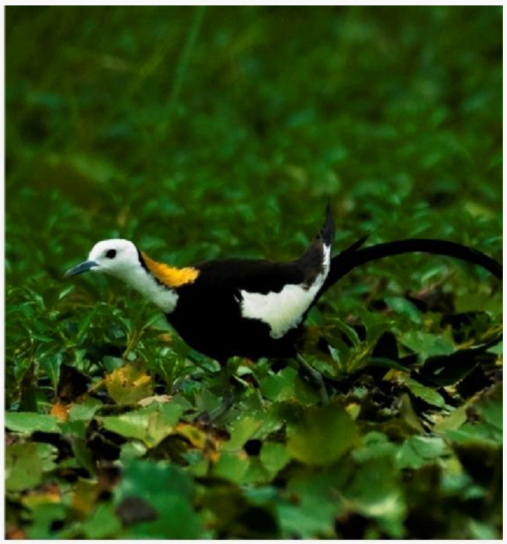

East Kolkata Wetlands

Management Action Plan 2021-2026

Department of Environment
Government of West Bengal

East Kolkata Wetlands Management Authority

The East Kolkata Wetlands (Conservation and Management) Act, 2006 represents an important landmark as it paved way for establishment of the East Kolkata Wetlands Management Authority (EKWMA) for conservation and management of the East Kolkata Wetlands (EKW) and for maters connected therewith and incidental thereto. The EKWMA was constituted under Section 3(1) of the EKW(C&M) Act, 2006.

As per the East Kolkata Wetlands (Conservation and Management) (Amendment) Act, 2017 notified by the State Government vide no. 304-L dated 17.03.2017, the EKWMA has been reconstituted. According to the said Amendment Act, 2017, the EKWMA is now a thirteen (13) member body headed by the Hon'ble Minister-in Charge, Department of Environment, Government of West Bengal along with the Chief Secretary and Secretaries of different Departments of State Government as well as four experts each in the areas of wetland ecology, hydrology, fisheries and socio-economics.

The EKWMA has been entrusted with wide range of responsibilities including demarcation of wetland boundary, prevention of unauthorised land use of EKW, pollution abatement and conservation of flora and fauna, awareness generation about the utility of the wetland, to promote basic conservation principles of sewage fed pisciculture and research on various aspects of EKW.

Wetlands International South Asia

Wetlands International South Asia is a non-government organisation working for sustaining and restoring wetlands, their resources and biodiversity in the South Asia region. Its office in New Delhi (India) was established in 1996 as a part of Wetlands International network. Wetlands International is a global, independent, non-profit organisation dedicated to conservation and restoration of wetlands, and presently works in over 100 countries through a network of 18 regional and national offices and expert networks headquartered in The Netherlands. Wetlands International is also one of the five International Organization Partners of the Ramsar Convention. In 2005, Wetlands International South Asia was registered under the Societies Registration Act of Government of India (retaining remit of South Asia region), consequently gaining an Indian legal entity while subscribing to the goals and targets of the Wetlands International network. The organisation endeavours to use a mix of approaches including technical knowledge, policy dialogue and field demonstrations for addressing various issues related to wetland management. To leverage change, the organisation works with national and state governments, knowledge centres, civil society as well as the private sector, often acting as catalysts to enable joined up actions. Given that securing a positive change in the status of wetlands and linked livelihoods takes considerable time, the organisation works for long-term engagement, forging strategic and innovative partnerships.

East Kolkata Wetlands

Management Action Plan

2021 – 2026

2021

This plan was drafted under the supervision of the Technical Committee, State Wetlands Authority, West Bengal comprising:

1. Dr. Kalyan Rudra, Chairman, West Bengal Pollution Control Board
2. Sri. Niraj Singhal, Chief Environment Officer, Environment Department
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In the preparation of the East Kolkata Wetlands Management Plan 2021-2026, the valuable contribution of the following experts is acknowledged:

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Photograph credits: EKWMA and WISA Photo Library unless cited

Cover: Wetland features of East Kolkata Wetlands

Back Cover: Water Hyacinth used as biological screens at East Kolkata Wetlands

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MESSAGE

The East Kolkata Wetlands are situated on the eastern fringes of Kolkata city. The wetlands naturally treat sewage generated from the city, through the shallow pisciculture ponds, where the sewage is fed on regulated basis. Besides the production of fish and vegetables, the wetlands act as a Carbon sink, help in flood buffering and climate regulation of the region, harbour rich biodiversity and provide many more environmental benefits. The wetlands save substantial capital and recurring costs involved in setting up of conventional Sewage Treatment Plants (STPs).

Water is life, and wetlands are the life support systems that ensure optimal functioning of the water cycle. Despite their tremendous value, wetlands are getting degraded globally due to natural and anthropogenic impacts. Considering the numerous challenges to the East Kolkata Wetlands, it was felt necessary to formulate an integrated Management Plan of the East Kolkata Wetlands for their conservation and sustainable development, ensuring livelihood opportunities for the wetlands communities.

The East Kolkata Wetlands Management Action Plan 2021-2026 comprises four basic components viz. Institutions and Governance, Water Management and Pollution Abatement, Conservation of Species and Habitats, and Sustainable Resource Development. The Plan is a major step forward towards the maintenance of East Kolkata Wetlands in a healthy condition to enable delivery of their full range of ecosystem services and sustaining biological diversity.

I would like to thank all officials and staff of the Environment Department and the East Kolkata Wetlands Management Authority for their contribution in preparing the East Kolkata Wetlands Management Action Plan 2021-2026.

Prof. (Dr.) Saumen Kumar Mahapatra
Minister-in-Charge, Environment Department
and
Chairman, East Kolkata Wetlands Management Authority

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Acronyms

AMSL	Above Mean Sea Level
BMC	Bidhannagar Municipal Corporation
BOD	Biochemical Oxygen Demand
BSI	Botanical Survey of India
BwN	Building with Nature
CAG	Community Action Groups
CBO	Community Based Organisations
CIFRI	Central Inland Fisheries Research Institute
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
COVID	Corona Virus Disease
CPCB	Central Pollution Control Board
CSO	Civil Society Organizations
DO	Dissolved Oxygen
DWF	Dry Weather Flow
EC	Electrical Conductivity
ECD	Ecological Character Description
EKW	East Kolkata Wetlands
EKWMA	East Kolkata Wetlands Management Authority
EKW Act	East Kolkata Wetlands (Conservation and Management) Act, 2006
FC	Faecal Coliform
FFC	Fishery Feed Canal
FIR	First Information Report
GHG	Greenhouse Gas
GP	Gram Panchayat
GPS	Global Positioning System
IESWM	Institute of Environmental Studies and Wetland Management
IMC	Indian Major Carps
IWMED	Institute of Wetland Management and Ecological Design
KLC	Kolkata Leather Complex
KMC	Kolkata Municipal Corporation

MCM	Million Cubic Metres
MLD	Million Litres per Day
MoEFCC	Ministry of Environment, Forest and Climate Change
MPN	Most Probable Number
MT	Metric Tonnes
NGO	Non-Government Organizations
NOC	No Objection Certificate
NPCA	National Plan for Conservation of Aquatic Ecosystems
NWC	National Wetlands Committee
pH	Potential of Hydrogen
PWD	Public Works Department
R-METT	Ramsar Site Management Effectiveness Tracking Tool
RSIS	Ramsar Sites Information Service
SHG	Self Help Group
SPM	Suspended Particulate Matter
SWF	Storm Weather Flow
SWOT	Strength, Weakness, Opportunity, and Threat
TC	Total Coliform
TON	Total Organic Nitrogen
TS	Total Solids
TSS	Total Suspended Solids
WBBB	West Bengal Biodiversity Board
WBPCB	West Bengal Pollution Control Board
WIAMS	Wetland Inventory, Assessment and Monitoring System
WISA	Wetlands International South Asia
WRR	Waste Recycling Region
ZSI	Zoological Survey of India

Executive Summary

Located to the eastern fringes of Kolkata City and spanning 12,500 ha, East Kolkata Wetlands (EKW) is a mosaic of landforms including predominantly water dominated areas (used as fish farms) to land centric usages for agriculture, horticulture and settlements. The existing wetland regime is a remnant of series of brackish wetlands connected to the freshwater as well as marine environments of the Gangetic Delta and the Bay of Bengal, in an ecological continuum with the Sundarbans. Over 260 shallow fish ponds in the EKW receive over 900 MLD pre-settled sewage from the Kolkata Metropolitan region through a network of locally excavated secondary and tertiary canals, which is used to produce annually 20,000 MT of fish, 50,000 MT of vegetables and irrigate 4700 ha of paddy lands. As the nutrient-rich effluent moves through the system, it is progressively cleaned, and nutrients are redirected to the growth of algae or agricultural products grown along the pond edges and agricultural lands. Algae and other aquatic plants are used to feed up to 17 species of fish cultured in these ponds, which in turn create nitrogen and phosphorus-rich water to irrigate the adjacent rice fields. The traditionally evolved natural water purification waste recovery practice saves the Kolkata City nearly Rs. 4,680 million annually in terms of the treatment cost of up to 65% of the City's sewage. These wetlands also lock in over 60% of carbon from wastewater, thus reducing harmful Green House Gas emissions from the region.

The wetland is inhabited by diverse species. Atleast 380 taxa under major flora including 93 plant families, 10 amphibians, 29 reptiles, 123 birds, 79 fish, 24 crustaceans, and 13 mammal species have been recorded from these wetlands.Marsh mongoose *Herpestes auropunctatus*is endemic to the region and also included in the schedule II of Indian Wildlife Protection Act, 1972. The traditional waste recovery practice provides subsistence opportunities for a large, economically underprivileged population of 0.15 million living in over 37 mouzas within its boundaries. EKW is also one of the few natural habitats providing recreational avenues for the urban and peri-urban population.

East Kolkata Wetlands Management Authority is the nodal government agency mandated to ensure wise use of the wetland within the regulatory framework defined by the Wetlands (Conservation and Management) Rules, 2017 (notified under the Environment (Protection) Act, 1986) and the East Kolkata Wetlands (Conservation and Management) Act, 2006 and rules.

The ability of EKW to provide ecosystem services and sustain biological diversity is enabled by:

a) Ingenious use of pre-settled sewage received from Kolkata City for resource recovery through aquaculture, horticulture and irrigation.
b) Hydrological gradient which enables distribution of sewage to different parts of the wetland.
c) Water-hyacinth mediated phytoremediation enabling wastewater treatment.
d) Indigenous knowledge of the fish-farmers on management of fish ponds for cultivation of diverse species of fish.
e) Diverse habitats which enables a range of plant and animal species to survive.
f) Land use control as set under the provisions of East Kolkata Wetlands (Conservation and Management) Act, 2006 and Wetlands (Conservation and Management) Rules, 2017.

India, as a signatory of the Ramsar Convention, is committed to achieving wise use of all wetlands in her territory. Wise use of wetlands is defined in the text of Ramsar Convention as 'the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development'. The evaluation of various wetland features has indicated following trends:

Adverse land use change: During 2000 – 2019, the area under fish farms, settlements and landfill has been observed to increase, while the area under horticulture and agriculture declined. The increase in area under fish farm area is largely on account of transformation from agriculture (more prominent after 2015). There is a conspicuous pressure on the conversion of fish farms in areas adjoining EM bypass.

Waste treatment function of the wetland being compromised: An increase in the presence of heavy metals along with the organic nutrients in the supply sewerage has been observed predominantly due to mixing of Kolkata city's industrial effluents. Wetland function of treating raw sewage can get affected by settling of heavy metals in the fish farm beds and also lead to bioaccumulation of heavy metals in fish and plant species. Presence of heavy metal contaminants in wetlands pose health risk to the producers and consumers dependent on resource harvest from wetlands.

Disturbed habitats: There is a reduction reported in the number of waterbird species being sighted in recent times. Increased urbanization in the periphery of wetland and shifting climate patterns has led to the reduction of key wetland species sighted in the area.

Invasive fish species: The rapid spread and population increase of suckermouth armoured catfishes in EKW in recent times is of concern, because of the notable possibility that these non-native catfishes may be adversely affecting fish germplasm and commercial fishery of this unique ecosystem.

Increasing population pressure: A rapid rise in population has been recorded in 2001-2011 which has grown as much as 4 times in some mouzas with population density, ranging from 100 to 4500 persons per square kilometre. This increased numbers have led to a greater demand for the wetland resources, particularly fish and food crops. The number of people dependent on fisheries has grown from 12000 to 20000 in the last two decades.

Increasing climate risks: The intensity of rainfall has increased while the duration has decreased meaning variations in freshwater flows. Wetland communities are highly vulnerable to impacts of climate change, including the risk of high floods and increase in temperature due to variating climate. The area around Salt Lake and Bantala is reported to have high rates of subsidence which can alter the topography and natural hydraulics of the wetland.

Solid waste challenge: The garbage dumping site at Mollar bheri within EKW has been stopped completely and fencing has been done along the water body to prevent spillage of legacy waste material into the water. Bio-mining of legacy waste has also been initiated at the site. Sustained efforts will be needed in this regard to protect EKW.

EKW needs to be managed for conservation of its natural remediation and resource recovery ability, biological diversity as well as securing sustained provision of its full range of ecosystem services which support livelihoods of dependent communities. The effectiveness of management will be reflected in the ability to sustain multiple use of the wetland, based on the traditional knowledge of resource recovery developed over time, without undermining the key ecological and social processes that underpin the functioning of EKW social-ecological system.

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.

Management Framework

The goal of management planning is to '*maintain East Kolkata Wetlands in a healthy condition to enable delivery of its full range of ecosystem services and sustain biological diversity values'*.

The purpose of management is to *'enable natural infrastructure services to the Kolkata city in the form of wastewater treatment, flood buffering and climate regulation; providing livelihood opportunities for wetlands communities in food production; and sustain diversity of biota in the landscape'*.

Management of EKW in 2021-2026 is structured around following eight objectives:

Objectives	**Desired outcome**
Objective 1. Land use and land cover of the wetland to be maintained in line with regulatory requirements under Wetlands (Conservation and Management) Rules, 2017 and East Kolkata Wetlands (Conservation and Management) Act, 2006.	No illegal transformation of land use
Objective 2. Sewage quantity and quality received within the wetland to be efficiently treated applying traditional waste recovery practices.	Tertiary channels to deliver sewage without use of pumps Equitable distribution of sewage Heavy metals concentration in sewage to be brought to safe levels
Objective 3. Diversity of biota within East Kolkata Wetlands to be maintained.	No species extirpation Counts to be maintained in the range of 20% deviation from average of last five years Sighting to be maintained in the range of 20% deviation from average of last five years
Objective 4. Species invasion threats to fisheries to be reduced.	To be reduced to a manageable level
Objective 5. Livelihood vulnerability of wetland-dependent communities to be reduced.	Non-declining harvest of fish and vegetables Wetland communities having income in the lower quintiles to gain additional sources of income

Objective 6. Individual and collective capacity and opportunities for stakeholders and wetland communities to participate in wetland management and contribute to wetland wise use to be enhanced.	Integration of community, rights and capacities in management plan implementation and monitoring An Integrated Wetlands Inventory, Assessment and Monitoring System to be put in place and used. Local action for addressing solid waste or preventing encroachment Community norms for preventing land use change or overharvesting of resources
Objective 7. Systematic wetlands inventory, assessment and monitoring system is used to inform management decisions and assess effectiveness.	Data to be available on all priority wetland features and threats to them Data to be systematically analyzed and presented in EKWMA meeting
Objective 8. Integration of multiple values of wetlands in sectoral developmental planning is enhanced.	EKWMA to meet regularly and consider implications of sectoral plans EKWMA to enable integration of role of EKW in programmes and actions plans on climate change, urban development, and disaster risk reduction

Following actions are proposed under four management components, namely: a) Institutions and Governance, b) Water Management and Pollution Abatement, c) Species and habitats, and d) Sustainable Resource Development and Livelihoods.

Component 1. Institutions and Governance

- Reorganizing and strengthening EKWMA with an efficient and results-oriented institutional structure, and gradual shift from an enforcement to a strategic role in wetland management. Reorganized set-up to have the following units: a) planning and design, b) enforcement, c) monitoring, and d) community engagement and communications.
- Demarcation of wetlands boundary by placing geo-tagged pillars, etc.
- Zoning of EKW

- Setting up an integrated wetland inventory, assessment and monitoring system to address the overall information needs of wetland management and to provide robust decision support system.
- Annual Ecosystem Health Report Card publication and communication of wetland monitoring information to decision-makers and stakeholders.
- Research on carbon and GHG flux, nutrient budgets, bioaccumulation and multiple values, etc.
- Communication, Education, Participation and Public Awareness through signage at major points, webpage, establishment of community advisory group, resource material and workshop and public events, etc.
- Mid-term and end-term review of management plan implementation to assess the extent to which stipulated objectives have been achieved with a high degree of resource efficiency and in participation with stakeholders.

Component 2. Water Management and Pollution Abatement

- Dredging 14 highly silted canals measuring 43.8 km, to enable flow of sewage by natural gradient
- Construction of a solid waste segregator near Bantala lockgate to regulate flow of solid waste.
- Development of constructed wetland system at Kulti outfall to augment waste water treatment beyond EKW region
- Consider the feasibility of establishment of a plastic waste recycling unit in Dhapa region.
- Declaration of EKW region as a no-plastic zone.

Component 3. Species and habitats

- Regular monitoring of waterbird population following standard protocols of the Asian Waterbird Census at all the major congregation sites within and around EKW
- Culture of indigenous fish species in Goltala bhery
- Mapping invasion pathways of Suckermouth Catfish, and undertake screening at various points along the DWF to prevent further spread.
- Revegetating peripheral areas of Nalban, Goltala Captain Bheri and some identified locations with Phragmites, Typha, Shola and other native species to improvise habitat of marsh mongoose, amphibian and reptilian species
- Construction of a wetland interpretation centre at Bantala sedimentation tank area with facilities such as: exhibits, viewing gallery, watchtowers, waste recycling models, children play area, auditorium and souvenir shop

Component 4. Sustainable Resource Development and Livelihoods

- Desilting bhery under cooperative ownership to increase productivity
- Construction of 4 hatcheries at Dhapa Manpur, Tardha Kapasati, Kharki and Kantipota for production of seeds of Indian major carps and air breathing catfishes
- On a demonstration basis, promoting crop diversification in agriculture and horticulture farms
- Strengthening community health infrastructure and comprehensive access to safe drinking water and sanitation facilities.

Budget and Financing

Over 2021-2026, implementation of management plan entails a budget of Rs. 119.8 crore. Of this, the component on institutions and governance is allocated 30.7%. This is followed by allocation of 27.4% for implementing actions under component for water management and pollution abatement. The components on sustainable resource development and conservation of species and habitats have been allocated 23.9% and 18% of the budget, respectively. Being aligned with the objectives of National Mission of Clean Ganga (of the Jal Shakti Mantralaya) and the National Plan for Conservation of Aquatic Ecosystems (of the Ministry of Environment, Forest and Climate Change), the East Kolkata Wetlands Management Authority may consider seeking funding from these sources, along with allocations from the state budget.

1 Introduction

1.1 East Kolkata Wetlands

The East Kolkata Wetlands[1] (EKW), located on the eastern fringes of Kolkata city, sustain one of the world largest integrated resource recovery systems based on a combination of aquaculture, agriculture and horticulture (Map 1). The Government of India designated EKW as Wetland of International Importance under Criteria 1of the Ramsar Convention in 2002 (as an example of wetland wise-use).

EKW is a critical natural infrastructure for Kolkata City. The wetland treats over 900 million litres of sewage generated by Kolkata Municipal Corporation every day (approximately 65% of total sewage generated in the metropolitan area) saving the city nearly Rs. 4,680 million annually in terms of treatment costs saved, as well as providing a much-needed flood buffer on the peri-urban interface. As the nutrient-rich effluent moves through a maze of fish farms, horticulture and agriculture system, it is progressively cleaned and nutrients are redirected to produce annually 20,000 MT of fish, 50,000 MT of vegetablesand irrigate 4700 ha of paddy lands. Over 60% of carbon from wastewater is also locked in various forms in the production process, thus reducing harmful Green House Gas emissions from the region. Atleast 380 taxa under major flora including 93 plant families, 10 amphibians, 29 reptiles, 123 birds, 79 fish, 24 crustaceans, and 13 mammal species have been recorded from these wetlands. The traditional waste recovery practice provides subsistence opportunities for a large, economically underprivileged population of 0.12 million living in the 37 revenue villages (locally called mouza) within its boundaries. EKW is also one of the few natural habitats providing recreational avenues for the urban and peri-urban population. The wetland provides strong arguments for the adoption of traditional knowledge of local communities for wise-use.

1.2 Management Planning Purpose

The Management Plan outlines the commitment of the Government of West Bengal for wise-use of EKW. Located on the peri-urban interface of Kolkata City, the wetland has been under constant pressures of conversion for settlements and agriculture. Changes in land use, siltation of channels, pollution and stakeholder conflicts can impaire wetland functioning. Mapping of the conservation area boundary for the wetland including the waste recycling region was done in 1985 by the State Planning Board, Government of West Bengal. Subsequently, the High Court of Kolkata passed an order in 1992 prohibiting changes in land use of the area and directed the state government to take recourse to statutory cover to protect EKW.

The notification of the East Kolkata Wetlands (Conservation and Management) Act in 2006 led to creation of the East Kolkata Wetland Management Authority (EKWMA) as a nodal agency for systematic implementation of wise use principles for the management of this Ramsar Site.

[1]The Ramsar Site was designated in 2002 with the name 'East Calcutta Wetlands' and remains so in the Ramsar database. In 2001, the Government of West Bengal decided to change the name of its capital city to Kolkata. The rules governing wetlands are titled 'East Kolkata (Conservation and Management) Rules, 2006 and the Authority as East Kolkata Wetlands Management Authority.

Picture 1. East Kolkata Wetlands provide immense ecological subsidies to the City of Kolkata

The Act took explicit cognizance of EKW as a Wetland of International Importance and its various ecosystem services, including the ability for the regulation of water regimes, wastewater treatment, source of groundwater recharge and other socio-cultural values. The Act defined the land use within the wetland, identifying each land parcel (as substantially water dominated, under agriculture, horticulture or settlements), and banned any further diminution of wetland area, change in ecological character, and overall land use. EKWMA was entrusted with the responsibility of implementing the Act, which included regulating land-use change, preventing unauthorized development and promoting integrated management of the wetland system. The current management plan is a response to the needs identified by the EKWMA to put in place an integrated strategy and action plan for ensuring wise use of the EKW.

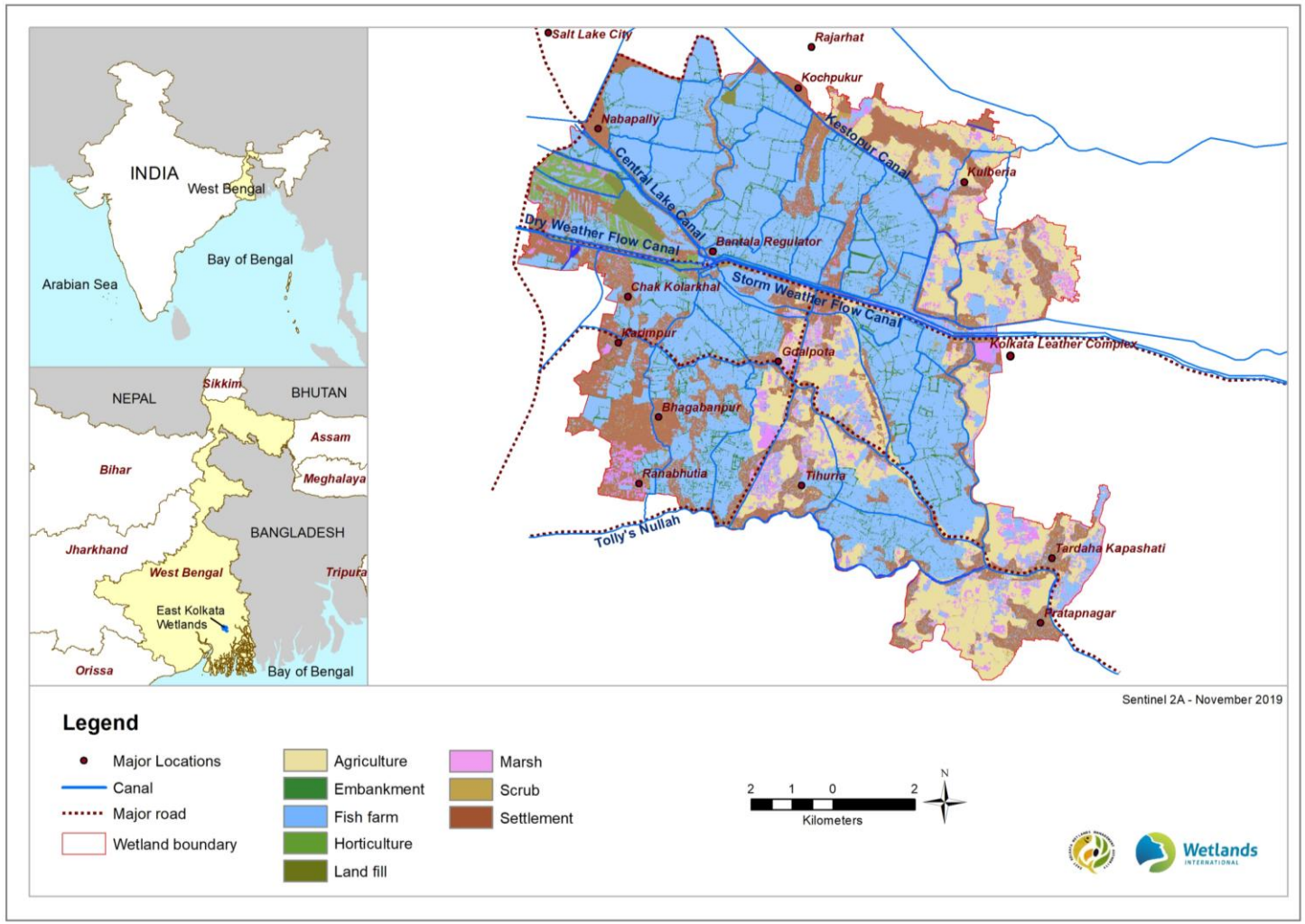
1.3 Management to-date: An overview

Upon its establishment in 2006, EKWMA collaborated with Wetlands International South Asia for formulating a management plan for EKW in 2008 for a period of five years. The goal of the plan was 'conservation and sustainable utilization of ecosystem services and biodiversity of EKW for ecological security and economic improvement of stakeholders'. The purpose was to 'establish effective management practices for EKW through coordinated actions at river basin level integrating coastal processes'. Seven management objectives related to institutional development, management zoning, water management, biodiversity conservation, sustainable fisheries development, sustainable agriculture development and livelihood improvement were laid down under the plan, to be implemented with a budget of Rs. 304 crores over five years (including funds from convergence sources).

The management plan was submitted to the MoEFCC for financial support under the National Wetlands Programme in 2009, and funding of Rs. 2.29 crores received during 2007-2013 for a limited number of activities, such as desilting of sewage channels, plantation, monitoring and implementation of zoning plan.

In 2010, theWetlands (Conservation and Management) Rules were notified by the Ministry of Environment, Forest and Climate Change (MoEFCC) , under the provisions of which discharge of sewage, dumping of solid waste and construction of permanent nature (except boat jetties) were prohibited in all notified wetlands, including all Ramsar Sites. Since some of these conditions were at variance with the State's East Kolkata Wetlands (Conservation and Management) Act, 2006 and hence remained unfulfilled for EKW, further funding from MoEFCC was stopped. Various interventions as envisaged in the management plan could not be implemented, resulting in the 2008 management plan implementation being kept in abeyance.

In 2017, the MoEFCC notified the Wetlands (Conservation and Management) Rules in supersession of the 2010 Rules, however there was no change in the list of prohibited activities. The EKWMA requested the National Wetlands Committee (NWC)of the MoEFCC for granting special permission for EKW, as utilization of sewage from Kolkata was the core driver of wetland functioning. The Committee considered the request of EKWMA in its two meetings (held on July 26, 2018 and November 5, 2019)and asked the CPCB to define the optimum quantity of sewage that may be permitted to flow into EKW to maintain ecological fucntions of these wetlands. The EKWMA was advised to frame a comprehensive management action plan to address development as well as conservation aspects related to EKW



Map 1. East Kolkata Wetlands

The entire financing of activities of EKWMA since 2012 has been with the support of the Government of West Bengal, which has allocated Rs. 5.35 crores on the basis of annual plans considered in the Authority's meetings at the beginning of each financial year. The activities undertaken include : a) desilting of sewage canals, b) demolition of illegal constructions (demolition is done by Kolkata Municipal Corporation on the basis of the recommendation and financial support of the Authority), c) monitoring and research, d) wetland delineation and e) communication and outreach. An overview of receipt and expenses of the Authority for 2006-2019 is summarized in Fig 1.

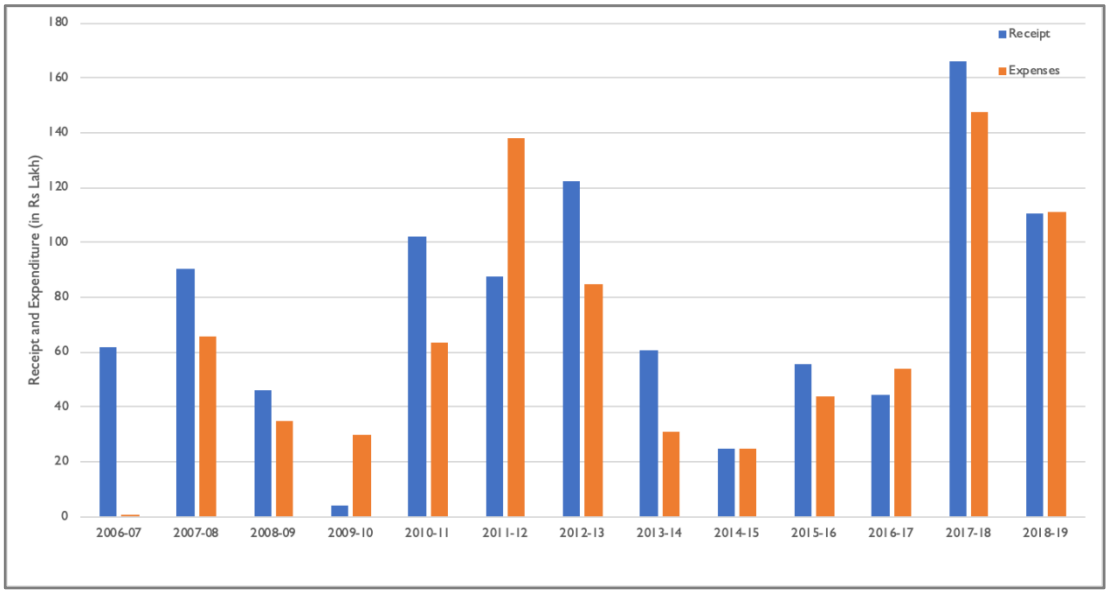


Figure 1.Financial flows of East Kolkata Wetlands Management Authority (2006-2019)

Apart from these activities, the Authority has considered several developmental projects to date, notable being the proposal for construction of an elevated corridor over the wetlands to ease traffic congestion in the Kolkata City. The Authority forwarded the proposal for consideration of the National Wetlands Committee, which in turn in their meeting of July 26, 2018, and November 05, 2019 approved the proposed alignment subject to the condition that there is no damage to the wetland. The EKWMA was also advised to present detailed Environmental Impact Assessment report with the members.

In 2019, a case against the EKWMA and Government of West Bengal on encroachment of the EKW area and violation of the East Kolkata Wetlands (Conservation and Management) Act, 2006 was filed in The Hon'ble National Green Tribunal. A task force was constituted to look into the solid waste dumping at Dhapa and Mollar Bhery area, encroachments and illegal plastic and industrial waste processing units along Basanti Highway. Following the report of the task force, the Government of West Bengal has submitted an affidavit to the court confirming a range of measures to control solid waste dumping were being taken up, including fencing of Molar Bhery area and bio-mining of waste, provision of waste segregation units, organic waste processor units, and integrated waste processing unit. The court also directed the Environment Department to submit an integrated management plan for wetland wise use.This plan has also been formulated taking into consideration the NGT's direction.

1.4 Approach and Methodology

Article 3.1 of the Ramsar Convention commits the Contracting Parties to put in place management arrangements to ensure wise use of all wetlands within their jurisdiction. The text of the Ramsar Convention defines wise use as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development".

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(Finlayson et al. 2011). The approach recognizes the human interdependency with wetland functioning and accommodates sustainable utilization of these ecosystems for the benefit of humankind in a way compatible with the maintenance of natural properties of the ecosystem. Wise use 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 (Finlayson 2012). The purpose of management planning is to outline the pathway through which wetland wise use can be achieved (Ramsar 2010).

The term wise use is often interpreted to indicate that human use of all wetlands is promoted by the Ramsar Convention; however, this needs careful consideration. The most recent update of the wise use definition was in 2005, wherein along with the definition cited in the previous paragraph, two footnotes were also placed. The first clarifies that 'ecosystem approaches' include the elements elaborated by the Convention on Biological Diversity – integrated management, stakeholders' participation in decision-making, transparency about tradeoffs, and equitability of the outcomes. Mechanisms such as integrated river basin management, integrated coastal zone management respond to this aspect.

The second footnote expands the phrase 'in the context of sustainable development' to recognize that development, though inevitable in most cases, is not an objective for every wetland. Wherever development is to take place, it has to be facilitated in sustainable ways by approaches elaborated in the Convention. Thus, when the concept of wise use is examined from the lens of sustainability, the elements of wetlands' conservation' and 'use' are reconciled to ensure that ecosystem retains capability for use now and into future, rather than 'using' or developing the wetlands at present. The onus of elaborating a pathway for achieving wise use outcome is on the management planning process.

The Ramsar Convention, in its Resolution XI.11 of 2012 has laid down principles for planning and management of urban and peri-urban wetlands. The resolution recommends that: a) thematic planning should be used as an essential tool to safeguard wetlands and their ecosystem services both within and beyond urban settlements; b) the consideration of wetlands within urban planning needs to be integrated fully with wider elements of spatial planning (such as Integrated River Basin Management, water resource management, the development of transport infrastructure, agriculture production, fuel supply, etc.), and c) alternative locations need to be identified for planned urban developments (both formal and informal built development) which do not lead to wetlands, or other natural ecosystems, being degraded or lost. It is suggested that environmental appraisal committees at government level should invariably involve wetland experts to gather valid opinion about the area before the site is granted clearance for developmental projects.

Conservation and sustainable development of EKW requires integrated planning and resource management at the river basin level recognizing the interconnectedness of the wetland system with its catchments. River basin-level planning requires an understanding of the carrying capacity of the basin to produce desired outputs (goods and services) from limited resource base and achieving equitable quality of life while maintaining desired environmental quality in the region. The planning for management calls for tradeoff between desired production and consumption levels. It also emphasizes on the development of supportive mechanisms within the generative capacity while maintaining the environmental quality. The challenge, therefore, is to conserve the ecological character and full range of ecosystem services of EKW while providing sustained benefits to the communities dependent upon the wetland for their sustenance.

The methodology for management planning is based on the New Guidelines for Management Planning for Ramsar Sites and Other Wetlands as adopted by the Contracting Parties to the Ramsar Convention on Wetlands in in 2002. These guidelines also form the basis of the wetlands management planning guidelines of the MoEFCC's National Plan for Conservation of Aquatic Ecosystems (NPCA).

Figure 2. Step-wise wetland management planning process

The NPCA guidelines recommend following a diagnostic approach – wherein the selection of management interventions is guided by knowledge of wetlands features and factors governing these features, and their relationship with broader societal conservation and development goal that wetland wise use is contributing to (Fig 2). Wetlands features are its ecological, social and institutional attributes, which collectively characterize a wetland. Wetlands are dynamic systems, and thus their features undergo cyclical and temporal changes. Factors (natural as well as anthropogenic) cause the wetland to move along a specific trajectory.

As the management plan was framed during COVID-19 epidemic, extensive fieldwork and stakeholder consultations were not feasible. The first draft of the management plan was reviewed by the Technical Committee of the Authority in a virtual meeting held on July 27, 2020. It is envisaged that this plan will be widely circulated and feedback of stakeholders taken on board prior to initiating implementation.

1.5 Management Plan Structure

The management plan includes eight chapters, in line with the structure recommended by the MoEFCC. The currentchapter provides the management planning context. The chapter 2 and 3 contain description and evaluation of wetland features and assessment of risk of adverse change. The effectiveness of current institutional arrangements in preventing the adverse change in wetland ecological character is analysed in Chapter 4. The management planning framework in discussed in Chapter 5, and the monitoring plan in Chapter 6. The action plan is in Chapter 7 and budget and financing discussed in Chapter 8 of the plan.

2 Description of Wetland Features

2.1 Physical regime

Located amidst Kolkata City on the west and River Kulti on the east between $22^0$25' to $22^0$40' N and $88^0$20' to $88^0$35' E, the EKW is a mosaic of landforms including predominantly water dominated areas (used as fish farms, locally known as bhery) to land centric usages for agriculture and horticulture. Settlements are interspersed between various land uses. The use of sewage as the basis of aquaculture, agriculture and horticulture production systems provides the rationale for considering the entire area as a single management unit. The wetland boundary has been defined in the East Kolkata Wetlands (Conservation and Management Act (2006).

As per images of May 2019, the wetland has 48% area under fish farms, 27% under agriculture and 20% under settlements. Canals and horticulture areas account for 2% of the area respectively, whereas the landfills account for the rest 1%. Being highly regulated, the wetland does not undergo much transformation in land use and landcover during pre and post monsoon season (Map 2 and Figure 3).

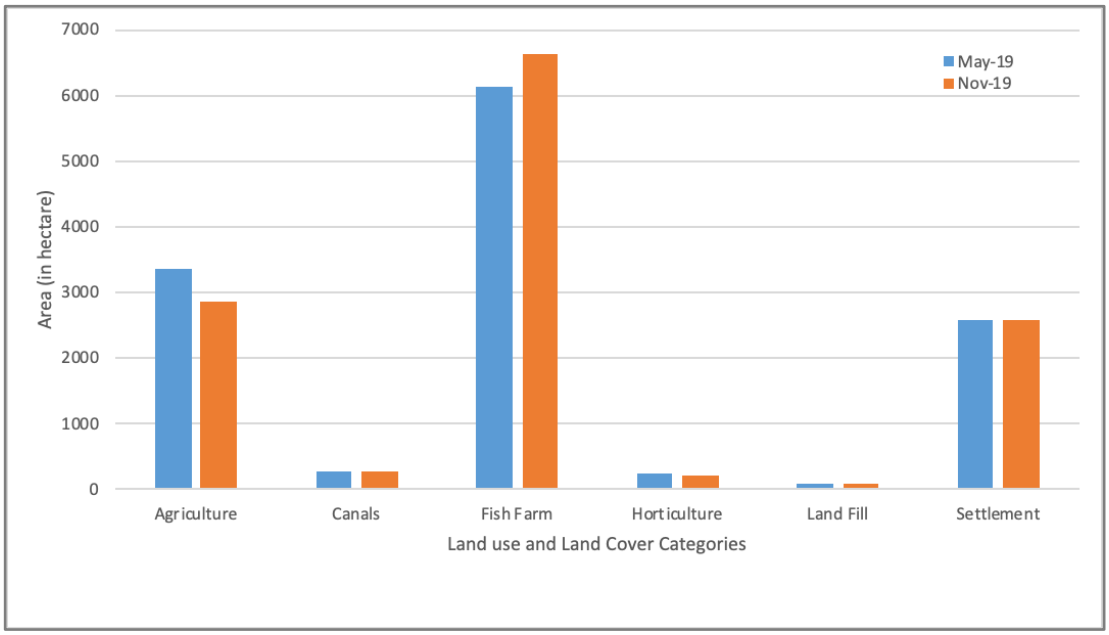


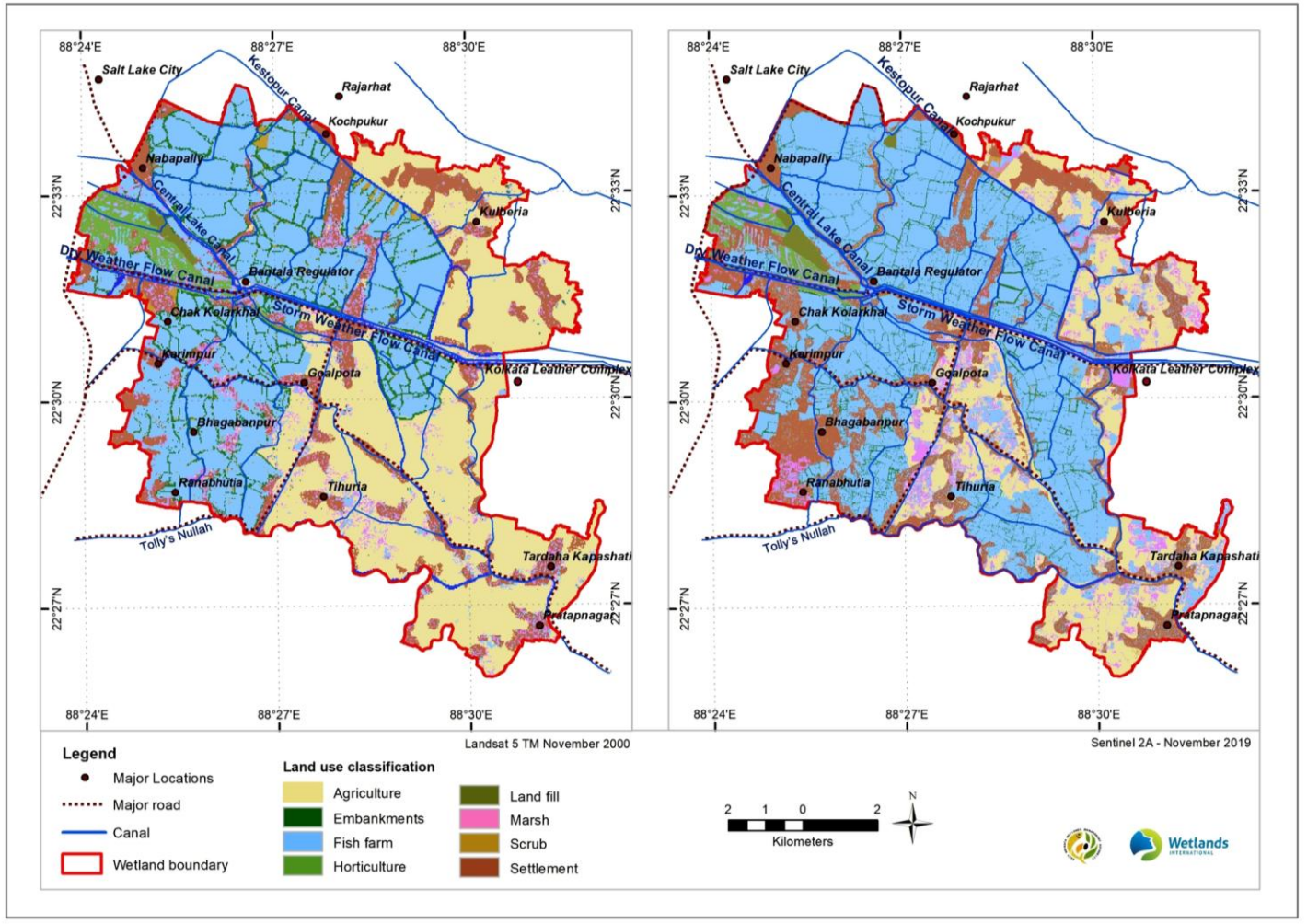
Figure 3. Land use and Land Cover transformation in East Kolkata Wetlands (2019)

The current wetland area is remnant of series of brackish water wetlands, which till the beginning of 20th centurymaintained active connection with the freshwater as well as marine environments of the Gangetic Delta Rivers and the Bay of Bengal, in an ecological continuum with the Sundarbans (also referred as Bidhyadhari wetlands). The Kolkata City grew on the levees of River Hooghly in the sixteenth century virtually without any drainage system. Initially, all the solid waste and sewerage was dumped into the river. Frequent outbreaks of malaria, plague and other diseases forced the city planners to abandon this practice and construct a system of sewers to discharge waste into EKW – then considered a malarious jungle with limited societal value. The wetland system acted as a vast spill area for the flood and tidal flows for the discharge of Hoogly and Bidhydhuree Rivers, in the process attenuating floods of the Kolkata City. However, the wetlands gradually lost their connectivity to freshwater and tidal environments due to deltaic processes. Human interference primarily in the form of channelization further quickened the process of silt deposition within the channels, and finally

the Bidhydhuree became defunct by the end of 18th century. With this, the sewage from the city became the dominant flows, which was used as an opportunity by private entrepreneurs to establish wastewater aquaculture, horticulture and agriculture in the late 18th and early 19th centuries. In 1864, a portion of the salt lakes was acquired for dumping solid wastes. Thus, over a period of time, the wetlands transformed from brackish water lakes to sewage fed fish farms, with large areas being converted for settlements and agriculture development. The post-independence surge of refugees to Kolkata City made the town planners further look into expansion of the urban area. This prompted reclaiming of more than 1,000 ha of the northern portion of wetland for the establishment of the Salt Lake City. In 1969, redistribution of land under land reforms led to further filling up of approximately 2,500 ha of water bodies for conversion into paddy fields. It was only during the eighties that the role of over 260 fish farmsin treating wastewater caught planners' attention, and the events leading to mapping of the WRR took place and the site designated as Ramsar in 2002.

The EKWMA, after its establishment in 2006 was entrusted with the task of boundary delineation based on the East Kolkata (Conservation and Management) Rules, 2006. Till then, the map prepared by the State Planning Board in 1985 and later on surveyed by Creative Research Group in 1996 and translated into geospatial framework was the planning basis. During 2005, the Department of Environment delineated the wetland boundary on cadastral maps at 1: 4,000 scale (104 such sheets were prepared).

Picture 2. Part of Dhapa landfill in East Kolkata Wetlands which has been treated



Map 2. Seasonal transformation in land use and land cover of East Kolkata Wetlands (2019)

To capture land use and land cover changes in the two decades since Ramsar designation, a change assessment was conducted based on satellite data of November 2000 (Landsat 5, 30 m resolution, November 9, 2000) and November 2019 (Sentinel 2A, 10 m resolution, November 21, 2019) (Map 3 and Fig 4). During this period, the area under fish farms, settlements and landfill has been observed to increase, while the area under horticulture and agriculture declined. Along the southern margins of the wetland (around Tardaha and Tardaha-Kapashati), extensive transformation of agricultural lands to fish farms can be seen, primarily attributed to the increased availability of sewage as an outcome of canal desilting operations. The area under waste dump have also increased, from just one location within the wetland (Dhapa) in 2000 to creation of a new site at Mollar Bhery; however, due to environmental concerns, waste dumping at Mollar Bhery has been stopped completely and steps have been taken to remedy the legacy waste.

The increase in area under fish farms during 2000 – 2019 is striking and significant. A longer term change assessment based on remote sensing images of 1973, 1989 and 2010 had indicated a continuous decline in fish farm area (1890 ha during 1973-1989 and an additional 1959 ha during 1989 – 2010) (Parihar et al. 2013). Similarly, a change assessment for 1990 – 2011 period had indicted a loss of 1,476 ha of area under wetlands (fish farms) to cropland and expansion of settlements (Mondal et al. 2017). A land use and land-cover change analysis matrix presented in Table 1 reveals that increase in fish farm area is largely on account of transformation from agriculture (more prominent after 2015).

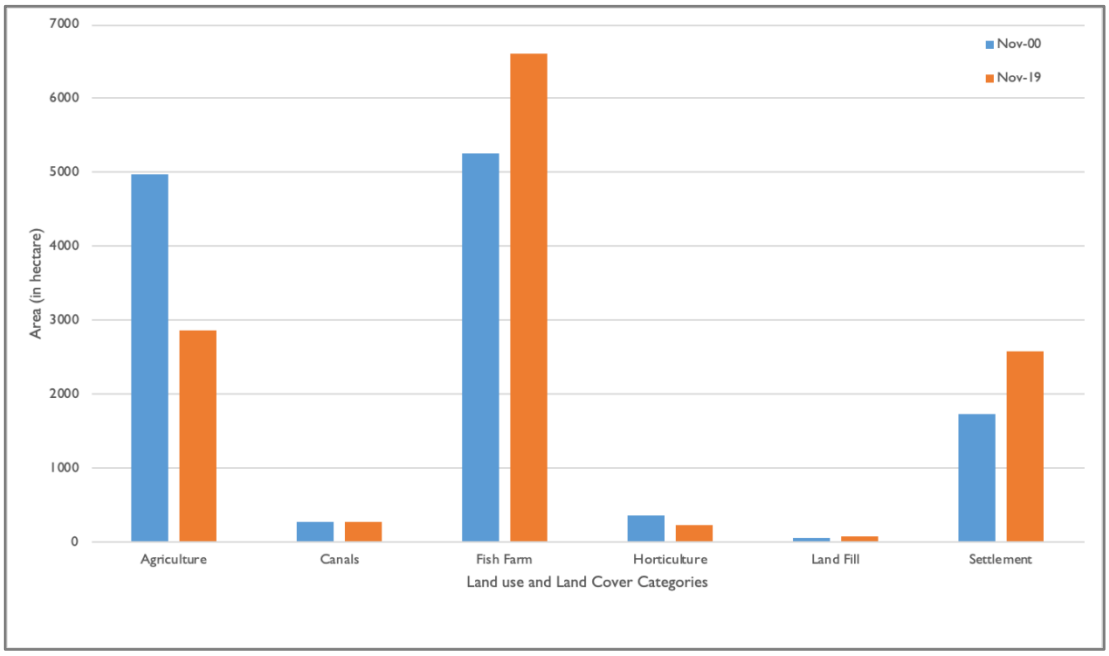
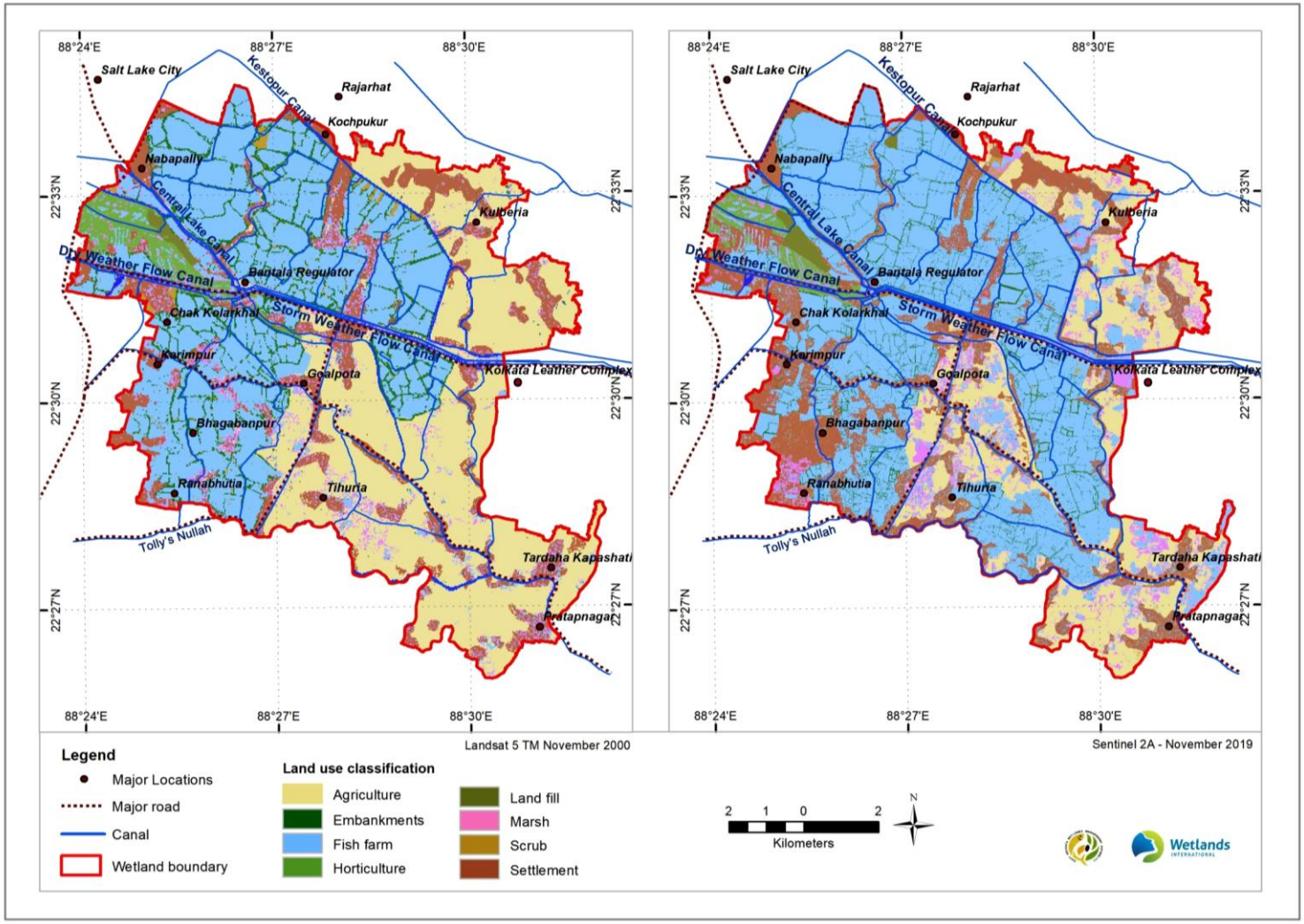


Figure 4. Changes in area under different land use and land cover categories in East Kolkata Wetlands (2000-2019)



Map 3. Land and Land cover of East Kolkata Wetlands (November 2000 and November 2019)

Picture 3. Fishing activities in East Kolkata Wetlands

The boundary demarcation based on physical verification of the site and examination of land records is an ongoing process. The EKWMA in consultation with Land and Land Reforms Department (currently known as Land & Land Reforms and Refugee Relief and Rehabilitation Department) has identified 2540 waypoints with geographical coordinates using geo-rectified satellite imageries and ground truthing. The work is nearly completion. The Authority plans to place physical pillars to demarcate the wetland boundary on ground.

