
VHF	Very High Frequency
WIAMS	Wetland Inventory, Assessment and Monitoring System
WISA	Wetlands International South Asia
WWF	World Wide Fund for Nature
ZSI	Zoological Survey of India

Executive Summary

Kanwar Jheel is part of an extensive floodplain wetland complex formed in the lower reaches of Gandak – Kosi interfan in North Bihar. Located at a distance of 21 km from Begusarai town, Kanwar is largest of a series of shallow permanent and ephemeral wetlands formed in the depression between River Burhi Gandak and palaeochannel of River Bagmati. During monsoon, Kanwar connects with 17 adjacent waterbodies to form a large inundated area extending to nearly 6700 ha. With retreat of monsoon, the inundation shrinks to around 600 ha forming two small patches, Mahalaya and Kochalaya, thus exposing 2600 ha of grasslands, large parts of which are used for agriculture.

Kanwar plays an important role in maintaining hydrological regimes of the region. Besides being an important water source, Kanwar buffers adjoining settlements from flood risk by accommodating significant proportion of runoff and bankflows of River Burhi Gandak. Nearly 15,000 households living in 17 villages in and around the wetland harvest fish and aquatic plants for use as food, fodder and thatch. Kanwar teems with waterbirds in the winters, and is one of the important congregation areas in North Bihar, especially for migrating ducks and coots. The island of Jaimangalagarh located in its southern part has high archaeological and cultural significance. Considering high waterbird diversity, Kanwar has been designated as a sanctuary by the name of 'Kanwar Lake Bird Sanctuary' since 1989 under the provisions of Indian Wildlife (Protection) Act, 1972.

Despite such high ecological and socio-economic significance, management of Kanwar has received little attention in the region's developmental programming. Driven by perceptions of being waterlogged wasteland, the wetland complex has been subject to extensive hydrological regime fragmentation and conversion for permanent agriculture. Shrinking resource base has accentuated conflict between farmers and fishers.

The evaluation of various wetland features was done through field surveys, collation of existing published and unpublished literature, interpretation of remote sensing imageries, consultation with state government departments and participatory appraisals with communities living around the wetland complex, underlining the severely degraded state of Kanwar. The following status and trends emerge:

- Kanwar wetland complex is going through a phase of shrinking inundation regimes due reduced riverine connectivity, reduced rainfall (particularly since 2001), and changing balance of surface-groundwater use in the region. Peak inundation area has declined from 7,400 ha to 4,100 during the 1980 – 2010.
- Area as well as intensity of permanent agriculture within Kanwar has increased. As per remote sensing imageries, area under permanent agriculture within wetland has more than doubled during 1989-2010. The number of cropping cycles has increased from one to three in most areas, and traditional crops replaced by water intensive varieties as sugarcane and mentha. Inflowing channels connecting adjoining waterbodies to Kanwar have been blocked to protect croplands resulting in impeded natural silt distribution. Wetland farming has transformed from being based on natural inundation regimes to highly dependent on groundwater.
- Changes in flood pulses received in wetlands have altered the seasonal dominance pattern of aquatic vegetation. Available information on species richness indicates dominance of stress tolerant species of rotifers, planktons and fish.

- Capture fisheries in Kanwar have declined significantly. Fishing operations for four months yield an average daily catch of 3 – 4 kilogram per person as compared to 8 – 12 kilogram in the 80s. The proportion of Indian Major Carps has declined from 15-27% of catch in 1981 to less than 2% at present. Forage fishes constitute more than 50% of present fish catch.
- Production from culture fisheries operations within *maun* and *chaur* areas around Kanwar Jheel is significantly low (265 kg / ha as compared to a potential production of 1,500 kg /ha provided all ecological conditions are met). Decreased connectivity with rivers, reduced surface water availability, shortage of fries and fingerlings, and weak institutional arrangements are key constraining factors.
- Kanwar has prominent significance as a waterbird habitat, particularly for over 50 migratory species. While the instances of waterbird poaching have been significantly curtailed since designation as a bird sanctuary, increasing area under permanent agriculture and shrinking inundation regime are adversely affecting habitat quality. The number of waterbirds visiting the wetland has declined in the last 5 years.
- The social contract between the fishers and farmers living around Kanwar, which enabled the two dominant stakeholder groups to use the wetland area within an intra-annual variation of inundation regimes has been stressed due to declining resources and changing land use. A majority of fishers have gradually shifted to culture fisheries and wage labour as source of livelihoods. Declining state of Kanwar has enhanced livelihood vulnerability of majority of households already burdened by weak physical, health and financial infrastructure.
- Management of Kanwar under the provisions of Wildlife Protection Act while addressing the objectives of protection of waterbirds, is insufficient to ensure maintenance of hydrological regimes, and engage communities institutions in management of wetland complex. *Maun* and *chaur* areas are managed for revenue generation without any consideration for maintaining landscape connectivity and biological diversity values. There is no mechanism in place to cumulatively assess the impact of sectoral developmental programmes on wetland ecosystem services and biological diversity.

Recommendations

Kanwar needs to be managed for conservation of its rich biological diversity as well as securing sustained provision of its full range of ecosystem services which support livelihoods of dependent communities. Effective management arrangements are required to be put in place so as to maintain essential ecological and hydrological functions that underpin delivery of wetland ecosystem services and maintenance of biological diversity. Management also needs to be dynamic and adaptive so as to accommodate uncertainties and challenges that emerge from multiple drivers and pressures, and allow for suitable modification based on continuous site monitoring and amalgamation of new information. The following recommendations are made for integrated management:

1. Constitution of Kanwar Management Authority

The Government of Bihar vide its notification no: Wildlife – 16/2012 34 (E) has constituted the Bihar Wetland Development Authority (BWDA) as the nodal policy-making and planning agency related to wetlands. Under the aegis of the BWDA, it is recommended to constitute Kanwar Management Authority (KMA) as a unified institutional mechanism for integrated

management of Kanwar and associated maun and chaur areas. Implementation of various sectoral plans of water management, fisheries development, biodiversity conservation, agriculture development and livelihood improvement will be coordinated through KMA. The authority will be responsible for monitoring the ecological character of the wetland complex, enforcing regulation, periodic review and updation of management plan, communication and outreach on wetland values and capacity building of concerned state government officials. The Governing Body of the authority may be constituted under the chairmanship of Minister (Environment and Forests), Government of Bihar with representatives from state government departments of water resources, fisheries and animal husbandry, agriculture, revenue, tourism, rural development; representatives of fisher and farming communities; and local experts.
An Executive Committee under the Conservator of Forests will approve plans and projects to be implemented through an office of Chief Executive. The registration of the authority under the Societies Registration Act will ensure flexibility in fund raising and project implementation.

The current regulatory regime in place for Kanwar needs to be rationalized to encourage stakeholder led management with due consideration for compatibility of land and water use practices with wetland regimes. Landscape transformation had rendered large parts of sanctuary unsuitable for birds. In the present circumstances, redefining the sanctuary area to include Mahalaya, Kochalaya, and Choti Kochalaya may be more meaningful and ecologically efficient. The larger sanctuary area could be designated as a 'conservation reserve' or 'community reserve' under Section 36A and 36B of Wildlife (Protection) Amendment Act, 2002, creating a basis for participatory management by enabling local communities to define and enforce management regimes with due ecological and social consideration.

2. Restoration of hydrological regimes

- Selective dredging and retraining of the 12 kilometer long channel between Jaimangalgarh and Burhi Gandak through Bagras Maun is required to enable monsoon flows from the River Burhi Gandak to flow into Kanwar. Existing sluices on the channel could be oprated to allow only gradual depletion of water till arrival of southwest monsoon. In situations of high water level build up creating flood risks for settlements, the sluices can be operated to act as outlets.
- Outflows from the outer channel of Kanwar can be regulated through a regulator at Harsainpul. The structure may consist of a 2m high check dam with regulators so as to prevent depletion of water below 35 meters amsl.
- Existing channel between Chanha and Matihani Chaur should be rejuvenated to enahcne hydrological connectivity. The feasibility of linking wetland complex with the river through sluices at Mohwalipur, Bariarpur and Basahi and connecting canals should also be assessed for implementation. The following existing drainages should be rejuvenated to enhance hydrological connectivity within wetland complex: Matihani Chaur to Guhabari Chaur (10.5 km), Matihani Chaur to Kanwar (10.0 km), Bikrampur chaur to Guhabari chaur (5.2 km), Nagri Jheel with channel leading to Guhabari Chaur (2.0 km), Rakshi Pond with channel leading to Kanwar (2.3 km) and Siltha chaur with channel leading to Kanwar (1.3 km).
- Selective dredging of 2614 ha of highly silted up areas of Bikrampur Chaur, Guhabari Jheel, Nagri Jheel, Rahuya Chaur, Dasin and Siltha Chaur, Pachaula Chaur, Bagras Maun should be carried out enhance water holding capacity and overall wetland water regime stability. Any further

modification of elevation profiles within wetland complex, especially for agriculture needs to be prevented.

- Hydrological regime requirement (water quantity and quality in spatial and temporal terms) for wetland functioning should be assessed and ensured through suitable modification of embankments on River Kosi and Gandak, and other upstream hydraulic structures.

3. Sustainable Fisheries Development

- Complementing the interventions for restoring hydrological regimes, fish diversity as well as productivity can be enhanced by demarcation and protection of fish breeding and spawning grounds, complete prohibition of use of small meshed size fishing gears (particularly mosquito nets or *Chattijal*), and restocking (for a period of five years) using fingerlings of carps and native fish varieties at an interval of one breeding cycle.
- Institutional structure of the three fisher cooperatives of Cheriabariapur, Chaurahi, Khanjahanpur and Bakhri should be revised to ensure professional management. Wherever required, bye laws for management of society operations may be facilitated. Training workshops on sustainable fish culture practices; management of fish hatchery; integrated fish farming; ornamental fish and crab culture; wetland values and functions and policy and regulatory requirements for fish culture should be organized. Seed capital support for culture fishery operations should be ensured through Fisheries Department and NABARD.
- A community multi stakeholder forum be created to manage various resource use conflicts associated with Kanwar.
- Improve utilization of fish production potential in the maun and chaur areas around Kanwar, through construction of two fish hatcheries of capacity 0.2 million seeds / cycle in Karor and Cheria-Bariarpur and modernization of existing nursery complex at Jaimanglagarh. One ice manufacturing unit should be constructed at Manjhaul fish market to meet ice requirement of fish vendors.

4. Enhancing biodiversity habitats

Identification, demarcation and management of waterbird habitats should be carried out based on inventory and mapping and constitution of bird protection committees. Wildlife staff should be periodically trained in waterbird assessment, monitoring and migration studies. Construction of watch towers, procurement of equipment for bird watching and mobile vans and boats for patrolling is required to improve surveillance. Aquatic vegetation needs to be monitored periodically, especially for the spread of emergent species. Pilot project on economic use of Phargmites may be set up in partnership with paper industry.

5. Sustainable agriculture development

- Regulation of cropping pattern within the core inundation area in line with fluctuating hydrological regimes, through reducing cropping cycle , allowing for lands to be left fallow during monsoons for natural soil enrichment and reducing area under water intensive perennial crops
- Promoting sustainable agri-practices which economize water use and enhance productivity such as System of Rice Intensification (SRI). Use of climate resilient crop varieties, bio-manures, multiple cropping, crop rotation and adoption of eco-friendly practices. Incentives in the form of farming equipment, training and soft loans may be provided to farmer groups for adoption of sustainable agro-techniques

6. Ecotourism development

Restoration of hydrological regimes and improvement of biodiversity habitats is likely to create significant ecotourism opportunities. For this purpose, a comprehensive ecotourism development plan with detailed zoning of the wetland complex taking into account habitat diversity, ecological requirements of wetland biota and cultural values associated with Kanwar should be developed and implemented.

7. Establishment of a hierarchical wetland inventory, assessment and monitoring system

An integrated system to support establishment of ecological and socioeconomic information baseline, assessing efficiency of management interventions and determining impacts of developmental projects on Kanwar and associated wetlands needs to be put in place. A state of the art wetland monitoring and research center may be established at Jaimangalagarh for monitoring the ecological, hydrological and socio-economic features of Kanwar and function as the coordinating center for all inventory and assessment programmes. The center shall be supported through a network of field stations established to monitor hydrological regimes, water quality, and related ecological aspects. Research on ecosystem services, hydrological regimes, waterbird habitat and health, fish breeding and migration, and climate risk and wetland vulnerability may be commissioned to inform wetland management.

8. Improvement of quality of life

- Comprehensive coverage of water, sanitation, health and disaster risk reduction facilities for 23 villages around Kanwar
- Introduction of dairying, duck farming, dry fish marketing, vegetable marketing and ornamental fish culture projects as alternate livelihoods for 2000 fishing households.
- Formation of SHG/farmers groups in 17 villages and implementation of following alternate income generation programme with technical support of Rajendra Agricultural University, Samastipur and Krishi Vigyan Kendras (KVKs) on mushroom cultivation; animal husbandry, poultry and dairy activities; seed and agri-produce trading; horticulture and enterprise development
- Strengthening community managed disaster risk reduction planning and infrastructure in all 17 villages around Kanwar who are routinely exposed to risks of flooding

Budget

Implementing the action plan is expected to entail an outlay of Rs. 150 crores over a period of 5 years. Of this, 49% is allocated to the component of ecosystem restoration, 40% for sustainable resource development and livelihood improvement and 11% for institutional development. Restoring hydrological regimes requires maximum outlay of Rs. 46 crores.

1 Introduction

Harvesting of fish and fodder in Kanwar

1.1 Background

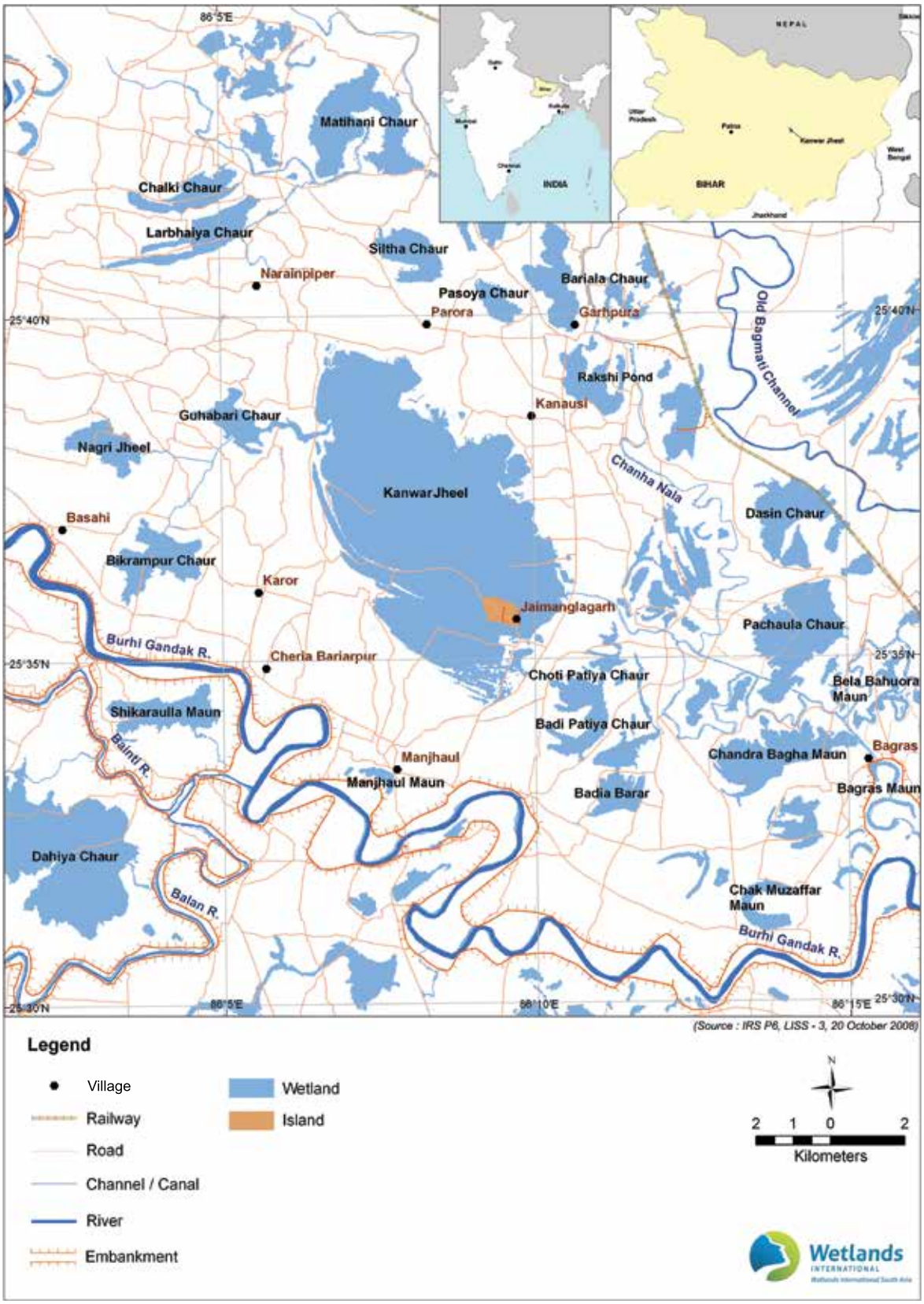
The management planning framework for Kanwar Jheel represents commitment of Government of Bihar to support conservation and wise use of this biodiversity rich, ecologically sensitive, and socio-economically important wetland of the state.

Kanwar Jheel is part of an extensive floodplain wetland complex formed in the lower reaches of Gandak – Kosi interfan in North Bihar. Located at a distance of 21 km from Begusarai town, Kanwar is largest of a series of shallow permanent and ephemeral wetlands formed in the depression between River Burhi Gandak and palaeochannel of River Bagmati. During monsoon, Kanwar connects with 17 adjacent waterbodies to form a large inundated area extending to nearly 6700 ha. With retreat of monsoon, the inundation shrinks to around 600 ha forming two small patches, Mahalaya and Kochalaya, thus exposing 2600 ha of grasslands, large parts of which are used for agriculture.

Kanwar plays an important role in maintaining hydrological regimes of the region. Besides being an important water source, Kanwar buffers adjoining settlements from flood risk by accommodating significant proportion of runoff and bankflows of River Burhi Gandak. Nearly 15,000 households living in 17 villages in and around the wetland harvest fish and aquatic plants for use as food, fodder and thatch. Kanwar teems with waterbirds in the winters, and is visited by over 60 species during their annual migration cycle. Besides birds, recorded biodiversity of Kanwar includes 51 ish, 77 terrestrial plants, 46 macrophyte, 44 phytoplankton, 71 zooplankton and 17 molluscan species, several of high conservation significance. The island of Jaimanglagarh located in the southern part of the wetland is associated with high archaeological significance. The temple of local deity, 'the Jaimangla' on the island forms an integral part of culture and belief system of the local communities.

Despite such high ecological and socio-economic significance, conservation and sustainable management of Kanwar has received very limited attention in state's developmental programing. Flood control embankments constructed along River Burhi Gandak during the 50s have impeded the thus impeding the natural hydrological connectivity of the river with the wetland complex. Support to policies for enhancing agriculture brought in tremendous pressure on the naturally fertile floodplain wetlands as Kanwar. Efforts to reduce area under permanent inundation were initiated in the 50s by constructing canals that connected the wetlands to River Burhi Gandak and aided drainage. Agriculture has gradually intensified with the reduction in inundation areas (from over 6000 ha in the 80s to 4100 ha in 2010), and traditional varieties giving way to more water demanding cash crops like sugarcane and mentha. Further, the waterbirds were subject to intensive poaching during the 80s. Reports of 1984 – 85 indicate that local duck trappers netted over 135,000 birds in one season alone. Shrinking resource base has further accentuated conflicts between farmers and fishers, the latter having to shift to culture fisheries and agriculture labour as source of livelihood. Kanwar has gradually transformed into contested common with wetland use made subservient to conflicting sectoral and stakeholder interests.

In an effort to control wanton killing of waterbirds, the Government of Bihar declared a large part of Kanwar Jheel as a sanctuary by the name of 'Kanwar Lake Bird Sanctuary' in 1989 under the provisions of Indian Wildlife (Protection) Act, 1972. Management of the protected area was vested with the State Forest Department. A management plan for the site considering the needs of protected area management was drafted in 2004 (GoB, 2004). However, final proclamation



Map 1 | Kanwar wetland complex

of sanctuary could not be done as private claims on the land still remain unsettled. Limited interventions in the form of afforestation of parts of Jaimanglagarh island were however made.

Kanwar Jheel, Bariela and Kusheshwarsthan were identified by the Government of Bihar as wetlands of national importance under the National Wetland Conservation Programme (presently merged into National Plan for Conservation of Aquatic Ecosystems - NPCA); though no substantial funding support was received under the programme.

In order to develop a coherent strategy for wetlands conservation, the Government of Bihar identified wetland management as one of the thematic areas for support under the World Bank – DFID Trust Fund supported Bihar Capacity Building Technical Assistance Programme. Considering the high ecological significance, complexity of resource use and associated pressures Kanwar Jheel was identified for development of an integrated management planning framework to create a basis for conservation and sustainable management of the site, and to bring in additional wetlands under the purview of integrated management subject to availability of resources, capacities and funding opportunities. An advisory group was constituted in 2011 to provide strategic direction and expert inputs to wetland restoration.

Wetlands International South Asia was assigned the task of developing the management planning framework for Kanwar Jheel, keeping in purview the requirements of the Wildlife (Protection) Act, 1972, the Wetlands (Conservation and Management) Rules, 2010 of the Ministry of Environment, Forests and Climate Change, Government of India (MoEFCC). The management planning process received extensive field support from the Government of Netherlands funded 'Partners for Resilience' programme being implemented by Wetlands International South Asia in Gandak-Kosi floodplains. The programme aims at building livelihood resilience to disaster risks by integrating ecosystem restoration component within disaster risk reduction, sustainable livelihoods and climate change adaptation strategies. The present management planning framework is the outcome of the support received under the DFID-World Bank Technical Assistance and Partners for Resilience programme.

1.2 Management planning purpose and objectives

Kanwar Jheel is a multi-functional ecosystem supporting rich biodiversity as well as livelihoods of dependent communities. Being situated in a densely populated, dynamic landscape, it is open to influences from natural as well as human factors. An overall agreement is essential between stakeholders on the overall strategy, mechanisms and actions required to ensure that Kanwar continues to sustain rich biodiversity and provide a diverse range of ecosystem services. Management planning process provides the basis for achieving such an agreement.

The need for maintaining wetland biodiversity, while at the same time delivering ecosystem services now and in the future for human well-being necessitates adoption of management approaches which recognize linkages between livelihoods, wetland functioning and biological diversity. India, as a Contracting Party to Ramsar Convention on Wetlands, is committed to wise use of all wetlands in her territory. Management planning is an instrument to outline the pathways through which wise use of wetlands can be achieved.

Wise use is the longest established example amongst intergovernmental processes, implementation of which have become known as ecosystem approaches for conservation and sustainable development of natural resources,

including wetlands. It is defined within the text of Ramsar Convention as "the maintenance of their ecological character, achieved through implementation of ecosystem approaches, within the context of sustainable development". Ecological Character is defined as "the combination of ecosystem components, processes and benefits / services that characterize the wetland at any given point of time". The wise use principle encourages stakeholder engagement and transparency in negotiating trade-offs and determining equitable outcomes for wetland conservation while promoting maintenance of environmental, economic and social sustainability.

Wise use has been highlighted as the guiding approach for wetland conservation in the National Environment Policy (2006), National Biodiversity Action Plan (2008) and as the primary objective of the National Plan for Conservation of Aquatic Ecosystems (NPCA) of the Ministry of Environment, Forests and Climate Change, Government of India.

Site-based management planning is also recognized as an element of a multi-scalar approach to wise use planning and management. The management plan provides a basis for linking with broad-scale landscape and ecosystem planning, particularly at the river basin scales, as policy and planning decisions at these scales affect conservation and wise use outcomes at site level. The following specific objectives are intended to be achieved through management planning:

- outlining a strategy for identification of site management objectives;
- describing management actions required to achieve objectives;
- determining the factors that affect, or may affect, the various site features and functions;
- defining monitoring requirements for detecting changes in ecological character;
- supporting resource mobilization;
- enabling communication within and between site managers and stakeholders; and
- ensuring compliance with local, national and international policies and regulatory frameworks.

1.3 Approach

Wetlands under the Gangetic floodplains evolve and function within physical templates, characteristics of which are determined primarily by the interaction between water and sediments. The ecological components, processes and services of Kanwar are influenced by land and water management practices within the immediate as well as indirect catchments of the wetland complex. Management planning for Kanwar therefore calls for an approach which recognizes the interconnectedness of wetland biological diversity and ecosystem services with land and water management in the river basin taking into account the external, natural and induced factors. The approach also needs to address climate change which has direct as well as indirect implications for wetland features as well as factors governing these features. The wise use principle encourages stakeholder engagement and transparency in negotiating trade-offs and determining equitable outcomes for wetland conservation while promoting maintenance of environmental, economic and social sustainability. An Integrated Water Resources Management (IWRM) has therefore been adopted as the management planning approach.

IWRM is based on the concept of water being an integral part of an ecosystem, a natural resource and a social and economic good, whose quantity and quality determines the nature of its use (Agenda 21, United Nations, 1992). The framework brings together stakeholders at all levels considering their needs and aspirations while ensuring conservation of the wetland

ecosystem within the river basin. A critical requirement for IWRM at river basin level is introduction of land use and water planning and management mechanisms, which focus at the river basin scale. More recent developments in the field encourage consideration of sociological aspects, particularly political economy and ecology while analysing hydrological processes which is highly relevant for wetlands of North Bihar in general and Kanwar in particular.

IWRM at river basin scale is also underlined in the New Guidelines for Management Planning as endorsed by the Eighth Meeting of Contracting Parties to the Ramsar Convention[1]. The need to integrate site management plans into public developmental planning system at local, regional and national levels is emphasized. In order to safeguard site and its features, the planning process recommends adoption of an adaptable management process which allows wetland managers to respond to the legitimate interest of others, adapt to ever-changing political climate, accommodate uncertain and variable resources, and survive the vagaries of nature.

The National Environment Policy (2006), Government of India, recommends integration of conservation and wise use of wetlands into river basin management involving all relevant stakeholders, in particular local communities, to ensure maintenance of hydrological regimes and conservation of biodiversity. It 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 ongoing rural infrastructure development and employment generation programmes. If considered as natural infrastructure capable of providing water and food security, buffering extreme events and supporting adaptation to climate change, the ecosystem services of Kanwar can support achieving outcomes for several sectoral development plans, particularly for water resources, agriculture, rural development and disaster risk reduction. The Wetlands (Conservation and Management) Rules, 2010 provide an institutional mechanism to prevent any fragmentation of hydrological regimes through hydraulic structures, diversions, encroachments or impeding flow pathways.

The broad approach for management planning is characterized by the following:

- Using wetland ecological character and basin level land and water management interactions as basis for setting management objectives and targets.
- Integrating wetland management within sectoral developmental programming particularly water resources, agriculture, fisheries, rural livelihoods and disaster risk reduction.
- Balancing needs of biodiversity conservation with securing livelihoods of wetland dependent communities.
- Promoting cross-sectoral institutional arrangements and involvement of local communities and stakeholders in wetland management.
- Integrated wetland inventory, assessment and monitoring system to support decision making.
- Preventive measures for combating the root cause rather than symptomatic handling of indicators of adverse changes in wetland ecological character.
- Integrating traditional knowledge and practices with assessments and management planning processes.
- Periodic monitoring and evaluation with focus on achieving goals and objectives.

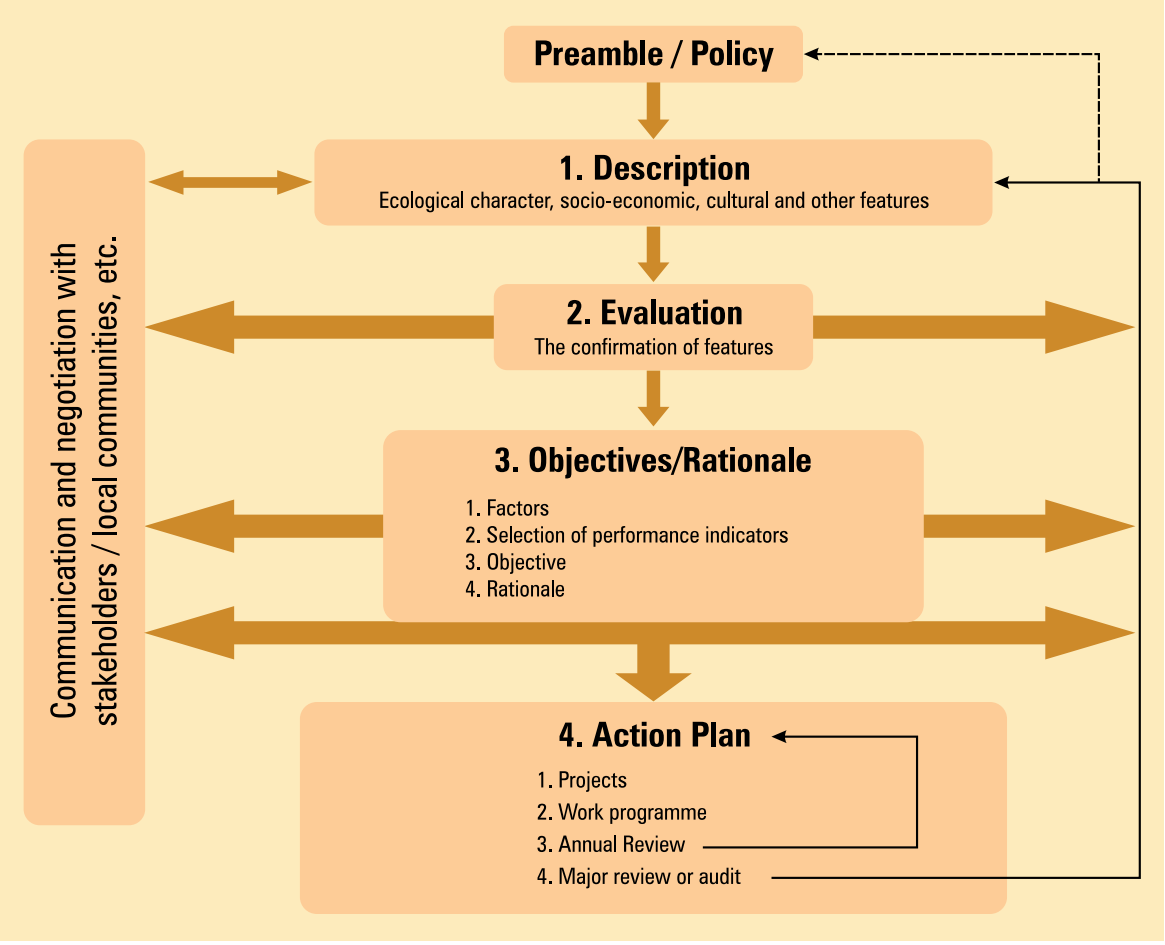
[1]Resolution VIII.14 – New Guidelines for management planning for Ramsar sites and other wetlands. Also available as Ramsar Handbook 18, Fourth Edition, 2010

1.4 Methodology

The methodology adopted for management planning follows largely the Ramsar guidelines, which recommend a diagnostic approach based on a critical evaluation of ecological, economic and socio-cultural features to identify objectives and operational limits (Fig. 1). The management planning includes the following steps:

- establishment of preamble/ policy;
- evaluation of wetland features and governing factors for describing status and trends in ecological character and identification of threats;
- review of current institutional arrangements in terms of ability to maintain ecological character and in particular respond to drivers and pressures that have adverse impacts;
- define a monitoring plan to support integrated management; and
- identification of management planning components, outcomes, performance indicators, activities and implementation strategy.

Management planning objectives were set based on consultation with Forest Department, MoEFCC and local stakeholders. Evaluation of wetland features was based on review of published



(Source: Ramsar Handbook 18)

Fig. 1 | Wetland Management Planning Framework

literature, GIS and remote sensing assessments, and expert consultations. An important part of evaluation was a socio-economic survey and participatory appraisals in 17 villages covering 481 households representing all stakeholder groups. Information from published literature, and field assessments were used to define status and trends in ecological character and to identify threats. These formed the basis for defining management objectives and strategies.

The management planning framework was formulated by a team of experts having specialization in water resources management, biodiversity conservation, protected area management, community livelihoods and institutional development.

A team of officials from concerned state government departments was constituted by Forest Department, Government of Bihar to facilitate access to government information (Annex I). Reviews were organized by World Bank and Government of Bihar to discuss management approaches and key intervention strategies.

1.5 Report structure

The management planning framework is presented in five sections. The purpose, approach and methodology have been outlined in the introductory chapter. Evaluation of wetland features and description of wetland ecological character is contained in Chapter 2. Chapter 3 recommends an institutional arrangement for integrated management of Kanwar wetland complex. Chapter 4 outlines monitoring and evaluation strategy whereas Chapter 5 contains the management planning framework and corresponding financial projections.

2

Description and evaluation of wetland features

A fisher in Kanwar

2.1 Evaluation of wetland features

Location and Extent

The Indo- Gangetic biogeographic region is characterized by the presence of numerous palaeo levees, cut off loops and ox-bows formed by meandering of river channels. Such channel avulsion has left many natural depressions and cut-off meanders, later fed by rainwater and overbank flows to form marshes and ephemeral wetlands locally termed as maun, chaur, taal and jheel areas.

Kanwar Jheel is the largest of a complex of 18 such interconnected wetlands formed in the lower reaches of River Burhi Gandak. Situated in Begusarai district in North Bihar, the wetland complex spans an area of nearly 10,000 ha between 25.5 – 25.74o N latitudes and 86.02 – 86.27o E longitudes. Roads connecting Rampur-Rajwa and Sanjat Chak mark the north and west boundaries of the complex. Channels of Burhi Gandak and Old Bagmati mark the southern and eastern margins respectively (Map 2.1).

Kanwar Jheel contains a mosaic of landforms including open water, marshes, plantations, agricultural lands and interspersed settlements. The entire complex gets inundated with monsoon to a maximum depth of 1.5 m. The eastern part maintains open water and marsh areas almost round the year, whereas in the rest, dried out marsh areas are cultivated.

Diffused hydrological boundaries and diversity of land uses, particularly increasing incursion of permanent agriculture within seasonally inundated areas pose challenges in defining extent of Kanwar. The Directory of Asian Wetlands refers Kanwar extent to be around 7,400 ha but does not provide corresponding spatial boundaries (Scott, 1989). Ghosh et al. (2004) based on an analysis of remote sensing imageries report that Kanwar covered an area of 6,786 ha in 1984 which shrunk to 6,043 ha by 2002. Imageries of 2010 indicate that the area under inundation has shrunk further to around 4,100 ha. Using current inundation area as wetland extent is gross underestimate, as it pertains to a period of less than average rainfall. During normal monsoon year, much larger areas are likely to be inundated.

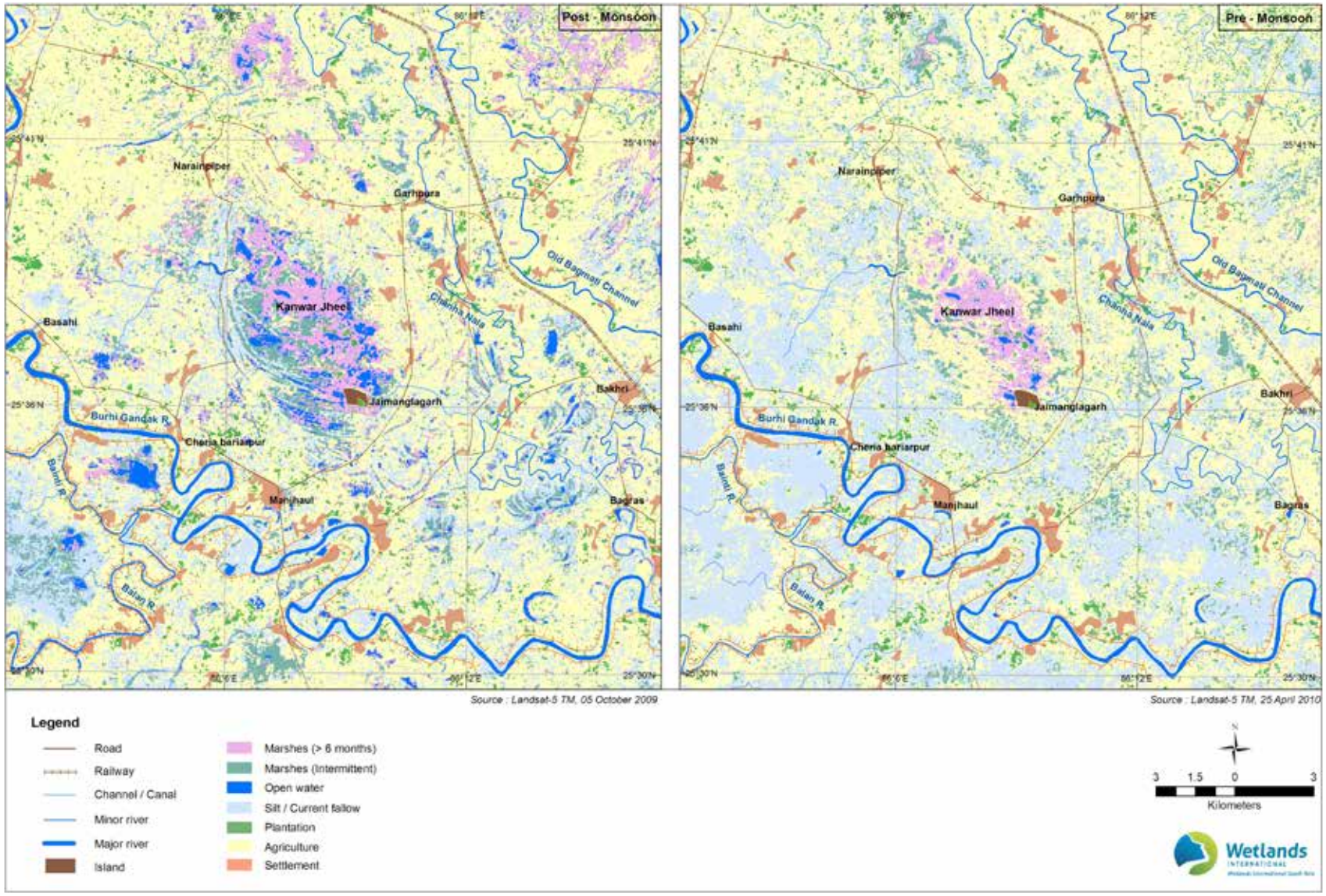
Interpretation of remote sensing imageries, inundation patterns and field interviews indicate that even after construction of embankment along River Burhi Gandak in the 1950s, Kanwar extended, during periods of high flows, to include Nagri Jheel, Bikrampur Chaur, Guhabari, and Chalki Chaur creating an inundation area of around 6,750 ha. Of this, nearly 1,500 ha were under agriculture and the rest as open water areas and intermittent marshes. Over a period of time, nearly 2,600 ha of wetland have been converted for permanent agriculture. Even within the current inundation area of 4,100 ha, an area of 1,775 ha is under agriculture (737 ha under permanent and the rest seasonal). Based on these analyses, the extent of Kanwar for the purpose

Chaur areas are shallow depressions in the inter-levee tracts bordering large rivers, which are seasonally inundated by the overspill from main river channel during the monsoon.

Maun are typical remnants of rivers, small and crescent-sha ped formed as the outer side of bends of slow-moving rivers gets eroded away more rapidly than the inner side, leading to channel avulsion. They are also called oxbow lakes

Taal refers to an expensive regimes of shallow ephermal wetland

Jheel is a large body of standing water that occupies an inland basin of appreciable size.



Map 2.1 | Seasonal changes in land use land cover in Kanwar Jheel

Table 2.1 | Area under land use and land cover categories in Kanwar (in ha)

	Post monsoon (October 2009)	Pre monsoon (April 2010)
Open water	602	100
Marsh	2759	1637
Plantation	237	237
Silt/Current fallow*	745	1603
Agriculture	2390	3153
Settlement	25	25
	6 755	6 755

*includes area under silt and sand.

(Source: Analysis of Landsat TM imageries, 30 m resolution)
Note: Silt/Current fallow includes areas under sand/silt and the areas left fallow in the respective cropping season

of management planning is estimated to be 6,750 ha, of which nearly 2,600 ha are converted agricult ural lands likely to be inundated during conditions of normal rainfall, bank flows and near-surface groundwater tables. Table 2.1 indicates the temporal dynamics of land use and land cover change within Kanwar. The Kanwar Bird Sanctuary with an area of 6,311.63 ha covers a major part of Kanwar Jheel. Map 2.2 indicates the land use and land cover of Kanwar as in 1976 and 1989.

Geology and Geomorphology

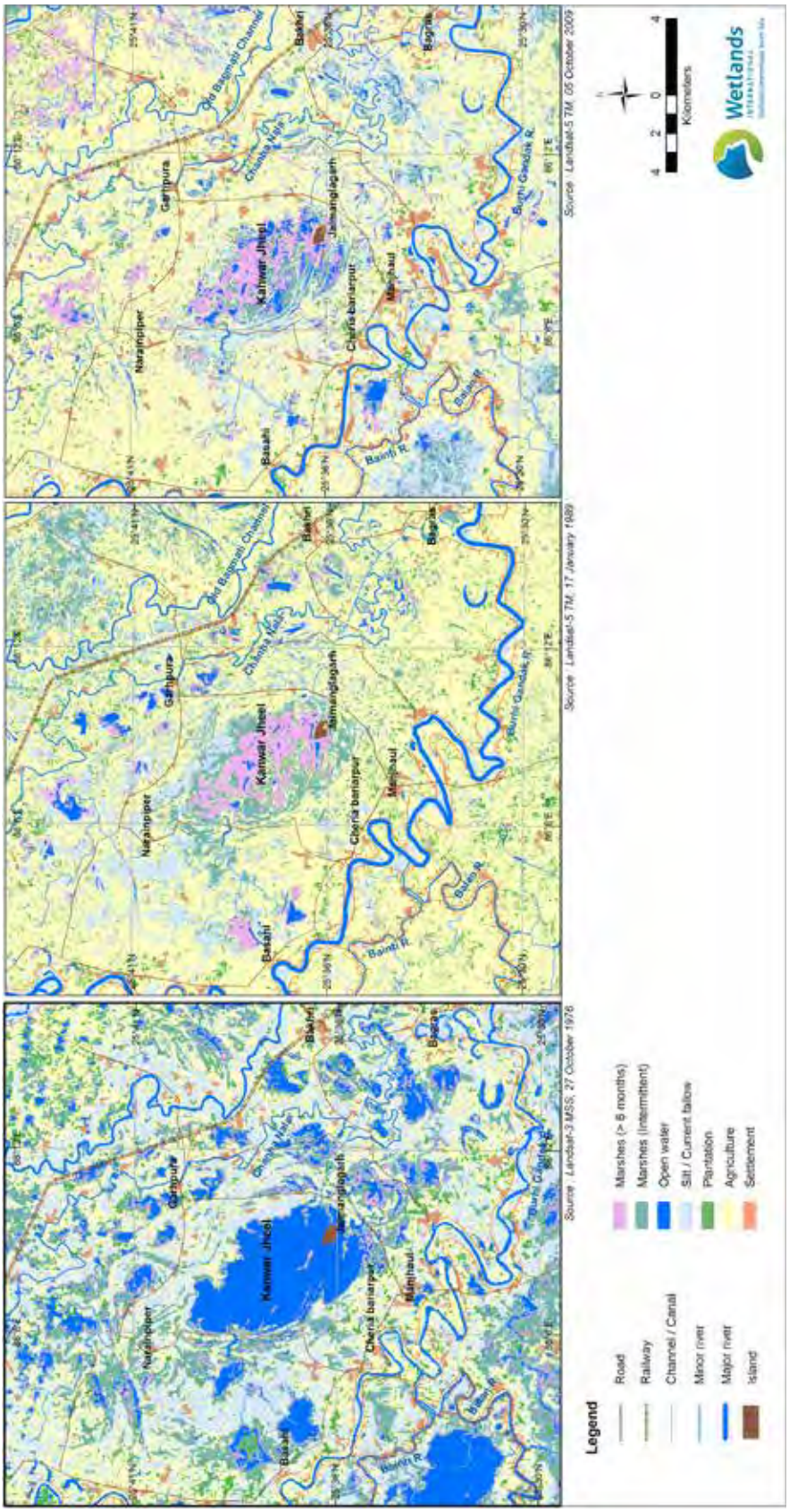
The Kanwar wetland complex plains is located within the North Bihar Plains. These are a part of the Indo-Gangetic plains which are one of the world's largest areas of quaternary alluvial sedimentation formed on the Indian Plate lithosphere flexed downwards in response to the over-riding of Himalayas following collision of the Indian and Asian plates. The Indo-Gangetic plains therefore mark the present extent of the evolving foreland basins of the Himalayas (Parkash and Kumar, 1991) and extend for about 200 km from the hills of Peninsular India in the south to the foothills of the Himalayas in the north.

The North Bihar plains are drained by eight major tributaries of River Ganges, namely Gandak, Burhi Gandak, Bagmati, Adhwara, Kamla-Balan, Kosi and Mahananda (from west to east) (Map 2.3). Based on their origin areas water sources, the river systems can be broadly classified into being mountain-fed (Gandak and Kosi originating in high mountains of Himalayas with a large upland source area), foothills fed (Bagmati system originating in the lower foothills bordering the alluvial plains), plains fed rivers (Burhi Gandak, fed by runoff from the plains or by sub-surface flows from the alluvium) and mixed fed rivers (as Kamla-Balan system drained by tributaries belonging to any of the two types). The mountain fed rivers are characteristically braided due to large fluctuation of discharge and sediment load. In contrast, the foothills fed river systems exhibit meandering morphology, are only braided proximally, and distally become unbraided and sinuous. The plain fed systems have drainage similar to the distal parts of foothills fed systems.

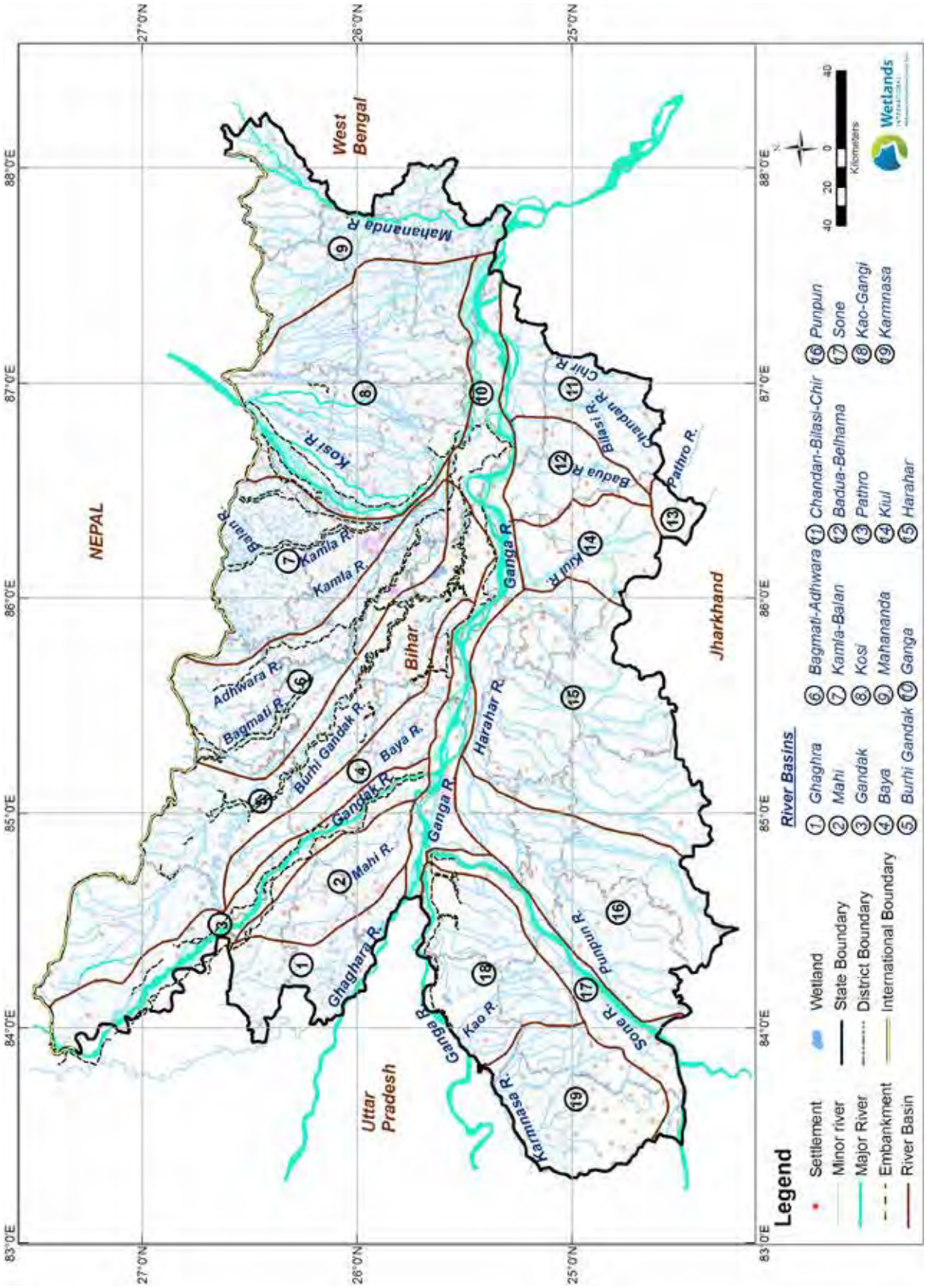
The river system, sediment flux and tectonism in the North Bihar plains give rise to two megafans, namely the Kosi and Gandak megafans. These are sites of high rate of sediment deposition, with their length and steepness affecting the infiltration of water in soil and ultimately governing the runoff. An interfan area exists between the two megafans, dividing into an 'upstream interfan area' of gently converging rivers that flow, on average, perpendicular to the mountain front and a 'downstream interfan area' where the more sinuous channels of Burhi Gandak, Bagmati, Kamla and Balan flow generally south-eastwards (Sinha and Friend, 1994).