The Wetlands (Conservation and Management) Rules, 2010subsequently replaced with (2017 Rules) prohibit permanent construction of any nature within the wetland due to which the EKWMA has stopped admitting any applications for land use conversion. However, some conversions have taken place illegally. The Authority has filed as many as357 FIRs in the eight police stations to report and take action against illegal land conversion and encroachment; however, the scale of encroachment is much larger considering the growing presser on land. Some gaps between the records of the Land and Land Reforms Department and East Kolkata Wetlands (Conservation and Management) Act, 2006 schedule have also been noted.

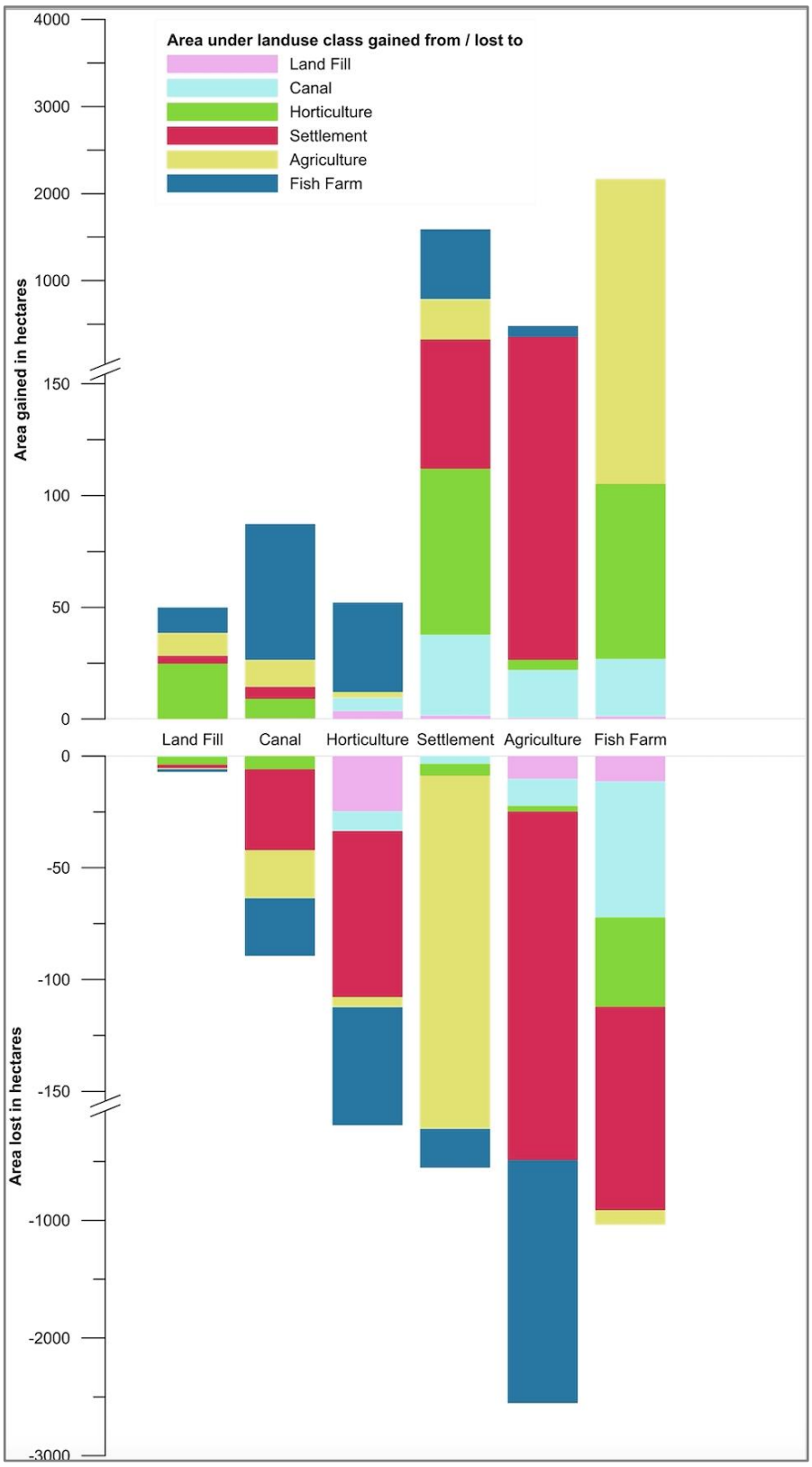


Figure 5. Land use transformation in East Kolkata Wetlands (2000-2019)

2.2 Wetland catchments

The EKW forms a part of the wetland regime of Gangetic Delta. The definition of Gangetic delta extent has evolved over a period of time. A group of experts belonging to an older school delineated the triangular tract encompassed by the Bhagirathi-Hugli in the west, the Ganga-Padma in the north, combined flow of the Jamuna and the Meghna in the east and Bay of Bengal in the south as the Ganga delta (Bagchi, 1944). Considering the role of the Brahmaputra in delta formation, the scholars of modern school treats entire alluvial plain of Bengal as the Ganga-Brahmaputra (GB) delta (Allison et al.2003; Bandyopadhyaya, 2007). It may be more appropriate to refer to the delta as Ganga-Brahmaputra-Meghna (GBM) delta, considering also the role of the latter in the depositional process. GBM delta is essentially a coalesce of deltas of the three rivers (Rudra, 2018), with an estimated deposit of half a million kilometer 3 of sediments.

EKW is an area of incomplete morphogenesis where fluvial and marine land-building processes were juxtaposed. These wetlands were connected till about a century ago with Bay of Bengal through Matla-Piyali-Adiganga distributaries, and was influenced by tidal action. The Bidyadhari, Sunti and Noai brought in freshwater into the wetland from the upstream reaches.

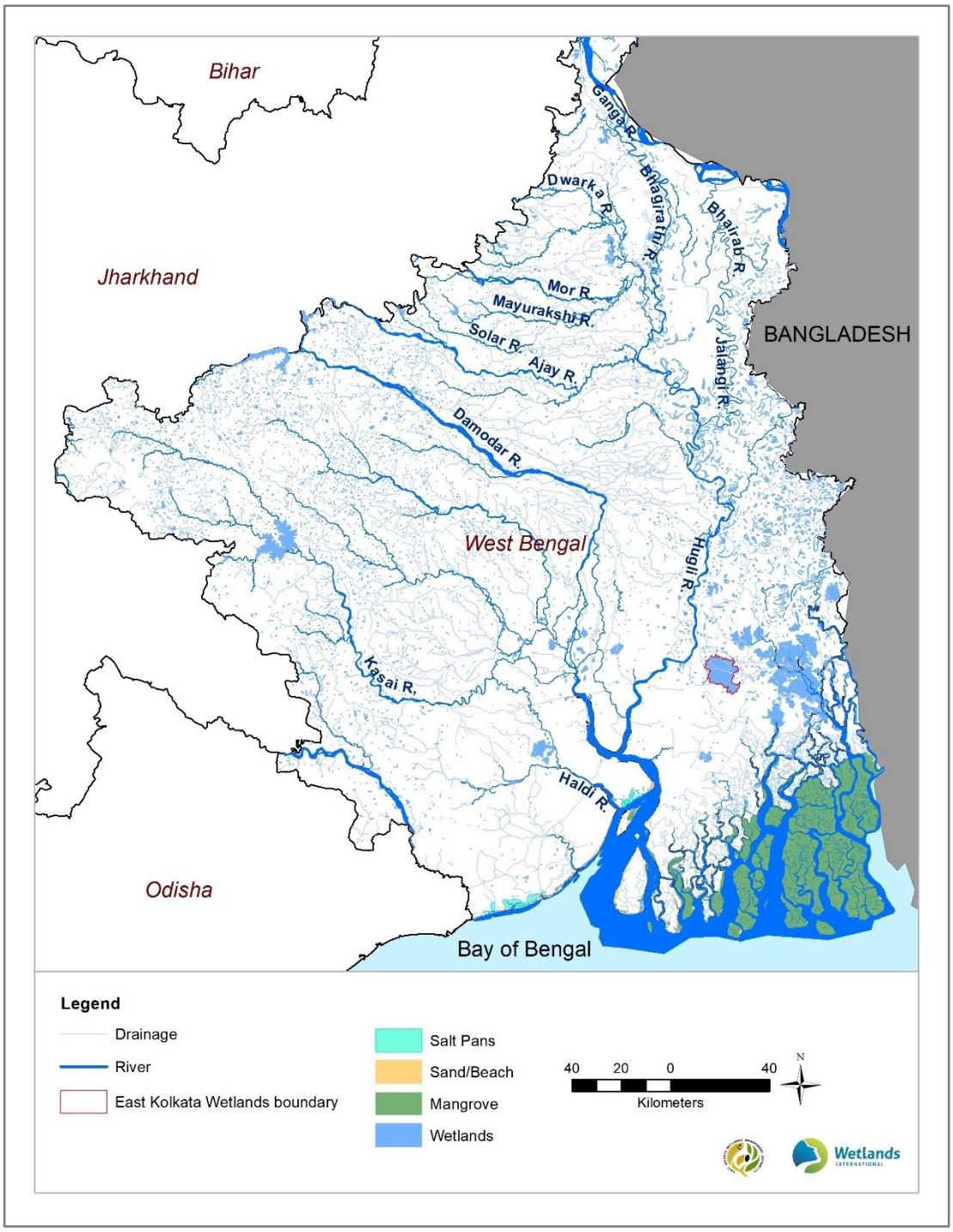
Over time, Jamuna, a cross channel connecting Hugli with Icchamati River became moribund. Changes also took place in the drainage of River Bidyadhari. The river originates from the Mathura bill near Kalyani and bifurcates at Tehatta. The western branch of the river which used to flow through the present site of Salt Lake City and discharged through Matla estuary can hardly be traced, whereas the eastern branch countinues to flow into the river Kulti Gang. During late 18th century Tolly's Nala was excavated between Garia to Samukpota, connecting Adiganga with the western branch of Bidyadhari. However, owing to the shifting of the main course of Ganges from Bhagirathi to Padma and westward migration of the former near Kalyani, the freshwater flows to the Bidhyadhari rapidly reduced leading to gradual domination of the tidal process over fluvial one.

The north south hydrological exchange between the freshwater and brackish water regimes was further altered when a system of locks and pumps were put in place in Kolkata City to drain its stormwater and sewage into the EKW. The flow regimes of the wetland have thus come to be dominated by sewage from the city, and their utilization for fisheries and agriculture. Therefore, since the mid-19th Century both fresh and brackish water regimes became feeble. The drainages of Bidhydhuri in the upstream gradually merged into the Kulti estuary, which is connected to the Bay of Bengal.

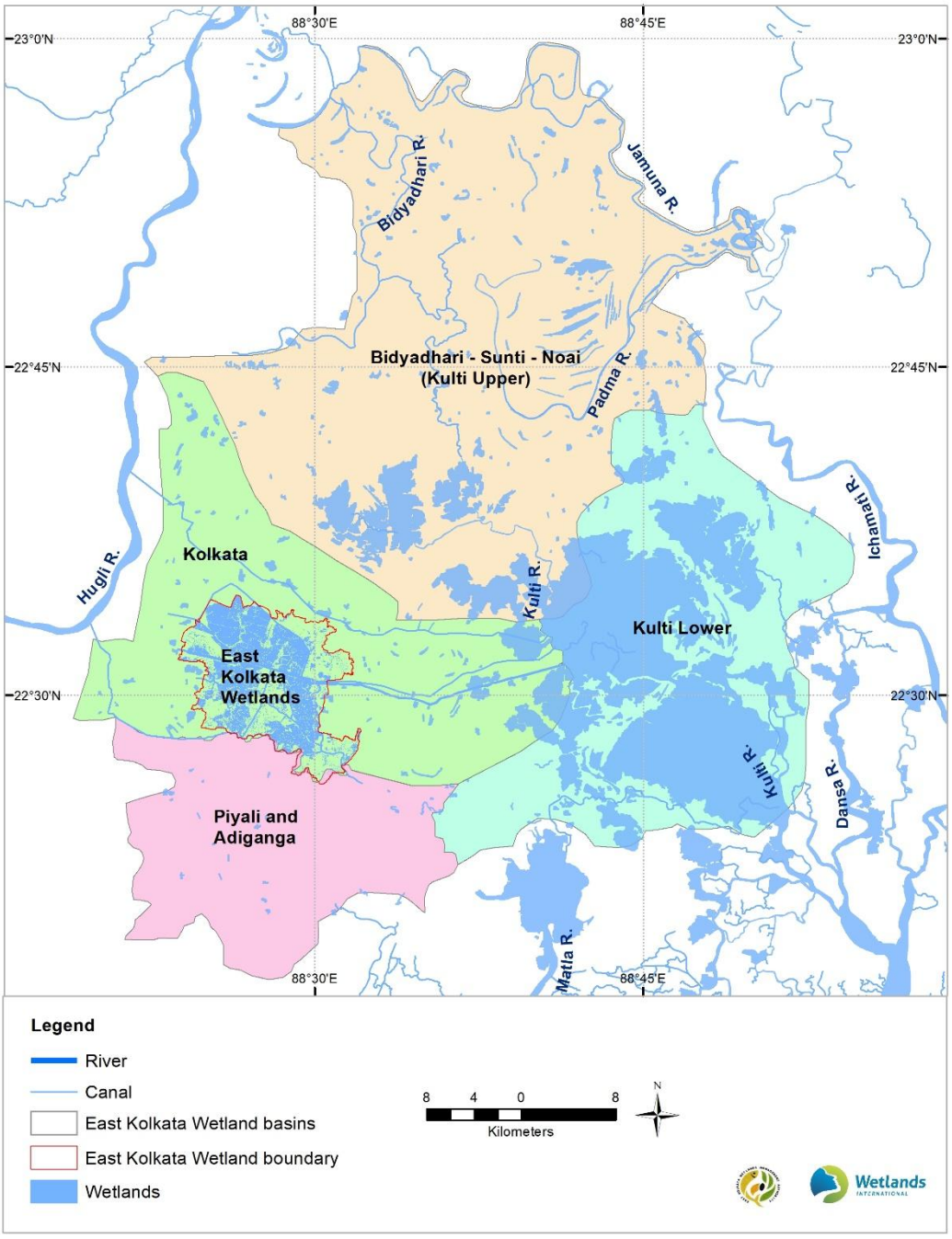
Considering the hydrological regimes, the southern part of GBM Delta forms an indirect catchment of the EKW. Yet, Kolkata, Piyali-Adiganga, Bidyadhari-Sunti-Noai (often referred as Kulti Upper), and Kulti lower basins are most significant (Map 5). Since the excavation of east-flowing wastewater canal, the hydrology of the EKW drastically changed and it was metamorphosed into a wastewater wetland. Hence, EKW receives the flows from the Kolkata Basin, i.e. those arising from the core areas of city system, suburban system and Manicktala, Topsia-Tangra, Tollygunge-Panchannagram systems, North and South Salt Lake basin and a very little part of lower Bagjola Basin (Map 6). Thus, the direct catchment of EKW comprises the following six sub-basins of Kolkata Basin:

a) Kolkata Sub Basin which contributes sewage flow as well as storm flow into the wetlands through an intricate network of channels, ultimately terminating into Dry Weather Flow and Storm Weather Flow channels.
b) North Salt Lake Basin comprises of the Kestopur canal. Bhangor Kata Khal, Circular canal.
c) South Salt Lake Basin consits of a low-lying area subject to inundated during the wet season. Nodor khal, Deyara Khal, Lalkuthi khal are flowing through this basin.
d) Kheyadaha-Sumidgiri Basin carried the sewage mainly by Sumidgiri canal, Bidyadhari canal, Boye Nala. Tilly's Nala is the extreme south boundary of both the South Salt Lake Basin and the Kheadaha -Sumidgiri basin.
e) Tollygunge-Panchannagram (T.P.) Basin carries the sewages of Jadavpur, Santoshpur, Kasba, Tiljala area of KMC. This area was basically a very low marshy land. Tolly's Nala and SWF are the southern and northern boundary of this basin respectively. A large number of intercepting channels and tributaries crisscrossed with T.P. Channel are passing through this basin.
f) Lower Bagjola Basin. Very little of this basin falls within the EKW.

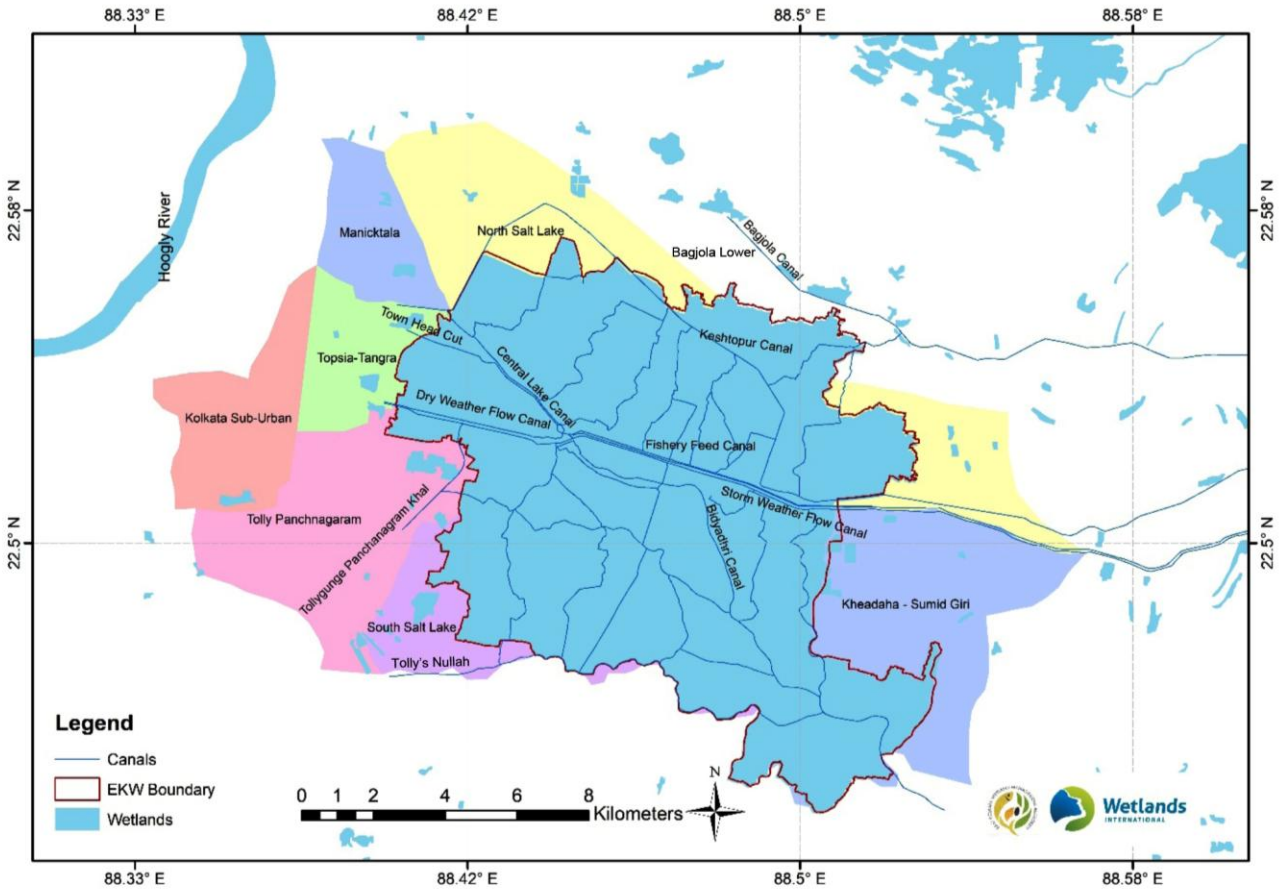
Picture 4. The Storm Water Flow Channel carries the monsoon runoff directly to Kulti River



Map 4. Wetlands of Southern Fraction of Ganga-Brahmaputra-Meghna Delta



Map 5. Catchment of East Kolkata Wetlands



Map 6. Direct catchment of East Kolkata Wetlands

2.2.1 Land use and land cover

Agriculture is the predominant land use within the indirect catchment of EKW, accounting for 59% of the total area, followed by settlements. Wetlands constitute 17% of the indirect catchment area. There is hardly any perennial vegetative cover within this region. The EKW located within the Kolkata Basin displays a complex mosaic of landuse categories including water spread areas, agriculture, horticulture and settlements.

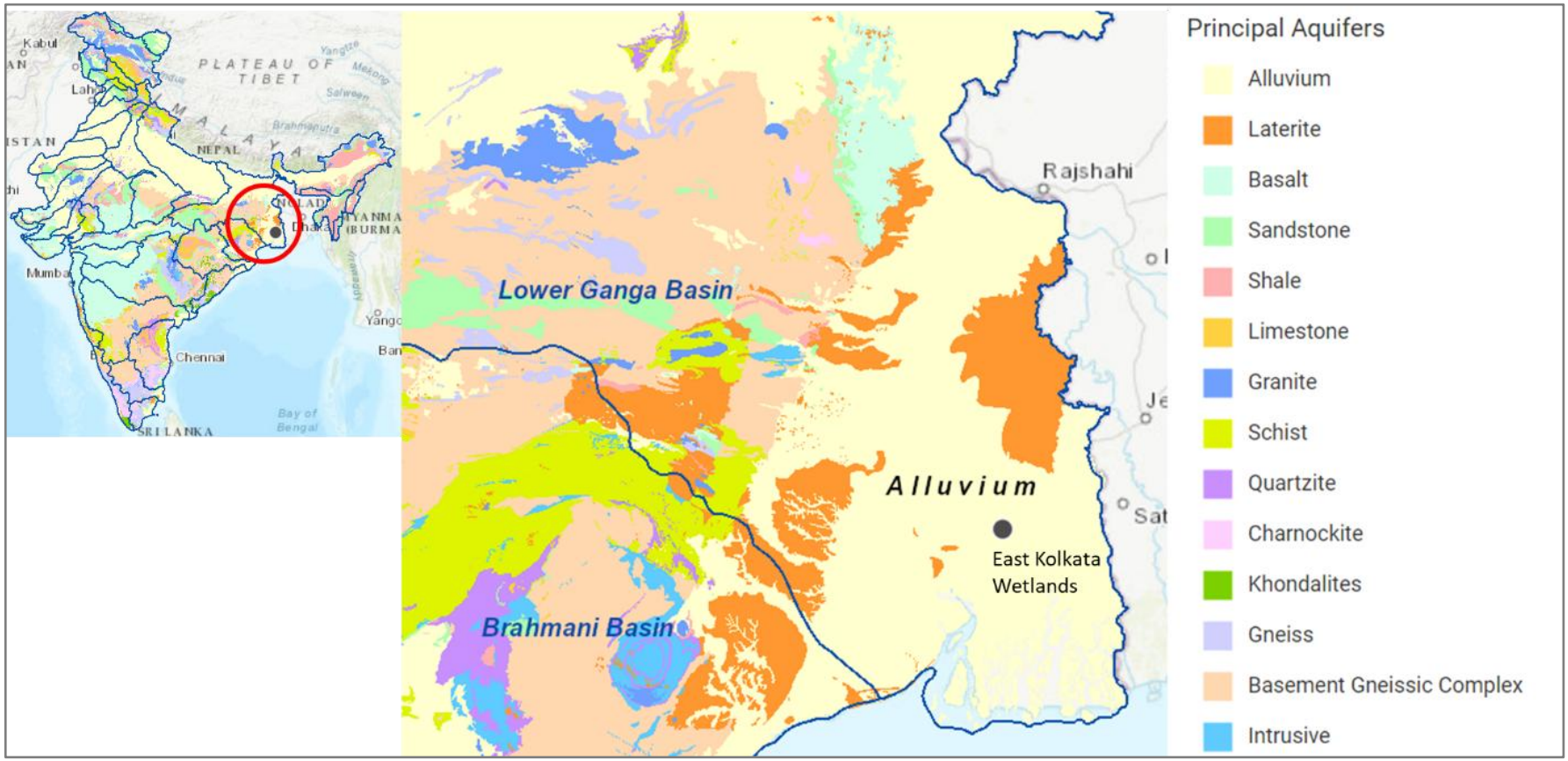
The land use within the East Kolkata Wetlands has been changing with the growing developmental pressures from the metropolitan as well as population within. As compared to 1959, there is a discernible conversion of wetlands for non-wetland purposes. The reclamation of salt lake city and construction of Eastern Metropolitan Bypass has also led to shrinkage of wetlands on the western boundary. Since 2000, a distinct conversion of wetlands to agricultural land and settlements can also be recorded (Mondal et al. 2017; Parihar et al. 2013).

2.2.2 Geology and Geomorphology

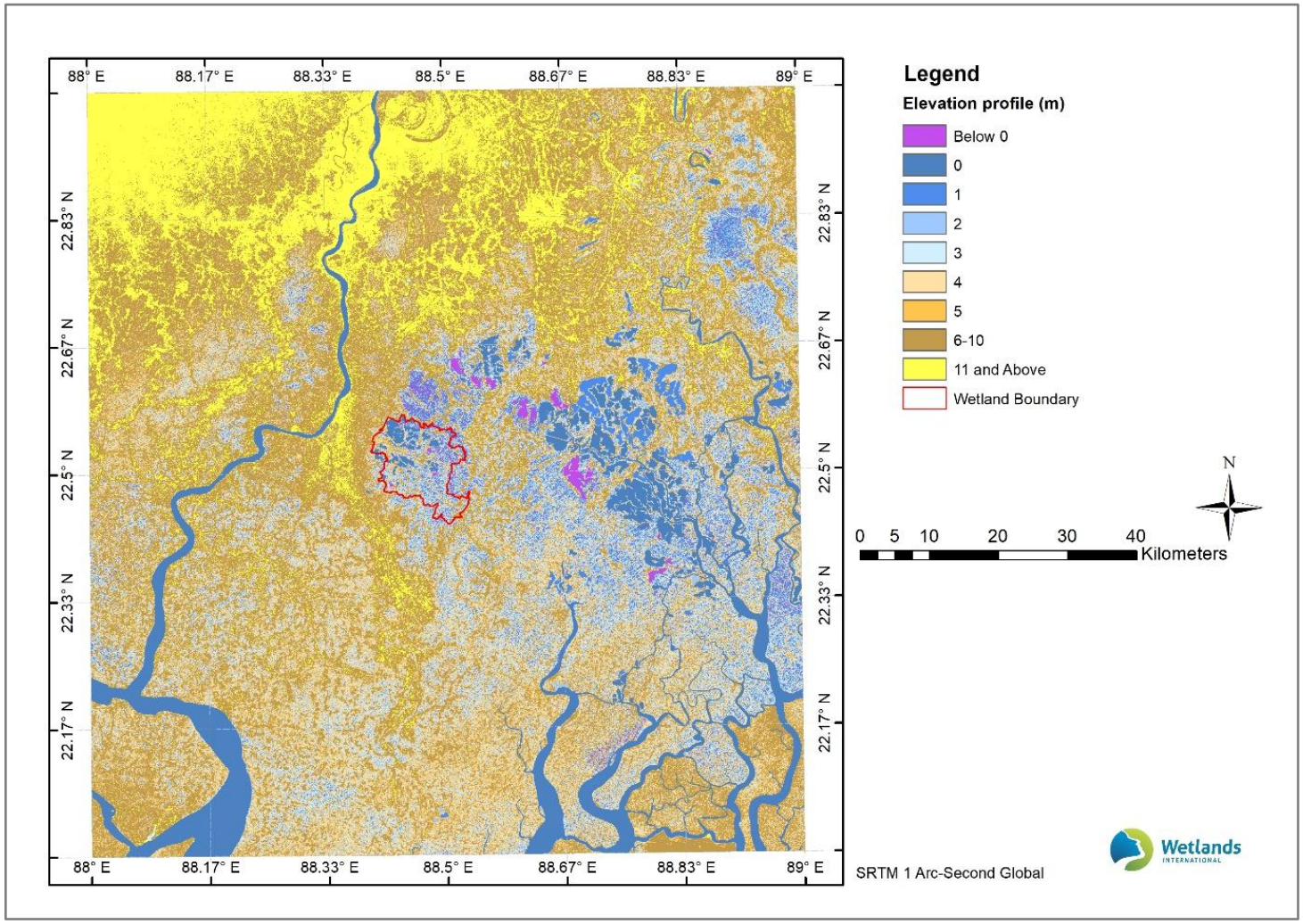
Located within the lower deltaic alluvial plain of the Ganga-Brahmaputra-Meghna Delta, the EKW is underlain with sediments deposited in successive stages by the river and consists of layers of clay, clay and calcareous concretions, peaty intercalations, sandy and silty clay and fine to coarse sand. The water table throughout the basin is high.

Based on lithological, floral, faunal and radiocarbon dating (Chaterji et al. 1959; Banerjee et al. 1984; Sen and Banerjee 1990; Barui and Chanda 1992; Hait et al. 1996) clay silt with a peaty intercalation is present below the wetlandsat two depth ranges from the surface 2-5 m and 12-12.6 m in the Holocene series of the Quaternary system, Sand, fine to coarse with clay lenses, gravel and calcareous concretions is present at a depth of 40 -246 m in the Pleistocene series of the Quaternary system and Clay layers are present from 246 – 614 m in the Pliocene series of the Tertiary system. Piezometric wells with screens placed at 40-220 m indicate that groundwater flows in a confined condition within a sandy aquifer sandwiched between two clayey beds (Sikdar 2000; Sikdar et al. 2002).

The catchment slopes from northwest to south east, the relief in the northern side is over 11 m amsl and in the southern side it is under 3 m amsl and pockets of areas within the catchments are below sea level. EKW is a part of the lower deltaic plain of the Ganga– Bhagirathi–Hugli river system wherein the land surface with its elevation of 2–6.5 m amsl slopes gradually towards the south and southeast (Map 8). This elevation differs locally because of paleo-levees, paleo-courses and stream channels.



Map 7. Aquifer system in East Kolkata Wetlands Catchment (India-WRIS 2020)



Map 8. Elevation profile of East Kolkata Wetlands catchment

2.2.3 Climate

EKW catchment has a Tropical wet-and-dry climate (Köppen climate classification Aw). The annual mean temperature is 25 °C; monthly mean temperatures ranges between from 17 °C and 32 °C (Stackhouse, 2020). Summers are hot and humid with temperatures in early 30's and during dry spells the maximum temperatures often exceed 40 °C during May and June. Winter tends to last for only about two and a half months, with seasonal lows dipping to 10 °C between December and January. The highest recorded temperature in the past 30 years is 46.6 °C and the lowest is 3.2 °C (Stackhouse, 2020). Often during early summer, dusty squalls followed by spells of thunderstorm and heavy rains fall in the catchment, bringing relief from the humid heat. These thunderstorms are convective in nature, and is locally known as *Kal baisakhi* (Nor'westers). Rains brought by the Bay of Bengal branch of South-West monsoon fall between June and September and supplies the catchment with most of its annual rainfall of ~1300 mm, the highest rainfall occurs during the monsoon in August ~306 mm (Stackhouse, 2020). The annual Average rainfall is ~1600 mm with an average humidity of 80% and wind speed ranging from 2.9 to 7.0 km per hour. Solar radiation varies between 150 and 250 Langley/day(Ghosh 2018). The average evapotranspiration ranges from 150- 200 mm per year (Stackhouse, 2020). The climate of area is predominantly influenced by northeast and southwest monsoons.

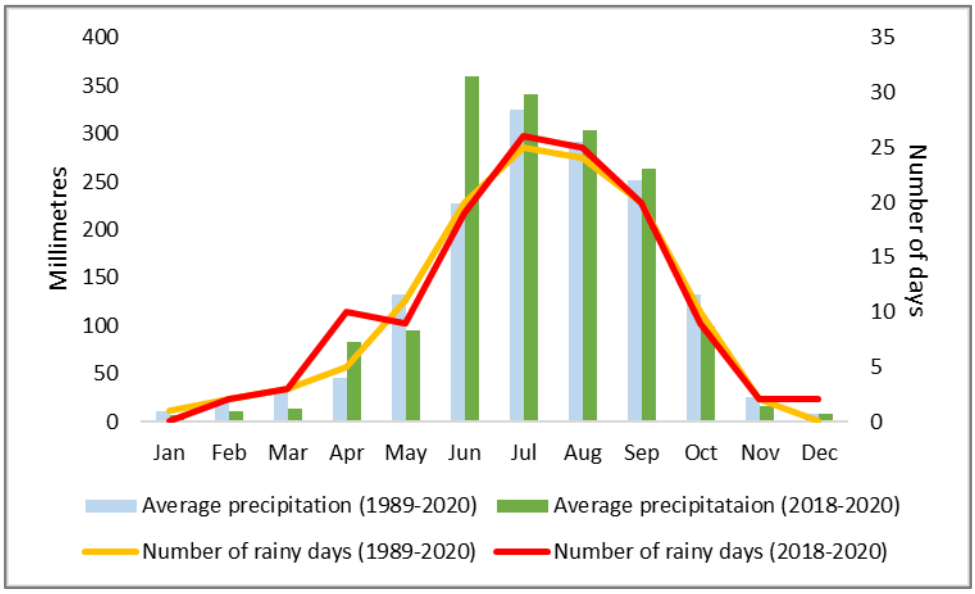


Figure 6. Precipitation trend in East Kolkata Wetlandsdirect catchment (1989 - 2020) (Stackhouse, 2020)

The City of Kolkata is perennially exposed to urban flooding which is the most critical climate-related hazard in Kolkata. Hydrological and hydraulic impacts resulting from increased precipitation in a changing climate by 2050 indicate the low lying areas of the city, essentially wetlands, are expected to be under prolonged inundation (Dasgupta et al. 2013).

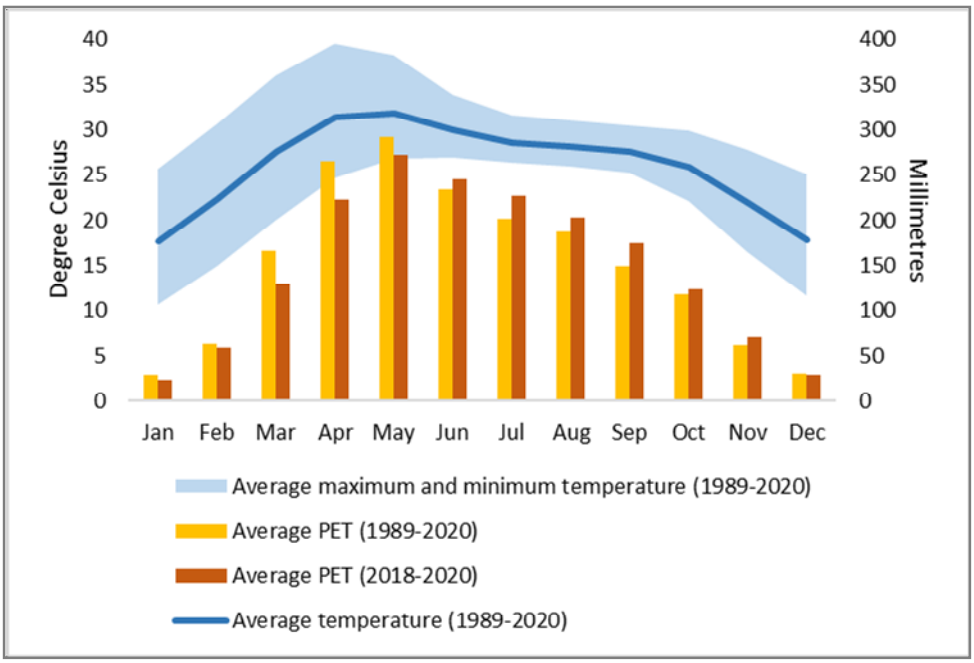


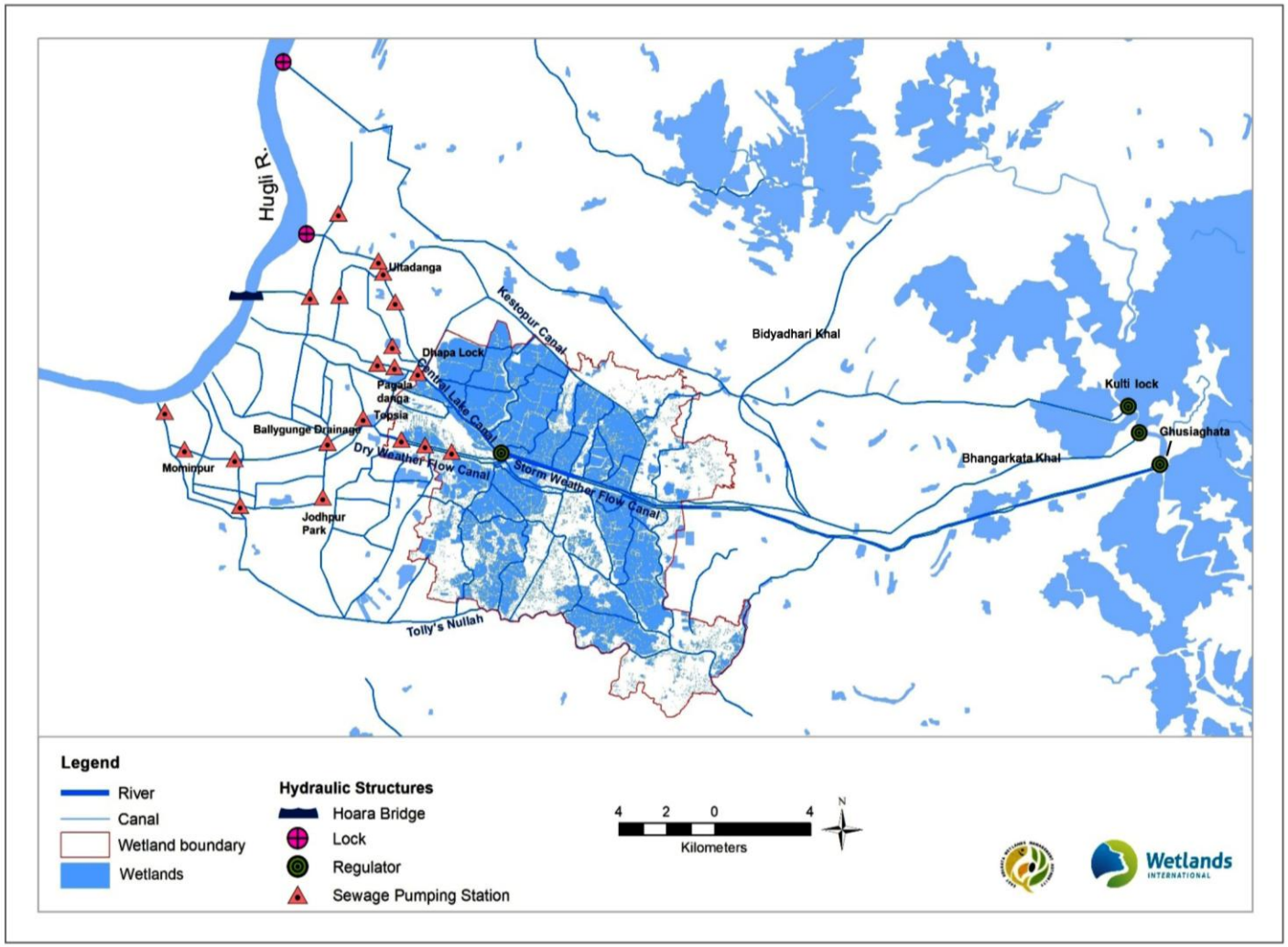
Figure 7. Temperature and evapotranspiration trend in East Kolkata Wetlands Basin (1989 – 2020) estimated using Thornthwaite's equation (Stackhouse, 2020)

2.3 Hydrological regimes

2.3.1 Hydrological set-up

Hydrological regimes of the EKW are highly modified and occur through drainage and sewerage channels which connect the urban and peri urban Kolkata located on the bank to Hooghly to the outfall system in Kulti. The flows of Kolkata sub basin, of which the wetland forms a part, are ultimately discharged to the two rivers, i.e. Hoogly and Kulti Rivers through its 1,412 km length of drainage system and interconnected network of drains and channels. Flows from the urban centers are transferred into the lead channels through a system of pumps. As the two rivers are subject to tidal actions, regulators have been constructed at the outfalls of channels to enable controlled discharge of the sewage.

Located within a deltaic area, and within a system subject to tidal action, the inflow and outflows are conditioned through various hydraulic structures, including sewage pumps and regulators (Map 9). The operation of these structures is governed by the need to ensure minimum waterlogging by transporting stormwater quickly from the Kolkata City and secondarily to ensure sewage availability within the fish farms and agriculture areas of the wetland. During the monsoons, all structures are synchronized to ensure water drainage to Kulti bypassing the wetland, with the locks ensuring that no tidal influx takes place towards the system. During the lead seasons, the structures are operated to pump sewage towards the wetland and thereafter to Kulti River.



Map 9. Hydraulic structures in East Kolkata Wetlands Basin

2.3.2 Waterand sediment regime

Presently, the overall inflows from the upstream watersheds to the wetland primarily comprise two elements, i.e. the dry weather flows and storm weather flows. Wastewater generated in Kolkata City accounts ~1400 MLD (Ghosh 2018) of which the total sewage treated in the EKW fisheries has been estimated as ~910 MLD to 930MLD (KMC Drainage Report, 2020), which is roughly 65% of daily sewage generation. However, given the fact that the Tollygunge – Panchannagram Basin and Topsia – Tangria Basin discharge directly into the SWF channel, which is then bypassed into the Kulti River, only 78% of the DWF emanating from the Kolkata city and its sub urban areas is drained into the wetlands, and is available for nutrient recycling. The storm weather flow emanating from these watersheds is linked to the rainfall patterns. An analysis of the rainfall within the Kolkata Basin indicates a concentration of 75% of the average rainfall of 1,600 mm within June – September. The total SWF generation from the upstream watersheds has been estimated to be 136 MCM. Including the dry weather flows, the overall flow generation from the upstream watersheds is 498 MCM (Figure 6).

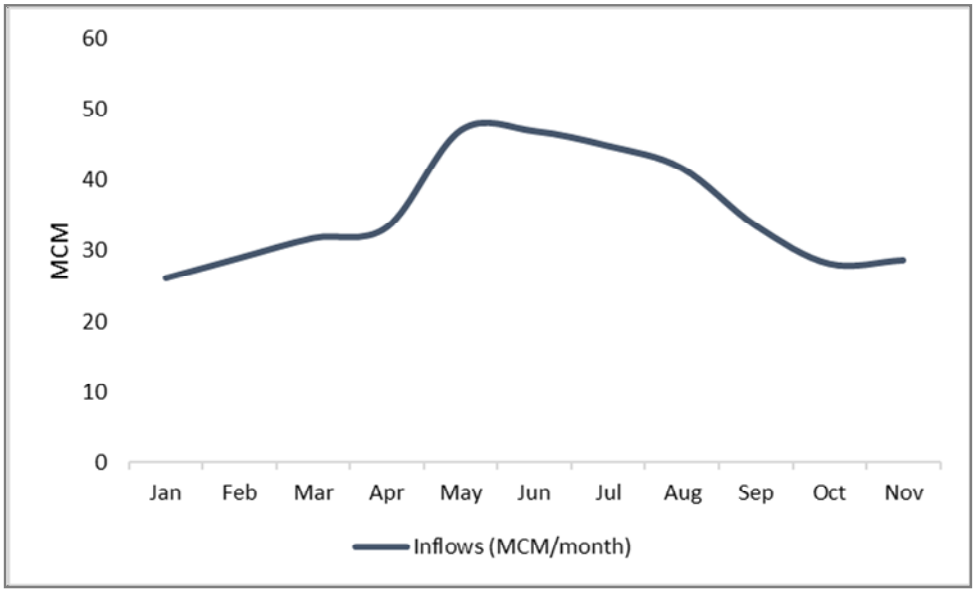
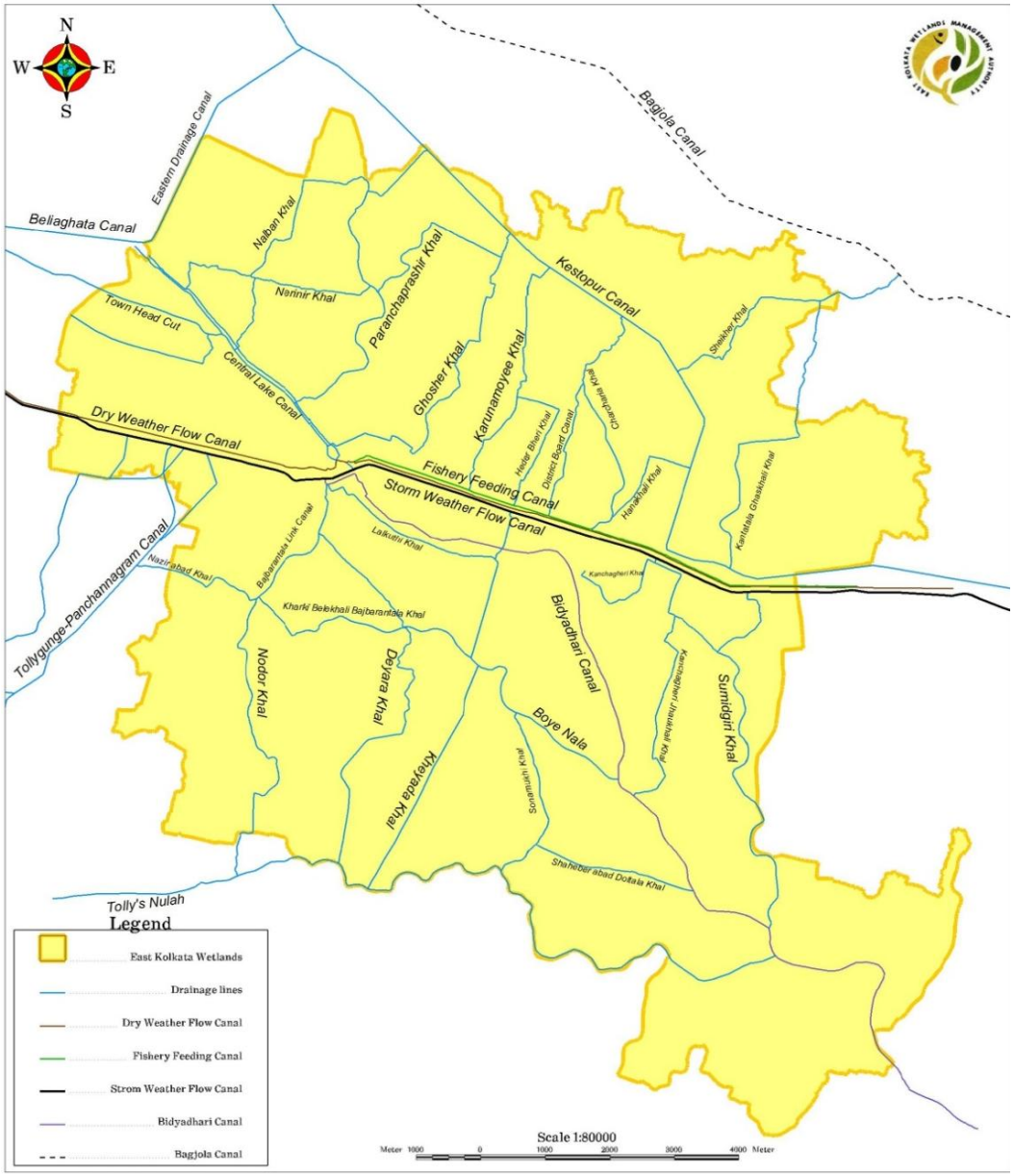


Figure 8. Inflows in East Kolkata Wetlands (Modelled)

An assessment of inflows from the upstream watersheds indicates that about 40% of upstream flows generation gets into the wetland. During the lean seasons, the wetland receives the DWF flows from the municipal region. During monsoons, the hydraulic structures divert the entire flows to the SWF, reducing the overall upstream inflow by nearly 85%. As the level of SWF is lower than the DWF, the flows naturally get into the former, and drains to Sundarbans through Kulti.



Map 10. Canal system of East Kolkata Wetlands

Picture 5. The Dry Weather Flow Channel

One of the key consequences of flow regulation through extensive channelization has been rapid enhancement in the natural siltation and sedimentation process within the Kolkata City sewerage system. In a natural course, the sediments would be expected to be accumulated within the wetlands, but due to extensive regulation of flows, there has been a higher rate of sedimentation within the upper watersheds of East Kolkata Basin. Another impact of extensive channelization and subsequent flow reduction is loss of self-cleansing velocity which conveys wastewater or storm water without long term deposition of solid material. A common design criterion is to maintain a value of 0.80 m/ sec with peak flow and 0.60 m/sec at average flows. However, with extensive siltation the hydraulic capacity of the various canals has reduced by 15% to 50% and this self-cleansing velocity cannot be maintained, which further augments siltation. In downstream reaches, within the channels of the wetland, the entire monsoon flows from upstream do not flow through the secondary channels, and therefore no flushing takes place. The limited monsoon rains available over the fish ponds are completely insufficient to ensure channel flushing. As a result, the ponds have to use pumps for lifting sewage, which would otherwise be available through normal gradient flow.

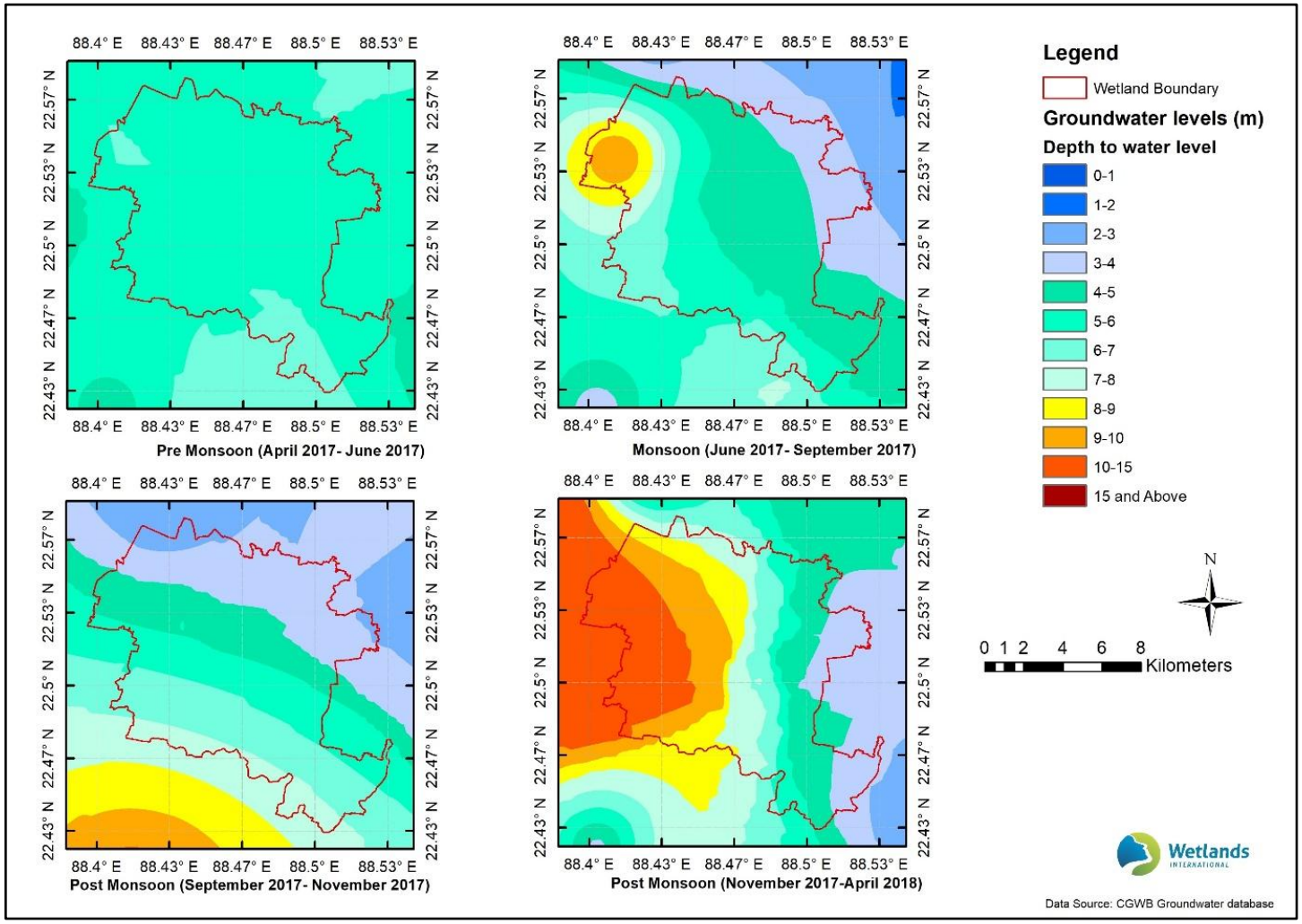
The EKW being a natural depression between the Kolkata city and Kulti estuary provides an enormous water holding capacity. In its natural regimes, this water holding capacity enabled the wetland to regulate the flow regimes and attenuate floods by storing peak monsoon flows as well as tidal flows. However, this natural function of the wetland has not been integrated into spatial planning, and instead reliance is on engineering structures wherein the monsoon flows are transported out from the basin into the downstream Kulti River. Given the fact that the delta building process within the banks has been prematurely interrupted and the city has only marginal elevations as compared to other reaches, the flood attenuation function of the wetlands would have provided a natural buffer against high flows.

Water use within the wetland is predominantly governed by its use for fisheries and agriculture within the EKW. Fisheries within the wetland are exclusively dependant on the sewage inflows, whereas agriculture uses monsoon runoff as well as ground water apart from effluent discharge from the fish farms. The current allocation pattern within different users has not been assessed comprehensively. Sewage for agricultural purposes is only accessible to mouzas fringing the fish farms. Agricultural areas lying at the tail end of the DWF channel and towards the north have no access to sewage and therefore depend on monsoon or groundwater through shallow pumps. In the long run, this has also been responsible for gradual reduction of agriculture in the wetland.

Picture 6. The Bantala regulator from where sewage is diverted to the wetland

2.3.3 Groundwater

The groundwater in EKW region is available from an average depth from the surface at 4-8 m in pre monsoon, 1-9 m in the monsoon and 1-10 m in the post monsoon periods. Due to the shallow levels of groundwater, an alluvial media and a hydraulic conductivity, fluctuations between the groundwater levels at shallow ranges are highly variable.



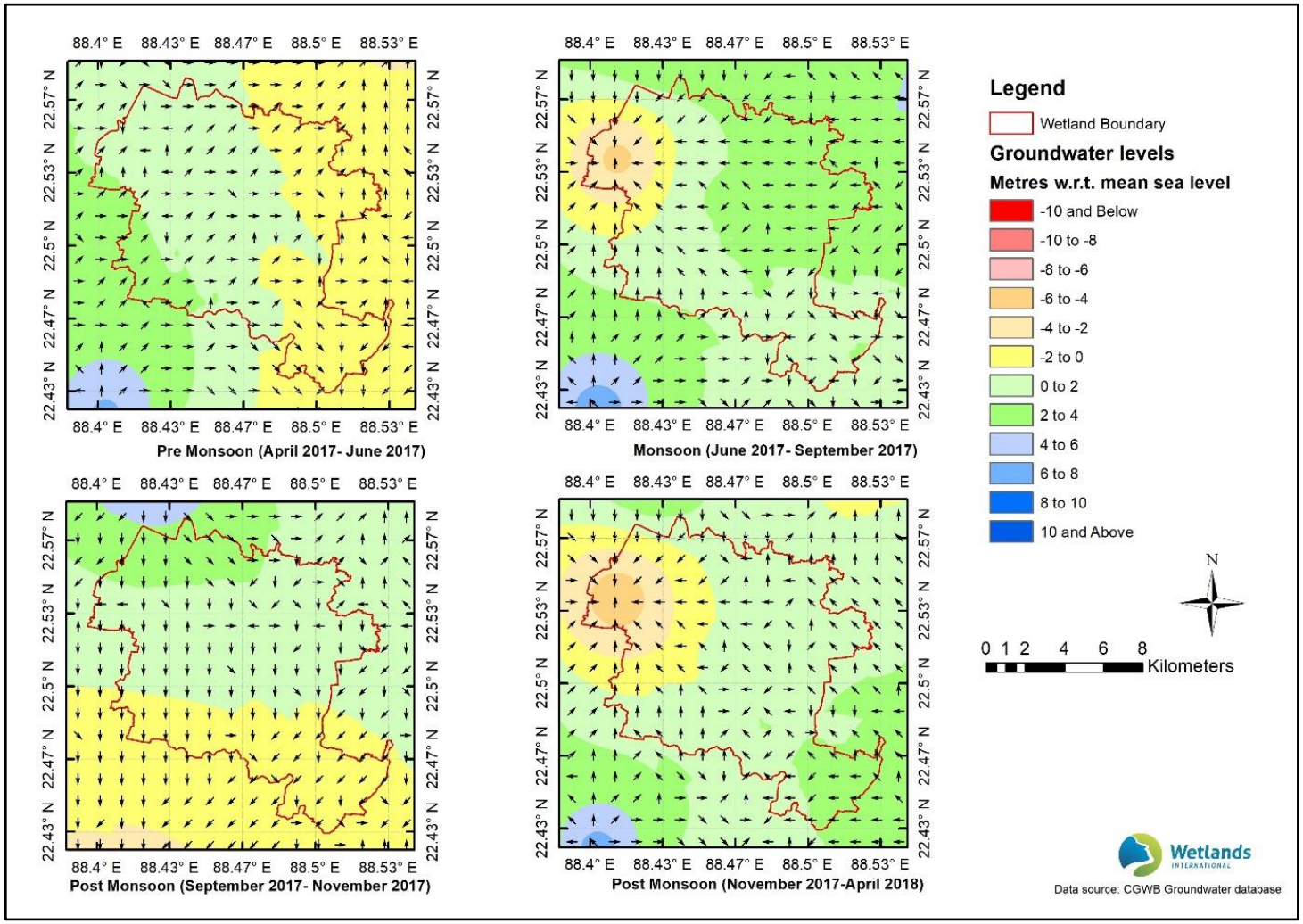
Map 11. Groundwater levels in East Kolkata Wetland

Groundwater levels in post monsoon (Map 11) indicate that a groundwater trough exists within the wetland near Dhapa–Manpur region and the groundwater moves towards this depression from the surrounding region. Several groundwater mounds are found in the adjoining areas of the wetlands from which the water flows in all directions. In and around Bantala the piezometric levels are within a meter below the surface, groundwater abstraction must be restricted in this region as it would result in volumetric compression the underlying aquiclude. If this water contains toxic material then the freshwater aquifer will be polluted. But in general, the groundwater flows from east to west.

An increasing trend of groundwater extraction in Kolkata has been observed since 1950s till present. In 1956, the groundwater pumping rate was ~ 55 MLD. With development of borewell technologies, the screens of the drinking water wells were placed within a depth interval of 100 to 140 for deep bore wells and 30-60m for shallow wells, for domestic use in 2010. Kolkata now pumps about 310 MLD of groundwater. It is anticipated that by 2025, 385 MLD of groundwater may be required for drinking, domestic and industrial purposes in Kolkata. This rate was calculated by projecting the past trends of groundwater abstraction at Kolkata for the period 1956–2006 (Sikdar 2000, Central Ground Water Board 2004) by the projected population in 2025.

In Salt Lake City, pumping began in 1969 with the construction of a single tube well with a discharge of 2.4 MLD. At present, 19 MLD of groundwater is extracted for drinking and domestic purposes. At the KLC Project area 5 MLD of groundwater is extracted today to meet the demand of the various industrial units. Industrial activity in the KLC Project area is likely to increase, requiring an additional 30 MLD of water by 2025. In the absence of any other source of water, this additional need will be met from 16 new tube wells planned to be constructed in the near future (Sahu et al, 2013). At present to meet the growing demand for agriculture and aquaculture, groundwater is being extracted at fast rate.

Unsustainable withdrawal of groundwater in the EKW due to rapid urbanization, aquaculture, agricultural and industrial development has posed a risk of land subsidence. The subsurface geology of the area consists of quaternary sediments of various grades and as groundwater occurs mostly under confined conditions except in those places where the top aquitard has been obscured due to the paleo channels. Currently, the hydraulic head exhibits a falling trend and it accelerates due to further overuse of groundwater, which leads to aquitard compression leading to land subsidence. Estimated land subsidence rate of the area ranges between 1.1 and 43.8 mm/year with an average of 13.5 mm/year (Sahu and Sikdar 2011).



Map 12. Groundwater levels and flow direction in East Kolkata Wetlands

2.3.4 Water quality

Wastewater of the city is discharged into the fish farms locally known as bhery. This wetland system exhibits immense potential in remediating the water quality by reducing the high amounts of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) it receives from the inflow on a daily basis. Each hectare of the shallow waterbody has the ability to remove 237 kg of BOD per day (Ghosh 2018). The bhery being shallow allows full vertical circulation of water to the surface where algal blooms occur. A solar radiation that is about 250 Langley's a day, allows sufficient photosynthesis which augment reoxygenation to allow for efficient BOD and pathogen/faecal coliform reduction. Factors that play role in water purification are the shallow ponds acting as stabilization ponds, abundant water hyacinth that absorbs heavy metals, sun light penetrating to the bed of the water body and other microbial components that help in bioremediation (Raychaudhuri et al, 2008).

The characteristics of wastewater is not uniform round the year, it actually varies not only in the different sections of the wetland but also from hour to hour at the same place depending on the weather conditions, availability of water and other agro-economic conditions.

Water quality is monitored by West Bengal Pollution Control Board on a monthly basis. The seasonal trend analysis of 2018-2019 period is illustrated in Figures 8 -13. Significant BOD and COD reduction is noticed as the inflows travel from Bantala lock gate to Ghaskhali lock gate passing through the fish farms. During monsoon with the dilution from rainwater falling directly over the surface of the wetland the overall concentration of BOD and COD is relatively lower as compared with other seasons. Thus, with the reduction of the BOD and COD the DO levels also rise during monsoon. The DO is observed to be at its best at the Bamanghata Jalpath outlet station.

On the other hand when the water flows from Bantala lock gate to Ghusiaghata lock gate travelling approximately 28 km, initial reduction of BOD, COD and increase in DO is observed, but, the dynamics is changed when the water travels around the Kolkata Leather Complex zone where a spike of BOD, COD takes place due to the occasional discharge of tannery effluents, which gradually subsides as it reaches Ghusisghata lock gate. The Kolkata Leather Complex has 4 CETPs of 20 MLD capacity funsional and 4 more modules of 20 MLD capacity are expected to be funsional by March 2022. These are positive developments for EKW.

Total organic nitrogen (TON) is lowered by almost 30% from levels recorded at Har Har Bhery inlet to Lock gate at Ghaskhali.Nitrate and ammonium levels are somewhat reduced due to the wetland function in the Uttar Hatgachha. Their levels are nearly uniform for post monsoon and summer seasons. The levels drop in the monsoon season and rise by almost a factor of two by the winter season. Phosphate levels drop 50% from summer to monsoon and rise by a factor of three in post monsoon and winter season. The observed phosphate levels at Uttar Hatgachha is significantly lower when compared with the levels at other monitoring stations.

The presence of heavy metals in inflowing sewage and fish farms has been debated on several occasions. Monitoring records of WBPCB do not indicate presence of heavy metals in any of the sampling sites, however, several independent studies contradict these findings (Nandi et al., 2013; Dutta et al., 2016). On the other hand, studies confirm bioaccumulation of heavy metals in fish and vegetables produced in EKW (Joystu 2017; CPCB 2019)

A study conducted by (Sahu and Sikdar, 2008) for 40 water samples from different hydrochemical facies around EKW indicated that 7.5% groundwater samples show "excellent" quality, a majority of the samples, about 52.5%, fell in the category of "good water"; 27.5% of the water samples were of the "poor" quality and "very poor" quality which is shown by 7.5%

of the collected groundwater samples. The study also pointed out that majority of the poor and water unsuitable for drinking was found within Bantala area and its buffers approximately up to 10 kilometres. More recent assessment and on a continued basis of groundwater quality is required to ensure that the water used by the communities living in the wetland is safe for use.

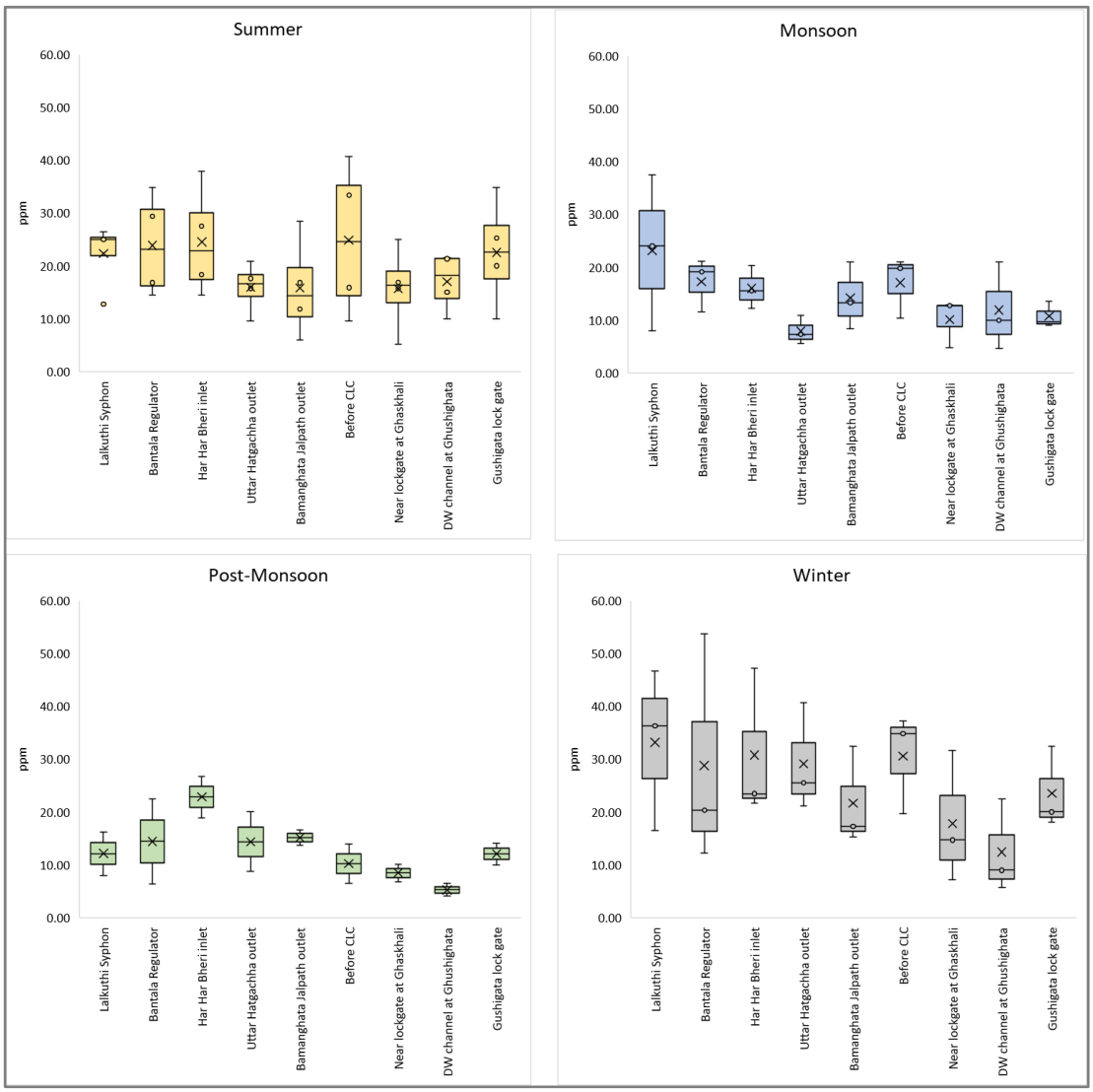


Figure 9. BOD at various stations in East Kolkata Wetlands (2018-20)

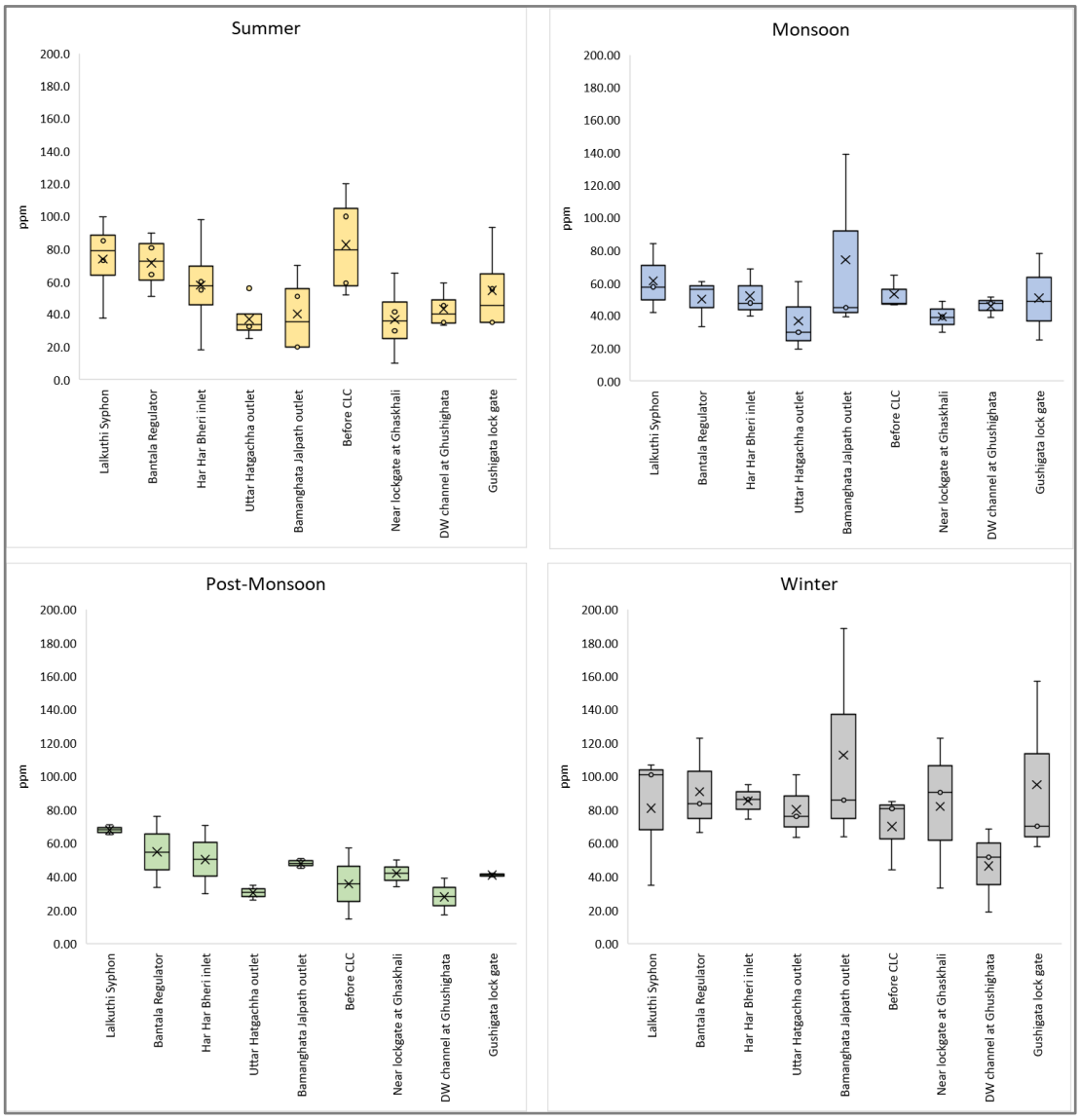


Figure 10. COD in various stations of East Kolkata Wetlands (2018-2020)

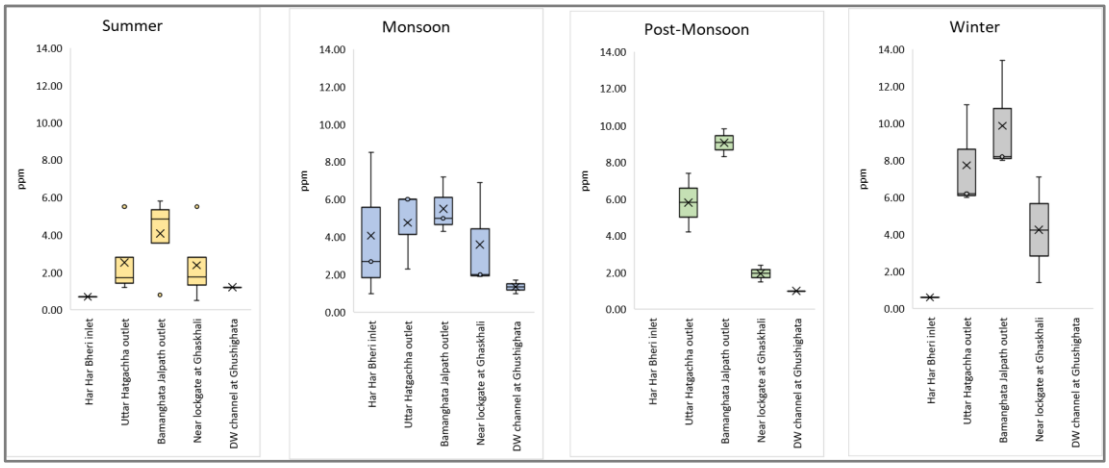


Figure 11. Dissolved Oxygen levels in various stations of East Kolkata Wetlands (2018-2019)

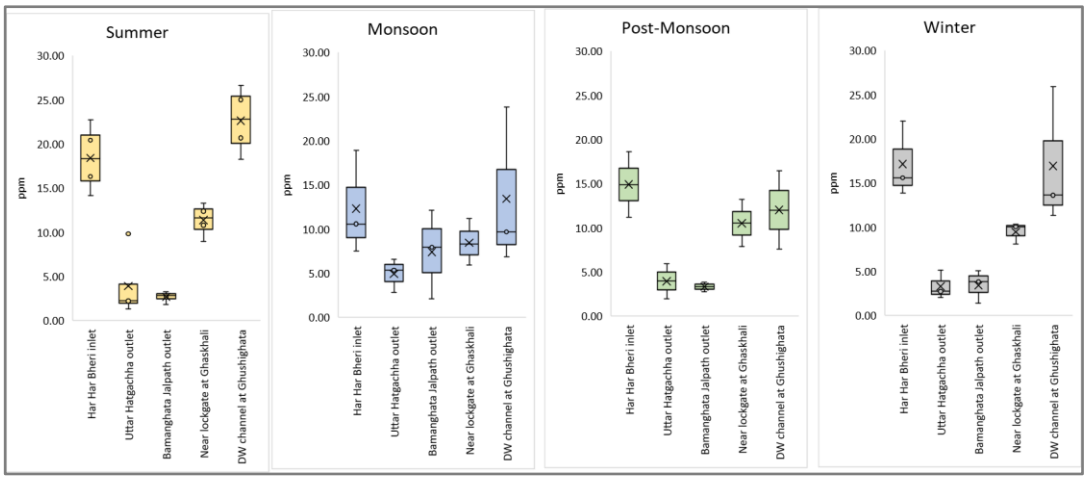


Figure 12. Total Nitrogen levels in various stations of East Kolkata Wetlands (2018-2019)

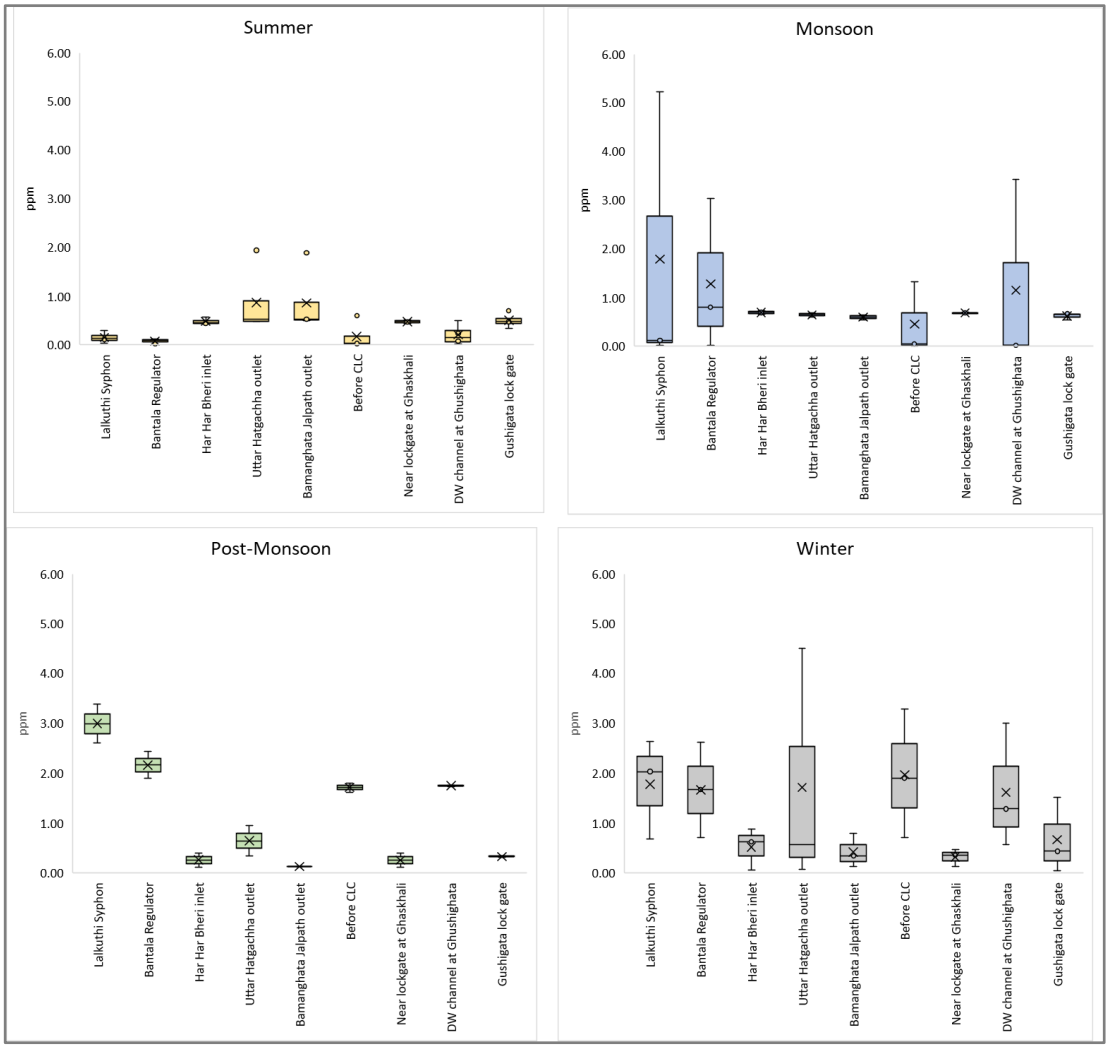


Figure 13. Nitrate levels in various stations of East Kolkata Wetlands (2018-2019)

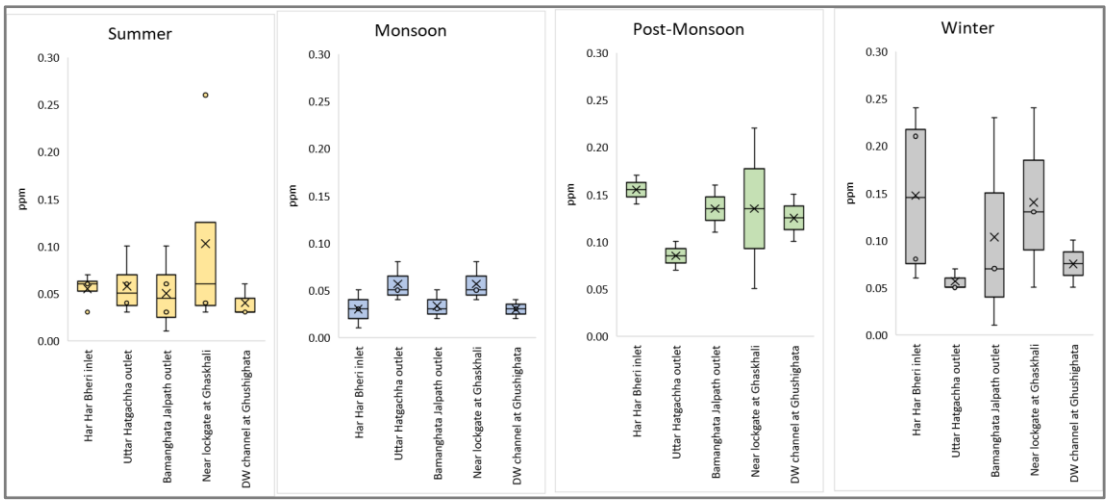


Figure 14. Phosphate levels at various stations of East Kolkata Wetlands (2018-2019)

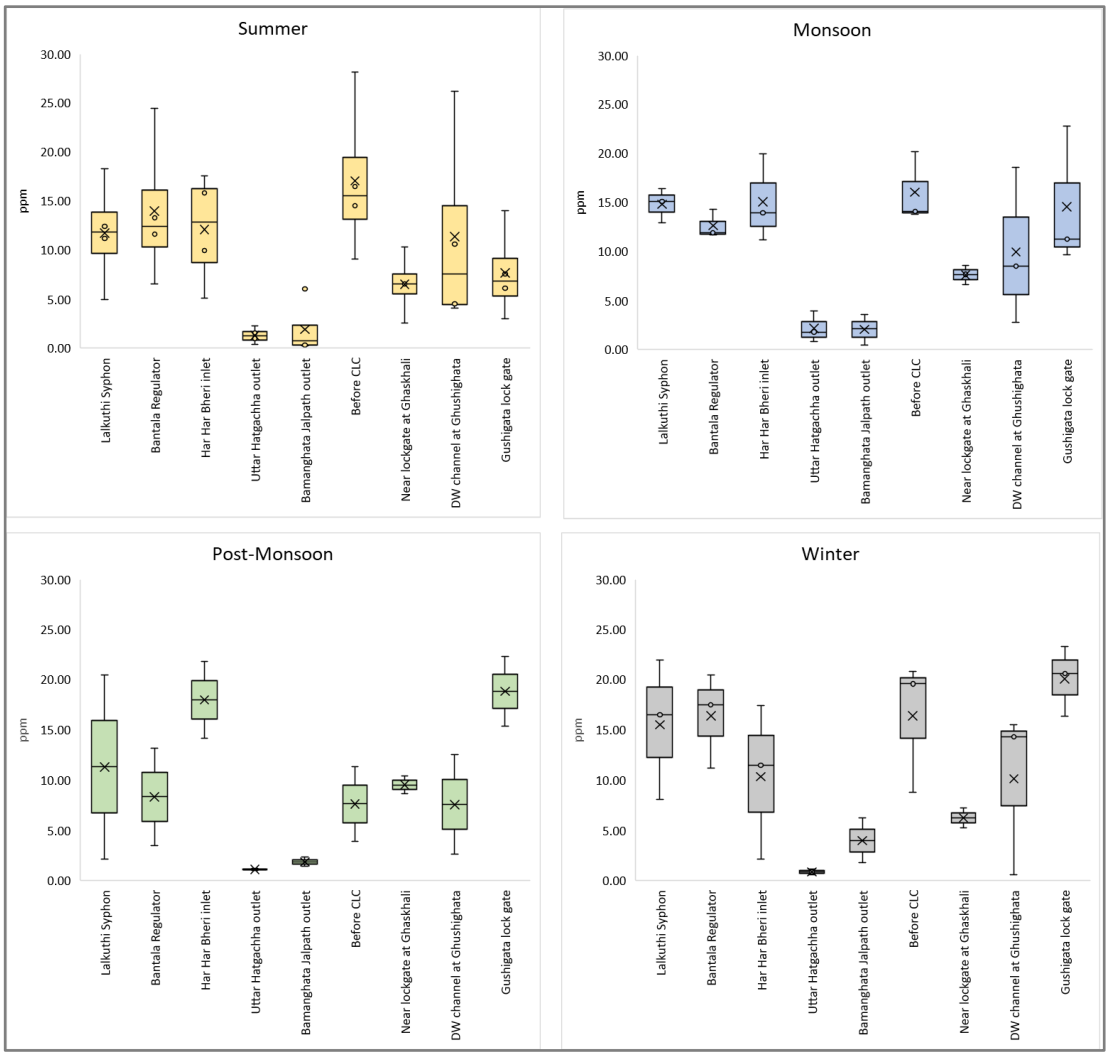
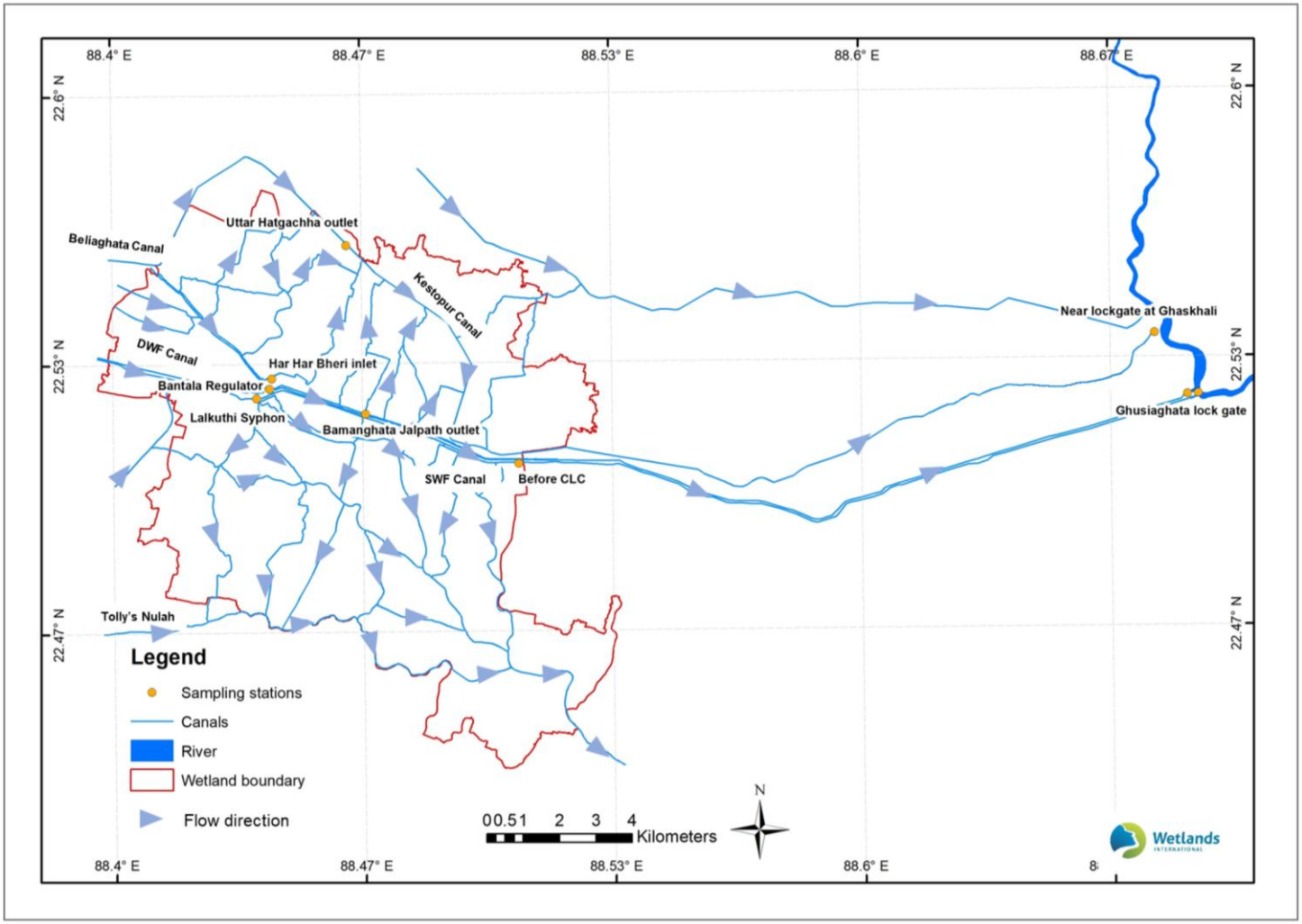


Figure 15. Ammonium levels at various stations in East Kolkata Wetlands (2018-2019)



Map 13. Water quality sampling stations in East Kolkata Wetland

2.3.5 Climate regulation

The low lying EKW act as storage reservoirs by absorbing majority of the excess flow fromrainwater runoff through its storm-water flow channel (SWF) and protecting the city fromfrequent monsoon flooding. The water holding capacity of the aquaculture ponds increases by an average depth of 10 to 15 cm during the monsoon season. The area has not experienced flooding for the last 3 decades regardless of the intensity of rain or quantum of flow of water into the wetlands. In addition, a large number ofoutlet channels syphoned to divert excess water have been designed by the local residents of the area, which contributes greatly towards averting floods (Banerjee 2017).

EKW is also referred to as the lungs of the Kolkata city. The air flowing over the waterbody humidifies the vapours into aerosol form, which captures dust and pollution particles and remove them permanently from the air stream. A study by (Disha 1996) indicated that the air samples collected over Dhapa dumping site had reduced SPM concentration over 67% in a village site downwind in the EKW system (Banerjee 2017).

The wetland system contributes to significant (over 60%) carbon reduction of the Kolkata city's emission. Unique phenomenon of algae–bacteria symbiosis occurs where algal photosynthesis, in the presence of sunlight, releases oxygen resulting in reduction of BOD. The solar energy trapped by the phytoplankton (blue-green algae) is consumed by the fishes. The plankton plays an important role in degrading the organic matter in the sewage discharged into the wetlands. Over growth of plankton might cause a problem of algal bloom, but the fishes grazing over the planktons keep it in check. The wastewater treatment in fish ponds is a direct contributor in reducing the GHGs to a great extent. A single STP treating the same amount sewage with similar efficiency to EKW would emit ~3500 tonnes of CO2 per year. EKW on the other hand due to its natural system of using solar energy is saving Kolkata city from ~3500 tonnes of CO2 per year (Mukherjee and Bardhan, 2019). Therefore, urban wetlands like EKW contribute towards urban resilience which is crucial for climate change mitigation and urban sustainability.

2.4 Species and Habitat

The biota of EKW co-exists within a mosaic of densely populated and intensely fragmented landscape.Over last hundred years or more, the EKW has undergone changes in salinity regimes with corresponding drastic changes in floral and faunal diversity. The review of literature indicates that wetland harboured a rich floral and faunal diversity when connected to the freshwater and tidal regimes. But presently, with the wetland being predominantly managed as a sewage fed aquaculture system, only a limited range of species is supported. Disappearance of marshes for development of aquaculture has seriously affected diversity.

2.4.1 Vegetation

The BSI has prepared a list of noteworthy plant species of EKW which is also incorporated in (Chandra, Raghunathan and Mao 2020). The list includes 381 species of 93 families (Fig 16). The first comprehensive study on flora of Salt Lake was carried out in the early nineteen twenties, wherein 70 species of plants from various zones distributed within embankments, main wetland and terrestrial area were recorded (Biswas 1927). The vegetation of the embankments and bunds was mostly colonized by the plant species dominated *by Fimbristylus ferruginea, Suarda maritime, Acanthus illicifolius, Excoecaria agalocha, Avicennia officinalis* etc. The main wetland area

Picture 7. Diverse habitats in East Kolkata Wetlands

was dominated by numerous algal species, in the deeper pockets of the wetland area and tall vegetation dominated by *Phragmites karka, Aegiceras majus, Typha elephantine* etc. The swamps and dry lands were mostly dominated by oligihaline and mesohaline shrubby plant species and several halophytic trees like *Sonnerata apetala, Avicennia officianalis*. A number of filamentous algae *Enteromorpha intestinalis, E. prolifera* etc) have been also reported. (De et al., 1989) recorded 97 plant species belonging to 41 families, among which 34 species were confined to saline water habitat. He also mentioned the presence of mangrove flora in the region. However, the recent study carried out by (Ghosh and Ghosh, 2003) a total of 106 aquatic plants belonging to 70 genera and 36 families have been reported. Some other studies also reported 96 species under 79 genera and 38 families (IWMED 2004). Among which there is hardly any submerged vegetation in the core fishing area except the plankton communities.

From the earlier studies it is inferred that in the past,Salt Lake supported rich vegetation including mangroves and other brackish-water species. Till date there are some remnants of earlier salt water vegetation like *Excoecaria agallocha, Achrostichum aureum and Acanthus ilicifolius.*However, distribution of these species is very sparse.

EKW harbours a variety of economically important plant species. Some of these plants have tremendous medicinal value and used traditionally by the communities for human and veterinary consumption. Besides several plant species such as *Bacopa monnieri, Enhydra fluctuans, Ipomea aquatica, Marsilea minuta* are used as vegetables by the local communities. *Cyperous rotundous, Phragmities karka and Typha angustifolia* are used by the local communities for thatching as well as for pulp, fibre and other uses. Several aquatic plants are used as green compost and manure apart from their usage as food for fish and water purification.

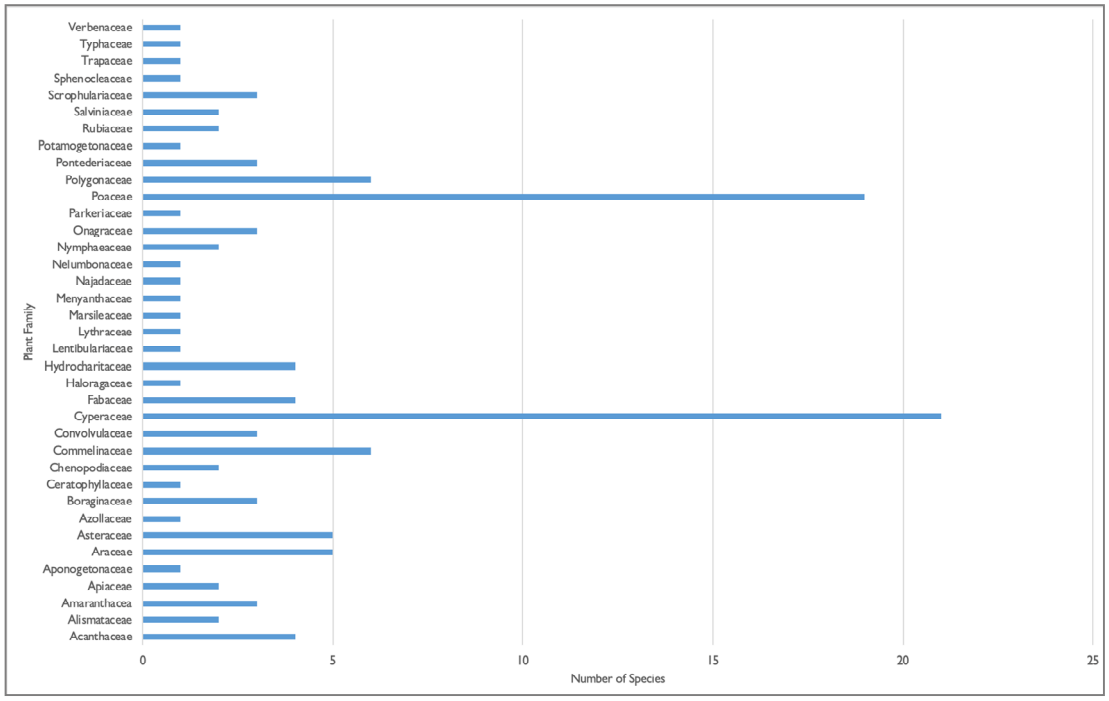


Figure 16. Distribution of noteworthy plant species found in East Kolkata Wetlands

2.4.2 Amphibia and Reptiles

ZSI has listed the presence of 10 amphibians and 29 reptiles from EKW (EKWMA, 2020). The reptiles include 9 lizard, 1 turtle, and 19 snake species. The invertebrates as well as lower vertebrates including fish and amphibian provide food to the reptilian species. A survey carried out between 1980 –
1995 indicated occurrence of 19 reptilian species overall including 2 species of snake, 2 of monitor lizard, 3 of common lizard and 1 species of fresh water tortoise.

2.4.3 Birds

In 2016, the EKWMA published a compilation of 267 bird species recorded in EKW since 1964 (EKWMA 2016). The list includes 93 waterbirds of which 36 are migratory. Zoological Survey of India carried out one of the first surveys of birds in EKW during 1964- 1969, wherein 248 species. Of these, only 162 species have variably noted during last 30 years. Moreover, at least 16 species have not been recorded after 1978-83 survey. Prakriti Samsad recorded 123 species of birds from Salt Lakes during 1978-83. Some of the land birds, bush lark, red-winged bush lark, pranklin's wren warbler has been recorded during this survey, but never before or after. It is likely that the reclamation of marshes and changes inflicted on aquatic and other species resulted in absence of larger species of birds like the Openbill Stork, Spoonbill and many other species of ducks and teals including Red crested Pochard, Tufted Pochard, Baer's Pochard, Brahminy Duck, Comb Duck, Bar-headed Goose etc. Additionally, the birds of prey like Brahminy Kite, Pallas's Fishing Eagle, Osprey and Laggar Falcon (and now Vultures) which used to be common in recent past are now no longer seen. The observation from annual bird population estimation under Asian Waterbird Census in Nalban bhery shows that still a handful of Gadwals, Garganeys, Snipes, gulls, Terns, Egrets and Cormorants also occur throughout the year though showing declining trends in population.