The north-south profile in the plains seems to reflect the dominance of supply of sediments from the Himalayas (ibid). The Kanwar wetland complex is situated in the Gandak – Kosi interfan area (Map 2.4).

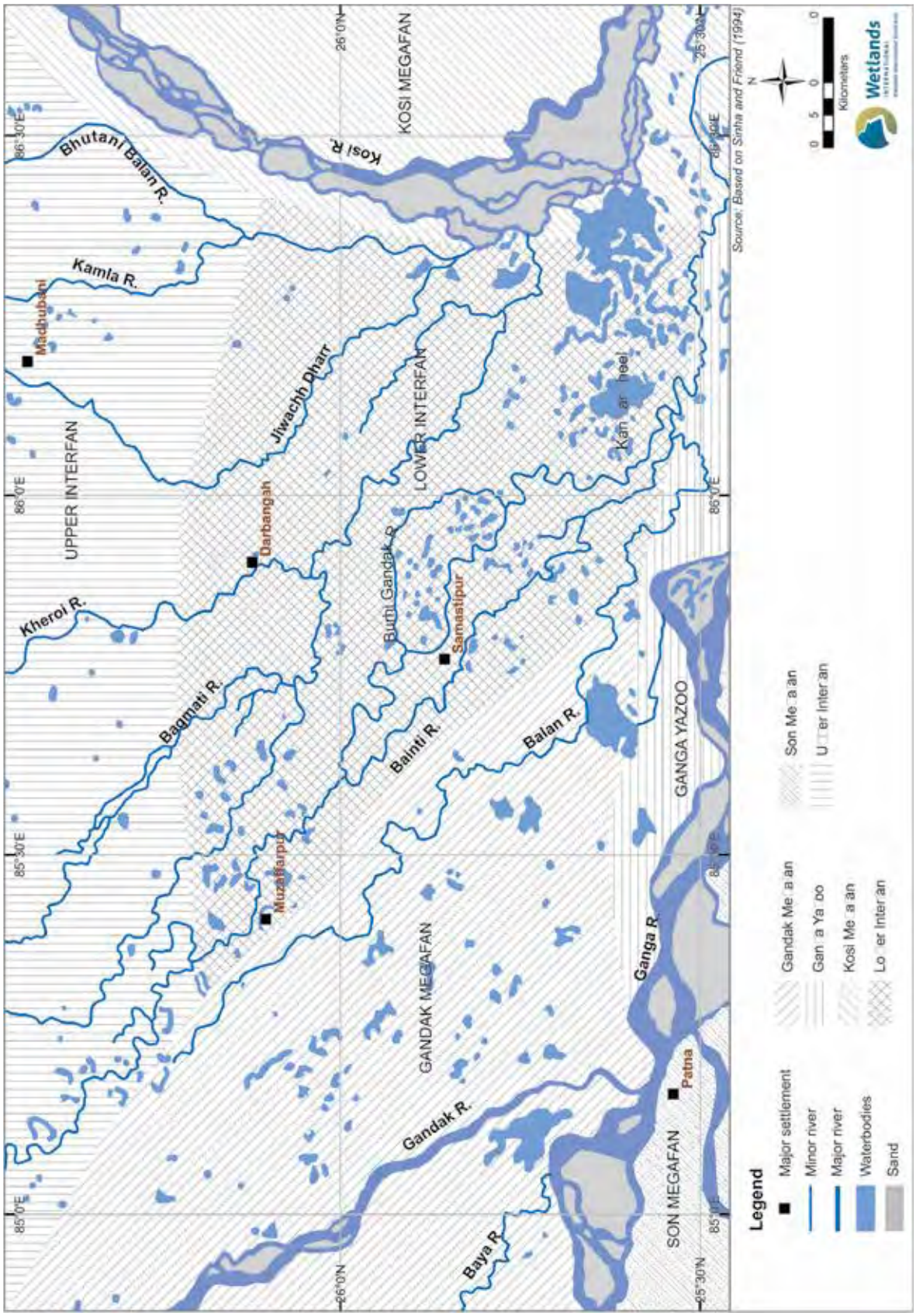
The entire Indo-Gangetic basin is believed to have been formed during late Palaeogene-Neogene times and abounds in buried faults and grabens. The Quaternary sediments of the Indo-Gangetic plains are traditionally subdivided



Map 2.2 | Land use land cover of Kanwar (1976, 1989 and 2009)



Map 2.3 | River basins of Bihar



Map 2.4 | Gandak and Kosi megafans and interfan areas

into the older and younger alluvium, locally called *Banger* and *Khader*. Entire area of Begusarai falls in the domain of *Khader* sediments. The megafans are underlain with extensive sand sheets, and the interfan area with minor sheets and sand ribbons. The rest of the interfan area is characterized by thick muddy sequences formed by overbank deposition. Sand and mud layers (representing channel margins), organic rich mud (representing low backswamp areas) and soil horizons are the other major sequences found in the alluvial plains (Sinha, 1995). Texturally, soil varies from sandy loam to loam in the meander scroll and levee areas, to silty loam and silt in flood basin areas of the Himalayan Rivers and from loam in the levees of Ganga to clayey loam and clay in the basin of River Burhi Gandak and River Bagmati (Map 2.5). Clayey silt and silty clay are the most dominant units in the floodplain sediments due to frequent and extensive overbank flooding of the interfan rivers carrying exceptionally high suspended sediment load (ibid) (Fig 2.1).

Formation of wetlands in the northern plains is closely related to the fluvial processes taking place in the northern plain rivers, key being lateral migration, bank erosion and overbank flooding. Their occurrence is most conspicuous in the Gandak-Bagmati interchannel area. The River Burhi Gandak (old Gandak) is believed to have developed on the palaeocourse of braided Gandak River, which migrated westward about 100 years ago apparently in discrete steps by avulsion (Sinha, 1996). Meander cut-offs have led to formation of several ox-bow lakes along the course of Burhi Gandak, of which Brahmapura, Manika, Motijheel are important and significant. Similarly, local alluvial topography developed through vertical accretion of floodplains and overbank flows of sediments have resulted in a number of backwater marshes of which Kanwar is prominent. Water levels in these marshes is sustained through a range of factors including rapid water delivery system through the palaeochannels and relative rise in water tables.

Within the wetland complex the southward progression of Burhi Gandak River is evidenced by the presence of predominating flood basin sediments at Bikrampur to channel fill and levee sediments at Cheria-Bariarpur south of Bikrampur and predominantly channel fill sediments at Sewari which is further south near Burhi Gandak River's present channel course. The micro-ridges of the flood plain are silty in nature, while the adjoining swale areas contain clayey loam. The floor of the Kanwar Jheel is covered by black clay mixed with peat.

Based on consideration of relief, maturity of land forms, degree of oxidation of soil profiles and indurations the area around Kanwar can be broadly divided into an active meander belt, the older floodplain and the Manjhaul Terrace (GSI, 1984). The Manjhaul terrace occupies the highest relief in comparison to the adjoining areas and comprises of loam and silty loam. The

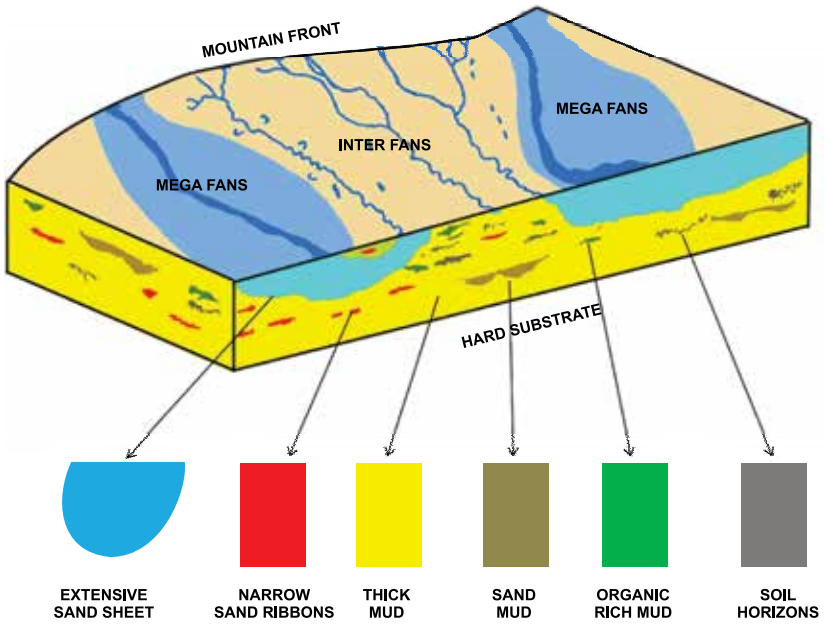
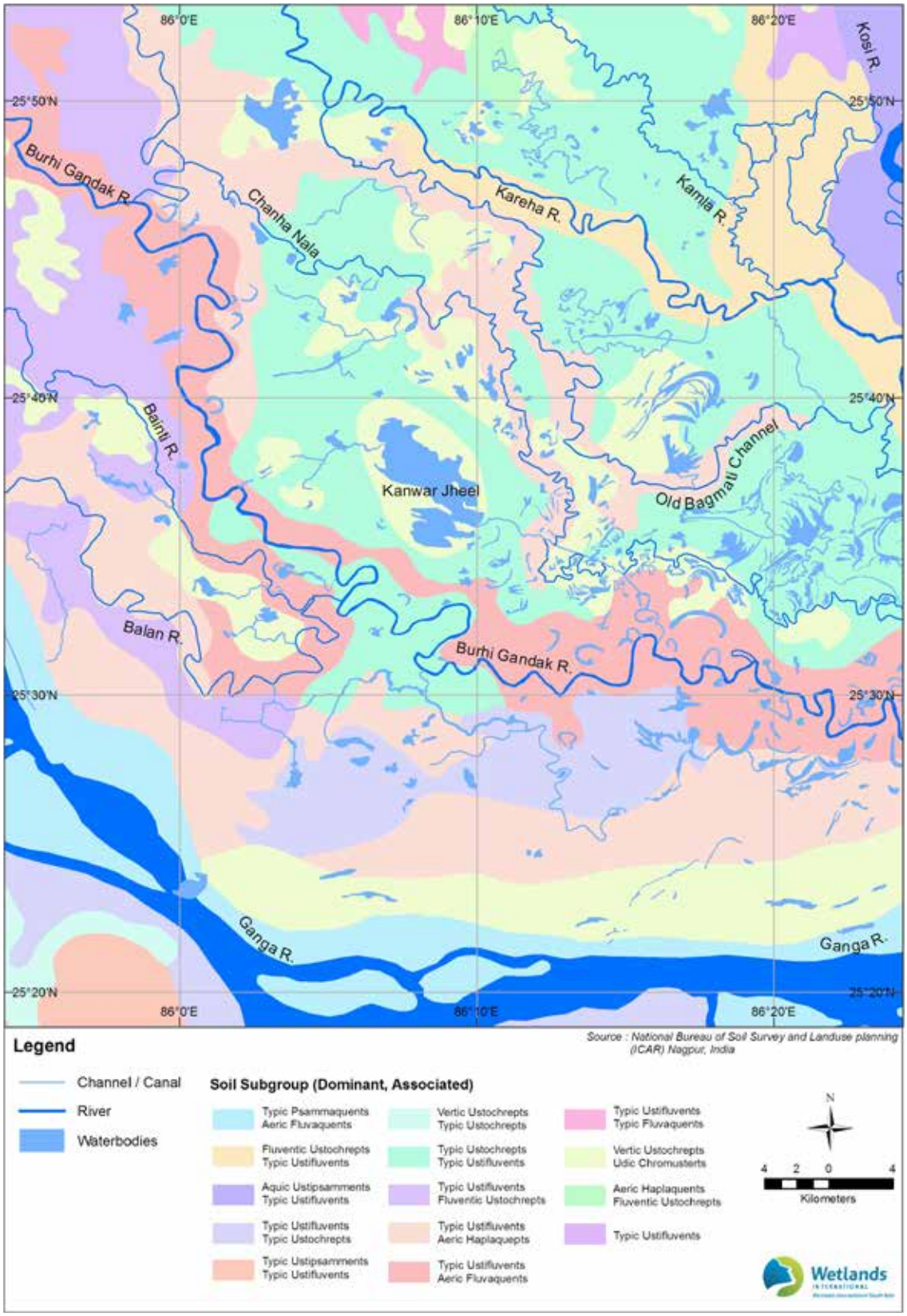


Fig. 2.1 | Alluvial architecture in Gandak-Kosi megafan and interfan area

(Source: Sinha, 1995)



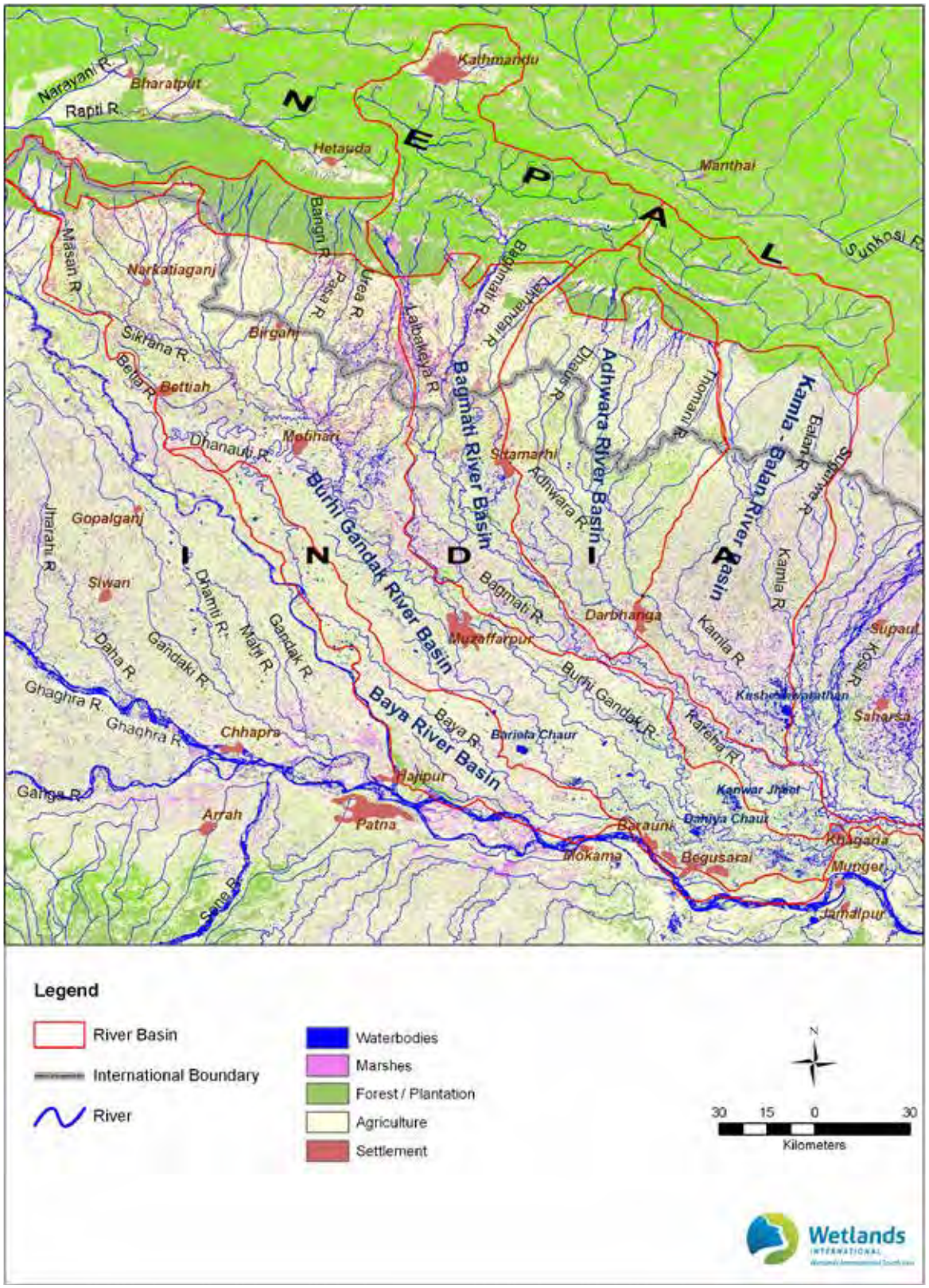
Map 2.5 | Soil types of River Burhi Gandak and adjoining river basins

alluvial profile of the entire area around Kanwar comprises of bottom gravelliferous sand deposits and top clay formation. This top clay occurs towards the western half of the area with varying thickness, the maximum thickness of 80 m is reported at village Kumbhi in the North West of Kanwar. It thins out at Garkhauli area in the south east and it is completely missing at village Kanausi in the east. This thinning out of clay formation shows apparent discontinuity of strata. Calcareous deposits ar e found beneath the top clay at places.

Wetland catchment

Kanwar wetland complex is located within the basin of River Burhi Gandak (Map 2.6). River Burhi Gandak is a perennial river originating from upper plains in West Champaran District (Chautarwa Chaur near Bishambharpur) and flowing for a length of around 550 km through the districts of East Champaran, Muzaffarpur, Samastipur and Begusarai before meeting Ganga near Khagaria. The River drains a catchment of 13,300 km^2. Sinha and Friend (1994) indicate the possibility of overbank connection with the main Gandak channel during the times of high flood, but it appears to receive most of its water from minor tributaries and floodplain sheet flows in the plains. In contrast with the neighbouring basins of Gandak, Bagmati, Adhwara, Kamla Balan and Kosi which have a sizeable proportion of basin located within the Himalayan mountains, the Basin of Burhi Gandak is entirely within the alluvial plains.

Views of Bailakhal (top left and right) and Dhanphar (bottom left and right during summer (left) and post monsoon (right)



Map 2.6 | Land use profile of Burhi Gandak, Adhwara and Kamla-Balan River Basins

Fig 2.2 and Table 2.2 provide the elevation profile, flow and sediment characteristics of River Burhi Gandak.

The basin of River Burhi Gandak has a north-south elevation profile (Map 2.7(a)). The crest, accounting for 15% of total area has an elevation ranging between 100-500 m amsl, followed by 57% of basin with extremely gentle relief ranging between 50 – 100 m amsl. The remaining segment of the basin (28%) which gradually merges into River Ganges has an extremely gentle relief ranging between 25 – 50 m amsl. These causes sluggishness in the drainage of flood water.

Sinha and Friend (1994) attribute this profile to the pattern of supply of sediments from the Himalayas (Map 2.7(a) and 2.7(b).

Land use of the basin is predominantly agricultural, accounting for over 70% of the area. The middle reaches are dotted with numerous oxbow lakes and abandoned channels. Post monsoon the water level in River Ganga remains high not allowing the flood waters of River Burhi Gandak to drain down. Hence, the lower reaches of the basin have larger wetland complexes in the form of naturally water waterlogged areas which connect to the rivers with flood pulses increasing significantly in size during monsoon and post monsoon periods, and rapidly shrinking in the summers.

While developmental activities within the entire basin have an influence on the state of Kanwar, for the purpose of management, it is useful to delineate a zone of direct influence, comprising direct inflow areas which need to be focused on a priority. An area of 3,100 km² indicated with hatches in Map 2.7(a) covering lower drainages of

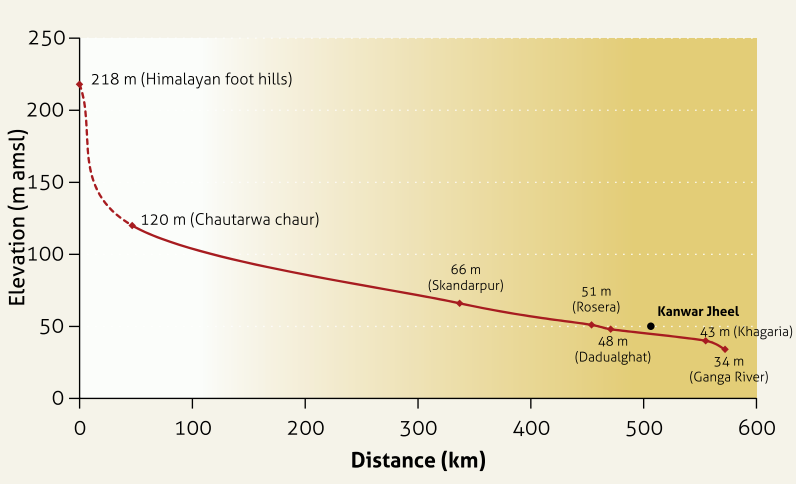


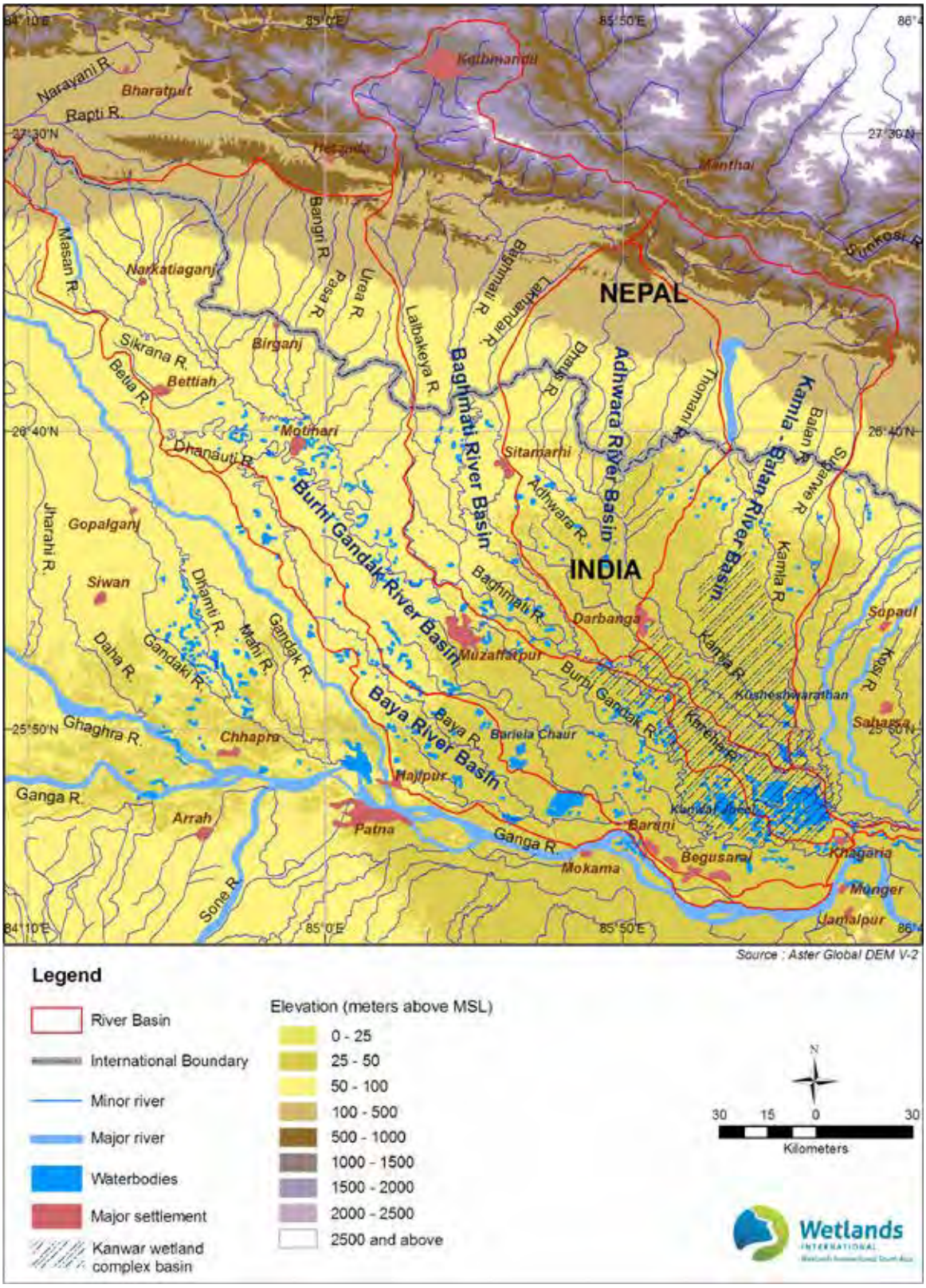
Fig. 2.2 | Elevation of River gauging stations of River Burhi Gandak *(Source: Sinha, 1995)*

Table 2.2 | Flow and sediment parameters of Burhi Gandak River at various river gauging sites

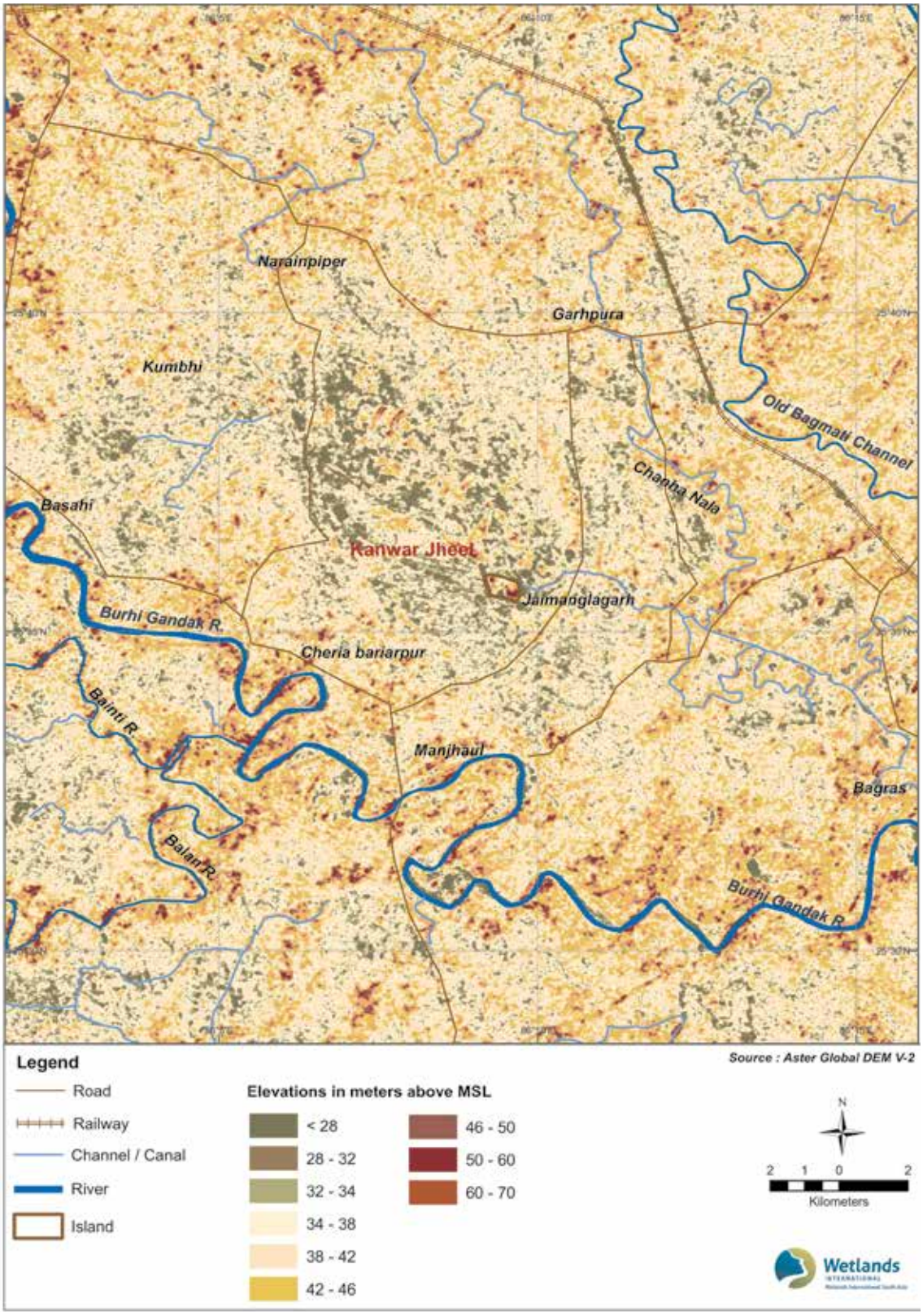
	Chanpatia	Sikanderpur	Rosera
Catchment above site (km²)	1 464	8 510	9 580
Average Annual Discharge (m³/sec)	58	287	273
Channel width – depth ratio[2]	23	30	30
Bankfull discharge (m³/sec)	500	2 050	950
Observed maximum discharge(m³/sec)	2 810	3 787	2 234
Mean annual flood (m³/sec)	600	1 900	1 400
Monthly sediment concentration (monsoon) (g/l)	NA	0.19-0.76	0.35-2.37
Average sediment yield (t/km²/year)	NA	647	1 573
Average sediment load (mt/year)	NA	6	15

Source: Compiled from Sinha and Jain (1998)

[2] Depth is calculated as the difference between zero and danger levels



Map 2.7(a) | Elevation profile of Burhi Gandak, Adhwara and Kamla-Balan River Basins



Map 2.7(b) | Elevation profile of Kanwar Jheel

Burhi Gandak, Adhwara and Kamla-Balan basins, can be discerned as the direct basin for wetland complex.

Hydrological regimes

Kanwar is yet to be subjected to systematic hydrological monitoring. The Water Resources Department maintains gauge and discharge records for three station within Burhi Gandak Basin, namely, Dadualghat on River Burhi Gandak, Dalsingh Sarai on River Balan and Godiya on River Baya. The Central Water Commission maintains records for four sites on the River Burhi Gandak, three of which (Sikandarpur, Samastipur and Rosera) are located upstream of Kanwar Jheel and one in downstream (Khagaria). The Bihar State Pollution Control Board measures a limited set of water quality parameters of the Burhi Gandak River at two stations. Kanwar Jheel is one of the monitoring sites. The Central Ground Water Board monitors 239 wells in the state of which 8 are located in Begusarai District. Besides these, a limited number of sporadic investigations have been carried out on the river – catchment characteristics and water quality by various institutions. The current description and analysis of hydrological regimes is based on interpretation of these available datasets. However, analyses is of indicative nature. There is an urgent need to develop and put in place a systematic hydrological regime monitoring protocol for Kanwar.

Water inflow and outflow

The major sources of water into Kanwar are rainfall, bank inundations received from River Burhi Gandak and groundwater. Ouflow is in the form of evapo-transpiration losses and abstraction of groundwater mainly for agriculture.

Overbank flows from River Burhi Gandak are mainly received during peak monsoon, when river is at high stage and in extreme conditions, as a result of breaching of embankments (as was the situation of 2007 floods). The river on an overall has a small average annual discharge (58 m^3/sec as compared to the major rivers as Kosi and Gandak which have an average annual discharge of 2,036 m^3/sec and 1,529 m^3/sec respectively). Analysis of flow data indicates an increase in monthly averages of June, reflecting the onset of monsoonal rainfall, with variable peak discharges at the lower stations. Bankfull inundations are common in the middle stretches of the river (between Sikanderpur and Khagaria) which is an important source of surface water inputs to the wetlands. Monthly hydrograph of river flows and water levels at various stations is presented in Fig. 2.3 and 2.4.

Located in the Indo-Gangetic plains, the region receives moderate to heavy rainfall (Fig. 2.5). Average annual rainfall for Begusarai District (for 1988-2012) was 1066.05 mm,

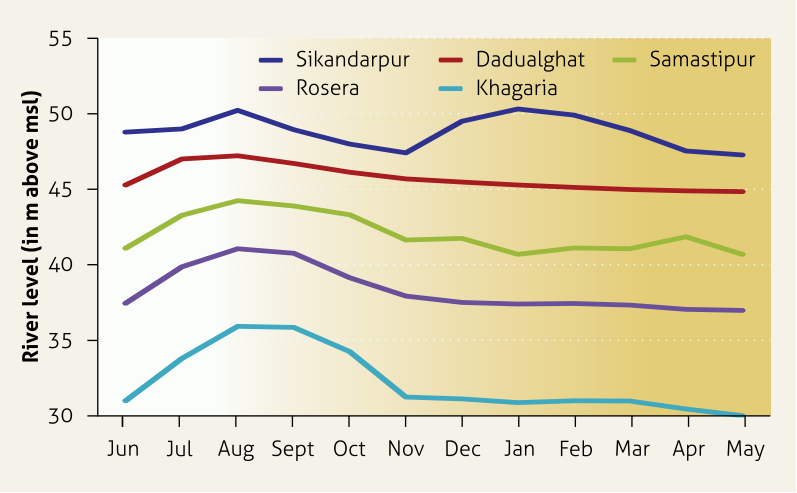


Fig 2.3 | Average monthly water level at various gauging stations of River Burhi Gandak (2002-2012)

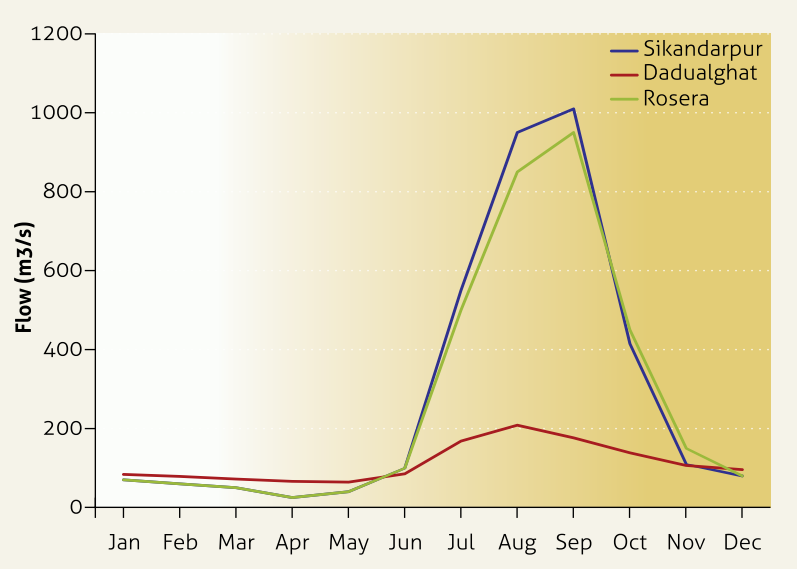


Fig 2.4 | Average monthly flow at various gauging stations of River Burhi Gandak (2002-2012)

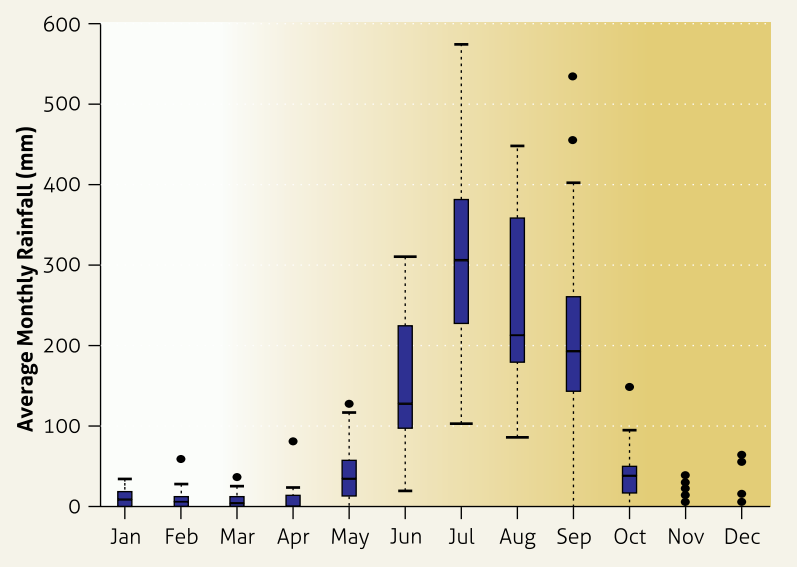


Fig 2.5 | Average monthly rainfall for Begusarai District (1989-2012)

of which nearly 85% is from the south-west monsoon. At the same time evapotranspiration rates are also very high.

In order to characterize water flux within Kanwar, a monthly water balance has been computed. Elevation – capacity relationship has been derived based on the digital elevation data. Inundation patterns have been derived from interpretation of satellite imageries for the 2008-2009, interpolated to derive monthly inundation areas. Estimation of evapotranspiration was based on meteorological data of Teghra (chosen based on availability of complete datasets). Since exclusive data on groundwater recharge, extraction and contribution received from bank inundations was not available, a net groundwater recharge quantity has been estimated adjusting all these parameters.

The water balance assessment indicates that in a given year, the wetland receives 26.9 MCM of water. There is a net recharge of groundwater from the period May – October, and a net discharge for rest of the period (Fig. 2.6). The assessment indicates an important role played by groundwater in maintaining the inundation areas. Notably, agriculture has been reported in dry months of April within Kanwar, whereas in adjoining areas, land is usually left fallow due to lack of water.

Sedimentation

Wetlands act as sediment traps, however, continual sediment accumulation impacts the overall hydrology of the ecosystem. While some sedimentation takes

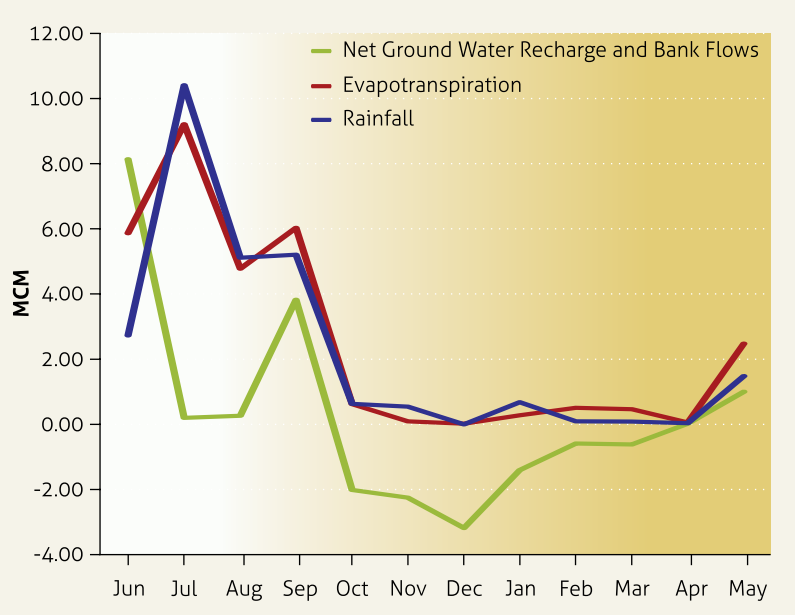


Fig 2.6 | Water balance of Kanwar Jheel

place naturally within any given basin, of particular concern is the contribution of human interference which needs management in the context of hydrological regimes of the wetland.

Kanwar wetland complex is located in an interfan area built largely by sediment and debris of the Himalayas brought down by the North Bihar rivers. Sediment assessments conducted for devising strategies for flood management have indicated high levels of sediment transport and deposition within floodplains (Sinha and Jain, 1998). Despite low flow volumes, the plains fed rivers (Burhi Gandak and Kamla Balan) have high sediment yields (even higher than Kosi). The average annual sediment load of River Burhi Gandak has been assessed to be 15 MT, with an annual yield of 1.24 MT / km^2 (as compared to 43 MT sediment load and 0.43 MT / km^2 sediment yield for Kosi). This indicates that the plains receive exceptional sediment influx from the high mountains, which, once deposited is remobilized in an exceptionally vigorous way by rivers. Further, the assessments indicate that such high concentration of suspended sediments in rivers are likely to be deposited with the channels as well as in the floodplains, creating a very gentle relief and maintain a uniform profile. As the time period of inundation after flooding is fairly high (over two to three months), there is an opportunity for the high velocity overbank flows to stabilize and deposit silt. Historically, interventions made to drain the wetland through construction of channels in the 1950s have been impeded by high volumes of sediments received during flood events of 1970s and 2007. Physical observations confirmed this fact, as major areas of Bikrampur Chaur and Nagri Jheel appeared to be silted.

Managing an optimal water depth in Kanwar is important for overall wetland processes, as well as a means to manage floods, which is a recurrent problem in North Bihar. During the present assessment, the water holding capacity of Kanwar was estimated to be around 27 MCM at 34 m amsl elevation. However, this is likely to be lower due to the embankments and bunds within the wetland area. Expansion of agriculture is also likely to mobilize silt into deeper areas.

Water quality

Surface water quality | Kanwar Jheel is a shallow, well oxygenated, alkaline, nutrient rich freshwater wetland. A summary of available surface water quality information is given in Table 2.3.

Water of Kanwar Jheel is alkaline with an average pH of 7.8. The pH is lower during

Table 2.3 | Physico-chemical properties of surface water in Kanwar

Data Source	1989-91 Ramakrishna et al. (2002)	1996 Sharma (1996)	2000-01 Roy (2008)	2011-2012 Central Pollution Control Board
Sampling Location				
Parameter				
Depth (m)	0.4-3.2	0.1-3.4	–	–
Transparency (m)	0.55-3.20	0.12-2.40	–	–
Water Temperature (°C)	17.0-35.0	18.0-31.0	–	–
pH	6.1-9.4	5.5-7.5	–	7.8
Conductivity (µmho/cm)	70-554	140-730	230-456	–
Dissolve Oxygen (mg/l)	2.2-11.0	1.2-8.0	–	6.8
Total Hardness (mg/l)	47-189	62-182	–	–
Nitrate (mg/l)	Trace-0.83	0.30-1.30	–	–
Phosphate (mg/l)	Trace-0.80	Trace-0.03	0.60-1.60	–
Biological Oxygen Demand (mg/l)	–	–	–	2.9
Total Coliform (Most Probable Number /100 ml)	–	–	–	3571
Faecal Coliform (Most Probable Number /100 ml)	–	–	–	1900

summer in the middle reaches which may be manifestation of thick stands of macrophytes and their subsequent decomposition. Water temperature was recorded to range between 18.0 and 31.0°C. Transparency within the wetland is moderate (0.12 m – 2.4 m) with lower values during monsoon in areas adjoining Guhabari, and higher values in Mahalaya – Kochalaya and Harsain bridge (on the irrigation channel). Transparency was relatively low during summer in the middle region which can be attributed to decompositi on of organic matter followed by release of nutrients in ambient water. The specific conductance value estimated during 2000-01 ranged between 230 and 456 µmho/cm (Roy et al., 2008) indicating advanced stages of eutrophication.

Recent observation by CPCB on dissolved oxygen content of Kanwar indicates the wetland to be well-oxygenated (6.8mg/l in 2011-12), however, the data pertains to a single station and no reference has been made to diurnal fluctuations. ZSI assessments of 1989-91 indicate a high spatial and temporal variation (2.2-11 mg/l), which can be considered relatively favourable for aquatic life, particularly fish. Reduction in water spread area during lean season accompanied with increasing level of nutrients, macrophyte colonization and reduction in dissolved oxygen content of water creates niches favourable for air breathing and forage fishes.

Nitrate-nitrogen and phosphate-phosphorus play an important role in biological productivity of aquatic ecosystems. High nutrient concentration within the wetland is evident from nitrate-nitrogen values (0.3-1.3 mg/l in 1996) and phosphate-phosphorus (0.6-1.6 mg/l during 2000-01). Nitrate concentration increases during monsoon with surface runoff. Reduction in nitrate-nitrogen concentration during summer may be attributed to utilisation by macrophytes. Despite a high phosphate concentration, absence of algal blooms in the wetland (barring a few locations around Mahalaya and Kochalaya) also appear to be linked with utilization by macrophytes.

Assessments conducted by CPCB during 2011-12, report high total and faecal coliform levels indicating water of Kanwar Jheel unsuitable for human use like drinking or bathing. The value for biological oxygen demand is also beyond the permissible limit for drinking.

Ground water quality | 8 wells of Central Ground Water Board provide a spatial and temporal picture of groundwater quality in areas around Kanwar. A summary of the available information is presented in Table 2.4.

Groundwater in areas surrounding Kanwar is alkaline (pH - 7.4), hard (330-345 mg/l), and has high iron (0.43 mg/l) and fluoride (0.9 mg/l) content. High values of alkalinity in areas around Kanwar indicate presence of bicarbonates beyond the permissible limit. The sodium absorption ratio, residual sodium carbonate, percent sodium and electrical conductivity place the groundwater under the class C3S1 (at Manjhaul and Cheria Bariarpur) of irrigation water i.e. with medium to high salinity hazard.

There is an increasing trend of dependence on groundwater for human and agriculture purposes in areas around Kanwar given the high variability in rainfall. High iron values are likely to have impact on the health of communities. Another emerging threat in the area is that of arsenic contamination, which has already affected several districts of North Bihar. Arsenic contamination in groundwater was first reported in the state in Bhojpur district during 2002, wherein concentrations beyond permissible limit of 0.05 mg/l were recorded in shallow aquifers within 50m below ground level. Central Ground Water Board (CGWB) has declared 6 districts, namely i.e. Bhojpur, Buxar, Saran, Samastipur and Begusarai as arsenic affected. Piezometers constructed to ascertain variation in arsenic concentration with depth confirmed presence of arsenic safe aquifers at depths beyond 100 m. CGWB has drilled 22 production wells in arsenic affected areas to tap safe drinking water for community water supply.

Table 2.4 | Physico-chemical properties of groundwater in areas around Kanwar

	1976-84	2005		2006		2008		Standard Limits (BIS-10500:1991) for drinking water	
	Bakhri	Bakhri	Cheria Bariarpur	Cheria Bariarpur	Manjhaul	Bakhri	Manjhaul	Acceptable limit	Maximum permissible limit
pH	7.2-8.2	7.5	7	8.3	8.2	7.4	7.4	6.5-8.5	No relaxation
Electrical conductivity (µS/cm @ 250C)	644-752	1000	3750	980	880	770	1050	1500	3000
Alkalinity (mg/l)	160-305	500	476	378	427	427	488	200	600
Total Hardness (mg/l)	160-305	390	1380	400	350	330	345	300	600
Chloride (mg/l)	39-113	43	887	78	57	21	85	250	1000
Sodium (mg/l)	28-41	38	220	72	56	23	77	-	200
Potassium (mg/l)	2-7.1	6.6	5.1	2	Tr	2.7	6.8		
Fluoride (mg/l)	0.15-0.5			0.9	0.9			1	1.5
Nitrate (mg/l)	6.0-15			1	1			45	100
Sulphate (mg/l)	9.0-60			37	88			200	400
Iron (mg/l)	0.03-.72			0.43				0.3	1

Water use and management

Water use and management policies and actions within the wetland and its river basin have significant influence on water regimes. Floodplain wetlands of Gangetic-Bramhaputra region have been traditionally used for agriculture and fisheries, and Kanwar complex is no exception. However, water management has emphasized on flood control and reclamation of waterlogged areas leading to significant impairment of natural hydrological regimes of the wetland ecosystem.

Traditional agriculture within Kanwar had evolved aligned to natural inundation regimes. During fifties, only higher elevation areas were cultivated with mainly deep water rice varieties[3] (locally called *desariya*). Maize and Bajra were also cultivated in smaller patches. A two pronged strategy to control floods was adopted, the first being construction of embankments along the river channel and second being draining the wetlands, which were perceived to be a waste of productive land resource and a source of floods as the regimes swelled during monsoon. A channel was therefore constructed connecting all the major waterbodies to enable draining water into River Burhi Gandak (via Bagras Maun), and reclaim land for agriculture.

Advent of irrigated agriculture, coupled with decline in inundation regime, led to extension of agriculture within the wetland during the seventies. Area under double cropping increased as new varieties of short-cycle rice crops were introduced which could be sown during June-July and harvested by November-December. Wheat was introduced as summer crop, mainly towards the western and southern fringes. Presently, nearly the entire area of the wetland complex is cultivated. Bikrampur and Nagri chaurs and eastern parts of the wetland (areas around Kanausi and Rajaur) are predominantly under sugarcane and maize.

Cultivation is done throughout the year, with paddy as the major *Kharif* crop (June – November), wheat and sugarcane during Rabi (December – April) and maize during *Garma* (April – June). Cultivation of mentha has recently received increased impetus within the wetland area (with support from KVK) in the southern fringes around Jaimanglagarh.

Changes in crops and irrigation patterns have consequences for water regime. Cultivated crops like mentha, paddy and sugarcane have high evapotranspiration rates as compared to native vegetation, and thereby need adequate irrigation. Within Kanwar complex, this is being done through increasing use of groundwater from shallow to deep borewells. The number of borewells within the complex has increased especially after 2007. Presently, even culture fishery within the wetland complex is being carried out using groundwater.