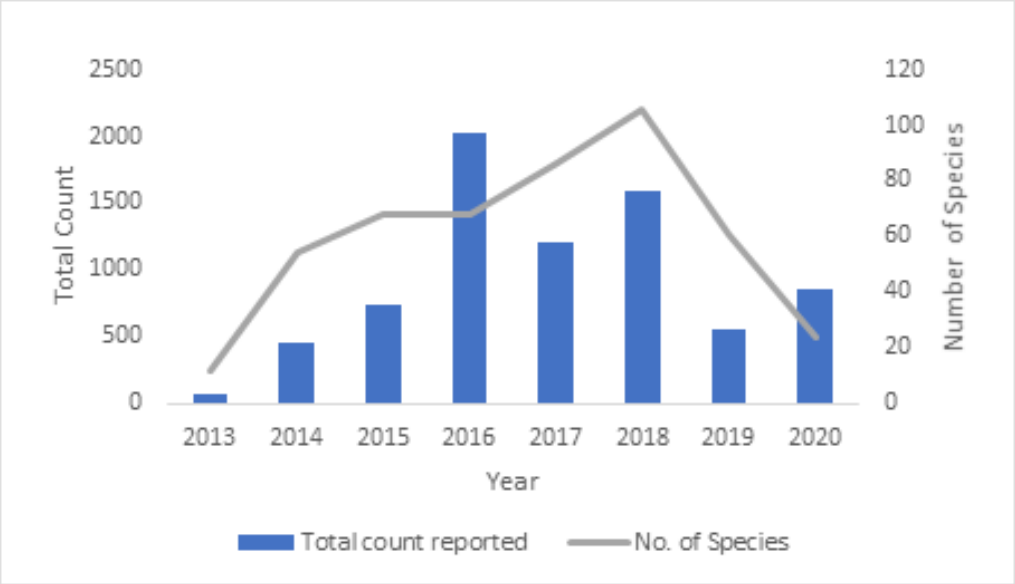
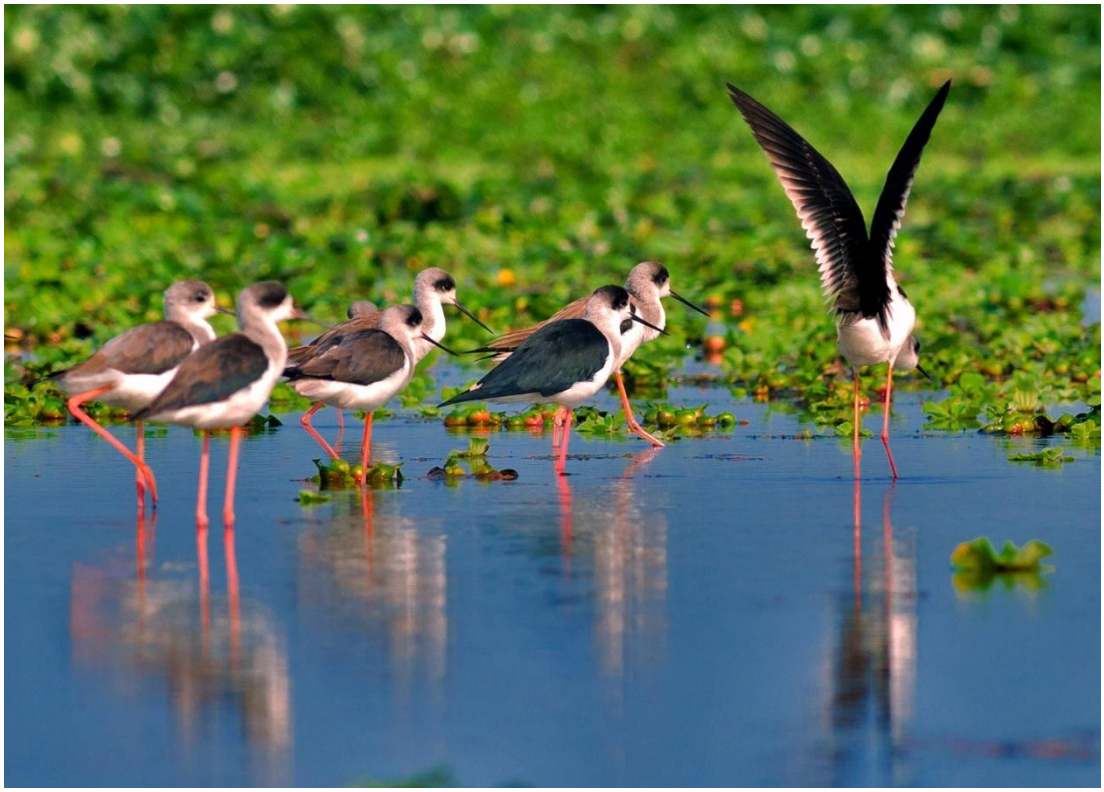


Figure 17. Bird count and species reported from Nalban Bhery



Picture 8. Black-winged Stilt in East Kolkata Wetlands (Credit: Kaushik Mukhopadhyay)

2.4.4 Mammals

ZSI has enlisted 13 mammal species from EKW. Marsh mongoose*Herpestes auropunctatus*is endemic to the region and also included in the schedule II of Indian Wildlife Protection Act, 1972(Mallick 2009).It borrows along the slopes of ponds and feeds on fishes and aquatic snails within the wetland.

Picture 9. A Marsh mongoose in East Kolkata Wetlands

2.4.5 Fish

The commercially important fin and shellfish in the EKW include 79 species of fish (Chandra, Raghunathan and Mao 2020), 11 species of prawns, 3 species of crabs and 20 species of molluscs (Mahapatra 2015). Among the fish species, 17 are culture species and 41 are wild species.

Traditionally, aquaculture in the EKW was predominantly of indigenous Indian Major Carps (IMC), (Rohu (Labeo rohita), Catla (Catla catla) and Mrigal (Cirrhinus mrigala), and sometimes minor carp Bata (*Labeo bata*). In the 60s, exotic fish species were introduced, which included Common carp (*Cyprinus carpio),*Silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenopharyngodon idella*) and Mozambique tilapia (*Oreochromis mossmbicus*). The Nile tilapia (*Oreochromis niloticus*) has replaced Mozambique tilapia in recent times. In limited quantities, Walking catfish (*Clarias batrachus*) and striped catfish (*Pangasianodon hypophthalmus*) are also produced, and attempts made to introduce Seabass (*Lates calcarifer*) enhance farm incomes (Bunting, Pretty, and Edwards 2010). 27 ornamental fish species of 21 families have also been recorded from EKW (Mahapatra and Lakra 2014).

Previously the fish fauna in the EKW system comprised both brackish water and fresh water forms. (Biswas1969) reported occurrence of 80 species of fishes from the Salt Lake. The low-lying region with saltwater lakes acting as spill reservoirs for the Bidyadhari were utilized for farming of brackish water fish such as Bhetki (*Lates calcarifer*), Parse (*Mugil parsia*), Bhangar (*Mugil tada*) and Prawns (*Macrobrachium rosenbergii*), etc. (Ghosh and Sen, 1987). (De et al., 1989), has reported occurrence of 40 fish species from EKW. CIFRI has observed entry of 4 exotic species (Crocodile fish) in EKW in recent years. Exotics *Clarius guriepinnus* and *Pangasius sutchi* have also been recorded from the aqua culture farm.

Indigenous species *Nandous nandus* and *Xenentodon cancila* which were abundant during 1980's has not been recorded at present. The rapid spread and population increase of suckermouth armoured catfishes belonging to the genus *Pterygoplichthys* (*Loricariidae*) in EKW in recent times is of increasing concern, because of the notable possibility that these non-native catfishes are adversely affecting fish germplasm and commercial fishery of this unique ecosystem (Hussan et al. 2019).

2.5 Livelihoods and Resource Linkages

2.5.1 Demographic features

The EKWhas 37 mouzas or revenue villages, covering two districts North 24 Parganas and South 24 Parganas Districts. The EKW area falls under two Municipal Corporations and seven Gram Panchayats. In South 24 Parganas, there are seven Gram Panchayats – Beonta I, Beonta II, Bamanghata, Tardaha, Kheyadaha I, Kheyadaha II, and Pratapnagar – that cover a majority of these mouzas. The majority of the wetlands area in North 24 Parganas comes under the jurisdiction of the Ward 35 and 36 of the Bidhannagar Municipal Corporation. There are six mouzas within the Kolkata Municipal Corporation jurisdiction (Chakraborty and Gupta 2019).

The human settlements fringe the fish farms and are located mostly towards south of the DWF channel or towards the eastern parts of the wetland. Settlements on the western periphery adjoining the Eastern Metropolitan Bypass Road are comparatively larger as compared to those on the east. The total population of the 37 villages as per 2011 census was 1.15 million.

The overall population density of the wetland is 866 people per sq.km. as per 2011 census. Scheduled caste and tribes form 83% of the population. Livelihoods of the wetland communities are distinctly linked to wetland resources, with 74% of the working population drawing sustenance through engagement in fish farming, agriculture and horticulture. The rest of the population seeks livelihoods through seeking employment within the metropolis and its associated areas.

Assessment of trends in population growth rates indicates a continuous increase since 1951 with a marginal decline during the decade 1981-91. This trend broadly is commensurate with the overall trend of stabilization of population within Kolkata City, and rapid expansion of sub urban and peri-urban interfaces of the city, including the population within the wetland.

Picture 10. Life in East Kolkata Wetlands is closely linked to wetland health

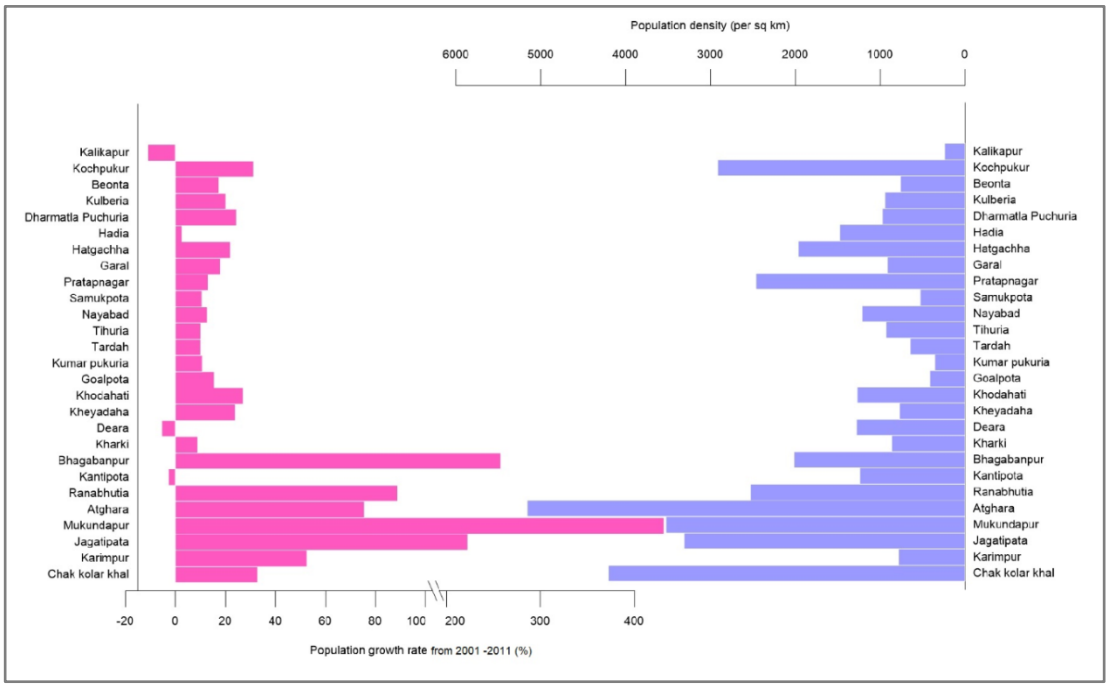


Figure 18. Population Density and Growth in East Kolkata Wetlands

Map 14. Mouza within East Kolkata Wetlands

For the purpose of management planning,a household survey of 30 respondents was undertaken covering a range of stakeholders to assess demographic trends, map their perceptions of wetland condition and their recommendations for wetland management. The limited survey was done due to restrictions imposed by CoVID-19 pandemic. The assessment indicates fish farming to be the primary source of income for 50% of the respondents, followed by agriculture and rag picking (Table 1).

Table 1. Perception ranking of responsibility for implementing wetland management measures

Occupation	Stakeholders					
	Agriculture farmers	Big Fish Farmers (area > 10 ha)	Cooperative fishers	Small Fish Farmers (area < 10 ha)	Vegetable farmers	Waste-collectors
Fish farming	7%	100%	100%	100%		
Agriculture	100%		20%	40%		
Vegetable farming					100%	
Small Shopkeeping						
Labour	100%					
Government Service						
Private Service						
Others					20%	100%

Access to social amenities within the wetland communities is limited leading to lower quality of life. The survey data shows very low levels of literacy amongst the respondents with 23% of the respondents illiterate and 33% of whom have attended class till V.

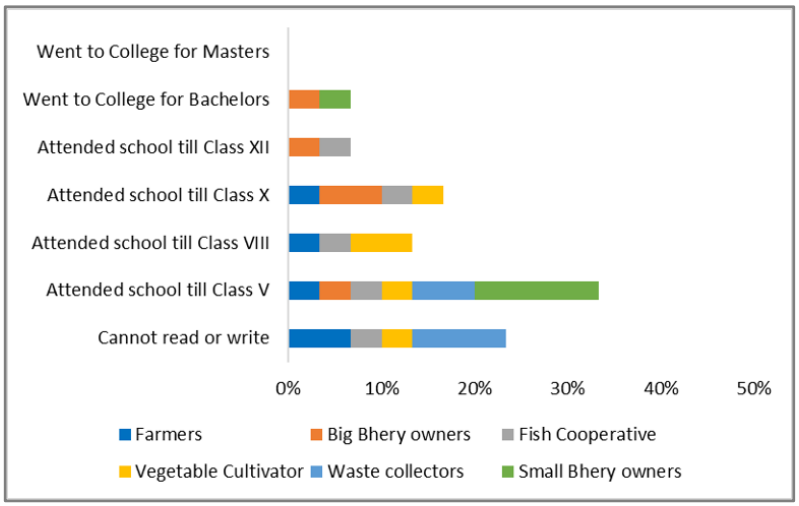


Figure 19. Education level of communities living in East Kolkata Wetlands

The survey also highlights inadequacy amongst stakeholders in terms of assets owned and access to social amenities. As per the survey, 59% of the families have kachha houses and 30% of families do not have separate bathrooms and cooking areas. Amongst the most striking disparities exist between rag pickers and the small bhery workers in terms of assets. Of all the respondents 94% of land ownership within EKW is of big bhery owners.

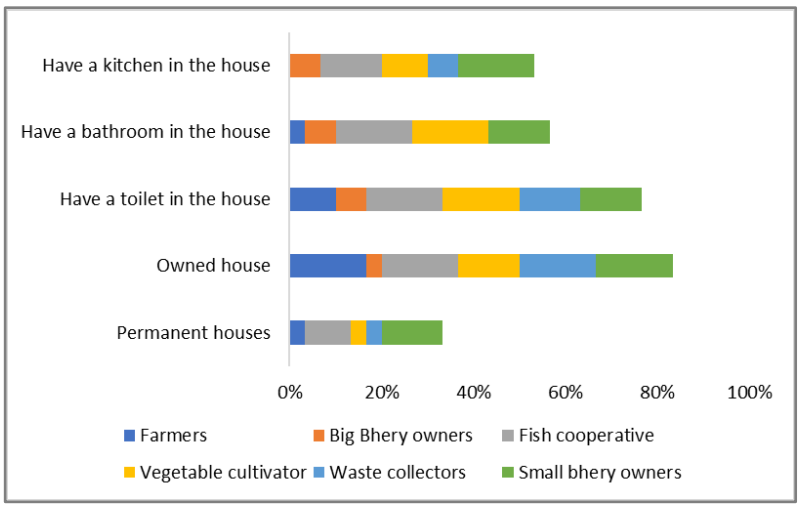


Figure 20. Possession of assets by communities living in East Kolkata Wetlands

2.5.2 Resource linkages

Ecosystem services, the benefits people receive from wetlands, provide the foundation of assessing wetlands-livelihoods inter linkages. Direct dependence on EKW is in the form of fish farming, agriculture and horticulture.

Picture 11. Sewage fed fish farming has evolved traditionally in East Kolkata Wetlands

2.5.2.1 Sewage fed fish farming

The traditional technology

Sewage fed fisheries form the dominant resource use within EKW. Over 250 fishponds (locally called bhery) receive sewage for culturing fish, and in the process remove nutrients and other heavy metals rendering wastewater treatment to the City of Kolkata. The practise has been continuing since the 1940s after an enterprising fish farmer discovered the virtue of using sewage water for fish farming.

Dr Dhrubajyoti Ghosh, who is credited with bringing national and international attention to this waste recycling system has described the ecological processes underpinning this fish farming practice in his book „Ecology and Traditional Wetland Practice" (Ghosh 2005). The process is paraphrased in the following paragraphs.

The network of pumps brings in the sewage from the Kolkata City to the open channels called the Dry Weather Flow channels of the Kolkata Drainage Outfall System. A regulator at Bantala raises the level of sewage so that further movement to fish ponds can be ensured by a natural hydraulic gradient. The drainage network consisting an intricate web of primary, secondary, and tertiary canals was engineered in such a way that it could distribute wastewater using gravity to the majority of fisheries.

The fish farms receive sewage in wastewater stabilisation pond. These shallow ponds create conditions more favourable condition for photosynthesis and full vertical circulation of water to the surface where algal blooms occur. The algae–bacteria symbiosis allows for efficient BOD and pathogen/faecal coliform reduction. The sunlight supports photosynthesis and the rapid growth of plankton, which helps degrade organic matter. Water hyacinth plays a special role in the functioning of this complex ecosystem by leaching out heavy metal ions from the surrounding water, with its dense root system acting as biofilters for the passive remediation of wastewater. The overgrowth of plankton is controlled by fish which grazes the plankton.

Once every three to four years in January, the ponds are allowed to dry out in rotation through natural evaporation; the embankments are repaired and vegetable is grown on the dry bed. After harvesting the vegetables, the fishers dig silt traps, wherein the deposited silt is repairing banks. Just prior to the release of the sewage into the bhery, the dry ground is tilled, and lime is scattered over it to decrease the acidity of the pond waters, making them more suitable for the fish.

The fish species used for aquaculture occupy different ecological niches of the pond system. When the nutrient-rich effluent moves through the system, it is progressively cleaned, and nutrients are redirected to the growth of algae or agricultural products grown along the pond edges. The natural water purification saves the Kolkata nearly Rs. 4,680 million annually (Dey and Banerjee 2018).

Picture 12. A bamboo screen filters solid waste from sewage before being brought into the fish farm

Fish production and productivity

The last detailed assessment of the number of bhery in EKW was done close to 2000, wherein approximately 260 numbers were counted. The size of bhery ranged roughly between 5 and 50 ha. Smaller fisheries under 2 ha exist mainly in Sonarpur and Tiljala, while large fisheries over 40 ha predominate in Bidhannagar; Bhangar is characterised by a mixture of small to medium-sized fisheries. Over 80 per cent of the bhery are under 20 ha in size, occupying approximately 30–40% of the total fishery area. The two state-owned fisheries, Nalban and Goltala, are the largest, comprising about 165 ha and 115 ha, respectively.

Fish yield in the EKW is two–four times higher than that of ordinary fish ponds. The yield is positively correlated to the area of the fish pond, increasing up to 6.5 MT where the effective area of the water body was above 70 ha (Ghosh 1999). The average annual fish production from the EKW during 2015-2020 (as per records of the Fisheries Department) has been estimated to be 22,000 MT. This compares well to the production of around 18,000 MT reported in 2002

(Bunting, S W, Kundu, N, and Mukherjee, M 2002; Bunting, Pretty, and Edwards 2010). However, the increase in the fishing area is not commensurate with fish production, indicating a possible decline in productivity.

The location of a bhery, i.e., its distance from the DWF canal is also a key variable determining the productivity and profit returns. Usually, a bhery located further from the DWF canal and smaller in size have a lower profitability as compared with those which are larger and located closer to the main canal.

Picture 13. Nutrient in sewage in directed to vegetation growth and fish

Fisheries management

The bhery are under three forms of ownership: a) government; b) cooperatives, and c) private. Bhery ownership by cooperatives has gradually reduced (from 27% to 6% during 2002-15) (Mukherjee 2020). Private fish pond owners rarely participate directly in fish growing but have leased out to leaseholders, who basically concentrate on how to minimise the cost of production. Many worker-run non-registered cooperatives have also leased out to leaseholders due to inability to generate capital (Chakraborty and Gupta 2019).

Fish is traded through seven auction markets: Chingrighata, Kestopur, Bamanghata, Bantala, Chowbaga, Garia, and Gangajoara. Chingrighata is the biggest market with an average daily sale of about 13 MT.

A multi-stakeholder analysis for EKW fisheries conducted by Forum for Policy Dialogue on Water Conflicts in India (Chakraborty and Gupta 2019) listed out the following issues related to the management of EKW fisheries:

- Cooperatives are apprehensive of the imminent threats of corporatization of cooperatives since the fisheries department has opted for the tender route of awarding license in recent years.
- The decline in sewage quantity and quality affects the fisheries as well as of the fishers.
- De-siltation of the fish ponds along with re-excavation of the canal distribution network

Food safety and health concerns

The safety of fish produced for human consumption from EKW has been questioned in recent times, as the sewage quality has changed. The 2019 CPCB report to the National Wetlands Committee (CPCB 2019) highlights the transformed character of sewage in its report as thus:

"We are no longer speaking of the raw sewage of the kind that entered the East Kolkata Wetlands when the bhery were established in 1920-30. Today industrial effluent makes up about 20% of Kolkata's daily total liquid waste and most of the untreated liquid mixes with Kolkata's stormwater and sewage, industrial runoff and household liquids are all mixed and end up in multiple canals that drain the city. The sewage that enters the Wetlands is a composite biodegradable and toxic, non-biodegradable matter, including a range of heavy metals. "

Monitoring records of WBPCB do not indicate presence of heavy metals in any of the sampling sites, However, heavy metal contamination in sewage has been indicated by several recent studies (Vicziany, Chattopadhyay, and Bhattacharyya 2017; Nandi et al., 2013; Sarkar et al., 2011; Joystu 2017). Though, there have been arguments that heavy metal accumulation was within safe levels within the fish muscles (the part that is generally eaten), and cooking at high temperatures reduces the concentrations, this fact has been contested (Nath and Bhoumik 2013) and close monitoring of bioaccumulation recommended (Kumar et al., 2010). Table 2 reproduces data on heavy metal concentrations in select fish species of EKW from (CPCB 2019).

Epidemiological evidences suggest that the communities living within the wetland are subjected to various kinds of diseases. Workers employed on the fish farms experience a range of health problems predominantly diarrhoea and those related to nutritional deficiencies revealed by the presence of anaemia, oedema, night blindness, and bleeding gums.

Vibrio parahaemolyticus, one of the most important diarrhoea-causing agent (after V. cholerae) in the Kolkata area, has been found in the intestines of fish from EKW (Das and Mandal 2018) suggesting why there is a high rate of diarrhoea amongst the workers.

Table 2. Concentration of heavy metals (mg/kg) for select fish samples

Fish species	Muscle	Liver	Gill
Tilapia Nilotica	Pb: 0.52 – 7.91 Cd: 0.07 – 0.75 Cr: 41.02 – 65.29	Pb: 0 – 7.93 Cd: 0.14 – 5.18 Cr: 0 – 33.09	Pb: 2.64 – 14.77 Cd: 0.06 – 1.08 Cr: 3.69 – 57.35
Tilapia Mosambica	Pb: 0 – 4.52 Cd: 0.04 – 0.09 Cr: 0 -4.55	Pb: 0 – 4.66 Cd: 0.24 -4.36 Cr: 16.82 – 43.54	Pb: 3.76 – 18.19 Cd: 0.08 – 1.19 Cr: 0 – 28.56
Labeo Rohita	Pb: 0 – 7.38 Cd: 0.05 – 0.67 Cr: 0 -63.29	Pb: 0 – 6.63 Cd: 0.16 – 0.2 Cr: 0 – 29.9	Pb: 6.94 - 26.50 Cd: 0.2 – 0.21 Cr: 0 – 42.93

(WHO and FAO permissible levels in fish tissue: Pb = 0.5 mg/kg; Cd = 0.5 mg/kg and Cr = 0.15 mg/kg)

Industrial effluents within the vicinity of EKW include the Bantala Leather Complex, which is located outside the boundaries of the wetland, and several old tanneries located in the eastern part of Kolkata Municipal Corporation. The Bantala Leather Complex was a response to Supreme Court order of 1992 to relocate the over 500 tanneries that had come about in Topsia and Tangra stretches of the municipality. However, leather shavings dumped along the EKW are a cause for worry and need to be monitor regularly.

2.5.2.2 Agriculture

Rice is cultivated using effluent water from the bhery, covering an area of 2637 ha. Rice cultivation is one of the major livelihoods within the wetland followed by cultivation of vegetables. In a study by Mukherjee et al 2013 efforts were made compare rice cultivation from untreated sewage water from the bhery and rice cultivation using ground water. The study concludes that rice harvest is less profitable when ground water is used.

Labour employed within the paddy fields are employed on a casual basis and therefore lack security of regular income. Labourers working for rice farmers usually have their own farms, yet work on the fields of larger farmers to earn extra incomes.

Picture 14. Agriculture forms the terminal use of sewage in East Kolkata Wetlands

2.5.2.3 Horticulture

Approximately 244 ha of agricultural farms are located within the EKW, and particularly in and around the Dhapa landfill area. There are around 3000 farm plots in Dhapa, ranging between 0.03 and 0.2ha, employing over 4000 people (Mukherjee and Ghosh 2015). Tradition of organic waste reuse forms the base of horticulture concentrated within Dhapa landfill areas. Organic waste makes the soil conditions extremely fertile and it is a common practice for farmers to crop 3-5 different varieties of vegetables on the same land. 55% area is used for double-cropping, while the rest is used for three crops in a year (Kundu & Chakraborty 2017, Mukherjee 2020). Almost 15 different types of vegetable are gown in EKW; production is estimated at 150 Metric Tonnes annually (Mukherjee 2020).

Picture 15. Vegetable cultivation in Dhapa region

Vegetable production from EKW meets nearly 20% of the vegetable requirement of the Kolkata city. Proximity to the city, availability of water makes horticulture a household activity in EKW, farmers even rent small plots for raising vegetables (Kundu and Chakraborty 2017). Labour employment within the horticulture sector is on a casual basis depending upon the availability from the manager's own household and workload; during busy periods of planting and harvesting more labour is likely to be employed. There is also a tendency of seeking employment into neighbouring farms for extra incomes.

As in fisheries, concerns have been raised on the levels of heavy metal accumulation in the vegetables grown in EKW. Table 3 presents data from a 2019 report of CPCB indicating that such risks do exists.

Table 3. Heavy metal concentrations in select vegetable samples of East Kolkata Wetlands

Vegetable	Heavy metal concentration (mg/kg)
Brinjal (*Solanum melongena*)	Pb: 6.32 – 10.2 Cd: 0.175-0.176 Cr: 23.89-26.62 Hg: BDL
Lal Shak (Root) (*Amaranthus cruentus*)	Pb: 17.16-89.82 Cd: 0.35-0.36 Cr: 35.22-67.73 Hg: 0-0.021
Lal Shak (Leaves) (*Amaranthus cruentus*)	Pb: 11.47-60.23 Cd: 0.175-0.176 Cr: 14.9-16.74 Hg: 0-0.011
Cauliflower (*Brassica oleraceae*)	Pb: 5-10.96 Cd: 0.175 Cr: 7.52-13.33 Hg: BDL
Maize (*Zea mays*)	Pb: 0-5.63 Cd: 0.174-0.176 Cr: 0-9.26 Hg: BDL

(WHO and FAO permissible levels in vegetables: Pb = 5 mg/kg; Cd = 0.1 mg/kg; Cr = 20 mg/kg and Hg = 0.03 mg/kg)

2.5.2.4 Waste collectors

The Dhapa in EKW was initially conceived as garbage-dumping ground. Kolkata generates 1.6 million tonnes of municipal solid waste annually and 4500 tonnes a day, which is entirely dumped into Dhapa dumping area within EKW.

Previously Dhapa site employed over 25000 people, waste collectors looking for objects that could be re-recycled, collecting approximately 10% of the total solid waste.

2.5.3 Community perception on wetlands conditions

There is a general perception that the health of EKW needs to be protected (Figure 17). Nearly half of the respondents (47%) indicated that EKW condition is on the decline. Reduced inflow of sewage in EKW and siltation of bhery over the last 10 years were indicated as the most significant trends. Instances of diseases amongst family members have increased with 50% respondents agreeing. Respondents perceptions whether pressure of builders and realtors have increased in EKW in last 10 years seem to vary with 23% strongly agreeing and 27% agreeing and 23% disagreeing.

Picture 16. Community participation during survey on EKW

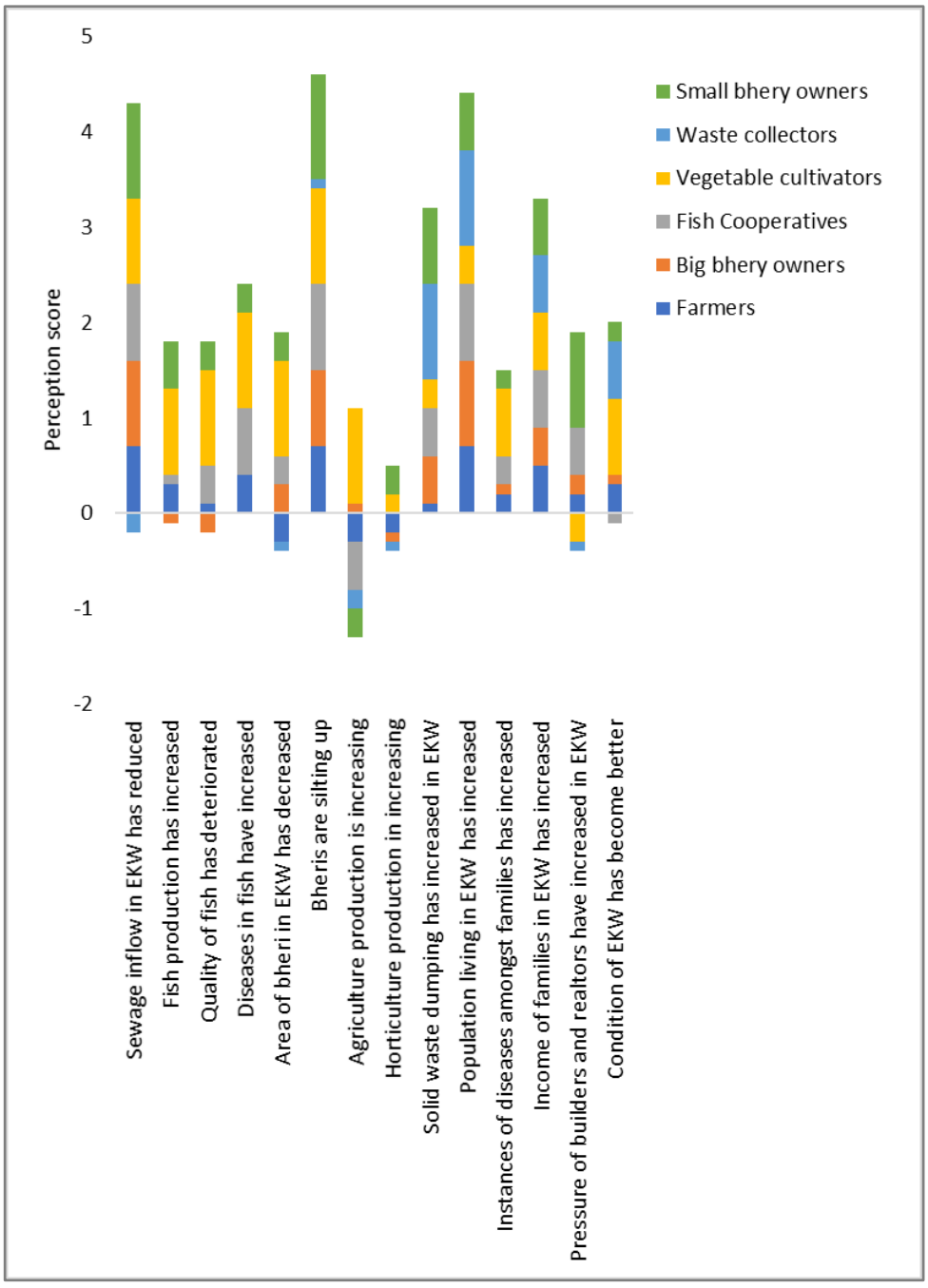


Figure 21. Community's perception score (6 to -6) of wetlands condition in the past decade

Perceptions of different occupation groups seem to vary when it comes to the condition of EKW over the last ten years. Agriculturists and waste collectors seem to disagree that the area of bhery has decreased over the last ten years where as respondents belonging to the groups of big bhery and fish cooperative seem to agree that bhery areas have decreased over the last 10 years.

Agriculture, big and small bhery groups seem to agree that diseases in fish may have increased over the last ten years. Apart from horticulture groups all the others state an increase in silt in the bhery. All the occupation groups don't strongly agree over the increase in agriculture and horticulture production. A majority of agriculture and big bhery groups agree that agriculture

production has increased over the last ten years, whereas rest of the groups disagree over the production increase of agriculture. All groups other than agriculturists and horticulturists perceive the threat of realtors has increased over the last 10 years.

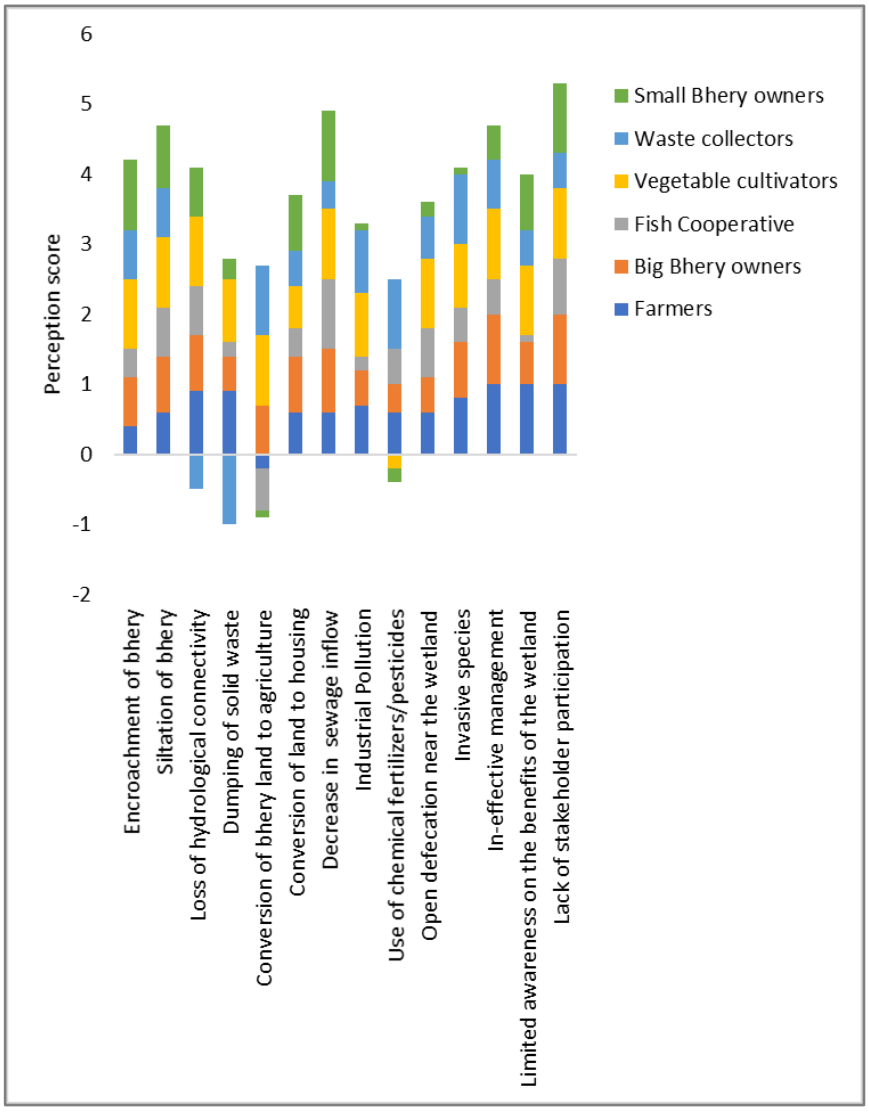


Figure 22. Community's perception score (6 to -6) of threat to wetlands

2.5.4 Community recommendations for wetland management

Improving income generation activities within EKW and provision of toilets and drinking water were the topmost choices for restoration measures followed by desiltation of bhery and channels (Figure 19). Improving awareness and stopping industrial discharge into the sewage were the other most sought out options for wetland management followed by improving tourism facilities within and strict enforcement of the EKW Act.

Community recommendations for wetland management vary across the stakeholder groups with a big bhery, fishing cooperatives and small bhery groups all choosing the options of stopping the Dhapa landfill. Small bhery groups seem to prefer reduction in fishing followed by stopping the Dhapa landfill and preventing encroachment of from builders. The perceived threat

from builders to small bhery operators and fish cooperatives seem larger compared with horticulture and agriculture groups. Agriculturists and waste collectors top most choice for wetland management is the enforcement of the EKW act. Stopping of industrial discharge in sewage were preferred by all groups in varying degree except for waste collectors.

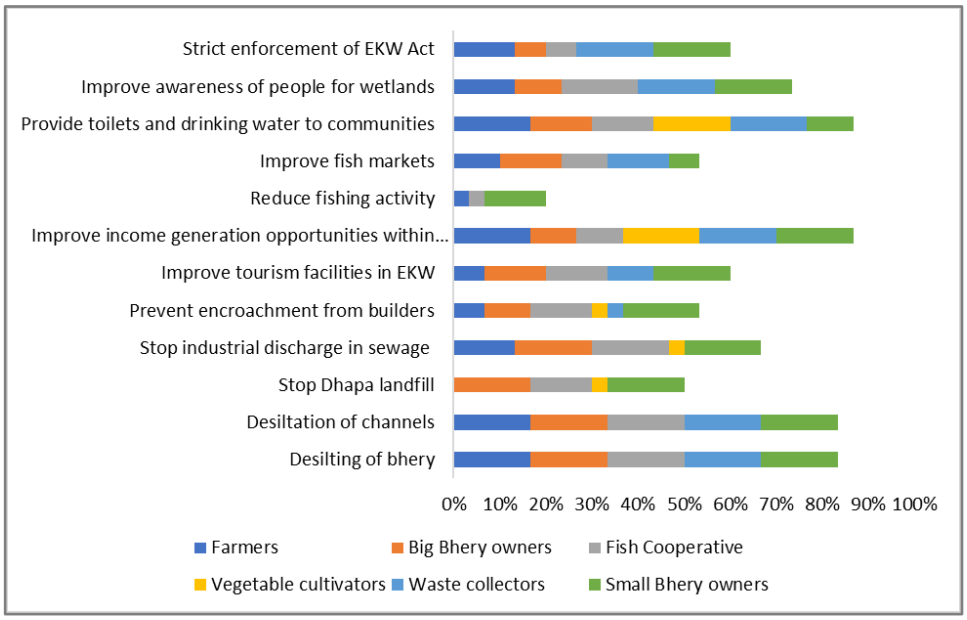


Figure 23. Stakeholder responses on agencies responsible for implementing various interventions in East Kolkata Wetlands

The respondents rank responsibility of Government of West Bengal as the highest for implementing the recommended measures followed by EKWMA and the central government (Figure 19). Implementation of measures such as desiltation of bhery and channels, income generation activities, provision of toilets and drinking water were all ranked to be implemented by Govt of West Bengal followed by EKWMA.

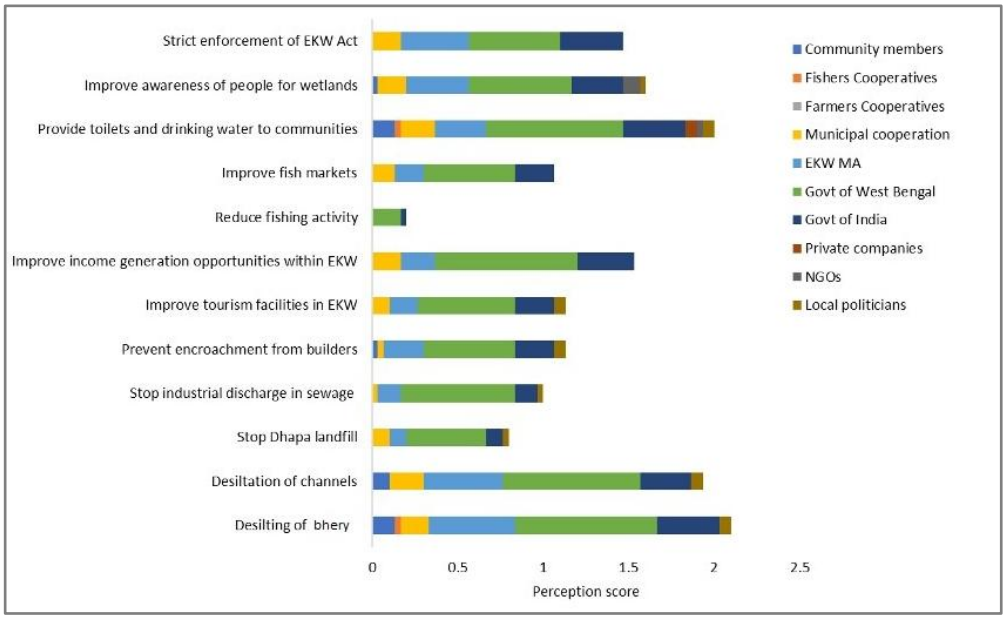


Figure 24. Perception ranking of responsibility for implementing wetland management measures

3 Evaluation of Wetland Features

India, as a signatory of the Ramsar Convention, is committed to achieving wise use of all wetlands in her territory. Wise use of wetlands is defined in the text of Ramsar Convention as 'the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development'. Ecological character is 'the combination of ecosystem components[2], processes[3] and services[4] that characterize the wetland at any given point in time.' Ecosystem Management of wetlands thus seeks to achieve the goal of 'maintenance of ecological character' or 'wetland wise use'.

Though sounding counter-intuitive, wise use as a wetland management approach is much wider than use of a wetland. The phrase 'in the context of sustainable development' recognizes that development, which may be inevitable in some cases, is not an objective for every wetland. Wherever development is to take place, it has to be facilitated in sustainable ways using approaches elaborated in the Convention (managing at basin scale, mainstreaming in urban developmental planning, participatory management amongst others). 'Ecosystem approaches' include the elements elaborated by the Convention on Biological Diversity – integrated management, stakeholders' participation in decision-making, transparency about trade-offs, and equitability of the outcomes. In totality, wise use is about 'maintaining the capability of the wetland' to support human well-being at present and in future, rather than 'use' or 'development' at present.

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

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

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

Changes to ecological character of wetlands outside natural variation may signal that uses of the site are unsustainable, and may lead to the breakdown of its ecological, biological and hydrological functioning (Ramsar Convention 1996, Resolution VI.1). Assessing and responding to risks of human induced adverse change in ecological character is therefore fundamental to achieving wise use of a wetland.

For wetland managers to be able to implement management that ensures maintenance of ecological character, it is important to identify and retain the site's essential ecological functions which underpin the wetland's ecosystem services and biodiversity. Implicit within this recommendation is the need to identify key elements of ecological character, maintaining which would constitute site's wise use. The extent to which ecological character is maintained and adverse human-induced changes prevented is reflected in these key features. Furthermore, a social-ecological systems perspective for defining and assessing ecological character enables consideration of the interactions social actors and institutions have with biophysical components of wetlands.

The Ramsar Convention's Guidelines for ecological character description are contained in Ramsar Resolution X.15. These elements have also been formally and systematically included in the 2015 revision of the Ramsar Information Sheet (RSIS) Format, which needs to be updated every six years.

This chapter of management plan presents an evaluation of ecological character of EKW, based on assessment of wetland features presented in previous chapter. A description of ecological character is provided herein, highlighting key elements maintenance of which may be the focus of management. Status and trends in the key elements are discussed next and followed by an analysis of threats and risks of adverse change in ecological character. The chapter concludes with a listing of the knowledge gaps.

3.1 Ecological Character Description

Located on the eastern fringes of Kolkata City and spanning 12,500 ha, East Kolkata Wetlands are a mosaic of landforms including predominantly water dominated areas (used as fish farms) to land centric usages for agriculture, horticulture and settlements. The existing wetland regime is a remnant of series of brackish wetlands connected to the freshwater as well as marine environments of the Gangetic Delta and the Bay of Bengal, in an ecological continuum with the Sundarbans.

Over 260 shallow fish ponds in the EKW receive over 900 MLD pre-settled sewage from the Kolkata Metropolitan region through a network of locally excavated secondary and tertiary canals, which is used to produce 20,000 MT of fish, 50,000 MT of vegetables and irrigate 4700 ha of paddy lands. As the nutrient-rich effluent moves through the system, it is progressively cleaned and nutrients are redirected to the growth of algae or agricultural products grown along the pond edges and agricultural lands. Algae and other aquatic plants are used to feed upto 17 species of fish cultured in these ponds, which in turn create nitrogen and phosphorus-rich water to irrigate the adjacent rice fields. The traditionally evolved natural water purification waste recovery practice saves the Kolkata City nearly Rs. 4,680 million annually in terms of treatment cost of upto 65% of the City's sewage. These wetlands also lock in over 60% of carbon from wastewater, thus reducing harmful Green House Gas emissions from the region.

The wetland is inhabited by diverse species. Atleast 120 plant, ten amphibians, 29 reptiles, 260 bird, 58 fish, 11 prawn, 3 mollusc, and 11 mammal species have been recorded from these wetlands. Marsh mongoose *Herpestes auropunctatus*is endemic to the region and also included in the schedule II of Indian Wildlife Protection Act, 1972.

The traditional waste recovery practice provides subsistence opportunities for a large, economically underprivileged population of 0.15 million living in over 37 mouzas within its boundaries. EKW is also one of the few natural habitats providing recreational avenues for the urban and peri-urban population.

East Kolkata Wetlands Management Authority is the nodal government agency mandated to ensure wise use of the wetland within the regulatory framework defined by the Wetlands (Conservation and Management) Rules, 2017 (notified under the Environment (Protection) Act, 1986) and the East Kolkata Wetlands (Conservation and Management) Act, 2006 and rules.

The ability of EKW to provide ecosystem services and sustain biological diversity is enabled by:

a) Ingenious use of pre-settled sewage received from Kolkata City for resource recovery through aquaculture, horticulture and irrigation.
b) Hydrological gradient which enables distribution of sewage to different parts of the wetland.
c) Water-hyacinth mediated phytoremediation enabling wastewater treatment.
d) Indigenous knowledge of the fish-farmers on management of fish ponds for cultivation of diverse species of fish.
e) Diverse habitats which enables a range of plant and animal species to survive.
f) Land use control as set under the provisions of East Kolkata (Conservation and Management) Act, 2006 and Wetlands (Conservation and Management) Rules, 2017.

3.2 Status and trends

Status and trends in key wetland features are presented in Table below, with reference to their condition at the time of Ramsar Site designation in 2002.

Table 4. Ecological Character Description

ECD descriptor	Current Condition (2018-2020)	Data source	Condition at time of Ramsar Site designation (2000 – 2002)	Data Source	Change description and evaluation (Adverse, Positive, Not Evaluated)
Wetland extent and regime					
Area	12500 ha	Sentinel 2B May 2019, Sentinel 2A November 2019	12500 ha	Landsat 5 November 2000	No change
Shape	Amoeba like	Sentinel 2B May 2019, Sentinel 2A November 2019	Amoeba like		No change
Area under fish farms	6100 ha	Sentinel 2B May 2019, Sentinel 2A November 2019	4431.21 ha	Landsat 5 November 2000	Increased. Positive change

Area under agriculture	3,350 ha	Sentinel 2B May 2019, Sentinel 2A November 2019	4,300 ha	Landsat 5 November 2000	A decrease in area under agriculture may reduce the capability of the landscape to treat wastewater. Adverse Change
Area under solid-waste dump	91 ha	Sentinel 2B May 2019, Sentinel 2A November 2019	49 ha	Landsat 5 ™ November 2000	Almost doubled in 2 decades Adverse Change
Settlement area inside wetlands	2400 ha	Sentinel 2B May 2019, Sentinel 2A November 2019	1560 ha	Landsat 5 ™ November 2000	Increased by over 50 %. An increase in settlements increases intensity of resource use as well as increases vulnerability of wetland communities. Adverse Change
Hydrological regimes					
Rainfall	1601 mm	Indian Meteorological Department	1383 mm	Indian Meteorological Department	The rainfall has increased. Not evaluated

Sewage inflow into wetland	Flow rate: ~ 900 MLD	CPCB, 2019	Flow rate: ~ 750 MLD	Ghosh, 2002	Positive change
Sewage distribution within different bhery and parts of wetlands	Fish farms in the southern use pumps to draw sewage				Not evaluated
Sedimentation	TSS: Inflows: 6-342 ppm Interim: 4-302 ppm Outflows: 8-462 ppm				Not evaluated
Sewage quality	*Inflows* BOD: 22 ppm (Average of 12 months) COD: 66.5 ppm (Average of 12 months) *Outflows* BOD: 11.8 ppm (Average of 12 months) COD: 47.1 ppm (Average of 12 months)	WBPCB, 2019-20 Inflows: Bantala to Bananghata Jalpath Interim: Kestopur canal after passing through the bhery. Outflows: Ghushighata after CLC	Inflows BOD:23 ppm COD:105 ppm Outflows: BOD:13 ppm COD: 80 ppm	Ghosh, 2002 Inflows: Bantala lock gate Outflows: Ghusiaghata lock gate	No Change.

Wetland Catchment					
Population density within catchment	866 people per km2		859 people km2		No change.
Development of waste treatment infrastructure within catchment	179 MLD	KMC Drainage Report 2020	120 MLD	Dey and Banerjee 2017	Impact not evaluated
Land use and land cover in the region adjoining the wetland	Surrounded by permanent settlements, built up areas dominant especially to the north and west.		59% of the area is agriculture followed by settlements.	MAP 2008	Built-up area around the wetland has increased, thus increasing runoff. Impact not evaluated
Species and Habitats	120 species 37 families of plants 10 amphibians 29 reptiles	ZSI			No baseline
Number of water-birds	267 bird species recorded since 1964, 90 aquatic 11 semi aquatic	EKWMA			Adverse change as nearly 30 species not sighted in recent times
Livelihood systems					
Number of people dependent on fisheries	20, 000	Mandal and Jana 2018	12, 000	MAP, 2008	Impact not evaluated

Number of people dependent on horticulture	4000	Mukherjee and Ghosh 2015	2640	Chakraborty and Gupta 2019	Impact not evaluated
Number of people engaged in waste collection and sorting	25,000	Mukherjee and Ghosh 2015	5000 people (2010)	Chakraborty and Gupta 2019	Impact not evaluated
Fish production	20,000 MT	Fisheries Department	18,000 MT	Bunting et al, 2010	No change
Vegetable production	50,000 Metric Tonnes annually, 150 MT per day	Kundu and Chakraborty 2017			Not assessed
Fish quality	Presence of heavy metals indicated	CPCB, 2019			Bioaccumulation may have increased health risks. Final report yet to come. Not evaluated

Health of wetland communities	Antibiotic residue and microbial counts are reported to be less than the permissible limit. Risks due to heavy metal contamination Skin problems of fish producers or catchers or other labourers who work in sewage ponds Fever, cholera, diarrhoea Edema of eyelids, tumour, congestion of nasal mucous membranes and pharynx, stuffiness of the head, and gastrointestinal, muscular, reproductive, neurological, and genetic malfunctions	Vicziany et al., 2017 Jana et al., 2018 Das and Mandal 2018 WBPCB 2014			Adverse Change
Institutions and Governance regimes					
Implementation of regulatory regimes	Over 350 violations of East Kolkata Wetlands (Conservation and Management) Act, 2006 recorded.				Adverse Change

3.3 Risk of adverse change in ecological character

Based on the analysis of status and trends, following factors of adverse change in ecological character have been identified. The management needs to address these risks through specific interventions.