A review of water management practices in the context of Kanwar clearly indicates emphasis on a structural approach to meet human requirements of water, without considering implications for ecological functioning of wetlands, or the possibility to use wetlands as natural infrastructure for meeting water management objectives, as flood control and food security.

Key issues

The entire Kanwar wetland complex is going through a phase of shrinking inundation regimes. Areas under inundation reported to be 6,700 - 7,400 ha in 1980s (Scott, 1989) shrunk to 6,043

[3] Variety of rice (*Oryza sativa*) grown in flooded conditions. It is planted in dry ground, usually prior to monsoons, and allowed to establish as young plants. With growing floods, accelerated growth in the internodes of the stems allows the plant to keep a part of foliage above water. When submerged, the plant is reported to grow over 25 cm in a day and upto height of 7m . Nature of flooding, particularly timing and rate of rise of water play an important role in determining crop density and survival.

ha by 2002 (Ghosh et al., 2004) and 4,100 ha by 2010. This can be attributed to a mix of factors, major being increase in area under permanent agriculture, declining rainfall and increased abstraction of groundwater.

Trend of increasing area under permanent agriculture is confirmed by land use land cover change analysis. During 1989 – 2010, the area under permanent agriculture within Kanwar has increased by around 103% (Table 2.5). The near 50% reduction in wetland area outside Kanwar is also majorly attributed to increasing permanent agriculture.

Changes have also been observed in the weather pattern, particularly rainfall. Analysis of available rainfall data pertaining to the period 1989 -2012 (24 years) for Begusarai District indicates decline in rainfall received during south-west monsoon (June – September), noticeably since the beginning of 2001. Barring 2007 and 2008, the rains have been far below long term average over this period (Fig. 2.7 and Table 2.6).

As indicated by the analysis of water balance, groundwater recharge plays an important role in maintaining water levels. While the aquifers in Indo-Gangetic plains are known to bear plentiful groundwater, abstraction within the direct catchment needs to be carefully managed.

Water management planning and decision making in the entire state is focused on meeting human needs related to water supply, irrigation and flood control, without considering the implications on ecosystems as wetlands. Structural approaches for flood control through construction of embankments have interfered with the natural connectivity of the rivers with floodplains, which is the most important variable in determining ecological character of floodplain wetlands of North Bihar.

Table 2.5 | Land use land cover change in Kanwar wetland complex (in ha)

	1989 (January)	2010 (April)
Kanwar Jheel		
Open water	226	100
Marsh	3 604	1 637
Plantation	99	237
Silt/Current fallow	1 269	1 603
Agriculture	1 550	3 153
Settlement	7	25
	6 755	6 755
Associated wetlands		
Open water	875	144
Marsh	4 249	2 260
	5 124	2 404

(Source: Analysis of Landsat TM imageries, 30 m resolution)

Biodiversity

Hydrological and ecological connectivity between the river channel, riparian zone, and floodplains underpin the high biological diversity and habitat heterogeneity existing in floodplain wetlands such as Kanwar. Floods and flood pulses connect the various lotic and lentic environments facilitating exchange of matter, species and energy. Habitat features usually follow a cyclic pattern as flood pulses initially reduce environmental

Table 2.6 | Rainfall trends in Begusarai District (1989 – 2012)

	1989-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2012	Long term average
South West Monsoon	1 047.9	864.86	1 143.82	803.84	810.8	749.6	893.94
North East Monsoon	39.2	47.78	73.54	47.56	61.2	26.75	75.00
Winter Rain	14.7	23.92	23.6	26.1	6.24	10.65	16.52
Hot Weather Rain	69.5	33.14	69.72	78.44	41.16	50.55	79.27
Annual	1 171.3	969.7	1 310.68	955.94	919.4	837.55	1 064.73

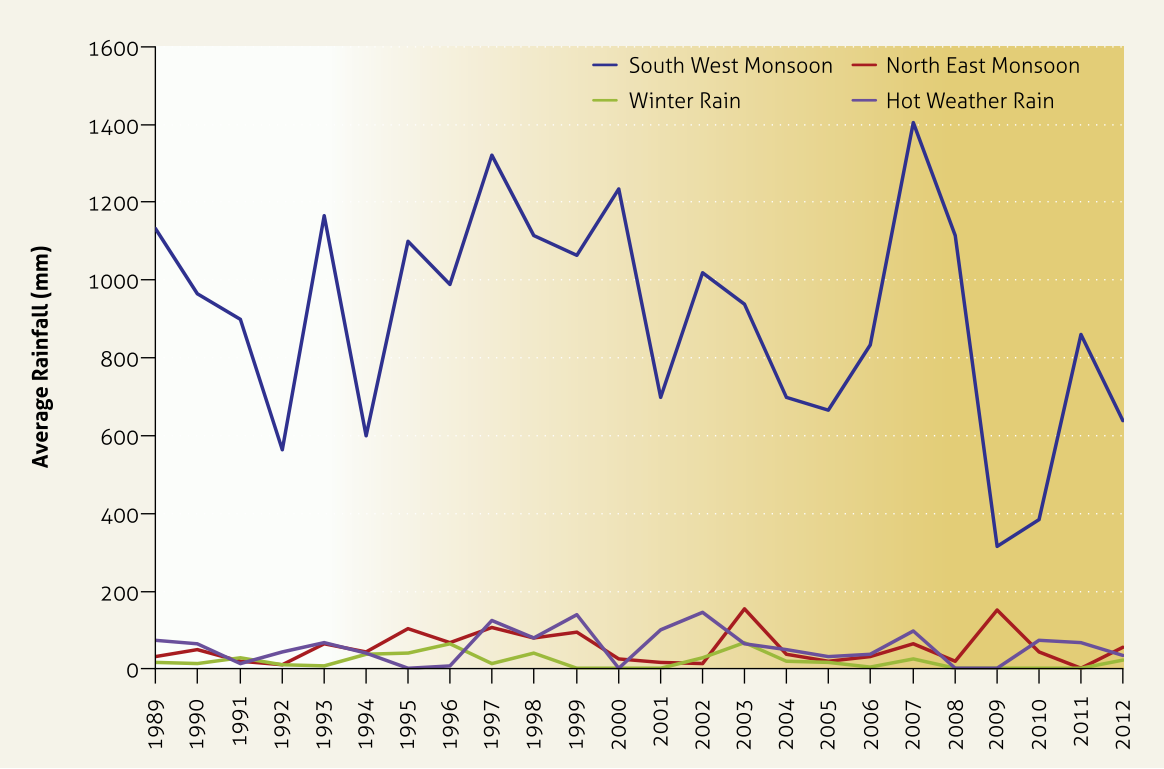


Fig 2.7 | Seasonal trends in rainfall in Begusarai District (1989 – 2012)

heterogeneity as distinct aquatic habitats are inundated, which gradually attain individuality in terms of habitat features and biotic communities as the pulses recede (Welcomme, 1979; Junk et al., 1989; Ward et al., 2002). Flood pulses renew nutrients, reduce anaerobic conditions, increase sediment diversity and open patches for colonization. A number of fish and invertebrate species are known to migrate between the river channel and inundated floodplain for spawning and feeding (Welcomme, 1979; Ward, 1989; Soderstorm, 1987). Research also indicates that in several circumstances, floodplain wetlands can be more important than the river channel for maintaining biodiversity, (Garcia and Laville, 2001) acting as refuge for flora and fauna and as spawning grounds for fish.

The importance of cyclic inundation for biodiversity of floodplain wetlands of North Bihar is apparent. Exchange of fish brooders and juveniles between the river channel and the floodplains helps to sustain high fish biodiversity and productivity of the entire Indo-Gangetic plains. The relative dominance of emergent, submerged and floating vegetation, as seen in different seasons in Kanwar, is also linked to flood pulses. With the onset of monsoon, high inundation with nutrient flux favours growth of submerged vegetation. The dominance shifts in favour of floating vegetation as water recedes and lotic pockets emerge in the wetland. The peripheral marshes are dominated by emergent macrophytes in the post monsoon and winter season. This also favours increased growth of benthic organisms which are important food sources for migrating waterbirds. Habitat fragmentation, particularly due to construction of flood control embankments, roads and

Mr. Ali Hussain, an avid birdwatcher has been maintaining waterbird records in Kanwar since more than a decade

other infrastructure has adversely affected the biodiversity of river as well as floodplain wetlands.

The overall information base on biodiversity of North Bihar wetlands in general and Kanwar in particular is limited and fragmented. Majority of the research is focused on biodiversity structures of rivers and wetlands, with very little emphasis placed on the ecological processes and the inter-connectivity of the riverine, riparian, lacustrine and palustrine environments. These limitations notwithstanding, assessments made by Central Inland Fisheries Research Institute (CIFRI), Kolkata constitute important time series information on the status and trends in fish diversity, production and general ecology of the wetlands since the early 80s. Zoological Survey of India (ZSI) has also created a baseline of floral and faunal diversity based on field assessments carried out during 1988-91. Waterbird census and informal observations by NGO networks and waterbird enthusiasts provide important insights to habitat features of Kanwar from the waterbird perspective.

The analysis presented in this section of the management plan builds upon the above mentioned information, sporadic published research by academic institutions, field visits during October 2012 – March 2013 and extensive consultations with forest department officials, local experts and fisher and farming communities. Special mention is made of the information and support provided by Mr. Ali Hussain of Manjhaul, a bird-trapper turned a waterbird conservationist of immense skills and local knowledge and a veritable treasure of information on birds and habitat of Kanwar.

Wetland biota

Biodiversity of floodplain wetlands of North Bihar reflect the characteristics of the broader riverine landscapes (including wetland complexes) which are part of and connected to River Ganges and its tributaries. Wetlands of North Bihar are characterized by high variability of inundation regimes and dominance of macrophytes. Biodiversity structure assessment for 17

Water hyacinth at Mahalaya (Dec, 2012)

selected *maun* and *chaur* areas within Gandak Basin indicate the presence of 295 species of phytoplankton, 39 species of zooplankton, 12 macrobenthos, 35 species of macrophytes (Sinha and Jha, 1997)[4], 76 fish species and 135 waterbirds (Menon, 1999). Of the 76 fish species reported from wetlands of North Bihar at least 19 have been classified as threatened, 5 endangered and 14 vulnerable as per IUCN Red List (Menon, 1999).

The richness of biodiversity in Kanwar is indicated by the recorded presence of 44 phytoplankton, 75 terrestrial plants, 46 macro phyte, 70 zooplankton, 17 mollusc, 50 fish and over 200 bird species. The wetland provides wintering ground to migratory waterbirds and is identified as an Important Bird Area (IBA) in the Central Asian Flyway. The lake supports criteria A1[5] and A4iii[6] of IBA. A picture of recorded biota of Kanwar along with the conservation significance is given in Table 2.7.

Flora | Recorded floral diversity at Kanwar includes 44 phytoplankton (Annex II) and 46 macrophyte species (Annex III) girdled and interspersed with patches of 75 terrestrial species (Annex IV).

Macrophytes dominate the floral diversity of Kanwar. Of the 46 recorded species, 9 are submerged, 9 floating and 28 emergent macrophytes. The deeper areas of wetland that contain water for large parts of the year (for example Mahalaya, Kochalaya, Choti Kochalaya, Chatar, Maisaha, and Banderi) have submerged vegetation, of which *Hydrilla verticillata,*

[4] The assessment does not include Kanwar Jheel

[5] A1: The site regularly holds significant numbers of a globally threatened species, or the other species of global conservation concern

[6] A4iii: The site is known or thought to hold, on a regular basis, ≥ 20,000 waterbirds or ≥ 10,000 pairs of sea birds of one or more species. Use of this criterion is discouraged where data quality permits A4i and A4ii to be used.

Table 2.7 | Record of species at Kanwar and their conservation status

Biodiversity Group		No. of Species	Record Date	Status						
				CR	EN	VU	NT	DD	LC	NE
Flora	Phytoplankton	44	1988-91	–	–	–	–	–	–	44
	Plants	121*	1988-91	–	–	–	–	2	35	84
Fauna	Zooplankton	70	1988-91	–	–	–	–	–	–	70
	Mollusca	17	1988-91	–	–	–	–	–	16	1
	Insecta	39	1988-91	–	–	–	–	–	6	33
	Pisces	35**	1988-91	–	–	–	2	1	28	4
	Amphibia	7	1988-91	–	–	–	–	–	7	–
	Reptilia	5	1989-90	–	–	–	–	–	2	3
	Aves	221	2001-13	5	3	5	14	–	194	–

CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near Threatened; DD=Data deficient; LC=Least Concern; NE= Not Evaluated
*Includes 46 macrophytes and 75 terrestrial species
**ZSI has reported presence of additional 15 species when the wetland connects to the river during floods, however, no list has been provided

Vallisneria spiralis, Najas minor, Ceratophyllum demersum, and *Potamogeton crispus* are dominant. During monsoon submerged vegetation spreads to the areas of Simraha, Mangardaha, Bela and Barko.

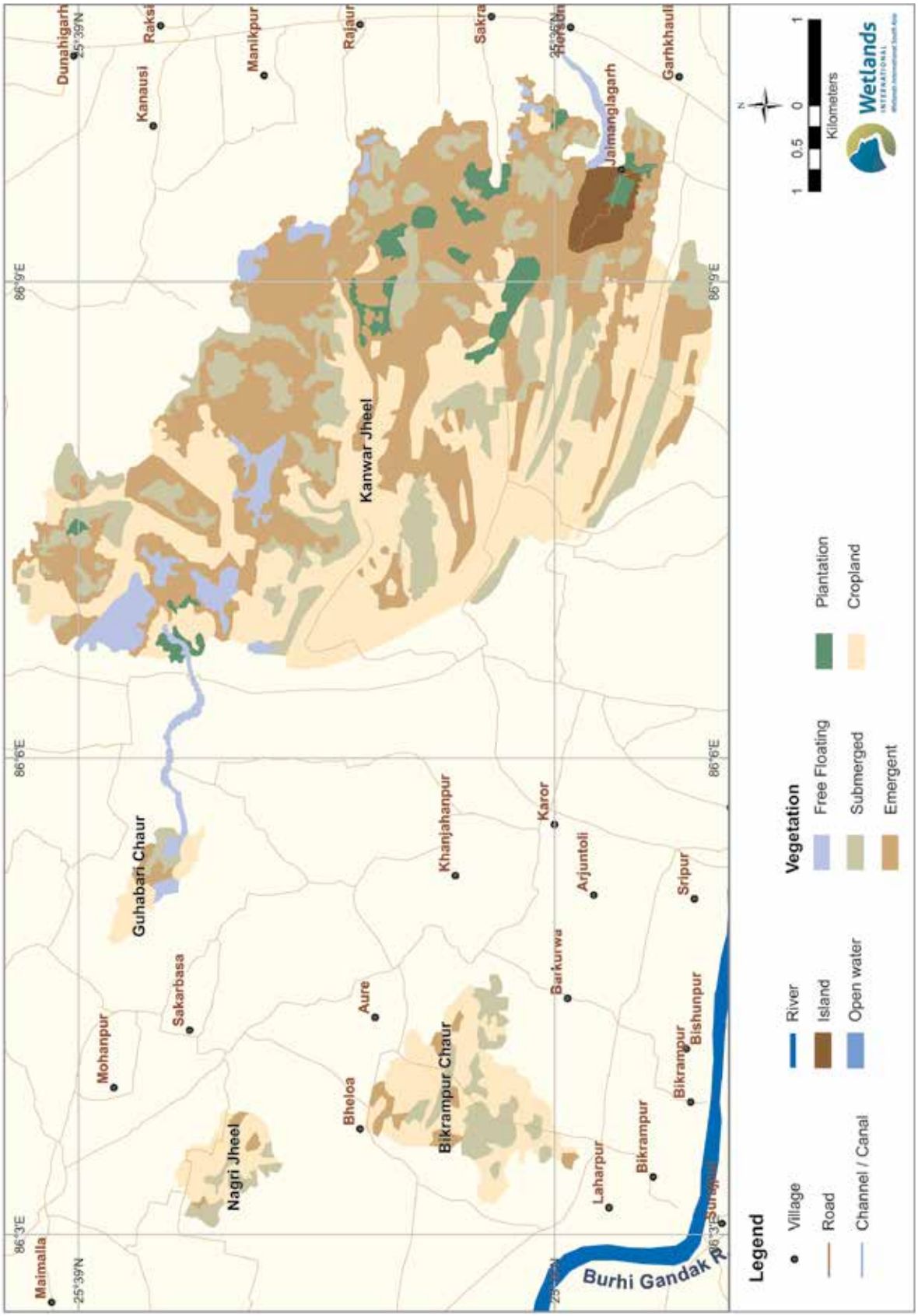
The rooted floating species, *Nelumbo nucifera, Nymphaea stellata, Trapa natans* are distributed all around the shallow region of the lake wherein water depth ranges between 0.5 – 1 m. The channels which connect Kanwar to Guhabari in the north and Burhi Gandak in the south are choked with free-floating and rooted emergent macrophytes primarily *Eichhornia crassipes* and *Ipomoea aquatica*. Emergents like *Phragmites karka, Sclerostachya fusca, Saccharum munja* and *Arundo donax* dominate the marginal areas of Mahalaya, Kochalaya, Maisaha and Daitya Dahi. Emergents invade the wetland replacing submerged vegetation as the water level recedes after September (Map 2.8).

Apart from macrophytes, 44 species of phytoplankton (Ramakrishna and Siddiqui, 2002) have been recorded in Kanwar with abundance ranging from 800-5000 units/litre (Sinha and Jha, 1997; CIFRI, 2002). The dominance of Cyanophyceae can be attributed to high nutrient status of the wetland. Barring the difference in numerical abundance, the planktonic species diversity in Kanwar Jheel exhibits almost identical spectrum as other wetlands of North Bihar.

Kanwar is interspersed with patches of terrestrial vegetation, reported to be constituted of 17 tree, 58 herb and shrub species (Ramakrishna and Siddiqui, 2002) (Annex IV). Trees found along the periphery include *Acacia nilotica, Borassus flabellifer, Barringtonia acutangula, Dalbergia sissoo, Terminalia arjuna, Syzygium cuminii, Ficus benghalensis, Leucaena leucocephala* and *Morus alba*. Within the wetland, plantation of *Syzygium cumini, Terminalia arjuna, Dalbergia sissoo, Albizia julibrissin, Bombax ceiba, Madhuca longifolia, Millettia pinnata and Trewia nudiflora* at Dhanphar, Banderi, Pichai in the central part and Bohra, Dashrath in the northern fringe has been done by Forest Department.

Fauna | Available information of faunal diversity of Kanwar pertains to zooplankton, benthos, waterbird and fish species.

Zooplankton | The ZSI has reported presence of 70 species of zooplankton from Kanwar belonging to Copepoda (3 species), Cladocera (27 species), Rotifera (29 species), Ostracoda (9



Map 2.8 | Vegetation in Kanwar Jheel

species) and Branchiopoda (2 species) (Siddiqui and Ramakrishna, 2002) (Annex V). Copepods are the dominant groups but rotifers exhibit higher species richness. Dominance of rotifers specifically *Brachionus* species is an indicator of high level of nutrient enrichment, also corroborated by water quality assessments.

Benthos | A total of 17 species of macro-invertebrates belonging to 9 genera and 7 families have been recorded from Kanwar (Annex VI). The benthic invertebrate density was observed to range between 220-5,414 units/m^2, dominated mainly by molluscan species (more than 96% at times). Gastropods which can tolerate stressed conditions for a longer period dominate the molluscan group. Four species of molluscs, namely *Pila globosa, Bellamya bengalensis, Lamellidens marginalis* and *L. corrianus* are harvested for consumption and limited trade by the communities (Subba Rao and Dey, 1989). The dominance of molluscans appears to be correlated with enhanced precipitation of calcium (by the macrophytes) leading to pockets of high alkalinity.

Fish | Riverine connectivity plays a critical role in structuring fish biodiversity of Kanwar. Assessments by CIFRI during 2007 and 2011 report the presence of 52 species in middle stretch of Ganga (Kanpur-Patna) and 54 species from Gandak (Vass et al., 2010; Srivastava, 2013). Of the 50 species reported in Kanwar, 26 species, mainly belonging to Cypriniformes, Siluriformes, Beloniformes, Channiformes, Perciformes and Mastacembeliformes are common with the Ganga and Gandak Rivers. ZSI records presence of 35

Gastropods in Kanwar

species throughout the year and an additional 15 when the river connects to the wetland in times of flood (ZSI, 2002), (however, no list has been provided for these additional species) (Annex VII). The diversity assessments have focused mainly on fin fishes, despite likelihood of presence of freshwater prawns and crabs which are abundantly found in the rivers of North Bihar. Interviews with local fishers confirm the presence of breeding grounds of *Wallago attu* in Mahalaya and Kochalaya. Detailed assessments are required to confirm fish breeding and spawning areas and migratory routes in the wetland and linked rivers.

Connectivity with river plays an important role in distributing the brooders and juveniles of Cypriniformes, Siluriformes, Beloniformes, Channiformes, Perciformes and Mastacembeliformes. Brooders of Indian Major Carps (IMC) move to rivers for breeding during monsoon. With the overbank flows juveniles are flushed to the adjacent riparian areas and floodplain wetlands which are rich in natural food availability and provide protection from predators. However, habitat fragmentation and depletion of riverine stocks of carps (Vass et al., 2010; Srivastava, 2013) has apparently impacted the availability of fish species, particularly Carps in the wetland system.

Analysis of catch composition based on CIFRI records indicate a gradual increase in air breathing species (*Clarias batrachus, Heteropneustes fossilis, Anabas testudineus*); catfishes (*Wallago attu, Mystus* sp.) and forage fishes. Dominance of air breathing species is an indicator of stressed environment with low water

String of forage fish caught in a line at Kanwar

level and dissolved oxygen. Similarly, increase in forage fish may be attributed to autobreeding and autostocking within the wetland, increased area under macrophytes, and reduced riverine recruitment. Further assessments are however, required for confirming these trends. Table 2.8 summarizes the transition in capture fisheries of Kanwar in relation to ecological conditions.

Waterbirds | Wetlands of North Bihar serve as important habitats for birds, especially those migrating along the Central Asian Flyway. Considering these values, eight of the 12 protected areas of Bihar have been identified as Important Bird Areas and potential Ramsar sites[7]. Wintering population of waterbirds, especially ducks have been spotted in good numbers

Table 2.8 | Changes in Kanwar fishery in relation with ecological conditions

Period	Ecological conditions	Fishery
1970	Connectivity with riverine flows, dissolved oxygen 5-7 mg/l, large open water areas and limited area under macrophyte	IMC dominated fishery along with feather backs, catfish, murrels and minnows; Fishery was remunerative as livelihood option
1980	Increased nutrient levels, decline in water flow, dissolved oxygen (5-7 mg/l), area under macrophytes increase	Decline in IMC catch, while increase in feather-backs, perches, catfish, murrels; however fishery remains viable
1990	Significant reductions in surface water, expansion of area under agriculture, increase in nutrient level, expansion in area under macrophytes, pockets of low DO observed	Forage and catfish population increased, IMC declined further, perches declined, greater presence of air-breathing fish; fishery under severe stress
2000	Diminished water flow into the lake, increasing trend in nutrients, area under marshes increase, macrophyte area increases, high fluctuation in DO; several areas anoxic	Dominance of forage and air-breathing fish species; IMC negligible; Economic returns reduce drastically

[7] These include, a system of chaurs in North Bihar; Gogabil Pakshi Vihar, Baghar beel and Baldia chaur; Kanwar Lake Bird Sanctuary; Kusheshwarsthan; Kurseala River course and Diara floodplain; Mokama taal; Nagi Dam and Nakti Dam Bird Sanctuary; Vikramshila Gangetic Dolphin Sanctuary.

Asian Openbill-Storks and Ibises at Badi Kochalaya

from several chaur areas surrounding Kanwar, for example Nagri jheel, Bikrampur, Rajakpur, Chalki, Sajanpur and the Dunhi support wintering waterbirds particularly ducks. Breeding colonies of Greater Adjutant, Lesser Adjutant and Black-necked Stork have been reported in the Kursela River Course. Mokama Taal is known to be habitat of 10 globally threatened and near threatened species. Good numbers of Bar- headed Geese can be regularly spotted at Nagi and Nakti Dam and Indian Skimmers at Vikramshila Gangetic Dolphin Sanctuary (Islam and Rahmani, 2004). However, as for other biodiversity groups, consistent data on species and numbers of waterbirds visiting wetlands is not available for several of the sites.

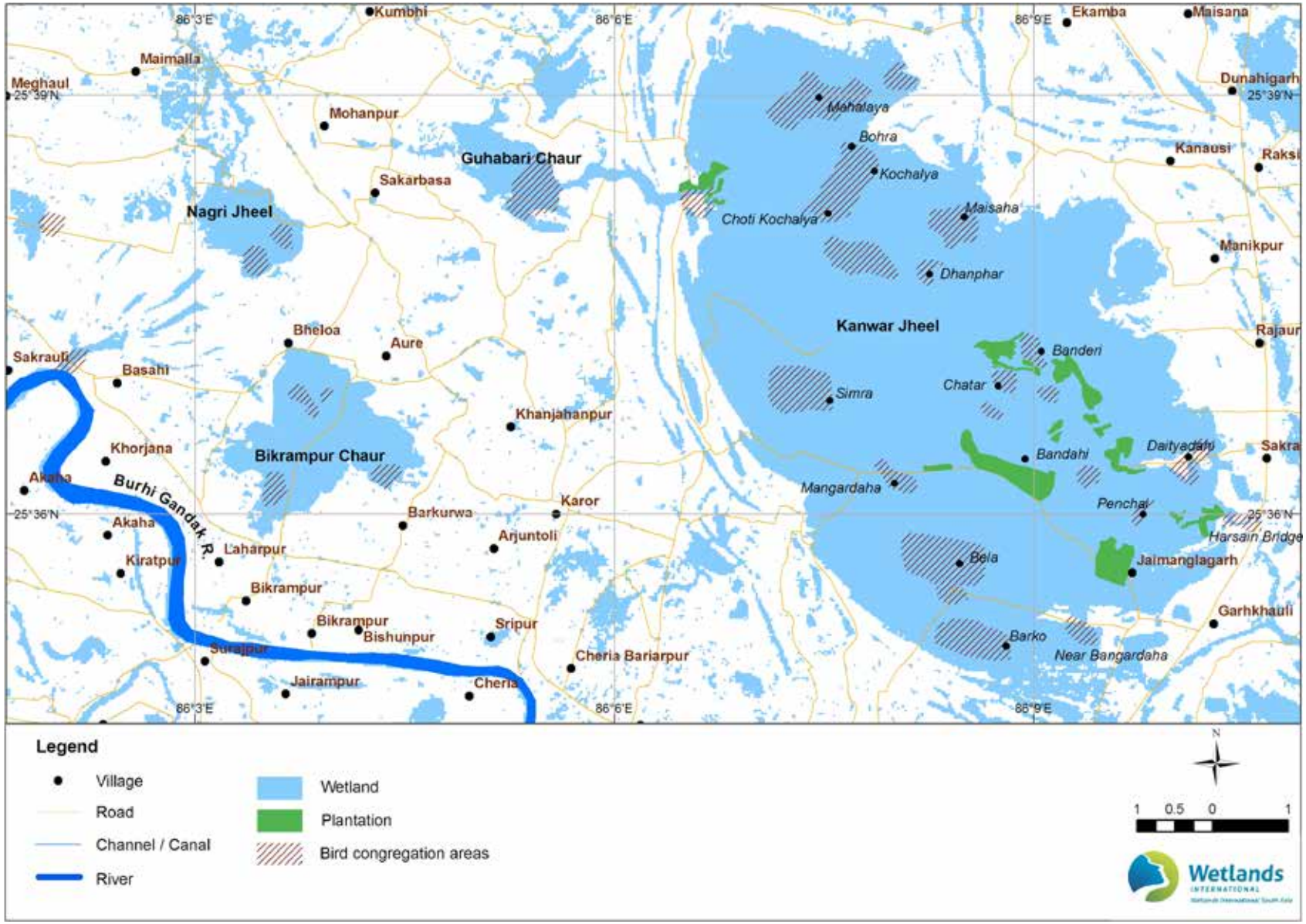
High avian diversity of Kanwar has been one of its most prominent features. Large congregations of Herons, Egrets, Openbill Stork, Black Ibis, Whistling Duck, Cotton Teal, Purple Moorhen, Little Grebe, Grey Pelican, Graylag Goose, Golden Plover and Common Snipe have been reported from Kanwar. The Openbill Stork *(Anastomosus oscitans)* can be spotted round the year. Groups Ciconiidae, Anatidae, Rallidae and Charadriidae dominate during September to March, whereas Jacanidae is present throughout the year (Roy et al., 2008).

Varying estimates of total number of bird species recorded at the wetland are available. Records of Forest Department, Government of Bihar indicate the presence of 168 species whereas ZSI based on a 1988-91 survey reports 166 species (Ramakrishna et al., 2002) from the wetland. Personal records of Ali Hussain maintained since 2001 indicate the number of species to be over 200. The assessments indicate 62 migratory waterbird species visit Kanwar (Annex VIII).

Analysis of conservation status of the reported species indicate two being critically endangered (*Gyps bengalensis, Gyps indicus*), two vulnerable (*Aquila clanga, Grus antigone*) and five near threatened species (*Anhinga melanogaster, Mycteria leucocephala, Ephippiorhynchus asiaticus, Threskiornis melanocephalus, Sterna acuticauda*) (Islam and Rahmani, 2004).

In terms of habitat use, nearly 20% of the wetland area as well as satellite areas were reported to have congregation sites for migrating waterbirds. The marshes around Mahalaya, Kochalaya and Chotti Kochalaya are the major ones, whereas flocks have also been observed in Maisaha, Dashrath, Dhanphar, Banderi, Chatai, Daityadahi, Penchai and Jaimanglagarh (Map 2.9). In terms of habitat preference, four migratory waterbirds were observed to utilize areas with open water and floating macrophytes; 25 species preferred areas with floating macrophytes and marginal emergents; and four species preferred marshes with terrestrial vegetation (Ramakrishna et al., 2002). Resident birds were mostly seen in the croplands.

There are no consistent records available on the number of waterbirds at Kanwar. The fisher community also engaged in bird trapping as a source of livelihood, particularly during the 70s and 80s. Shahi (1982) estimated that 70,000 ducks, coots and other waterbirds were netted at the site during the winters of 1981-82 and sold in Manjhaul market. State Forest Department report (referred in the Scott, 1989) mentions 135,000 birds trapped at Kanwar during the winters of 1984-85. Analysis of 33,954 birds trapped during 1983-94 revealed that over 90% were migratory waterbirds (Scott, 1989). The instances of waterbird hunting have been largely curtailed since the proclamation of large parts of Kanwar Jheel as a Bird Sanctuary under the Wildlife (Protection) Act, 1972. Recent observations indicate a decline in number of waterbirds visiting Kanwar. Waterbird census conducted by Mandar Nature Club as a part of Asian Waterbird Census programme for parts of Kanwar indicate 11,453 numbers of 17 species in 1996 and 2,263 of 20 species in 1999. Interviews



Map 2.9 | Bird congregation areas in Kanwar Jheel

with local bird watchers confirmed a declining trend in number of migratory waterbirds, particularly in the last five years when the wetland regime has been shrinking rapidly.

Human use

Fishery | Fisheries has been one of the important economic activity around Kanwar complex, particularly of *Sahni* community. Fishing operations in the wetland complex can be broadly classified into two categories, with Kanwar being a capture fishery source, and the associated *maun* and *chaur* areas used for extensive to semi intensive culture based fishery.

Connectivity with the riverine environments and abundance of fresh recruitment and food makes Kanwar an important source of capture fisheries. Of the 36 species reported in the wetland (ZSI, 2002) 26 are of economic value and are sold in local markets. Fishing is mainly concentrated in monsoon and post monsoon months (June - October), and continues in small patches during the rest of the year. Over 13 types of traditional nets and gears are used for various species (Table 2.9). Boats, nets (of mesh sizes ranging from 0.8 - 6 cm), box traps, lines, rods and hooks are the major implements. Wooden country boats made of shafts and banana stems, and upto 5 m in length and 2 m in width are used in open water areas with sufficient depth. Use of drag nets and cast nets has gradually declined over the years as area under macrophytic vegetation has increased.

Trends assessed based on interviews with the fishers and analysis of catch data of CIFRI indicates that capture fisheries have been reduced to a bare minimum and can no longer support livelihoods as used to be the case in 60s and 70s. Fishing operations for four months (July to October) yield an average catch of 3-4 kg/day/

Fishers with fish catch from Kanwar at Manjhaul market

Table 2.9 | Fishing gear used in Kanwar

Type of gear	Mesh size	Fish commonly trapped
Drag net Chattijal	2 cm	Minor carps, trash fish and prawns
Gill net Tiar net (with foot rope)	6 cm	*Wallago attu, Mystus seenghala, M. aor*
Tiar net (without foot rope)	2.4 cm	Small fish of all kinds
Cast net Bikhra jal	1-3 cm	Juvenile of major carps, *Chela sp., Puntius sp., Mystus cavasius*
Scoop net Bisra net	1-1.5 cm	Minor carps, trash fishes, smaller cat fish
Bisra jal	0.8-1 cm	All kinds of small fish, juveniles and prawns
Bag net Kharail jal	Varying mesh size	All types and size of fish
Miscellaneous gears Thapi net Arsi Bari Birti Kanra Sahat	 Conical basket Cubical or rectangular basket Bamboo screen Hemispherical basket Bamboo with sharp iron Bamboo with 12 sharp iron pears at one end	 *Channa* sp. *Puntius ap.* *Catfish, minor carps* *Channa sp., Macroganthus aculeatum* *Catfish and Notopterus* *Catfish and Notopterus*

person at present as compared to 8-12 kg/day/person during the late 80s. More than 50% of the present daily catch is dominated by forage fishes, whereas the Indian Major Carps dominated wetland fisheries in the 70s (Table 2.10), (Sinha and Jha, 2008). Rampant use of very small mesh nets has been a major concern as it sieves through everything from the lake bottom and ambient waters.

Presently nine *maun* and *chaur* areas around Kanwar are used for extensive to semi intensive culture based fisheries (Table 2.11). A mix of Indian Major Carps (*Catla catla, Labeo rohita, Cirrhinus mrigala*) and exotic carps (*Hypophthalmicthys molitrix, Ctenopharyngodon idella, Cyprinus carpio*) are used for stocking these waterbodies. Stocking operations begin with the onset of monsoon, wherein advanced fingerlings (of around 100 mm,15 g each) at an average rate of 2,000 per acre are stocked. An acre of farm requires an investment of Rs. 60,000 as cost of fingerlings and general maintenance, which upon harvest yields a revenue ranging between Rs. 70,000 to Rs. 1,00,000. Interviews with fish farmers indicated that owing to sufficient availability of natural food and nutrients ensured primarily through connectivity with the rivers during floods, there was in general no requirement for supplementary feed. However, ponds and tanks which lacked hydrological connectivity require artificial feed, mostly groundnut oil cakes and rice bran or even branded fish feed available in the market.

Table 2.10 | Trend in percentage contribution of capture fish catch in Kanwar

	IMC	Minor carp	Catfish	Feather-back	Murrels /Air breathing	Minnows
1981	15-27	20-28	8-17	10-16	5-8	25-30
1985	12-18	18-23	13-17	11-17	9-12	30-36
1990	8-10	19-20	17-19	12-16	10-13	40-43
1995	5-9	11-13	18-20	10-13	15-20	50-56
2000	4-6	6-9	13-15	9-11	18-23	50-63
2005	2-3	6-11	16-17	6-9	23-26	59-63
2011	0-2	5-8	16-17	4-9	28-31	64-71

Table 2.11 | Areas and rent of culture based fishing sources around Kanwar

Blocks	Name of Jalkar	Area (ha)	Rent (Rs. thousand)
Bakhri	Pachela Chaur	82	52
	Gidwari Kerani Chaur	20.8	10.6
	Badia Barar Jalkar	6	4.3
	Nauki Maun Parihara	12.3	5
	Bela Bahuara Maun	72.2	7
	Bagras Maun	20.4	28
Garhpura	Dahsin Chaur	53.2	49
	Karsado Chaur	8.5	7.5
Cheria Bariarpur	Manjhaul Maun	14.5	4.8

(Source: Data based Hand Book 2011-12 (Draft report). Directorate of Fisheries, Dept. of Animal & Fisheries Resources, Government of Bihar, Patna)

Assessments carried by CIFRI during 2008 indicated very low fish production in the *maun* and *chaur* areas (265 kg / ha as compared to a potential productivity of 1,500 – 2,000 kg/ ha provided all ecological conditions are met) (Sinha and Jha, 2008). Area and annual rents from *Jalkars* in areas around Kanwar as provided by Department of Fisheries is presented in Table 2.11. A key factor impeding production is decreased connectivity with the rivers and reduced surface water availability which has induced the farmers to depend on groundwater for culture operations. Several factors, including high levels of total hardness limit productivity. Further, instance of arsenic contamination in ground water is an additional threat to fish physiology and human health. Several of the waterbodies are under extensive macrophytic invasion owing to the runoff received from agricultural fields and sugar mills. This has also negatively impacted production.

Shortage of fries and fingerlings are a major constraint for culture based fisheries in the state. As against a demand of 900 million fries, only 342.25 million could be produced within the state through its 92 carp hatcheries (Directorate of Fisheries, GoB 2012). Decreased connectivity and fragmentation of water regimes has further impacted natural recruitment of carp species.

Vegetation | Most predominant human use of vegetation is that of macrophytes as food, fuel, fodder for the cattle, fish feed and in decoration. Kanwar is an important source of fodder and fuelwood for the neighbouring villages. *Leersia hexandra* (Garar), *Sacciolepis myosuroides* (Ghass), *Eichhornia crassipes* (Jal kumbhi) and *Commelina bengalensis* (Kankua ghass), *Cyperus rotundus* (Chichorh), *C. iria* (Mootha) are the major species used as fodder. Dried *Saccharum spontaneum* (Kans ghass), *Phragmites karka* (Narkat) and *Cyperus iria* are extensively used as

Box trap for catching murrels in Kanwar

fuelwood. It is estimated that around 3,700 and 1,800 households depend on Kanwar for their fuelwood and fodder requirements respectively.

Communities harvest several aquatic plants for use as medicines like flowers of *Nymphaea nouchali* (Koka), leaves of *Centella asiatica,* fish food *(Ceratophyllum demersum* and *Hydrilla verticillata* also known as Darah ghass), and handicrafts *(Phragmites karka, Cyperus iria)* at a very low scale. Chaur and maun areas are used for cultivation of *Euryale ferox* (Makhana). An average household harvests about 45 kgs in a year.

Fruits of *Trapa natans*; whole plant of *Nelumbo nucifera,* flower of *Nymphaea nouchali*; leaves and stem of *Ipomoea aquatica*, and underground stem of *Colocasia esculenta* (Kacchu) harvested from the wetland complex are used as vegetables. The flowers of *Nelumbo nucifera* and *Nymphaea nouchali* are used for decoration and worship.

Mollusc | Communities around Kanwar collect four species of molluscs *Pila globosa* (Bara ghonga), *Bellamya bengalensis* (Chota ghonga), *Lamellidens marginalis* and *L. corrianus* as food. Collection is majorly done by the fishers during post monsoon season.

Threats

The biodiversity of Kanwar is being adversely affected as is indicated by several trends, notably increase in area under macrophytes, changing composition of fisheries in favour of forage fishes, lower fish catch, dominance of hardy species of benthos, and lower number of waterbirds migrating to the lake. The major threats include the following:

- Habitat fragmentation and reduced connectivity with riverine environment due to construction of embankments, roads and other structures
- Expansion of areas under permanent agriculture
- Reduced availability of surface water due to changes in inundation pattern
- Increased nutrient enrichment from the neighbouring agricultural fields and local runoff
- Use of small mesh size nets for fisheries
- Risk of invasion, especially by emergent macrophytes *Phragmites karka* and exotic fish species like Tilapia.

Key issues

Information available on Kanwar biodiversity is patchy, conducted with a specific purpose to fulfil

Bagras Maun which connects the channel from Kanwar to River Burhi Gandak

academic and research needs and do not provide a true representation of wetland biodiversity. Absence of a systematic knowledgebase and monitoring system for biodiversity fails to address the possible reasons for change within biotic community.

Private land ownership within the wetland area has led to the expansion of agricultural activities without any consideration for the conservation of important bird congregation areas. Further, the protected area based approach fails to link biodiversity change and habitat restoration with sectoral planning programmes.

Livelihoods

The ecological state of Kanwar Jheel influences as well as influenced by livelihood systems linked directly and indirectly to the wetland. These linkages range from core requirements for water and food, to the choices and trade-offs communities make and the governance systems that influence their behaviour in and around the wetland complex. The social, economic and political contexts in which wetland ecosystem services integrate with livelihood assets provide important insights for defining wise-use strategies (Kumar et al. 2011).

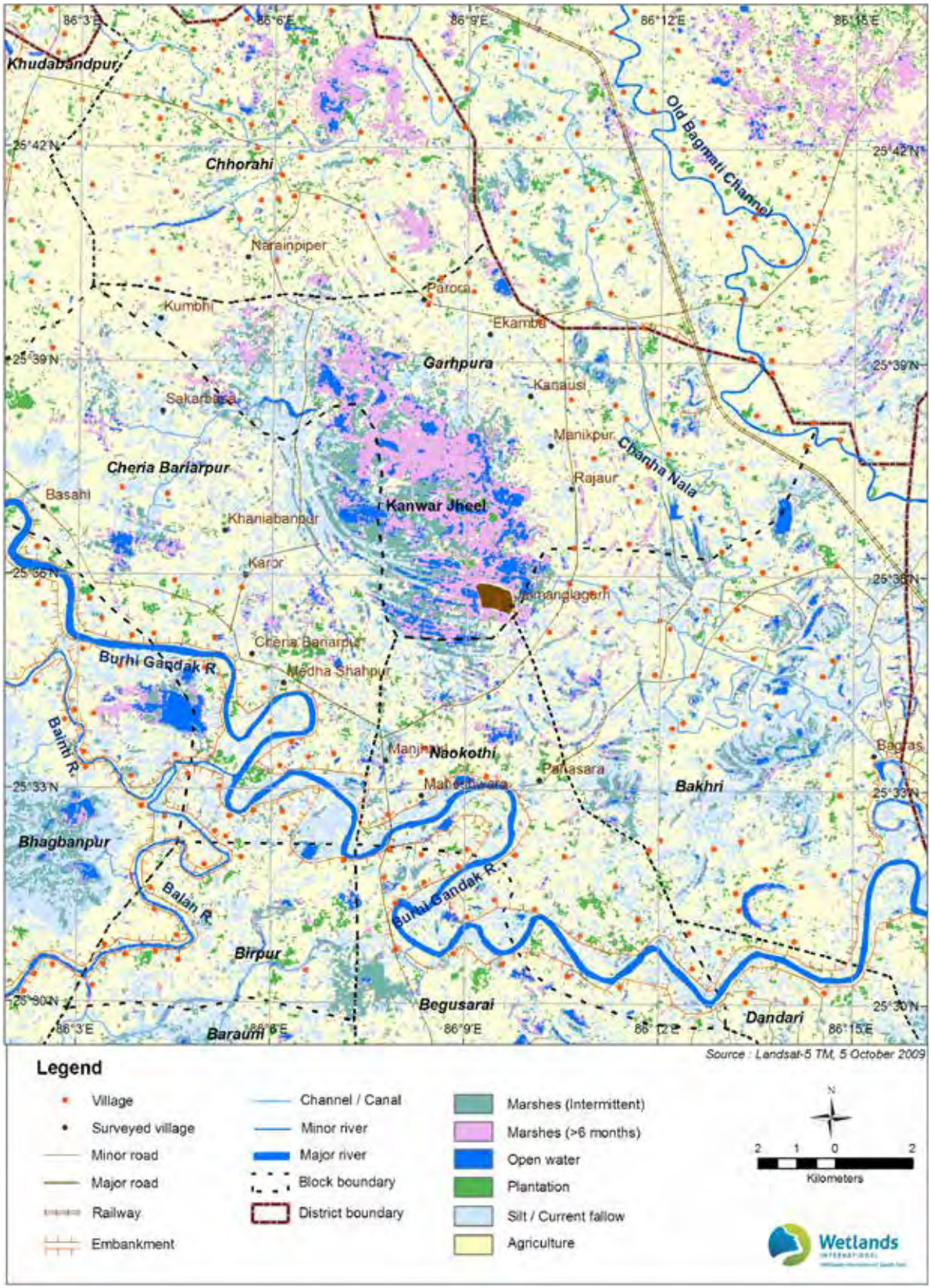
Despite resource use conflicts being identified as a major concern by several researchers, existing information on wetland – livelihood interlinkages in Kanwar is very limited. Early references to the conflict of fishing rights in Kanwar have been made in the 1885 judgement of Calcutta High Court. References to dependence on wetland resources by fishers, land use conflicts and unsustainable harvest have also been made in description of Kanwar Jheel in the Directory of Asian Wetlands (Scott, 1989) and the Directory of Indian Wetlands, (anonymous 1993). A detailed account of waterbird hunting by fisher communities of Kanwar has been presented in Shahi (1982). Limited account of socioeconomic status of fisher communities has been summarized in the status report by Zoological Survey of India (ZSI, 2002) and Kanwar management plan prepared by the Forest Department (GoB, 2004).

More recently, Wildlife Institute of India has supported research on social and economic considerations in conserving Kanwar Lake (Ambastha et al., 2007). The assessment focuses on wetland use pattern in three villages located inside the sanctuary and attributes a willingness to accept compensation value of US$ 27, 500 per household in case the land is taken over for consolidation of Kanwar wetland sanctuary. While the study does provide useful information on extent of wetland products harvested, it does not present an overall picture of resource dependence and management needs.

To address the gaps in information, the analysis of socio-economic features and governing factors has been based on surveys and participatory appraisals conducted in villages in and around Kanwar. The survey was carried out during October 2012 – January 2013 and covered 481 households within 17 villages (Map 2.10). Of these, 13 villages are located around the Kanwar Bird Sanctuary whereas four villages are located towards the channel confluence with River Burhi Gandak. Personal interviews were also conducted with fisher cooperative representatives, farmers and local NGOs to get historical trends, stakeholder perspectives and interventions required for wetland management. The analysis has been complemented with data and statistics obtained from the Directorate of Economics and Statistics, GoB and Census of India.

Profile of communities living in and around Kanwar

The Kanwar wetland complex spans within six blocks of Begusarai District and one



Map 2.10 | Villages around Kanwar Jheel

block of Samastipur District (namely Cheria Bariarpur, Naokothi, Bakhri, Garhpura, Chhorahi, Khudabandpur, and Hasanpur). The district occupies an important position in agricultural as well as industrial landscape of Bihar. Located in the highly fertile floodplains of River Ganges, agriculture is the key economic activity, accounting for nearly 40% of the land use, and livelihood source for 89% of working population. Begusarai is known for production of milk as well as cash crops like oilseeds, tobacco, jute, potato, red chilies, and tomato. Barauni, wherein a cluster of major industries as Indian Oil Refinery, Barauni Thermal Power Station and Hindustan Fertilizers Limited are located, is a major industrial center of the state. The overall population of the seven blocks as per 2001 census was 936,266 with a population density of 1,067 persons per square kilometre. The headquarters of Begusarai District, the Begusarai town is located 21 km from the wetland complex. The State Highway 55 connects its western and southern periphery at Manjhaul and Cheria Bariarpur.

The wetland complex is located in a rural agrarian setting, and surrounded by 23 villages, 10 of which are located within the sanctuary boundary[8]. The overall population of these villages as per 2001 census was 125,841 (Annex XII). Fishers and farmers are the major groups inhabiting these villages. While farmers engage mostly in agriculture within and outside the wetland area, fishers have diversified into a range of activities including wage labour, small and marginal farming and running small businesses. This is reflected in the analysis of primary and secondary occupations wherein agriculture and fishing are the predominant sources of income and employment (for 35% and 27% of households respectively). A significant proportion also earns livelihoods through wage labour (30%) (Table 2.12). A minority have livelihoods based on small business (2%) and government or private service (6%). Marginal farmers (those who cultivate areas less than 2.5 acres and are predominantly sharecroppers) constitute 85% of the farming households. Agriculture land of area between 2.5 – 5 acres is cultivated by 12% of the farming communities, with a minority (3%) having agricultural land in excess of 5 acres. On an overall, dependence on wage labour is very high in the region, as it forms secondary occupation for 35% of households, majority being fishers.

Literacy levels are considerably low, with only 27% of the adults being literate. Illiteracy amongst females is higher, with only 17% females being literate. Except households

Table 2.12 | Occupation profile of communities living in and around Kanwar

	% to total households	Primary and secondary occupation (%)				
		Agriculture	Fishery (Capture and Culture)	Small Business	Service	Wage labour
Farmers	37					
Marginal	28	100	2	1	1	39
Small	6	100	0	0	0	20
Large	1	100	0	0	0	0
Fisher	27	8	100	0	0	54
Entrepreneur	2	19	16	100	3	0
Service	6	20	5	0	100	0
Labourer	30	13	9	0	0	100

[8] GoB (2004) refers to 15 villages around Kanwar. The list has been extended to include 8 villages which are located around Vikrampur Chaur and Nagri Jheel.

engaged in service, none reported having any vocational training. Implicit within these statistics is the prevailing caste based power structures in the region, and the fishers belong to lower social strata in terms of economic and political affluence.