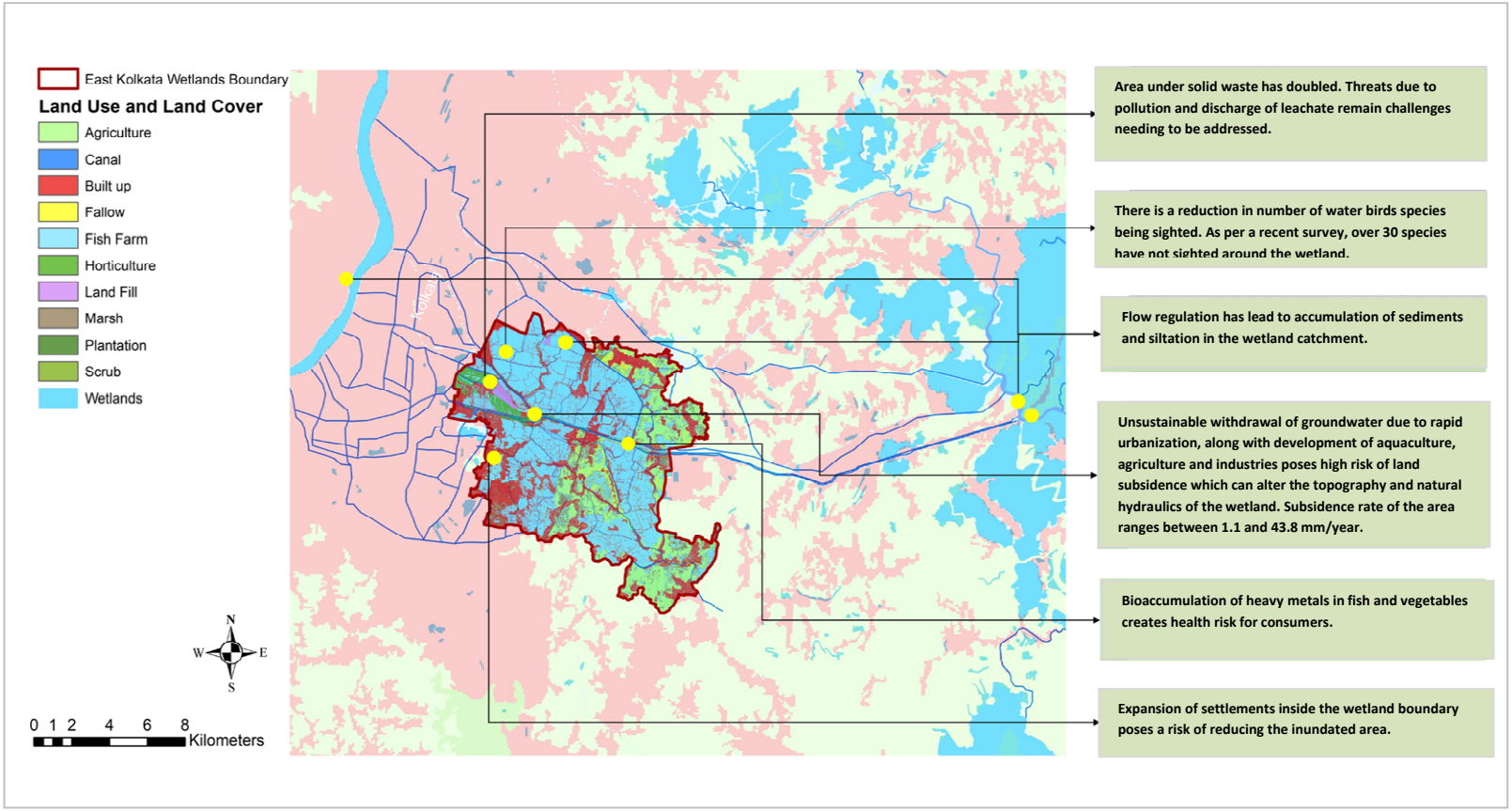


Figure 25. Major risks assessed in East Kolkata Wetlands

Table 5. Threats and associated impacts on East Kolkata Wetlands

Threats	Impacts (known / likely)
Encroachments	• Reduced waste treatment capability • Increased pressure on species habitats • Increased vulnerability of assets
Heavy metal contamination	• Health risks due to bioaccumulation
Solid waste dumping **A few plastic reprocessing units have cropped up along the Bantala, Basanti High Way Road side areas, in violation of the Plastic Waste Management Rules, 2016 and the Plastic Waste Management (Amendment) Rules, 2018. These illegal units emit toxic plumes, and create health risks for the communities.**	Reduced waste assimilation capacity of the wetland Adverse impacts on health of wetland communities
Land subsidence **The area around Salt Lake and Bantala is reported to have high rates of subsidence which can alter the topography and natural hydraulics of the wetland.**	Altered topography may adversely impact natural hydrology
Sedimentation of channels **Fish farms located away from Dry Weather Flow channel are not flushed naturally and have relatively higher rates of sedimentation. Several fish farms in the Southern part of the wetland need to use electrical pumps to draw sewage.**	Reduced access to sewage increases energy usage for pumping, reducing overall efficiency of waste water treatment
Invasive species **The rapid spread and population increase of suckermouth armoured catfishes belonging to the genus *Pterygoplichthys* (*Loricariidae*) in EKW in recent times is of increasing concern, because of the notable possibility that these non-native catfishes may adversely affect fish germplasm and commercial fishery of this unique ecosystem.**	Adverse impacts on wetlands biota.

Climate Change impacts **Wetland communities are highly vulnerable to impacts of climate change, including risk of high floods and increase in temperature.**	Increased vulnerability of wetland communities

3.4 Key knowledge gaps

The current monitoring of wetland is limited to assessing land-use change through remote sensing, select water quality parameters, and fish production. Some of the major knowledge gaps include:

a) Climate vulnerability of wetland and risk mitigation options
b) Impacts of heavy metals on food production systems and consequent health risks
c) Impacts of soil waste dumping and plastic waste on wetland environment

4. Institutional Arrangements

The wise use principle of wetland management recognises that addressing wetland degradation requires incorporation of linkages human societies have with wetlands within all spheres of management. Institutions and governance systems structure the relationship human societies have with wetlands, and thus, have an important bearing on wise use outcomes.

Institutions encompass all formal interactions among stakeholders and social structures that determine how decisions are taken and implemented, how power is exercised, and how responsibilities are distributed. Various collections of institutions come together to form governance systems, which include interactions between different centres of power in the society at different scales from local to global. Institutions and governance systems determine, to various degrees, the access to, and the control, allocation and distribution of components of nature and anthropogenic assets and benefits to people. Formal institutions are often embedded in informal institutions, which collectively define the overall institutional environment. Most importantly, institutions and governance influence the direct and indirect drivers of change in a wetland ecosystem. The degree of fit of institutions and governance systems with functioning of EKW at basin scale is one of the key determinants of wise use.

Wetlands are open systems and subject to the influence of a range of developmental planning and resources management decisions being implemented within their river basins and beyond. An important institutional pre-requisite is to ensure arrangements for cross-sectoral coordination, so that various programmes pursued by the different government as well as private agencies do not work for cross-purposes, generating adverse outcomes for wetlands. Institutions also need to be adaptable, to be able to accommodate new information and perspectives on wetlands, needs of diverse stakeholder groups, and an uncertain political environment. Since communities living in and around a wetland have a direct bearing on the ecological state, and often have nuanced management systems based on traditional knowledge, institutional arrangements need to have adequate representation of such communities and knowledge systems. The institutions also need an adequate regulatory backing to be able to enforce measures required to prevent detrimental activities around wetlands.

Institutional requirements for conservation and sustainable management of the EKW is defined by the ability to ensure integration of site management within broad scale environmental and developmental programming (at river basin scale), and enabling stakeholder participation. This section of the management plans contains an analysis of institutional arrangements in the context of integrated management of EKW.

4.1 Existing Institutional and Governance Arrangements

4.1.1 Government organizations

East Kolkata Wetlands Management Authority is the nodal agency constituted as per the provisions under the East Kolkata Wetlands (Conservation and Management) Act, 2006, most recently amended in March 2017 through The East Kolkata Wetlands (Conservation and Management) (Amendment) Act, 2017. The authority is constituted with the Secretaries of different state government departments (Environment, Land and Land Reforms and Refugee Relief and Rehabilitation, Fisheries, Forests, Panchayat and Rural Development, Irrigation and Waterways

and Tourism under the chairmanship of Minister-in-Charge, Environment Department of Government of West Bengal. Chief Secretary to Government of West Bengal is the Vice-Chairperson of the EKWMA. Secretary, Environment Department is the Member Secretary of the Authority. The Authority also includes four experts drawn from the fields of wetland ecology, hydrology, fisheries and socioeconomics. The authority has been entrusted with a range of responsibilities including:

- Demarcation of wetland boundaries
- Prevention of unauthorized development projects or unauthorized use of wetland area
- Enforcement of land use control and prevention, prohibition or regulation of developmental activities
- Management of wetland based on conservation principles and guided by management plan prepared in conformity with Ramsar guidelines
- Pollution abatement and conservation of flora and fauna
- Research on various aspects of wetlands
- Communication and outreach on values and functions of wetlands
- Networking with other Ramsar sites

The office of authority is housed within the Department of Environment and is headed by the Member Secretary. The Authority currently has 17 staff, functioning under the Chief Technical Officer (Table 7). Of these, three (including the Chief Technical Officer) are employees of Government of West Bengal and the rest are employed on ad-hoc basis.

Table 6. Staff strength in East Kolkata Wetlands Management Authority

Division	Number of officers	Function
Legal	1 Senior Law Officer *(@) 1 Technical Officer (Law) 1 Technical Assistant	Address all legal matters resulting from enforcement of EKWCM Act
Monitoring and Research	1 Technical Officer* (@) 1 Scientific Officer 2 Field Supervisors 5 Technical Assistants	GIS and Remote Sensing Environmental monitoring Scientific and technical documentation
Accounts	2 Technical Assistants	Maintenance of accounts and preparation of financial statement of the Authority
Office Support	3 peons	Office assistance

(* = head of the division, @ = permanent employee of Government of West Bengal)

Picture 17. Demolition of illegal structures in East Kolkata Wetlands is a major task of the Authority

Police authorities keep vigil on any unauthorised activities in the EKW, submit charge sheet within stipulated time and provide security in case of violation of law and order situation. The Authority also receives support from District Administration, Municipal Corporations, PWD and other Government Departments and agencies in the implementation of various activities.

*Department of Environment*is overall responsible for protection of the EKW as EKWMA is set up under this Department. West Bengal Pollution Control Board (WBPCB), Institute of Environmental Studies and Wetland Management (erstwhile IWMED) and West Bengal Biodiversity Board (WBBB) (three parastatal organisations within the Department) are responsible for research and monitoring activities. The Department has also constituted the West Bengal State Wetlands Authority as the nodal institutions for policy, regulation and management of wetlands at the state level.

*Department of Land & Land Reforms*has the authority for land transfer and conversion and has a pivotal role in management of land use in the EKW area. As per the operative legislation, all applications for conversion of land within the EKW are scrutinized by the EKWMA and based on their recommendations, such proposals are sanctioned by the Land & Land Reforms Department in exercise of powers under section 4C of The West Bengal Land Reforms Act (1955, most recently amended in 2017).

*Department of Irrigation & Waterways*manages the main drainage channels in EKW area namely dry weather flow (DWF), Storm Weather Flow (SWF) and Fishery Feeding canal (FFC). Fisheries get sewage from the intrinsic network of canals originating through these channels. This department also has the responsibility for flow of sewage, regulation of lock gates at Bantala and construction of lock gates and pumping stations.

Department of Fisheries is responsible for the production and improvement of the sewage fed fisheries in this area. The Department also operates two fisheries at Nalban and Goltala, and oversees functioning of fishery co-operatives.

Department of Forest is responsible for conservation and maintenance of various kinds of trees /plantation grown in non-forest areas included in EKW.

*Department of Panchayat & Rural Development*is focused on the non-urban areas which include parts of the EKW, and are authorized to sanction the building plans under (The West Bengal Panchayat Act, 1973 and as amended from time to time). According to the order of Panchayat Department dated 04.09.2014 "no Panchayat body shall accord approval to any building plan within the East Kolkata Wetlands area except in strict compliance with the provision of the East Kolkata Wetlands (Conservation and Management) Act, 2006 and the relevant rules under the said Act". The district planning committees are also empowered to co-ordinate development activities in parts of wetlands under their control. *Gram Panchayat (GP), Panchayat Samity and Zilla Parishad Local Govt.* are elected tiers in rural areas. GPs are amalgamations of 10-15 villages and ZPs consist of a number of Panchayat Samity. GPs and other tiers of panchyati-raj tiers have the critical role at the lowest levels of govt. in the WRR and are direct representatives of the residents of the WRR.

The Urban Development and Municipal Affairs Department sanctions building plans (including those for public amenities) within the urban areas of the EKW under *Kolkata Municipal Corporation (KMC)* and Bidhannagar Municipal Corporation (BMC). KMC is authorised to sanction building plan for its areas in the EKW; however NOC from the EKWMA is necessary according to the KMC order no. 18 of 2013-14 dated 31.01.2014. *KMC also* manages the discharge of city's sewage water from its pumping stations, solid waste disposal and land ownership of garbage farms at Dhapa.

*Agriculture Department*works for development of agriculture and allied sector in a holistic manner by ensuring farmers' access to skills, technologies, markets and financial inclusion.

Different parastatals of the Department of Environment

Institute of Environmental Studies and Wetland Management (IESWM)was established in 1986 by the Department of Fisheries. *It is one of the most prominent research organizations in the Waste Recycling Region (WRR).* Currently, IESWM is under the Department of Environment, Government of West Bengal.

West Bengal Pollution Control Board (WBPCB). Established in 1974, the WBPCB is the statutory authority for abatement and control of pollution. *West Bengal Biodiversity Board (WBBB)* is focused on inventorization and documentation of biodiversity of the State.

Scientific and research support is also provided by *Zoological Survey of India, Botanical Survey of India and Central Inland Fisheries Research Institute (CIFRI)*. A number of Universities in West Bengal are carrying out research projects and other activities related to sewage fisheries.

4.1.2 Fishery Cooperatives

Cooperatives (government as well as private) form a small proportion of EKW fishery, and their proportion has declined from 28% to 6% during 2002-2015 (Mukherjee 2020). Trends in increasing privatization of bhery has also been recorded in other studies (Chakraborty and Gupta 2019). Much of their interest is in production activities, and their engagement in EKW management issues is limited to that of sewage distribution and desiltation of inflowing channels.

4.1.3 Rules and Regulations

The East Kolkata Wetlands (Conservation and Management) Act, 2006 defines the boundary of the wetland and also sets the regulatory regime for EKW. The Act stipulates maintenance of preservation of wetland area, maintenance of its ecological character and land use as settled on the date of promulgation of rules. A process for change in land use has also been laid down – although the broader mandate remains in favour of preserving current/existing land use. The EKWMA has been regularly filing cases upon contravention of these rules, and as on date, over 350 FIRs have been filed by the Authority in eight police stations having jurisdiction over the wetland area.

The West Bengal Inland Fisheries Act, 1984 (amended in 1993) accords the right to the State Government for regulating fisheries for the purpose of conservation and propagation of fish by restricting a range of activities including engines, hydrological regulation, net size, and fishing methods. Section 17A specifies that no person shall put any water area including embankment, which is capable of being used as fisheries or any naturally or artificially depressed land holding, which retains water for more than six months in a year to such use, other than fisheries…. It further states that no person shall fill up any water area including embankment or naturally or artificially depressed land holding as aforesaid, with a view to converting into solid land for the purpose of any building thereon or for any other purpose, or divide any water area so as to make any such part for any purpose other than pisciculture. Section 8 of the Act provides for state government taking over management and control of any pisciculture tank, if the norms as laid under the Act are not being complied with, or taking over the fishery is in public interest.

The West Bengal Land Reform Act (1955) and its amendments regulate land use and assign the land rights holder the responsibility to ensure preservation of the character of land in line with the purpose for which the rights were given in the first place (Section 4B). A process for change in land use has been specified in the said Act. According to the notification vide no. 4297-LR/1A-05/GE(M) dated 17.09.2009, the District Land and Land Reforms Officer shall not make any order directing change of character of any land having water body unless he has made a prior consultation in writing with the Fisheries Department and the Environment Department. A 2016 notification by Environment Department (425/EN/O-42/2014) necessitates creation of compensatory waterbody in case where waterbodies are reclaimed for developmental purposes, and authorizes West Bengal Pollution Control Board, through its regional offices in different locations to receive, examine and authorize proposal received from respective district land and land reforms officers for conversion or alteration of water bodies, except EKW.

In 2017, the Ministry of Environment, Forest and Climate Change (MoEFCC) notified the Wetlands (Conservation and Management) Rules, 2017 under the Environment (Protection) Act, 1986. The Act is applicable to all Ramsar sites and wetlands notified under these rules. Solid waste dumping and discharge of untreated waste and effluents from industries, cities, towns and villages have been listed under prohibited activities in the notified wetlands. Similarly, construction of any permanent nature has been prohibited. Meeting these conditions in EKW is difficult as the sewage from Kolkata is the major inflow source, and the wetland is inhabited by nearly 0.15 million people.

Besides the Wetlands Rules, The Indian Forest Act, 1927 and the Indian Wildlife (Protection) Act, 1972, The Indian Fisheries Act, 1897, The Water (Prevention and Control of Pollution) Act, 1974, The Environment (Protection) Act, 1986 and The Biological Diversity Act, 2002

provide substantive legal and regulatory framework for conservation of Indian wetlands including EKW.

4.2 Gaps

The constitution of EKWMA has been hailed as a landmark in wetlands conservation in India, as it was the first wetlands authority to be backed by legislation. With increasing developmental pressures, the need for integrated management has become pertinent. The multiplicity of organizations and laws effecting different parts of the wetlands and different ecosystem components (water, land, fish, biota) makes compliance a chalange.

Strenght, weakness, opportunities and threats (SWOT) annalisis of EKWMA are summarized in Table 7.

Table 7. SWOT Analysis of current institutional arrangements for EKW management

Strength	Weakness
• **EKW presents a unique wetland wise use model – balancing human use with goal of maintenance of ecological character.** • **Ramsar designation commits the state government and the central government to conserving wetland character and putting in place effective management arrangements for the same.** • **EKWMA provides an institutional architecture for resolving inter-departmental conflicts.** • **Wetlands (Conservation and Management) Rules, 2017 and East Kolkata Wetlands (Conservation and Management) Act, 2006 provide a robust regulatory framework for addressing developmental threats on the wetland.**	• EKWMA has modest human and financial resources to deliver wetland management related functions. • Much of available management resources are used for enforcement of extant rules and regulation. • Current structure of EKWMA does not allow for robust stakeholder engagement. • EKWMA does not have a comprehensive wetlands inventory, assessment and monitoring system to assess changes in wetland character and determine management response options. • Penal measures/procedures are not explicitly defined in the Wetlands (Conservation and Management) Rules, 2017 which is currently used for regulating different developmental activities in the wetland. However, it is clearly mentioned in the East Kolkata Wetlands (Conservation & Management) Act, 2006. • EKWMA operates through district administrative machineries, who are burdened with a large number of other responsibilities. • Multiplicity of agencies and government departments managing different aspects of wetland requires much coordination. • Integration of wetlands conservation with plans for climate change and disaster risk reduction is limited. • Mechanisms for aligning developmental planning within the inflowing catchments and downstream areas needs strengthening.
Opportunities	**Threats**
• **The information on wetland functioning and biodiversity values has improved thus creating a robust basis for adaptive management.** • **Management zoning may help resolve conflicts over land use and also help balance multiple interests.** • **A vibrant civil society network exists which can play a bridging**	• Commercial interests due to high market value of the land in Kolkata Metro pose a threat to wetlands conservation. • Legal framework forEKWis litigated. The State's East Kolkata Wetlands (Conservation and Management) Act, 2006 and the Wetlands (Conservation and Management) Rules, 2017 are the subject matter of writ petitions in the Hon'ble High Court

role between government and EKW communities to support integrated management of the wetland.	

4.3 Proposed Arrangements

*Reorganization of EKWMA:*EKWMA requires a more efficient and results-oriented institutional structure, and gradual shift from an enforcement role to a strategic role in wetland management. A reorganised set up may include following units:

a) Wetland monitoring unit: Responsible for systematic wetland inventory, assessment and monitoring.
b) Engineering unit: Responsible for carrying out minor engineering and construction works.
c) Community engagement unit: Responsible for liaison with community and civil society organisations, and ensuring integration of community concerns within management actions.
d) Enforcement unit: Responsible for assessing adherence to the various regulatory provisions, and liaison with concerned state government department for ensuring action in case of violations.
e) Communication and outreach unit: Responsible for external communications, by a communications plan.

*Sustainable financing mechanism:*A gradual shift to financing through appropriate allocations within the state budgets would need to be made so that core wetland monitoring and management functions are not interrupted if the financing of projects is not available. EKWMA should also be capable of rendering consultancies and support to other states on wetland management issues, which could be an additional source of revenue.

*Policy coherence:*Development in and around EKW should be based on a single and coherent policy, which should guide various agencies in the design of various programmes. EKWMA should be consulted before implementation of developmental programmes, to ensure that no adverse impacts on the wetlands result from such interventions.

5 Management Framework

Management of EKW needs to be based on recognition of the full range of ecosystem services and biodiversity values of the wetland and their mainstreaming into developmental planning at all levels. The effectiveness of management will be reflected in the ability to sustain multiple use of the wetland, based on the traditional knowledge of resource recovery developed over time, without undermining the key ecological and social processes that underpin the functioning of EKW social-ecological system. Wise use of EKW will be realized when the capability of the wetland to provide its ecosystem services and sustain rich biota is maintained now as well as in future, on pathways that are aligned with ecosystem principles and guided by sustainable development. Sustainable development framework, as adopted in 2015, call for addressing five elements – People, Partnership, Planet, Peace and Prosperity.

The evaluation of wetland features, as summarized in Chapter 2 and 3 of the management plan and the institutional arrangements in Chapter 4 indicate that the current management arrangements are focused on regulation and select provisioning ecosystem services of the wetland, at the cost of regulating and supporting services. Most of the wetland features have been oriented to support production systems within the wetland. The sustainability of such a management approach is limited, as it is centres on a few wetland processes (primarily nutrient cycling) which are known to operate within ecological thresholds and if not managed within limits can cause the wetland system to change its state and functions.

As the impacts of climate change unfold over the Kolkata City and the Gangetic Delta, extreme precipitations, increase in temperatures and tropical cyclogenesis are likely to become more frequent. The ability of EKW to buffer extreme events, regulate local hydrology, as well as prevent release of harmful GHGs indicate the relevance of these wetlands in mitigation as well as adapting to climate change. At the same time, climate change and the ongoing developmental pressures may lead to intensification of exiting risks as well as creating new risks of the ecosystem, thereby calling for systematic monitoring, and periodic adaptation in management approaches on the basis of new information that is generated in the process.

The current chapter sets out the management planning framework, including setting the management goal and purpose, management strategy, objectives, targets and indicators, and likely risks and risk mitigation options pertaining to implementation of management plan.

5.1 Management Goal and Purpose

The goal of management planning is to '*maintain East Kolkata Wetlands in a healthy condition to enable delivery of its full range of ecosystem services and sustain biological diversity values'*.

The purpose of management is to *'enable natural infrastructure services to the Kolkata city in the form of wastewater treatment, flood buffering and climate regulation; providing livelihood opportunities for wetlands communities in food production; and sustain diversity of biota in the landscape'*.

5.2 Management Strategy

Building with Nature

Building with Nature (BwN) is a comprehensive engineering approach that seeks to enhance the use of natural ecological processes to achieve efficient and sustainable infrastructural designs to provide a set of desired benefits. The BwN concept for EKW is motivated and supported by nature that may also offer environmental, economic, and social benefits, while increasing resiliency.

EKW offers wide range of natural infrastructure that have multiple functionalities like that of a water treatment plant, flood buffer, carbon sink, sediment trap, fish farms, agricultural farms, horticulture farms, temperature regulators, rich biodiversity etc.

BwN will be enabled in EKW management through the following process

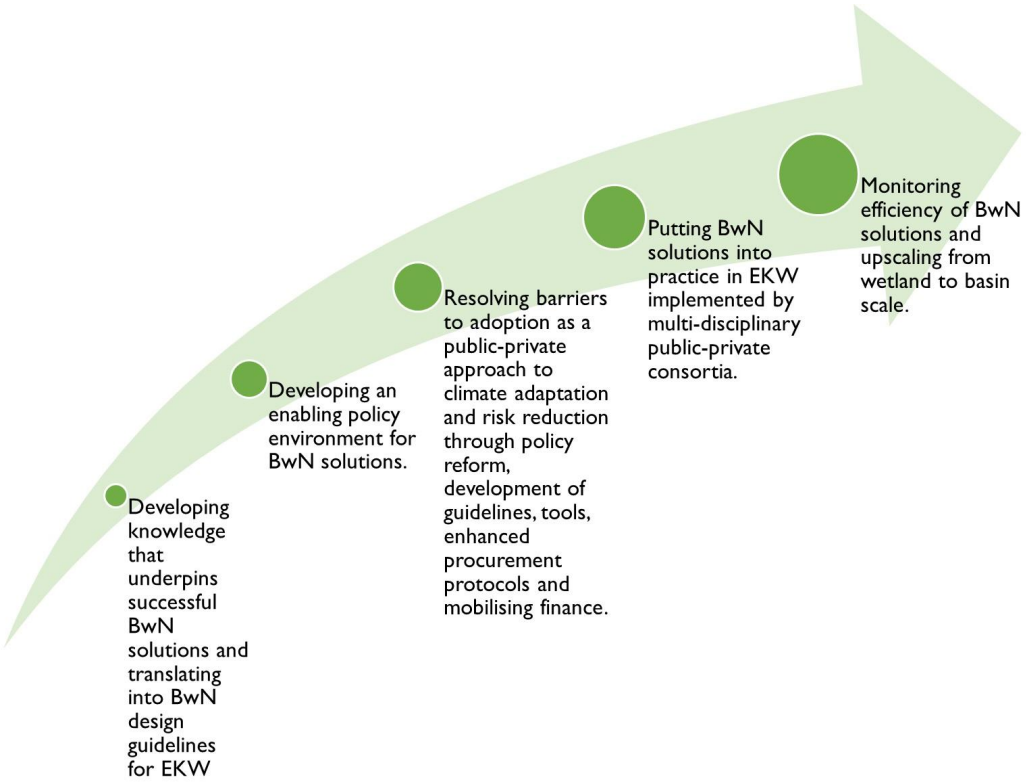


Figure 26. Embedding the concept of BwN in EKW management plan

Implementing BwN yields a wide variety of benefits for various ecosystem services some of these include:

Table 8. Benefits offered by natural infrastructure within the BwN concept

Benefit	Natural infrastructure that provide benefit
Carbon sequestration	With no treatment plant present for Kolkata city EKW helps reduce the carbon footprint ~3500 tonnes of CO2 per year which is nearly 60% of Kolkata city's emission.
Improved water quality	Devised by local fishermen and farmers, these wetlands serve as the natural sewage treatment plant for the city treating over 900 MLD of raw sewage. The algae and fish consume the organic nutrients and lower its concentration by significant amounts.
Enhanced water availability	Spanning over 12500 ha EKW for much of the year act like sponge soaking up excess water thereby recharging groundwater and storing water in the surface for agro-economic activities.
Retained soil moisture	The plant belt along the bhery help maintain soil moisture by natural adsorption process.
Reduced sedimentation	The depressions in the wetlands trap sediments and enhance the soil quality.
Controlled soil erosion	The plant belt along the bhery control soil erosion by holding on to the soil by their roots
Regulated air temperature	The relative humidity over EKW is higher than the surrounding area. The air transports these water droplets to the city of Kolkata thereby cooling the air.
Controlled floods	Placed in the flood plains of Kulti and Hooghly river, the vast spanning wetlands trap excess water during floods which are then used for various purposes.
Bioremediation	Organic and Inorganic nutrients are significantly reduced by the water hyacinth wall around the boundaries of the bhery.
Habitat for rich Biodiversity	The EKW provides suitable habitat areas for a variety of resident and migratory species.

Management zoning for multiple use

The ability of EKW to provide the diverse ecosystem services while also harbouring diverse biota is linked with multiple use the wetland is put to. The balance of land use between aquatic usages (fish farms) and non-aquatic usages (horticulture, agriculture and settlements) is key to ecosystem functioning. The land use control principle of the East Kolkata Wetlands (Conservation and Management) Act, 2006 and Wetlands (Conservation and Management) Rules, 2017 provide the regulatory architecture under which management zoning of EKW can be framed for meeting conservation, development and regulation related outcomes.

Adaptive management

EKW, as several other wetland ecosystems, have an inherent uncertainty and unpredictability in their behaviour owing to complex and multi-scalar ecological, social and institutional interactions that shape their features and governing factors. There are a number of reasons, including:

- Environmental variation that is uncontrollable (such as increasing intensity of precipitation)
- Partial observability (as not all wetland features and factors can be monitored)
- Partial controllability of actions (as management interventions are implemented through a number of agencies)
- Structural uncertainty arising out of lack of complete understanding of how the ecosystem functions

Given that the knowledge on ecosystem is always likely to be incomplete, an adaptive management based on iterative learning, and using that learning to improve management using a goal-oriented and structured process (Fig 15) shall be applied. Adaptive management will be enabled in management of EKW by a combination of processes, such as:

- Structured decision making to clarify management goals, objectives and actions, involving stakeholders
- Investing into monitoring and learning for management. Each management intervention in reality is an experiment based on a working hypothesis of ecosystem functioning. Monitoring enables assessment whether the hypothesis works in reality (for example, whether changing sewage composition is leading to epidemiological concerns for the wetlands communities)
- Investing into cross-scale communication. Understanding change at multiple scales (such as City Environments, Gangetic Delta) may help getter a better understanding of ecosystem functioning and variability.
- Adaptive governance, based on collaborative and participatory management which has the flexibility of sharing management responsibilities. Successful adaptive governance has required leadership with a vision, systematic monitoring, complementary legislation framework which allows for adaptive management, information flow amongst stakeholders, and clear opportunities for stakeholders to collaborate.

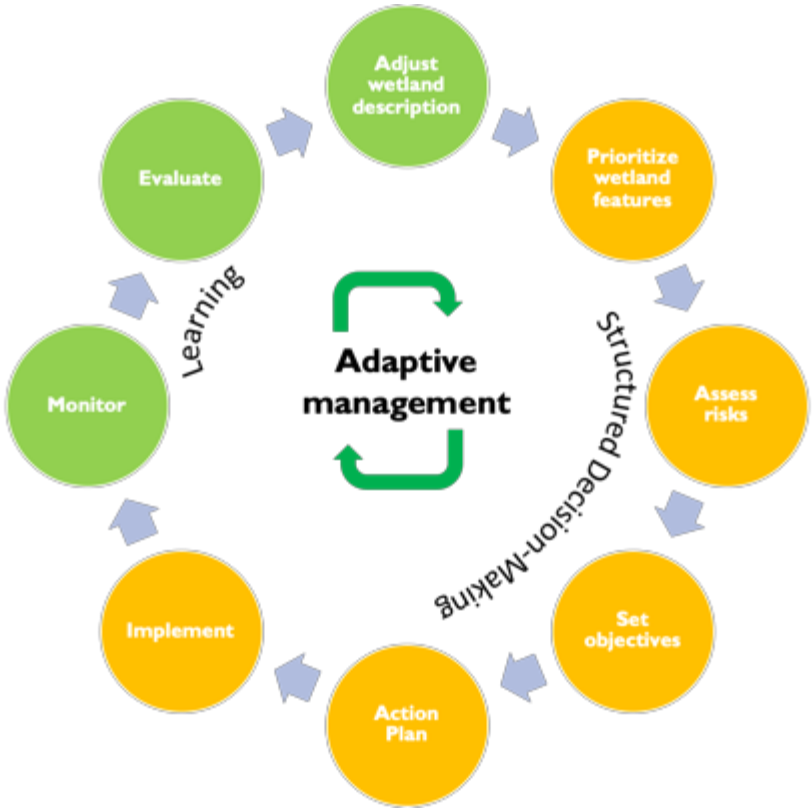


Figure 27. The Adaptive Management Cycle (after Allen et al, 2011)

Multiple values of nature and nature's contribution of people

Management plan implementation will take into account the diverse ways in which nature and nature's contribution to people support well-being. These will include intrinsic values (the value of EKW as an ecosystem with its complex ecological functions), instrumental values (the value of EKW towards meeting food security, water quality regulation and climate moderation), and relational values (the values linked with sense of place and cultural identity which communities attribute to EKW). The management plan will be built on the full range of values to bring in multiple perspectives in decision-making and implementation of programmes.

Focus on behaviour change

The management plan entails a shift from a high emphasis on wetland regulation to inducing positive behaviour within wetlands communities and stakeholders which are aligned with wise use. The EKWMA will use strategic communication to inform stakeholders on the role of EKW in their overall well-being, and the ways these groups can engage in ensuring that the wetland continues to deliver their wide-ranging services. Information, education and communication tools, tailor-made to the needs of various stakeholder groups, would be proactively used to trigger behaviour change, along with building capacities and opportunities for participation in wetlands management.

5.3 Management Objectives and Performance indicators

The management strategies have been translated into eight objectives which reflect the desired state of key features of wetlands. For each feature, the performance indicators are the attributes which can indicate change. The desired outcome reflects the target which the management plan envisages to achieve within five years, thus providing a monitoring framework to assess effectiveness. These indicators and targets have also been integrated into the monitoring plan discussed on Chapter 6 of the management plan.

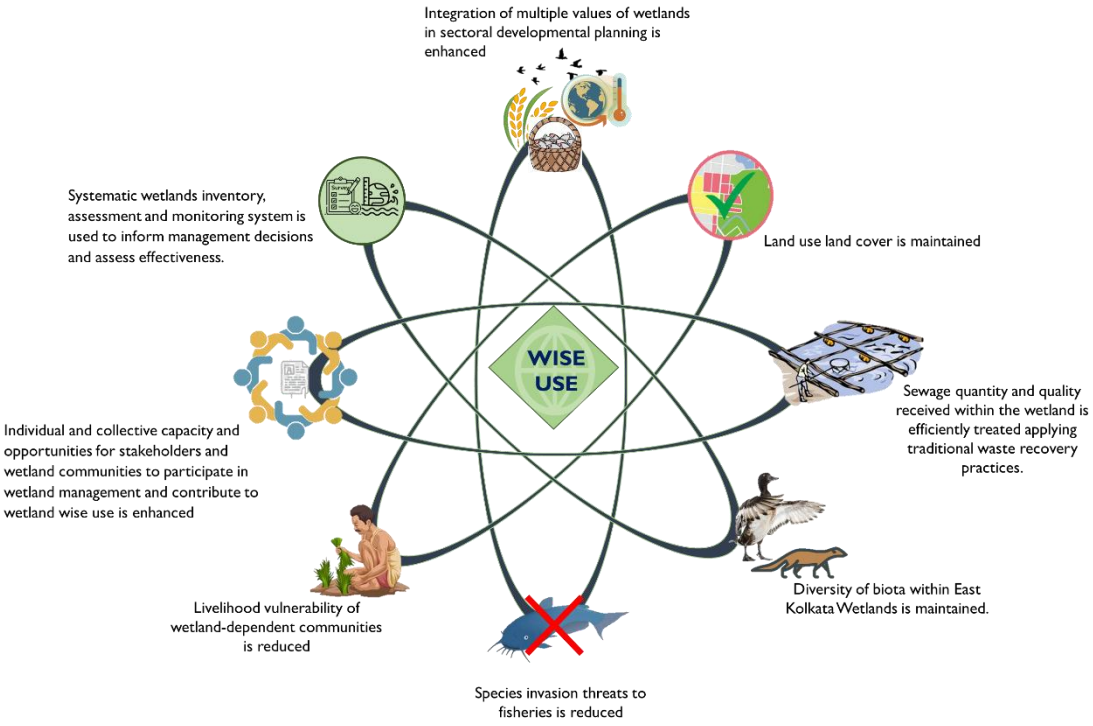


Figure 28. Wise use of wetlands for the maintenance of ecological character at East Kolkata Wetlands

Table 9. Management objectives, performance indicators and targets

Objectives	Performance Indicators	Desired outcome
Objective 1. **Land use and land cover of the wetland is maintained in line with regulatory requirements under Wetlands (Conservation and Management) Rules, 2017 and East Kolkata Wetlands (Conservation and Management) Act, 2006.**	Land use and land cover change in comparison with the 2000 baseline Number of violations of the Wetlands (Conservation and Management) Rules, 2017	No illegal transformation of land use Violations are reduced by atleast 60%

	and East Kolkata Wetlands (Conservation and Management) Act, 2006	
Objective 2. **Sewage quantity and quality received within the wetland is efficiently treated applying traditional waste recovery practices.**	Sewage availability through natural hydrological gradient Quality of sewage	Tertiary channels deliver sewage without use of pumps Equitable distribution of sewage. Heavy metals concentration in sewage is brought to safe levels
Objective 3. **Diversity of biota within East Kolkata Wetlands is maintained.**	Species richness Population of migratory waterbirds Population and habitat of marsh mongoose	No species extirpation Counts are maintained in the range of 20% deviation from average of last five years Sighting is maintained in the range of 20% deviation from average of last five years
Objective 4. **Species invasion threats to fisheries is reduced.**	Occurrence of invasive species in fish catch	Reduced by atleast 80% of occurrence in 2020
Objective 5. **Livelihood vulnerability of wetland-dependent communities is reduced.**	Resource productivity (fish catch, vegetable harvest) Instances of waterborne diseases Diversification of income sources	Non-declining harvest of fish and vegetables Reduced by atleast 80% of occurrence in 2020 Wetland communities having income in the lower quintiles gain additional sources of income
Objective 6. **Individual and**	Participation of wetland	Integration of community,

collective capacity and opportunities for stakeholders and wetland communities to participate in wetland management and contribute to wetland wise use is enhanced.	communities in management plan implementation	rights and capacities in management plan implementation and monitoring
	Effective wetlands inventory	An Integrated Wetlands Inventory, Assessment and Monitoring System is put in place and used.
	Evidences of affirmative behaviour change within communities living in and around EKW supporting wise use of wetlands	Local action for addressing solid waste or preventing encroachment
	Evidences of community-led collaborative action for wise use of wetlands	Community norms for preventing land use change or overharvesting of resources
Objective 7. **Systematic wetlands inventory, assessment and monitoring system is used to inform management decisions and assess effectiveness.**	Availability of time-series data on wetland ecological character	Data is available on all priority wetland features
	Availability of data on threats leading to adverse change in ecological character.	Data in available on threats
	Evidences of use of data generated from wetlands inventory, assessment and monitoring system in decision-making.	Data is systematically analysed and presented in EKWMA meeting.
Objective 8. **Integration of multiple values of wetlands in**	Number of sectoral policies (wherein	EKMWA meets regularly and considers implications

sectoral developmental planning is enhanced.	integration of wetlands is relevant) which take into account wetlands values.	of sectoral plans. EKWMA enables integration of role of EKW in programmes and actions plans on climate change, urban development, and disaster risk reduction.

In the table below, a mapping of each of the objectives against the values (derived from Chapter 2), threats (derived from Chapter 3) and indirect drivers (derived from Chapter 4) is presented.

Table 10. Mapping of management objectives against wetland values and threats

	Management Plan Objectives							
	Obj. 1	Obj. 2	Obj. 3	Obj. 4	Obj. 5	Obj. 6	Obj. 7	Obj. 8
Ecosystem Services								
Wastewater treatment	++	+++			+	+		
Carbon sequestration	++	+++				+		
Flood buffering	++				+	+		
Wetland products	++	+++	+	+	++	+		
Recreation			++	++	+++	++		
Relational values					+++	+++		
Biodiversity								
Diverse biota			+++	+++				
Threats (Direct)								
Encroachments	+++					+	++	
Heavy metal contamination in sewage		+++						
Increased solid waste dumping	+++							
Land subsidence							++	
Sedimentation of channels		+++						
Invasive species			+++	+++				

Climate change local impacts		++					++	
Threats (Indirect)								
Lack of clarity on regulation						+	++	
Limited stakeholder engagement in governance					+++	+++	+++	
Limited capacity within EKWMA for integrated management						+++	++	+++
Limited consideration of full range of wetland values in sectoral planning and decision making			+	+		++	+++	++

5.4 Risks and Risk Mitigation Options

The management plan design is based on certain assumption. The table below identifies the risks of these assumptions impacting management plan implementation adversely, and possible risk management measures.

Table 11. Risks and risk mitigation measures

Risks	Risk management measures
At goal level	
Local communities participate in the conservation and management of the EKW	A Community Advisory Group will be constituted to advice of management plan implementation and disseminate information within communities
At objective level	
Trained human resources are available for management of EKW	EKWMA staff will be imparted training on various aspects of wetlands management, and hand-holding support provided.
Communities are sufficiently organized to engage in and take ownership of the project activities	The Community Advisory Group will be used as a mechanism to support and strengthen community networks.
A long-term financial framework is established for maintaining the expanded EKWMA programme	Funding from various convergence sources will be leveraged, including from private sector organizations.

At Output level	
Qualified trainers and experts are available	A roster of experts and trainers will be prepared for supporting capacity development.
Strategies offer flexibility for adaptation	EKWMA will present progress of management plan implementation in the meetings. Data from monitoring will also be analysed to assess effectiveness of interventions.
Robust monitoring mechanisms and application of scientific approach for resolving conflicting issues	A Wetlands Inventory, Assessment and Monitoring system will be put in place in the first year of management plan implementation
Capable NGOs are available to assist community-based activities	EKWMA will put in place a process of selecting and inducting NGOs in management plan implementation

6 Monitoring Plan

Management of EKW 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 this Ramsar Site. Equally important is to be able to assess effectiveness of management in terms of ability to develop and implement an integrated planning, management and evaluation system to secure wise use of the wetland.

The current section of the management plan describes a monitoring framework for EKW to support integrated management for wetland wise use. The section details monitoring purpose and strategy and associated resource requirements. The monitoring plan is proposed to be applied both at the scale of wetland ecosystem, as well as institutional arrangements supporting management. Thus, a section outlining strategy and framework for assessing management effectiveness is also included. The cost implications of the monitoring plan have been factored in the Chapter 7 (management planning framework) and Chapter 8 (budget and financing).

6.1 Monitoring Objective

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

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

6.2 Monitoring Strategy

Monitoring strategy responds to the following information needs EKW:

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

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

- the aquatic environment of EKW
- East Kolkata Wetlands
- EKW Basin

A hierarchical classification of inventory, assessment and monitoring needs for EKW is presented in Table13. The information needs for inventory are derived from the core datasets needed to establish a baseline on ecological character[5] for EKW, and contain all the essential ecosystem components, processes and services, as well as management related parameters that characterize the site. Within the aquatic environment, information needs pertain to sewage inflow, quality, its uptake for resource recovery, and ecosystem services such as wastewater treatment, flood buffering and carbon sequestration. At the level of wetland, information needs pertain to land-sue and landcover change, and threats such as solid waste dumping. At the basin scale, the information requirement is related to geo-morphological and climatological setup, as well as basin wide management arrangements, particularly those related to land and water resources and urban planning. At all levels, information on institutional arrangements and management practices is included so as to enable creation of a baseline on sectoral programmes, and the linked stakeholders, which are likely / have an impact on the wetland state. 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 EKW have been derived from assessment of ecological character carried out for development of the management plan. Four cluster of needs have been identified: a) land use and land cover change, to assess the dynamics of land use within the catchment; b) hydrological regimes, to assess the flux of water, sediments and nutrients; c) ecological components and processes, to assess the biodiversity, habitat quality and resource productivity; and d) socioeconomics and livelihoods to assess the trends in ecosystem services – livelihoods interlinkages.

This monitoring information adequately addresses the needs of East Kolkata Wetlands (Conservation and Management) Act, 2006 and Wetland (Conservation and Management)

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

Rules, 2017 of the Ministry of Environment, Forests and Climate Change. A list of wetland features, indicators and corresponding methodology and data collection frequency is provided as Table 14.

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

Inventory, assessment and monitoring form an integral part of wetland management, and thereby core activity of EKMWA. The management plan proposes to establish a dedicated wetland monitoring unit with adequate infrastructure support to effectively deliver this function.

Linkages also need to be developed so that data from the existing monitoring networks of different agencies (for example, inundation and flooding 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 West Bengal Pollution Control Board; and fish production from Fisheries Department) can be accessed and shared. Similarly, provision for participation of NGOs and civil society in monitoring programme has also been built, especially for socioeconomics and livelihoods aspects and biodiversity monitoring (for example, waterbird census being implemented by NGOs under the aegis of Asian Waterbird Census). Thematic management needs-based research can be taken up by specialized agencies such as ZSI, BSI, CIFRI, Indian Statistical Institute Kolkata to complement the monitoring programme.

Table 12. Inventory, assessment and monitoring needs for managing East Kolkata Wetlands

	Information Purpose		
Information Scale	**Inventory**	**Assessment**	**Monitoring**
East Kolkata Wetlands (aquatic region)	**Physical extent** (area, depth) **Sewage quantity and quality** **Status of canals** (maintenance of natural gradient) **Harvest** (fish and aquatic species)	**Water quality improvement** (extent of reduction in BOD, COD, nutrients and heavy metals) **Carbon sequestration** (carbon stored in various forms in resource recovery process) **Fish production trends** **Trends in invasive species**	**Land use and Land cover change** in fish farm areas **Sewage quality** (presence of heavy metals and toxic chemicals) **Spread of fish invasives** **Bioaccumulation** in fish

	Biota (plant and animal species) **Socioeconomics** (return on fisheries, cooperatives operation, status of fishfarm workers and owners)	**Trends in number and population of species**	**Disease** (related to sewage fed fisheries operations) incidence in fish farm workers and owners
East Kolkata Wetlands	**Physical setting** (area, boundary, connectivity) **Water regime** (sewage flows, inflow -outflow balance, surface-groundwater interactions, inundation regimes, quality, regulation) **Harvest of produce from wetland region** (vegetables, food crops and others) **Groundwater** (level, abstraction and quality) **Biota** (plant and animal species) **Socioeconomics** (return on fisheries, horticulture and	**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) **Water quality trends** (extent of reduction in BOD, COD, nutrients and heavy metals) **Soil quality trends** **Inundation trends** **Groundwater level and quality trends** **Air quality trends** (PM 2.5, PM 10, temperature, humidity) **Carbon sequestration** (carbon stored in various forms in resource recovery	**Land use and Land cover change** (with respect to 2000 baseline) **Bioaccumulation** in vegetables and crops

	agriculture; incomes and assets) **Sectoral programmes and institutional arrangements** for management of land and water resources and biodiversity conservation	process) **Trends in key species** (waterbirds, marsh mongoose) **Production trends** (vegetables, food crops)	
East Kolkata Wetland Catchments	**Geology and Geomorphology** (Soils, elevation, slope, drainage pattern) **Climate** (Precipitation, Temperature) **Land use and land cover** **Water regimes** (river flows, runoff, upstream abstraction)	**Climate risk and vulnerability** (changes in runoff and implications for EKW)	**Urban planning** (water regulating structures and water allocation, sewage treatment infrastructure development, expansion of settlements) and implications for EKW

Table 13. 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 EKW	% area under various land use and cover classes (agriculture, , settlements, wetlands)	High	GIS and Remote Sensing Radar sensed data	Once every year
Compliance with East	Violations	High	Mobile based surveillance system operated by	Daily

Kolkata Wetlands (Conservation and Management) Acts, 2006 and Wetlands (Conservation and Management) Rules, 2017			communities' wardens Drone mapping and other technologies for surveillance of land use change .	One every six months
Hydrological Regimes				
Water flux	Sewage inflow	High	Monitoring stations at Bantala and Ghusighata lock gates	Daily
	Sewage outflow	High		Daily
	Sediment inflow	High		Annual
	Sediment outflow	High		Annual
Water holding capacity	Bathymetry	High	Bathymetric surveys	Once in 5 years
Inundation Regime	Seasonal fluctuation in waterspread area	High	Remote sensing	Once in 5 years
Sewage quality	Temperature	Medium	Standard procedures of APHA	Monthly
	pH	High		Monthly
	Dissolved Oxygen	High		Monthly
	Specific Conductance	High		Monthly
	Nutrients and Nutrient Cycling (Nitrate, Phosphate, Silicate)	High		Monthly
	Cations and Anions (Calcium, Magnesium, Sulphate, Chloride, Fluoride, Sulphite)	High		Monthly
	Chemical Oxygen Demand	High		Monthly
	Heavy metals (Arsenic, Mercury, Cadmium, Chromium,Lead)	High		Monthly
	Biological oxygen demand	Medium	Standard procedures of APHA	Monthly
	Total Coliform	Medium		Annual
	Faecal coliform	Medium		Annual
Wetland soils	Texture	Low	Standard procedures of	Annual

	pH	High	APHA	Annual
	Organic carbon	High		Annual
	Available nitrogen	High		Annual
	Available phosphorus	High		Annual
	Available calcium carbonate	Medium		Annual
	Heavy metals (Arsenic, Mercury, Cadmium, Chromium, Lead)	High		Annual
Ground water	Water level	High	Methodology approved by Groundwater Estimation Committee (1997)	Seasonal (Summer, Monsoon, Post-monsoon, Winter)
	Conductivity	Medium		Annual
	Total hardness	Medium		Annual
	Chloride	Medium		Annual
	Fluoride	High		Annual
	Arsenic	High		Annual
	Heavy metals	High		Annual
Water abstraction	Water abstracted for irrigation	Medium	Survey	Annual
	Water abstracted for domestic use	Medium		
Air quality	Suspended Particulate Matter (PM 2.5, PM 10)	High	Standard procedures laid by CPCB for air quality monitoring	Daily
	Temperature and Relative Humidity	High		
Ecosystem Processes and Biodiversity				
Flora	Phytoplankton (diversity and abundance)	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Periphyton	Medium		Seasonal
	Macrophytes (diversity and abundance	High		Seasonal
	Species invasion	High	Habitat Sampling and Remote sensing (using high resolution data)	Once in 2 years
	Primary production	High	Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal

	Bioaccumulation in vegetables and food grains	High	Environmental monitoring protocols of ICAR - CIFRI /Standard procedures of APHA	Bi-annual
Fauna	Zooplankton (diversity and abundance)	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Aquatic macro-invertebrates	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Aquatic Insects	Medium	Taxonomic studies, Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Seasonal
	Fish diversity	High	Taxonomic studies	Once in 5 years
	Amphibians, Reptiles, Mammals	High	Taxonomic studies	Once in 5 years
	Fish catch and effort (number of harvest cycles, catch)	High	Standard procedures in Central Inland Fisheries Research Institute Bulletin No. 10	Monthly
	Bioaccumulation in fish	High	Environmental monitoring protocols of ICAR - CIFRI / Standard procedures of APHA	One every year
	Water Bird population and diversity	High	Census and Taxonomic studies	Annual
	Avian disease	Medium	Surveillance	Annual
Socioeconomics and livelihoods				
Community dependence on wetland ecosystem services	Fish catch and vegetable production	High	Socioeconomic survey	Monthly
	Performance of cooperatives (Capitalization, infrastructure, catch processed, membership)	High		Annual
	% contribution of fisheries and horticulture to income and	High		Bi-annual

	employment			
	Number of tourists visiting wetland and direct and indirect spending	High		
Livelihood status of wetland dependent communities	Physical capital, financial capital, social capital, human capital indicators of livelihood systems	Medium		
	Instances of diseases related to working in Sewage -Fed Fisheries	High		
	Number of reported instances of conflicts	Medium		

6.3 Assessing management effectiveness

EKW are dynamic ecosystems and so are their management needs. Management plans, which are developed based on assumptions known to managers, need to be periodically assessed to make sure that the set goals and objectives are being achieved.