A comparative picture of livelihood assets is presented in Table 2.13. Households with members in service, large farmers and businessmen have better and higher assets as compared to marginal and small farmers, fishers and wage labourers. The quality of housing was observed to be related to incomes, with the farmers and small entrepreneurs having better quality housing as compared to others. However, the quality of water and sanitation facilities was observed to be very low, with only 18% of the households having toilets and 2% separate drainage. For most of the occupation categories, less than one third houses reported having toilets, except large farmers (100%) and small businessmen (61%).

Access to clean energy sources was also observed to be low, with only 6% reporting using LPG as the primary source of energy for cooking. The dependence on fuelwood was observed

Table 2.13 | Asset holding by various stakeholder categories

Livelihood assets	Unit	Stakeholder category						
		Agriculture Farmers			Fishers	Small business men	Engaged in Service	Wage labourers
		Marginal	Small	Large				
Quality of housing								
Pucca houses	% households	32	67	100	11	100	39	17
Toilets	% households	31	33	100	10	30	61	5
Separate drainage	% households	0	0	33	0	0	14	5
Main drinking water source								
Handpump	% households	98	100	100	98	100	100	100
Wells	% households	2	0	0	2	0	0	0
Use fuelwood for cooking	% households	90	94	67	96	100	86	93
Are electrified	% households	10	25	100	21	40	43	13
Use LPG for cooking	% households	11	6	33	4	6	32	3
Agricultural land and livestock								
Own agricultural land	% households	86	97	100	53	50	57	0
Land cultivated (including on sharecropping, renting)	Average, acres	0.94	3.26	11.33	1.3	0.25	3.9	0
Own livestock	% households	69	87	100	35	30	64	16
Own poultry	% households	1	0	0	6	0	0	1
Occupational implements								
Own bullock cart	% households	0	0	0	0	0	0	0
Own tractor	% households	4	3	33	0	0	18	0
Own tiller	% households	4	0	0	0	0	0	1
Own irrigation pumps	% households	8	0	33	0	0	14	0

Livelihood assets	Unit	Stakeholder category						
		Agriculture Farmers			Fishers	Small business men	Engaged in Service	Wage labourers
		Marginal	Small	Large				
Own boats	% households	7	0	0	24	0	0	0
Own nets	% households	1	0	0	58	10	7	0
Own traps	% households	0	0	0	38	10	7	0
Education								
Adult literacy	% adults in household	32	45	82	23	23	57	15
Adult literacy (female)	% adult female in household	19	23	29	15	14	29	14
Vocational training	% households	0	0	0	1	0	18	0
Income and expenditure pattern								
Household income from all sources								
Average	Rs. per annum	74,043	103,333	193,333	61,536	114,111	128,600	51,135
Std. Deviation	Rs. per annum	67,624	72,909	122,202	18,880	107,201	88,976	22,882
Proportion of expenditure on								
Food	% of monthly expenditure	68	68	52	68	63	63	66
Education	% of monthly expenditure	8	10	30	7	9	10	5
Health	% of monthly expenditure	8	8	7	7	7	8	7
Income sufficient to meet household needs	% households	21	64	100	39	70	88	22
Have savings	% households	27	100	100	19	50	52	36
Main source of credit	% households							
Local money lender		89	85	50	83	76	30	93
Banks		0	0	0	0	0	0	0
Landowners		1	0	0	16	21	0	0
Outstanding credit								
Average	Rs.	21,828	33,077	10,000	14,646	18,889	36,190	14,231
Std. Deviation	Rs.	19,854	21,654	0	12,525	18,099	35,493	8,759
Membership to institutions and networks								
Village Panchayats	% households	1	3	0	7	0	11	0
Agricultural cooperatives	% households	13	17	8	0	10	21	0
Fisher cooperatives	% households	29	0	0	30	20	4	2
Self-help groups	% households	1	0	0	2	0	0	0
Women's associations	% households	0	0	0	0	0	0	0
Females as members of institutions	% households	0	0	0	6	0	7	0

to be high across all occupation categories (89% households reported use of fuelwood as main cooking energy source). Nearly all (98%) households reported depending on shallow bore handpumps for water for domestic use. Only one fifth of the houses were electrified.

Ownership of agricultural land is one of the key factors influencing the overall livelihood status. While nearly half of the households owned land (52%), the average area put to farming was highly variable. The large farmers tilled on an average 11.33 acres, whereas it was 3.26 and 0.94 acres for small and marginal farmers respectively. Over half of the fishers owned agricultural land, tilling 1.3 acre on an average. Trends in ownership of livestock were almost similar to those of agricultural land holding. Wage labourers reported no agricultural land holding and less than one fifth owned livestock. Ownership of poultry was reported only by fishers.

Average annual household income in the respondent households ranged between Rs. 0.51 – Rs. 2 lakhs. Large farmers and those engaged in service had the highest incomes (Rs. 1.2 – Rs. 1.9 lakhs), followed by those of small farmers and business (Rs. 1.03 – 1.14 lakhs). Annual incomes of marginal farmers and fishers ranged between Rs. 0.61 – Rs. 0.74 lakhs. Wage labourers earned the least of all, average being Rs. 51,135. The overall adequacy of the income to meet household needs was reported to be low, with over two thirds (68%) of the respondents stating the current level of income to be insufficient. Food accounted for nearly half of the household expenditure.

Majority of households (69%) reported supplementing income from local resources with migration, which is an important strategy for coping with low incomes and lack of opportunities for domestic employment, and since long, has been a part of livelihood strategy particularly in rural Bihar (Table 2.14). The number of persons who migrated formed 24% of adult population and 34% of the overall working population. The proportion of income from migration sources constituted over 40% for the small and marginal farmers and fishers, whereas ranged between 15 – 25% for other categories. The proportion of households with migrating members was significantly higher for wage labourers, small farmers and fishers (ranging between 70-80%, as compared to 20-30% for the rest of the categories).

Trends in migration have an apparent relationship with changing land use and productivity of the wetland. In the fifties, fisheries based livelihoods were predominant, and the instances of migration were very limited. Reduction in water levels and concomitant expansion of agriculture forced the fishers into wage labour within the expanding farms. With increase in population and better earning opportunities outside the area, the trend in migration has been increasing. Expansion of agriculture farming within the wetland complex

Table 2.14 | Average annual household income classified by migration

Households migration characteristics	% to total households surveyed	Annual household income from local sources (Rs.)	Annual household income from employment sources at place where migrated (Rs.)	Total annual household income (Rs.)
Alteast one member migrating for work	69%	36,726	26,110	62,836
No member migrating for work	31%	80,646		80,646

has created local employment opportunities for the farmers as well as fishers. However, with very low land holding, the need for additional income sources is higher. The preference for wage labour is also attributed to low education. Migration is seasonal in nature, mostly concentrated during the months of October – March (wherein cropping is complete and maintenance of the crops is relatively less labour intensive). Nearly 80% of migration is attributed to the lack of local employment and nearly 18% to insufficiency of incomes. The contribution of income from migration sources is apparent, and forms 42% of the total household income from all sources. Annual income from all sources for the households with atleast one migrating member was higher by 28% as compared to one with no migrating member.

Access to formal banking and credit institutions was also reported to be low. Banking services were accessed by only 37% of the households, despite 63% reporting savings. Local money lenders were the major source of credit, accessed by 85% of the households. Average outstanding credit was 33% of the household income, and ranged from a minimum of 7% for large farmers to 93% for wage labourers.

Village Panchayats are the main community institutions existing in the villages around Kanwar. One third of the fishers are members of the fisher cooperatives, formed to enable participation in fishing lease in the *maun* and *chaur* areas. Presently there are four functional co-operatives in an around Kanwar wetland complex. The *Cheriya Bariarpur Matasaya Jivi Samiti* registered in 1996 under the Bihar Cooperative Societies Act, 1935 is the major fish cooperative operational within the wetland complex. Each fisher pays Rs. 1 to get registered in the society and Rs. 10 to sublease a portion of a specific *maun* and *chaurs* (*Jalkars*).The membership tenure with the co-operative is for a life time, and is transferrable to family members (any one surviving family member) upon death. The co-operative societies also issue guideline outlining rules and regulations *(Niyamawali)* to maintain transparency and discipline among its members.

Similarly, farmer cooperatives exist to gain access to government support in the case of floods and droughts. The farmer groups also act as pressure groups to prevent acquisition of farming land for sanctuary purposes. On an overall, the degree of organization was low, within the villages as only 40% had membership to any formal or informal institution. Participation of females in these institutions was further limited, with only 1% of the households having female members as members to any institution

Wetland-livelihood interlinkages

Ecosystem services, the benefits people receive from wetlands, provide the foundation of assessing wetlands-livelihoods inter linkages. A ranking of wetland ecosystem services as perceived by the respondent households is presented in Fig 2.8. Overall, the regulating services of Kanwar, i.e. groundwater recharge and ability to buffer floods are ranked as being most important. Cultural values linked to the wetlands and ability to sustain high biodiversity was ranked next in priority.

These were followed by the provisioning services linked with supporting agriculture, source of fish, and plants for food and fodder. The role of Kanwar as a source of water for domestic use was assigned the least rank, as there are very limited instances of its direct use. Farmers valued the agriculture related services higher, whereas fishers ranked provisioning as well as regulating services equally.

On similar lines, 97% of the respondents stated wetland degradation to be of significant consequence at household as well as village level. The most likely impact of degradation was

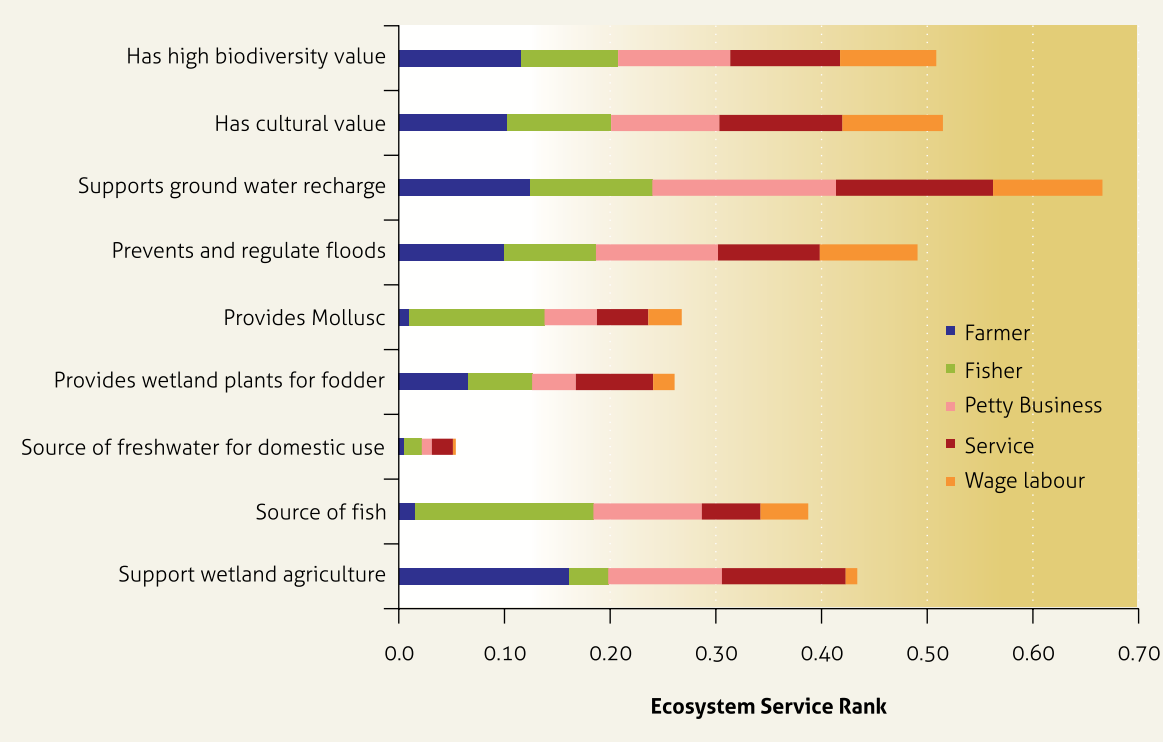


Fig. 2.8 | Ecosystem services of Kanwar as perceived by communities

on livelihoods (72% and 76% at household level and village level respectively), followed by reduced water availability (72% and 76% at household level and village level respectively). Reduced availability of wetland products (fish and aquatic plants) was expressed as an important impact by 56% of the respondents. Overall, 40% of respondents indicated loss of biodiversity as an impact at household as well as village levels.

Direct dependence on Kanwar wetland complex is in the form of wetland agriculture, capture fishing, agriculture, and harvest of aquatic plants for human consumption as well as fodder. Of those surveyed, 68% reported direct dependence for income generation or household consumption. Fishers and wage labourers have the most diverse dependence (Table 2.15). Harvesting fuelwood and fodder from the wetland cut across all stakeholder groups. Projecting from the census population of the 23 villages using the proportion of main and marginal workers, the number undertaking farming in the wetland has been assessed to be 3,500. The number undertaking capture fishing has been estimated to be 3,000, with 1,700 engaged in culture fisheries in *maun* and *chaur* areas. Nearly 20,000 people harvest fuelwood from the wetland area, whereas 8,000 harvest fodder. The number of people collecting shells has been assessed to be 4,000. On an overall, over 15,000 households directly depend on the wetland for various products. In terms of seasonality, the diversity of direct products was the maximum during post monsoon and winter (Fig. 2.9). On an average, 38% of the annual income is from wetland based activity, the highest being for fishers (62%), followed by marginal and small farmers (48% and 43% respectively) (Fig 2.10). A brief description of key wetland uses follows:

Table 2.15 | Household direct dependence on wetland

	Agriculture Farmers			Fisher	Small business men	Service Engaged in	Wage labourer
	Marginal	Small	Large				
Wetland agriculture	96%	67%	54%	25%	50%	55%	47%
Fishery							
Capture	13%	0%	0%	84%	0%	0%	19%
Shellfish collection	6%	0%	0%	43%	25%	0%	9%
Culture	1%	0%	0%	24%	0%	0%	1%
Harvest aquatic vegetation							
Vegetables	5%	0%	0%	28%	25%	0%	6%
Fodder	52%	77%	67%	25%	25%	45%	25%
Fuelwood	91%	77%	67%	92%	100%	82%	98%
Water for domestic use	0%		0%	2%	0%	0%	0%

(% ages are derived from the total number of households in a stakeholder category)

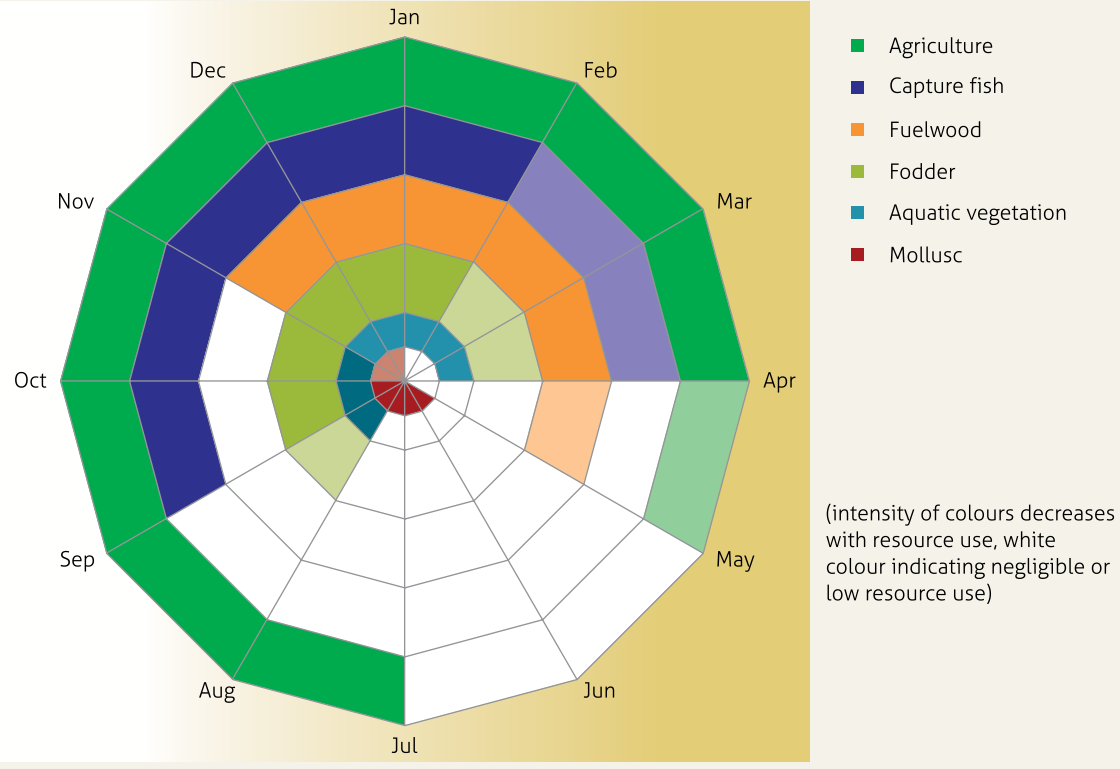


Fig. 2.9 | Seasonality of resource use in Kanwar Jheel

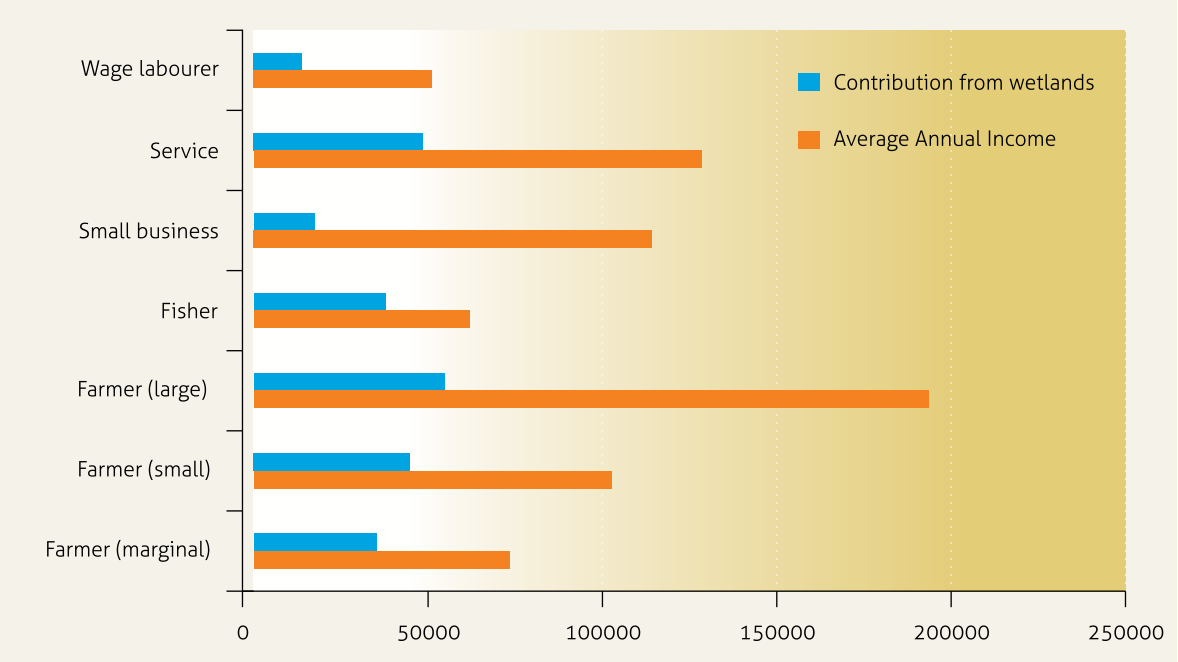


Fig. 2.10 | Income derived from wetland based sources

Wetland agriculture | Agriculture within Kanwar wetland complex is the primary source of livelihoods of 31% of the households living around the wetland, whereas another 25% depend on it as secondary employment. Most of the land within the wetland complex is under private holdings and currently used for double cropping. Wheat, mustard and sugarcane are cultivated as winter crops, whereas paddy is cultivated during the *Kharif* season. Wetland agriculture is dependent on high soil moisture and better water availability as compared to those in the upstream reaches. This is also validated by groundwater assessments which indicate that the water within the wetland complex retains a higher level as compared to other parts of the district particularly during post-monsoon period. The highly fertile silt received from the riverine inundations supports high agricultural productivity.

Changes in inundation regimes over the years have brought significant changes in farming systems. Interviews conducted with farmers indicated that during the fifties agriculture was limited only to upland areas surrounding Jaimanglagarh, Rajour, Manikpur and Parora locally called *rahi* (lower areas with near permanent inundation were called *nausi*). Jowar and Bajra were the major crops grown. The area of wetland complex is reported to extend to over 8,900 ha in these times, with lowland areas remaining inundated all year round. Till late 70s, it was possible to travel by boat from Kanwar to Bariella and Kusheshwarsthan.

Presently over 2,600 ha of wetland area is under permanent agriculture. The expansion and intensification of agriculture within the wetland complex is entirely based on groundwater extraction. The survey indicated that 36% of the landowners had installed borewells, with depths

Entrance to *Jaimanglagarh* Island

in excess of more than 200 feet at present in some areas.

Fisheries | Fisheries within the Kanwar wetland complex forms base of livelihoods of 32% of the respondent households. Of this, 91% identified this as the main source of household income, and only 8% as a supplementary income source. Fishing around the wetland area is an exclusive occupation of caste fishers, *Sahnis*.

The Kanwar Jheel area is primarily an open access capture source, whereas majority of the associated *maun* and *chaur* areas are leased by the fisher cooperatives from the state fisheries department for semi intensive culture fishing. The gradual reduction in areas under permanent and seasonal inundation has a distinct impact on fishing practices in Kanwar. Capture fishing within the inundated areas was traditionally done as a low intensity social enterprise with payment of rents to the private landowners. An informal territorial demarcation of the capture fishing area existed, with each village fishing only within its boundaries. The deeper areas were used for net fishing, whereas traps were used in the marsh areas located in the margins.

With changes in inundation pattern and decline in connectivity with riverine environments, competition grew alongwith conflicts on fishing rights. The fisheries transformed from high value mix of Indian Major Carps in the seventies and eighties to low economic value air-breathing fishes and minnows at present. Use of very small mesh (*Chatti jals*) size nets and traps has further impacted species recruitment. As areas under permanent inundation declined, the use of boats also diminished. Presently, most of the fisher households reported buying or constructing a boat only in the periods of good monsoon, and subsequently using it as firewood or for timber purposes. The prospect of secure production through culture techniques has

gradually shifted the focus of fishers to collective fishing in the *maun* and *chaur* areas associated with Kanwar.

Kanwar complex is also a rich source of edible molluscs (*Pila globosa and Belamia bengalensis* locally called Bada and Chhota Ghongha respectively due to their relative sizes). The harvest is mainly done by fisher families, as supplementary source of income by 57% households. The meat sells in the local market at the rate of Rs. 30-50 per kilogram. The harvest is usually maximum during the months of June – September, the period wherein capture fisheries is also relatively higher, and the access enhanced due to reduced area under vegetation.

Harvest of aquatic vegetation | The wetland is a source of fuelwood for 93% of the households. *Phragmites karka*, (locally called Narkat) available in abundance within the complex and dries quickly as compared to other sources and is the most preferred species of fuelwood. *Cyperus iria* (locally called Danti ghas), a grass species inhabiting the marshy fringes, is also harvested with the stem used as fuelwood. The harvest is mostly done during the winter and early summer (November – March), and is mostly for domestic consumption (only 13% of households reporting occasional harvesting). Harvesting of fuelwood is almost exclusively done by the female members of all age groups.

A small section of the communities also harvest aquatic plants for use as vegetables, of which lotus (*Nelumbo nucifera*.) and Singhada (*Trapa natans*) are main. Their availability is mostly in the deeper parts of the wetland (Mahalaya, Kochalaya, and Mahisaha) during the months of July to October. Makhana is harvested from *maun* and *chaur* areas leased by the fisheries department. Most of the harvest,

Water lily growing in Kanwar

barring *Euryale ferox*, is of subsistence level, usually done by older fishers who no longer engage in fishing.

Wetlands as buffer for extreme events | A key indirect value of Kanwar to the communities living in and around is its ability to buffer extreme events. The plains of North Bihar are some of most susceptible areas in India prone to flooding, and have experienced frequent loss of life and property over the last several decades. Shallow depressions as Kanwar wetland complex provide buffer to bank inundations by absorbing the flows and thereby reducing the risk of damages within the settlements around the complex. The water thus retained also recharges groundwater, and supports agriculture during lean seasons. However, weak integration of role of wetlands in flood defence and focus on structural approaches as embankments has promoted fragmentation of natural regimes of the wetlands. While not much of research has been carried out to quantify the hydrological regimes of the wetland, communities distinctly identify the flood buffering function as an important natural defence.

Cultural and recreational values linked to wetland | The scenic beauty of Kanwar, until the recent past, has made it a popular local recreation site. The island temple of Jaimanglagarh is associated with historical values. Several excavations from the area have been dated to pre-historic and Mughal periods. It is also believed that the site was used by Buddhist scholars from the period of Gautam Buddha. The temple holds an important place in the local culture, with several festivities and celebrations taking place nearly all the year round. An important feature here is the presence of a large number of monkeys (owing to which the island is also called "monkey island" in local parlance).

Jaimangla Temple

Vulnerability contexts

Weak physical and financial asset base | An analysis of assets clearly indicates that barring a small number of households comprising large farmers, those engaged in service, and small business, the communities have weak physical and financial asset base. In particular, annual incomes of wage labourers, marginal farmers and fishers, are way below state averages (ranging from Rs. 8,500 – Rs. 12,300 annual per capita as compared to Rs. 24,681 for the state[9]). The number of households stating the income to be insufficient for meeting household needs within these communities is significantly high at 61 – 78%. A ranking of access to a range of basic livelihood amenities (food and nutrition, drinking water for domestic use, toilets, electricity, water and land for agriculture, roads, markets, primary and maternal health care, primary and vocational education, saving and credit, and local conflict resolution mechanisms) indicated low scores for all, except markets and roads (Fig 2.11). In particular, low ranks were assigned to access to sanitation, electricity, credit and water for agriculture. Similarly, access to information related to core economic activities (agriculture and fisheries), climate (weather and flood forecasts) and various developmental schemes were observed to be very low (ranked below 0.3 on a scale of 0 to 1).

Resources use conflicts | Reduction in inundation area and concomitant changes in land use within the Kanwar wetland complex have

[9] Per capita annual income at current prices for 2011-12 (GoB, 2012)

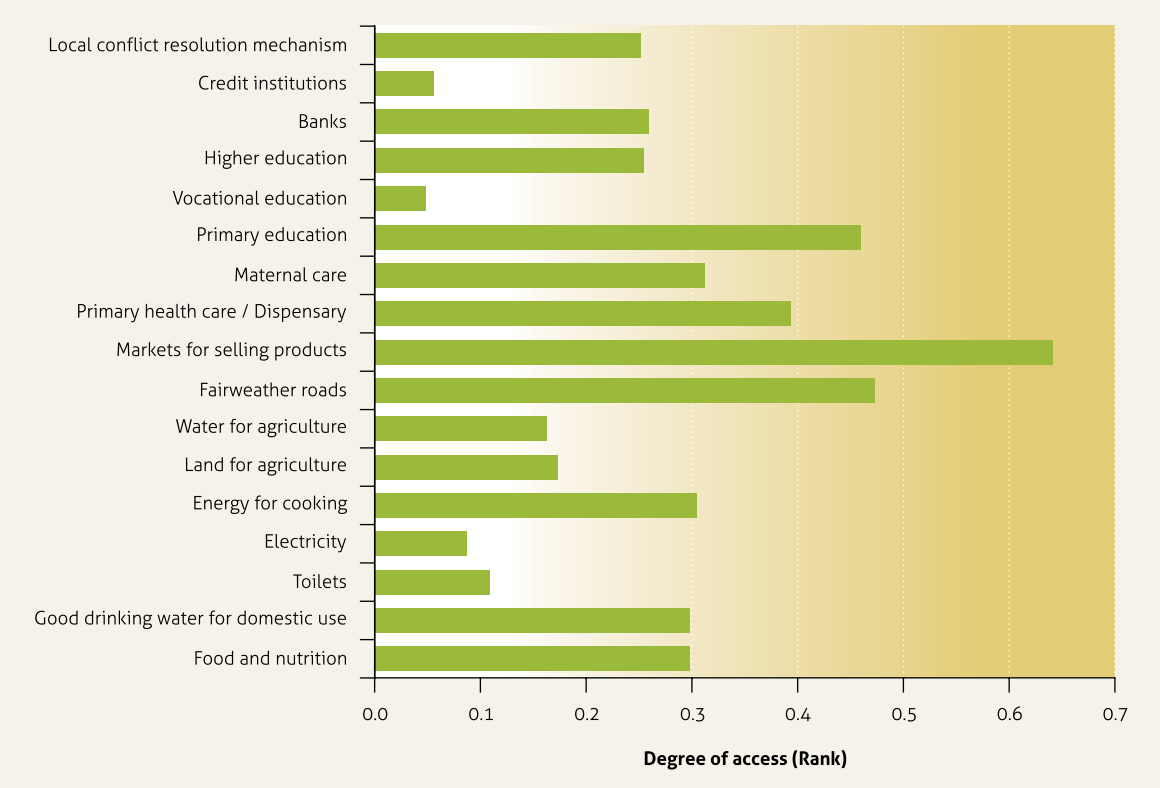


Fig. 2.11 | Degree of access to various amenities

led to marked resource use conflicts, particularly between farmers and fishers.

The gradual extension and intensification of agriculture within Kanwar has almost completely crowded out capture fisheries within the wetland. The outcomes has been in the form of conflict between farmers and fishers, the former supporting further wetland conversion wherein the latter demanding more water into the wetland to increase inundation areas. The resource conflict has a distinct connotation in terms of power relationship, with the farmers belonging to relatively affluent sections of the society, and the fishers to the lowest strata.

Increasing water stress | Rainfall and bank inundations play a major role in governing water regimes of Kanwar. The use of wetland for agriculture and fisheries is critically linked to inundation pattern within the wetland complex. However, the entire Begusarai District has been experiencing high variability in rainfall, particularly deficits since 2000. The communities have responded by increasing emphasis on groundwater, both for agriculture and fisheries. The number of irrigation borewells within the wetland complex has been increasing steadily since 2000, with over one third of farmers owning independent bores at present.

While the Gangetic floodplain aquifers have comparatively higher water potential, there are obvious limitations to the extent of development. Recent assessments undertaken by Central Ground Water Board as well as by scientific organizations indicate high arsenic and iron contamination

Farmer pumping groundwater in Kanwar using shallow borewell

within several parts of Begusarai District. A rapidly shrinking wetland regime, increasing variability in rainfall and declining water quality are gradually increasing water stress, which is only expected to intensify if appropriate interventions for integrated management of water resources are not made.

Increasing variability in rainfall and local water regimes is also stressing the coping capacities of the communities. Interviews with communities indicate that till seventies, it was possible to prepare for floods as the periodicity was known, and there was sufficient time to create grain and fuel banks and move to higher grounds during monsoons. However, over 60% of the respondents felt that floods and droughts have become more frequent and unpredictable. During floods, the access to already scant water and sanitation infrastructure becomes further stressed. Access to any form of flood forecast locally was ranked very low (0.22 on a scale of 0 – 1). None of the communities reported being part of disaster management planning, further increasing vulnerability to water stress.

Marginal role of communities in wetland management | The current institutional arrangements provide very little scope for engagement of communities and community based institutions in management of wetland complex. With a major part declared as bird sanctuary, the onus for raising resources, developing management strategies and ensuring effective implementation of the regulatory provisions of Wildlife (Protection) Act 1972 is on the state government. Even the management of maun and chaur areas by the Department of Fisheries is revenue centric rather than being based on environmental sustainability principles. Prior to seventies, fishers had a greater role in management of wetland, and had evolved resource use systems aligned to the hydrological regimes. Informal agreements on areas to be

Head loads of fuelwood being harvested from Kanwar

fished were implemented, and a range of gears used suited to differing habitats, deeper areas being used for nets, marginal areas for box traps. Reduction in inundation area and the gradual predominance of agriculture has increased pressure over limited resources and a breakdown of these informal management arrangements. The fishers have become passive players, adapting to the situation by either increased dependence on wage labour, and for those relatively well-endowed by engaging in culture fisheries. The farmers too are apprehensive of land being taken over for sanctuary purposes, and have formed collectives as Kanwar Bachao Sangharsh Samiti to ensure fair deal in case acquisition is actually eventuated. Declaration of eco-sensitive zone is further expected to put constraints on communities living within the buffer zone. The status of communities has shifted from being owners and managers of wetland complex to being participants of contested commons alongwith vagaries of nature.

Imbalance in gender relationships | While the quality and level of asset holding within the region reflects long term development gaps, several of the assets have differential consequences in terms of gender relationships. Low access to water, sanitation and clean energy has disproportionate adverse impacts on women. Levels of literacy in females were observed to be much lower than the males. Similarly, women have very limited representation of in formal or informal village institutions. Given the important role of a gender balanced society in securing sustainable management of natural resources, this imbalance needs to be factored in designing wetland wise use strategies.

Community perception on the state of Kanwar and management needs

A high majority (97%) of the respondents agreed that Kanwar was degrading, and that the decline had negative implications at household (96%) as well as village level (94%). The likely implications ranged from impacts on primary source of income (72%), reduced water availability (68%) to increase in flood and droughts (14%).

A ranking of the perceived problems of Kanwar is presented in Fig. 2.12. Adverse changes in local climate, particularly less rainfall was identified as the most important problem for the wetland, followed by less water being received into the wetlands. Siltation was also assigned a high score. Ineffectiveness of institutions responsible for wetland management was also identified as an important problem.
Loss of connectivity with River Burhi Gandak and Kosi and conversion of associated wetlands were assigned nearly equivalent ranks. Species invasion and pollution of water were accorded the lowest significance (rank 0.2 and 0.07 respectively). Loss of hydrological connectivity and adverse changes in water regimes of the wetland were identified as the key drivers of wetland degradation.

Rankings assigned by the community to solutions for managing Kanwar, are mostly aligned with problem identification (Fig 2.13). Increase in hydrological connectivity, rejuvenation of associated wetlands and control of sediment loading in the wetland system received high priorities. Interventions centred on livelihoods included promoting tourism, livelihood diversification and sustainable fisheries development. Restoration of biodiversity habitats, especially for waterbirds was also accorded high priority. Regulatory interventions in the form of regulation of landuse was identified, whereas regulation of encroachment inside wetland was accorded lower priority.

All the respondents covered in the survey recognized Forest Department as being the nodal agency for responsible for wetland management at present. However, when asked for a preference

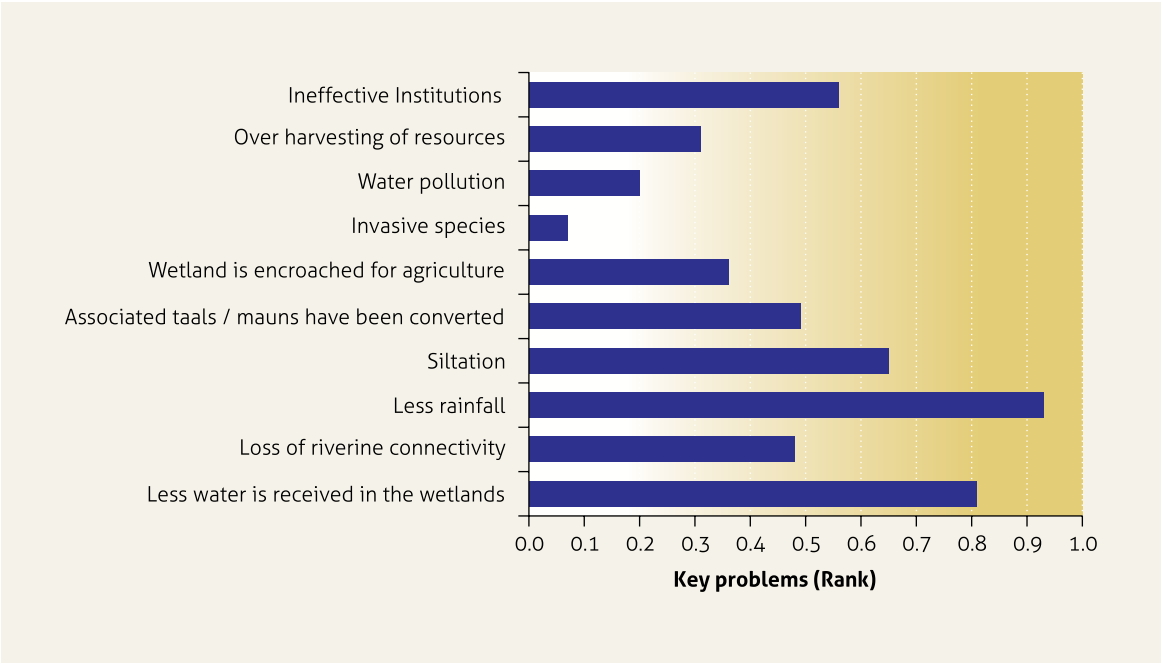


Fig. 2.12 | Community perception of problems in Kanwar

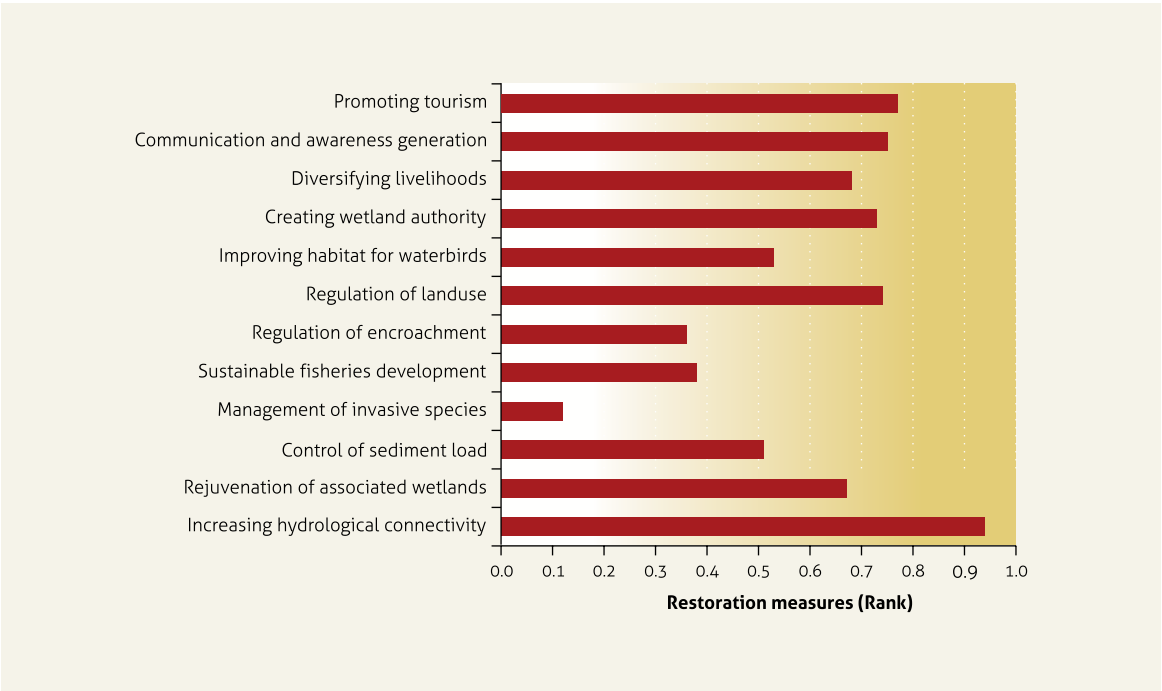


Fig. 2.13 | Community recommendations for restoration measures to be undertaken in Kanwar

for an institutional arrangement for wetland management, a separate wetland authority was ranked the highest (rank = 0.77), and way ahead of other alternatives as management by local non-government organizations (rank = 0.35) and by state Department of Fisheries (rank = 0.24). Notably, management led by the gram panchayats as well as Forest Department were considered of least preference (rank 0.13 and 0.15 respectively).

2.2 Ecological Character Description

Management planning, assists in outlining strategies, mechanisms and actions through which wise use of wetlands is achieved. Wise use of wetlands entails "maintenance of their ecological character, achieved through implementation of ecosystem approaches, within the context of sustainable development". This requires defining ecological character building on review of ecological, hydrological, socio-economic and institutional features related to wetland, and identification of those essential ecological and hydrological functions which ultimately secure provision of ecosystem services[10].

The core of definition of ecological character is the description of components, processes and ecosystem services at a given time (for example while listing as a Ramsar site). Ecological character definition allows identification of critical components, processes and services, and identifies changes thereof, which require management intervention. Ecological character is an indicator of health of the wetland ecosystem, and thereby is an important benchmark for management. Changes to ecological character of the wetlands, outside natural variation may signal that uses of the site are unsustainable, and may lead to the breakdown of the ecological, biological and hydrological functioning of the wetland system (Ramsar Convention 1996, Resolution VI.1).

Frameworks for ecological character definition are provided in Ramsar Resolution X.15. Besides the Convention, the Government of Australia has made efforts for setting up a national framework and guidance for Ecological Character Description (Department of Environment, Water, Heritage and the Arts, Government of Australia, 2008).

Kanwar Jheel is 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 of wetlands reflects its interlinkages with livelihood systems, and thereby provides key insights into the ways ecological character connects with livelihood capitals, institutions and finally human- wellbeing.

The framework used for describing ecological character of Kanwar builds on the Ramsar Framework (Resolution X.15) modified to the context of Kanwar, particularly including livelihood capitals of wetland dependent communities within ecological character description. The overall conceptual model is presented as Fig. 2.14. The following definitions have been used:

Ecosystem components | The living (biotic) and non-living (abiotic) constituents of wetland ecosystem.

- Geomorphic setting (landscape, catchment, river basin)
- Climate (precipitation, wind, temperature, evaporation, humidity)
- Physical setting (area, boundaries, topography, shape, bathymetry, habitat type and connectivity)

[10] A major consideration for adding this section to the plan is considering the intent of Government of Bihar to declare Kanwar as a Wetland of International Importance.

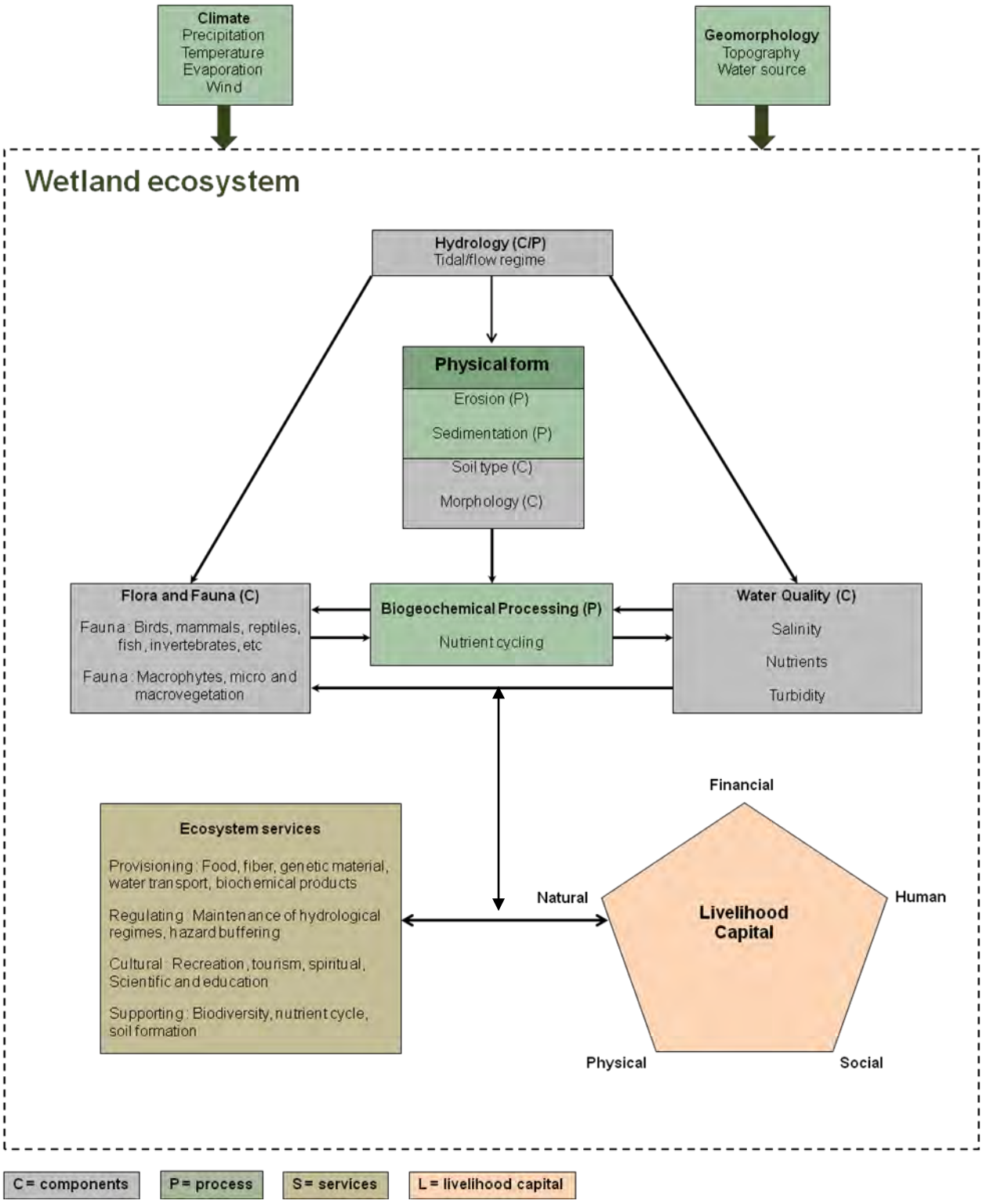


Fig. 2.14 | Framework for Ecological Character Description

- Water regime (inflow, outflow, balance, surface – groundwater interactions, inundation regime, tidal regime, quality)
- Wetland Soil (texture, chemical and biological properties)
- Biota (Plant and animal communities)

Ecosystem processes | 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.

- 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)
- Species interaction (Competition, predation, succession, herbivory)

Ecosystem services | Benefits obtained by humans from ecosystems

- Provisioning (fisheries, use of aquatic vegetation for economic purpose, wetland agriculture, biochemical products)
- Regulating (maintenance of hydrological regimes)
- Cultural (recreation and tourism, spiritual, scientific and educational value)

Status and trends in ecological character

Kanwar Jheel forms part of an extensive floodplain wetland regime formed in the lower reaches of Gandak – Kosi interfan. Its significance in terms of biological diversity and ecosystem services can be characterized in terms of the following ecological character elements:

- As a **nearly natural floodplain wetland of Indo-Gangetic plains** supporting a diversity of resource use co-existing with rich biological diversity
- As an **important habitat for migratory waterbirds** in the Central Asian Flyway
- As a **resource base for communities** living around the wetland harvesting fish, vegetables, molluscs, and fodder for sustenance and livelihoods
- As a **source of groundwater recharge** and **buffer for floods**
- As an **avenue for recreation** and **an integral part of local culture and belief systems**

Maintenance of the aforementioned ecological character element is underpinned by the following processes:

- **Variable inundation regime** (connecting with the adjoining Bikrampur, Nagri and Chalki *chaurs* during monsoon and gradually receding to small isolated pockets during summers) which enable creation of a diverse habitat mosaic of open water areas, marshes, grasslands and croplands
- **Surface-ground water connectivity** which support maintenance of groundwater tables and overall inundation regime
- **Connectivity with the riverine environment** which through exchange of water, sediments, nutrients and species enables fisheries productivity, maintenance of water quality and macrophytic diversity
- **Resource harvest** particularly of macrophytes as *Phragmites* and *Eichhornia* which help to prevent their proliferation
- **Social contract** between fishers and farmers which allow a diverse user group to benefit from wetland resources

While these ecological components, processes and services have been prioritized based on review of features and stakeholder consultations, a complete analysis of status and trends is presented in Table 2.16.