The effectiveness of management towards achieving the overarching objective of maintenance of ecological character can be greatly enhanced if following questions are periodically reflected upon:

- What is the current status of the EKW?
- Is the management achieving the goal of maintenance of ecological character?
- What are the current and future threats?
- Are adequate resources available for implementing management, and if not, how can they be improved?
- Are management processes adequate, effective and efficient?
- What other steps can be taken to improve management?

The Contracting Parties to the Ramsar Convention adopted the R-METT (Ramsar Site Management Effectiveness Tracking Tool) to assist Ramsar site managers in assessing effectiveness of management in achieving wetland wise use outcomes. The assessment looks into the following aspects:

- **Context** of management (wetland ecological character, threats and risks of adverse change).
- **Management planning** that defines how the management goals and objectives have been defined.
- **Inputs** including human, technical and financial resources applied to implement management actions.
- **Process** of management plan implementation.

- **Outputs** (tangible and intangible) that result from implementation of management actions.
- **Outcomes** with respect to the objectives defined by the management plan

It is proposed that management effectiveness assessments for EKW is done atleast once in five years, so that management action plans are revised and updated to reflect the condition of wetlands as well as ability of management to prevent adverse change in ecological character. A baseline assessment is proposed to be done at inception of the management plan.

6.4 Infrastructure and human resources requirements

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

- Remote Sensing and GIS unit with advanced capabilities of remote sensing image processing, preparation of maps and development and maintenance of spatial datasets
- Ecological monitoring laboratory with capabilities for analysis of chemical, physical and biological properties of water and soil
- Mobile based citizen reporting system for recording and reporting illegal encroachments
- 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

Deployment of the aforementioned resources can be done in a cost-effective manner by applying the lessons and expertise of the existing infrastructure created by the state government for management of EKW. Need based training programmes will also be conducted to upgrade skills of the concerned state government departments and agencies.

6.5 Reporting

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

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

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

Outcomes of specific assessments, for example ecological character status and trends, economic valuation, environmental flows etc. could be made available in the form of technical

report series, with an extended summary for general readership. As the monitoring programs get sophisticated over a period of time, real time monitoring options through use of satellite-based data communication techniques can be explored.

6.6 Quality control

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

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

Specification of objectives for sampling programme

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

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

Documentation: Procedures for field sample record keeping and methods documentation

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

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

Performance audit procedures, including data and systems audit

6.7 Review and adaptation

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

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

7 Action Plan

Activities to meet the eight objectives have been clustered under four components: Institutions and Governance, Water management and Pollution Abatement, Species and Habitats and Sustainable Resource Development.

Table 14. Management plan components

Component	Objectives
Component 1 – Institutions and Governance	Objective 1. Land use and land cover of the wetland is maintained in line with regulatory requirements under Wetlands (Conservation and Management) Rules, 2017 and East Kolkata Wetlands (Conservation and Management) Act, 2006 Objective 6. Individual and collective capacity and opportunities for stakeholders and wetland communities to participate in wetland management and contribute to wetland wise use is enhanced. Objective 7. Systematic wetlands inventory, assessment and monitoring system is used to inform management decisions and assess effectiveness. Objective 8. Integration of multiple values of wetlands in sectoral developmental planning is enhanced.
Component 2. Water management and pollution abatement	Objective 2. Sewage quantity and quality received within the wetland is efficiently treated applying traditional waste recovery practices.
Component 3. Species and habitats	Objective 3. Diversity of biota within East Kolkata Wetlands is maintained. Objective 4. Species invasion threats to fisheries is reduced.
Component 4. Sustainable Resource Development and Livelihoods	Objective 5. Livelihood vulnerability of wetland-dependent communities is reduced.

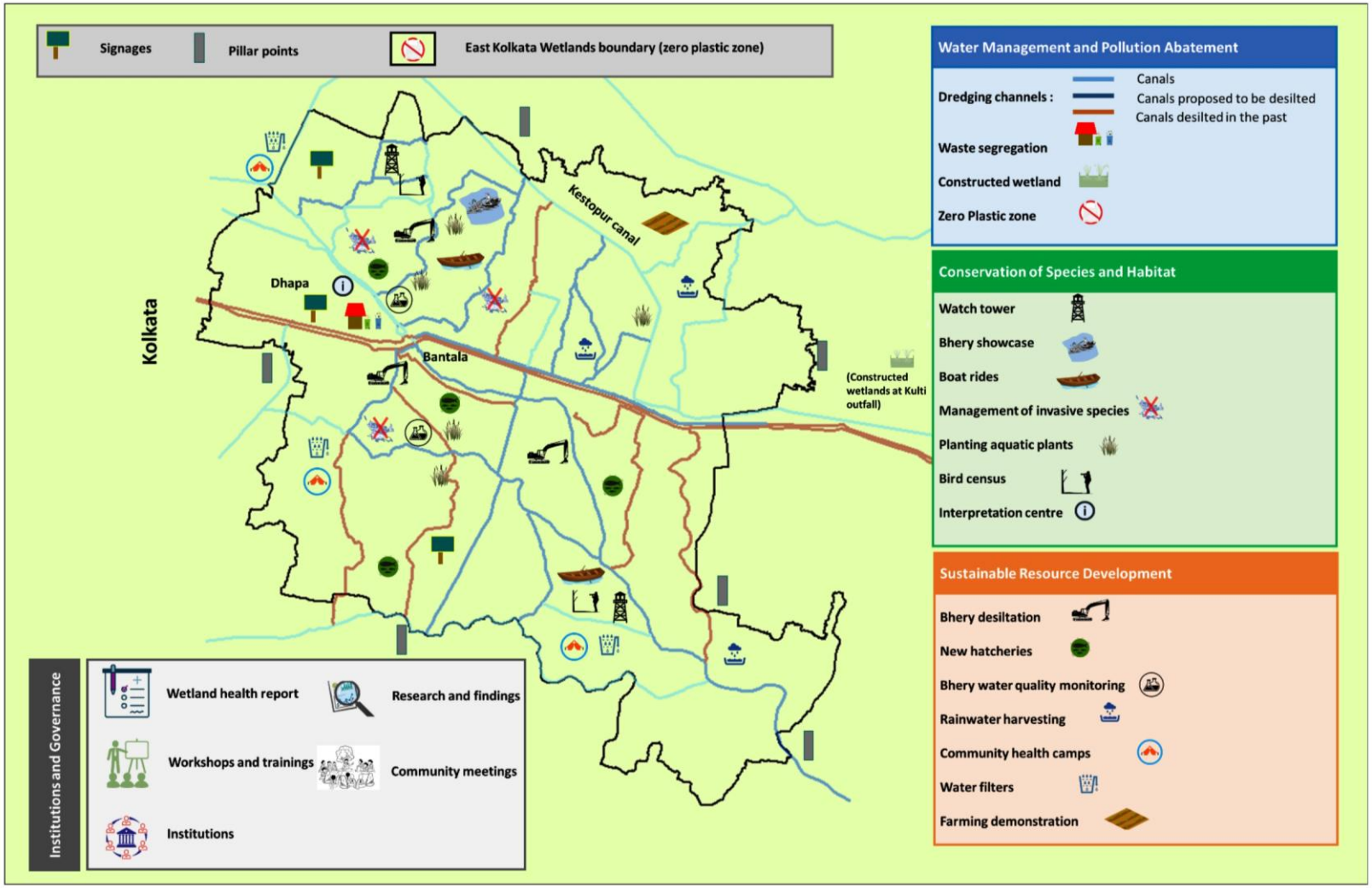


Figure 29. Management interventions proposed at East Kolkata Wetlands

Component 1. Institutions and Governance

1.1 EKWMA Reorganization and Strengthening

EKWMA requires an efficient and results-oriented institutional structure, and gradual shift from an enforcement to a strategic role in wetland management. A reorganised set up is proposed to include following units:

- Planning and Design unit: Responsible for strategic planning for conservation and wise use, including assessing adherence to the various policy mandates and regulatory provisions.
- Enforcement unit: Responsible for ensuring compliance with extant regulation, and coordinating with line departments on implementation of penal provisions.
- Wetland monitoring unit: Responsible for systematic wetland inventory, assessment and monitoring. The unit can function out of Institute of Environmental Studies and Wetland Management which has existing infrastructure to support ecological and hydrological monitoring of the wetland.
- Community engagement and communications unit: Responsible for liaison with community and civil society organisations, and ensuring integration of community concerns within management actions. This unit will be also responsible for external communications, based on a communications plan.

The following activities are also proposed to be taken with due approval of the Governing Body of EKWMA:

- Sustainable financing mechanism: A gradual shift to financing through appropriate allocations within the state budgets would need to be made so that core wetland monitoring and management functions are not interrupted if the financing of projects is not available. EKWMA may also render research and consultancy support to other states on wetland management issues, which could be an additional source of revenue.
- Policy coherence: Development programmes around EKW need to be based on a single and coherent policy, which should guide various agencies in the design of various programmes. A mechanism for ensuring that EKWMA is consulted before implementation of developmental programmes is proposed to be developed.

1.2 Wetland demarcation

It is proposed to demarcate wetland boundary by placing geo-tagged pillars all along the wetland periphery. Demarcation will be done using geo-tagged boundary pillars (approximately 1600 pillars are required to be placed at 500 m interval).

Activities to be carried out are as follows:

a) Completion of field reconnaissance survey

b) Placement of geo-tagged pillars

1.3 Management zoning

For the ease of management, and also ensuring compliance with the extant regulatory regimes, it is proposed to segment the wetland into four major zones (Map 15):

- Fishery zone: Wetland area that is subjected to use for fish cultivation using sewage water and subject to multiple land ownership. The zone can be used additionally by providing regulating services for absorbing storm water flows during monsoon, act as a flood storage and help recharge ground water.

- Agriculture zone: A part of the wetland permanently being used for cultivation of rice and other crops. The zone can additionally be managed by using open spaces for storing excess flood water and allow infiltration of stormwater. The zone has the potential to attract wintering waterbirds if organically farmed. Rainwater harvesting in agricultural fields to enhance availability of freshwater.

- Horticulture zone: Part of the solid waste dumping area on the western periphery of the wetland which has been converted as a waste recycling region for cultivating vegetables. The zone can be maintained as an area for practicing horticulture. Dhapa dumpsite of KMC has been existing at this zone of EKW much prior to the declaration of Ramsar site. KMC is conscious of its responsibility in maintaining a healthy environment. However, resource recovery system such as composting, biomethanation, material recovery facility (MRF) for recycling, sanitary land filling is recommended in the zone.

- Nature protection zone: A part of the wetland where biodiversity value is the highest, and habitat use by migratory species. The zone can act as a buffer for species when moving between rural and urban areas. The zone also has the potential to be used as a site for recreation and ecotourism, within the framework of existing provisions of Wetlands (Conservation and Management) Rules, 2017, and other extant regulation.

The zoning plan will guide management interventions. Following steps are proposed:

- Finalization of zoning plan in consultation with stakeholders
- Preparation of zonal management plans
- Implementation of zonal management plans within the framework of action plan as described in this document.

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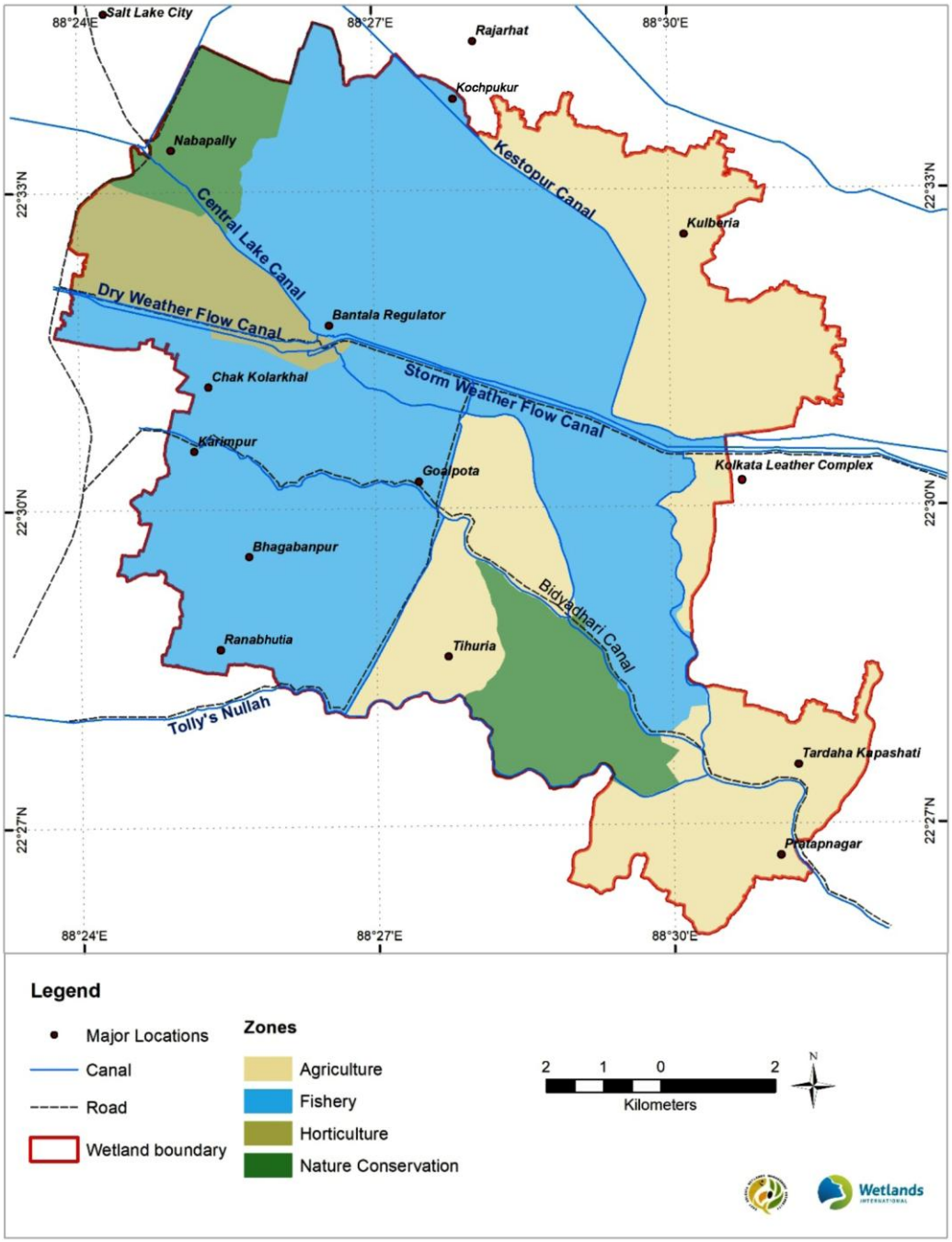


Map 15. Proposed management zones of East Kolkata Wetlands

1.4 Wetlands 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 5 of the management plan. The following activities are proposed:

1.4.1 Establishment of wetland monitoring and research centre

To support monitoring and research activities related to EKW, a robust and upgraded laboratory is required to established.

1.4.2 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:

- 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;
- development of GIS based database management system

1.4.3 Wetland monitoring and evaluation

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

1.4.4 Surveillance system

A mobile-based surveillance system for recording infringements to Wetlands (Conservation and Management) Rules, 2017 and East Kolkata Wetlands (Conservation and Management) Act, 2006 is proposed to be developed. The app-based system will enable 'community wardens' to transmit information on violations in EKW to EKWMA through geotagged pictures and related data.Drone mapping and other sophisticated technologies such as installation of CCTV will also be used for surveillance of land use change.

1.4.5 Ecosystem Health Report Card

It is proposed to develop an Ecosystem Health Report Card, and publish annually to assess and communicate wetland monitoring information to decision-makers and stakeholders. The health report card summarizes indicators along major indices (water quality, catchment status, biodiversity status) which represent various ecosystem features of the lake, and are reported against respective thresholds set in line with management goals.

Following activities are to be taken:

- Convening a methodology workshop for EKW wetlands monitoring unit for firming up variables to be used for assessment and data requirements
- Development of Ecosystem Health Report Card
- Report card publication
- Stakeholder dissemination workshop

1.5 Research

Following specific research studies are proposed to be commissioned to address the knowledge gaps in assessing status and trends in ecological character:

- Carbon and GHG Flux assessment – to assess the role of EKW in sequestering carbon and GHG, and this integrate role of these wetlands in climate change mitigation strategies
- Nutrient budget - to assess the quantity of nutrients entering EKW, its uptake in resource recovery practices and discharge downstream
- Bioaccumulation studies – to assess the chain of heavy metal contamination in EKW, quantity of toxic metals accumulating in fish, vegetables and crops cultivated in EKW and possible remedial measures
- Multiple values assessment – to assess multiple values communities living in and around EKW associate with the wetland, the underlying reasons and the ways in which this value can be orientated towards behaviour change for wetland wise use

1.6 Capacity Development

To support integrated management of EKW, the human capacity of EKWMA and concerned line departments as well as stakeholders will be enhanced by training workshops on:

- Integrated wetlands management
- Wetlands inventory assessment and monitoring
- Land use planning for multiple wetlands use
- Wetlands and climate change mitigation and adaptation
- Integrating wetlands wise use in developmental planning
- Conducting excursions (National and International), developing course module relating to wetland/environment management

1.7 Communication, Education, Participation and Public Awareness

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

1.7.1 Signage

Signage indicating EKW as a Ramsar Site, is proposed to be placed at all major entry points of the wetlands complex, namely along Basanti Road, EM Bypass and Bantala Lock Gate. Signage are also proposed in the 7 Panchayat Offices and school premises inside wetlands.

At the 19th meeting of the Ramsar Standing Committee, 29 October-1 November 1996, the members adopted a decision that defines recommended wording for signs at all Ramsar Sites, when translated into the local languages of the sites. The decision reads as follows: The Contracting Parties should endeavor to place descriptive signs at all Ramsar Sites, and these signs should include the Ramsar logo, as well as the following suggested text (amended for EKW):

> THIS SITE, COVERING 12,500 HECTARES, HAS BEEN DESIGNATED BY THE GOVERNMENT OF INDIA FOR INCLUSION IN THE LIST OF WETLANDS OF INTERNATIONAL IMPORTANCE ESTABLISHED UNDER THE CONVENTION ON

WETLANDS, THE INTERNATIONAL TREATY SIGNED IN RAMSAR (IRAN) IN 1971 TO PROMOTE THE CONSERVATION AND SUSTAINABLE USE OF WETLAND AREAS WORLDWIDE.

The protection and management of this site is under the responsibility of: EAST KOLKATA WETLANDS MANAGEMENT AUTHORITY, DEPARTMENT OF ENVIRONEMNT, GOVERNMENT OF WEST BENGAL.

1.7.2 Webpage

The webpage www.ekwma.in shall be periodically updated with information, datasets and communication products on EKW. The website will be an important public interface of EKWMA and Government of West Bengal on issues related to EKW.

1.7.3 Community Participation

To enable participation of wetland communities in management, following actions are envisaged:

1.7.3.1 Establishment of a Community Advisory Group

The Community Advisory Group shall function as a wetland community platform to engage with EKWMA and other line departments on wetland management issues. Specifically, the group shall:

- Articulate community views and suggestions on various management interventions
- Support implementation of various management activities on ground
- Promote awareness on wetland values and functions within community stakeholders
- Support adoption of new technologies aimed at reducing livelihood vulnerabilities and advancing wise use
- Work with EKWMA to promote behaviour change within communities towards wise use of wetlands

The platform meetings shall be convened atleast once every six months, and decisions taken shall be placed in the meetings of the EKWMA.

1.7.3.2 Community wardens

The Community Advisory Group shall be encouraged to appoint community wardens to work as a para-network of wetland monitoring group. The community wardens will be responsible for collecting information on various aspects of wetlands features, and through a mobile-app system, transmit the same to the EKWMA. The community wardens will also be engaged in the awareness and outreach programmes.

1.7.4 Resource material

Resource material on following themes are proposed to be published:

- East Kolkata Wetlands Ramsar Site
- Traditional Waste Recovery Practice and Wetland Wise Use
- Environmental monitoring system in EKW

- Citizen participation in wetlands management
- Biological diversity of EKW
- People of EKW

1.7.5 Newsletter

An annual newsletter highlighting progress made in management plan implementation and key emerging issues related to EKW is proposed to be published annually in English and Bengali, and disseminated to all stakeholders.

1.7.6 Workshops and public events

Public events are proposed to be organized on the eve of World Wetlands Day (Feb 2), World Environment Day (June 5) and International Day for Biological Diversity (May 22) as a means of reaching out to public on the issues of wetland conservation and wise use. Public events on specific issues, as pollution control or water management are also proposed to be organized as a means of engaging with stakeholders.

1.8 Monitoring Plan Review

A mid-term and end-term review of management plan implementation is proposed to assess the extent to which stipulated objectives have been achieved with a high degree of resource efficiency and in participation with stakeholders. A committee on wetlands is proposed to be formed by EKWMA to carry out the evaluation, specifically looking at the following elements:

- Degree to which wetland ecological character is being maintained as a result of management being applied
- Implementation quality, timeliness and resourcing of activities
- Quality and comprehensiveness of wetlands monitoring
- Effectiveness of management being applied, in terms of design, activities, outcomes and impacts
- Quality of stakeholder engagement in implementation of various activities and discharging wetland management functions
- Changes in external environment, requiring adaptation in management plan

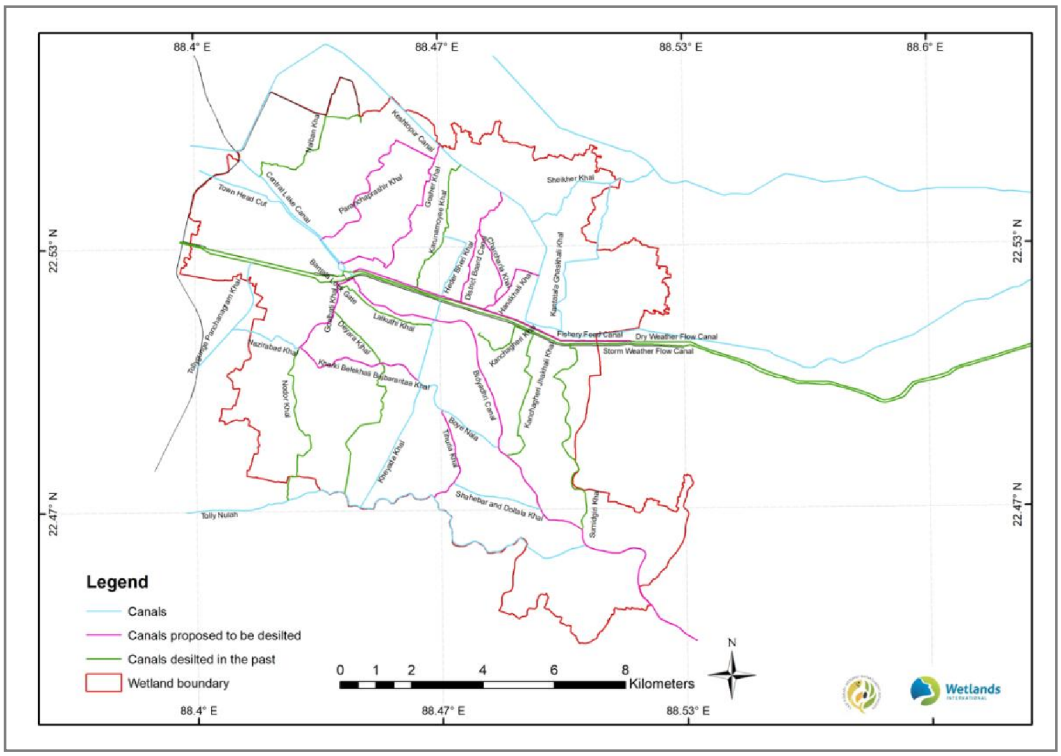
Component 2. Water Management and Pollution Abatement

2.1Dredging of channels

14 highly silted canals measuring 43.8 km are proposed to be dredged to restore their natural flows and enable flow of sewage to different fish farms (Map 16). The desilting will be carried to restore the natural profiles. Other canals may be added as per requirements.

Table 15. Canals to be desilted in East Kolkata Wetlands

	District	Canal Name	Length (km)
1	South 24 - Parganas	Bidyadhuree -1	7.97
2	South 24 - Parganas	Bidyadhuree -2	7.58
3	South 24 - Parganas	Bidyadhuree -3	0.89
4	South 24 - Parganas	Khanaberia Khal	0.3
5	South 24 - Parganas	Kharki Khal	2.71
6	South 24 - Parganas	District Board Khal Phase 1	2.53
7	South 24 - Parganas	Tihuria Khal	4.45
8	South 24 - Parganas	Chacharia Khal	2.89
9	South 24 - Parganas	Hanakhali Khal	0.99
10	South 24 - Parganas	District Board Khal Phase 2	2.89
11	South 24 - Parganas	Goalbati Khal	1.48
12	North 24 - Parganas	Paran Chaprasi Khal	4.67
13	North 24 - Parganas	Naobhanga Khan (part)	3.38
14	North 24 - Parganas	Ghosher Khal (part)	1.1



Map 16. Canals proposed to be desilted in East Kolkata Wetlands

2.2 Waste Segregation at EKW inlet

It is proposed to construct a solid waste segregator near Bantala lockgate to regulate flow of solid waste. The exact location of the waste segregator would be decided in consultation with Department of I&W and KMC.

2.3 Constructed wetlands at Kulti outfall

The wastewater discharged into Kulti River is not always upto the standards set by Pollution Control Board for discharge into rivers. In order to further augment waste water treatment beyond EKW region, it is proposed to build a system of constructed wetlands prior to discharge into River Kulti. The design of constructed wetlands will be based on EKW, but will use more aquatic vegetation beds through which sewage from DWF would be passed through.

The location of constructed wetlands and design will be finalized in the first year of management plan implementation, and the wetland development work taken up in the second and third year of the management plan, subject to availability of land.

2.4 Solid waste management

A plastic waste recycling unit is proposed to be established in the Dhapa region. Recovered plastic may be used to make plastic boards or road construction material. The waste-collectors will form an integral part of the solid waste management system.

2.5 Treating Dhapa Leachate

A300 KLD effluent treatment plant to treat the leachate of Dhapa has been constructed by KMC. The EKWMA will coordinate with KMC to ensure that the effluent is treated to the desired level.

2.6 Zero-plastic zone

EKW may be designated a zero-plastic zone. A management framework for this purpose, including components on regulation and behaviour change will be drawn up, in consultation with stakeholders.Screens are proposed to be placed at all inlets to prevent transport of plastic in the canal system of the wetland.

Component 3. Conservation of Species and Habitats

3.1 Asian Waterbird Census

Regular monitoring of waterbird population following standard protocols as the Asian Waterbird Census at all the major congregation sites within and around EKW shall be maintained in a coordinated manner so as to understand comprehensively the significance of the wetlands for waterbirds (both resident and migratory) and to plan and monitor habitat management strategies and actions.

The management plan will support mid-winter counts of waterbird as per Asian Waterbird Census protocol. The census may be carried out in collaboration with NGOs such as Prakriti Samsad, with prior experience in conducting such census. Census programmes will include training of prospective census participants and local waterbird enthusiasts.

Data collected during this monitoring work will include collection of detailed information on habitat structure and seasonal abundance and changes in different prey items (aquatic flora and fauna). Information collected should enable realistic population estimates of the different waterbirds and trends to be developed and provide guidance for management activities.

3.2 Bird health

Knowledge of the health of resident and migratory species that inhabit the wetlands is critical to understanding the risk and potential of transmission of avian diseases to other birds and animals, domestic poultry and people. Specific studies need to be undertaken to establish a baseline of the common and potentially harmful avian diseases, including the highly pathogenic strains of avian influenza that have a zoonotic potential.

Under the aegis of management plan, a training on wild bird disease will be provided to staff of Wildlife Department, EKWMA and select NGOs.

3.3 Culture of indigenous fish species

Culture of indigenous fish species which are often avoided in culture ponds but are in great demand by the local people, is proposed to be carried out in Goltala bhery which is owned by the government. EKWMA may also invite proposals from the willing fishery owners (govt/private/cooperatives etc.) for technical and financial support from EKWMA for culture of indigenous fish species. The seeds for indigenous fish species such as Koi (Anabas testudineous), Magur (Clarius batrachus) and Pangus (Pangasius pangasius) and others can be produced in the four hatcheries already proposed for the enhancement of fish yield.

3.4 Managing invasion of Suckermouth Catfish

Eradication of Suckermouth Catfish is regarded difficult, potentially time consuming and not feasible economically and hence efforts should be focused to contain the current established populations and preventing future introductions). So, to prevent new introduction, EKW farmers are sieving sewage water through multilayer screen before taking it to their ponds and also practicing intensive netting to limit upsurge of existing population. It is proposed to undertake further research on the invasion pathways, and undertake screening at various points along the DWF to prevent further spread of this fish invasive.

3.5 Rehabilitation of aquatic vegetation

It is proposed to revegetate peripheral areas of Nalban, Goltala Captain Bhery and some identified locations with Phragmites, Typha, Shola and other native species to improvise habitat of marsh mongoose, amphibian and reptilian species which prefer impounded water of submerged vegetation for breeding.

There should be complete ban on removal of vegetation from the bhery designated for biodiversity conservation and allow natural regeneration through protective measures. The underground rhizomes, turions and other vegetative parts should be used for propagation of these plant species. It is recommended that economically important plant species should be grown on the banks of bhery.

3.6 Communication and education facilities

3.6.1 Interpretation center

A wetland interpretation center is proposed to be constructed at Bantala sedimentation tank (defunct) area near Bantala lockgate on the land belonging to KMC and Irrigation and Waterways Department subject to their approval. A 12-hectare land for this purpose has been identified by the KMC, and will be transferred to the EKWMA for this purpose.

The following facilities are proposed to be developed in the interpretation complex:

Exhibits including posters, models, flying patterns hanging from ceiling, wetland birds interactive panel and ecosystem food chain

Viewing Gallery comprising panels highlighting the ecological, socioeconomic and cultural aspects. Desks fitted with adequate displays, bird identifications books and wooden benches should be constructed along the gallery

Watchtower to enable visitors to have a view of the EKW landscape. The watchtower would be equipped with binocular facilities.

Waste recycling model of East Kolkata Wetlands indicating treatment of wastes through natural processes and functions of wetlands

Children's Play area consisting of open dioramas and floorings with underwater paintings should be developed as a special section to cater to the young visitors. The area should have several innovative environment-oriented games and interactive food chain, fish trap games, jigsaw puzzles etc

Auditorium having audio-visual facilities for screening documentaries and arranging talks / workshops / meetings

Souvenir Shop for visitors having wetland products, wetland biodiversity replicas, reading materials, photographs, maps for the visitors to take away on payment basis as memorabilia from the visit

3.6.2 Bhery showcase

It is proposed to develop a showcasing of wastewater utilization in bhery to the visitors. Local communities would be trained to guide visitors about the process of wastewater recovery system and values and function of this special ecosystem. East Kolkata Wetland Authority will develop some models, aquarium, herbariums and boards to describe their operations.

Four to six bhery have been proposed for this purpose - Nalban Bhery, Goltala Bhery, Captian bhery, Charcharia Bhery, Jhograshisa and Gompota Bhery.

3.6.3 Guided boat rides

Restoration of hydrological regimes and the consequent enhancement in waterspread area would provide an opportunity for boating for the nature lovers. Guided boat rides shall be arranged for nature lovers to help them explore various aspects of EKW. While cruising through wetlands, the tourists will enjoy the beautiful view of birds as well. Local community groups shall be trained to take up interpretation activities. Guided boat rides are proposed at Nalban Bhery, Goltala Bhery and Charcharia Bhery. six boats are proposed to be used for these activities.

Component 4. Sustainable Resource Development

4.1 Sustainable Fisheries Development

4.1.1 Bhery desiltation

It is assessed that production in nearly 30% of bhery under cooperatives are lower due to excessive silt deposition. Under the management plan, a one-time desiltation of bhery under cooperatives would be supported, so that an optimal water column (upto 0.8 m) and natural gradient of water flow can be maintained. The excavated silt will be used to strengthen embankments or used as manure in agricultural farms. The selection of bhery will be done in consultation with the CAG, and would be based on a commitment with the cooperative to maintain the bhery in the good condition to support fish production.

The activities to be undertaken are:

- Meeting of CAG to prepare a list of bhery needing desiltation
- Preparation of estimate of desiltation to be carried out
- Desiltation of the ponds
- Transport of silt to embankments or agricultural farms

4.1.2 Establishment of new hatcheries

It is proposed to construct 4 hatcheries for production of seeds of Indian major carps and air breathing catfishes in Dhapa Manpur, Tardha Kapasati, Kharki and Kantipota for enhancement of fish yield from East Kolkata Wetlands. The proposed hatcheries with a production capacity of 0.15 million fry / unit for air breathing fishes and 1 million / unit for freshwater fish are proposed to be operated through fish cooperatives.

The revenue generated through sale of fish seeds would be used for operation and maintenance of the hatchery units.

The activities to be undertaken are:

- Formation of SHGs for management of hatcheries and defining rules for management of infrastructure and sharing of usufruct
- Construction of hatchery including brood tank, larval rearing tank, feed culture tank, and generator shed
- Maintenance and hatchery operation including brood stock maintenance, breeding using inducing agents, and larval rearing

4.1.3 Bhery water quality monitoring

As a part of the wetland monitoring programme under Component 1, it is proposed to cover upto 30% of bhery into a water quality monitoring programme. As a part of this programme, each bhery operator will:

- Receive a training on water quality monitoring, covering measurement of parameters and their thresholds
- Receive a water quality testing kit

The water quality data will be uploaded on the monitoring platform through a specially designed app for the purpose. The EKWMA will collate the data and share an overview with the bhery operators on a periodic basis.

4.2 Sustainable Agriculture and Horticulture Development

4.2.1 Promoting rain water harvesting

Rainwater harvesting can lead to a better utilization of the agricultural land by sustainable intensification and diversification of crops. Several farms have ponds that have become derelict owing to silt deposition.

The management plan shall support desiltation and renovation of the farm ponds with a proper engineering layout up to 1m depth, so that rain water can be utilized in cultivation of low-irrigation rabi crops such as chilli, watermelon, cucurbits, mung bean etc.

4.2.2 Diversification of cropping pattern

4.2.2.1Agriculture

On a demonstration basis, the management plan will support crop diversification in agriculture farms so as to retain agricultural productivity and enhance economic returns to the farmers. Upto 100 farmers will be provided support for cultivation of latest varieties of mung bean, chili and other suitable crops in rabi season.

4.2.2.2 Horticulture

On a demonstration basis, upto 100 horticulture farmers will be provided training in:

a) Cultivation of fruit crops such as Guava, Ber (Kul) and Sapota (clusters around Bhangor I and II are suited)
b) Cultivation of high-value vegetables such as green and yellow capsicum and ornamental cabbage
c) Floriculture (Jasmine, Marigold and Sunflower)
d) Medicinal plants (Holy Basil, Ghritokumari and others)

Farmers will be provided training for each of these techniques, and the cost of inputs as well as marketing support will be provided, with support of Krishi Vigyan Kendra and Extension Units of Agriculture Department. Identification of beneficiaries will be done by CAG.

4.3 Community infrastructure

4.3.1 Community Health camps

Health camps for wetlands communities will be run in collaboration with the Department of Health and Family Welfare to address the health hazards.

4.3.2 Safe drinking water

Arsenic filters would be provided to the wetland communities to reduce the risk of contracting water borne diseases.

8 Budget and Financing

8.1 Budget

Management plan implementation will entail a budget of Rs. 119.8 crore. Of this, the component on institutions and governance is allocated 30.7%. This is followed by allocation of 27.4% for implementing actions under component for water management and pollution abatement. The components on sustainable resource development and conservation of species and habitats have been allocated 23.9% and 18% of the budget respectively.

Table 16. Component wise budget for management plan implementation

Management Plan Components	Amount (Rs Lakh)	%	Year 1	Year 2	Year 3	Year 4	Year 5
Component 1: Institutions and Governance	**3677.5**	**30.7**	**1010.5**	**2220.5**	**258.5**	**81.5**	**106.5**
Component 2: Water Management and Pollution Abatement	**3281.5**	**27.4**	**15.5**	**1171.5**	**1371.5**	**711.5**	**11.5**
Component 3: Conservation of Species and Habitat	**2159**	**18**	**16.5**	**1077**	**1048.5**	**13**	**4**
Component 4: Sustainable resource development	**2862.5**	**23.9**	**542.5**	**1628**	**590.5**	**50**	**51.5**
Grand Total	11980.5	100	1585	6097	3269	856	173.5

EKWMA shall have the authority to change/revise the indicative allocations in this budget proposal, depending upon the circumstances and considering the "needs" of the wetlands management.

Table 18. Detailed activity wise budget

	Activity		Sub activity	Physical Target	Unit	Rate	Amount (Rs Lakh)	Year 1		Year 2		Year 3		Year 4		Year 5	
								Physical Target	Amount	Physical Target	Amount	Physical Target	Amount	Physical Target	Amount	Physical Target	Amount
	Component 1: Institutions and Governance						3677.5		1010.5		2220.5		258.5		81.5		106.5
	1.1	EKWMA Reorganization and Strengthening															
		1.1.1	Reorganization proposal	1	study	30,00,000	30				30.00		-		-		-
		1.1.2	Stakeholder workshop	1	workshop	5,00,000	5				5.00		-		-		-
	1.2	Wetland demarcation															
		1.2.1	Field survey for identification of pillar points		LS		5		5.00								
		1.2.2	Placement of pillars	1600	pillars	10,000	160		-	800.00	80.00	800.00	80.00		-		-
		1.2.3	Replacement and maintenance			LS	20								10.00		10.00
	1.3	Management zoning															
		1.3.1	Stakeholder workshop	1	workshop	2,00,000	2	1.00	2.00		-		-		-		-
		1.3.2	Preparation of zonal management plans	1	plan	50,00,000	50		20.00	1.00	30.00		-		-		-
	1.4	Wetlands Inventory, Assessment and Monitoring System															
		1.4.1	Establishment of wetland monitoring and research centre														
			Upgradation of Laboratory			LS	200		100.00		100.00						
			Research associates	4	persons / annu	24,00,000	120	4.00	24.00	4.00	24.00	4.00	24.00	4.00	24.00	4.00	24.00
		1.4.2	Development of wetlands database management system														
			Database system design	1	Consultancy	LS	20		20.00								
			Maintenance	to be done by Research Associates													
		1.4.3	Wetlands monitoring and evaluation														
			Survellience system														
			System design	1	consultancy	10,00,000	10	1.00	10.00								
			Infrastrcture procurement (CCTV, Drones) (including O&M)				2000		500.00		1,500.00						
			App design	1	consultancy	10,00,000	10	1.00	10.00								
			Travel and Contingencies		per annum	6,00,000	30		6.00		6.00		6.00		6.00		6.00
			Annual monitoring report publication	5	publication	2,00,000	10	1.00	2.00	1.00	2.00	1.00	2.00	1.00	2.00	1.00	2.00
		1.4.4	Ecosystem Health Report Card														
			Methods workshop	1	workshop	1,00,000	1	1.00	1.00								
			Report preparation and publication	3	Report Cards	1,50,000	4.5	1.00	1.50			1.00	1.50			1.00	1.50
			Stakeholder workshop	2	workshops	2,50,000	5					1.00	2.50			1.00	2.50
	1.5	Research															
		1.5.1	Carbon and GHG flux assessment														
			Inception workshop	1	workshop	1,50,000	1.5	1.00	1.50								
			Study	1	study	40,00,000	40		10.00		20.00		10.00				
			Result sharing workshop	1	workshop	2,50,000	2.5					1.00	2.50				
			Publication	1	publication	2,50,000	2.5					1.00	2.50				
		1.5.2	Hydrological Assessment and Nutrient budget														
			Inception workshop	1	workshop	1,50,000	1.5	1.00	1.50								
			Study	1	study	40,00,000	40		10.00		20.00		10.00				
			Result sharing workshop	1	workshop	2,50,000	2.5					1.00	2.50				
			Publication	1	publication	2,50,000	2.5					1.00	2.50				

		1.5.3	Bioaccumulation studies																
			Inception workshop	1	workshop	1,50,000	1.5	1.00	1.50										
			Study	1	study	40,00,000	40		10.00		20.00		10.00						
			Result sharing workshop	1	workshop	2,50,000	2.5					1.00	2.50						
			Publication	1	publication	2,50,000	2.5					1.00	2.50						
		1.5.4	Multiple values (Biodiversity & Economic) assessment																
			Inception workshop	2	workshop	1,50,000	3	2.00	3.00										
			Study	2	study	40,00,000	80		20.00		40.00		20.00						
			Result sharing workshop	2	workshop	2,50,000	5					2.00	5.00						
			Publication	2	publication	2,50,000	5					2.00	5.00						
	1.6	Capacity Development																	
		1.6.1	Training Needs Assessment	1	study	10,00,000	10	1.00	10.00										
		1.6.2	Training workshops																-
		1.6.2.1	For EKWMA and concerned state government agencies																
			Integrated wetlands management	1	training	5,00,000	5	1.00	5.00										
			Wetlands inventory, assessment and monitoring	1	training	5,00,000	5			1.00	5.00								
			Wetland and climate change adaptation	1	training	5,00,000	5					1.00	5.00						
			Integrating wetlands in developmental planning	1	training	5,00,000	5							1.00	5.00				
		1.6.2.2	For NGOs/ CBOs/ CSOs	5	trainings	2,50,000	12.5	1.00	2.50	1.00	2.50	1.00	2.50	1.00	2.50	1.00	2.50		
		1.6.2.3	For communities	10	trainings	1,50,000	15	2.00	3.00	2.00	3.00	2.00	3.00	2.00	3.00	2.00	3.00		
	1.7	Communication and Outreach																	
		1.7.1	Signage	50	units	10,00,000	500	20.00	200.00	30.00	300.00								
		1.7.2	Webpage	1	consultancy	10,00,000	10	1.00	10.00		-								
		1.7.3	Community engagement meetings	20	meetings	50,000	10	4.00	2.00	4.00	2.00	4.00	2.00	4.00	2.00	4.00	2.00		
		1.7.4	Resource material	10	publications	4,00,000	40		-	3.00	12.00	4.00	16.00	2.00	8.00	1.00	4.00		
		1.7.5	Newsletter	5	publications	4,00,000	20	1.00	4.00	1.00	4.00	1.00	4.00	1.00	4.00	1.00	4.00		
		1.7.6	Public Events	15	events	5,00,000	75	3.00	15.00	3.00	15.00	3.00	15.00	3.00	15.00	3.00	15.00		
	1.8	Management Plan Implementation Review																	
		1.8.1	Mid-term review	1	assessment	20,00,000	20					1.00	20.00						
		1.8.2	End-term review	1	assessment	30,00,000	30									1.00	30.00		
Component 2: Water Management and Pollution Abatement							**3281.5**		**15.50**		**1,171.50**		**1,371.50**		**711.50**		**11.50**		
	2.1	Dredging of channels																	
		2.1.1	Field surveys and preparation of estimates			LS	4		4.00										
		2.1.2	Dredging / Re-excavation of Canals	44	km	20,00,000	880			20.00	400.00	24.00	480.00						

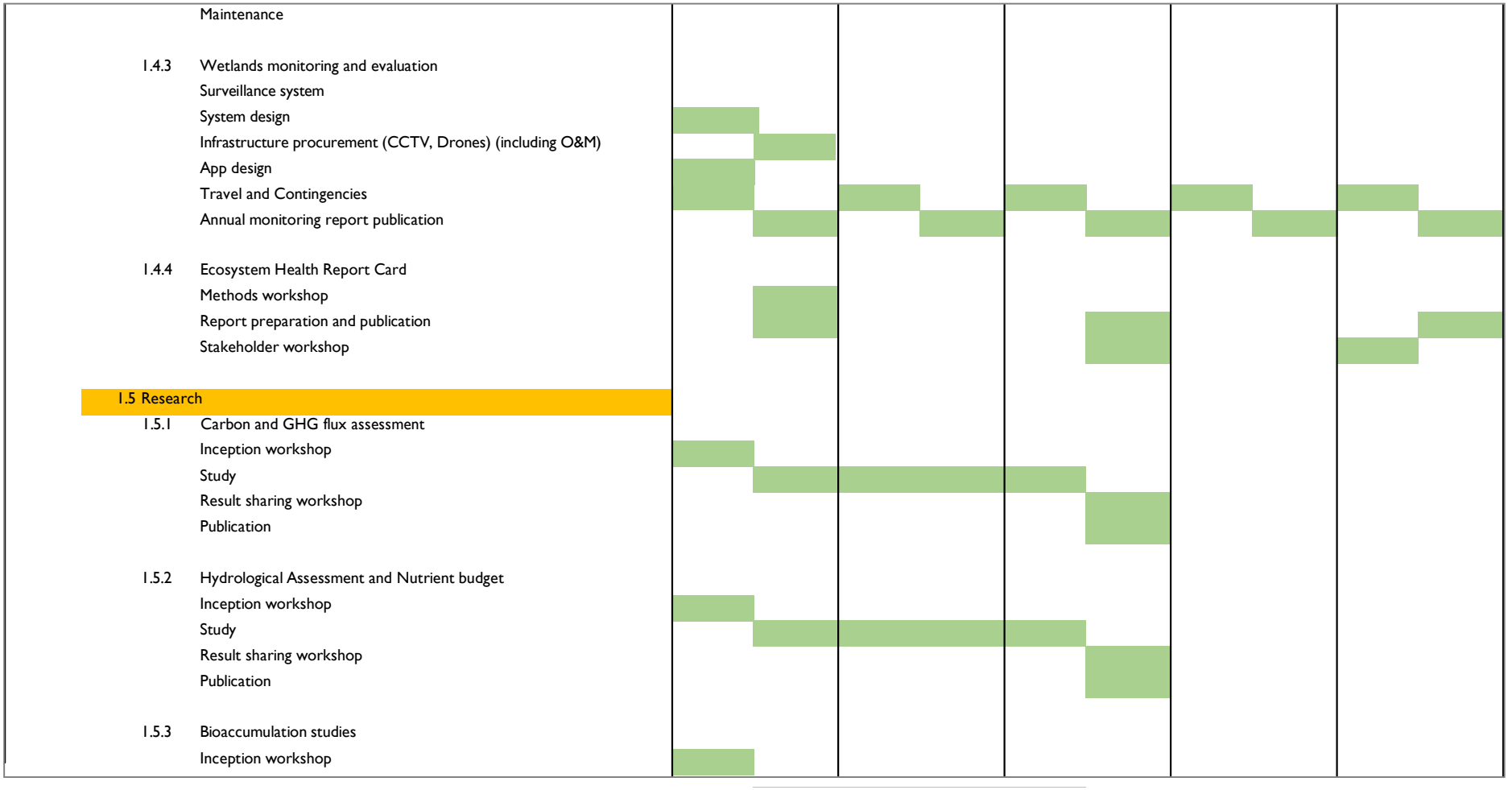
2.2	Waste segregation unit at EKW inlet							-	1.00	50.00		-		-		-
	2.2.2	Installation of waste segregation unit	1	unit	50,00,000	50										
2.3	Constructed wetlands at Kulti outfall							-		-		-		-		-
	2.3.1	Design and Estimation			LS	5				5.00						
	2.3.3	Creation of constructerd wetlands	20	ha	3,00,000	60						60.00				
2.4	Plastic waste recycling unit							-		-		-		-		-
	2.4.1	Design and Estimation			LS	5				5.00						
	2.4.2	Installation of waste recycling unit			LS	120						120.00				
2.5	Treating Dhapa leachate															
	2.5.1	Anaerobic biological treatment				50		10.00		10.00		10.00		10.00		10.00
	2.5.2	Solid Waste Management and Biomining of Mollar Bhery	300000	lakh tonne	700	2100			1,00,000.00	700.00	1,00,000.00	700.00	1,00,000.00	700.00		
2.6	Establishing plastic free zone															
	2.6.1	Sensitization workshop	15	workshops	50,000	7.5	3.00	1.50	3.00	1.50	3.00	1.50	3.00	1.50	3.00	1.50
	2.6.2	Plastic waste collection units	10	units	60,000	6			3.00	1.80	3.00	1.80				
	2.6.3	Outreach material	20	publications	40,000	8	5.00	2.00	10.00	4.00	5.00	2.00				
Component 3: Conservation of Species and Habitat						**2159**		**16.50**		**1,077.00**		**1,048.50**		**13.00**		**4.00**
3.1	Asian waterbird census															
	3.1.1	Training	5	trainings	1,50,000	7.5	1.00	1.50	1.00	1.50	1.00	1.50	1.00	1.50	1.00	1.50
	3.1.2	Annual Census	5	census	2,00,000	10	1.00	2.00	1.00	2.00	1.00	2.00	1.00	2.00	1.00	2.00
	3.1.3	Reporting	5	reports	50,000	2.5	1.00	0.50	1.00	0.50	1.00	0.50	1.00	0.50	1.00	0.50
3.2	Bird health conservation															
	3.2.1	Training workshops for wild bird disease management	2	workshops	1,50,000	3		-	1.00	1.50			1.00	1.50		
	3.2.2	Establishing baseline	to be done by Research Associates					-		-				-		
	3.2.3	Surveillance and reporting	to be done by Research Associates					-		-				-		
3.3	Culture of indigenous fish species															
	3.3.1	Feasibility assessment	1	study	10,00,000	10	1.00	5.00		5.00		-		-		-
	3.3.2	Training for selective breeding	2	trainings	2,50,000	5		-	1.00	2.50	1.00	2.50		-		-
	3.3.3	Establishing fish stock				5		-		-		5.00		-		-
	3.3.4	Surveillance and reporting	to be done by Research Associates													
3.4	Management of invasive species															
	3.4.1	Study on species pathways	1	study	15,00,000	15	1.00	7.50		7.50		-		-		-
	3.4.2	Screening of pathways and eradication				15		-		5.00		5.00		5.00		-
3.5	Rehabilitation of aquatic vegetation															
	3.5.1	Site assessment	1	study		5		-		-	1.00	5.00		-		-
	3.5.2	Vegetation regeneration / reestablishment	10	ha	50,000	5		-		-	5.00	2.50	5.00	2.50		-