Table 2.16 | Status and trends in ecological character of Kanwar Jheel

Ecological Character Descriptor		Status	Data assessment year and source	Trends
Ecosystem Components				
1	**Physical Form**			
1.1	Area	Kanwar Jheel forms a part of an extensive floodplain wetland complex formed in the lower reaches of Gandak-Kosi interfan in North Bihar. In years of high rainfall, vast areas of North Bihar are flooded wherein the floodplains coalesce with the rivers to form a regime extending to hundreds of square kilometres. Even after construction of embankment on River Burhi Gandak in the 1950s, Kanwar extended, during periods of high flows, to include Nagri Jheel, Bikrampur Chaur, Guhabari, and Chalki Chaur creating an inundation area of around 6,750 ha. Over a period of time, nearly 2,600 ha of wetland area have been converted for permanent agriculture.	1989, 2010,Remote Sensing data	The entire Kanwar wetland complex is going through a phase of shrinking inundation regimes. Areas under inundation reported to be 6,700 - 7,400 ha in 1980s (Scott, 1989) shrunk to 6,043 ha by 2002 (Gho sh et al., 2004) and 4,100 ha by 2010. This can be attributed to a mix of factors, major being increasing area under permanent agriculture, declining rainfall and increased abstraction of groundwater. During 1989 – 2010, the area under permanent agriculture within Kanwar increased by around 103%. The near 50% reduction in wetland area outside Kanwar is also majorly attributed to increasing permanent agriculture.
1.2	Bathymetry	Shallow wetland with average depth of the lake varying from 0.1m to 3.4 m. Comprehensive bathymetric survey is yet to be conducted.	1989-91, ZSI (2002) and 1996, Sharma (1996)	No previous bathymetric records are available.
1.3	Shape	Saucer shaped		No discernible trend
2	**Wetland Soils**			
2.1	Texture	Clayey silt and silty clay are the most dominant units in the floodplain sediments formed due to frequent and extensive overbank flooding of the interfan rivers carrying exceptionally high suspended sediment load		No discernible trend
2.2	Chemical properties	Lake sediment is slightly acidic with rich organic carbon, high conductivity, high available nitrogen and high available phosphorus. • pH: 5-6.5 • Organic carbon: 2.5-17.94 %, • Specific conductivity: 248-820 millimhos cm-1 • Available nitrogen: 1.42- 1.51g/100g of soil • Available phosphorus: 3.6-7g/100g of soil	1991-92, ZSI (2002)	No previous assessments available
2.3	Biological properties	Assessments yet to be carried out		No previous assessments available.
3	**Physico-chemical Water**			
3.1	Nutrients	Nutrient rich waters • Nitrate: 0.3-1.3 ppm • Phosphate: 0.6-1.6 ppm • Silicate: 32-46ppm	1988-89, Singh and Roy (1990); 1996, Sharma (1996)	Comparison with assessment of 1989-91 (Siddiqui and Ramakrishna, 2002) indicate increasing trend in nitrate (trace to 0.83 ppm) and phosphate (trace to 0.85 ppm) No data available to discern trend for silicate
3.2	Conductivity	140-730 µmho/cm	1996, Sharma (1996)	Comparison with assessment during 1989-91 (Ramakrishna et al. 2002) indicates increase in conductivity (108-554 millimhos cm-2 during 1989-91)
3.3	Cations and Anions	• Calcium: 40-78 ppm • Magnesium: 6-12 ppm • Sulphate: 1.26-1.64 ppm • Chloride: 14-26 ppm	1989-91, Siddiqui and Ramakrishna (2002)	No previous data available
3.4	Temperature	Tropical wetland with surface water temperature ranging from 18-310C	1996, Sharma (1996)	Assessments conducted during 1989-91 indicate comparable results (18-350C)
3.5	Dissolved Oxygen	Well oxygenated (6.8 mg/l)	2012,CPCB (2012); 1996, Sharma (1996)	Assessments of 1996 comparable to 1989-91 (2.2-11.0 ppm). Low dissolved oxygen was observed during summer which can be attributed to large areas under macrophytes.
3.6	pH	7.8	2012, CPCB (2012); 1996, Sharma (1996)	Comparison with assessments during 1989-91 reveal presence of pockets with low pH which can be attributed to colonization and decomposition of macrophytes
3.7	Nutrient cycling	Assessments yet to be carried out		No previous assessments available.
3.8	Transparency	The transparency varies from 0.12-2.4 m. The inlet channel of the lake has higher transparency values during monsoon.	1996, Sharma (1996)	As compared to assessment of 1989 – 91 (Ramakrishna et al., 2002), transparency has declined from 0.5 – 2.86 to the values of 1996. Decline most significant in areas near Guhabari and outlet channel.
3.9	Biological Oxygen demand	Value for biological oxygen demand during 2011-12 is 2.9 mg/l. As per CPCB criterion, wetland water is not fit for domestic use.	2011-12, CPCB (2012)	No previous assessments to discern trends

Ecological Character Descriptor		Status	Data assessment year and source	Trends
3.10	Total and faecal coliform	High value of total and faecal coliform (3571 MPN/100ml and 1900 MPN/100ml respectively during 2011-12) recorded making water unfit for any human use.	2011-12, CPCB (2012)	No previous assessments to discern trends
4	**Biota**			
4.1	Wetland plants	46 species of macrophytes recorded in the wetland till date. Dominant submerged forms include *Hydrilla verticillata, Vallisneria spiralis, Najas minor, Ceratophyllum demersum* and *Potamogeton crispus* found mainly in deeper pockets. Emergents like *Phragmites karka, Sclerostachya fusca, Saccaharum munja, Ipomoea aquatica* and *Arundo donax* dominate the marginal areas. Free floating species as *Eichhornia crassipes* and *Pistia stratiotes* dominate the inlet and outlet channels of the lake. Assessments conducted during 1989-91 indicate the presence of 17 trees and 60 herbs and shrubs alongwith aquatic species.	1989-91, Ramakrishna and Siddiqui (2002); Nandan and Singh (2004); Sinha and Jha (1997); CIFRI (2000)	35 species of macrophytes has been reported from the wetland of North Bihar (Sinha and Jha, 1997). *Phragmites karka, Cyperus iria, Eichhornia crassipes* and *Ipomea aquatica* have proliferated extensively. High biomass of the macrophytes 4-20kg/m2 has been reported. Coverage of *E. crassipes* ranges 50-100% in areas around Bikrampur *chaur* and canal connecting the wetland to River Burhi Gandak. Further assessments are required to know the current status of terrestrial vegetation in view of plantation activities carried out by the Forest Department.
4.2	Vertebrate fauna			
4.2.1	Fish	36 species recorded, which increase to 51 during overbank connections. One species of commercially important crab *Paratelphusa spinigera* has also been reported from the wetland.	Sinha and Jha (1997); ZSI (2002); Tiwary et al., 2009	Catch statistics of 1980 – 2010 indicate reduction in proportion of carps, and increase in proportion of air breathing and forage fishes.
4.2.2	Amphibians	7 species recorded.	Sarkar and Ray (2002)	13 species of anurans have been reported from Bihar without any particular reference to the place of collection (Venkateswarlu and Murthy, 1972)
4.2.3	Reptiles	5 species recorded.	Sanyal et al. (2002)	No previous records to discern trends
4.2.4	Waterbirds	Kanwar is recognized as an Important Bird Area under category A1 (site regularly holds significant numbers of a globally threatened species) and A4 iii (site is known or thought to hold on a regular basis more or less 20,000 waterbirds). Critically endangered: *Gyps bengalensis, Gyps indicus* Vulnerable: *Aquila clanga, Grus Antigone* Near threatened species: *Anhinga melanogaster, Mycteria leucocephala, Ephippiorhynchus asiaticus, Threskiornis melanocephalus, Sterna acuticauda*); Over 200 species of birds recorded, of which 56 are migratory waterbirds.	2001-11, Asian Waterbird census	Number of waterbirds visiting the wetland has been on a decline due to increasing anthropogenic pressure on the habitat and reduced inundation area. However, these trends are based on expert consultations and need to be backed by systematic monitoring.
4.2.5	Mammals	Temple monkeys (*Macaca mulatta),* fox *(Vulpes bengalensis), jackals (Canis canis), nilgai (Boselaphus tragocemalus)* and hare *(Lepus nigricollis)*	Alfred and Ramakrishna (2002)	No previous assessments to discern trends
4.3	Phytoplanktons	44 species reported. Abundance of phytoplankton ranges from 800-5000 units/litre with *Cyanophyceae* being the most dominant group	1989-91, Ramakrishna and Siddiqui (2002)	295 species of phytoplankton have been reported from wetlands of North Bihar (Sinha and Jha, 1997) and 166 from Kanwar wetland complex (CIFRI, 2008). Hence, the lower number of species reported needs to be interpreted with caution keeping in view the limitations of assessment time frame.
4.4	Zooplankton	71 species belonging to Copepoda (3 sp.), Cladocera (28 sp.), Rotifera (29 sp.), Ostracoda (9 sp.) and Brachinopoda (2 sp.) have been reported.	1989-91, Siddiqui and Ramakrishna (2002)	18 genera of zooplankton species have been reported from the wetlands of North Bihar (Sinha and Jha, 1997) and 36 species from Kanwar wetland complex (CIFRI, 2008). Further assessments are required to corroborate the values of zooplanktons reported from Kanwar .
4.5	Aquatic macro-invertebrates	17 species of macro-invertebrates belonging to 9 genera and 7 families	Surya Rao et al. (2002)	9 species of macro-invertebrates reported from wetlands of North Bihar (Sinha and Jha, 1997). No previous assessments reported for Kanwar wetland complex to discern trends.
5	**Climate**			
5.1	Precipitation	Kanwar wetland complex located in a zone of medium to high rainfall. During a normal year, 1,028 mm of rainfall is received, of which 89% is during south-west monsoon.	2012, Indian Meteorological Department	Analysis of available rainfall data pertaining to the period 1989-2012 (24 years) for Begusarai District indicates decline in rainfall received during south-west monsoon (June – September), particularly since during the beginning of 2001. Barring 2007 and 2008, the rains have been far below long term average during this period.
5.2	Air Temperature	Air temperatures during 2012 range from 12.1 – 39.20C	2012, Indian Meteorological Department	No trends discernible

Ecological Character Descriptor		Status	Data assessment year and source	Trends
5.3	Evaporation	Assessments yet to be carried out		No historical records / assessments available
5.4	Wind	Assessments yet to be carried out		No historical records / assessments available
5.5	Humidity	Assessments yet to be carried out		No historical records / assessments available
6	**Geomorphology**			
6.1	Topography	Kanwar wetland complex forms a part of the River Burhi Gandak Basin. The crest, accounting for 15% of area has elevation between 100 – 500 m amsl followed a middle stretch with relief ranging between 50 – 75 m amsl. The remaining part of the basin (wherein Kanwar is located) has extremely gentle relief ranging between 25 – 50 m amsl.	Sinha and Friend (1994)	The Indo-Gangetic plains, on a geological time scale, are known to be sinking by a few millimetres each year as compared to Himalayas.
6.2	Connectivity to surface waters	During high flows, the flows of River Burhi Gandak connect with Kanwar, Nagri Jheel and Bikrampur chaurs. The inundation gradually recedes till the summers wherein open water surfaces are largely confined to deeper depressions at Mahalaya, Kochalaya and Chhoti Kochalaya		Natural connectivity of surface waters has been impeded by construction of embankments, roads and extension of permanent agriculture within the wetlands.
6.3	Water sources	Major water sources are rainfall, groundwater flows and bankflows during monsoon.	Ghosh et al. (2004)	Prior to development of channel flows of Gandak and Bagmati, overbank spills of Ganga and Kosi used to drain Kanwar Jheel (Ghosh et al., 2004)
6.4	Soils	Soil mostly comprises of unaltered alluvium. Soil texture in Gandak-Kosi interfan varies from sandy loam to loam in the meander scrolls and levee areas, to silty loam and silt in flood basin areas and from clayey loam in the basin of Ganga to clayey loam and clay in the basin of River Burhi Gandak and Bagmati. The micro-ridges of the flood plain are silty in nature, while the adjoining swale areas contain clayey loam. The floor of the Kanwar Jheel is covered by black clay mixed with peat.	Sinha (1996) and GSI (1984)	No historical records / assessments available.
6.5	Erosion	Assessments to ascertain erosion are yet to be carried out. However, the sediment flux of 15 X 109 kg/yr at Rosera station in Burhi Gandak, upstream of Kanwar is an indication of erosion in catchment area.	Sinha and Friend (1994)	No historical records / assessments available.
7	**Hydrology**			
7.1	Water balance	The water holding capacity of Kanwar is 27 MCM at 34 m amsl. Wetland receives 26.9 MCM of water through rainfall, of which 28.3 MCM is lost as evapo-transpiration. The rest is made available through groundwater recharge.	2002-12, Indian Meteorological Department and WISA (DEM assessment, 2103)	No historical records / assessments available.
7.2	Groundwater infiltration and seepage	The total annual groundwater recharge from rainfall and other sources in and around Kanwar Jheel during 2008-09 is 7,741 ha-m. The net annual groundwater availability and existing gross groundwater draft for irrigation is 6,966 ha-m and 4,155 ha-m respectively.	2008-09,CGWB (2011)	Comparison with assessments conducted during 2004 indicates decline in annual recharge, net groundwater availability and existing gross groundwater draft for irrigation (9438 ha-m, 8971 ha-m and 5098 ha-m respectively during 2004). However, increasing trends have been observed in natural discharge i.e. from 474 ha-m during 2004 to 775 ha-m during 2008-09.
7.3	Surface -groundwater interactions	Kanwar acts as a groundwater recharge during May- October (net recharge 13.45 MCM) and discharge for the rest of the year (net discharge 10.05 MCM)	2002-12, Indian Meteorological Department	No historical records / assessments available.
7.4	Inundation regime	The inundation regime of the wetland extends to an area of ~10,000 ha connecting 17 associated waterbodies during monsoon. The wetland shrinks to an area of ~600ha in summer exposing agricultural land.		Areas under inundation reported to be 6,700 - 7,400 ha in 1980s (Scott, 1989) shrunk to 6,043 ha by 2002 (Ghosh et al., 2004) and 4,100 ha by 2010.
8	**Energy - nutrient dynamics**			
8.1	Primary production	Assessments yet to be carried out		No historical records / assessments available.
8.2	Nutrient cycling	Assessments yet to be carried out		No historical records / assessments available.
8.3	Carbon cycling	Assessments yet to be carried out		No historical records / assessments available.
8.4	Decomposition	Assessments yet to be carried out		No historical records / assessments available.
8.5	Oxidation -reduction	Assessments yet to be carried out		No historical records / assessments available.

Ecological Character Descriptor		Status	Data assessment year and source	Trends
Ecological processes				
9	**Process that maintain animal and plant population**			
9.1	Fish recruitment	Capture fish production with the wetland is maintained by recruitment from the rivers, particularly of Indian Major Carps. However, no quantitative information is available. Kanwar is known to provide a natural habitat and breeding ground for *Wallago attu* (a near threatened indigenous catfish)	CIFRI(2008)	During 1960's, 60% of the carp seed was recruited from riverine source. Decline in carp and hilsa, large catfishes was reported since 1972 in the Gangetic river system between Kanpur to Patna. This was represented in the stock structure as well as recruitment pattern.
9.2	Fish migration	Recruitment of juveniles occurs during flooding season in Indo-Gangetic basin and associated wetland systems. However, information regarding migratory route of species to Kanwar Jheel from connecting water bodies is not documented.		
10	**Species interaction**			
10.1	Competition	Assessments yet to be carried out		No historical records / assessments available.
10.2	Predation			
10.3	Succession			
10.4	Herbivory			
11	**Physical processes**			
11.1	Stratification	Assessments yet to be carried out		No historical records / assessments available
11.2	Mixing	Assessments yet to be carried out		No historical records / assessments available
11.3	Sedimentation	Sediment assessments conducted for devising strategies for flood management have indicated high levels of sediment transport and deposition within floodplains. Despite low flow volumes, Burhi Gandak has high annual sediment load (around 15 MT) and annual yield of 1.24 MT / km2. Further, the assessments indicate that such high concentration of suspended sediments in rivers are likely to be deposited with the channels as well as in the floodplains, creating a very gentle relief and maintain a uniform profile. As the time period of inundation after flooding is fairly high (over two to three months), there is an opportunity for the high velocity overbank flows to stabilize and deposit silt. Historically, interventions made to drain the wetland through construction of channels in the 1950s have been impeded by high volumes of sediments received during flood events evidenced during 1970s.	Sinha and Jain (1998)	No historical records / assessments available Physical observations confirmed this fact, as major areas of Bikrampur Chaur and Nagri Jheel appeared to be silted, as compared to the main Kanwar.
11.4	Erosion	Assessments yet to be carried out		No historical records / assessments available
Ecosystem Services				
12	**Provisioning Services**			
12.1	Fisheries	Socio-economic surveys carried in 2012 indicated that 3,000 households living in and around Kanwar depended on wetland fisheries as source of livelihoods. Fishing in wetlands is mainly carried out by caste fishers, locally called sahni. The current fish yield of the wetland is estimated to be 54 MT in present. Catch is dominated by forage fish (>50%), followed by catfish and featherbacks (35%) and rest by major carps. Edible molluscs, *Pila globosa, Bellamya bengalensis, Lamellidens marginalis* and *L. corrianus* and crab *Paratelphusa spinigera* are harvested as a supplementary income source by 57% households.	2012, WISA Socio-economic survey	The capture fisheries in the wetland have declined with shrinkage in inundation areas and reduced connectivity with the riverine environments. During 1970's, Indian Major Carps (IMC) dominated the capture fishery along with feather backs, loaches and catfish. Over the years there has been a considerable decline in IMC from 15-27 % of the total catch during 1981 to 0-2% during 2011. Capture fish yield is estimated to have declined considerably from 365 MT in 1970s and 238 MT in 1980s to present values. A majority of fishers have shifted to culture fisheries and wage labour as a source of livelihood.
12.2	Wetland agriculture	Major part of Kanwar is under private land holding and used for agriculture. Cultivation is done throughout the year, with paddy being the major *Kharif* crop (June –November), wheat and sugarcane cultivated during Rabi (December – April) and maize during *Garma* (April – June).		Overall intensity of wetland agriculture has increased. The number of cropping cycles has increased from one to nearly three during the last three decades. Indigenous varieties (particularly of rice) have been replaced by water intensive varieties. Introduction of sugarcane and mentha have increased the overall water requirement, being met through extraction of groundwater.

Ecological Character Descriptor		Status	Data assessment year and source	Trends
12.3	Use of aquatic vegetation for economic purposes	Harvest of aquatic vegetation plays a crucial role in local economy. Approximately 45kg of Makhana (*Euryale ferox*) is harvested annually per household. 0.5% of the harvest is used for domestic consumption and rest is sold in local markets to generate an income of Rs. 1000 / household / annum. Fruits of *Trapa natans* (Singada) and leaves, stems and fruits of *Nelumbo nucifera* (Lotus) are harvested for household consumption. Flowers of *Nymphaea nouchali* are utilised to prepare local medicines. *Ceratophyllum demersum* and *Hydrilla verticillata* are used as fish food. *Phragmites karka* and *Cyperus iria* are harvested for preparing mats, thatching and fuelwood. Major species harvested as fodder are *Leersia hexandra, Sacciolepis myosuroides* and *Eichhornia crassipes*.	2004, Nandan and Singh (2004): 2012, Socio-economic survey, WISA	No discernible trends
12.4	Biochemical products	Recently cultivation of Mint (*Mentha arvensis*) is done in 4sq km area within the wetland in dry season. The leaves of mint are collected at a price of Rs. 11,000 / quintal from local farmers and used to extract crude mentha oil at Bauna village near Barauni. The crude oil is sold at a price of Rs. 1000-2000/ lt. The crude extract is send to Bararbanki in UP for further processing.	2012, Socio-economic survey, WISA	No discernible trends
13	**Regulating Services**			
13.1	Maintenance of hydrological regimes	Kanwar Jheel is a shallow depression located in the lower part of the Burhi Gandak basin accommodates significant proportion of rainfall and overbank flows of River Gandak and protects the adjoining settlements from flood risk. The wetland also serves as a groundwater recharge area and maintains higher groundwater for a large part of the year which supports agriculture and fisher y.		No discernible trends
14	**Cultural services**			
14.1	Recreation and tourism	Island of *Jaimanglagarh* present in the southern tip of Kanwar Jheel is associated with several excavations of high archaeological significance. The island is popularly known as the Monkeys' Island for presence of sizeable population of Rhesus macaque. The island is frequented by local tourists of Bihar. During winter, areas of *Guhabari, Jaimanglagarh* and upland areas (*rahis*) which serve as congregation sites for migratory waterbirds are visited by local bird watchers.		Tourism is unorganized, and has declined with decreasing water regimes.
14.2	Spiritual	*Jaimanglagarh* hosts the temple of local deity, Goddess Durga. The temple is highly reverred by local communities living in and around, making the site an important centre for local pilgrimage and religious festivals.		No discernible trends
	Scientific and educational	Preliminary investigations on biodiversity and limnology have been conducted by Zoological Survey of India. Sporadic studies on water quality, birds and resource utilisation of Kanwar Jheel have been conducted by individual authors and academic institutions.		No discernible trends

Box 1:

Designating Kanwar as a Wetland of International Importance under Ramsar Convention

The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for conservation and wise use of wetlands. Designation of a wetland as Ramsar Site commits the contracting party to take actions for wise use, and thereby increases funding opportunities for site management. Other benefits for site management include encouragement to partnerships that focus on river basin scale conservation efforts, and can be useful in dealing with off-site development that could threaten the site. Ramsar designation also helps with raising funds for restoration and education initiatives. In several wetlands, designation is accompanied with increased attention to a site, which can lead to increased interest by the scientific community. Public awareness of a site's Ramsar designation can highlight its importance, and provide opportunities for ecotourism development benefitting the wetland communities. The Ramsar Site status has been an important driver for restoration action in Lake Chilika, Loktak Lake and other sites.

Designation of Kanwar as a Wetland of International Importance (Ramsar site) under the Ramsar Convention on Wetlands requires that one of the nine criterions (related to waterbirds, fish, and plant and animal species of conservation significance in a given biogeographic region) are met. The criterions also need adequate justification from available science-base and monitoring information.

Given the high number of waterbirds that use Kanwar as a habitat, the most important criterion to use for site designation is Criteria 5 (Regularly supports 20,000 or more waterbirds). Kanwar is recognized as an Important Bird Area (IBA) under category A1(Threatened Species) and A4iii (≥ 20,000 waterbirds). However, the available counts (for the year 1996, 1999, 2009 and 2010 – counts conducted by Mandar Nature Club under the Asian Waterbird Census programme) do not justify these numbers. Estimates of 1982 indicate that 70,000 ducks, coots and other waterbirds were netted at Kanwar Jheel (Sahi, 1982 quoted in WWF, 1993), which indicates presence of high number of waterbirds at the site.

Kanwar qualifies as a Ramsar site based on Criterion 1 (example of a natural or near natural wetland type within the appropriate biogeographical region). Kanwar represents natural floodplain wetlands characteristic of the Gangetic Delta and plains eco-region (major habitat types being tropical and subtropical floodplain rivers and wetland complexes). Site designation is also supported under criterion 4 (supports an indigenous fish sub species in life history stages), as Kanwar supports breeding ground of Wallago attu, a near threatened fish species. An evaluation of features of Kanwar against the criteria used by Ramsar Convention for designating Wetlands of International Importance is presented below.

Evaluation of features of Kanwar against Ramsar site criterions

Ramsar Criterion	Description	Features of Kanwar supporting designation under the criteria
Criteria 1	A representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region	Kanwar represents a near natural floodplain wetland of the Indo-Gangetic region which supports livelihoods of large populations along with sustaining rich biodiversity.
		In terms of Ramsar classification of wetlands, Kanwar is an inland wetland Type W with shrub dominated marshes on inorganic soils (permanent/ seasonal / intermittent). Seasonal intermittent lakes and pools are also found representing inland wetland Type P.
Criteria 2	Supports vulnerable, endangered, or critically endangered species or threatened ecological communities	Kanwar is a natural habitat for 2 critically endangered (Gyps bengalensis , Gyps indicus) and two vulnerable (Aquila clanga, Grus antigone) species of birds
Criteria 4	Supports plant and / or animal species at a critical stage in their life cycle, or provides refuge during adverse conditions	Supports life stages of Wallago attu, a near threatened fish species. It is one of the largest, voracious and predatory of the local catfish which thrives well in rivers and floodplains. Despite being widely distributed, species is overfished causing considerable decline in the population in southern West Bengal of 26.7% over four decades from 1960 to 2000 (Mishra et al., 2009). In another study in northeastern Sunderbans, the species is known to have declined by 99% in four years (1997-2001) (Patra et al., 2005).
Criteria 5	Regularly supports 20,000 or more waterbirds	KAnwar is an Important Bird Area supporting criteria A1 (Globally Threatened Species) and A4iii (≥ 20,000 waterbirds). Records of waterbird hunting at the site during 1984-85 indicate exceptionally large numbers. However, consistent census records are not available, and thereby cannot be used as primary feature for designation.

Threats to ecological character

The analysis of wetland features and governing factors as discussed in section 2.1 of the report highlight trends which have (likely to have) adverse impacts on ecological character of Kanwar, and thereby limit the possibility of achieving wise use. These trends have been analysed to derive threats, and are largely symptomatic of ineffective management arrangements. These threats, alongwith the description of a desired state of ecological character, form the basis of developing management strategy.

Threats	Likely impact on ecological character (C= Components, P = Processes and S = Services)	Likelihood of change in near future (H = High, M = Medium, L = Low)
Declining areas under inundation The area annually inundated in Kanwar has been gradually shrinking, from 6700 - 7,400 ha in 1980s (Scott, 1989) to 6,043 ha by 2002 (Ghosh et al., 2004) and 4100 ha by 2010.	Enhance rates of terrestrialization of aquatic habitats, reduced habitat mosaic (C),and ecosystem services (availability of fish, aquatic vegetation and groundwater recharge)	High
Expansion in area under permanent agriculture within wetland Areas under permanent agriculture within the wetland have been increasing. Wetland agriculture in the 50s was mostly concentrated in upland areas (towards the southern and eastern fringes). Gradually, as inundation areas have declined and more silt accumulated in wetland, more and more areas have been brought into permanent agriculture. During 1989 – 2010, area under permanent agriculture nearly doubled. The near 50% reduction in wetland area outside Kanwar is also majorly attributed to conversion for permanent agriculture. The cropping pattern has also changed with more areas being brought under water demanding crops as sugarcane and mentha.	Enhance rates of terrestrialization of aquatic habitats, reduced habitat mosaic (C),water regime (C) and ecosystem services (availability of fish, aquatic vegetation and groundwater recharge)	High
Habitat fragmentation The natural connectivity of the wetland with the riverine environment has been impeded by construction of embankment along the river, channels across wetlands, roads and farm bunds. Reduced connectivity with the rivers is one of the factors behind lower recruitment of fish juveniles, and predominance of small size forage fish in Kanwar.	Reduce species exchange between riverine and wetland environment (P), overall water regime (C) and productivity of fisheries (S)	High
Increased pressure on waterbird habitats Kanwar is one of the most important wetlands for waterbirds in the Indo-Gangetic Plains. It once supported huge numbers of migratory ducks and coots such as *Fulica atra* throughout winters, as well as large concentrations of resident species, such as Dabchick (*Tachybaptus ruficollis*) and Asian Openbill (*Anastomus oscitans*). Till the 80s, birds, particularly migrating waterbirds were subject to intensive trapping and Manjhaul town a major bird market. Since the declaration of major parts of Kanwar as Bird Sanctuary, waterbird hunting has been considerably controlled, but incidences of killing by poisoning have been reported. Further increased human activity in the bird congregation area (particularly permanent agriculture) and reduction in grasslands has adversely affected the waterbird habitats. Census estimates for 1996 – 2010 have recorded less than 3,000 waterbirds at the site.	Reduced habitat for wetland biota (C), and cultural services (S)	High
Increased dependence on groundwater for wetland –agriculture and culture fisheries Communities undertaking farming and culture fisheries have responded to declining water regimes within Kanwar and reduced connectivity with the rivers by increased abstraction of groundwater. The use of shallow borewells has increased significantly since 2007.	Reduced overall inundation regime (C) and water balance (C)	Medium
Increasing area under emergent macrophytes The overall area under emergent macrophytes (particularly *Phragmites karka*) has increased within the wetland. The northern fringes of Kanwar (areas around Mahalaya and Kochalaya) which used to retain water for longer periods of time and Phragmites only during post monsoon period) are presently totally colonized by thick stands round the year, making even navigation very difficult.	Enhance siltation (P), and negatively impact processes that maintain wetland biota (C)	Medium
Use of small mesh size gears for fisheries The use of small mesh sizes gears, for example Chattijal, which have the capability of scouring virtually all living organisms from the wetland bottom has increased as the catch has shifted towards fish of smaller sizes.	Impact species recruitment (P), maintenance of biota (C), and productivity of fisheries (S)	Medium / Low
Declining availability of wetland resources The overall availability of wetland resources, particularly fish and aquatic plants. Capture fisheries for four months at present yield an average catch of 3 – 4 kg/person/day as compared to 8 – 10 kg/ day/person during eighties. More than 50% of the catch is dominated by forage fishes, whereas Indian Major Carps dominated wetland fisheries in the 70s. Availability of submerged plants (Darah Ghas - *Hydrilla verticilata* and *Ceratophyllum demersum*), rooted free floating (Kamal - *Nelumbo nucifera*, Koka-*Nymphaea nouchali*, Singada -*Trapa natans*, Kaccchu- *Colocasia esculenta*) has also declined significantly as area under inundation have declined. The availability of Brahmi (*Centella asiatica*) (leaves used as medicines) which was abundantly available has become very sparse particularly in the last five years.	Reduced provisioning services (S), and linked impacts on livelihood capitals of wetland dependent communities.	High / Medium
Increasing resource use conflicts Management of Kanwar till late 80s was based on an informal agreement between fishers and farmers which allowed both the groups to benefit from variable inundation regimes. Declaration of sanctuary has led to contestation of land rights, as major areas are under private holdings. There is an overall emphasis on increasing area under agriculture, thereby crowding out capture fisheries.	Reduced effectiveness of management affecting all components, processes and services indirectly	High

2.3 Key management issues

Absence of systematic wetland monitoring and evaluation

There is no system presently in palace to monitor ecological, hydrological and socio-economic status of the wetland and dependent communities. Much of the existing information is based on sporadic and one time research, or limited sampling done for purposes other than characterizing the wetland. Absence of robust baselines of wetland status and trends greatly reduce effectiveness of management planning.

Water allocation biased towards human uses compromising ecosystem requirements

Water plays a dominant role in controlling the environment and associated plant and animal life of Kanwar. Water and sediments provide the physical template within which the wetland evolves and functions. In order to maintain ecological health, Kanwar requires sufficient water of adequate quality, at the right time and pattern. This necessitates consideration of water needs of Kanwar and associated wetlands in any plan for water use and management within the river basin. However, water management in the entire North Bihar region is governed by human uses, primarily flood protection and agriculture. Construction of embankments for flood control has fragmented the natural hydrological regime of riverine floodplain wetlands. Major parts of Kanwar wetland complex have been reclaimed for permanent agriculture, thereby altering the natural inundation regime which earlier used to create a mosaic of habitats suited for wide range of biological diversity sustained by the wetland.

Limitations and ineffectiveness of protected area based wetland management approaches

Management of Kanwar is predominated by protected areas approaches following declaration of Bird Sanctuary in 1989. Prior to this, management of Kanwar was based on an informal agreement between the farmers (who owned the land rights) and fishers (permitted to fish in the inundated areas as per an 1885 judgement of the erstwhile High Court of Kolkata). Declaration of wetland as a sanctuary has greatly limited use and harvest of wetland resources, which constitute an integral part of maintenance of ecological processes. The current management has also been ineffective in regulating fragmentation of the entire wetland landscape, particularly through rapid expansion of permanent agriculture within the wetland boundaries. On an overall, the wetland is at best a contested landscape with its ecological processes and services compromised by stakeholder interests and overall prevalence of land uses that aggravate conversion of an aquatic ecosystem to a terrestrial ecosystem.

Full range of wetland ecosystem services and biodiversity not integrated in sectoral developmental planning

The focus of managing Kanwar has been centred on conserving biodiversity, mainly waterbirds, by regulating human pressures as hunting. The ecosystem services of Kanwar, as manifested through its role in groundwater recharge, reducing flooding risk and providing water and food security has not been considered while developing and implementing sectoral plans. Of particular concern is the emphasis on structural approaches for water management (e.g.

construction of embankments for flood control) which have over a period of time greatly altered the natural connectivity of the rivers and the floodplains and supported bringing in more areas under permanent agriculture.

Absence of institutional mechanisms for integrated management of Kanwar

There is currently no mechanism in place for implementing integrated management plans and ensuring coordination between various sectors and government departments implementing plans with consequences for Kanwar.

3

Institutional arrangements

3.1 Review of existing institutional arrangements

Institutions play an important role in governing and coordinating relationships between various wetland stakeholders, and thereby their fit with ecological character has an important influence on wise use outcomes. Institutional requirements for conservation and sustainable management of the wetland complex are defined by the ability to ensure integration of site management within broad scale environmental management and development programming (including river basin management), and enabling participatory management, particularly ensuring involvement of local communities whose livelihoods are linked to wetland ecosystem.

Current institutional arrangements that have most significant influence on the ecological character of Kanwar are those related to management of protected areas, water resources, fisheries and agriculture.

Management of protected areas: Prioritization of wetlands for conservation in Bihar has been largely based on biodiversity values, with particular reference to waterbirds. A network of protected areas has therefore emerged as the main institutional framework for wetland management, with the Environment and Forest Department as the nodal agency. Of the 12 protected areas in Bihar, 8 are wetland complexes. Six of these sanctuaries including Kanwar Jheel, Bareila, Nagi and Nakti Dam, Udaypur, Bhimbandh alongwith Kushewarsthan and Gogabeel (closed areas) Kanwar Jheel support significant diverisity of migratory waterbirds. Vikramshila Gangetic Dolphin Sanctuary, a 50 kilometer stretch of Ganges River between Sultanganj to Kahalgaon in Bhagalpur District was designated as a protected area in 1991 for the endangered Gangetic dolphins. Notably, this is the only protected area for Gangetic Dolphins in Asia.

Kanwar was accorded a protected area status to control wanton killing of waterbirds as a source of livelihoods for the fishers living in Manjhaul and adjoining villages. Under the provisions of Indian Wildlife (Protection) Act, 1972, a notice indicating the Kanwar area to be government land was issued in 1986 by the Collector of Begusarai. Private claims to the land were invited for settlement, for which over 260 claims were received. The wetland area was declared as a closed area under the name "Kanwar Lake Pakshi Vihar" in 1987. Further, in 1989, an area of 6311.63 ha (lying within 10 villages) was declared as a Bird Sanctuary through Bihar Gazette notification (no. 781 dated 20 June, 1989) (Annex XIII).

Three sites, i.e. Kanwar Jheel, Bariela and Kusheshwarsthan were recommended by the Government of Bihar for inclusion within the list of wetlands of national priority under the National Wetland Conservation Programme (NWCP) (presently merged into NCPA). Partial financial assistance for afforestation and clearing of channels was received under the national programme. An advisory group to provide strategic direction and provide expert inputs to wetland restoration was constituted in 2011.

The Wildlife (Protection) Act, 1972 provides the regulatory framework for protected areas. However, its implementation has been constrained by a range of factors. The final proclamation of the sanctuary is yet to be done as the private claims on land are not settled. The sanctuary boundaries are yet to be demarcated. Dedicated staffing for enforcement of provisions related to sanctuary has also not been done. Management of the sanctuary is currently placed with the Divisional Forest Office, Begusarai Division which is already facing limitations of staff and infrastructure. On the other hand, specific restrictions have been imposed on the communities which include prohibition of transfer

of land rights, and curtailment of right to fish and harvest resources.

Recently, the Environment and Forest Department following the directive of Ministry of Environment, Forests and Climate Change for declaration of eco-sensitive zones has developed a draft proposal for notification of eco-sensitive zone around Kanwar Lake Bird Sanctuary. A boundary of 500 meters has been proposed as eco-sensitive zone for which a range of activities have been classified as being completely prohibited, regulated and permitted. It is also proposed to develop a zonal master plan, which , inter alia, includes provisions for preventing any change in land use from green (for example agriculture and horticulture) to non-green uses.

Fisheries management: The Kanwar complex is a rich source of fisheries and base of livelihoods of sahni community. Kanwar area is managed as a capture fisheries source, whereas the associated chaur and maun areas are used for culture based fisheries. Capture fishing within the inundated areas was traditionally done as a low intensity social enterprise with payment of rents to the private landowners. The rights of sahni community are based on British period judgment dated August 1895, wherein they were permitted to use nets on payment of rents to the landowners. An informal territorial demarcation of the capture fishing area exists, with each village fishing only within its boundaries.

Maun and chaur areas beyond the Kanwar Sanctuary are within the jurisdiction of State Department of Animal Husbandry and Fisheries. The Bihar Fish Jalkar Management Act (2006) as amended in 2007 and 2010 provides the overarching framework for management of these areas. The term Jalkar refers to a range of wetlands (including tanks, ponds, lakes, rivers, water course channels etc) in which makhana (Euryale ferox), singhara (Trapa natans) and fish are reared and is under the administration of Department of Animal Husbandry and Fisheries. As per provisions under the Act, these jalkars are leased to fisher cooperatives in a seven year cycle. The lease value is set based on average production (generally for the past five years) and average prices are set by a price fixation committee. Presently there are four functional co-operatives in an around Kanwar wetland complex.

While the history of ownership of the maun and chaur is disputed, the right to engage in fishing in these water bodies was ensured way back in 1897(through the Indian Fisheries Act, 1897 which addresses matters pertaining to fisheries and the auctioning and leasing of waterbodies which fall within the territories governed by the Act). The first cooperative to organize collective fishing in Begusarai district was established in year 1956 under the Bihar Co-operative Societies Act, 1935. It consisted fishers from three blocks from Garhpura, Bakhri and Cheriya-Bariarpur covering 12 villages around Kanwar. However it gradually became moribund due to lack of capital, reduced participation of fishers, and emerging disputes. In the 1970s, when the management of wetlands was transferred from the Revenue Department to Fisheries Department, collective fishing through cooperatives was made mandatory for obtaining fishing rights through leases. The Kanwar Jheel Pariyojana Matsaya Jivi Samiti was formed during 1989 consisting fishers from 16 villages but it was dissolved in 2005. Presently, the Cheriya-Bariarpur Matasaya Jivi Samiti registered in 1996 under the Bihar Co-operative Societies Act, 1935 is the major fish cooperative operational within the wetland complex.

Maun and chaur areas are leased out for a period of 7 years at a time, by a statutory committee of the District Fisheries Office exclusively to the fisherman co-operatives against

a deposit, which is popularly called as Jamabandi. The co-operative societies further sub-lease the water bodies to their members by charging 15% over and above the Jamabandi. Each fisher pays Rs. 1 to get registered in the society and Rs. 10 to sub-lease a portion of a specific maun and chaur (Jalkars). The membership tenure with the co-operative is for a life time, and is transferrable (by submitting an application to change the name of the member, alongwith all membership documents and details) to family members (any one surviving family member) upon death. The co-operative societies also issue guideline outlining rules and regulations to maintain transparency and discipline among its members. While there is a near balance in gender terms within membership, only a few women are known to lease Jalkar.

Till the 80s, the maun areas were reported to have abundant natural stocking through the riverine inundations. However, with progressive decline in connectivity, a gradual shift to artificial stocking has taken place. Decreasing availability of water within the maun areas is a major challenge affecting productivity and overall profitability.

The present production is not even sufficient to cater to the needs of local markets in Begusarai. As less water is available from the rivers and rain, there is increased dependence on groundwater, which is not of suitable quality for fisheries. There is also increased competition in the local markets from fish imported from Andhra Pradesh.

The Department of Animal Husbandry and Fisheries is in the advanced stages of notifying a Fisheries Policy, which aims at 'development, efficient management, and effective use of fisheries resources for sustainable advancement of livelihoods, food, nutrition and environmental security and inclusive socio-economic growth. The ecological fragility of floodplains and wetlands is recognized, and ox-bow lakes will be focused upon to enhance culture fisheries. Apparently, the Department uses a very narrow definition of wetlands, and intends to promote a varied management regime in order to meet the fish production requirements.

Water Resources Management: Management of rivers is within the ambit of Water Resources Department, formerly known as Irrigation Department. Its focus is on creation and utilization of irrigation potential and flood control. Irrigation, flood management and water drainage rules, 2003 provide the overarching implementation framework for the various programmes. A major emphasis of flood management is through construction and maintenance of embankments. As per the statistics of the Department, for a river length of 2,943 km, 3,629 km of embankments have been constructed providing protection to 29,490 km2 of total 68,800 km2 flood prone areas identified in the state.

The approach for management of Kanwar wetland complex has been based on its perception as a waterlogged area and a wasteland. Efforts have been made to drain its waters and reclaim land for agriculture since the fifties. The focus on structural approaches to water management has been at a high cost to the natural regimes of the wetland system. While floodplain management and use of wetlands as flood detention structures have been identified as non-structural measures for flood control, no plans or interventions are in place or even under consideration. There is at present no mechanism available to assess the impacts of interventions and projects made by the department on Kanwar wetland complex.

The recent project proposal for construction of the River Burhi Gandak-Noon-Baya-Ganga link has to be analysed for its implications on Kanwar and associated wetlands. The focus remains on

structural approaches to water management, apparently at a high cost to the natural regimes of the wetland system.

Agriculture Development: Agriculture within the areas which dry out after monsoon is the most predominant land use within the Kanwar wetland complex. Most of these lands are under private holdings.

Encouraging agricultural growth to guarantee food security is an important aspect of agricultural policy of the country. While the farming decisions are individual, state support to a number of flood control and irrigation measures to bring more areas under cultivation in an attempt to reduce poverty and malnutrition has led to conversion of large areas of Kanwar for agriculture. Major agricultural expansions took place around Kanwar during the 1970s and 1980s post the green revolution which emphasised on the use of high yielding varieties of wheat and maize with conjunctive use of modern farm techniques including irrigation. Traditional bio-manures as ashes and cow dung were replaced by chemical fertilizers and pesticides.

The overall agriculture policy also supports expansion of irrigated area through tapping of phreatic aquifers using shallow tube wells (one million tube wells scheme being the flagship). The expansion and intensification of agriculture within the wetland complex is entirely based on groundwater extraction. There has been a rapid increase in small bores. Available data on gross area irrigated for Begusarai indicates an increase in area under tubewells from 88,000 hectares in 2005-06 to 105,000 hectares in 2009-10. During 2004 – 2009, the stage of groundwater development (existing groundwater draft expressed as a percentage of net annual groundwater availability) increased from 56% to 59% - one of the highest in the state. The number of tubewells in the district has also increased by 20% (from 88,184 to 105,402) during 2006-07 to 2009-10[11]. While these data in general indicate intensification of groundwater use, further investigations are required to assess the overall impact on hydrological regimes of the wetland.

The livelihoods of small, marginal farmers and share croppers have been impacted as they are unable to bear the escalating costs of agriculture and as a result are forced to migrate.

The notification of Kanwar sanctuary has put the agriculture farmers in conflict with park management. There is an evident threat within the farming communities of loss of highly productive agriculture land to the park. They have already made several representations to the government to take a rational view of the acquisition of the land and ensure adequate compensation is paid. Local forums as Kanwar Bachao Sangharsh Samiti have emerged as the rallying point for this purpose.

A review of the current institutional arrangements in the context of conservation and sustainable management of Kanwar Wetland complex indicates the following issues:

- **Impacts on wetlands not considered in sectoral programmes:** Implementation of sectoral programmes, specifically those related to water management and agriculture development has significant implications for hydrological regimes of Kanwar. Kanwar has been treated as a waterlogged area for which interventions for enhancing drainage have been carried out. Increased ground water abstraction for agriculture has almost been in parallel to reduced bank inflows into the wetland system, thereby further reducing the overall water availability. There is no mechanism currently

[11] Government of Bihar (2011). Bihar Through Figures – 2011. Directorate of Economics and Statistics, Government of Bihar, Patna, Bihar

in place wherein the cumulative impacts of sectoral programmes can be systematically evaluated and adverse impacts on wetlands prevented.

- **Stakeholder conflicts:** Kanwar is a multiple use system, used for farming as well as fishing by communities living in and around. The decline in inundation regimes has led to predominance of farming, gradually crowding out the stakes of fishers. Expansion and intensification of agriculture is also in conflict with maintenance of biodiversity habitats. There is presently no institutional mechanism to resolve these conflicts with due consideration to the needs of wetland management.
- **Insufficiency of protected area approaches:** The present wetland management arrangements based on protected area approaches are insufficient to fully address the drivers of wetland degradation. Issues related to maintenance of hydrological connectivity and balancing multiple stakeholder needs, critical to sustenance of the wetland ecosystem, cannot be addressed by patch-centric management.

In summary, the review indicates that in absence of a defined institutional mechanism for wetland management, there is significant risk of changes in wetland ecological character to the detriment of wetland biodiversity and ecosystem services.

3.2 Wetland management institutions: experiences and lessons learnt

Efforts for developing institutional arrangements for conservation and sustainable management of wetlands within India are in place since last three decades. This section provides an overview of these efforts to provide a background for developing an institutional architecture for management of Kanwar Jheel and other wetlands of Bihar.

National scenario: The Indian Constitution, in its Article 51-A(g) stipulates 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. The MoEFCC, at its inception in 1985, identified wetland conservation and sustainable management as one of its important programming themes. India's assent to the Ramsar Convention in September 1982 provided an important backdrop to this decision. The Ministry established the National Wetland Conservation Programme (NWCP) in 1986 to provide the overarching policy framework and financial assistance to the state governments for implementation of site management plans. In 2001, the National Lake Conservation Plan (NLCP) was introduced to address pollution issues 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 included 170 wetlands.

The policy architecture for wetlands is currently defined within the broader national environment policy. The National Conservation Strategy and Policy Statement on Environment and Development issued in 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 of 2006 laid down specific policy elements for wetlands. Wetlands have been identified as components of 'freshwater resources'. Recommended policy actions include integration in developmental planning, management based on prudent use strategies, 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 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 the state governments. A Central Wetlands Regulatory Authority (CWRA) has been constituted for the purpose of enforcing the rules, to evaluate proposals for wetland notification sent by the SGs and set thresholds for activities to be regulated.

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 National Water Policy (2012) provides an important policy framework for linking wetlands to water resources management. The policy recommends adoption of a basin approach for water resources management, and identified conservation of river corridors, water bodies and associated ecosystems as an important action area. Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWRRD) has several programmes that contribute to wetland conservation. The National Mission for Clean Ganga includes an allocation for restoration of wetlands within River Ganga Basin, however, a comprehensive strategy is yet to be defined. The MoWRRD also coordinates implementation of pilot scheme for "National Project for Repair, Renovation & Restoration (RRR) of Water Bodies directly linked to Agriculture" since January, 2005. The scheme supports restoration and augmentation of storage capacities of water bodies, including recovery and extension of their lost irrigation potential. In 2013, the Ministry of Urban Development (MoUD) has issued an advisory on conservation and restoration of waterbodies in urban areas, identifying funding streams of the MoUD and MoWRRD for urban wetlands. The National Action Plan for Climate Change has identified eight missions, implementation of which forms the core intervention strategy for climate change mitigation and adaptation. Wetland conservation and sustainable management is included as a subcomponent of National Water Mission.

Scenario in States: At state level, wetlands have been mostly placed within the programmatic ambit of Departments of Environment and Forests, Science and Technology, Housing and Urban Development (for wetlands in urban areas) or fisheries. Of the 26 Ramsar Sites designated by the country as on date, management is placed under the departments of forests, wildlife, and environment for 11 sites, whereas science and technology is the nodal institution for nine sites. One site each has been placed under department of irrigation and fisheries.

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

placed under the aegis of Irrigation and Flood Control Department, but later on transferred under the administrative control of the Forest and Environment Department. In 1992, the Government of Odisha constituted the Chilika Development Authority to address the pressures on Chilika Lake, the largest brackishwater lagoon on the east coast threatened by 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 entrusted the mandate for conservation of all waterbodies of the state in 2004. The State of Odisha constituted a distinct wetland authority for the entire state in 2012.

Most of the wetland authorities have been formed as government societies under the provisions of the Societies Registration Act. The governance structure includes a governing body for strategic planning and decision making; an executive body for approving management plans and projects and an authority office to implement the approved actions plans. The authorities mostly function as strategic bodies responsible for planning, ecosystem monitoring, networking, stakeholder participation and awareness generation. Field implementation of the restoration activities is organized through line departments and external agencies. East Kolkata Wetlands Management Authority and Loktak Lake draw their constitution and powers through specific acts, and therefore have "statutory authority" in the true sense. The Government of Odisha is also in advanced stages of considering a regulatory backing for Chilika Development Authority, particularly to control detrimental fishing practices. In Kerala, the Conservation of Paddy Land and Wetland Act, 2008, bans conversion of wetlands. In 2015, the SGs of Karnataka and Rajasthan have enacted legislations for conservation of wetlands. Absence of a regulatory backing to the authorities is seen as a major constraint for most of the wetland management authorities.

The ability of the wetland authorities to spearhead design and implementation of integrated restoration plans is evident. Of the seven authorities, five have site management plan in place and are implementing management plans. The Chilika Development Authority has successfully enabled a participatory ecosystem restoration leading to restoration of ecological environs as well livelihoods of dependent communities. The restoration of Chilika has been recognized by Ramsar Convention with the prestigious Ramsar Wetland Conservation Award to the Authority in 2002, and removal of the site from the Montreaux Record. Loktak Development Authority has formulated an integrated management plan for the site at river basin level and has been able to secure financial support of Rs. 400 crores from the Planning Commission for implementation of the plan. The Lake Conservation Authority implemented a restoration plan for Bhoj wetlands with financial support of Japan Bank for International Cooperation leading to tangible improvement in lake environments. However, changing complexities within the river basin and securing financial support have been major challenges faced by most of the authorities.