3.6	Communication and education facilities															
3.6.1	Interpretation centre	10,000	m2	20,000	2000		-		1,000.00		1,000.00		-		-
	Exhibits						-		-		-		-		-
	Viewing gallery						-		-		-		-		-
	Watchtower	3	units	2,50,000	7.5		-		-	3.00	7.50		-		-
	Nature trails	2	units	12,50,000	25			1.00	12.50	1.00	12.50				
	Waste recycling model of EKW						-		-		-		-		-
	Children play area						-		-		-		-		-
	Auditorium						-		-		-		-		-
	Souvenir shop						-		-		-		-		-
3.6.2	Bhery showcase						-		-		-		-		-
	Training of community members as guides	3	trainings	1,50,000	4.5		-	2.00	3.00	1.00	1.50		-		-
	Establishing bhery models	3	bhery	2,00,000	6		-	2.00	4.00	1.00	2.00		-		-
3.6.3	Guided boat rides														
	Purchase of boats	6	boat	5,00,000	30		-	6.00	30.00		-		-		-
	Training of boatmen	3	trainings	1,00,000	3		-	2.00	2.00	1.00	1.00		-		-
Component 4: Sustainable resource development					**2,862.50**		**542.50**		**1,628.00**		**590.50**		**50.00**		**51.50**
4.1	Sustainable fisheries Development														
4.1.1	Bhery disiltation														
		Costed within community consultation													
	Meeting of CAG to prepare a list of bhery needing desiltation	meetings													
	Desiltation design and estimate preparation			LS	15				15.00						
	Bhery Desiltation	25	bhery	1,00,00,000	2500	5.00	500.00	15.00	1,500.00	5.00	500.00	-	-	-	-
	Transportation of silt to embankments or agricultural farms						-		-		-		-		-
4.1.2	Establishment of new hatchery														
	Formation of SHG														
	Training workshops	4	trainings	1,50,000	6		-	4.00	6.00		-		-		-
	Fish hatchery establishment	4	hatcheries	10,00,000	40		-			2.00	20.00	2.00	20.00		-
	Operation and maintenance	4	hatcheries	6,00,000	24		-				-			4.00	24.00
4.1.3	Bhery water quality monitoring														
	Training on water quality monitoring	5	trainings	1,50,000	7.5		-	3.00	4.50	2.00	3.00		-		-
	Provision of water quality kits	500	kits	10,000	50		-	300.00	30.00	200.00	20.00		-		-
	App for data collection and management	1	app		10	1.00	10.00		-		-		-		-
4.2	Sustainable agriculture and horticulture development														
4.2.1	Promoting rain water harvesting														
	Training	10	trainings	1,50,000	15		-	5.00	7.50	5.00	7.50		-		-
	Unit establishment	10	clusters	2,50,000	25		-	5.00	12.50	5.00	12.50		-		-
	Handholding support				5		-		-		-		2.50		2.50
4.2.2	Diversification of cropping pattern														
	Training on cultivation of crops	10	trainings	1,50,000	15	5.00	7.50	5.00	7.50		-		-		-
	Demonstration plots	10	ha	4,00,000	40	5.00	20.00	5.00	20.00						
	Handholding support				5						2.50		2.50		
4.3	Community infrastructure														
4.3.1	Health camps	5	camps	5,00,000	25	1.00	5.00	1.00	5.00	1.00	5.00	1.00	5.00	1.00	5.00
4.3.2	Safe drinking water	40	community filt	2,00,000	80		-	10.00	20.00	10.00	20.00	10.00	20.00	10.00	20.00
Grand Total					11,980.50		1,585.00		6,097.00		3,269.00		856.00		173.50

8.2 Phasing of Activities

Table 19. Phasing of activities

Activity	Sub activity	Year 1		Year 2		Year 3		Year 4		Year 5	
		1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half	1 st Half	2 nd Half
Component 1: Institutions and Governance											
1.1 EKWMA Reorganization and Strengthening											
1.1.1	Reorganization proposal										
1.1.2	Stakeholder workshop										
1.2 Wetland demarcation											
1.2.1	Field survey for identification of pillar points										
1.2.2	Placement of pillars										
1.2.3	Replacement and maintenance										
1.3 Management zoning											
1.3.1	Stakeholder workshop										
1.3.2	Preparation of zonal management plans										
1.4 Wetlands Inventory, Assessment and Monitoring System											
1.4.1	Establishment of wetland monitoring and research centre										
	Upgradation of IESWM Laboratory										
	Research associates										
1.4.2	Development of wetlands database management system										
	Database system design										


Maintenance
1.4.3 Wetlands monitoring and evaluation
Surveillance system
System design
Infrastructure procurement (CCTV, Drones) (including O&M)
App design
Travel and Contingencies
Annual monitoring report publication
1.4.4 Ecosystem Health Report Card
Methods workshop
Report preparation and publication
Stakeholder workshop
1.5 Research
1.5.1 Carbon and GHG flux assessment
Inception workshop
Study
Result sharing workshop
Publication
1.5.2 Hydrological Assessment and Nutrient budget
Inception workshop
Study
Result sharing workshop
Publication
1.5.3 Bioaccumulation studies
Inception workshop

	Study										
	Result sharing workshop										
	Publication										
1.5.4	Multiple values assessment										
	Inception workshop										
	Study										
	Result sharing workshop										
	Publication										
1.6 Capacity Development											
1.6.1	Training Needs Assessment										
1.6.2	Training workshops										
1.6.2.1	For EKWMA and concerned state government agencies										
	Integrated wetlands management										
	Wetlands inventory, assessment and monitoring										
	Wetland and climate change adaptation										
	Integrating wetlands in developmental planning										
1.6.2.2	For NGOs and CBOs										
1.6.2.3	For communities										
1.7 Communication and Outreach											
1.7.1	Signage										
1.7.2	Webpage										

1.7.3	Community engagement meetings										
1.7.4	Resource material										
1.7.5	Newsletter										
1.7.6	Public Events										
1.8	Management Plan Implementation Review										
1.8.1	Mid-term review										
1.8.2	End-term review										
Component 2: Water Management and Pollution Abatement											
2.1	Dredging of channels										
2.1.1	Field surveys and preparation of estimates										
2.1.2	Dredging										
2.2	Waste segregation unit at EKW inlet										
2.2.2	Installation of waste segregation unit										
2.3	Constructed wetlands at Kutli outfall										
2.3.1	Design and Estimation										
2.3.2	Creation of constructed wetlands										
2.4	Plastic waste recycling unit										
2.4.1	Design and Estimation										
2.4.2	Installation of waste recycling unit										
2.5	Treating Dhapa leachate										
2.5.1	Anaerobic biological treatment										
2.5.2	Solid Waste Management and Biomining of Molar Bhery										

2.6 Establishing plastic free zone											
2.6.1	Sensitization workshop										
2.6.2	Plastic waste collection units										
2.6.3	Outreach material										
Component 3: Conservation of Species and Habitat											
3.1 Asian waterbird census											
3.1.1	Training										
3.1.2	Annual Census										
3.1.3	Reporting										
3.2 Bird health conservation											
3.2.1	Training workshops for wild bird disease management										
3.2.2	Establishing baseline										
3.2.3	Surveillance and reporting										
3.3 Culture of indigenous fish species											
3.3.1	Feasibility assessment										
3.3.2	Training for selective breeding										
3.3.3	Establishing fish stock										
3.3.4	Surveillance and reporting										
3.4 Management of invasive species											
3.4.1	Study on species pathways										
3.4.2	Screening of pathways and eradication										
3.5 Rehabilitation of aquatic vegetation											
3.5.1	Site assessment										
3.5.2	Vegetation regeneration / reestablishment										

3.6 Communication and education facilities												
3.6.1	Interpretation centre											
	Exhibits											
	Viewing gallery											
	Watchtower											
	Waste recycling model of EKW											
	Children play area											
	Auditorium											
	Souvenir shop											
3.6.2	Bhery showcase											
	Training of community members as guides											
	Establishing bhery models											
3.6.3	Guided boat rides											
	Purchase of boats											
	Training of boatmen											
Component 4: Sustainable resource development												
4.1 Sustainable fisheries Development												
4.1.1	Bhery disiltation											
	Meeting of CAG to prepare a list of bhery needing desiltation											
	Desiltation estimate preparation											
	Bhery Desiltation											
	Transportation of silt to embankments or agricultural farms											
4.1.2	Establishment of new hatchery											
	Formation of SHG											

	Training workshops										
	Fish hatchery establishment										
	Operation and maintenance										
4.1.3	Bhery water quality monitoring										
	Training on water quality monitoring										
	Provision of water quality kits										
	App for data collection and management										
4.2 Sustainable agriculture and horticulture development											
4.2.1	Promoting rain water harvesting										
	Training										
	Unit establishment										
	Handholding support										
4.2.2	Diversification of cropping pattern										
	Training on cultivation of crops										
	Demonstration plots										
	Handholding support										
4.3 Community infrastructure											
4.3.1	Health camps										
4.3.2	Safe drinking water										

8.3 Financing Arrangements

The management plan may be financed under the National Mission of Clean Ganga (NMCG) under the relevant scheme guidelines. Additional sources of funds may be the National Plan for Conservation of Aquatic Ecosystems of the MoEFCC, which requires that the state government provides 40% of matching funds.

References

Alam, M, Alam, M.M, Curray, J.R.,Chowdhury, M.L.R and Gani,M.R.(2003): 'An overview of the sedimentary geology of the Bengal Basin in the regional tectonic framework and basin fill history', Sedimentary Geology, 155, 179-208.

Allison, M.A., Khan, S.R., Goodbred Jr., S.L., Kuehl, S.A. (2003). Stratigraphic evolution of the late Holocene Ganges-Brahmaputra lower delta plain. Sedimentary Geology, 155, 317–342.

Bagchi, K.(1944): The Ganges Delta, University of Calcutta, Calcutta.

Bandyopadhyay, S. (2007). Evolution of the Ganga Brahmaputra delta: A review. Geographical Review of India, 69(3), 235–268.

Banerjee M, Sen PK, Dastidar AG 1984. "On the depositional condition of the Holocene sediments of Bengal basin with remarks on environmental condition of the soft grey clay deposition in Calcutta". Indian Geotech Conf 84(1):63–69

Banerjee, Sarmila and Dey, Debanjana 2017 "Eco-system Complementarities and Urban Encroachment: A SWOT Analysis of the East Kolkata Wetlands, India," Cities and the Environment (CATE): Vol. 10: Iss. 1, Article 2.

Banerjee, Sarmila and Dey, Debanjana 2017. "Eco-system Complementarities and Urban Encroachment: A SWOT Analysis of the East Kolkata Wetlands, India," Cities and the Environment (CATE): Vol. 10: Iss. 1, Article 2.

Barui NC, Chanda S 1992. "Late Quaternary pollen analysis in relation to palaeoecology, biostratigraphy and dating of Calcutta peat". Indian Natl Sci Acad 58B (4):191–200

Bhadra, T, Mukhopadhyay A, and Hazra Sugata. 2017. "Identification of riverdiscontinuity using geo-informatics to improve freshwater flow & ecosystem services in Indian Sundarban delta". Springer Remote Sensing/Photogrammetry, 137–152. doi:10.1007/978-3-319-46010-9_10

Biswas B 1969. "Unpublished records of Zoological Survey of India". In Ghosh A.K. 1990. Biological Resources of wetlands of East Calcutta. Indian Journal of Landscape System and Ecological Studies. 13(1): 10-23.

Biswas KP 1927. "Flora of the Salt Lakes, Calcutta", Journal of Department of Science, University of Calcutta, 8.

Brown, S. And Nicholls, R.J. (2015): Subsidence and human influences in mega deltas: The case of the Ganges-Brahmaputra-Meghna, Science of the Total Environment 527-528, 362-374.

Bunting, S W, Kundu, N, and Mukherjee, M. 2002. "Situation Analysis: Production Systems and Natural Resource Management in PU Kolkata." Working Paper. Stirling, UK: Institute of Aquaculture.

Bunting, Stuart W., Jules Pretty, and Peter Edwards. 2010. "Wastewater-Fed Aquaculture in the East Kolkata Wetlands, India: Anachronism or Archetype for Resilient Ecocultures? Wastewater-Fed Aquaculture in the EKW." Reviews in Aquaculture 2 (3): 138–53. https://doi.org/10.1111/j.1753-5131.2010.01031.x.

CGWB (Central Ground Water Board), 2004. "Hydrogeology and ground water development of North-24 Parganas District, West Bengal". Kolkata: Government of India, CGWB Eastern Region, Technical report, series D.

Chakraborty G., and Das Gupta D 2019. "From conflict to co-production a multi stakeholder analysis in preserving East Kolkata Wetlands". Forum for policy dialogue on water conflicts in India

Chakraborty, Gorky, and Dhruba Das Gupta. 2019. "From Conflict to Co-Production A Multi-Stakeholder Analysis in Preserving the East Kolkata Wetlands." Pune: Forum for Policy

Chandra, K., Raghunathan, C. and Mao, A.A. 2020. Biodiversity Profile of East Kolkata Wetlands, 1- 326 Jointly published by the Director, Zool. Surv. India, Kolkata and East Kolkata Wetlands Management Authority, Department of Environment, Govt. of West Bengal

Chaterji GC, Deshmukh DS, Sinha SC, Niyogi BN 1959. "Some recent observations on the depth of sediment in the Ganga valley below Varanasi. Ganga Valley: a symposium". ONGC, Dehradun

CPCB. 2019. "Summary of the Detailed Study Taken by East Kolkata Wetlands Management Authority, Institute of Environmental Studies & Wetland Management and Central Pollution Control Board, Eastern Regional Directorate, Kolkata." Kolkata: Central

Pollution Control Board.
Curry, J.R. (1994): 'Sediment volume and mass beneath the Bay of Bengal'. Earth and Planetary Science Letters, 125, 371-383.
Curray, J.R., Emmel, F.J, Moore, D.G.(2003). The Bengal Fan: morphology, geometry, stratigraphy, history and process; Marine and Petroleum Geology 19, 1191-1223.
Das A., and Mandal A., 2018. "Waste systems: Its utility and analyses in aquaculture". In: Jana B., Mandal R., Jayasankar P. (eds) Wastewater Management Through Aquaculture. Springer, Singapore
Dasgupta, R. 1973. "Contribution of botany of a portion of Salt Lakes, West Bengal", Ind.Mus. Bull., vol. 1.
Dasgupta, S., Gosain, A.K., Rao, S., Roy, S., Sarraf, M., 2013. "A megacity in a changing climate: the case of Kolkata". Climatic Change 116, 747–766. https://doi.org/10.1007/s10584-012-0516-3
Dasgupta, S. and Panigrahi, A., 2014. Studies on The Effect Of Aquatic Pollution On Ichthyofaunal Diversity Of The East Kolkata Wetlands. International Journal of Research in Applied, Natural and Social Sciences, 2(4), pp.145-152.
De, M., Bhunia, S. and Sengupta, T. 1989. "A Preliminary Account on Major Wetland Fauna of Calcutta and Surroundings". Ecology 3 (9): 5-11
Dey, Debanjana, and Sarmila Banerjee. 2018. "How Expensive Is the Decay of East Kolkata Wetlands? An Estimation of Opportunity Cost for Kolkata." In Sustainable Urbanization in India, edited by Jenia Mukherjee, 181–205. Exploring Urban Change in South Asia. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-10-4932-3_10.
Dutta, Joystu, Arpita Saha, and Abhijit Mitra. 2016. "Impact of Acidification on Heavy Metal Levels in a Bheri of East Kolkata Wetlands (EKW), a Ramsar Site in the Indian Sub-Continent." International Journal of Development Research 7 (7): 15452–58.
EKWMA. 2016. "Birds of East Kolkata Wetlands." East Kolkata Wetlands Management Authority.
EKWMA, 2020. Pictorial Guide Amphibians, Reptiles and Mammals of East Kolkata Wetlands. East Kolkata Wetlands Management Authority and Zoological Survey of India.
Finlayson, C Max. 2012. "Forty Years of Wetland Conservation and Wise Use: EDITORIAL." Aquatic Conservation: Marine and Freshwater Ecosystems 22 (2): 139–43. https://doi.org/10.1002/aqc.2233.
Finlayson, C Max, Nick Davidson, Dave Pritchard, G Randy Milton, and Heather Mackay. 2011. "The Ramsar Convention and Ecosystem-Based Approaches to the Wise Use and Sustainable Development of Wetlands." Journal of International Wildlife Law & Policy 14 (3–4): 176–98.
Ghosh, D. and S. Sen, 1987. "Ecological History of Calcutta's Wetland Conversion". Environ. Conserv., 14: 219-226. DOI: 10.1017/s0376892900016416
Ghosh, D., 2005. "Ecology and Traditional Wetland Practice: Lessons from Wastewater Utilisation in the East Calcutta Wetlands". 1st Edn., Worldview, Kolkata, pp: 120.
Ghosh, Dhrubajyoti. 1999. "Wastewater Utilisation in East Calcutta Wetlands." Occasional Paper. Nieuwehaven, The Netherlands: IRC. 2005. Ecology and Traditional Wetland Practice: Lessons from Wastewater Utilisation in the East Calcutta Wetlands. Kolkata: Worldview.
Ghosh, S. K., and Ghosh D. 2003. "Community based rehabilitation of wetlands in West Bengal, India", S. B. Ray et al. (ed.), Contemporary Studies in Natural Resource Management in India, Forest Studies Series, Inter-India Publication, New Delhi.
Ghosh, S., 2018. "Wastewater-Fed Aquaculture in East Kolkata Wetlands: State of the Art and Measures to Protect Biodiversity", in: Jana, B.B., Mandal, R.N., Jayasankar, P. (Eds.), Wastewater Management Through Aquaculture. Springer Singapore, Singapore, pp. 119–137. https://doi.org/10.1007/978-981-10-7248-2_6
Hait AK, Das HK, Ghosh S, Ray AK, Chanda S 1996. "Environmental variations in Late Quaternary sequence of Kolaghat, West Bengal, India". Curr Sci 70(12):1089–1093
Hussan, Ajmal, J.K. Sundaray, R.N. Mandal, Farhana Hoque, Arabinda Das, P.P. Chakrabarti, and S. Adhikari. 2019. "Invasion of Non-Indigenous Suckermouth Armoured Catfish of the Genus Pterygoplichthys (Loricariidae) in the East Kolkata Wetlands: Stakeholders' Perception." Indian Journal of Fisheries 66 (2). https://doi.org/10.21077/ijf.2019.66.2.86267-05.
Indiawris.gov.in. 2020. India-WRIS. [online] Available at: <https://indiawris.gov.in/wris/#/Aquifer>

[Accessed 20 July 2020].
Jana S. 2018. "Socioeconomic Impacts and Cost-Benefit Analysis of Wastewater-Fed Aquaculture". In: Jana B., Mandal R., Jayasankar P. (eds) Wastewater Management Through Aquaculture. Springer, Singapore
Joystu, Dutta. 2017. "Bioaccumulation of Toxic Heavy Metals in the Edible Fishes of Eastern Kolkata Wetlands (EKW), the Designated Ramsar Site of West Bengal, India." International Journal of Aquaculture and Fishery Sciences, March, 018–021. https://doi.org/10.17352/2455-8400.000023.
Khatun, A., Pal, S., Mukherjee, A., Samanta, P., Mondal, S., Kole, D., Chandra, P. and Ghosh, A., 2016. Evaluation of metal contamination and phytoremediation potential of aquatic macrophytes of East Kolkata Wetlands, India. Environmental Health and Toxicology, 31, p.e2016021.
KMC Drainage Report, 2020.Report on S&D Department for Chief Secretary's Environmental Monitoring Cell. 1-3
Kumar, Bhupander, Kurunthachalam Senthil Kumar, Mahalakshmi Priya, Debapriyo Mukhopadhyay, and Rita Shah. 2010. "Distribution, Partitioning, Bioaccumulation of Trace Elements in Water, Sediment and Fish from Sewage Fed Fish Ponds in Eastern Kolkata, India." Toxicological & Environmental Chemistry 92 (2): 243–60. https://doi.org/10.1080/02772240902942394.
Kumar, Ritesh. 2018. "East Kolkata Wetlands and the Regulation of Water Quality." In The Wetland Book, edited by C. Max Finlayson, Mark Everard, Kenneth Irvine, Robert J. McInnes, Beth A. Middleton, Anne A. van Dam, and Nick C. Davidson, 1293–99. Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-90-481-9659-3_222.
Kundu, N., & Chakraborty, A. 2017. "Dependence on Ecosystem Goods and Services: A Case Study on East Kolkata Wetlands, West Bengal, India". Wetland Science, 381–405. doi:10.1007/978-81-322-3715-0_20
Mahapatra, B K, and W S Lakra. 2014. "Ornamental Fishes of East Kolkata Wetland, West Bengal, India." International Journal of Scientific Research 3 (12): 406–8.
Mallick, Jayanta Kumar. 2009. "View of Endemic Marsh Mongoose Herpestes Palustris (Carnivora_ Herpestidae) of East Kolkata Wetlands, India: A Status Report." Journal of Threatened Taxa 1 (4).
Mondal, Biswajit, Gour Dolui, Malay Pramanik, Santu Maity, Sumantra Sarathi Biswas, and Raghunath Pal. 2017. "Urban Expansion and Wetland Shrinkage Estimation Using a GIS-Based Model in the East Kolkata Wetland, India." Ecological Indicators 83 (December): 62–73. https://doi.org/10.1016/j.ecolind.2017.07.037.
Mukherjee, A. and Bardhan, S., 2019. "An Assessment of Direct and Indirect Emission Reduction Potential of Natural Wetland Systems of Kolkata, India". International Journal of Applied Engineering Research, 14(8), p.1923.
Mukherjee, J., & Ghosh, A. 2015. "Water justice city profile: Kolkata, India". https://www.bartlett. ucl.ac.uk/dpu/water-justice/outputs/Kolkata_report.pdf. Mukherjee, Jenia. 2020. "Untamed Practices." In Blue Infrastructures, by Jenia Mukherjee, 85–123. Exploring Urban Change in South Asia. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-3951-0_4.
Mukherjee, V., Das, A., Akhand, A., & Gupta, G. 2013. "Toxicity and profitability of rice cultivation under wastewater irrigation: the case of the East Calcutta Wetlands". Ecological Economics, 93, 292–300. doi: 10.1016/j.ecolecon.2013.06.010
Nandi, S, C Srivastava, and K M Agarwal. 2013. "Heavy Metal Concentration in Surface Water of East Kolkata Wetland." Indian Journal of Public Health Research & Development 4 (4): 227–30.
Nath, Susanta, and Madhumita Bhoumik. 2013. "Levels of Toxic Metals in Edible Fish from a Wetland of India." International Journal of Environmental Sciences 3 (5): 1509–15.
Niyogi, S. and Ray, S., 2017. "Attempt to Grab EKW Land Foiled" | Kolkata News - Times Of India.
Oldham.(1870): President's address. Proceedings, Asiatic Society of Bengal for February, 1870, Calcutta.
Parihar, Seema Mehra, Soma Sarkar, Amitava Dutta, Shilpi Sharma, and Tanushree Dutta. 2013. "Characterizing Wetland Dynamics: A Post-Classification Change Detection Analysis of the East Kolkata Wetlands Using Open Source Satellite Data." Geocarto International 28 (3): 273–87. https://doi.org/10.1080/10106049.2012.705337.

Raychaudhuri, S., Mishra, M., Nandy, P., & Thakur, A. R.2008. "Waste management: A case study of ongoing traditionalpractices at east Calcutta Wetland". American Journal of Agricultural and Biological Science, 3(1), 315–320. https://doi.org/10.3844/ajabssp.2008.315.320

Rennell, J. (1780): A Bengal Atlas, London. (edited by Kalyan Rudra (2016) and published by Sahitya Samsad, Kolkata.

Rudra, K.(2008): Banglar Nadikatha (in Bengali). Sahitya Samsad, Kolkata.

Rudra, K. (2012): Atlas of Changing River Courses in West Bengal, Sea Explorers' Institute, Kolkata.

Rudra, K.(1999): 'The hypothesis of easterly flight of the Ganga water: Fact or Fiction', Indian Journal of Geography and Environment, 4, Deptt. of Geography, Vidyasagar University,52-55

Rudra, K. (2014): Changing river courses in the western part of the Ganga–Brahmaputra delta. Geomorphology, 227, 87–100.

Rudra, K. (2015): Ref: Changing river courses in the western part of the Ganga–Brahmaputra, Geomorphology 250 (2015) 454–458.

Rudra, K. (2018): Rivers of the Ganga-Brahmaputra-Meghna delta / A Fluvial Account of Bengal. Springer.

Sahu, P, and P K Sikdar. 2011. "Threat of Land Subsidence in and around Kolkata City and East Kolkata Wetlands, West Bengal, India." Journal of Earth System Science 120 (3): 435–46. https://doi.org/10.1007/s12040-011-0077-2.

Sahu, P., Sikdar, P.K., 2008. "Hydrochemical framework of the aquifer in and around East Kolkata Wetlands, West Bengal, India". Environ Geol 55, 823–835. https://doi.org/10.1007/s00254-007-1034-x

Sarkar, Subhasis, Phani Bhusan Ghosh, Alok Kumar Sil, and Tapan Saha. 2011. "Heavy Metal Pollution Assessment through Comparison of Different Indices in Sewage-Fed Fishery Pond Sediments at East Kolkata Wetland, India." Environmental Earth Sciences 63 (5): 915–24. https://doi.org/10.1007/s12665-010-0760-7.

Sen PK, Banerjee M 1990. "Palynoplankton stratigraphy and environmental changes during Holocene in Bengal basin, India". Rec Palaeobot Palynol 62:25–35

Sikdar PK 2000. "Geology of the Quaternary Aquifers of the Twin City of Calcutta–Howrah". J Geol Soc India 56:169–181

Sikdar PK, Mondal S, Saha L, Sarkar SS, Banerjee S 2002. "Environmental impact assessment of a proposed info-tech complex in East Calcutta wetlands". Environmentalist 22(4): 241–260

Subhayan Dutta and Swati Chakraborty 2017 The Effect of Pollution on Hydrological Parameters Analysis of East Kolkata Wetland Area. International Journal of Development Research. Vol. 07, Issue, 09, pp.15452-1545

Stackhouse, P., 2020. NASA POWER | Data Access Viewer. [online] Power.larc.nasa.gov. Available at: <https://power.larc.nasa.gov/data-access-viewer/> [Accessed 15 July 2020].

Vicziany, M., Chattopadhyay, D., Bhattacharyya, S., 2017. "Food from Sewage: Fish from the East Kolkata Wetlands and the Limits of Traditional Knowledge". South Asia: Journal of South Asian Studies 40, 619–644. https://doi.org/10.1080/00856401.2017.1341038

Vishwakarma, A., Kunte, A., Mishra, D., Panchal, S., and Kundu S., 2014. "Dhapa Dumpsite Environmental and Social Assessment Report". West Bengal Pollution Control Board http://documents1.worldbank.org/curated/en/383421497427377147/pdf/SFG3430-V1-EA-P091031-Box402914B-PUBLIC-Disclosed-6-14-2017.pdf.

Vivekananda Mukherjee and Gautam Gupta 2011. Toxicity and Profitability of Rice Cultivation under Waste-Water Irrigation: The Case of the East Calcutta Wetlands. SANDEE Working Papers, ISSN 1893-1891; WP 62–11

WBPCB, 2019-20. Analysis Report of Kolkata Sewage Canal from March, 2019 to February, 2020. West Bengal Pollution Control Board.

Annexes

A1 List of mouzas

District	Panchayet/	Police	*Mouza*	J.L.	Status
24-Parganas (South)	Kolkata Municipal Corporation	Pragati Maidan/ Anandapur	Dhapa	2	Part mouza
			Chowbaga	3	Full
		Pragati Maidan	Bonchtala	4	Part mouza
			Dhalenda	8	Full
		Pragati Maidan/ Anandapur	Paschim Chowbaga	9	Full mouza
		Anandapur	Nonadanga	10	Part mouza
	Kheyadaha - 2 Gram Panchayat	Narendrapur	Chak Kolar Khal	1	Full
			Karimpur	2	Full
			Jagatipota	3	Full
			Mukundapur	4	Full
			Atghara	5	Full
			Ranabhutia	6	Full
			Kantipota	7	Full
			Bhagabanpur	8	Full
			Kharki	9	Full
			Deara	10	Full
	Kheyadaha - 1 Gram Panchayat		Kheadaha	11	Full
			Khodahati	12	Full
			Goalpota	13	Full
			Kumapukuria	14	Full
			Tardaha	15	Full
			Tihuria	16	Full
			Nayabad	17	Full
	Pratapnagar Gram Panchayat	Sonarpur	Samukpota	91	Full
			Pratapnagar	92	Full
			Garal	93	Full
	Banamghata Gram Panchayat	Kolkata Leather Complex	Dakshin Dhapa	1	Full
			Kochpukur (Erstwhile Dhapa	2	Part mouza
			Hatgachha	4	Full
			Hadia	5	Full
	Beonta - 2 Gram Panchayat		Dharmatala	6	Full
			Kulberia	7	Full
	Beonta - 1 Gram		Beonta	27	Full
	Tardaha Gram		Tardaha Kapashati	38	Full
	Kolkata Municipal Corporation	Purba Jadabpur	Kalikapur	20	Part mouza
24-Parganas (North)	Bidhannagar Municipal Corporation	South Bidhan	Dhapa Manpur	1	Part mouza
		Electronics Complex	Thakdari	19	Part mouza

A2 List of species

Data Source – Chandra, Raghunathan, and Mao 2020. Biodiversity Profile of East Kolkata Wetlands. Jointly published by the Director, Zool. Surv. India, Kolkata and East Kolkata Wetlands Management Authority, Department of Environment, Govt. of West Bengal

1. List of Protozoa: Free-living Ciliates

Taxa
Phylum CILIOPHORA Class GYMNOSTOMATEA Order SPATHIDIIDA
Family LACRYMARIIDAE 1. Lacrymaria olor (Müller, 1786) Bory, 1824 Order HAPTORIDA
Family DIDINIIDAE 2. Didinium nasutum (Müller, 1773) Stein, 1859 Order PLEUROSTOMATIDA
Family LITONOTIDAE 3. Litonotus lamella (Müller, 1773) Schewiakoff, 1886 4. Litonotus fasciola (Ehrenberg, 1838) Wrzesniowski, 1870 Class CYRTOPHORIA Order CYRTOPHORIDA
Family CHILODONELLIDAE 5. Chilodonella uncinata (Ehrenberg, 1838) Strand, 1928 6. Trithigmostoma steini (Blochmann, 1895) Foissner, 1988 (Synonym- Chilodontopsis bengalensis Ghosh, 1921) Class PROTOSTOMATEA Order PROSTOMATIDA
Family COLEPIDAE 7. Coleps hirtus (Müller, 1786) Nitzsch, 1827 Class LITOSTOMATEA Order DILEPTIDA
Family DILEPTIDAE 8. Dileptus anatinus Golińska, 1971 Class HYPOTRICHEA Order EUPLOTIDA Family EUPLOTIDAE 9. Aspidisca lynceus Müller, 1773 Family GASTROCIRRHIDAE 10. Euplotoides woodruffi Gaw, 1939 Order STICHOTRICHIDA
Family HYPOTRICHIDIIDAE 11. Hypotrichidium conicum Ilowaisky, 1921 Order UROSTYLIDA
Family UROSTYLIDAE 12. Urostyla grandis Ehrenberg, 1830 Order OXYTRICHIDA

Family OXYTRICHIDAE 13. *Oxytricha granulifera* Foissner & Adam, 1983 14. *Stylonychia mytilus* (Müller, 1773) Ehrenberg, 1830 Class OLIGOTRICHEA Order HALTERIIDA
Family HALTERIIDAE 15. *Halteria grandinella* (Müller, 1773) Dujardin, 1841 Class OLIGOHYMENOPHOREA Order PENICULIDA
Family PARAMECIIDAE 16. *Paramecium caudatum* Ehrenberg, 1834 Order HYMENOSTOMATIDA
Family FRONTONIIDAE 17. *Frontonia sp.* Order PERITRICHIDA
Family VORTICELLIDAE 18. *Vorticella sp.* Class HETEROTRICHEA Order HETEROTRICHIDA
Family STENTORIDAE 19. *Stentor coeruleus* (Pallas, 1766) Ehrenberg, 1830 Family SPIROSTOMIDAE 20. *Spirostomum teres* Claparède & Lachmann, 1858 Class NASSOPHOREA Order NASSULIDA
Family LEPTOPHARYNIDAE 21. *Leptopharynx costatus* Mermod, 1914 Order SYNHYMENIIDA
Family ORTHODONELLIDAE 22. *Orthodonella gutta* (Cohn, 1866) Kahl, 1931 (Synonym- *Trachelius gutta* Sahrhage, 1915)

2. List of Protozoa: Free-living Testate Amoebae

Taxa
Phylum AMOEBOZOA Luhe 1913 Class TESTACEA LOBOSEA de Saedeller,1934 Order ARCELLINIDA Kent,1880
Family ARCELLIDE Ehrenberg 1832 1. *Arcella arenaria* Greef,1866 2. *Arcella discoides* Ehrenberg, 1843 3. *Arcella vulgaris* Ehrenberg,1830
Family MICROCORYCIIDAE DeSaedeleer, 1934 4. *Diplochlamys leidy* Greeff, 1888

Family MICROCHLAMYIIDAE Ogden, 1985
5. *Pyxidicula operculata* (Agardh, 1827) Ehrenberg, 1838
6. *Pyxidicula invisitata* Awerinzew, 1906

Family CENTROPYXIDAE Jung, 1942
7. *Centropyxis aculeata* Stein, 1857
8. *Centropyxis sylavtica* DeLandre, 1929
9. *Centropyxis cassis* (Wallich, 1864) DeLandre, 1929
10. *Centropyxis ecornis* (Ehrenberg, 1841) Leidy, 1879
11. *Centropyxis minuta* DeLandre, 1929
12. *Centropyxis spinosa* (Cash and Hopkinson, 1905) DeLandre, 1929

Family TRIGINOPYXIDAE Loeblich and Tappan, 1964
13. *Cyclopyxis arcelloides* (Penard, 1902) DeLandre, 1929
14. *Cyclopyxis eurystoma* (DeLandre,1929) DeLandre, 1929
15. *Triginopyxis arcula* (Leidy,1879) Penard, 1912

Family PLAGIOPYXIDAE Bonnet and Thomas, 1960
16. *Bullinularia indica* (Penard,1907) DeLandre,1953
17. *Plagiopyxis declivis* Bonnet and Thomas, 1955

Family DIFFLUGIIDAE Wallich, 1864
18. *Diffiugia acuminata* DeLandre, 1929
19. *Diffiugia accutissima* DeLandre, 1931
20. *Diffiugia corona* Wallich 1864
21. *Diffiugia curvicaulis* Penard, 1899
22. *Diffiugia elegans* Penard, 1890
23. *Diffiugia globulosa* (Dujardin, 1837) Penard, 1902
24. *Diffiugialobostoma* Leidy, 1879
25. *Diffiugia bryophila* (Penard,1902) Jung, 1942
26. *Diffiugia oblonga* Ehrenberg, 1838
27. *Diffiugia urceolata* Carter, 1864

Family HELEOPERIDAE Jung, 1942
28. *Heleopera sylavtica* Penard, 1890

Family NEBELIDAE Taranek, 1882
29. *Quadrulella symmetrica* (Wallich,1864) Schulze,1875

Family LESQUEREUSIIDAE Jung, 1942
30. *Lesqueruesia modesta* Rhumbler, 1895
31. *Lesqueruesia spiralis* (Ehrenberg, 1840)
Phylum RHIZARIA Cavalier -Smith,2002
Class TESTACEA FILOSEA de Saedeleer,1934
Order EUGLYPHIDA Copelandm1956

Family EUGLYPHIDAE Wallich, 1864
32. *Euglypha ciliata* Ehrenberg, 1848
33. *Euglypha compressa* Carter,1890
34. *Euglypha laevis* Perty 1849
35. *Euglypha rotunda* Wailes and Penard 1911
36. *Euglypha strigosa* (Ehrenberg, 1848)
37. *Euglypha tuberculata* Dujardin, 1841
38. *Tracheleuglypha dentata* (Vejdowsky, 1832) DeLandre, 1928

Family Assulinidae Lara et al., 2007 39. *Placocista spinosa* (Carter, 1865) Leidy, 1879
Family Cyphoderiidae deSaedeleer, 1934 40. *Cyphoderia ampulla* (Ehrenberg, 1840) Leidy, 1878
Family TRINEMATIDAE Hoogenraad et de Groot, 1940 41. *Trinema enchelys* (Ehrenberg, 1838) Leidy, 1878 42. *Trinema lineare* Penard, 1890

3. List of Rotifers

Taxa
Phylum Rotifera Class Eurotatoria Subclass Monogononta Order Ploima
Family: Brachionidae 1. *Anuraeopsis fissa* Gosse, 1851 2. *Brachionus angularis* Gosse, 1851 3. *B.bidentatus* Anderson, 1889 4. *B. calycifiorus* Pallas, 1766 5. *B. caudatus* Barrois and Daday, 1894 6. *B. ahlstromi* Lindeman, 1939 7. *B. diversicornis* Daday, 1883 8. *B. falcatus* Zacharias, 1898 9. *B. forficula* Wierzejski, 1891 10. *B. plicatlis* Muller, 1786 11. *B. quadridentatus* Hermann, 178" 12. *B. rubens* Ehrenberg, 1838 13. *B. urceolaris* Muller, 1773 14. *Brachionus sp.* 15. *Keratella tropica* (Apstein, 1907) 16. *Keratella sp.* 17. *Platyionus patulus* (Muller, 1786)
Family: Lecanidae 19. *L. leontina* (Turner, 1892) 20. *L. papuana* (Murray, 1913) 21. *L.signifera* (Jennings, 1896) 22. *Lecane (Monostyla) decipiens* (Murray, 1913) 23. *L. (Monostyla) sp.*
Family: Lepadellidae 24. *Lepadella sp.*
Family: Trichocercidae 25. *Trichocerca (Diurella) similis* (Wierzejski,1893) 26. *Trichocerca (Diurella) weberi* (Jennings, 1903)

Family: Asplanchnidae 28. *A. intermedia* Hudson, 1886 29. *Asplanchna sp.* Order: Floscullariacea
Family: Filinidae 30. *Filinia longiseta* (Ehrenberg, 1834) 31. *Filinia opoliensis* (Zacharias, 1898) 32. *Filinia sp.*
Family: Testudinellidae 33. *Testudinella patina* (Hermann, 1783)
Family: Scaridiidae 34. *Scaridium longicaudum* (Muller, 1786) Subclass: Bdelloidea
Family: Philodinidae 35. *Rotaria sp.* 36. *Philodina citrina* Ehrenberg, 1830 37. *Philodina sp.*

4. List of Soil Nematodes

Taxa
Phylum NEMATODA Rudolphi, 1808 (Lankester, 1877) Order DORYLAIMIDA Pearse, 1942 Suborder DORYLAIMINA Pearse, 1936 Superfamily DORYLAIMOIDEA De Man, 1976 Family DORYLAIMIDAE De Man, 1976 Subfamily DORYLAIMINAE De Man, 1976 Genus DORYLAIMUS Dujardin, 1845 1. *Dorylaimus bengalensis* Sen, Chatterjee & Manna, 2011
Subfamily LAIMYDORINAE Andrássy, 1969 Genus LAIMYDORUS Siddiqi, 1969 2. *Laimydorus baldus* Baqri & Jana, 1982 3. *Laimydorus istvani* Sen, Chatterjee & Manna, 2012 4. *Laimydorus siddiqii* Baqri & Jana, 1982
Subfamily THORNENEMATINAE Siddiqi, 1969 Genus INDODORYLAIMUS Ali & Prabha, 1974 5. *Indodorylaimus baqrii* Sen, Chatterjee & Manna, 2012 6. *Indodorylaimus asaccatus* Sen, Chatterjee & Manna, 2012
Genus SICAGUTTUR Siddiqi, 1971 7. *Sicaguttur sartum* Siddiqi, 1971
Genus COOMANSINEMOIDES Sen, Chatterjee & Manna, 2012 8. *Coomansinemoides wasimi* Sen, Chatterjee & Manna, 2012
Family APORCELAIMIDAE Heyns, 1965 Subfamily APORCELAIMINAE Heyns, 1965 Genus APORCELAIMELLUS Heyns, 1965 9. *Aporcelaimellus amylovorus* (Thorne & Swanger, 1936) Heyns, 1965 10. *Aporcelaimellus baqrii* Ahmad & Jairajpuri, 1982 11. *Aporcelaimellus chauhani* Baqri & Khera, 1975 12. *Aporcelaimellus coomansi* Baqri & Khera, 1975 13. *Aporcelaimellus indicus* Baqri & Jairajpuri, 1968 14. *Aporcelaimellus papillatus* (Bastian, 1865) Baqri & Khera, 1975

15. *Aporcelaimellus tritici* (Bastian, 1865) Andrassy, 1986
Family QUDSIANEMATIDAE Jairajpuri, 1965 Subfamily DISCOLAIMINAE Siddiqi, 1969 Genus DISCOLAIMUS Cobb, 1913 16. *Discolaimus tenax* Siddiqi, 1964
Genus DISCOLAIMIUM Thorne, 1939 17. *Discolaimium mazhari* Baqri & Jairajpuri, 1968
Genus DISCOLAIMOIDES Heyns, 1963 18. *Discolaimoides bulbiferus* (Cobb, 1906) Heyns, 1963
Superfamily LONGIDOROIDEA Thorne, 1935 Family XIPHINEMATIDAE Dalmasso, 1969 Subfamily XIPHINEMATINAE Dalmasso, 1969 Genus XIPHINEMA Cobb, 1913 19. *Xiphinema americanum* Cobb, 1913 20. *Xiphinema inaequale* Khan & Ahmad, 1976 21. *Xiphinema manasiae* Sen, Chatterjee & Manna, 2010
Superfamily BELONDIROIDEA Thorne, 1939 Family BELONDIRIDAE Thorne, 1939 Subfamily BELONDIRINAE Thorne, 1939 Genus AXONCHIUM Cobb, 1920 Genus AXONCHIUM Cobb, 1920 22. *Axonchium (Axonchium) coomansi* Sen, Chatterjee & Manna, 2011
Superfamily TYLENCHOLAIMOIDEA Filipjev, 1934 Family MYDONOMIDAE Thorne, 1964 Subfamily MYDONOMINAE Thorne, 1964 Genus DORYLAIMOIDES Thorne & Swanger, 1936 Subgenus DORYLAIMOIDES Thorne & Swanger, 1936 23. *Dorylaimoides (Dorylaimoides) geraldi* Sen, Chatterjee & Manna, 2012
Subgenus Longidorylaimoides Jairajpuri and Ahmad, 1992 24. *Dorylaimides (Longidorylaimoides) parvus* Thorne & Swanger, 1936 Family LEPTONCHIDAE Thorne, 1935 Subfamily TYLEPTINAE Thorne, 1935 Genus TYLEPTUS Thorne, 1939 25. *Tyleptus projectus* Thorne, 1939
Suborder NYGOLAIMINA Ahmad & Jairajpuri, 1979 Superfamily NYGOLAIMOIDEA Thorne, 1935 Family NYGOLAIMIDAE Thorne, 1935 Subfamily NYGOLAIMINAE Thorne, 1935 Genus AQUATIDES Heyns, 1968 26. *Aquatides heynsi* Sen, 2017
Genus LAEVIDES Heyns, 1968 27. *Laevides laevis* (Thorne, 1939) Thorne, 1974
Family NYGELLIDAE Andrassy, 1958 Subfamily NYGELLIBNAE Andrassy, 1958 Genus NYGELLUS Thorne, 1939 28. *Nygellus shamimi* Sen, 2015
Family AETHOLAIMIDAE Jairajpuri, 1965 Sfamily AETHOLAIMINAE Jairajpuri, 1965 Genus AETHOLAIMUS Williams, 1962 29. *Aetholaimus indicus* Jairajpuri, 1965
Order TYLENCHIDA Thorne, 1949 Suborder TYLENCHINA Chitwood in Chitwood and Chitwood, 1950 Infraorder TYLENCHATA Sidiqi, 2000 Superfamily TYLENCHOIDEA Örley, 1880 Family BELONOLAIMIDAE Whitehead, 1960 Subfamily TELOTYLENCHINAE Siddiqi, 1960

Genus TYLENCHORHYNCHUS Cobb, 1913 30. *Tylenchorhynchus mashhoodi* Siddiqi & Basir, 1959 31. *Tylenchorhynchus swarupi* Singh & Khera, 1978 Genus TROPHURUS Loof, 1956 32. *Trophurus clavicaudatus* Sen, Chatterjee & Manna, 2012
Family HOPLOLAIMIDAE Filipjev, 1934 Subfamily HOPLOLAIMINAE Filipjev, 1934 Genus HOPLOLAIMUS Daday, 1905 33. *Hoplolaimus indicus* Sher, 1963
Genus SCUTELLONEMA Andrassy, 1958 34. *Scutellonema bengalensis* Sen, 2019
Family PRATYLENCHIDAE Thorne, 1949 Genus HIRSCHMANNIELLA Luc & Goodey, 1963 35. *Hirschmanniella oryzae* (van Breda De Hann, 1902) Luc & Goodey, 1963 36. *Hirschmanniella gracilis* (de Mann, 1880) Luc & Goodey, 1963

5. List of Soil Mites

Taxa
Family: HYPOCHTHONIDAE Berelese, 1910 Genus *Nothrolohmannia Balogh*, 1968 1. *Nothrolohmannia calcarata* Balogh ,1968
Family LOHMANIIDAE Berlese, 1916 Genus *Papillacarus* Kunst, 1959 2. *Papillacarus hirsutus* Aoki, 1961 Genus *Javacarus* Balogh, 1961 3. *Javacarus (Javacarus) kuehnelti* Balogh, 1961 Genus Annectacarus Grandjean, 1950 4. *Annectacarus sp.*
Family ORIBOTRITIIDAE Balogh, 1943 Genus *Indotritia* Jacot, 1929 5. *Indotritia* sp. Family PHTHIRACARIDAE Perty, 1841 Genus *Hoplophorella* Berlese, 1923 6. *Hoplophorella (Hoplophorella) vitrina* Berlese, 1913 7. *Hoplophorella lanceoseta* (Balogh & Mahunka, 1981)
Family NOTHRIDAE Berlese, 1896 Genus *Nothrus* Koch, 1836 8. *Nothrus sp.* Family BASILOBELBIDAE Balogh, 1961 Genus Basilobelba Balogh, 1958 9. *Basilobelba* sp.
Family NIPPOBODIDAE Aoki, 1959 Genus *Nippobodes* Aoki, 1959 10. *Nippobodes sp.*
Family DAMPFIELLIDAE Balogh,1961 Genus *Damp□ella* Sellnick, 1931 11. *Damp□ella prostrata* Aoki, 1965
Family OPPIIDAE Sellnick, 1937 Genus *Lasiobelba* Aoki, 1959 12. *Lasiobelba (Lasiobelba*) kuehnelti Csiszar, 1961 Genus *Brachioppiella* Hammer, 1962 13. *Brachioppiella (Brachioppiella) periculosa* Hammer, 1962 Genus *Multioppia* Hammer,1961

14. *Multioppia stellifera* Hammer, 1961
Genus *Amerioppia* Hammer, 1961
15. *Amerioppia sp.*
Family ARCEREMAEIDAE Balogh, 1972
Genus *Arceremaeus* Hammer, 1961
16. *Arceremaeus incaensis* Hammer, 1961*
Family TECTOCEPHEIDAE Grandjean, 1954
Genus *Tectocepheus* Berlese, 1896
17. *Tectocepheus sp.*
18. *Tectocepheus velatus velatus* Michael, 1880

Family AUSTRACHIPTERIIDAE Luxton, 1985
Genus *Lamellobates* Hammer, 1958
19. *Lamellobates molecula* Berlese, 1916
Genus *Hypozetes* Balogh, 1959
Hypozetes laysanensis Aoki, 1964

Family ORIBATELLIDAE Jacot, 1925
Genus *Cuspidozetes* Hammer, 1962
20. *Cuspidozetes armatus* Hammer, 1962*
Genus Lamellobates Hammer,1958
Lamellobates molecula Berlese, 1916
Family DRYMOBATIDAE J. & P. Balogh, 1984
Genus *Rykella* Balogh, 1962
21. *Rykella insignis* Balogh, 1962
Family MOCHLOZETIDAE Grandjean, 1960
Genus *Mochlozetes* Grandjean, 1930
22. *Mochlozetes penetrabilis* Grandjean, 1930*
Family ORIBATULIDAE Thor, 1929
Genus Oribatula Berlese, 1896
23. *Oribatula lata* Hammer, 1961
Family SCHELORIBATIDAE Jacot, 1935
Genus *Monoschelobates* Balogh & Mahunka, 1969
24. *Monoschelobates parvus* Balogh & Mahunka, 1969 Genus Scheloribates Berlese, 1908
25. *Scheloribates (Scheloribates) curvialatus* Hammer, 1961
26. *Scheloribates thermophilus* Hammer, 1961
27. *Scheloribates (Scheloribates) huancayensis* Hammer, 1961
28. *Scheloribates (Scheloribates) pallidulus* Koch, 1841
29. *Scheloribates pauliensis* Perez-Inigo & Baggio, 1980
30. *Scheloribates elagantulus* Hammer, 1961
31. *Scheloribates sp.*
Genus *Perscheloribates* Hammer, 1973
32. *Perscheloribates (Perscheloribates) albialatus* Hammer, 1961
Family PROTORIBATIDAE J. and P. Balogh, 1984
Genus *Protoribates* Berlese, 1908
33. *Protoribates (Protoribates) magnus* Aoki, 1982
34. *Protoribates (Protoribates) capucinus* Berlese, 1908
Genus *Vilhenabates* Balogh, 1963
35. *Vilhenabates minutus* Balogh, 1958*
36. *Vilhenabates (Phalacrozetes) sinatus* Aoki,1965
Genus *Setoxylobates* Balogh and Mahunka, 1967
37. *Setoxylobates foveolatus* Balogh and Mahunka, 1967

Family HAPLOZETIDAE Grandjean, 1936
Genus *Indoribates* (*Haplozetes*) Willman, 1935
38. *Indoribates sp.*
Genus *Trachyoribates* Berlese, 1908
39. *Trachyoribates ovulum* Berlese, 1908
40. *Trachyoribates pinguis* Balogh & Mahunka, 1978
41. *Trachyoribates sp.*

Genus *Pilobatella* Balogh & Mahunka, 1967 42. *Pilobatella punctata* Balogh & Mahunka, 1967
Family GALUMNIDAE Jacot, 1925 Genus *Galumna* Heyden, 1826 43. *Galumna abellifera* Hammer,1958 44. *Galumna australis* (Berlese, 1914) 45. *Galumna pallida* Hammer, 1958 46. *Galumna sp*. Genus *Pergalumna* Grandjean, 1936 47. *Pergalumna numerosa* Sellnick, 1923 48. *Pergalumna magnipora* Hammer, 1961 Genus *Cryptogalumn*a Grandjean, 1957 49. *Cryptogalumna cryptodonta* Grandjean, 1957 Genus *Psammogalumn*a Balogh, 1943 50. *Psammogalumna hungarica* Sellnick, 1925

6. List of Spiders

Taxa
Family: ARANEIDAE 1. *Araneus mitificus* (Simon, 1886)
2. *Argiope* sp.
3. *Argiope catenulate* (Doleschall, 1859)
4. *Cyclosa neilensis* Tikader, 1977
5. *Eriovixia* sp.
Family: CLUBIONIDAE 6. *Clubiona filicata* O. Pickard-Cambridge, 1874
Family: HERSILIIDAE 7. *Hersilia savignyi* Lucas, 1836
Family: LYCOSIDAE 8. *Lycosa bistriata Gravely*, 1924
9. *Pardosa pseudoannulata* (Bösenberg & Strand, 1906)
10. *Pardosa sumatrana* (Thorell, 1890)
11. *Trochosa punctipes* (Gravely, 1924)
12. *Trochosa* sp.
13. *Wadicosa quadrifera* (Gravely, 1924)
Family: OXYOPIDAE 14. *Oxyopes hindostanicus* Pocock, 1901
Family: SALTICIDAE 15. *Hyllus semicupreus* (Simon, 1885)
16. *Menemerus bivittatus* (Dufour, 1831)
17. *Myrmarachne melanocephala* MacLeay, 1839
18. *Phaeacius lancearius* (Thorell, 1895)
19. *Plexippus paykulli* (Audouin, 1826)
20. *Rhene rubrigerax* (Thorell, 1887)
21. *Rhene* sp.
Family: TETRAGNATHIDAE 22. *Guizygiella* sp.
23. *Guizygiella melanocrania* (Thorell, 1887)
24. *Tetragnatha javana* (Thorell, 1890)
25. *Tetragnatha keyserlingi* Simon, 1890
26. *Tetragnatha nitens* (Audouin, 1826)
27. *Tetragnatha* sp.
28. *Tetragnatha vermiformis Emerton*, 1884

Family: THERIDIIDAE 29.*Argyrodes argentatus* O. Pickard-Cambridge, 1880
Family: THOMISIDAE 30. *Camaricus formosus* Thorell, 1887
31. *Runcinia insecta* (L. Koch, 1875)
32. *Thomisus* sp.