The following are the key lessons and experiences with reference to establishing 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 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 the integrated plans, evaluate implementation effectiveness and suggest mid-course corrections.
- **Capacity and financing:** The success of wetland authorities is closely related to availability of adequate human and financial resources to design and implement ecological restoration plans. Infrastructure for wetland monitoring and evaluation forms a critical part of this capacity.
- **Adaptable management:** Wetland management institutions need to be adaptable to be able to work in a changing ecological and socio-political landscapes. The success of management is linked to the ability to modify management based on a continuous evaluation of features and governing factors.
- **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 on the governing body enables better coordination and ensured 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 biodiversity.
- **Regulatory regimes:** Wetlands are open systems and as such are exposed to a range of pressures including from unsustainable use. In several circumstances, application of state acts and regulations provide a means to regulate these activities to ensure ecological integrity of wetlands. However, in 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.

3.3 Proposed institutional arrangement for managing Kanwar

The State Government of Bihar, in response to an advisory of the Ministry of Environment, Forests, and Climate Change regarding setting up of wetland management authorities, has constituted the Bihar State Wetland Development Authority (BWDA) as the nodal agency for wetland management in the state. The BWDA has been assigned the following roles:

- Establish policy for conservation and sustainable management of wetlands of the state
- Identify wetlands and recommend designation as Wetland of International Importance (under Ramsar Convention) or national importance (under National Programme on Conservation of Aquatic Ecosystems of the MoEFCC)
- Review the documents pertaining to wetland identification and classification as per the standards of the state government and notify to various departments
- Advise state governments on wetland conservation and sustainable management

- Recommend measures for enforcing national and state level wetland regulatory framework
- Resolve disputes regarding boundaries and multiple rights existing within wetlands
- Seek support from other state, national and international agencies to further conservation and sustainable management of wetlands of Bihar

The committee has members drawn from departments of forests and environment, water resources, rural development, fisheries and animal resources, finance, tourism, revenue, and ecology and environment. Constitution of BWDA provides an institutional platform for cross sectoral planning and policy making for wetlands of the state. Till the time of writing this report, the authority was yet to meet, and details of functioning were yet to be worked out.

The review of wetland components, processes and services underlines the need to consider the Kanwar wetland complex (including the area currently designated as Kanwar Bird Sanctuary and associated maun and chaur areas vested with Fisheries Department for culture based fisheries) as a single management unit for achieving conservation and wise use outcomes. Maintenance of wetland features, particularly hydrological regimes which underpins its ecosystem services and biodiversity values will require interventions at the catchment scale. In addition, land use within the wetland as well as within the catchment will need to be regulated in line with ecological characteristics and inundation patterns. Such a management regime requires coordinating a number of sectoral programmes involving several state government departments and external agencies. Based on the experiences in other wetlands, it is recommended to constitute a Kanwar Management Authority (KMA) under the ambit of BWDA and administrative control of the Forest Department, Government of Bihar (which is also responsible for management of the protected area network) to coordinate implementation of management plan and ensure conservation and wise use of the wetland complex.

The Authority may be registered as a non-profit organization under Societies Registration Act, 1860 to enable flexibility in raising financial resources from public and private sources. As per the provisions of the Act, a Memorandum of Association defining the jurisdiction, aims and objectives and governance structure will need to be submitted to the Registrar of Authorities. Rules and Regulations detailing the membership, powers and functions of governing and executive bodies, accounting and audit procedures, and management of property of the authority will also need to be formulated and submitted to the Registrar.

Mission: The KMA will work towards the mission "to conserve, restore and sustainably manage Kanwar wetland complex to maintain and enhance their biodiversity and ensure sustained provision of their full range of ecosystem services to support well-being of dependent communities".

The authority may be mandated to manage the Kanwar wetland complex, which includes Kanwar Jheel and associated maun and chaur areas.

Functions: KMA will serve as the nodal planning, management and regulatory body for Kanwar wetland complex. Its functions will include outlining integrated management plan, coordinating implementation, enforcing regulation, raising resources for site management, networking and collaboration, capacity building, and communication and outreach. The authority can draw its powers from the Wetland (Conservation and Management) Rules, 2010. For this, the required procedure for notification of these wetlands under the rules will need to be completed. Specific functions are as below:

1. Integrated management planning	1.1	Formulate integrated management plans for conservation and wise use of Kanwar wetland complex
	1.2	Work towards mainstreaming wetland management in sectoral developmental programming, inter alia, water resources development, rural development, agriculture, fisheries development and tourism
2. Wetland management	2.1	Coordinate implementation of management plan components aimed at: a) restoration of hydrological regimes, including improvement of water quality b) control of silt loading from catchments c) management of plant and animal invasives d) ecological restoration and habitat improvement e) sustainable development of capture and culture fisheries f) improving livelihoods and quality of life of wetland dependent communities g) community-managed eco-tourism development
	2.2	Work towards resolution of stakeholder conflicts
3. Regulation	3.1	Act to regulate and control activities leading to adverse change in ecological character of wetland complex
	3.2	Ensure compliance with the existing national and state level regulatory frameworks related to wetlands
	3.3	Approach the state government for enactment of any regulation for achieving conservation and sustainable management of wetland complex
4. Monitoring and Evaluation	4.1	Develop and maintain a wetland inventory, assessment and monitoring system, based on scientific guidelines, to assess and respond to changes in wetland components, processes and services
	4.2	Commission strategic environmental assessments for developmental projects likely to create advers impacts on wetland biodiversity and ecosystem services
	4.3	Collate and disseminate periodic reports on status of Kanwar wetland complex
5. Capacity Building	5.1	Upgrade management and professional skills of authority members, staff and local communities involved in wetland management
6. Research	6.1	Promote multi-disciplinary research on wetlands to support integrated and adaptive management
7. Networking and collaboration	7.1	Collaborate with other state, national and international institutions to promote the cause of conservation and sustainable management of Kanwar wetland complex
8. Awareness generation	8.1	Develop and coordinate implementation of a communication and outreach strategy for Kanwar wetland complex
	8.2	Create awareness on wetland biodiversity and ecosystem services by organizing special events, communication and other channels as may be appropriate
9. Financial management and fund raising	9.1	Secure funds for implementation of wetland management plans by developing collaborative projects for funding support by state, national and international donors
	9.2	Acquire by gift, purchase, exchange, lease, hire or otherwise any property movable or immovable necessary for implementing the objectives of the society
	9.3	Draw, accept, make and endorse for the purpose of the authority, discount and negotiate Government of India and other promissory notes, bills of exchange, cheques or other negotiable instruments.

Governance: A three tier governance structure is proposed for KMA with the Governing Body at the apex, an Executive Committee responsible for approval of implementation plans and projects, and an office of the Chief Executive to implement the programmes (Table 3.1).

The Governing Body will provide the overall strategic direction for integrated management of Kanwar wetland complex. The members of the BWMA may be co-opted as members of the Governing Body of KMA. In addition, representatives of the farmer and fisher communities may be included. The Chief Executive of the KMA will function as the Member Secretary.

The Executive Committee is envisioned to be responsible for operationalization of the strategic direction as set by the Governing Body through implementation plans and projects. The Committee will approve management plans and various projects of the authority. In case deemed necessary, the Executive Committee may constitute a scientific advisory group to advise on scientific and technical merit of the suggested interventions, and inform the Committee on the effectiveness of interventions.

Implementation of the plans and projects will be done through the office of the Chief Executive in coordination with line departments. The office will be responsible for inventory,

Table 3.1 | Governance Structure of KMA

Governance level	Role and Functions	Membership
Governing Body	• Approve integrated management plan for Kanwar wetland complex	Chairperson
	• Approve annual plan an d budget of the authority	• Minister, Forest and Environment Department, GoB
	• Make, amend or repeal bye laws of the authority	Members
	• Enter into an agreement for an behalf of the authority for furtherance of its objectives	• Minister, Department of Water Resources, GoB
	• By resolution, appoint advisory boards or other special committees to support implementation of objective of the authority	• Minister, Department of Rural Development, GoB
		• Minister, Department of Animal Husbandry and Fisheries Resources Development, GoB
		• Minister, Finance Department, GoB
		• Chief Secretary, GoB
		• Secretary, Environment and Forests, GoB
		• Principal Chief Conservator of Fore sts, GoB
		• Chief Wildlife Warden, GoB
		• Principal Secretary, Department of Animal Husbandry and Fisheries Resources Development, GoB
		• Principal Secretary, Department of Water Resources, GoB
		• Principal Secretary, Agriculture Department, GoB
		• Chief Engineer, Department of Water Resources, GoB
		• Principal Secretary, Department of Tourism, GoB
		• Principal Secretary, Rural Development
		• Director, Ecology and Environment Department, GoB
		• Chairman, Bihar State Pollution Control Board
		• Advisor (Wetlands), Ministry of Environment, Forests and Climate Change, GoI
		• District Collector (Begusarai)
		• Representative, Fisher Cooperative
		• Representative, Farmer Community
		• Representative, Non-Government Organization working on wetland issues of the state
		• Experts (2) drawn from universities / research institutions
		Member Secretary
		• Chief Executive, KMA
Executive Committee	• Appoint and maintain service conditions of staff of the authority	Chairperson
	• Grant approval for integrated management plans for implementation	• Chief Wildlife Warden, GoB
	• Seek funds for implementation of wetland management plans	Members
	• Constitute sub-committees for implementation of management plans	• Conservator (Begusarai Division)
	• Enforce regulations for maintenance of ecological character of Kanwar wetland complex	• District Collector, Begusarai
		• Director, Animal Husbandry and Fisheries Department, GoB
		• Director, Ecology and Environment, GoB
		• Chief Engineer, Water Resources
		Member Secretary
		• Chief Executive, KMA
Office of Chief Executive, KMA	• Formulate, coordinate and supervise the projects	
	• Institute and defend proceedings on behalf of the authority	
	• Wetland assessment, monitoring and evaluation	
	• Communication and outreach	
	• Capacity building and training	
	• Research and development	

assessment and monitoring; conduct periodic review of management plan implementation to support decision making; create awareness amongst stakeholders ; build capacity of wetland managers and stakeholders and conduct research and development on various aspects of Kanwar wetland complex .

Staffing pattern | The office of the KMA will be headed by a Chief Executive who will be overall responsible for implementation plans of the Authority. Following implementation units are proposed to deliver various functions of the Authority:

- Project management: responsible for consolidating annual plans, developing implementation strategies, project monitoring and evaluation
- Wetland inventory, assessment and monitoring: responsible for monitoring of wetland features, development of inventory of features and assessing status and trends, coordinating research and management of research and monitoring facilities
- Community livelihoods: responsible for sustainable fisheries, agriculture, microenterprise development, ecotourism
- Capacity building and networking: responsible for capacity building including education and awareness on wetland values and functions to stakeholders, networking with national and international agencies to support wetland management.
- General administration: responsible for finance and office administration

4 Monitoring Plan

Ibises in flight over Kanwar

4.1 Monitoring objectives

Management of Kanwar Jheel 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 Kanwar Jheel.

The present system for monitoring Kanwar Jheel is highly fragmented and disjointed. A few agencies (for example, Department of Water Resources, Central Water Commission, Central Ground Water Board, State Pollution Control Board, Zoological Survey of India, NGOs as Mandar Nature Club and others) collect information on specific parameters of interest. There is no systematic collection of data on various wetland features limiting the possibility of objectively defining the status and trends of various wetland features, and identification of related drivers and pressures.

Developing a monitoring plan for Kanwar requires addressing the inter-related requirements of wetland inventory (the collection and collation of core information for wetland management), and wetland assessment (identification of status and threats to wetlands as a basis for collection of more specific information). The imperative therefore is to put in place an integrated Wetland Inventory, Assessment and Monitoring System (WIAMS) to address the overall information needs of wetland management, and to provide a robust decision support system for the same. The specific objectives for establishing WIAMS include:

- Developing an up-to-date and scientifically valid information on status and trends of wetland features and influencing factors;
- Establishing a baseline for measuring change in ecological character;
- 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;
- Assessing efficiency of wetland management interventions;
- Determining impacts of developmental projects on ecosystem components, processes and services;
- Identifying risks to ecological character and support development of response strategies.

4.2 Monitoring strategy

Ecological character of Kanwar Jheel is influenced by a range of drivers and pressures acting at multiple scales and mediated by several factors. The monitoring strategy is therefore aimed at detecting any change causing or likely to have adverse effect on ecological character (and limiting the possibility of achieving wise use) to ensure appropriate management response.

As described within the monitoring objectives, information needs for Kanwar include inventory (to establish the ecological character baseline), assessment (to assess status, trends and threats to wetland) and monitoring (of the existing status and trends, including reduction in existing threats or appearance of new threats). Since, these information pertain to different spatial scales, the overall requirements can be classified at four hierarchical levels: a) Kanwar Jheel wetland site, b) Kanwar wetland complex, of which Kanwar Jheel forms a part, c) Gandak-Kosi floodplain sub-basin constituting the area directly draining into the wetland complex and zone of direct influence (indicated in map 2.7) and d) Gandak-Kosi Basin (a sub-basin of River Ganges).

A hierarchical classification of inventory, assessment and monitoring needs for Kanwar 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[11] for Kanwar, 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

Table 4.1 | Inventory, assessment and monitoring needs for managing Kanwar Jheel

	Information Purpose		
Information Scale	**Inventory**	**Assessment**	**Monitoring**
Gandak Kosi basin	**Geomorphic setting** **Climate** (precipitation, temperature, evaporation) **Water regimes** (riverine flows, bank flows and connectivity with wetlands, regulation, abstraction) **River basin and sub-basin management planning**	**Climate risk and vulnerability** (perception of climate related risks based on sensitivity and adaptive capacity of critical ecological character elements, ecological character change scenarios and risk management options)	No direct monitoring proposed at this stage. Information on land use and land cover change to be derived
Gandak-Kosi floodplain sub basin	**Climate** (precipitation, temperature, wind, humidity, evaporation) **Land use, land cover and management practices** **Water regimes** (riverine flows, bank flows and connectivity with wetlands, regulation, abstraction) **Sectoral programmes and institutional arrangements** for management of land and water resources and biodiversity conservation	**Environmental flows** (degree to which the water and sediment flows required to maintain ecological integrity and ecosystem services of Kanwar are provided for and maintained)	**Land use and land cover change** **Hydrological regimes** (riverine flows of water and sediment; inundation regime; riverine connectivity; surface-groundwater connectivity; water quality; water use pattern)
Kanwar wetland complex	**Climate** (precipitation, temperature, wind, humidity, evaporation) **Physical setting** (area, boundary, connectivity) **Water regime** (inflow, outflow, balance, surface-groundwater interactions, inundation regimes, quality) **Sediment regime** (inflow, outflow, balance, distribution and transport) **Biota** (plant and animal communities, conservation status) **Energy and nutrient dynamics** (primary production, nutrient cycling) **Species interaction** (invasion) **Processes that maintain animal and plant population** (migration) **Ecosystem services, stakeholders and tradeoffs** (regulatory, provisioning, cultural, supporting) **Institutional arrangements** (governance, formal and informal rights and ownership, application of acts and regulations)	**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) **Fish migration** **Bird habitat assessment**	**Hydrological regimes** (water and sediment inflow, outflow and balance; inundation regime; riverine connectivity; surface-groundwater connectivity; water quality; water use pattern) **Ecological components and processes** (abundance and diversity of plankton, benthos, macrophytes, fish and birds; fish catch, effort, recruitment and migration; waterbird congregation sites and habitat quality) **Socioeconomics and livelihoods** (community dependence on wetland resources, ecosystem services and livelihood interlinkages, conflicts)
Kanwar Jheel wetland site	**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 nutrient dynamics** (primary productivity, nutrient cycling, carbon cycling, decomposition, oxidation-reduction) **Processes that maintain animal and plant population** (recruitment, migration) **Species interaction** (competition, predation, succession, herbivory) **Ecosystem services, stakeholders and trade-offs** (regulating, provisioning, cultural, supporting) **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) **Ecosystem services valuation and tradeoffs**	**Hydrological regimes** (water and sediment inflow, outflow and balance; water and sediment chemical quality; water use pattern) **Ecological components, processes and services** (abundance and diversity of plankton, benthos, macrophytes, fish and birds; fish catch, effort, recruitment and migration; waterbird congregation sites and habitat quality) **Socioeconomics and livelihoods** (community dependence on wetland resources, ecosystem services and livelihood interlinkages, conflicts)

[11] Derived from the core inventory fields required for ecological character description are 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 2)

arrangements, particularly those related to land and water resources. As the floodplain sub-basin is the zone of direct influence on the wetland complex, information needs include land and water management practices which have direct influence on the status of wetland complex. Within the wetland complex, the focus is on assessing the habitat connectivity and water, sediment, energy and nutrient flux which influence ecological character of Kanwar. 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 to have an impact on the wetland state.

Information needs related to assessment are aimed at deriving the status, trends and existing/ likely threats to wetland system. At the site and wetland complex scale, the focus is on deriving ecological character change, and the vulnerability of ecological character change, based on deriving limits of acceptable change for the ecological character feature of interest. Specific assessments related to fish migration, waterbird habitats and invasive macrophytes have also been identified based on the review of wetland features contained in previous chapters. At the floodplain sub basin scale, the focus is on deriving environmental flows which are necessary for maintaining ecological integrity of the wetland complex, maintenance of biodiversity and ecosystem services. At the Gandak-Kosi basin level, 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.

Information needs for monitoring Kanwar Jheel 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 wetland as well as in the basin and sub-basin scales; 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) socio-economics and livelihoods to assess the trends in ecosystem services – livelihoods interlinkages. These monitoring information requirements adequately address the needs of Wetland (Conservation and Management) Rules, 2010 of the Ministry of Environment and Forests[2] which will become applicable if Kanwar is designated as Ramsar site or exclusively 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 in Table 4.2.

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.

[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 4.2 | 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 Gandak-Kosi basin and floodplain complex sub basin	% 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
	Land use and land cover change within Kanwar wetland complex	% area under open water, vegetation, agriculture, settlements	High		Biannual
	Connectivity	Degree of fragmentation of wetland complex	High		Annual
Hydrological Regime					
	Water and sediment flux	Water inflow	High	Monitoring at gauging stations	Annual
		Water outflow	High		Annual
		Sediment inflow	Medium		Annual
		Sediment outflow	Medium		Annual
	Water holding capacity	Bathymetry	High	Bathymetric surveys	Once in 10 years
	Inundation regime	Seasonal fluctuation in waterspread area	High	Remote sensing	Seasonal
	Surface water quality	Temperature	Medium	Standard procedures of APHA	Monthly
		pH	High		Monthly
		Dissolved Oxygen	High		Monthly
		Specific Conductivity	High		Monthly
		Alkalinity	Medium		Monthly
		Nitrate	High		Monthly
		Phosphate	High		Monthly
		Transparency	Medium		Monthly
	Biological properties	Biological Oxygen Demand	Medium	Standard procedures of APHA	Annual
		Total Coliform	Medium		Annual
		Faecal coliform	Medium		Annual
	Sediment quality	Texture	Low	Standard procedures of APHA	Annual
		pH	Medium		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 for agriculture	No. of bore wells	High	Survey	Once in 5 years
		No. of tube wells	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
		Macrophytes (diversity and abundance)	High		Seasonal

Parameter		Indicator	Priority	Monitoring Method	Monitoring Frequency
		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
		Macrobenthos (diversity and abundance)	High	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
		Shell and fin fish diversity	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 (number of juveniles)	High	Sampling and Taxonomic studies as per Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
		Fish breeding, spawning and migration pattern	High	Specific assessments and tagging experiments	Once in 5 years
		Bird population and diversity	High	Census and Taxonomic studies	Annual
		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	Number of households harvesting wetland resources for livelihoods	High	Socioeconomic survey	Once in 5 years
		% contribution of wetland resources to income and employment	High		
		Indirect household benefit from increased availability of water attributed to wetland as compared to non-wetland areas	High		
		Number of tourists visiting wetland and direct and indirect spending	Medium		
	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		

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 Kanwar. The management plan proposes establishment of a Wetland Management Authority for Kanwar, which, amongst other functions, will also be responsible for creating the ecological character baseline; assessing pressures on wetlands and associated risks of adverse change in ecological character; and monitoring to determine extent of any change and associated risks.

For the authority to be able to discharge these functions appropriately, a wetland monitoring unit is proposed to be constituted with adequate human and technical resources. The structure of monitoring team (to function as a part of the wetland management authority) is presented in Annex XIV. While the monitoring team will be responsible for day to day monitoring, specialized assessments will be carried through engagement of expert agencies. The management authority will also be responsible for compilation of inventory information and its periodic updation.

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 Bihar 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 socio-economics 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)

4.3 Infrastructure and human resources requirements

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

Under the aegis of the current management plan, it is proposed to invest into the following infrastructure for the said purpose:

- 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 of analysis 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 along with metadata, as per the quality control procedures suggested in the following sections.
- Network of hydro-meteorological and water quality stations for hydro-biological monitoring

At a later stage, the authority would need to be equipped with hydrological and ecological modelling facilities to be able to make sophisticated projections of changes in wetland state.

The human resources required to implement the monitoring programme are described in the organogram for the wetland monitoring unit. Training on wetland monitoring for the monitoring staff, alongwith those of concerned state government departments would be carried out as a part of the overall capacity development programme for the authority.

4.4 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 setting up the monitoring programme.

Periodic reports, for example as a part of the annual report of the wetland management authority should aim to provide a summary overview of the outcomes of monitoring.

Special publications, for example wetland atlases containing 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.

4.5 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

4.6 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.

5 Management Planning Framework

Fisher in Kanwar

5.1 Goal and Purpose

The Kanwar wetland complex needs to be managed to secure its rich biodiversity as well as livelihoods of wetland dependent communities. Given the role of fluvial processes in governing the key ecological components and processes, there is a need to mainstream biodiversity and full range of ecosystem service values of Kanwar in sectoral developmental programming at river basin scale.

The management plan aims to achieve the long term goal of **'conservation and wise use of Kanwar wetland complex for ecological and livelihood security of local communities'**. The purpose is to **'put in place effective management arrangements for Kanwar wetland complex involving all stakeholders, particularly local communities at river basin level'.**

5.2 Management Strategy

Kanwar Management Authority as nodal agency for wetland management and intersectoral coordination | Integrated management of Kanwar requires a dedicated institution for coordinating implementation of sectoral action plans, maintaining an overview of status and trends of wetland and associated catchments, creating an environment for stakeholder engagement and representing the concerns related to wetlands in sectoral planning. It is proposed to constitute Kanw ar Management Authority (KMA), under the aegis of Bihar Wetland Development Authority (BWDA) to coordinate implementation of management action plan and maintain an overview of state of ecological character of the wetland complex.

Restoration of hydrological regimes | Kanwar is going through a phase of gradual shrinkage in inundation regime due to a range of factors particularly reduced rainfall and fragmentation of landscape due to expansion of permanent agriculture. Restoration of inundation regimes to at-least the levels observed in the 80s is required to ensure maintenance of aquatic habitat diversity and slow down terrestrialization processes in the wetland complex. This can be ensured by: a) regulating outflows; b) enhancing connectivity within wetland complex; c) enhancing water holding capacity of the wetland complex; d) enhancing riverine inflows into wetland complex, and e) allocating water for wetland functioning at the basin scale.

The outflow channel aids depletion of water levels in Kanwar leading to reduction in inundation regimes. This can be prevented by regulating outflows through a hydraulic structure at Harsainpul. A gated structure can be constructed at the head of the outflow channel to ensure that water level in Kanwar is allowed to be maintained around 35 m amsl. The gates can be operated to prevent flooding conditions in adjoining settlements.

Rejuvenation of natural channels connecting Chanha Nal with Maithani Chaur and Kanwar; and Bikrampur, Nagri Jheel, Guhyabari Chaur, Rakshi Pond and Siltha Chaur with Kanwar will enhance hydrological connectivity within wetland complex.

Two River Gauging Station (on Burhi Gandak at Basahi and Bagras) and two hydrometric monitoring stations (at Jaimangalgarh, and Mahalya) also need be established to address hydrological data requirement for management purposes.

In medium to long term, the structure of embankments along River Kosi and River Gandak can be revisited to accommodate hydrological regime requirement of Kanwar, as these rivers carry proportionally much higher flows as compared to River Burhi Gandak. The flows of River Kosi used to naturally drain into Kanwar prior to construction of embankments.

The aforementioned options were discussed in a Secretary level meeting held on June 16,

2015 with the State Government Departments of Water Resources and Environment and Forests. Following detailed consideration of the proposed measures, it was agreed that:

a) Department of Water Resources would prepare a detailed proposal for construction of regulator at Harsainpul, and rejuvenation of channels connection maun and chaur areas with Kanwar.

b) Department of Fisheries would identify all maun and chaur areas that require desiltation, and prepare a detailed proposal for the same

c) Department of Environment would identify critically silted up areas of the wetland, and prepare a detailed project proposal

d) Two river gauging stations (at Bagras and Basahi) and two hydrometric stations (at Jaimangalgarh, and Mahalya / Kochalaya) be established to meet data requirements for planning purposes. Operationalization of these stations to be done by Department of Environment and Forests.

e) All new proposals to be implemented in Kanwar and associated main and chaur areas to be taken up only after review and approval of the Bihar Wetland Development Authority.

The minutes of the meeting are enclosed as Annex XVI.

Management zoning for multiple ecosystem services and biodiversity values| The multiplicity of land uses coexisting with high biological diversity and interlinkages with fluvial processes calls for adopting a management zoning approach for the floodplain wetland complex basin. The current inundation area (including open water areas and permanent and intermittent marshes) which sustain waterbird population can be treated as core zone, wherein the emphasis should be on maintenance of ecological character by prioritizing maintenance of waterbird habitats and capture fisheries. The buffer which includes areas under permanent agriculture and maun and chaur areas used for culture based fisheries can be managed as sustainable production systems, ensuring that production processes do not create direct adverse impact on ecosystem components and processes (e.g. through discharge of nutrient rich flows, impeding hydrological regimes). In the entire basin, land and water use needs to be influenced to ensure that wetlands retain hydrological connectivity with the rivers and surface-groundwater interactions are in balance (for example, by limiting extraction of groundwater beyond the level wherein changes in net recharge in Kanwar takes place).

The management of Kanwar as a bird sanctuary also needs to be rationalized considering the fact that landscape transformation has rendered several parts of sanctuary unsuitable for birds, and that some level of resource use and harvest is required to maintain ecosystem processes as well as to provide for livelihoods of dependent communities. In the present circumstances, making the sanctuary area enveloping Mahalaya, Kolchalaya, and Choti Kochalaya may be more meaningful and ecologically efficient. The larger sanctuary area can be designated as a 'conservation reserve' or 'community reserve' under Section 36A and 36B of Wildlife (Protection) Amendment Act, 2002, creating a basis for participatory management by enabling local communities to define and enforce management regimes with due ecological as well as social considerations. However, to set the process in motion, a lot of ground in terms of achieving the required community consensus would need to be covered. It would be important to align management of Kanwar towards variable inundation regimes.

The trend in declaring high biodiversity protected areas with private land use titles as conservation reserves is increasing. Jammu and Kashmir has so far declared 35 sites as conservation reserves 14 of which are wetlands. Hokera (Ramsar site), Mirgund, Shallbugh, Hygam,

Mulgam, Tsomoriri, Norrichain, Hanley/Chusul marshes are a few examples. In Uttranchal the Asan conservation reserve has been established near at the confluence of the Yamuna hydel canal and River Asan. In Punjab, Keshopur-Chhamb, a marsh system with extensive private ownership has been declared as a community reserve and is being managed as such.

The Department of Environment and Forests initiated a consultation process with the District Administration of Begusarai to identify wetland areas under permanent as well as intermittent inundation. A field survey alongwith the officials of forest department, and district administration was conducted on April 27-29, 2015. Basedon the discussions held during the visit, a map of inundation boundary has been prepared by the district administration, enclosed with the management plan as Annex XVII. This map, in consultation with experts and stakeholders, can be used as a basis for rationalizing boundaries of the protected area.

Balancing biodiversity conservation and livelihoods | Managing Kanwar requires seeking a balance between securing biological diversity of the wetland as well as livelihoods of the dependent communities. Management planning therefore envisages making investments for biodiversity conservation alongwith sustaining resource productivity within natural thresholds as well improving well-being of the wetland dependent communities by augmenting water, sanitation and health infrastructure, creating opportunities for livelihood diversification, especially through positive incentives for wetland stewardship.

Monitoring and evaluation for ecological character change | Monitoring and evaluation is critical to assess changes in ecological character of Kanwar wetland complex. 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 developmental projects on Kanwar and associated wetlands. An important part of the strategy would be to involve stakeholders, particularly local communities and civil society organizations in wetland monitoring. The KMA would 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 building | A major factor limiting integrated management of Kanwar is lack of effective capacity amongst concerned state government departments, stakeholders and local communities. The management plan therefore emphasizes on building capacity on wetland management, particularly recognizing biodiversity and ecosystem services features and governing factors and integrating these in planning, decision making and implementation at all levels.

Adaptive management | Given the range of drivers and pressures that act on Kanwar at multiple spatial, temporal and political scales, its management planning needs to be prepared for and accommodative of uncertainties and challenges. This is envisaged to be achieved by using adaptive management strategy allowing for suitable modification of management based on continuous site monitoring and assessment of new information. Since the ability of the plan to meet all site management objectives is influenced by availability of information as well as resources, management is considered as a process, with planning gradually getting complex from a minimal version to the one meeting all site management requirements as resources and information become available. However, lack of full scientific uncertainty should not be used as a reason to postpone measures to prevent ecological degradation.

5.3 Action Plan

The integrated management framework for Kanwar envisages ecosystem conservation and sustainable resource development and livelihood improvement as the major components, supported by a cross cutting component on institutional arrangements (Fig 5.1). Ecosystem conservation comprises three sub-components, namely management zoning, water management and biodiversity conservation. Sustainable fisheries and agriculture development, ecotourism development and improvement of quality of life form the subcomponents of sustainable resource development and livelihood improvement.

Component 1 | Institutional development

Expected results:

- An effective arrangement for cross sectoral coordination and multi-stakeholder engagement in wetland management established and operationalized
- Systematic wetland inventory, assessment and monitoring system established to support decision making and management
- Capacity of concerned state government departments and agencies, civil society organizations and local communities for integrated wetland management enhanced
- Stakeholders, particularly local communities are aware of status and trends in Kanwar, management strategies and actions

Activities

1.1 Establishment of KMA

KMA is proposed to be established as a nodal agency mandated for coordinating integrated management of Kanwar wetland complex. The Authority may be registered as a non-profit organization under Societies Registration Act,

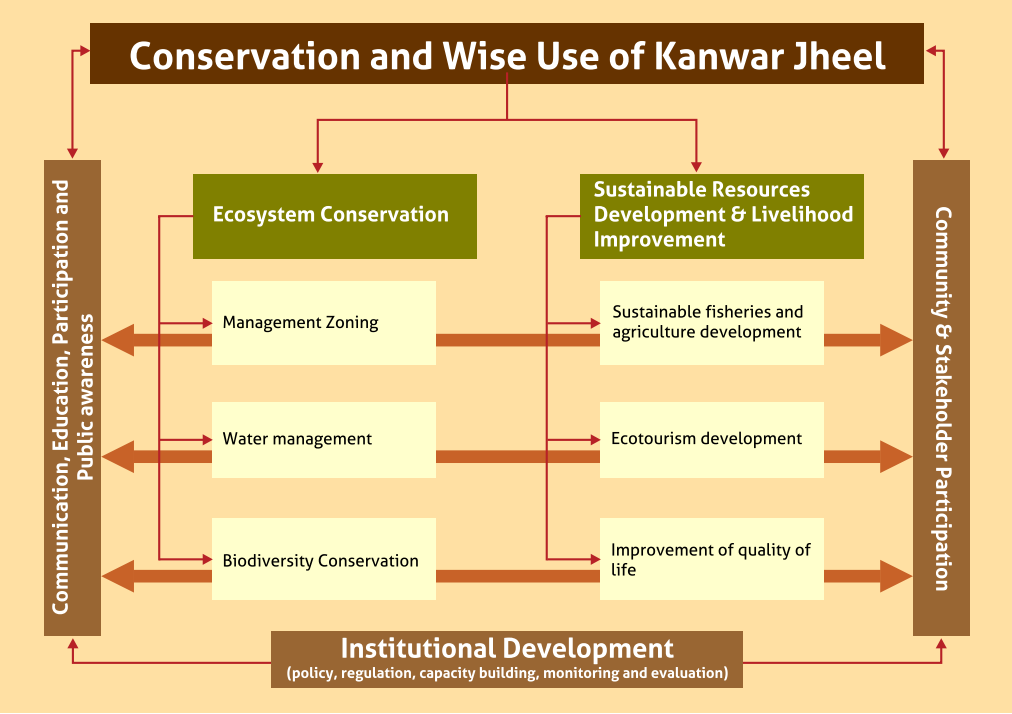


Fig. 5.1 | Management planning framework for Kanwar

1860 to enable flexibility in raising financial resources from public and private sources. As per the provisions of the Act, a Memorandum of Association defining the jurisdiction, aims and objectives and governance structure will need to be submitted to the Registrar of Authorities. Rules and Regulations detailing the membership, powers and functions of governing and executive bodies, accounting and audit procedures, and management of property of the authority will also need to be formulated and submitted to the Registrar. A three tier governance structure is proposed for KMA with the Governing Body at the apex, an Executive Committee responsible for approval of implementation plans and projects, and an office of the Chief Executive to implement the programmes. Activities to be undertaken include:

- Finalization of Memorandum of Association and governance structure
- Notification of KMA
- Registration under Societies Registration Act
- Staffing and work allocation as per the structure suggested in Section 3.
- Conducting business as per the Terms of Reference outlined in Section 3.3

1.2 Establishment of integrated wetland inventory, assessment and monitoring system

An integrated wetland inventory, assessment and monitoring system is proposed to be set up to address the overall information needs of wetland management and to provide robust decision support system for the same. Specific objectives and a detailed framework have been outlined in Chapter 4 of the management plan. The following activities are proposed:

1.2.1 Establishment of wetland monitoring and research centre

A state of the art wetland monitoring and research center is proposed to be established at Jaimanglagarh for monitoring the ecological, hydrological and socioeconomic features of Kanwar and function as the coordinating center for all inventory and assessment programmes. The center shall be supported through a network of field stations established to monitor hydrological regimes, water quality, and related ecological aspects. A list of necessary equipment to be procured for the center is in Annex XV.

1.2.2 Development of database management system

A database system for storing, retrieving and analysing the WIAMS 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

1.2.3 Wetland monitoring and evaluation

Wetland monitoring and inventory protocols for land use and land cover, hydrological regimes, ecosystem processes and biodiversity and socioeconomics and livelihoods as proposed in Section 4.2 will be implemented.

1.2.4 Assessment studies

The following assessment studies are proposed to be commissioned to support wetland 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 floodplain 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; risk management options

1.3 Capacity building

Capacity building of BWDA, concerned state government departments, agencies and local communities is proposed to be undertaken through professional training in integrated wetland management, water management, biodiversity conservation, wetland inventory and assessment and sustainable livelihoods. Critical infrastructure for wetland management including communication equipment and networking of various field stations and monitoring sites will also be undertaken for effective functioning of BWDA.

1.4 Communication and outreach

Stakeholder engagement in wetland management will be promoted through creating awareness on values and functions of Kanwar, management strategies adopted and opportunities for participation. Specific activities to be undertaken include:

- Workshops and public events on Kanwar involving media, research agencies, NGOs and CBOs
- Kanwar Rangers Camp for school children wherein students get to spend time and effort in learning about wetlands through Kanwar and are recognized as Kanwar Rangers on successful completion of camp
- Maintenance of an interactive web-site for Kanwar
- Observation of World Wetlands Day and other environment related occasions
- Development of resource material on Kanwar, including posters, brochures, pamphlets, films and education kits
- Publication of newsletter

Component 2 | Ecosystem conservation

Expected Results

- Inundation regime in Kanwar restored to support habitat diversity and capture fisheries
- Key biodiversity habitats and migratory pathways are restored and enhanced
- Scientific management of emergent macrophytes and other aquatic vegetation using ecologically and socially efficient approaches
- Zoning plan for direct floodplain basin developed in consultation with stakeholders to harmonize land and water use with ecological character of Kanwar

Activities

2.1 Management zoning

This would involve GIS based identification and delineation of the following management zones:

- Kanwar Jheel
- Kanwar Jheel wetland complex
- Kanwar Jheel wetland complex direct catchment

For each of these, a zonal plan setting thresholds of various developmental activities will need to be set with due consideration of the wetland component and / or process likely to be affected. These zoning plans will support revision of existing management regimes for declaring Kanwar as a community reserve or a conservation reserve with boundaries and activities based on ecological boundaries.

2.2 Water management

2.2.1 Restoration of inundation regimes

Inundation regime of Kanwar wetland complex can be restored by restricting outflows and improving hydrological connectivity within different parts of wetland complex. Specific activities to be taken up are as follows:

- **Construction of a regulator at Harsainpul**

  Outflows from the wetland can be managed by constructing a regulator at Harsainpul. The structure may consist of a 2m high check dam with regulators so as to prevent depletion of water below 35 meters amsl.

- **Rejuvenation of Chanha Nala**

  There is a need to rejuvenate the natural connectivity of Chanha Nala with Kanwar. Channelisation of Budhi Gandak River, siltation and expansion of settlements in the Nala bed has restricted the river inflows into the Chanha Nala. Adequate inflows in to Chanha Nala can be ensured through provision of sluice at Mohwalipur, and subsequent dredging of the channel connecting Chanha with Matihani Chaur, a length of 15.9 km.

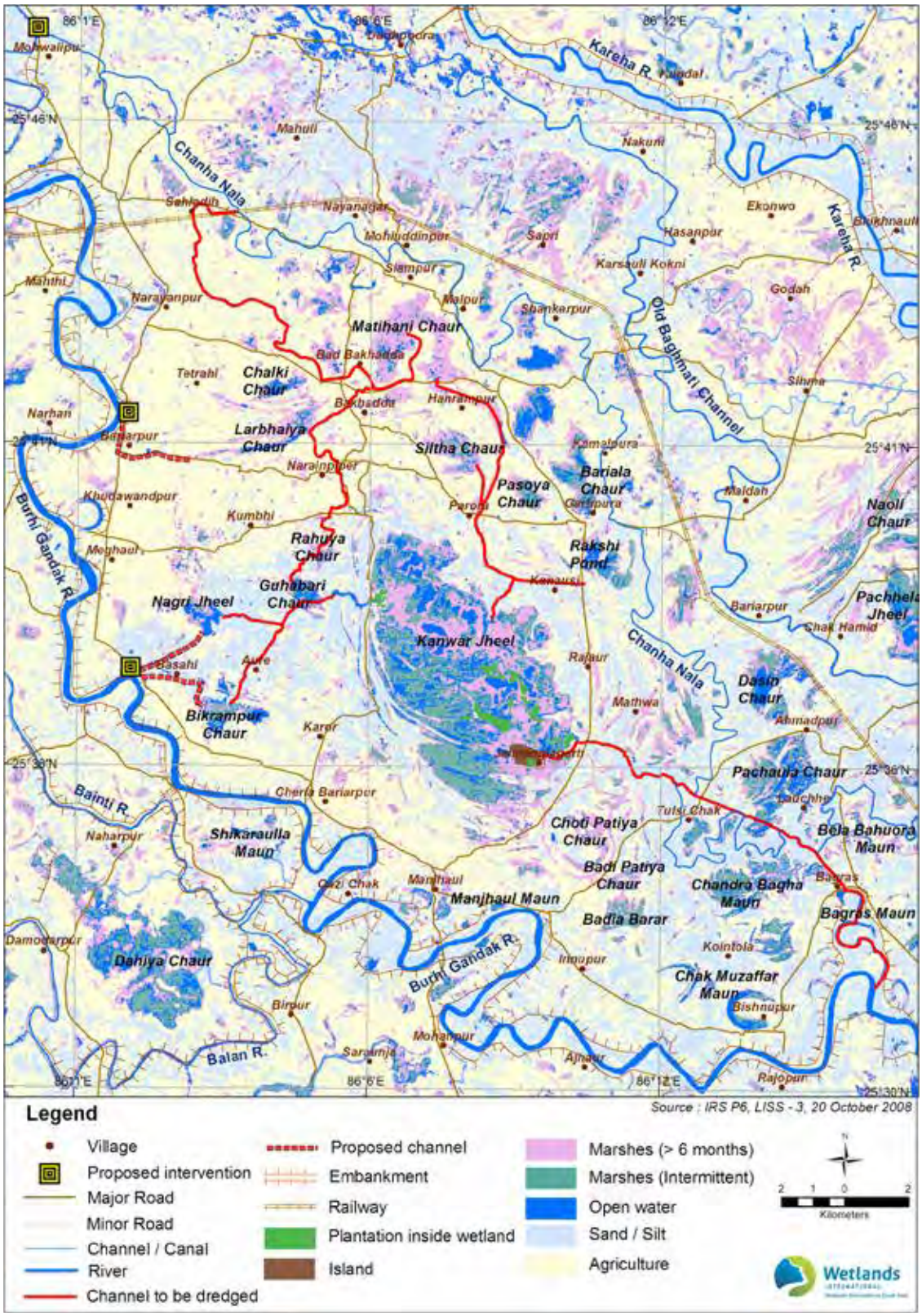
- **Rejuvenation of natural channels connecting associated wetlands**

  Matihani Chaur, Siltha Chaur, Chalki and Larbhaiya Chaur, Rakshi Maun and Dunhi Chaur form part of the Kanwar wetland regime which over a period have become isolated due to land use changes in the intervening areas. The stability of these waterbodies is essential to retain adequate amount of water in Kanwar. Loss of hydrological connectivity, as used to prevail in natural circumstances within these waterbodies will lead to their rapid degradation. It is therefore envisaged to rejuvenate natural drainages between these waterbodies including their connection with Kanwar through selective dredging. The following existing drainages are proposed to be rejuvenated to enhance hydrological connectivity within wetland complex (Map 5.1):

  - Matihani Chaur to Guhabari Chaur - 10.5 km
  - Matihani Chaur to Kanwar – 10.0 km
  - Bikrampur Chaur to Guhabari Chaur - 5.2 km
  - Nagri Jheel with channel leading to Guhabari Chaur - 2.0 km
  - Rakshi Pond with channel leading to Kanwar - 2.3 km
  - Siltha Chaur with channel leading to Kanwar - 1.3 km

2.2.2 Improving water holding capacity

Selective dredging of highly silted up areas of Bikrampur chaur and Nagri jheel is proposed to be carried out to enhance their water holding capacity and overall wetland water regime stability. Any further modification of elevation profiles within wetland complex, especially for agriculture would also be prevented. Selective dredging of 2614 ha of highly silted up chaur and maun areas (Map 5.2) is proposed to increase water holding capacity of the complex:



Map 5.1 | Channel proposed to be dredged

Map 5.2 | Areas to be desilted

- Nagri Jheel, Guhabari Jheel and Rahuya Chaur – 966 ha
- Bikrampur Chaur – 757 ha
- Larbhaiya Chaur – 286 ha
- Manjhaul Maun- 116 ha
- Areas of Chandra Bagha Maun – 285 ha
- Areas of Dasin Chaur- 107 ha
- Areas of Siltha Chaur- 107 ha
- Areas of Pachaula Chaur- 276 ha
- Bagras Maun – 122 ha

2.2.3 Environmental flows assessment and implementation

There is a need to define the hydrological regime (water quantity and quality in spatial and temporal terms) required for maintenance of values and functions of Kanwar based on stakeholder led hydrological, ecological and socioeconomic assessments. The assessment outcomes would also include identification of appropriate interventions required to achieve the desired hydrological regimes. Specific activities include the following:

- Assess current hydrological regimes of Kanwar with specific emphasis on biodiversity and ecosystem services interlinkages
- Evaluate current water use within lake basin and conflicting interests
- Assess water regime requirements for ecological purposes with emphasis on habitat improvement of waterbirds, regeneration of natural fisheries and water quality improvement
- Assess current and future water use for agriculture development and domestic purposes
- Develop current and future flow scenarios based on hydrological, ecological and socioeconomic modeling in view of any planned hydrological interventions in the wetland catchment Identify preferred option based on ecological and economic evaluation
- Identify hydrological intervention needs to achieve the required flow regimes in Kanwar wetland complex

2.3 Biodiversity conservation

2.3.1 Improving waterbird habitats

- Identification, demarcation and maintenance of following forms of waterbird habitats based on inventory and habitat mapping:
  - 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 migratory ducks and geese
  - Reed beds and open marsh vegetation for nesting species
  - Trees along wetland edge for tree nesting species
  - Patches of wet grasslands and open grounds for grazing ducks, geese and shorebirds
  - Marking of representative number of individuals of selected species with VHF transmitters or satellite / GPS transmitters to plot daily and seasonal movement patterns of resident and migratory waterbirds to understand their dependence on network of wetlands'
- Regulatory actions for restoring on breeding waterbird populations that depend on reed beds, trees and other vegetation:
  - In areas important for reed nesting species, grazing and harvesting of macrophytes need to be completely banned during breeding season
  - For areas of tree nesting species, cutting of trees and tall bushes along the periphery of the wetland to be banned

- Identification of potential areas for restoration and improvement as waterbird habitats

- Formation of bird protection committees to monitor waterbird habitats and to control any human disturbance. Incentives in the form of recognition and training as bird guides could be provided to the committee members.
- Capacity building of wildlife staff through periodic training in waterbird assessment, monitoring, research and migration studies
- Augmenting surveillance infrastructure including construction of watch towers, procurement of equipment for bird watching and mobile vans and boats for patrolling

2.3.2 Managing aquatic vegetation

Reduced inundation over a period of time have resulted in an increase in area under emergent macrophyte Phragmites karka. The thick growth of free floating and rooted emergent macrophytes primarily Eichhornia crassipes and Ipomoea aquatica has choked the channel mouths that connect Kanwar to Guhabari Chaur in the north and Burhi Gandak River in the south. Excessive growth of emergent as well as rooted and free floating vegetation is a major concern for wetland management, considering its effects on water flow, siltation rates, reduction in oxygen levels, increase in population of prey fishes, waterbird habitats and fishing and navigation within the wetland. The following actions are proposed:

- Detailed mapping of extent of aquatic vegetation using fine resolution imageries and ground truthing
- Economic use of macrophytes such as Phragmites considering its high fiber content. Pilot projects in partnership with paper industry and others to assess viability of developing community led enterprise based on harvested biomass
- Interventions based on pilot experimentation for controlling proliferation of vegetation using mechanical and biological methods:
  - Mechanical removal – cutting and completely uprooting stands with specialized equipment
  - Biological control in small areas using domestic waterfowl
  - Habitat management – improving hydrological connectivity and breaking mono-specific stands to control spread

Component 3 | Sustainable resource development and livelihood improvement

Expected results

- Sustainable enhancement in productivity of capture and culture fisheries in Kanwar wetland complex
- Enhanced efficiency of water use in agriculture and adoption of sustainable agriculture practices within wetland boundaries
- Gradual reduction in direct livelihood dependence on Kanwar through appropriate diversification of livelihoods and additional income generation
- Wetland based ecotourism developed as an incentive for communities to benefit from biodiversity conservation and maintenance of wetland habitat
- Comprehensive access to water, sanitation and health infrastructure to communities living around Kanwar

Activities

3.1 Sustainable fisheries development

3.1.1 Strengthening fisher cooperatives

The three fisher cooperatives of Cheria Bariapur, Chaurahi, Khanjahanpur and Bakhri are the key community institutions managing fishery operations in the wetland complex. The following

interventions are proposed for strengthening fisher cooperatives:

- Revisiting institutional structure to ensure genuine co-operative character owned by their members, governed by their elected representatives and managed professionally. Wherever required, bye laws for management of society operations may be facilitated
- Training workshops on:
  - Sustainable fish culture practices
  - Management of fish hatchery
  - Integrated fish farming
  - Ornamental fish and crab culture
  - Wetland values and functions
  - Policy and regulatory requirements for fish culture
- Seed capital support for culture fishery operations through linkages with Fisheries Department and NABARD
- Awareness on wetland values and functions

3.2.2 Creation of a Community Multi-stakeholder Forum for conflict resolution

A community multi stakeholder forum is proposed to be created to manage various resource use conflicts associated with Kanwar. The forum will provide a platform for all local stakeholders to present, discuss and arrive at local solutions for managing various resource uses related to Kanwar.

3.2.3 Rejuvenating capture fishery

Complementing the interventions for restoring hydrological regimes, the following interventions are proposed to ensure fish diversity as well as productivity:

- Demarcation and protection of fish breeding and spawning grounds. During the present survey, Mahalaya, Kochalaya (deeper part), Channaha naladhar, Boharadhar, Sahara naladhar,and Guhabari mouth were noted to be potential breeding and / or spawning grounds. Community enforced regulation may be implemented to prevent fishing activity during the breeding season.
- Complete prohibition of use of small meshed size fishing gears (particularly mosquito nets or Chatti jal), promoting gears of mesh sizes 4 cm and above
- Restocking of the Kanwar@ of 2000 fingerlings of carps and native fish varieties at an interval of one breeding cycle for 5 years

3.2.4 Enhancing availability of fish seed

In order to promote effective utilization of fish production potential in the maun and chaur areas around Kanwar, following interventions are proposed:

- Construction of 2 fish hatcheries of capacity 0.2 million seeds / cycle in Karor and Cheria-Bariarpur with two brood tanks, and a nursery, rearing and stock pond each. Operation of fish hatchery is to be done by the fish cooperative on a no-profit and loss basis. The members of the cooperatives are to be provided access to fish seed at a reduced rate and on a priority. Fries to be used for restocking Kanwar, Revenue generated will form a corpus fund to be used for operation and maintenance of hatcheries, and for other developmental purposes
- Modernization of existing nursery complex at Jaimanglagarh (production capacity is likely to be around 0.4 million seeds / cycle)

3.2.5 Improvement of harvesting and post harvesting infrastructure

- Provision of 2000 ice boxes for short term storage
- Construction of one ice vending machine at Manjhaul fish market to meet ice requirement of fish vendors.

3.2.6 Monitoring and Research

- Monitoring of catch statistics
- Identification and demarcation of breeding and spawning grounds
- Monitoring of environmental variables as per Wetland Inventory, Assessment and Monitoring Framework

3.2 Sustainable agriculture development

- Regulate cropping pattern within the core inundation area in line with fluctuating hydrological regimes, through reducing cropping cycle , allowing for lands to be left fallow during monsoons for natural soil enrichment and reducing area under water demanding perennial crops
- Promoting sustainable agri-practices which economize water use and enhance productivity. Technology options as System of Rice Intensification (SRI) are known to reduce water use by 40-50% and enhance productivity by 20-30%. Incentives in the form of farming equipment, training and soft loans to be provided to farmer groups for adoption of sustainable agro-techniques.
- Promoting integrated rice–fish farming systems in core zones that are in line with the inundation regimes.
- Use of climate resilient crop varieties, bio-manures, multiple cropping, crop rotation and adoption of eco-friendly practices
- Establishment of centers for supply of quality agricultural inputs
- Incentives in the form of farming equipment, training and soft loans to be provided to farmer groups for adoption of sustainable agro-techniques
- Formation of SHG/farmers groups in 17 villages and implementation of following alternate income generation programme with technical support of Rajendra Agricultural University, Samastipur and Krishi Vigyan Kendras (KVKs) on
  - Mushroom cultivation
  - Animal husbandry, poultry and dairy activities
  - Seed and agri produce trading,
  - Horticulture - Mango and leechi cultivation
  - Enterprise development
- Reducing intensity of chemical fertilizer and pesticide use through promoting organic cultivation and establishment of centers for supply of quality agricultural inputs
- Monitoring and research activities pertaining to changes in land use and land cover within Gandak-Kosi basin and Kanwar wetland complex, Overall water use pattern within basin, Surface runoff and trends in nutrient enrichment

3.3 Ecotourism development

- Development of comprehensive ecotourism development plan with detailed zoning of wetland taking into account habitat diversity, ecological requirements of wetland biota and cultural values associated with Kanwar
- 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 Jaimanglagarh at the nodal unit for communication, education and public participation programmes
- Training to local communities to act as field guides for tourists

3.4 Improvement of quality of life

- Comprehensive coverage of water, sanitation and health facilities for villages around Kanwar

particularly focussing on fisher communities, through construction of 200 community toilets and provision of safe drinking water supply to 1000 fishing households

- Introduction of dairying, duck farming, dry fish marketing, vegetable marketing and ornamental fish culture projects as alternate livelihoods for 2000 fishing households. Priority may be accorded to interventions in areas which have witnessed loss in incomes due to declaration of sanctuary.
- Promoting alternate / additional livelihood options based on value addition to existing resources (e.g. handicrafts based on macro-vegetation), micro-enterprise to reduce pressure on wetland resources (apiculture, mushroom cultivation, natural dyes etc.)
- Strengthening community managed disaster risk reduction capability in all 17 villages through:
  - promoting risk reduction planning and contingency planning,
  - implementation of individual preparedness interventions (family survival kit, participation in disaster preparedness drills and promoting use of insurance),
  - community risk reduction interventions (Fuel bank, grain bank, raised plinths of houses handpumps and toilets, and construction of flood shelters, training in search, rescue and first aid)

5.4 Prioritization and Phasing

In order to effectively and efficiently allocate resources, interventions have been planned to follow a phased strategy. On immediate priority is establishment of KMA and rejuvenation of hydrological regimes of Kanwar. In the medium term, interventions for reorganizing the regulatory basis of wetland management in line with management zoning, enhancing biodiversity habitats, improving livelihoods of wetland dependent communities. Strengthening institutional basis for wetland management through building capacity and creating awareness at all levels would also form a part of this phase. In the long term, it is expected that hydrological rejuvenation and revising institutional arrangements would provide conducive environments for ecotourism development and upscaling management to include associated wetlands of the Kanwar complex.

5.5 Budget

Implementing the aforementioned action plan is expected to entail an outlay of Rs. 300 crores over a period of 5 years. Of this, 49% is allocated to the component of ecosystem restoration, 40% for sustainable resource development and livelihood improvement and 11% for institutional development. Restoring hydrological regimes is allocated the maximum outlay of Rs. 136 crores. A summary of component costs is provided in table below. However, detailed estimates need to be worked out for finalization of the actual outlay.

A majority proportion of the budget can be financed by creating convergence opportunities with existing central and state government developmental schemes. The following opportunities exist:

- **Swacch Bharat Mission –** for improving sanitation and drinking water facilities in villages around Kanwar
- **National Rural Livelihood Mission –** for alternate and additional livelihood opportunities for fisher and farming community living in and around wetland complex
- **Schemes of Fisheries Department -** for construction of fish hatchery, ice vending

machine, improvement of waterbodies and institutional support to fisher cooperatives

- **Schemes of agriculture department –** to promote organic agriculture and improved farm practices
- **Schemes of Department of Water Resources –** to improve hydrological connectivity within wetland complex
- **National Plan for Conservation of Aquatic Ecosystem –** to support wetland inventory, assessment and monitoring; capacity building of wetland managers

Components and Activities	Physical target Unit	Year 1	Year 2	Year 3	Year 4	Year 5
1 Institutional Development		**1555**	**1075**	**625**	**75**	**75**
2 Ecosystem Conservation		**1185**	**10515**	**2900**	**30**	**30**
2.1 Management zoning			25	10	10	10
2.2 Water management		1050	10030	2520	0	0
2.3 Biodiversity Conservation		135	460	370	20	20
3 Sustainable resource development and livelihood improvement		**730**	**1830**	**6310**	**2285**	**780**
3.1 Sustainable fisheries development		210	710	610	585	80
3.2 Sustainable agriculture development		20	20	900	500	500
3.3 Ecotourism development		0	0	2400	600	100
3.4 Improvement of quality of life		500	1100	2400	600	100
		3470	**13420**	**9835**	**2390**	**885**

(all figs in Rs. Lakhs)

Components and Activities	Physical target	Unit	Year 1	Year 2	Year 3	Year 4	Year 5
1 Institutional Development			**1555**	**1075**	**625**	**75**	**75**
1.1 Establishment of BMWA			10				
1.2 Establishment of WIAMS							
a) Establishment of wetland reseacrh and monitoring center	1 unit with satellite stations		1000	500	500		
a) Development of database management system			30				
b) Wetland monitoring and evaluation			10	10	10	10	10
c) Assessment studies	5	studies		50	50		
1.3 Capacity building			500	500	50	50	50
1.4 Communication and outreach			5	15	15	15	15
2 Ecosystem Conservation			**1185**	**10515**	**2900**	**30**	**30**
2.1 Management zoning				25	10	10	10
2.2 Water management			1050	10030	2520	0	0
a) Rejuvenating hydrological connectivity	16	km	1000	7500			
b) Improving waterholding capacity	0.3	Mcum		2500	2500		
c) Environmental flows assessment and implementation			50	30	20		
2.3 Biodiversity Conservation			135	460	370	20	20
a) Improving waterbird habitats							
Identification and demarcation of habitats			10				
Habitat regulation			5				
formation of bird protection committees			10	10			
Capacity building				100	20	20	20
Augmenting surveillance infrastructure			100				
b) Managing invasive macrophysics							
Detailed mapping			10				
Economic utilization				200	200		
Pilot interventions				150	150		
3 Sustainable resource development and livelihood improvement			**730**	**1830**	**6310**	**2285**	**780**
3.1 Sustainable fisheries development			210	710	610	585	80
a) protection of breeding and spawning grounds			5	5	5	5	5
b) regulation of gears			5	5	5	5	5
c) Construction of fish hatcheries	3	Units		500	50	25	20
d) Capacity building of fisher cooperatives			200	200	50	50	50
e) Provision of ice boxes and improvized crafts and gears					500	500	
3.2 Sustainable agriculture development			20	20	900	500	500
a) Promoting sustainable agro-practices			20	20	900	500	500
3.3 Ecotourism development			0	0	2400	600	100
a) Development of comprehensive plan					250		
b) Bird watching infrastructure development					50		
c) Interpretation centre					2000	500	
d) capacity building of local communities					100	100	100
3.4 Improvement of quality of life			500	1100	2400	600	100
a) Sanitation and safe drinking water facilities	11000	households	500	500	1000		
b) Promoting alternate / additional livelihood systems	4500	households		600	1400	600	100
			3470	**13420**	**9835**	**2390**	**885**

References

Alfred, J. R. B. and Ramakrishna 2002. Kabar Lake Wetland-an Overview. In: Fauna of Kaabar Lake (Bihar), Wetland Ecosystem Series, 4, Zoological Survey of India, Kolkata, India, pp. 1–14.

Ambastha, K., Hussain, S. A. and Badola, R. 2007. Resource dependence and attitudes of local people toward conservation of Kabartal wetland: A case study from the Indo-Gangetic plains. *Wetlands Ecology and Management*, 15: 287–302.

Anonymous 1993. Directory of Indian Wetlands, WWF-INDIA, New Delhi and AWB Kuala Lumpur, xvi + 264 pp; 32 maps.

Bhartariya, K. G. 2008. *Chemical quality of ground water of Bihar State (2006–07).* Central Ground Water Board, New Delhi.

CPCB 2012. Water quality status of River Ganga and its tributaries during the Year (2011–2012), Bihar State Pollution Control Board

Census 2011. Ministry of Home Affair, Government of India, New Delhi, India.

CGWB 2011. Dynamic ground water resource of Bihar State (As on 31st March 2011). Central Ground Water Board, Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India, Faridabad, India.

CGWB 2007. Dynamic ground water resource of Bihar State (As on 31st March 2007), Central Ground Water Board, Ministry of Water Resources, Mid-Eastern Region Patna, India.

CIFRI 2000. Environmental impact assessment of inland waters for sustainable fisheries management and conservation of biodiversity. *Eds.* M. Sinha, B. C. Jha and M. A. Khan. *CIFRI Bulletin.*

CIFRI 2002. Culture based fisheries in Inland Fisheries Development. *Eds.* V. V. Sugunan, B. C. Jha and M. K. Das. *CIFRI Bulletin.*

CIFRI 2008. The status of the River Ganges in middle stretch. *Eds.* K. K. Vass, R. K. Tyagi, V. Pathak, H. P. Singh and R. N. Seth. *CIFRI Bulletin.*

Department of the Environment, Water, Heritage and the Arts 2008. National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands. Module 2 of the National Guidelines for Ramsar Convention in Australia. Australian Government. Department of the Environment, Water, Heritage and the Arts, Canberra, Australia.

Soil Map of Bihar. National Bureau of Soil Survey and Landuse Planning, ICAR, Nagpur, India.

Garcia, X. F. and Laville, H. 2001. Importance of floodplain waters for the conservation of chironomid (Diptera) biodiversity in a 6th order section of the Garonne River (France). *International Journal of Limnology*, Vol. 37: 35–47.

Ghosh, A. K., Bose, N., Singh, K. R. P and Sinha, R. K. 2004. Study of spatio-temporal changes in the wetlands of North Bihar through remote sensing. ISCO 2004 - 13th *International Soil Conservation Organisation Conference* – Brisbane, July 2004, 1–4.

GoB 2004. *Management Action Plan for Kawar Lake, 2004–2005 to 2008–2009.* Department of Environment and Forests, Government of Bihar, India.

GoB 2012. *State Domestic Product,* Directorate of Economics and Statistics, Government of Bihar, Patna, India

GSI 1984. *Report on the Geomorphological and Geological Mapping in Parts of Begusarai District, Bihar.* Progress Report for Field Season 1973–74, Geological Survey of India, Patna.

Indian Meteorological Department 2012. District Rainfall data. Hydromet Division, New Delhi retrieved from http://www.imd.gov.in/on 5th July 2013.

Islam, M. Z. and Rahmani, A. R. 2004. *Important Bird Areas in India: Priority sites for Conservation.* Indian Bird Conservation Network: Bombay Natural History Society and Bird Life International, U.K.

Junk, W.J., Bayley, P.B and Sparks, R.E. 1989. The flood pulse concept in river-floodplain system.Can. Spec. *Publ Fish.Aquat.Sci* 106: 110–127 pp.

Kumar, R., Horwitz, P., Milton, G. R., Sellamuttu, S. S., Buckton, S. T., Davidson, N. C., Pattnaik, A. K., Zavagli, M and Baker, C. 2011. Assessing wetland ecosystem services and poverty interlinkages: a general framework and case study. *Hydrological Sciences Journal.* 56(8)1602–1621

Menon, A.K.G 1999. Check list-fresh water fishes of India. Record of Zoological Survey of India, Occasion Paper No. 175: 1–366.

Mishra, S.S., Acharjee, S.K., and Chakraborty, S.K 2009. Development of tools for assessing conservation categories of siluroid fishes of fresh water and brackish water wetlands of South West Bengal, India. Environ. Biol. Fish, 84(4): 395–407.

Mohindra, R. and Prakash, B. 1994. Geomorphology and neotectonic activity of the Gandak megafan and adjoining areas, middle Gangetic plains, India.J. Geol. Soc. India 43: 149–157.

Nandan, K.B and Singh, C.B. 2004. Useful Macrophytes in Kanwar Lake, North Bihar, India. *Indian journal of Forestry,* Vol. 27(3), pp. 241–244.

Parkash, B and Kumar, S 1991. The Indo Gangetic Basin. In: Sedimentary Basins of India, Tectonic Context (*Ed.* by S.K. Tandon, C.C. Pant and S.M. Casshypa) Gyanodaya Prakashan, Nainital, India, 147–170.

Patra, M. K., Acharjee, S. K and Chakraborty, S. K 2005. Conservation categories of siluroid fishes in North-East Sundarbans, India. *Biodiversity and Conservation* 14: 1863–1876.

Ramakrishna and Siddiqui, S. Z. 2002. Macrophytic vegetation. In: Fauna of Kabar Lake (Bihar), Wetland Ecosystem Series 4, Zoological Survey of India, Kolkata, India, pp. 39–45.

Ramakrishna, Muley, E. V., Siddiqui, S. Z. and Pandey, A. K. 2002. Limnology. In: Fauna of Kabar Lake (Bihar), Wetland Ecosystem Series 4, Zoological Survey of India, Kolkata, India, pp. 15–22.

Ramarao, K.V., Singh, K. P and Ramakrishna 2002. Pisces. In: Fauna of Kabar Lake (Bihar), Wetland Ecosystem Series 4, Zoological Survey of India, Kolkata, India, pp. 89–106.

Ramsar Convention Secretariat, 2010. *Managing wetlands: Frameworks for managing Wetlands of International Importance and other wetland sites.* Ramsar handbooks for the wise use of wetlands, 4th edition, vol. 18. Ramsar Convention Secretariat, Gland, Switzerland

Roy, S. P., Ramanand, R., Prabhakar, A.K. and Singh, J. P. 2008. Sustainable Development of Kawar Lake, Begusarai (North-Bihar, India). *Proceedings of Taal, 2007: The 12th World Lake Conference*, 1578–1585.

Sanyal, D.P., Talukdar, S. K. and Duttagupta, G. 2002. Reptilia. In: Wetland Ecosystem Series 4, Fauna of Kabar Lake: Zoological Survey of India, Kolkata, India, pp. 113–116.

Sarkar, A. K. and Ray, S. 2002. Amphibia. In: Fauna of Kabar Lake (Bihar). Wetland Ecosystem Series 4, Zoological Survey of India, Kolkata, India, pp. 107–112.

Scott, D.A. (ed) 1989. *A Directory of Asian Wetlands*. IUCN, Gland, Switzerland and Cambridge, U.K. xiv + 1181 pp. 33 maps

Shahi, S.P. 1982. Birds massacre in Manjhaul. *Hornbill*, 1982(3): 17–22.

Sharma, U. P. 1996. Biodiversity of Kawar Lake (Begusarai) North Bihar: A bird's paradise of India. In: *Environment and Biodiversity*: In the context of South Asia. Ecological Society, Khatmandu, Nepal, 241–247.

Sharma, U.P. 1996. Ecology of the Koshi River in Nepal- India (North-Bihar): A typical River Ecosystem. *Environment and Biodiversity*, 92–99.

Siddiqui, S. Z. and Ramakrishna 2002. Zooplankton. In: Fauna of Kabar Lake (Bihar), Wetland Ecosystem Series 4, Zoological Survey of India, Kolkata, India, pp. 47-56.

Singh, J. P. and Roy, S. P 1990. Some aspect of Ecology of bird of Kawar lake, Begusarai (Bihar). *Bio. Bull. Of India,* 11(1): 1–8.

Sinha, R. 2009. Dynamics of a River System-the Case of the Kosi River in North Bihar. *E-Journal Earth Science India*, Vol. 2. (I), pp. 33–45

Sinha, M. and Jha, B.C. 1997. Ecology and Fisheries of Ox-Bow Lakes of North Bihar. *CIFRI Bulletin.* No. 74.

Sinha, R and Jain, V. 1998. Flood Hazards of North Bihar Rivers, Indo-Gangetic Plains, Flood Studies in India. *Geological Society of India Memoir,* V.41, pp. 27–52.

Sinha, M and Jha, B. C. 1997. Ecology and fisheries of Ox-bow lakes (Maun) of North Bihar-A threatened Ecosystem. *CIFRI Bulletin* No. 74.

Sinha, M. and Jha, B. C. 1997. *Uttar Bihar ki matsyiki jol sansadhan-bartaman obostha ebong bhabhi sambabnay. CIFRI Bulletin.*

Sinha, R. 1995. *Sedimentology* of Quaternary alluvial deposits of the Gandak-Kosi interfan, North Bihar. *Journal Geological Society of India*, Vol. 46: 521–532.

Sinha, R. 1996. "Channel avulsion and floodplain structure in the Gandak-Kosi interfan, north Bihar plains, India", *Zeitschrift fur Geomorphologie N.F., Suppl.-Bd,* 103: 249–268.

Sinha, R. and Friend, P. F. 1994. "River systems and their sediment flux, Indo-Gangetic plains, northern Bihar, India", *Sedimentology*, 41: 825–845.

Sinha, R and Jain, V. 1998. Flood Hazards of North Bihar Rivers, Indo-Gangetic Plains, Flood Studies in India. *Geological Society of India Memoir,* Vol. 41: 27–52.

Sinha, V. R. P. and Jha, B. C. 2008. Threatened wetlands need rehabilitation to enhance fish production in India. *Proceedings National Academy of Science in India,* Vol. 78, Spl. Issue.

Soderstorm, O. 1987. Upstream movements of invertebrates in running waters-a review. *Arch. Hydrobiol* 111: 197–208.

Srivastava, P.K. 2013. Fish Diversity and Conservation Perspective of Gandak River, India. *Our Nature,* 11(1): 76–84.

Subba Rao N.V. and Dey, A. 1989. Freshwater Molluscs in Aquaculture, In: Handbook of Freshwater Molluscs of India. Zoological Survey of India, Calcutta, India, pp. 225–232.

Tiwary, N.P., Kumar, P., Prasad, R.R., Kumari, M. and Kumar, R. 2009. Prospects and Constraints of Crab Culture in Wetlands of Bihar, India. *Our Nature,* 2009: 230–232.

United Nations 1992. Agenda 21, United Nations Conference on Environment & Development Rio de Janerio, Brazil, 3 to 14 June 1992.

Vass, K.K., Tyagi, R.K., Singh, H.P. and Pathak, V. 2010. Ecology, changes in fisheries and energy estimates in the middle stretch of the river Ganges. *Aquatic Ecosystem Health Management,* 13(4): 374–384.

Venkateswarlu, T. and Murthy T. S. N. 1972. Fauna of Bihar State India. Part 2. Amphibia. *Indian J. Zootomy*, 13(3): 129-130.

Ward J. V., Tockner, K., Arscott, D.B and Claret, C. 2002. Riverine landscape diversity. *Freshwater Biology*, 47: 517–539.

Ward, J. V. 1989. Riverine-wetland interactions. In: Fresh water Wetland and Wildlife, *eds.* R.R. Sharitz and J.W. Gibbons, *DOE Symp.* Ser. 61, Oak Ridge, Tennessee, 385–400.

Welcomme, R. L. 1979. *Fisheries Ecology of floodplain Rivers.* Longman London, U.K.

ZSI 2002. *Fauna of Kabar Lake (Bihar), Zoological Survey of India.* Wetland Ecosystem Series 4, Kolkata, India, pp. 1–134.

Nodal Officers designated by various department of Government of Bihar to support management planning for Kanwar

1. Mr. Prabhat Kumar Gupta
   Conservator of Forests, Muzaffarpur Circle
   Aranya Vihar, Gandak Colony, Shirpur, P.O. MIC, Beta
   Muzaffarpur, Bihar
   Phone: 0621–2271979

2. Mr. Sunil Kumar Singh
   Executive Engineer
   Water Resource Department
   Sinchai Bhawan, Patna, Bihar
   Phone: 0612–2217649

3. Mr. Nishat Ahmad
   Director (Fisheries)
   Fisheries Directorate
   Canteen Talab, Old Secretariat Complex
   Patna, Bihar
   Phone: 0612–2210819

4. Mr. Rabindra Kumar Verma
   Deputy Director (Plan)
   Department of Agriculture
   Mithapur Farm, Patna, Bihar
   Phone: 0612–2351099

5. Mr. Rakesh Kumar
   Member Secretary
   Bihar State Pollution Control Board
   BELTRON Bhavan, 2nd Floor, Shastri Nagar
   Patna, Bihar
   Phone: 0612–2281050

6. Mr. D.P. Singh
   Superintending Engineer
   Public Health Engineering Department
   Nirman Bhawan, Patna, Bihar
   Phone: 0612–2292594

Phytoplankton recorded at Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Cyanophyceae

1. *Microcystis aeruginosa* Kutz.
2 *Spirulina menenghiana* Zanard. ex Gomant.
3. *Oscillatoria limosa* Ag. ex Gomant.
4 *Oscillatoria principes* Vauch.
5. *Lyngbya gracilis* (Menegh.) Raben.
6. *Anabaenopsis* sp.
7. *Anabaena sphaerica* Bornet & Flahault.
8. *Nostoc linckia* (Roth.) Born & Flahult.
9. *Rivularia aquatica* De Wilde.
10. *Chroococcus minutus* (Kutz.)

Chlorophyceae

11. *Volvox sphaerica* Ehrenberg.
12. *Hydrodictyon reticulatum* (Linn.) Laqerh.
13. *Pediastrum tetras var excisum* (Raben.)
14. *Pediastrum duplex* Meyen.
15. *Coelastrum intermedium* (Bohlin.) Korshikov.
16. *Ankistrodesmus falcatus* (Corda.) Ralfs.
17. *Scenedesmus quadricauda var longispina* (Chodat.) Smith.
18. *Scenedesmus dimorphus* (Turpin.) Kuetzing.
19. *Scenedesmus arquatus var. capitata* Smith.
20. *Selenastrum gracile* Reinsch.
21. *Oocystis parva* West. & West.
22. *Chlorella vulgaris* Beyernick.
23. *Tetradon minimum* Braun. Hansgirg.
24. *Zygnaema globosum* Czurda.
25. *Spirogyra hyalina* Cleve.
26. *Spirogyra affinis* (Hass.) Petit.
27. *Spirogyra paludosa* Czurda.
28. *Cosmarium hammeri* Reinsch.
29. *Cosmarium auriculatum* Reinsch.
30. *Cosmarium maximum* (Borgesen.) West & West.
31. *Closterium monoliferum* (Ralfs.) Ehrenberg.
32. *Closterium reniforme* (Ralfs.) Archer.
33. *Chara verticillata* Roxb.
34. *Nitella flexilis* (Linn.) Agardh.

Bacillariophyaceae

35. *Navicula viridis* (Nitzsch.) Ehrenberg.
36. *Nitzschia* sp.
37. *Cymbella cistula* (Hemprich) O. Kirchner
38. *Asteronella* sp.
39. *Gomphonema* sp.
40. *Pinnularia major* (Kützing.) Rabenhorst.
41. *Melosira* sp.
42. *Fragilaria* sp.

Euglenophyceae

43. *Euglena viridis* (Müller.) Ehrenberg.
44. *Phacus hispida* (Eichn.) Lemm.

Macrophytes recorded at Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Hydrocharitaceae

1. *Hydrilla verticillata* (Linn.f.) Royle.
2. *Vallisneria spiralis* Linn.
3. *Najas minor* All.
4. *Nechamandra alternifolia* (Roxb. ex Wight.) Thwaites.
5. *Ottelia alismoides* (Linn.) Pers.

Scrophulariaceae

6. *Limnophila indica* (Linn.) Druce.
7. *Limnophila racemosa* Benth.

Lentibulariaceae

8. *Utricularia stellaris* Linn.f.

Smilacaceae

9. *Smilax zeylanica* Linn.

Haloragaceae

10. *Myriophyllum tuberculatum* Linn.

Nelumbonaceae

11. *Nelumbo nucifera* Gaertn.

Nymphaeaceae

12. *Nymphaea stellata* Wild.

Menyanthaceae

13. *Nymphoides cristata* (Roxb.) O.Tuts.
14. *Nymphoides indicum* (Linn.) Solms.

Pontederiaceae

15. *Eichhornia crassipes* (Martz.) Solms.
16. *Monochoria hastata* (Linn.) Solms.

Potamogetonaceae

17. *Potamogeton crispus* Linn.
18. *Potamogeton nodosus* Pair.

Poaceae

19. *Hygroryza aristata* (Retz.) Nees.
20. *Phragmites karka* (Retz.) Trin.ex.Steud
21. *Saccharum spontaneum* Linn.
22. Oryza sativa Linn.
23. Eragrostis nutans (Retz.) Nees. ex Steud.
24. Eriochloa punctata (L.) Ham.
25. Panicum paludosum Roxb.
26. Panicum repens Linn.

Convolvulaceae

27. *Ipomoea aquatica* Forssk.
28. *Ipomoea chrysoides* Ker-Gawl.
29. *Merremia emarginata* (Burn.f.) Hallifer.

Alismataceae

30. *Caldesia parnassifolia* (L.) Parl.

Commelinaceae

31. *Commelina communis* Linn.
32. *Commelina diffusa* Burm.f.

Onagraceae

33. *Ludwigia peploides* (Kuntze) Raven.

Marsileaceae

34. *Marsilea quadrifolia* Linn.

Cyperaceae

35. *Cyperus pumilus* Linn.
36. *Cyperus rotundus* Linn.
37. *Scirpus supinus* (Linn.) Lye.
38. *Scirpus articulatus* Linn.
39. *Fimbristylis woodwarti* Clarke.
40. *Juncellus alopecuroides* (Rottb.) Clarke.

Acanthaceae

41. *Hygrophila polysperma* (Roxb.) Anderson.

Polygonaceae

42. *Polygonum hydropiper* Linn.

Boraginaceae

43. *Heliotropium indicum* Linn.

Rhamnaceae

44. *Ziziphus mauritiana* Lam.

Leguminosae

45. *Tephrosia hamiltonii* Drum.
46. *Crotalaria verrucosa* Linn.

Terrestrial plants recorded in and around Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Anacardiaceae

1. *Mangifera indica* Linn.

Fabaceae

2. *Acacia arabica* (Lam.) Willd.
3. *Acacia nilotica* (L.) Wild. ex Delile.
4. *Albizia lebbeck* (L.) Benth.
5. *Dalbergia sissoo* Roxb.
6. *Tamarindus indica* Linn.
7. *Aeschynomene indica* Linn.
8. *Cassia occidentalis* Linn.
9. *Desmodium gangeticum* (Linn.) DC
10. *Indigofera linifolia* (Linn.f.) Retz.
11. *Neptunia oleracea* Lour.
12. *Sesbania javanica* Miq.
13. *Teramnus labialis* (L.f.) Spreng.
14. *Vicia sativa* Linn.

Lecythidaceae

15. *Barringtonia acutangula* (L.) Gaertn.

Moraceae

16. *Ficus benghalensis* Linn.
17. *Ficus glomerata* Roxb.
18. *Ficus religiosa* Linn.
19. *Ficus tinctoria* G. Forst
20. *Ficus heterophylla* Linn. f.

Dipterocarpaceae

21. *Shorea robusta* Roth.

Meliaceae

22. *Azadirachta indica* A. Juss.

Salicaceae

23. *Salix tetrasperma* Roxb.

Arecaceae

24. *Phoenix sylvestris* (L.) Roxb.
25. *Phoenix dactylifera* Linn.

Myrtaceae

26. *Syzygium cumini* (L.) Skeels.

Menispermaceae

27. *Stephania hernandifolia* Welp.

Capparidaceae

28. *Gynandropsis gynandra* (L.) Briq.

Malvaceae

29. *Abelmoschus abelmoschus* Medic.
30. *Abutilon indicum* (Link.) Sweet.
31. *Malachra capitata* Linn.
32. *Sida acuta* Burm. f.
33. *Sida humilis* Willd.
34. *Urena lobata* Linn.
35. *Corchorus aestuans* Linn.

Sterculiaceae

36. *Melochia corchorifolia* Linn.

Oxalidaceae

37. *Biophytum sensitivum* (Linn.) DC.

Onagraceae

38. *Ludwigia adscendens* (Linn.) Hara.
39. *Ludwigia perennis* Linn.

Cucurbitaceae

40. *Benincasa hispida* Thunb.
41. *Bryonopsis laciniosa* Linn.
42. *Coccinia grandis* (Linn.) Voigt.
43. *Luffa acutangula* (Linn.) Roxb.
44. *Momordica dioica* Roxb. ex Willd.

Rubiaceae

45. *Oldenlandia corymbosa* Linn.

Asteraceae

46. *Ageratum conyzoides* Linn.
47. *Eclipta prostrata* (Linn.) Linn.
48. *Veronia axillaris* Less.

Apocynaceae

49. *Tabernaemontana citrifolia* Linn.

Boraginaceae

50. *Heliotropium indicum* Linn.
51. *Trichodesma indicum* (Linn.) R.Br.

Plantaginaceae

52. *Bacopa monnieri* (Linn.) Pennel.
53. *Scoparia dulcis* Linn.

Martyniaceae

54. *Martynia annua* Linn.

Acanthaceae

55. *Asystasia gangetica* (L.) T. Anderson
56. *Hygrophila auriculata* (Schum.) Heyne.
57. *Peristrophe bicalyculata* (Retz.) Ness.
58. *Rungia parviflora* Ness.

Verbenaceae

59. *Phyla nodiflora* (Linn.) Greene.

Lamiaceae

60. *Anisomeles indica* (Linn.) Kuntze.
61. *Leucas aspera* Spreng.
62. *Leucas lavandulaefolia* Rees.
63. *Ocimum basilicum* Linn.
64. *Ocimum tenuiflorum* Linn.

Amaranthaceae

65. *Achyranthes aspera* Linn.
66. Aerva lanata (Linn.) Juss. ex Schult.
67. *Alternanthera sessilis* (Linn.) R. Br. ex DC.
68. *Amaranthus tenuifolius* Willd.
69. *Chenopodium murale* Linn.
70. *Digera muricata* (Linn.) Mart.

Basellaceae

71. *Basella alba* Linn.

Euphorbiaceae

72. *Croton bonplandianum* Baill.
73. *Euphorbia hirta* Linn.

Phyllanthaceae

74. *Phyllanthus urinaria* Linn.

Poaceae

75. *Bambusa bambos* (L.). Voss.

Zooplanktons recorded at Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Copepoda

Diaptomidae

1. *Heliodiaptomus viduus* (Kiefer, 1932)
2. *Heliodiaptomus* sp.
3. *Phyllodiaptomus blanci* (Guerne and Richard, 1896)

Cladocera

Sididae

4. *Pseudosida bidentata* (Herrick, 1884)
5. *Diaphanosoma sarsi* (Richard, 1894a)

Daphniidae

6. *Daphnia lumholtzi* (Sars, 1895)
7. *Scapholebris kingii* (Sars, 1903b)
8. *Simocephalus vetulus* (O.F. Muller, 1776)

Moinidae

9. *Moina brachiata* (Jurine,1820)

Bosminidae

10. *Bosmina longirostris* (O.F. Muller, 1776)
11. *Bosminopsis deitersi* (Richard, 1895)

Macrothricidae

12. *Macrothrix spinosa* (King, 1853)
13. *Ilyocryptus spinifer* (Herrick, 1882)

Chydoridae

14. *Echiniscus odiosa* (Gurney, 1907)
15. *Pleuroxus aduncus* (Jurine, 1820)
16. *Pleuroxus trigonella* (O.F. Muller, 1776)
17. *Alonella excisa* (Fischer, 1854)
18. *Chydorus barrois* (Richard, 1849)
19. *Chydorus sphaericus* (O.F. Muller, 1776)
20. *Chydorus parvus* (Daday, 1898)
21. *Chydorus reticulatus* (Daday, 1898)
22. *Chydorus ventricosus* (Daday, 1898)
23. *Chydorus flaviformis* (Birge, 1898)
24. *Alona dravidi* (Richard, 1895a)
25. *Alona rectangula* (Sars, 1826a)
26. *Alona rectangula richardi* (Stingelin, 1895)
27. *Bipertura karua* (King, 1853)
28. *Bipertura affinis* (Leydig, 1860)
29. *Oxyurella singalensis* (Daday, 1860)

Polyphemidae

30. *Polyphemus pediculus* (Limne, 1761)

Rotifera

Notommatidae

31. *Cephalodella forficula* (Ehrenberg)

Synchaetidae

32. *Synchaeta* sp.

Trichocercidae

33. *Trichocerca similis* (Wierzenski, 1893)
34. *Trichocerca cylindrica* (Sudzuki, 1956)

Asplanchnidae

35. *Asplanchna* sp.

Brachionidae

36. *Brachionus calyciflorus* (Pallas, 1776)
37. *Brachionus quadridentatus* (Hermann, 1783)
38. *Brachionus diversicornis* (Daday, 1895)
39. *Brachionus patulus* (Muller, 1776)
40. *Brachionus falcatus* (Zacharias, 1898)
41. *Brachionus angularis* (Grosse, 1851)
42. *Keratella cochlearis* (Gosse, 1857)
43. *Keratella tropica* (Apstein, 1907)
44. *Keratella valga* (Ehernberg, 1834)
45. *Platyias quadricornis* (Ehrenberg, 1832)
46. *Dipleuchanis propatula* (Goose, 1886)

Trichotriidae

47. *Trichotria tetractis* (Ehrenberg, 1830)

Euchlanidae

48. *Euchlanis dilatata* (Ehrenberg, 1832)

Lecanidae

49. *Lecane (Lecane) ungulata* (Goose, 1886)
50. *Lecane (Lecane) papuana* (Murray, 1913)
51. *Lecane (Lecane) luna* (O.F. Muller, 1776)
52. *Lecane (Lecane) luna f. dorsicalis* (Sharma)
53. *Lecane (Lecane) eontia* (Turner, 1892)
54. *Lecane (Lecane) ploensis* (Voigt, 1902)
55. *Lecane (Lecane) ludwigii* (Eckstein, 1892)
56. *Lecane (Monostyla) lunaris* (Ehrenberg, 1832)
57. *Lecane (Monostlya) hamata* (Stokes, 1859)
58. *Lecane (Monostyla) bulla* (Gosse, 1851)
59. *Lecane (Monostyla) styrax* (Harrings, and Myers. 1859)

Ostracoda

Cyprididae

60. *Cypris subglobosa* (Sowervy, 1840)
61. *Cypricercus* sp.
62. *Strandesia purpurescens* (Brady, 1886)
63. *Cypretta* sp.
64. *Stenocypris major* (Baird, 1859)
65. *Stenocypris derupta* (Vavra, 1906)
66. *Stenocypris hislopi* (Ferguson, 1969)

Notodromadidae

67. *Centrocypris* sp.

Eucandonidae

68. *Candonopis* sp.

Branchiopoda

Caenestheriidae

69. *Caenestheriella indica* (Gurney, 1906)

Cyclestherida

70. *Cyclestheria hislopi* (Baird, 1859)

Benthos recorded at Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Gastropoda

Viviparidae

1. *Bellamya bengalensis* f. *typica* (Lamarck, 1882)
2. *Bellamya bengalensis* f. *annandalei* (Kobelt, 1909)
3. *Bellamya bengalensis* f. *doliaris* (Gould.)
4. *Bellamya dissimilis* (Mueller, 1774)

Ampullariidae

5. *Pila globosa* (Swainson, 1822)

Bithyniidae

6. *Bithynia pulchella* (Benson, 1836)
7. *Gabbia orcula* (Frauenfeld, 1862)

Thiaridae

8. *Thiara (Melanoides) tuberculata* (Mueller.)
9. *Thiara (Tarebia) lineate* (Gray.)

Lymnaeidae

10. *Lymnaea (Pseudosuccinea) acuminata* f. *typica* (Lamarck.)
11. *Lymnaea (Pseudosuccinea) acuminata* f. *rufescens* (Gray.)
12. *Lymnaea (Pseudosuccinea) acuminata* f. *gracilior* (Martens.)

Planorbidae

13. *Gyraulus convexiusculus* (Hutton.)
14. *Gyraulus euphraticus* (Mousson.)
15. *Indoplanorbis exustus* (Deshayes.)

Bivalvia

Unionidae

16. *Lamellidens corrianus* (Lea.)
17. *Lamellidens marginalis* (Lamarck.)

Fish species recorded at Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Notopteridae

1. *Notopterus notopterus* (Pallas, 1769)

Cyprinidae

2. *Amblypharyngodon mola* (Hamilton, 1822)
3. *Catla catla* (Hamilton, 1822)
4. *Chela laubuca* (Hamilton, 1822)
5. *Cirrhinus mrigala* (Hamilton, 1822)
6. *Esomus danricus* (Hamilton, 1822)
7. *Labeo bata* (Hamilton, 1822)
8. *Labeo calbasu* (Hamilton, 1822)
9. *Labeo rohita* (Hamilton, 1822)
10. *Osteobrama cotio cotio* (Hamilton, 1822)
11. *Puntius sophore* (Hamilton, 1822)

Cobitidae

12. *Lepidocephalichthys guntea* (Hamilton, 1822)

Bagridae

13. *Mystus bleekeri* (Day, 1877)
14. *Mystus cavasius* (Hamilton, 1822)
15. *Mystus tengara* (Hamilton, 1822)

Siluridae

16. *Ompak bimaculatus* (Bloch, 1794)
17. *Wallago attu* (Bloch & Schneider, 1801)

Clariidae

18. *Clarias batrachus* (Linnaeus, 1758)

Heteropneustidae

19. *Heteropneustes fossilis* (Bloch, 1774)

Belonidae

20. *Xenentodon cancila* (Hamilton, 1822)

Channidae

21. *Channa striata* (Bloch, 1793)
22. *Channa marulius* (Hamilton, 1822)
23. *Channa punctata* (Bloch, 1793)

Synbranchidae

24. *Monopterus cuchia* (Hamilton, 1822)

Ambassidae

25. *Chanda nama* (Hamilton, 1822)
26. *Parambassis ranga* (Hamilton, 1822)

Badidae

27. *Badis badis* (Hamilton, 1822)

Nandidae

28. *Nandus nandus* (Hamilton, 1822)

Anabantidae

29. *Anabas testudineus* (Bloch, 1792)

Gobiidae

30. *Glossogobius giuris* (Hamilton & Buchanan, 1822)

Osphronemidae

31. *Trichogaster fasciata* (Bloch & Schneider, 1801)

Mastacembelidae

32. *Macrognathus aculeatus* (Bloch, 1786)
33. *Mastacembelus armatus* (Lacepède, 1800)
34. *Mastacembelus puncalus* (Hamilton, 1822)

Tetraodontidae

35. *Tetraodon cutcutia* (Hamilton, 1822)

List of Bird Species recorded at Kanwar

FAMILY	Scientific name	Common name	IUCN Status	Waterbird Species
ACCIPITRIDAE	*Accipiter badius*	Shikra	LC	
ACCIPITRIDAE	*Aquila clanga*	Greater Spotted Eagle	VU	+
ACCIPITRIDAE	*Aquila fasciatus*	Bonelli's Eagle	LC	
ACCIPITRIDAE	*Butastur teesa*	White-eyed Buzzard	LC	
ACCIPITRIDAE	*Circus aeruginosus*	Western Marsh-harrier	LC	+
ACCIPITRIDAE	*Circus macrourus*	Pallid Harrier	NT	
ACCIPITRIDAE	*Circus melanoleucos*	Pied Harrier	LC	
ACCIPITRIDAE	*Elanus caeruleus*	Black-winged Kite	LC	
ACCIPITRIDAE	*Gyps bengalensis*	White-rumped Vulture	CR	
ACCIPITRIDAE	*Gyps fulvus*	Griffon Vulture	LC	
ACCIPITRIDAE	*Gyps indicus*	Indian Vulture	CR	
ACCIPITRIDAE	*Haliaeetus leucoryphus*	Pallas's Fish-eagle	VU	+
ACCIPITRIDAE	*Haliastur indus*	Brahminy Kite	LC	+
ACCIPITRIDAE	*Milvus migrans*	Black Kite	LC	
ACCIPITRIDAE	*Neophron percnopterus*	Egyptian Vulture	EN	
ACCIPITRIDAE	*Pernis ptilorhyncus*	Oriental Honey-buzzard	LC	
ACCIPITRIDAE	*Sarcogyps calvus*	Red-headed Vulture	CR	
ACCIPITRIDAE	*Spilornis cheela*	Crested Serpent-eagle	LC	
AEGITHINIDAE	*Aegithina nigrolutea*	White-tailed Iora	LC	
ALAUDIDAE	*Calandrella brachydactyla*	Greater Short-toed Lark	LC	
ALAUDIDAE	*Calandrella raytal*	Indian Short-toed Lark	LC	
ALAUDIDAE	*Eremopterix griseus*	Ashy-crowned Sparrow-lark	LC	
ALAUDIDAE	*Galerida cristata*	Crested Lark	LC	
ALAUDIDAE	*Mirafra erythroptera*	Indian Lark	LC	
ALCEDINIDAE	*Alcedo atthis*	Common Kingfisher	LC	+
ALCEDINIDAE	*Ceryle rudis*	Pied Kingfisher	LC	+
ALCEDINIDAE	*Halcyon smyrnensis*	White-throated Kingfisher	LC	
ALCEDINIDAE	*Pelargopsis capensis*	Stork-billed Kingfisher	LC	+
ANATIDAE	*Anas acuta*	Northern Pintail	LC	+
ANATIDAE	*Anas clypeata*	Northern Shoveler	LC	+
ANATIDAE	*Anas crecca*	Common Teal	LC	+
ANATIDAE	*Anas formosa*	Baikal Teal	LC	+
ANATIDAE	*Anas penelope*	Eurasian Wigeon	LC	+
ANATIDAE	*Anas platyrhynchos*	Mallard	LC	+
ANATIDAE	*Anas poecilorhyncha*	Western Spot-billed Duck	LC	+
ANATIDAE	*Anas querquedula*	Garganey	LC	+
ANATIDAE	*Anas strepera*	Gadwall	LC	+

List of Bird Species recorded at Kanwar

FAMILY	Scientific name	Common name	IUCN Status	Waterbird Species
ANATIDAE	*Anser anser*	Greylag Goose	LC	+
ANATIDAE	*Anser indicus*	Bar-headed Goose	LC	+
ANATIDAE	*Aythya baeri*	Baer's Pochard	CR	+
ANATIDAE	*Aythya ferina*	Common Pochard	LC	+
ANATIDAE	*Aythya fuligula*	Tufted Duck	LC	+
ANATIDAE	*Aythya marila*	Greater Scaup	LC	+
ANATIDAE	*Aythya nyroca*	Ferruginous Duck	NT	+
ANATIDAE	*Dendrocygna bicolor*	Fulvous Whistling-duck	LC	+
ANATIDAE	*Dendrocygna javanica*	Lesser Whistling-duck	LC	+
ANATIDAE	*Netta rufina*	Red-crested Pochard	LC	+
ANATIDAE	*Nettapus coromandelianus*	Cotton Pygmy-goose	LC	+
ANATIDAE	*Sarkidiornis melanotos*	Comb Duck	LC	+
ANATIDAE	*Tadorna ferruginea*	Ruddy Shelduck	LC	+
ANATIDAE	*Tadorna tadorna*	Common Shelduck	LC	+
ANHINGIDAE	*Anhinga melanogaster*	Oriental Darter	NT	+
ARDEIDAE	*Ardea cinerea*	Grey Heron	LC	+
ARDEIDAE	*Ardea purpurea*	Purple Heron	LC	+
ARDEIDAE	*Ardeola grayii*	Indian Pond-heron	LC	+
ARDEIDAE	*Botaurus stellaris*	Great Bittern	LC	+
ARDEIDAE	*Bubulcus ibis*	Cattle Egret	LC	+
ARDEIDAE	*Casmerodius albus*	Great Egret	LC	+
ARDEIDAE	*Egretta garzetta*	Little Egret	LC	+
ARDEIDAE	*Ixobrychus cinnamomeus*	Cinnamon Bittern	LC	+
ARDEIDAE	*Ixobrychus flavicollis*	Black Bittern	LC	+
ARDEIDAE	*Ixobrychus minutus*	Little Bittern	LC	+
ARDEIDAE	*Ixobrychus sinensis*	Yellow Bittern	LC	+
BUCEROTIDAE	*Ocyceros birostris*	Indian Grey Hornbill	LC	
BURHINIDAE	*Burhinus oedicnemus*	Eurasian Thick-knee	LC	+
BURHINIDAE	*Esacus recurvirostris*	Great Thick-knee	NT	+
CAMPEPHAGIDAE	*Pericrocotus erythropygius*	White-bellied Minivet	LC	
CAMPEPHAGIDAE	*Tephrodornis pondicerianus*	Common Woodshrike	LC	
CHARADRIIDAE	*Charadrius dubius*	Little Ringed Plover	LC	+
CHARADRIIDAE	*Charadrius hiaticula*	Common Ringed Plover	LC	+
CHARADRIIDAE	*Pluvialis apricaria*	Eurasian Golden Plover	LC	++
CHARADRIIDAE	*Pluvialis fulva*	Pacific Golden Plover	LC	+
CHARADRIIDAE	*Pluvialis squatarola*	Grey Plover	LC	+
CHARADRIIDAE	*Vanellus cinereus*	Grey-headed Lapwing	LC	+
CHARADRIIDAE	*Vanellus duvaucelii*	River Lapwing	NT	+

List of Bird Species recorded at Kanwar

FAMILY	Scientific name	Common name	IUCN Status	Waterbird Species
CHARADRIIDAE	*Vanellus gregarius*	Sociable Lapwing	CR	+
CHARADRIIDAE	*Vanellus indicus*	Red-wattled Lapwing	LC	+
CHARADRIIDAE	*Vanellus leucurus*	White-tailed Lapwing	LC	+
CHARADRIIDAE	*Vanellus malarbaricus*	Yellow-wattled Lapwing	LC	
CICONIIDAE	*Anastomus oscitans*	Asian Openbill	LC	+
CICONIIDAE	*Ciconia ciconia*	White Stork	LC	+
CICONIIDAE	*Ciconia episcopus*	Woolly-necked Stork	VU	+
CICONIIDAE	*Ciconia nigra*	Black Stork	LC	+
CICONIIDAE	*Ephippiorhynchus asiaticus*	Black-necked Stork	NT	+
CICONIIDAE	*Leptoptilos dubius*	Greater Adjutant	EN	+
CICONIIDAE	*Leptoptilos javanicus*	Lesser Adjutant	VU	+
CICONIIDAE	*Mycteria leucocephala*	Painted Stork	NT	+
COLUMBIDAE	*Columba livia*	Rock Pigeon	LC	
COLUMBIDAE	*Stigmatopelia chinensis*	Spotted Dove	LC	
COLUMBIDAE	*Streptopelia decaocto*	Eurasian Collared-dove	LC	
COLUMBIDAE	*Streptopelia orientalis*	Oriental Turtle-dove	LC	
COLUMBIDAE	*Streptopelia tranquebarica*	Red Collared-dove	LC	
CORACIIDAE	*Coracias benghalensis*	Indian Roller	LC	
CORACIIDAE	*Coracias garrulus*	European Roller	NT	
CORVIDAE	*Corvus splendens*	House Crow	LC	
CORVIDAE	*Dendrocitta vagabunda*	Rufous Treepie	LC	
CUCULIDAE	*Centropus sinensis*	Greater Coucal	LC	
CUCULIDAE	*Clamator jacobinus*	Pied Cuckoo	LC	
CUCULIDAE	*Cuculus micropterus*	Indian Cuckoo	LC	
CUCULIDAE	*Eudynamys scolopaceus*	Asian Koel	LC	
CUCULIDAE	*Phaenicophaeus leschenaultii*	Sirkeer Malkoha	LC	
DICRURIDAE	*Dicrurus macrocercus*	Black Drongo	LC	
ESTRILDIDAE	*Amandava amandava*	Red Avadavat	LC	
ESTRILDIDAE	*Lonchura atricapilla*	Chestnut Munia	LC	
ESTRILDIDAE	*Lonchura malabarica*	White-throated Munia	LC	
ESTRILDIDAE	*Lonchura punctulata*	Scaly-breasted Munia	LC	
ESTRILDIDAE	*Lonchura striata*	White-rumped Munia	LC	
FALCONIDAE	*Falco cherrug*	Saker Falcon	EN	
FALCONIDAE	*Falco naumanni*	Lesser Kestrel	LC	
FALCONIDAE	*Falco peregrinus*	Peregrine Falcon	LC	
FALCONIDAE	*Falco subbuteo*	Eurasian Hobby	LC	
GLAREOLIDAE	*Cursorius coromandelicus*	Indian Courser	LC	

List of Bird Species recorded at Kanwar

FAMILY	Scientific name	Common name	IUCN Status	Waterbird Species
GLAREOLIDAE	*Glareola lactea*	Small Pratincole	LC	+
GLAREOLIDAE	*Glareola pratincola*	Collared Pratincole	LC	+
GRUIDAE	*Anthropoides virgo*	Demoiselle Crane	LC	+
GRUIDAE	*Grus grus*	Common Crane	LC	+
HIRUNDINIDAE	*Hirundo rustica*	Barn Swallow	LC	+
JACANIDAE	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	LC	+
JACANIDAE	*Metopidius indicus*	Bronze-winged Jacana	LC	+
LANIIDAE	*Lanius collurio*	Red-backed Shrike	LC	
LANIIDAE	*Lanius cristatus*	Brown Shrike	LC	
LARIDAE	*Childonias hybridus*	Whiskered Tern	LC	+
LARIDAE	*Sterna aurantia*	River Tern	NT	+
LARIDAE	*Sterna hirundo*	Common Tern	LC	+
MEROPIDAE	*Merops orientalis*	Little Green Bee-eater	LC	
MEROPIDAE	*Merops philippinus*	Blue-tailed Bee-eater	LC	
MONARCHIDAE	*Terpsiphone paradisi*	Asian Paradise-flycatcher	LC	
MOTACILLIDAE	*Anthus cervinus*	Red-throated Pipit	LC	+
MOTACILLIDAE	*Anthus hodgsoni*	Olive-backed Pipit	LC	
MOTACILLIDAE	*Anthus richardi*	Richard's Pipit	LC	+
MOTACILLIDAE	*Anthus rufulus*	Paddyfield Pipit	LC	
MOTACILLIDAE	*Anthus trivialis*	Tree Pipit	LC	
MOTACILLIDAE	*Motacilla alba*	White Wagtail	LC	+
MOTACILLIDAE	*Motacilla cinerea*	Grey Wagtail	LC	+
MOTACILLIDAE	*Motacilla flava*	Yellow Wagtail	LC	+
MUSCICAPIDAE	*Cercomela fusca*	Indian Chat	LC	
MUSCICAPIDAE	*Copsychus malabaricus*	White-rumped Shama	LC	
MUSCICAPIDAE	*Culicicapa ceylonensis*	Grey-headed Canary-flycatcher	LC	
MUSCICAPIDAE	*Eumyias thalassinus*	Verditer Flycatcher	LC	
MUSCICAPIDAE	*Ficedula parva*	Red-breasted Flycatcher	LC	
MUSCICAPIDAE	*Luscinia svecica*	Bluethroat	LC	
MUSCICAPIDAE	*Phoenicurus ochruros*	Black Redstart	LC	
MUSCICAPIDAE	*Saxicola caprata*	Pied Bushchat	LC	
MUSCICAPIDAE	*Saxicola torquatus*	Common Stonechat	LC	
NECTARINIIDAE	*Nectarinia asiatica*	Purple Sunbird	LC	
ORIOLIDAE	*Oriolus oriolus*	Eurasian Golden Oriole	LC	
ORIOLIDAE	*Oriolus xanthornus*	Black-hooded Oriole	LC	
PANDIONIDAE	*Pandion haliaetus*	Osprey	LC	+
PASSERIDAE	*Passer domesticus*	House Sparrow	LC	

List of Bird Species recorded at Kanwar

FAMILY	Scientific name	Common name	IUCN Status	Waterbird Species
PASSERIDAE	*Petronia xanthocollis*	Chestnut-shouldered Petronia	LC	
PELECANIDAE	*Pelecanus crispus*	Dalmatian Pelican	VU	+
PELECANIDAE	*Pelecanus onocrotalus*	Great White Pelican	LC	+
PELECANIDAE	*Pelecanus philippensis*	Spot-billed Pelican	NT	+
PHALACROCORACIDAE	*Phalacrocorax niger*	Little Cormorant	LC	+
PHASIANIDAE	*Francolinus francolinus*	Black Francolin	LC	
PHOENICOPTERIDAE	*Phoenicopterus roseus*	Greater Flamingo	LC	+
PITTIDAE	*Pitta brachyura*	Indian Pitta	LC	
PLOCEIDAE	*Ploceus benghalensis*	Black-breasted Weaver	LC	
PLOCEIDAE	*Ploceus philippinus*	Baya Weaver	LC	
PODICIPEDIDAE	*Podiceps cristatus*	Great Crested Grebe	LC	+
PODICIPEDIDAE	*Tachybaptus ruficollis*	Little Grebe	LC	+
PSITTACIDAE	*Psittacula krameri*	Rose-ringed Parakeet	LC	
PSITTACIDAE	*Psittacula roseata*	Blossom-headed Parakeet	NT	
PYCNONOTIDAE	*Pycnonotus cafer*	Red-vented Bulbul	LC	
PYCNONOTIDAE	*Pycnonotus leucotis*	White-eared Bulbul	LC	
RALLIDAE	*Amaurornis phoenicurus*	White-breasted Waterhen	LC	+
RALLIDAE	*Fulica atra*	Common Coot	LC	+
RALLIDAE	*Gallicrex cinerea*	Watercock	LC	+
RALLIDAE	*Gallinula chloropus*	Common Moorhen	LC	+
RALLIDAE	*Porphyrio porphyrio*	Purple Swamphen	LC	+
RALLIDAE	*Porzana parva*	Little Crake	LC	++
RALLIDAE	*Porzana porzana*	Spotted Crake	LC	+
RALLIDAE	*Porzana pusilla*	Baillon's Crake	LC	+
RALLIDAE	*Rallus aquaticus*	Water Rail	LC	+
MEGALAIMIDAE	*Megalaima haemacephala*	Coppersmith Barbet	LC	
MEGALAIMIDAE	*Megalaima lineata*	Lineated Barbet	LC	
MEGALAIMIDAE	*Megalaima zeylanica*	Brown-headed Barbet	LC	
RECURVIROSTRIDAE	*Himantopus himantopus*	Black-winged Stilt	LC	+
RECURVIROSTRIDAE	*Recurvirostra avosetta*	Pied Avocet	LC	+
RHIPIDURIDAE	*Rhipidura albicollis*	White-throated Fantail	LC	
ROSTRATULIDAE	*Rostratula benghalensis*	Greater Painted-snipe	LC	+
SCOLOPACIDAE	*Actitis hypoleucos*	Common Sandpiper	LC	+
SCOLOPACIDAE	*Arenaria interpres*	Ruddy Turnstone	LC	
SCOLOPACIDAE	*Calidris ferruginea*	Curlew Sandpiper	LC	+
SCOLOPACIDAE	*Calidris minuta*	Little Stint	LC	+
SCOLOPACIDAE	*Calidris subminuta*	Long-toed Stint	LC	+

List of Bird Species recorded at Kanwar

FAMILY	Scientific name	Common name	IUCN Status	Waterbird Species
SCOLOPACIDAE	*Calidris temminckii*	Temminck's Stint	LC	+
SCOLOPACIDAE	*Gallinago gallinago*	Common Snipe	LC	+
SCOLOPACIDAE	*Gallinago stenura*	Pintail Snipe	LC	+
SCOLOPACIDAE	*Limosa limosa*	Black-tailed Godwit	NT	+
SCOLOPACIDAE	*Lymnocryptes minimus*	Jack Snipe	LC	+
SCOLOPACIDAE	*Numenius arquata*	Eurasian Curlew	NT	+
SCOLOPACIDAE	*Philomachus pugnax*	Ruff	LC	+
SCOLOPACIDAE	*Tringa erythropus*	Spotted Redshank	LC	+
SCOLOPACIDAE	*Tringa glareola*	Wood Sandpiper	LC	+
SCOLOPACIDAE	*Tringa nebularia*	Common Greenshank	LC	+
SCOLOPACIDAE	*Tringa ochropus*	Green Sandpiper	LC	+
SCOLOPACIDAE	*Tringa stagnatilis*	Marsh Sandpiper	LC	+
SCOLOPACIDAE	*Tringa totanus*	Common Redshank	LC	+
SCOLOPACIDAE	*Xenus cinereus*	Terek Sandpiper	LC	+
STRIGIDAE	*Asio flammeus*	Short-eared Owl	LC	
STRIGIDAE	*Athene brama*	Spotted Owlet	LC	
STRIGIDAE	*Otus bakkamoena*	Collared Scops-owl	LC	
STURNIDAE	*Acridotheres fuscus*	Jungle Myna	LC	
STURNIDAE	*Acridotheres ginginianus*	Bank Myna	LC	
STURNIDAE	*Acridotheres tristis*	Common Myna	LC	
STURNIDAE	*Sturnus contra*	Asian Pied Starling	LC	
STURNIDAE	*Sturnus erythropygius*	White-headed Starling	LC	
STURNIDAE	*Sturnus malabaricus*	Chestnut-tailed Starling	LC	
STURNIDAE	*Sturnus pagodarum*	Brahminy Starling	LC	
SYLVIIDAE	*Acrocephalus aedon*	Thick-billed Warbler	LC	
SYLVIIDAE	*Phylloscopus collybita*	Common Chiffchaff	LC	
THRESKIORNITHIDAE	*Platalea leucorodia*	Eurasian Spoonbill	LC	+
THRESKIORNITHIDAE	*Plegadis falcinellus*	Glossy Ibis	LC	+
THRESKIORNITHIDAE	*Pseudibis papillosa*	Red-naped Ibis	LC	+
THRESKIORNITHIDAE	*Threskiornis melanocephalus*	Black-headed Ibis	NT	+
TIMALIIDAE	*Turdoides caudata*	Common Babbler	LC	
TIMALIIDAE	*Turdoides malcolmi*	Large Grey Babbler	LC	
TIMALIIDAE	*Turdoides striata*	Jungle Babbler	LC	
TYTONIDAE	*Tyto alba*	Barn Owl	LC	
UPUPIDAE	*Upupa epops*	Eurasian Hoopoe	LC	

\+ Waterbirds
++ Vagrant Waterbirds

Insects recorded at Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Odonata

Coenagrionidae

1. *Ischnura senegalensis* (Rambur, 1842)

Libellulidae

2. *Crocothemis servilia* (Drury, 1773)
3. *Diplacodes trivialis* (Rambur, 1842)
4. *Pantala flavescens* (Fabricius, 1798)
5. *Rhyothemis variegata* (Linnaeus, 1763)

Gomphidae

6. *Ictinogomphus rapax* (Rambur, 1842)

Coleoptera

Dytiscidae

7. *Canthydrus laetabilis* (Walker, 1858)
8. *Cybister limbatus* (Fabricius, 1775)
9. *Cybister posticus* (Aube, 1838)
10. *Cybister sugillatus* (Erichson, 1834)
11. *Cybister tripunctatus asiaticus* (Sharp, 1882)
12. *Hydaticus* sp.
13. *Hyphoporus* sp.
14. *Laccophilus anticatus* (Sharp, 1890)
15. *Laccophilus rufulus* (Regimbart, 1889)
16. *Laccophilus sharpi* (Regimbart, 1889)

Gyrinidae

17. *Dineutus* sp.

Hydrophilidae

18. *Berosus indicus* (Motschulsky, 1861)
19. *Berosus pulchelus* (MacLeay.)
20. *Hydrophilus rufocinctus* (Bedel, 1888)
21. *Hydrophilus* sp.
22. *Regimbertia* sp.
23. *Sternolophus rufipes* (Fabricius, 1792)

Hemiptera

Corixidae

24. *Micronecta* sp.

Nepidae

25. *Ranatra filiformis* (Fabricius, 1790)
26. *Ranatra varipes* (Stal, 1861)
27. *Laccotrephes elongates* (Montandon, 1913)
28. *Laccotrephes griseus* (Guérin, 1835)

Pleidae

29. *Plea* sp.

Belostomatidae

30. *Diplonychus annulatum* (Fabr.)
31. *Lethocerus indicus* (Lepeletier et Serville, 1775)

Gerridae

32. *Gerris spinolae* (Lethierry and Severin)
33. *Gerris adelaidis* (Dohrn, 1860)
34. *Limnogonus parvulus* (Stal, 1859)
35. *Limnogonus nitidus* (Mayr, 1865)

Veliidae

36. *Microvelia douglasi* (Scott, 1874)

Hydrometridae

37. *Hydrometra greeni* (Kirkaldy, 1898)

Mesoveliidae

38. *Mesovelia vittigera* (Horvath, 1895)
39. *Merragata pallescens* (Distant, 1909)

Amphibians recorded at Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Bufonidae

1. *Duttaphrynus melanostictus* (Schneider, 1799)

Microhylidae

2. *Microhyla ornata* (Dumeril and Bibron, 1841)

Ranidae

3. *Hylarana erythraea* (Schlegel, 1837)

Dicroglossidae

4. *Euphlyctis cyanophlyctis* (Schneider, 1799)
5. *Fejervarya limnocharis* (Gravenhorst, 1829)
6. *Hoplobatrachus tigerinus* (Daudin, 1803)

Rhacophoridae

7. *Polypedates maculatus* (Gray, 1830)

Reptiles recorded at Kanwar

(Source: ZSI, 2002 updated based on IUCN Red List of Threatened Species. Version 2014.3)

Trionychidae

1. *Lissemys punctata* (Bonnaterre, 1789)

Agamidae

2. *Calotes versicolor* (Daudin, 1802)

Colubridae

3. *Xenochrophis piscator* (Schneider, 1799)
4. *Xenochrophis cerasogaster* (Cantor, 1839)

Homalopsidae

5. *Enhydris enhydris* (Schneider, 1799)

Villages in and around Kanwar

Sl No	Villages	Population
	Bhagwanpur	
1	Maheshpur	1,705
	Cheria Bariarpur	
2	Kumbhi	5,684
3	Cheria Bariarpur	4,734
4	Karor	6,742
5	Sakarbasa	4,920
6	Aure	788
7	Mohanpur	381
8	Shahpur	5,435
9	khanjahanpur	8,257
10	Majhaul	31,261
11	Jaimangal Garh	538
	Chhorahi	
12	Parora	4,251
13	Ekamba	4,803
14	Dumri	2,596
15	Pansalla	2,991
16	Narayanpipar	5,396
	Garhpura	
17	Kanausi	2,179
18	Manikpur	2,849
19	Rajaur	4,420
20	Sakra	3,354
21	Dunahi	2,642
	Naokothi	
22	Pahsara	14,694
23	Maheshwara	5,221
	Total	**125,841**

Government of Bihar Notification for proclamation of Kanwar as Bird Sanctuary

Bihar Gazette (extraordinary) 20th June 1989

The 20th June 1989

S.O. 781 — Whereas the Governor of Bihar is satisfied that the area of villages mentioned in Schedule with Thana numbers, plot numbers, area and boundaries under columns 4, 5, 6 and 7 respectively appended hereto situated in the district of Begusarai are of adequate ecological, faunal, flora, geo-morphological and natural significance and it is necessary to protect, propagate and develop Wildlife and its habitat in these areas.

Now, therefore, in exercise of the powers conferred under sub-section (4) of section 18 of the Wildlife (Protection) Act, 1972 (No. 53 of 1972), the Governor of Bihar is pleased to declared the areas specified in the schedule hereto annexed situated in the district of Begusarai as a "Sanctuary".

2. This "Sanctuary" shall be called "The Kanwar Lake Bird Sanctuary".

3. This notification would take effect from the date of publication in the Gazette.

[Van-Prani — 42/89]
By order of the Governor of Bihar,
A. N. P. SINHA,
Special Secretary to Government

SCHEDULE

Details of the areas of Begusarai District constituting "Kabar Lake Bird Sanctuary"

Serial No.	Name of Village	Thana	Thana No.	Plot No.	Area in hectares	Boundaries
1	2	3	4	5	6	7
1	Manjhol (P)	Cheria-Bariyarpur	191	1 to 226, 1327, 1722 to 2675, 2716 to 2742, 2814 to 2873, 2900 to 2903, 7200 to 7828, 7843 to 7852, 7854 to 7990, 8301, 8358 to 8400, 8478, 8479, 8568, 8576 to 8578, 8585, 8835, 8841 to 8847, 9000 to 9277, 2312 / 8627, 1756 / 8121, 1741/ 8622, 7175 / 8546, 7408 / 8356, 9169 / 8287, 9642 / 9168,	1386.48	North to North-East — Naraina piper to Swain in Narainpiper Garhpura Road and plot nos. 2015, 2014, 2013, 1992, 1994/1808, 1706, 1676, 1677, 1678, 1682, 1688, 1689, 1699, 1703, 1708, 1709, 1710, 1711, 1712, 1713, 1714, 1715, 1716, 1717, 1718, 2089 (of Village Parora, Thana Cheria Bariarpur), 185, 84, 1513, 1546, 1527, 1533, 1554, 1559, 1325(of Village Ekmba, Thana Cheria Bariarpur)
2	Jai Mangalpur (P)	Ditto	190	34 to 53, 108 to 256, 270 to 295	420.48	..
3	Jai Mangalgarh (P)	Ditto	189	1 to 11	38.45	..
4	Sakara (P)	Ditto	187	1255 to 1258, 1351, 1352	119.38	1187, 1198, 1260, 1250, 872, 874, 975, 878, 880, 1208, 906 'of village Kanosi, Thana Bakhari)
5	Rasoor (P)	Bakhari	130	25 to 39, 41, 43 to 50, 52 to 72, 95 to 99, 35/2545, 2546, 2555, 1149,	429.79	2, East Plot nos 900, 1194, 3, 34, 35, 36, 45, 44, 1125, 1128, 1130, 1131, 1135, 1136, 1137, 1138, 1139, 145, 1146, 1147, 1192, 1149,

				2548, 2519.		1151, 1154, 1115, 1157, 960, 962, 964, 967, 968, 969, 972, 974, 979, 1181, (of Village Manikpur, Thana Bakhari);
6	Kanosi (P)	Ditto	128	865 to 990, 1100 to 1123, 1104/1204, 1217 to 1223, 1250, 1257 to 1260, 1320 to 1322, 1325 to 1329, 1333, 1432 to 1446, 1449, 1450.	105.63	52, 53, 54, 57, 59, 76, 69, 70, 2546, 2555, 138, 2549, 164, 180, 183 (of Village Rajour, Thana Bakhari);
7	Sirpur Ekmba (P)	Cheria-Bariyarpur	116	1400, 1455, 1499, 1501, 1513, 1527, 1546 to 1560, 2032 to 2348, 2449 to 2599, 2601, 3029 / 3447, 3553 to 3590, 3606 to 3610, 3628, 2136 / 3629, 1153 / 3638, 2290 / 3640, 3025 / 3653, 3610 / 3655, 3657 to 3671, 3610 / 3672, 3673 to 3727	3055.04	813, 819, 1255, 1258 (of village Ekmba, Thana Cheriya Bariyarpur), 1327, 9253, 8301, 8479, 9249, 9241, 9240, 9237, 9235 (of village Manjhol, Thana Cheriya Bariyarpur), 34, 63, 07, 118, 284, 194, 255, 252, 272, 270, 278, 295(of village Jai Mangalpur, Thana Cheriya Bariyarpur)
8	Parora (P)	Cheria-Bariyarpur	119	1676 to 1693, 1699 to 1722, 1732 to 1808, 1992, 1994, 1995, 2008 to 2011, 2013 to 2019, 2025, to 2049, 2070 to 2084.	64.35	3. South — Plot nos. 1722, 2902, 2903, 2905, 2863, 2843, 2850, 2808, 2840, 2803, 2741, 2743, 2835, 2734, 2744, 2745, 2729, 2727, 2726, 2723, 2722, 2717, 2713, 2714, 2670/8881,

9	Narainpipur (P) (Chhawla)	Ditto	117	631 to 656, 659 to 682, 700 to 712, 717 to 779, 861 to 887, 900 to 1010, 1100 to 1165, 1169 to1176, 1201 to 1215, 1263, 2300 to 2604, 2610, 2268/2383, 2388/2602.	574.67	2726, 2723, 2722, 2717, 2713, 2714, 2670[illegible], 2671, 2663, 2662, 2658, 2648, 2645, 2653, 2651, 2650, 2620, 7179, 7180, 7181, 8012, 8011, 8010, 8009, 8007, 8006, 7995, 7845, 7841, 7840, 7839, 7838, 7837, 7853, 7854, 7878, 7879, 7820, 7884, 7875, 7897, 7898 (of Village Manjhol, Thana Cgera Bariyarpur).
10	Manikpur (P)	Bachari	129	658, 662, 682, 2/1194 to 34, 34 to 44, 47, 48, 1/1182, 1123 to 1131, 1129/1185, 1135 to 1149, 1158/1186, 1151 to 1166, 1162/1187, 1162/1191, 1170 to 1181, 1191 to 1200, 1099/1205, 1174/1192, 1174/1189, 1175/1193, 960 to 980	117.36	4. West — Narainpiper to Dahela, Bridge in Narainpiper – Sripur Road and Plot nos. 26, 20, 22, 24, 107, 108, 109, 110, 112, 113, 114, 115, 116, 117, 118, 119, 120, 90, 91, 92, 95, 286, 211, 212, 65, 62, 63, 261, 296, 9349, 9612, 9014, 9016, 9017, 9018, 9031, 9032, 9034, 9037, 9038, 8568, 8565, 8566, 8567, 8555, 7360, 7359, 7358, 7357, 7354, 7351, 7350, 7045, 7344, 7333, 7332, 7331, 7327, 7325, 7324, 7322, 7321, 22, 7314, 1863, 1862, 1861, 1860, 1956, 1858, 1857, 1854, 1856, 1852, 1851, 1850, 1848, 1847, 1827, 1812, 1777, 1776, 1775, 1760, 1757, 1752, 1755, 1754, 8928, 1744, 1738, 1724 (of Village Manjhol, Thana Cgera Bariyarpur).
					6511.63	

बिहार सरकार
पर्यावरण एवं वन विभाग

अधिसूचना

पटना 15, दिनांक

संख्या- वन्य-प्राणी वन पर्या0 13/2005-2839 /पा0वा0, वन्य-प्राणी (संरक्षण) अधिनियम, 1972 (1972 की 53) तथा संशोधित 2002 की धारा 18 (ग) के अधीन प्रदत्त शक्तियों का प्रयोग करते हुए राज्य सरकार अनुमंडल पदाधिकारी बेगूसराय को उनके क्षेत्रीय अधिकारिता के भीतर पड़ने वाली कांवर झील पक्षी आश्रयणी के लिये वन्य-प्राणी (संरक्षण) अधिनियम, 1972 की धारा 19 से 25 के अधीन कार्यों के निपटारे के लिए प्राधिकृत करती है।

2- पर्यावरण एवं वन विभाग द्वारा इससे संबंधित पूर्व में निर्गत अधिसूचना संख्या-762 (ई) दिनांक 13-11-2003 को इस हद तक पुनरीक्षित किया जाता है।

3- यह अधिसूचना तुरत प्रभाव होगी।

बिहार राज्यपाल के आदेश से,

ह0/-
(देव नन्दन यादव)
सरकार के उप सचिव।

ज्ञापांक वन्य-प्राणी-वन पर्या0 13/2005-2839 /पा0वा0 पटना 15, दि0 27/11/09

प्रतिलिपि- श्रीमान् पर्यावरण मुद्रणालय, गुलजारबाग, पटना को को सूचनार्थ एवं आवश्यक कार्रवाई हेतु प्रेषित।

2- अनुरोध है कि इस राजपत्र के असाधारण अंक में प्रकाशित कराकर इसकी प्रतियाँ विभाग को प्रेषित की जाय।

ह0/-
(देव नन्दन यादव)
सरकार के उप सचिव।

आदेश

ज्ञापांक वन्य-प्राणी-वन पर्या0 13/2005-2839 /पा0वा0, पटना 15, दि0 27/11/09

प्रतिलिपि- सभी विभागाध्यक्ष/प्रमंडलीय आयुक्त, मुंगेर/जिला पदाधिकारी, बेगूसराय/अनुमंडल पदाधिकारी, बेगूसराय को सूचनार्थ प्रेषित।

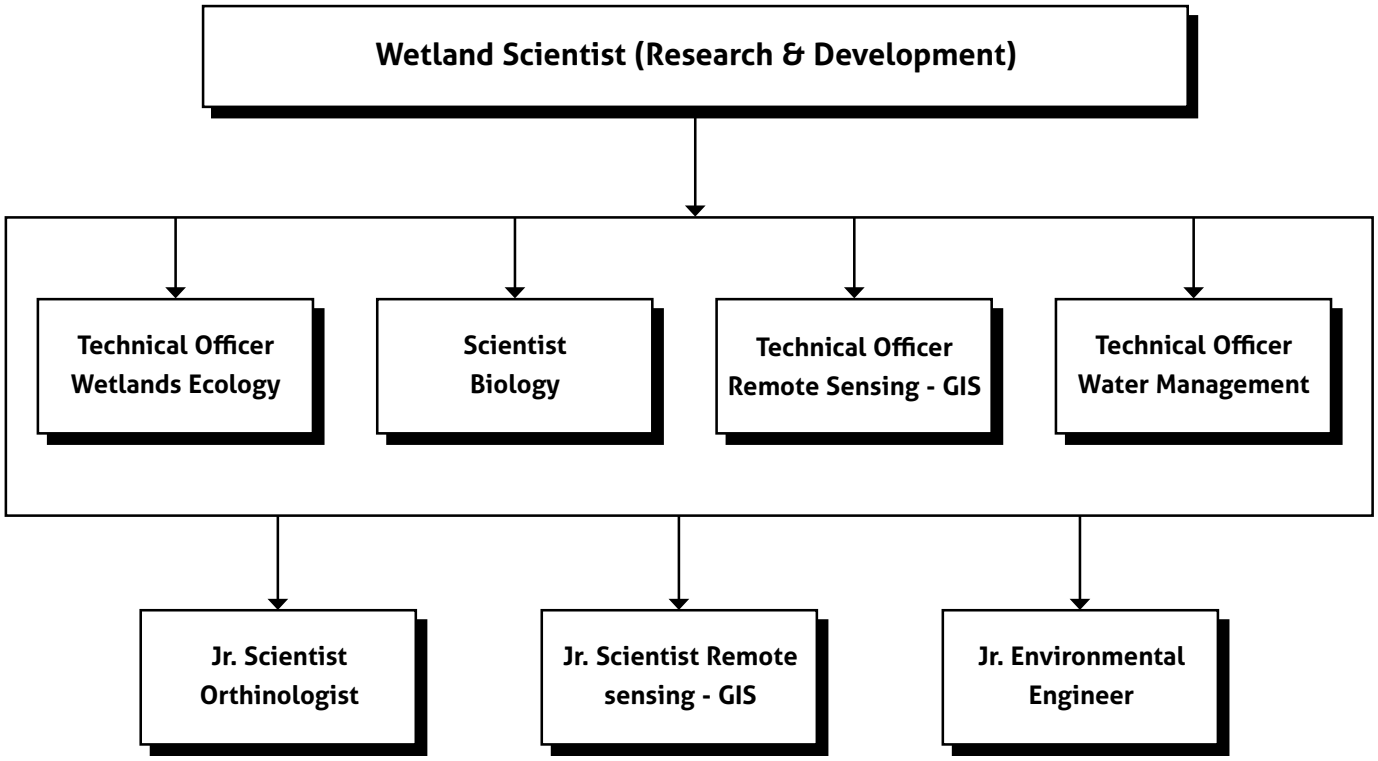
ह0/-
(देव नन्दन यादव)
सरकार के उप सचिव।

ज्ञापांक वन्य-प्राणी-वन 13/2015-2839/पा0का0 पटना 15, दि0 27/11/

प्रतिलिपि- प्रधान मुख्य वन संरक्षक, बिहार, पटना/ क्षेत्रीय मुख्य वन संरक्षक, पटना/मुजफ्फरपुर/वन प्रमंडल पदाधिकारी, भूमरात्र/ संबंधित पदाधिकारियों को सूचनार्थ एवं आवश्यक कार्रवाई हेतु प्रेषित।

देव नन्दन प्रसाद
सरकार के उप सचिव।

Proposed structure of monitoring team for Kanwar



List of equipment for wetland monitoring and research center

Hydrological Equipment and Material

- Automatic Weather Station
- Sunshine recorder
- Automatic water level recorder
- Current meters
- Wireless Station
- Thermo-hydrograph
- Digital depth- temperature analysers
- Ecosounders
- Fibreglass boat with outboard motor
- Poles fixed for float observations, Wading rods and cable and drum (cranes) for lowering current meters
- Metal plates with levels marked and fixed on permanent piers (outflow site)

Fisheries Equipment

- Fishing gears
- Plankton nets
- Buoys
- GPS
- Fisheries Assessment Softwares (ELEFAN, CEDA, etc)
- Fish base Application – Fish identification

Research Equipment

- DR 4000 Spectrophotometer (Hach, USA)
- UV spectrophotometer
- Digital pH and conductivity meters (Hanna)
- Multiparameter Water quality meter
- Water quality multi parameter probes
- Paqua Lab with bacteriological assembly (U.K)
- Distillation unit
- Kjeldahl assembly
- Incubators
- Autoclave
- COD digester (Hach USA)
- BOD Incubator
- Automatic pippettes
- Digital Flame photometers (Systronics)
- Electronic Balance
- Centrifuge machines
- Cold centrifuge machine
- Grinders
- Automatic sieves
- Hot air oven
- Magnetic stirrers
- Burners & heaters
- Ekmans Grab and potable dredgers
- Plankton samplers
- Glassware and Chemicals

GIS Equipment

GIS software

- GIS Workstation
- A0 Size Digitizer
- Plotters (HP)
- A0 size scanner
- GPS

Computing and Networking Equipment

- Terminals (I 5)
- Notebooks
- Laser printer Colour
- Deskjet / Inkjet printer A3
- Online UPS 2KVA
- Broadband Internet connection
- MS Project software, MS Office software and other software

Documentation and Display equipment

- Photocopier (Cannon)
- Overhead projector
- LCD Panel
- Digital camera
- Video camera
- Binoculars
- Telescope

Facilities

- Furnishing and accessories
- Vehicle – one
- Silent Generator 15 KVA

Record of discussions of meeting held on June 16, 2015 at Department of Water Resources

कॉबर ताल पक्षी आश्रयणी तथा सम्बद्ध आद्रभूमि संरक्षण हेतु प्रबंधन योजना के संबंध में जल संसाधन एवं मत्स्य पालन क्रिया–कलापों के पहलुओं के संदर्भ में सम्पन्न बैठक की कार्यवाही

तिथिः 16.06.2015, समयः 12 बजे मध्याह्न; स्थानः जल संसाधन विभाग का सम्मेलन कक्ष, सिचाई भवन

उपस्थिति

प्रधान सचिव, पर्यावरण एवं वन विभाग तथा सचिव, जल संसाधन विभाग के स्तर पर बैठक हुई जिसमें जल संसाधन विभाग, मत्स्य संसाधन तथा पर्यावरण एवं वन विभाग के पदाधिकारियों/प्रतिनिधियों तथा प्रबंधन योजना निर्माण कार्य में संलग्न संस्थान *वेटलैंड इन्टरनैशनल–साउथ एशिया* के विशेषज्ञ ने भाग लिया। बैठक के प्रतिभागियों की सूची संलग्न है।

कार्यवाही

1. सर्वप्रथम डॉ. रितेश कुमार, वेटलैंड इन्टरनेशनल–साउथ एशिया द्वारा कॉबर ताल एवं सम्बद्ध आद्र भूखण्डों (चौर–मॉन) के hydrological regimes को पुनर्स्थापित करने के उपायों पर प्रकाश डाला गया। इसके अन्तर्गत निम्नांकित मुद्दों/पहलुओं की चर्चा की गयीः

(क) विगत दशकों में कॉबर ताल के inundation regime में काफी shrinkage हुआ है जिस कारण इस झील के wetland resources and biodiversity values तथा fisheries resources पर खतरा बना हुआ है। कॉबर ताल के biodiversity values and ecosystem services को बनाये रखने के लिये इस झील के inundation regime को यथा सम्भव पुनर्स्थापित करना अनिवार्य है।

(ख) कॉबर ताल के inundation regime को बहाल करने के निम्नांकित व्यावहारिक विकल्प बताया गयाः–

i. Regulating outflows
ii. Enhancing connectivity within wetland complex
iii. Enhancing water holding capacity of the wetland complex
iv. Enhancing riverine inflows
v. Allocating water for wetland functioning at basin complex

2. तदुपरान्त कॉबर ताल के inundation regime को बहाल करने के विकल्पों पर विचार विमर्श किया गया। इनमें उपरोक्त के प्रथम तीन विकल्पों (Regulating outflows, Enhancing connectivity within wetland complex, Enhancing water holding capacity of the wetland complex) पर केन्द्रित उपाय करना तत्काल व्यावहारिक एवं उपयुक्त पाया गया। इन उपायों के क्रियान्वयन में विशेष रूप से Outflow regulation हेतु संरचनाओं के निर्माण/संस्थापन–संचालन में व्यावहारिक तथा प्रयोजनसिद्ध पहलु यह भी होगा कि सड़कों, आवासीय मकानों तथा अन्य सार्वजनिक एवं लोक उपयोग की

अवसंरचनाओं की वर्तमान elevations का ध्यान में रक्खा जाय, जिससे कि इन संरचनाओं एवं परिवेशों का जलप्लावन से प्रतिरक्षण हो सके। इनमें प्राप्त फलाफल के मूल्यांकन के उपरान्त यदि कॉबर झील में inundation regime के पर्याप्त रूप से पुर्नस्थापन में सफलता नहीं प्राप्त होती हो वैसी परिस्थिति में ही विस्तृत सर्वेक्षण एवं जल आगम–निर्गम की गणना इत्यादि करते हुए उपरोक्त क्रमांक IV (Enhancing riverine inflows) तथा V (Allocating water for wetland functioning at basin complex) के दूरगामी संदर्भ में कालान्तर में कार्रवाई विचारणीय होगी।

साथ ही इन उपायों के प्रभाव एवं उपयोगिता के अनुश्रवण तथा base level water management planning के लिये hydrometric stations की स्थापना करना भी उपयुक्त पाया गया।

इसी के साथ *राज्य आद्रभूमि विकास प्राधिकरण* के माध्यम से कॉबर ताल एवं सम्बद्ध वेटलैंड क्षेत्र में जल संसाधन, मत्स्य संसाधन, वन एवं पर्यावरण तथा कृषि प्रक्षेत्रों के विकास कार्यक्रमों/परियोजनाओं का विनयमन कराना भी वांछित होगा।

3. उपरोक्त विचार–विमर्श के अंतर्गत निम्नांकित विन्दुओं पर कार्रवाई किया जाना तय किया गया–

i. Outflow regulation के लिए कॉबर झील से निःसृत कॉबर नाला में हरसन पुल के पास एक हाइड्रॉलिक नियंत्रण संरचना का संस्थापन किया जाय। इसके अंतर्गत दो मीटर उँचा चेक डैम तथा इसके उपर दो मीटर की उँचाई पर यांत्रिक गेट का निर्माण उपयुक्त होगा। इस संरचना से 35 AMSL (अनुमानित) के जल स्तर का संरक्षण संभव हो सकेगा।

ii. कॉबर झील के इर्द–गिर्द विभिन्न चौरों–मान को कॉबर ताल से एवं आपस में जोड़ने वाले सम्पर्क नालों (यथा – मैथानी चौर और कॉबर को जोड़ने वाला चन्हा नाला, विक्रमपुर, नगरी झील, गुहीयाबारी चौर, रकक्षी तालाब और शिलथा चौर के साथ कॉबर का सम्पर्क नाला) की उड़ाही करायी जाय एवं उनके प्रवाह को फिर से बहाल किया जाय। इस कार्य से कॉबर ताल वेटलैंड कॉम्पलेक्स के विभिन्न जल निकायों का जुड़ाव सुदृढ़/संवर्धित होगा।

उपरोक्त दोनों अवयवों के लिए जल संसाधन विभाग द्वारा कार्य योजना का सूत्रण इत्यादि आवश्यक कार्रवाई शीघ्र की जाय।

iii. Enhancing water-holding capacity of the wetland complex हेतु –

क) कॉबर झील के इर्द–गिर्द विभिन्न चौरों–मान (जिनमें 12 जलकर एवं अन्य 5 परित्यक्त मान हैं) की पहचान कर उनके disiltation तथा उनमें मत्स्योत्पादन के संबर्धन (sustainable culture fishery) हेतु कार्रवाई पशु एवं मत्स्य संसाधन विभाग द्वारा की जाय। मत्स्य निदेशालय द्वारा इसके लिए आवश्यक कार्य योजना प्राथमिकता से तैयार की जाय।

ख) कॉबर ताल के जल संचयन क्षमता को बढ़ाने के लिए उक्त ताल में अत्यधिक गाद् (siltation) वाले पारिस्थितिकीय रूप से महत्वपूर्ण अंशों की पहचान कर वहाँ न्यूनतम जल स्तर की आवश्यकता का आकलन कर तद्नुरूप उड़ाही की जाय। पर्यावरण एवं वन विभाग द्वारा इसके लिए उपयुक्त कार्य–योजना शीघ्र बनाया जायेगा।

iv. प्रबंधन हेतु अनुश्रवण के लिए दो *River Gauging Station* बूढ़ी गंडक नदी के बसही और बगरस में तथा दो *Hydrometric Station* जयमंगलगढ तथा महाल्या/कोचाल्या/ गोहियावारी में जल संसाधन विभाग द्वारा स्थापित किया जायेगा।*वेटलैंड इन्टरनैशनल–साउथ एशिया* द्वारा इन अनुश्रवण केन्द्रों के लिए विशिष्टियाँ शीघ्र उपलब्ध कराया जायेगा। इन अनुश्रवण केन्द्रों पर आँकड़ों के संग्रहण एवं संधारण की व्यवस्था पर्यावरण एवं वन विभाग द्वारा की जायेगी।

v. कॉबर ताल एवं संबद्ध चौर–मान वाले समस्त क्षेत्र में जल संसाधन, कृषि, मत्स्यपालन एवं वानिकी सेक्टरों की किसी भी नयी परियोजना का क्रियान्वयन राज्य आद्र भूमि विकास प्राधिकरण के अनुशंसा के उपरान्त ही किया जाय। इसके लिए शीघ्र प्राधिकरण के तरफ से निर्देश जारी करने की कार्रवाई पर्यावरण एवं वन विभाग द्वारा की जाय।

कृषि विभाग के प्रतिनिधि उपस्थित नहीं रहने के कारण उक्त सेक्टर से संबंधित पहलुओं पर विचार विनिमय नहीं हो सका।

बैठक धन्यवाद ज्ञापन के साथ समाप्त हुई।

ह0/–
प्रधान सचिव, पर्यावरण एवं वन विभाग

कार्यालय–निदेशक, पारिस्थितिकी एवं पर्यावरण, पर्यावरण एवं वन विभाग, बिहार सरकार, पटना

ज्ञापांकः– 566 दिनांकः– 13-07-2015

प्रतिलिपि– सचिव, जल संसाधन विभाग, बिहार/ मुख्य अभियंता (उत्तरी), जल संसाधन विभाग, बिहार/मुख्य अभियंता, योजना एवं अनुश्रवण, जल संसाधन विभाग/ मुख्य अभियंता, समस्तीपुर, जल संसाधन विभाग/ उप निदेशक, मत्स्य, पशु एवं मत्स्य संसाधन विभाग, बिहार/ डॉ. रितेश कुमार, संरक्षण कार्यक्रम प्रबंधक, वेडलैंड इन्टरनेशनल साउथ एशिया, नई दिल्ली/ अपर प्रधान मुख्य वन संरक्षक–सह–मुख्य वन्यप्राणी प्रतिपालक, बिहार, पटना / क्षेत्रीय मुख्य वन संरक्षक, मुजफ्फरपुर को सूचनार्थ एवं आवश्यक कार्यार्थ प्रेषित।

13/7
निदेशक, पारि. एवं पर्या.

कॉवर ताल पक्षी आश्रयणी तथा सम्बद्ध आद्रभूमि संरक्षण हेतु प्रबंधन योजना के संबंध में जल संसाधन एवं मत्स्य पालन क्रिया–कलापों के पहलुओं के संदर्भ में सम्पन्न बैठक

तिथिः 16.06.2015, समयः 12 बजे मध्याह्न; स्थानः जल संसाधन विभाग का सम्मेलन कक्ष, सिचाई भवन

उपस्थिति सूची

1. श्री विवेक कुमार सिह, प्रधान सचिव, पर्यावरण एवं वन विभाग
2. श्री दीपक कुमार सिंह, सचिव, जल संसाधन विभाग
3. श्री बी0 ए0 खान, प्रधान मुख्य वन संरक्षक, बिहार
4. श्री राजेश कुमार, मुख्य अभियंता (उत्तरी), जल संसाधन विभाग
5. श्री एस0 एस0 चौधरी, अपर प्रधान मुख्य वन संरक्षक–सह–मुख्य वन्यप्राणी प्रतिपालक, बिहार
6. डॉ० रितेश कुमार, संरक्षण कार्यक्रम प्रबंधक, वेटलैंड इन्टरनैशनल–साउथ एशिया
7. श्री भारत ज्योति, निदेशक, पारिस्थितिकी एवं पर्यावरण
8. श्री संतोष तिवारी, क्षेत्रीय मुख्य वन संरक्षक, मुजफ्फरपुर
9. श्री इन्दुभूषण कुमार, मुख्य अभियंता, (योजना एवं अनुश्रवण)
10. श्री कुमार जयंत प्रसाद, मुख्य अभियंता, समस्तीपुर
11. श्री राजबंश चौधरी, अधीक्षण अभियंता (योजना एवं अनुश्रवण)
12. श्री कृष्णा कुमार, अधीक्षण अभियंता (जल निकासी अंचल, समस्तीपुर)
13. श्री सुमन कुमार, उपनिदेशक, मत्स्य, पशु एवं मत्स्य संसाधन विभाग
14. श्री टुनटुन सिंह, व्याख्याता, मत्स्यपालन, पशु एवं मत्स्य संसाधन विभाग
15. श्री सुनील कुमार सिंह, कार्यपालक अभियंता
16. डॉ० सुरेश प्रसाद, सहायक वन संरक्षक, पारिस्थितिकी एवं पर्यावरण निदेशालय

Communication received from District Administration, Begusarai regarding innundated areas within Kanwar Jheel Bird Sanctuary

बेगूसराय समाहरणालय
(जिला राजस्व शाखा)

पत्रांक..... /रा0 दिनांक..... /

प्रेषक,

जिला पदाधिकारी,
बेगूसराय।

सेवा में

डा0 रितेश कुमार,
संरक्षण कार्यक्रम प्रबंधक,
वेटलैण्ड अन्तराष्ट्रीय डिफेन्स एशिया,
ए–25 द्वितीय तल, डिफेन्स कॉलनी,
नई दिल्ली–110024

विषय :– **कॉवर ताल आद्रभूमि संरक्षण तथा पक्षी आश्रयणी की प्रबंध योजना का सूत्रण।**

प्रसंग :– **निदेशक, पारिस्थितिकी एवं पर्यावरण, बिहार, पटना के पत्रांक 692 दिनांक 21.8.2015**

महाशय,

उपर्युक्त विषयक प्रासंगिक पत्र के आलोक में बेगूसराय जिला के मंझौल अनुमंडल क्षेत्र में पड़ने वाले कॉवर झील पक्षी आश्रयणी से संबंधित नक्शा की प्रति संलग्न कर आवश्यक कार्रवाई हेतु भेजा जा रहा है।

विश्वासभाजन

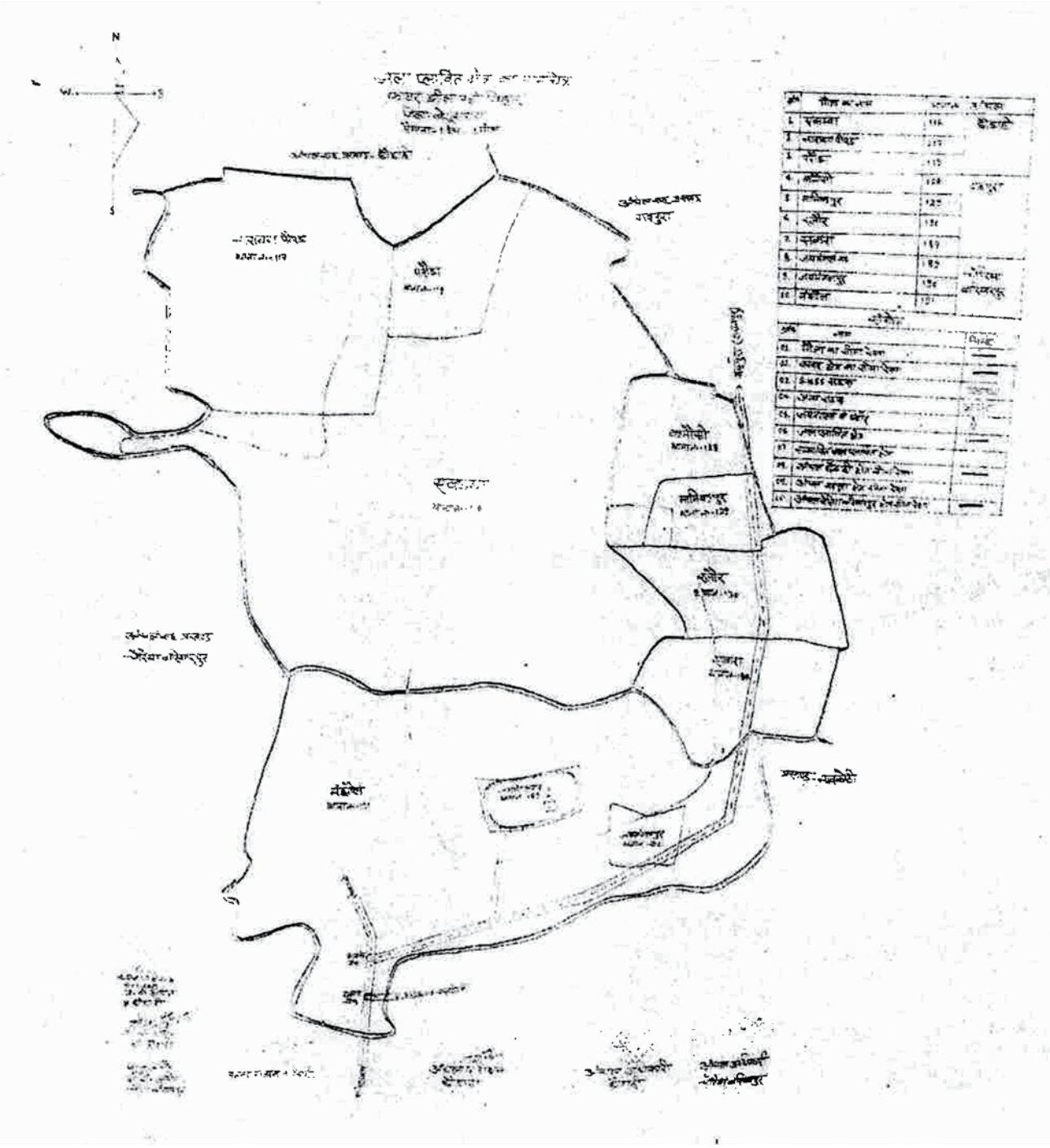
अनुलग्नक :– यथोक्त।

जिला पदाधिकारी
बेगूसराय।

ज्ञापांक 1147 /रा0 दिनांक 24.8.2015

प्रतिलिपि :– निदेशक, परिस्थितिकी एवं पर्यावरण (पर्यावरण एवं वन विभाग बिहार सरकार) पटना को उनके पत्रांक 692 दिनांक 21.8.2015 के आलोक में वांछित नक्शा की एक प्रति सहित सूचनार्थ एवं आवश्यक कार्रवाई हेतु प्रेषित।

जिला पदाधिकारी
बेगूसराय।



Stay in touch

Wetlands International South Asia
A-25, Second Floor, Defence Colony
New Delhi-110 024, India
Tel: +91-11-24338906, 32937908

Email: wi.southasia@wi-sa.org
URL: http://south-asia.wetlands.org

Wetlands International
@WetlandsInt
Wetlands International

Wetlands
INTERNATIONAL