7. List of Crustacea: Cladocerans

Taxa
Phylum Arthropoda Super Class Crustacea Class Branchiopoda Super Order Cladocera Order Ctenopoda
Family Sididae 1 *Diaphanosoma excisum* Sars, 1885 2 *D. sarsi* Richard, 1894 3 *Pseudosida bidentata* Herrick, 1884 Order Anomopoda
Family Daphnidae 4 *Ceriodaphnia cornuta* Sars, 1885 5 *Ceriodaphnia sp.* 6 *Daphnia sp.* 7 *Simocephalus vetulus* (O.F. Muller, 1776)
Family Moinidae 8 *Moina micrura* Kurz, 1874 9 *Moina sp.* 10 *Moinadaphnia macleayi* (King,1853) 11 *Moinodaphnia sp.*
Family Bosminidae 12 *Bosmina longirostris* (Muller, 1785) 13 *Bosmina sp.*
Family Macrothricidae 14 *Macrothrix goeldii* Richard,1897
Family Chydoridae Subfamily Chydorinae 15 *Chydorus sphaericus* (O.F. Muller, 1776) 16 *Coronatella rectangula* (G.O.Sars, 1862) 17 *Pleuroxus siilis* Vavra,1900
Subfamily Aloninae 18 *Alona affnis* (Leydig, 1860) 19 *Alona quadrangularis* (O.F. Muller, 1776) 20 *Alona sp.* 21 *Biapertura karua* (King, 1853) 22 *Notoalona globulosa* (Daday, 1898) 23 *Kurzia longirostris* (Daday, 1898) 24 *Kurzia sp.* 25 *Cladoceran neonates*

8. List of Crustacea: Ostracods

Taxa
Phylum Arthropoda Superclass Crustacea Class Ostracoda Order Podocopida Suborder Podocopa
Family: Cyprididae 1. *Cypris subglobosa* Sowerby, 1840 2. *Strandesia sp.* Subfamily Stenocyprinae 3. *Stenocypris major* (Baird) 1859

9. List of Crustacea: Copepods

Taxa
Phylum Arthropoda Superclass Crustacea Class Copepoda Order Calanidae Subfamily Diaptomidae *1. Heliodiaptomus contortus* (Gurney, 1907) 2. *Heliodiaptomus viduus* (Gurney, 1916)
Family: Pseudodiaptomidae 3. *Pseudodiaptomus annandalei* Sewell, 1919
Family: Cyclopididae Subfamily Eucyclopinae 4. *Eucyclops* sp. 5. *Mesocyclops hyalinus* (Rehberg, 1880) 6. *Mesocyclops leuckarti* (Claus, 1857) 7. *Microcyclops varicans* Sars, 1863 8. *Thermocyclops rylovi rylovi* (Smirnov, 1928) Order Harpacticoida 9. *Euterpina acutifrons* (Dana 1847) 10. *Cyclopoid nauplii* 11. *Cyclopoid copepodite*

10. List of Crustacea: Crabs and Shrimps

Taxa
Kingdom Animalia Phylum Arthropoda Subphylum Crustacea Class Malacostraca Subclass Eumalacostraca Superorder Eucarida Calman, 1904 Order Decapoda Latreille, 1802 Suborder Dendrobranchiata Spence Bate, 1888 Superfamily Penaeoidea Rafinesque, 1815 Family Penaeidae Rafinsque, 1815 Genus *Metapenaeus* Wood-Mason in Wood-Mason & Alcock, 1891
1. *Metapenaeus brevicornis* (H. Milne Edwards 1837 [in Milne Edwards, 1834-1840]) Genus *Penaeus* Fabricius, 1798
2. *Penaeus merguiensis* de Man, 1888 [in de Man, 1887-1888]
3. Penaeus *semisulcatus* De Haan, 1844 [in De Haan, 1833-1850]
4. *Penaeus indicus* H. Milne Edwards, 1837 Suborder Pleocymata Burkenroad, 1963 Infraorder Anomura Macleay, 1838 (Hermit crabs) Superfamily Paguroidea Latreille, 1802 Family Diogenidae Ortman, 1892 Genus *Clibanarius* Dana, 1852
5. *Clibqnarius padavensis* de Man, 1888 [in de Man, 1887-1888] Infraorder Caridea Dana, 1852(Prawns/Shrimps) Superfamily Atyoidae De Haan, 1849 (in De Haan, 1833-1850) Family Atyidae De Haan, 1849 (in De Haan, 833-1850) Genus *Caridina* H. Milne Edwards, 1837

(in H. Milne Edwards, 1834-1840)
6. *Caridina gracilirostris* de Man, 1892
7. *Caridina gracilipes* De Man, 1892
8. *Caridina propinqua* De Man, 1908 Superfamily Palaemonoidea Rafinesque, 1815 Family Palaemonidae Rafinesque, 1815 Genus *Leptocarpus* Holthuis, 1950
9. *Leptocarpus fluminicola* (Kemp, 1917) Genus *Macrobrachium* Spence Bate, 1868
10.*Macrobrachium lamarrei lamarrei* (H.M.Edwards)
11. *Macrobrachium malcolmsonii* (H. Milne-Edwards, 1844)
12. *Macrobrachium rosenbergii* (de Man, 1879)
13. *Macrobrachium rude* (Heller, 1862)
14. *Macrobrachium* sp. Genus *Palaemon* Weber, 1795
15. *Palaemon styliferus* H. Milne Edwards, 1840 [in H. Milne Edwards, 1834-1840- De Man (1908)] Infraorder Brachyura, Latreille, 1802 (Crabs) Section Eubrachyura, Saint Laurent, 1980 Subsection Thoracotremata Guinot, 1977 Superfamily Grapsoidea, MacLeay, 1875 Family *Varunidae* H. Milne Edwards, 1853 Genus *Varuna* H. Milne Edwards
16. Va*runa litterata* (Fabricius, 1798)-De Man (1908) Superfamily Ocypodoidea Rafinesque, 1815 Family Ocypodidae, Rafinesque, 1815 Genus TubucaBott, 1973
17. *Tubucaacuta* (Stimpson, 1858) Subsection Heterotremata Guinot, 1977 Superfamily Pilumnoidea Samouelle, 1819 Family Pilumnidae Samouelle, 1819 Genus Benthopanope Davie, 1989

18. *Benthopanope indica* (de Man, 1887 [in de Man, 1887-1888]) Superfamily Gecarcinucoidea Rathbun, 1904 Family Gecarcinucidae Rathbun, 1904 Genus Sartoriana Bott, 1969
19. *Sartoriana spinigera* (Wood-Mason, 1871) Superorder Peracarida Calman, 1904 Order Isopoda Latreille, 1817 Suborder Cymothoida Wagele, 1989 (A parasitic Crustacean) Superfamily Bopyroidea Rafinesque, 1815 Family Bopyridae Rafinesque, 1815 Genus *Probopyrus* Giard & Bonnier, 1888
20. *Probopyrus prashadi* (Chopra, 1923) Superorder PeracaridaCalman, 1904 Order Isopoda Latreille, 1817 Suborder Oniscidea Latreille, 1802 Family Porcellionidae, Brant, 1831 Genus *Porcellio* Latreille, 1804
21. *Porcellio assamensis* Chopra, 1924 Order Mysida Boas, 1883 (Opposum Shrimps) Family Mysidae Haworth, 1825 Genus *Gangemysis* Derzhavin, 1924
22. *Gangemysis assimilis* (W. Tattersall, 1908) Genus *Mesopodopsis* Czemiavsky, 1882
23. *Mesopodopsis orientalis* (W. Tattersall, 1908) Order Amphipoda Suborder Gammaridea
24. *Gammarid amphipods*

11. List of Apterygotan fauna

Taxa
COLLEMBOLA Family Neanuridae
1. *Protanura carpenteri* Mukherjee, 1932
2. *Paleonura siva* (Yosii, 1966) Cassagnau, 1982
3. *Friesea excelsa* Denis, 1936
Family Hypogastruridae 4. *Ceratophysella indica* (Salmon, 1956)
5. *Ceratophysella indovaria* (Salmon, 1970)
6. *Xenylla obscura* Imms, 1912
7. *Xenylla reducta* Prabhoo, 1971
Family Onychiuridae 8. *Allonychiurus indicus* (Choudhuri & Roy, 1965) Pomorski, 2000
Family Tullbergidae 9. *Paratullbergia indica* Salmon, 1965
Family Brachystomellidae 10. *Brachystomella terrafolia* Salmon, 1944
Family Isotomidae 11. *Isotomodes dagamae* Prabhoo, 1971
12. *Hemisotoma thermophila* (Axelson, 1900) Bagnall, 1949
13. *Ballistura bengalensis* Yosii, 1966
14. *Isotomurus balteatus* (Reuter,1876) Handschin, 1929
15. *Isotomurus palustris* (Muller, 1776) Borner, 1906
16. *Isotomurus ciliatus* Stach, 1947
17. *Folsomides purvulus* Stach, 1922
Family Entomobryidae 18. *Homidia cingula* (Borner, 1906) Yosii, 1959
19. *Sinella curviseta* Brook, 1882
20. *Lepidocyrtus (Lanocyrtus) caeruleicornis* Bonet, 1930
21. *Lepidocyrtus (Lepidocyrtus) curvicollis* Bourlet, 1841
22. *Lepidocyrtus (Acrocyrtus) heterolepis* Yosii, 1959
23. *Lepidocyrtus (Acrocyrtus) malayanus* Yosii, 1959
24. *Lepidocyrtus (Cinctocyrtus) medius* Schaeffer, 1898
25. *Lepidocyrtus (Ascocyrtus) scaber* Ritter, 1911
26. *Lepidocyrtus magnificus* Carpenter, 1924
27. *Dicranocentrus indicus* Bonet, 1930
28. *Dicranocentrus cercifer* (Imms, 1912) Mari Mutt, 1979
29. *Alloscopus tetracanthus* (Borner, 1906)
30. *Seira indica* (Ritter, 1911) Yosii, 1966
31. *Seira indra* (Imms, 1912)
32. *Seira lateralis* Yossi, 1966
33. *Seira punctata* (Ritter, 1911)

Family Paronellidae 34. *Salina bengalensis* Mitra, 1973
35. *Salina celebensis* (Schaeffer, 1898) Yosii, 1959
36. *Salina indica* (Imms, 1912) Yosii, 1960
37. *Salina striata* (Handschin, 1928)
38. *Salina yosii* Salmon, 1964
39. *Dicranocentroides fiavescens* Yosii, 1966
40. *Cyphoderopsis ceylonica* Yosii, 1966
41. *Cyphoderus javanus* Borner, 1906
42. *Cyphoderus albinus* Nicolet, 1842
Family Neelidae 43. *Neelus murinus* Folsom, 1896
44. *Megalothorax minimus* Willem, 1900
Family Arrhopalitidae 45. *Pygmarrhopalites habei* (Yosii, 1956)
Family Sminthuridae 46. *Sminthurus parvullus* Ritter, 1911
47. *Sminthurus viridis* (Linn. 1758) Bourlet, 1843
48. *Sphyrotheca gangetica* Yosii, 1966
Family Dicyrtomidae 49. *Calvatomina pagoda* (Yosii, 1966)
DIPLURA 50. *Lepidocampa juradoi bengalensis* Rani & Mitra, 1977
ZYGENTOMA Family Lepismatidae
51. *Acrotelsa collaris* (Fabricius, 1793)
52. *Ctenolepisma longicaudata* Escherich, 1905
53. *Ctenolepisma ciliata* (Dufour, 1831)
54. *Ctenolepisma nigra* (Oudemans, 1890)

12. List of Odonata: Dragonflies and Damselflies

Taxa
Order: Odonata Suborder: Zygoptera Superfamily: Coenagrionoidea Family: Coenagrionidae 1. *Agriocnemis pygmaea* (Rambur) 2. *Ceriagrion cerinorubellum* (Brauer) 3. *Ceriagrion coromandelianum* (Fabricius) 4. *Ischnura aurora* (Brauer) 5. *Ischnura senegalensis* (Rambur) 6. *Onychargia atrocyana* (Selys) 7. *Pseudagrion microcephalum* (Rambur) 8. *Pseudagrion rubriceps* (Selys) Suborder: Anisoptera Superfamily: Aeshnoidea Family: Aeshnidae

9. *Anax guttatus* (Burmeister) Superfamily: Gomphoidea Family: Gomphidae Superfamily: Libelluloidea Family: Libellulidae 10. *Ictinogomphus rapax* (Rambur) 11. *Brachydiplax chalybea* (Rambur) 12. *Brachythemis contaminata* (Fabricius) 13. *Bradinopyga geminata* (Rambur) 14. *Crocothemis servilia* (Drury) 15. *Diplacodes trivialis* (Rambur) 16. *Lathrecista asiatica* (Fabricius) 17. *Macrodiplax cora* (Brauer) 18. *Neurothemis tullia* (Drury) 19. *Orthetrum pruinosum* (Burmeister) 20. *Orthetrum sabina* (Drury) 21. *Pantala flavescens* (Fabricius) 22. *Rhodothemis rufa* (Rambur) 23. *Rhyothemis variegata* (Linnaeus) 24. *Trithemis aurora* (Burmeister) 25. *Trithemis festiva* (Rambur) 26. *Trithemis pallidinervis* (Kirby)

13. List of Orthoptera: Grasshoppers and Crickets

Taxa
1. *Acrida exaltata* (Walker, 1859) Tribe Phlaeobini Brunner von Wattenwyl, 1893 Genus *Phlaeoba* Stål, 1860
2. *Phlaeoba infumata* Brunner von Wattenwyl, 1893
3. *Phlaeoba panteli* Bolivar, 1902 Subfamily Catantopinae Genus *Diabolocatantops* Jago, 1984
4. *Diabolocatantops innotabilis* (Walker, 1870) Genus *Choroedocus* Bolivar, 1914
5. *Choroedocus capensis* (Thunberg, 1815)
6. *Choroedocus robustus* (Serville, 1839) Tribe Oxyrrhepini Tinkham, 1940 Genus *Oxyrrhepes* Stål,1873
7. *Oxyrrhepes obtusa* (Haan, 1842) Genus *Pachyacris* Uvarov, 1923
8. *Pachyacris vinosa* (Walker, 1870) Tribe Paraconophymatini Otte, 1995 Genus *Paraconophyma* Uvarov, 1921
9. *Paraconophyma scabra* (Walker, 1870) Genus *Xenocatantops* Dirsh & Uvarov, 1953
10. *Xenocatantops humilis* (Serville, 1839) Subfamily Eyeprepocnemidinae Genus *Eyprepocnemis* Fieber, 1853
11. *Eyprepocnemis alacris alacris* (Serville, 1839)

Genus *Eupreponotus* Uvarov, 1921
12. *Eupreponotus inflatus* Uvarov, 1921 Genus *Heteracris* Walker, 1870
13. *Heteracris pulchra* (Bolivar, 1902) Genus *Tylotropidius*
14. *Tylotropidius varicornis* (Walker, 1870) Subfamily Gomphocerinae Genus *Aulacobothrus* Bolivar, 1902
15. *Aulacobothrus luteipes luteipes* (Walker, 1871) Genus *Leva* Bolivar, 1909
16. *Leva indica* (Bolivar, 1902) Subfamily Hemiacridinae Tribe Hieroglyphini Genus *Hieroglyphus* Krauss, 1877
17. *Hieroglyphus banian* (Fabricius, 1798) Subfamily Oedipodinae Genus *Aiolopus* Fieber, 1853
18. *Aiolopus thalassinus tamulus* (Fabricius, 1798) Genus *Gastrimargus* Saussure, 1884
19. *Gastrimargus africanus africanus* (Saussure, 1888) Genus *Heteropternis* Stål, 1873
20. *Heteropternis respondens* (Walker, 1859) Genus *Morphacris* Walker, 1870
21. *Morphacris fasciata* (Thunberg, 1815) Genus *Oedaleus* Fieber, 1853
22. *Oedaleus abruptus* (Thunberg, 1815)
23. *Oedaleus senegalensis* (Krauss, 1877) Genus Trilophidia Stål, 1873
24. *Trilophidia annulata* (Thunberg, 1815) Genus *Dittopternis* Saussure, 1884
25. *Dittopternis venusta* (Walker, 1870) Genus *Locusta* Linnaeus, 1758
26. *Locusta migratoria migratoria* (Linnaeus, 1758) Subfamily Coptacridinae Genus *Epistaurus* Bolivar, 1889
27. *Epistaurus sinetyi* Bolivar, 1902
28. *Eucoptacra saturata* (Walker, 1870) Subfamily Oxyinae Genus *Gesonula* Uvarov, 1940
29. *Gesonula punctifrons* (Stål, 1861) Genus *Oxya* Serville, 1831
30. *Oxya fuscovittata* (Marschall, 1836)
31. *Oxya hyla* Serville, 1831
32. *Oxya nitidula* (Walker, 1870)
33. *Oxya velox* (Fabricius, 1787) Subfamily Tropidopolinae Tribe Tristriini Mishchenko, 1945 Genus *Tristria* Stål, 1873
34. *Tristria pulvinata* (Uvarov, 1921) Tribe Tropidopolini Jacobson, 1905 Genus *Tropidopola* Stål, 1873
35. *Tropidopola longicornis* (Fieber, 1853) Subfamily Cyrtacanthacridinae Genus *Cyrtacanthacris* Walker, 1870

36. *Cyrtacanthacris tataricatatarica* (Linnaeus, 1758) Genus *Patanga* Uvarov, 1923
37. *Patanga succincta* (Johansson, 1763) Genus *Schistocerca* Stål, 1873
38. *Schistocerca gregaria* (Forskal, 1775) Subfamily Spathosterninae Genus *Spathosternum* Krauss, 1877
39. *Spathosternum prasiniferum prasiniferum* (Walker, 1871) Superfamily Pyrgomorphoidea Family Pyrgomorphidae Genus *Atractomorpha* Saussure, 1862
40. *Atractomorpha crenulata* (Fabricius, 1793)
41. *Atractomorpha psittacina* (Haan, 1842) Tribe Tagastini Bolivar, 1905 Genus *Tagasta* Bolivar, 1905
42. *Tagasta indica* Bolivar, 1905 Genus *Chrotogonus* Serville, 1838
43. *Chrotogonus* (*Chrotogonus*) *trachypterus trachypterus* (Blanchard, 1836) Superfamily Tetrigoidea
Family Tetrigidae Subfamily Scelimeninae Genus *Indoscelimena* Günther, 1938
44. *Indoscelimena angulata* (Hancock, 1915)
45. *Indoscelimena flavopicta* (Bolivar, 1909)
46. *Indoscelimena saussurei* (Hancock, 1915) Tribe Thoradontini Kevan, 1966 Genus *Thoradonta* Hancock, 1909
47. *Thoradonta nodulosa* (Stål, 1860)
48. *Thoradonta spiculoba* Hancock, 1912
49. *Thoradonta bengalensis* Shishodia, 1991 Tribe Criotettigini Kevan, 1966 Genus *Criotettix* Bolivar, 1887
50. *Criotettix bispinosus* (Dalman, 1818)
51. Criotettixinornatus (Walker, 1871) Genus *Eucriotettix* Hebard, 1929
52. *Eucriotettix rufescens* (Kirby, 1914) Genus *Loxilobus* Hancock, 1904
53. *Loxilobus striatus* Hancock, 1915 Subfamily Tetriginae Genus *Coptotettix* Bolivar, 1887
54. *Coptotettix hancockus* Shishodia & Varshney, 1987 Genus *Euparatettix* Hancock, 1904
55. *Euparatettix indicus* (Bolivar, 1887)
56. *Euparatettix personatus* (Bolívar, 1887)
57. *Euparatettix tricarinatus* (Bolivar, 1887) Genus *Hedotettix* Bolivar, 1887
58. *Hedotettix costatus* Hancock, 1912
59. *Hedotettix gracilis* (Haan, 1842) Genus *Paratettix* Bolivar, 1887
60. *Paratettix histricus* (Stål, 1861)
61. *Paratettix variabilis* Bolivar, 1887 Genus *Ergatettix* Kirby, 1914
62. *Ergatettix dorsifera* (Walker, 1871)

63. *Ergatettix interruptus* (Brunner von Wattenwyl, 1893) Suborder ENSIFERA Infraorder Oedischioidea Superfamily Grylloidea Family Gryllidae Subfamily Gryllinae Genus *Acheta* Fabricius, 1775
64. *Acheta domesticus* (Linnaeus, 1758) Genus *Gryllus* Linnaeus, 1758 Subgenus *Gryllus* Linnaeus, 1758
65. *Gryllus* (*Gryllus*) *bimaculatus* De Geer, 1773 Genus *Gryllodes* Saussre, 1874
66. *Gryllodes sigillatus* (Walker, 1869) Genus *Modicogryllus* Chopard, 1961 Subgenus *Modicogryllus* Chopard, 1961
67. *Modicogryllus* (*Modicogryllus*) *confirmatus* (Walker, 1859) Genus *Plebeiogryllus* Randell, 1964
68. *Plebeiogryllus guttiventris guttiventris* (Walker, 1871) Genus *Velarifictorus* Randell, 1964 Subgenus *Velarifictorus* Randell, 1964
69. *Velarifictorus* (*Velarifictorus*) *aspersus* (Walker, 1869) Genus *Loxoblemmus* Saussure, 1877
70. *Loxoblemmus equestris* Saussure, 1877 Subfamily Oecanthinae Tribe Oecanthini Genus *Oecanthus* Serville, 1831
71. *Oecanthus rufescence* Serville, 1839 Family Trigonidiidae Subfamily Nemobiinae Tribe Nemobiini Saussure, 1877 Genus *Dianemobius* Vickery, 1973
72. *Dianemobius fascipes* (Walker, 1869) Genus *Nemobius* Serville, 1838
73. *Nemobius strigipennis* (Chopard, 1928) Genus *Pteronemobius* Jacobson and Bianchi, 1905 Subgenus Pteronemobius Jacobson, 1904
74. *Pteronemobius* (*Pteronemobius*) *heydenii* concolor (Walker, 1871) Genus *Polionemobius* Gorochov, 1983
75. *Polionemobius taprobanensis* (Walker, 1869) Subfamily Trigonidiinae Tribe Trigonidiini Genus *Amusurgus* Brunner von Wattenwyl, 1893 Subgenus *Amusurgus* Brunner von Wattenwyl, 1893
76. *Amusurgus* (*Amusurgus*) *fulvus* Chopard, 1969
77. *Amusurgus* (*Amusurgus*) *oedemeroides* (Walker, 1871) Genus *Natula* Gorochov, 1874
78. *Natula longipennis* (Serville, 1838) Genus *Homoeoxipha* Saussure, 1874
79. *Homoeoxipha lycoides* (Walker, 1869) Subfamily Euscyrtinae Genus *Euscyrtus* Guérin-Méneville, 1844 Subgenus *Osus* Gorochov, 1987
80. *Euscyrtus* (*Osus*) *concinnus* (Haan, 1842)
81. *Euscyrtus* (*Osus*) *hemelytrus* (Haan, 1842) Family Phalangopsidae

Subfamily Cachoplistinae Tribe Cachoplistini Saussure, 1877 Genus *Cacoplistes* Brunner, 1873 Subgenus *Laminogryllus* Gorochov, 2003
82. *Cacoplistes* (*Laminogryllus*) *rogenhoferi* Saussure, 1877 Family Gryllotalpidae Subfamily Gryllotalpinae Genus *Gryllotalpa* Latreille, 1802
83. *Gryllotalpa africana* Beauvois, 1805 Superfamily Tettigonioidea Family Tettigoniidae Subfamily Conocephalinae Tribe Copiphorini Karny, 1912 Genus *Euconocephalus* Karny, 1907
84. *Euconocephalus incertus* (Walker, 1869)
85. *Euconocephalus pallidus* (Redtenbacher, 1891) Subfamily Phaneropterinae Genus *Trigonocorypha* Stål, 1873
86. *Trigonocorypha unicolor* (Stoll, 1787) Subfamily Pseudophyllinae Genus *Sathrophyllia* Stål, 1874
87. *Sathrophyllia femorata* (Fabricius, 1787) Genus *Onomarchus* Stål, 1874
88. *Onomarchus leuconotus* (Serville, 1839) Subfamily Pseudophyllinae Tribe Phyllomimini Genus *Acanthoprion* Pictet & Saussure, 1892
89. *Acanthoprion suspectum* (Brunner von Wattenwyl, 1895) Tribe Cocconotini Genus *Meroncidius* Serville, 1831
90. *Meroncidius ochraceus* (Stoll, 1813) Subfamily Listroscelidinae Tribe Phisidini Jin, Xingbao, 1987 Genus *Phisis* Stål, 1860
91. *Phisis pectinata* (Guérin, 1832) Subfamily Meconematinae Genus *Xiphidiopsis* Redtenbacher, 1891 Subgenus *Xiphidiopsis* Redtenbacher, 1891
92. *Xiphidiopsis* (*Xiphidiopsis*) *straminula* (Walker, 1871)

14. List of Blattodea: Isoptera- Termites

Taxa
Order BLATTODEA Wattenwyl,1882 Infraorder ISOPTERA Brulle, 1832 Family RHINOTERMITIDAE Froggatt, 1897 Subfamily COPTOTERMITINAE Holmgren, 1910 Genus *Coptotermes* Wasmann, 1896
1. *Coptotermes ceylonicus* Holmgren, 1911
2. *Coptotermes kishori* Roonwal and Chhotani, 1962 Subfamily HETEROTERMITINAE Frogatt, 1897 Genus *Heterotermes* Froggat, 1897
3. *Heterotermes indicola* (Wasmann, 1902)

Family TERMITIDAE Latreille, 1802 Subfamily MACROTERMITINAE Kemner, 1934 Genus *Odontotermes* Holmgren, 1910
4. *Odontotermes assmuthi* Holmgren, 1913
5. *Odontotermes feae* (Wasmann, 1896) Genus *Microtermes* Wasmann, 1902
6. *Microtermes obesi* Holmgren, 1912
7. *Microtermes unicolor* Snyder, 1933

15. List of Terrestrial Bugs (Hemiptera)

Taxa
ORDER HEMIPTERA SUBORDER AUCHENORRHYNCHA INFRAORDER FULGOROMORPHA FAMILY FLATIDAE SUBFAMILY FLATINAE TRIBE NEPHESINI SUBTRIBE CRYPTOFLATINA Genus *Melicharia* Kirkaldy, 1900
1. *Melicharia sinhalana* Kirkaldy,1900 INFRAORDER CICADOMORPHA SUPERFAMILY CERCOPOIDEA FAMILY APHROPHORIDAE SUBFAMILY APHROPHORINAE TRIBE CLOVIINI Genus *Clovia* Stål, 1866
2. *Clovia conifera* (Walker, 1851)
3. *Clovia puncta* (Walker, 1851) TRIBE PTYELINI Genus *Ptyelus* St. Farg. & Serville, 1825
4. *Ptyelus inconspicuus* Dist. 1908
5. *Ptyelus declaratus* Melich, 1903 SUPERFAMILY MEMBRACOIDEA FAMILY MEMBRACIDAE SUBFAMILY CENTROTINAE TRIBE LEPTOCENTRINI Genus *Leptocentrus* Stål, 1866
6. *Leptocentrus taurus* Fabr, 1775 TRIBE GARGARINI Genus *Gargara* Amy. & Serv., 1843
7. *Gargara robusta* Distant, 1907
8. *Gargara mixta* Buckt., 1903 FAMILY CICADELIIDAE SUBFAMILY CICADELLINAE TRIBE CICADELLINI Genus *Cofana* Melichar, 1926
9. *Cofana spectra* (Distant, 1908) SUBFAMILY DELTOCEPHALINAE TRIBE CHIASMINI Genus *Exitianus* Ball, 1929
10. *Exitianus indicus* (Distant, 1908)

11. *Exitianus nanus* (Distant, 1975) Genus *Nephotettix* Matsumura, 1902
12. *Nephotettix nigropictus* (Stål, 1870) TRIBE PENTHIMIINI Genus *Penthimia* Germar, 1821
13. *Penthimia compacta* Walker, 1851 TRIBE HECALINI Genus *Hecalus* Stål, 1864
14. *Hecalus porrectus* (Walker, 1858) SUBFAMILY IASSINAE TRIBE KRISNINI Genus *Krisna* Kirkaldy, 1900
15. *Krisna strigicollis* (Spinola, 1852) SUBFAMILY IDIOCERINAE TRIBE IDIOCERINI Genus *Amritodus* Anufriev, 1970
16. *Amritodus atkinsoni* (Lethierry, 1889) Genus Idioscopus Baker, 1915
17. *Idioscopus nitidulus* (Walker, 1870) SUBORDER HETEROPTERA INFRAORDER CIMICOMORPHA SUPERFAMILY REDUVIOIDEA FAMILY REDUVIIDAE SUBFAMILY HARPACTORINAE Genus 14. *Scipinia* Stål, 1861
18. *Scipinia horrida* (Stål, 1859) INFRAORDER PENTATOMORPHA SUPERFAMILY PENTATOMOIDEA FAMILY DINIDORIDAE SUBFAMILY DINIDORINAE Genus *Coridius* Illiger, 1807
19. *Coridius ianus* (Fabricius, 1775) FAMILY PENTATOMIDAE SUBFAMILY PENATOMINAE Genus *Eysarcoris* Hahn, 1834
20. *Eysarcoris guttiger* (Thunberg, 1783)
21. *Eysarcoris montivagus* (Distant, 1902)
22. *Eysarcoris ventralis* (Westwood, 1837) Genus *Acrosternum* Fieber, 1860
23. *Acrosternum graminea* (Fabricius,1787) FAMILY SCUTELLERIDAE Genus *Chrysocoris* Hahn, 1834
24. *Chrysocoris stolli* (Wolff.,1801) Genus *Fitha*
25. *Fitha ardens* (Walker, 1867) SUPERFAMILY COREOIDEA FAMILY ALYDIDAE SUBFAMILY MICRELYTERINAE Genus 19. *Leptocorisa* Latreille, 1829
26. *Leptocorisa oratoria* (Fabr.,1794)
27. *Leptocorisa varicornis* (Fabricius, 1803) FAMILY COREIDAE SUBFAMILY COREINAE Genus *Cletomorpha* Mayr,1866
28. *Cletomorpha hastata* (Fabricius, 1787) Genus *Cletus* Stål, 1860

29. *Cletus bipunctatus* (Westwood, 1842)
30. *Cletus punctulatus* (Westwood, 1842)
31. *Cletus punctiger* (Dallas, 1852)
32. *Cletus trigonus* (Thumberg, 1783)
33. *Cletus borealis* (Blotte.,1934)
34. *Cletus pygophorus* Gupta & Singh, 2013 SUPERFAMILY LYGAEOIDEA FAMILY LYGAEIDAE SUBFAMILY LYGAEINAE Genus *Spilostethus* Stål, 1868
35. *Spilostethus hospes* (Fabricius, 1794)
36. *Spilostethus pandurus* militaris (Fabricius, 1763) Genus *Graptostethus* Stål, 1868
37. *Graptostethus argentatus* (Fabricius, 1803)
38. *Graptostethus quadrisignatus* Distant,1879
39. *Graptostethus servus* (Fabricius, 1787) SUBFAMILY ORSILLINAE TRIBE NYSIINI Genus *Nysius* Dallas, 1852
40. *Nysius ceylanicus* (Motschulsky, 1863) FAMILY GEOCORIDAE SUBFAMILY GEOCORINAE Genus *Geocoris* Fallen, 1814
41. *Geocoris ochropterus* Fieber, 1844 FAMILY RHYPAROCHROMIDAE SUBFAMILY RHYPAROCHROMINAE TRIBE RHYPAROCHROMINI Genus *Dieuches* Dohrn, 1860
42. *Dieuchus insignis* (Distant, 1904) TRIBE MYODOCHINI Genus *Pseudopachybrachius* Malipatil, 1978
43. *Pseudopachybrachius* guttus Malipatil, 1978 Genus *Paraeucosmetus* Malipatil, 1978
44. *Paraeucosmetus* pallicornis (Dallas, 1852) Genus *Paromius* Fieber, 1860
45. *Paromius exiguous* (Distant, 1904)

16. List of Aquatic and Semi-Aquatic (Heteroptera)

Order HEMIPTERA Linnaeus, 1758 Suborder HETEROPTERA Latreille, 1810 Infraorder NEPOMORPHA Popov, 1968 Superfamily NEPOIDEA Latreille, 1802 Family NEPIDAE Latreille, 1802 Subfamily NEPINAE Latreille, 1802 Genus *Laccotrephes* Stål, 1866
1. *Laccotrephes griseus* (Guérin-Méneville, 1844)
2. *Laccotrephes maculatus* (Fabricius, 1775) Subfamily RANATRINAE *Douglas & Scott, 1865* Genus *Ranatra Fabricius, 1790*
3. *Ranatra digitata* Hafiz & Pradhan, 1947
4. *Ranatra elongate* Fabricius, 1790
5. Ranatra filiformis Fabricius, 1790

6. *Ranatra varipes varipes* Stål, 1861 Family BELOSTOMATIDAE Leach, 1815 Subfamily BELOSTOMATINAE Leach, 1815 Genus *Diplonychus* Laporte, 1833
7. *Diplonychus annulatus* (Fabricius, 1781)
8. *Diplonychus molestus* (Dufour, 1863)
9. *Diplonychus rusticus* (Fabricius, 1781) Superfamily PLEOIDEA Fieber, 1851 Family PLEIDAE Fieber, 1851 Genus *Paraplea* Esaki & China, 1928
10. *Paraplea frontalis* (Fieber, 1844) Superfamily NOTONECTOIDEA Latreille, 1802 Family NOTONECTIDAE Latreille, 1802 Subfamily ANISOPINAE Hutchinson, 1929 Genus *Anisops* Spinola, 1837
11. *Anisops bouvieri* Kirkaldy, 1904
12. *Anisops breddini* Kirkaldy, 1901
13. *Anisops kuroiwae* Matsumura, 1915
14. *Anisops sardeus sardeus* Herrich-Shaffer, 1850
15. *Anisops tahitiensis* undblad, 1934 Subfamily NOTONECTINAE Latreille, 1802 Genus *Enithares* Spinola, 1837
16. *Enithares ciliate* (Fabricius, 1798) Genus *Nychia* Stål, 1860
17. *Nychia Sappho* Kirkaldy, 1901 Superfamily CORIXOIDEA Leach, 1815 Family CORIXIDAE Leach, 1815 Subfamily CYMATIAINAE Walton, 1940 Genus *Cymatia* Flor, 1860
18. *Cymatia apparens* (Distant, 1910) Family MICRONECTIDAE Jaczewski, 1924 Genus *Micronecta* Kirkaldy, 1897 Subgenus *Basileonecta* Hutchinson, 1940
19. *Micronecta (Basileonecta) scutellaris scutellaris* (Stål, 1858) Subgenus *Pardanecta* Wrblewski, 1962
20. *Micronecta (Pardanecta) haliploides* Horváth, 1904 Subgenus *Sigmonecta* Wrblewski, 1962
21. *Micronecta (Sigmonecta) quadristrigata* Breddin, 1905 Infraorder *Mesovelia* GERROMORPHA Popov, 1971 Superfamily MESOVELIOIDEA Douglas & Scott, 1867 Family MESOVELIIDAE Douglas & Scott, 1867 Subfamily MESOVELIINAE Douglas & Scott, 1867 Genus Mulsant & Rey, 1852
22. *Mesovelia easaci* Jehamalar & Chandra, 2017
23. Mesovelia vittigera Horváth, 1895 Superfamily HYDROMETROIDEA Billberg, 1820 Family HYDROMETRIDAE Billberg, 1820 Subfamily HYDROMETRINAE Billberg, 1820 Genus Hydrometra Latreille, 1796
24. Hydrometra greeni Kirkaldy, 1898
25. *Hydrometra okinawana* Drake, 1951* Superfamily GERROIDEA Reuter, 1910 Family VELIIDAE Amyot & Serville, 1843 Division MICROVELIIFORMES Andersen, 1982 Subfamily MICROVELIINAE China & Usinger, 1949 Genus *Microvelia* Westwood, 1834

Subgenus *Dilutovelia* Zettel, 2012
26. *Microvelia (Dilutovelia) leveillei leveillei* (Lethierry, 1877) Subgenus *Picaultia* Distant, 1913
27. *Microvelia (Picaultia) douglasi* Scott, 1874 Family GERRIDAE LEACH, 1815 Subfamily RHAGADOTARSINAE Lundblad, 1933 Genus *Rhagadotarsus* Breddin, 1905 Subgenus *Rhagadotarsus* Breddin, 1905
28. *Rhagadotarsus (Rhagadotarsus) kraepelini* Breddin, 1905 Subfamily GERRINAE Bianchi, 1896 Genus *Aquarius* Schellenberg, 1800
29. *Aquarius adelaidis* Dohrn, 1860 Genus *Neogerris* Matsumura, 1913
30. *Neogerris parvulus(Stål, 1859)* Genus *Limnogonus Stål, 1868* Subgenus *Limnogonus Stål, 1868*
31. *Limnogonus* (*Limnogonus*) *fossarum fossarum* (Fabricius, 1775)
32. *Limnogonus* (*Limnogonus*) *nitidus* (Mayr, 1865)

17. List of Ants

Taxa
Superfamily: Vespoidea Family: Formicidae Latreille?, 1809 Subfamily: Dolichoderinae Forel, 1878 Genus: *Dolichoderus* Lund, 1831
1. *Dolichoderus thoracicus* (Smith, F., 1860) Genus *Tapinoma* Foerster, 1850
2. T*apinoma indicum* Forel, 1895 Subfamily: Formicinae Latreille, 1809 Genus: *Anoplolepis* Santschi, 1914
3. *Anoplolepis gracilipes* (Smith, F., 1857) Genus *Camponotus* Mayr, 1861
4. *Camponotus compressus* (Fabricius, 1787)
5. *Camponotus dolendus* Forel, 1892
6. *Camponotus parius* Emery, 1889
7. *Camponotus sericeus* (Fabricius, 1798) Genus: *Lepisiota*
8. *Lepisiota opaca* (Forel, 1892)
9. *Lepisiota frauenfeldi* (Mayr, 1855) Genus *Nylanderia*
10. *Nylanderia bourbonica* (Forel, 1886)
11. *Nylanderia indica* (Forel, 1894) Genus *Oecophylla*
12. *Oecophylla smaragdina* (Fabricius, 1775) Genus *Paratrechina*
13. *Paratrechina longicornis* (Latreille, 1802) Genus: *Plagiolepis*
14. *Plagiolepis jerdonii* Forel, 1894 Genus: *Polyrhachis*
15. *Polyrhachis dives* Smith, F., 1857
16. *Polyrhachis lacteipennis*
17. *Polyrhachis illaudata* Walker, 1859 Subfamily: Myrmicinae Lepeletier de Saint- Fargeau, 1835

Genus: *Aphaenogaster* Mayr, 1853
18. *Aphaenogaster feae* Emery, 1889 Genus: *Carebara* Westwood, 1840
19. *Carebara affinis* (Jerdon, 1851) Genus: *Cardiocondyla* Emery, 1869
20. *Cardiocondyla wroughtonii* (Forel, 1890)
21. *Cardiocondyla kagutsuchi* Terayama, 1999 Genus *Crematogaster* Lund, 1831
22. *Crematogaster aberrans* Forel, 1892
23. *Crematogaster buddhae* Forel, 1902
24. *Crematogaster hodgsoni* Forel, 1902
25.*Crematogaster rogenhoferi* Mayr, 1879
26. *Crematogaster subnuda* Mayr, 1879 Genus *Meranoplus* Smith, F., 1853
27. *Meranoplus bicolor* (Guérin-Méneville, 1844)
28. *Meranoplus rothneyi* Forel, 1902 Genus: *Monomorium* Mayr, 1855
29. *Monomorium dichroum* Forel, 1902
30. *Monomorium fioricola* (Jerdon, 1851)
31. *Monomorium Monomorium* Bolton, 1987
32. *Monomorium orientale* Mayr, 1879
33.*Monomorium pharaonic* (Linnaeus, 1758) Genus: *Pheidole* Westwood, 1839
34. *Pheidole indica* Mayr, 1879
35. *Pheidole megacephala* (Fabricius, 1793)
36. *Pheidole multidens* Forel, 1902
37. *Pheidole pronotalis* Forel, 1902
38. *Pheidole watsoni* Forel, 1902 Genus: *Solenopsis* Westwood, 1840
39. *Solenopsis geminate* (Fabricius, 1804) Genus: *Tetramorium* Mayr, 1855
40. *Tetramorium obesum* André, 1887
41. *Tetramorium guineense* (Bernard, 1953) Genus: *Trichomyrmex* Mayr, 1865
42. *Trichomyrmex destructor* (Jerdon, 1851) SubFamily: Ponerinae Saint-Fargeau, 1835 Genus: *Bothroponera* Mayr, 1862
43. *Bothroponera sulcate* (Mayr, 1867) Genus: *Brachyponera* Emery, 1900
44. *Brachyponera jerdonii* (Forel, 1900)
45. *Brachyponera nigrita* Emery, 1895) Genus: *Diacamma* Mayr, 1862
46. *Diacamma rugosum* (Le Guillou, 1842) Genus: *Hypoponera* Santschi, 1938
47. *Hypoponera shattucki Bharti*, Akbar, Wachkoo & Singh, 2015 Genus: *Pseudoneoponera* Donisthorpe, 1943
48. *Pseudoneoponera rufipes* (Jerdon, 1851 Subfamily: Pseudomyrmecinae Smith, M.R., 1952 Genus: *Tetraponera* Smith, F., 1852
49. *Tetraponera nigra* (Jerdon, 1851)
50. *Tetraponera rufonigra* (Jerdon, 1851)

18. List of Hymenoptera: Vespidae

Taxa
Family VESPIDAE Subfamily EUMENINAE Genus *Eumenes* Latre Me, 1802
1. *Eumenesatrophicus* (Fabricius, 1798)
2. *Eumenesmacropsde* Sassure,1852 Genus Antodynerusde Saussure, 1855
3. Antodynerus flavescens flavescens (Fabricius, 1775) Genus *Antepiponade* Saussure, 1855
4. *Antepiponabiguttata* (Fabricius,1787) Subfamily POLISTINAE Genus *Polistes* Latreille, 1802
5. *Polistes* (*Gyrostoma*) *olivaceus* (De Geer, 1773) Genus *Ropalidia* Guérin-Méneville, 1831
6. *Ropalidiabrevita* Das & Gupta, 1989
7. *Ropalidiavariegata* (Smith,1852) Subfamily VESPINAE Genus *Vespa* Linnaeus, 1758
8. *Vespa orientalis* Linnaeus, 1771
9. *Vespa tropicahaematodes* Bequaert, 1936
10. *Vespa tropicatropica* (Linnaeus,1758)

19. List of Chalcidids

Taxa
1. *Antrocephalus fascicornis* (Walker, 1871)
2. *Antrocephalus phaeospilus* Waterston, 1922
3. *Brachymeria minuta* (Linnaeus, 1767)
4. *Brachymeria podagrica* (Fabricius, 1787) Genus *Dirhinus* Dalman
5. *Dirhinus bakeri* (Crawford, 1915) Genus *Hockeria* Walker
6. *Hockeria gibsoni* Narendran, 1989
7. *Hockeria hayati* Narendran, 1989
8. *Hockeria manii* Narendran, 1989
9. *Hockeria opisinae* Narendran, 1989 Genus *Kriechbaumerella* Dalla Torre
10. *Kriechbaumerella pulvinata* (Masi, 1932)
11. *Kriechbaumerella rufimanus* (Walker, 1860)

20. List of Encyrtidae

1. *Acerophagus papaya* Noyes and Schauff
2. *Anagyrus aquilonaris* (Noyes and Hayat)
3. *Anagyrus dactylopii* (Howard)

4. *Anagyrus tricolor* (Girault)
5. *Anomalicornia tenuicornis* Mercet
6. *Cheiloneurus bengalorensis* (Subba Rao)
7. *Copidosoma fioridanum* (Ashmead)
8. *Indaphycus planus* Hayat
9. *Neodusmetia sangwani* (Subba Rao)
10. *Metaphycus Mercet*
11. *Ooencyrtus utetheisae* (Risbec, 1951)
12. *Prochiloneurus albifuniculus* (Hayat, Alam and Agarwal)
13. *Prochiloneurus pulchellus Silvestri*
14. *Pseudleptomastix mexicana* Noyes and Schauff, 2003 (introduced species)
15. *Rhopus* sp. Foerster
16. *Syrphophagus* hofferi (Hayat)
17. *Tassonia gloriae* (Girault)

21. List of Coleopterans: Beetles

S. No	Taxa	Habitat
	Suborder ADEPHAGA Family Gyrinidae	
1.	*Dineutus* (*Protodineutus*) *indicus* Aubé, 1838	Aquatic
2.	*Orectochilus productus* Régimbart, 1884	Aquatic
3.	Family Carabidae *Amblystomus* sp.	Predator
4.	*Callytron limosum* (Saunders, 1834)	Predator
5.	*Calochroa sexpunctata* Fabricius, 1775	Predator
6.	*Cicindela aurovittata* Brulle, 1838	Predator
7.	*Cylindera* (*Eugrapha*) *minuta* (Olivier, 1790)	Predator
8.	*Neocollyris bonelli* (Guerin, 1834)	Predator
9.	*Neocollyris crassicornis* (Dejean, 1825)	Predator
10.	*Pogonus* (*Pogonus*) *biroi* Csiki, 1907	Predator
11.	Family Haliplidae *Haliplus angustifrons* Régimbart, 1892	Aquatic
12.	*Canthydrus laetabilis* (Walker, 1858)	Aquatic
13.	Family NoteridaeFamily Dytiscidae *Cybister javanus* Aube, 1838	Aquatic
14.	*Cybister limbatus* (Fabricius, 1775)	Aquatic
15.	*Cybister tripunctatus* lateralis (Fabricius, 1798)	Aquatic
16.	*Eretes sticticus* (Linnaeus, 1767)	Aquatic
17.	*Hydaticus* sp.	Aquatic
18.	*Hydroglyphus fiammulatus* (Sharp, 1882)	Aquatic
19.	*Hydroglyphus inconstans* (Régimbart, 1892)	Aquatic
20.	*Hydrovatus acuminatus* Motschulsky, 1859	Aquatic
21.	*Hydrovatus bonvouloiri* Sharp, 1882	Aquatic
22.	*Hydrovatus confertus* Sharp, 1882	Aquatic
23.	*Laccophilus anticatus* Sharp, 1890	Aquatic
24.	*Laccophilus flexuosus* Aube, 1838	Aquatic
25.	*Laccophilus inefficiens basalis* Motschulsky, 1859)	Aquatic
26.	*Laccophilus parvulus* Aubé, 1838	Aquatic
27.	*Laccophilus sharpi Suborder POLYPHAGA*	Aquatic
28.	Family Hydrophilidae *Amphiops materpedestris* Sharp, 1890	Aquatic
29.	*Amphiops mirabilis* Sharp, 1890	Aquatic
30.	*Berosus* (*Enoplurus*) *fairmairei* Zaitzev, 1908	Aquatic
31.	*Berosus* (*Enoplurus*)*indicus* Motschulsky, 1861	Aquatic
32.	*Enochrus* (*Methydrus*) *esuriens* (Walker, 1858)	Aquatic
33.	*Helochares anchoralis* Sharp, 1890	Aquatic

34.	*Regimbertia attenuate* (Fabricius, 1801)	Aquatic
35.	*Stemolophus rufipes*(Fabricius, 1792)	Aquatic
36.	Family Spercheidae *Spercheus belli belli* Champion, 1919	Aquatic
37.	Family Scarabaeidae *Adoretus fiavus* Arrow 1917	Chafer
38.	*Adoretus lacustris* Arrow 1917	Chafer
39.	*Adoretus lasiopygus* Burmeister, 1855	Chafer
40.	*Adoretus versutus* Harold, 1869	Chafer
40.	*Adoretus versutus* Harold, 1869	Chafer
41.	*Anomala bengalensis* (Blanchard, 1851)	Chafer
42.	*Anomala biharensis* Arrow, 1917	Chafer
43.	*Anomala bilobate* Arrow, 1912	Chafer
44.	*Anomala polita* (Blanchard, 1851)	Chafer
45.	*Heteronychus lioderes* Redtenbacher, 1867	Chafer
46.	*Oryctes rhinoceros* (Linnaeus, 1758)	Chafer
47.	*Xylotrupes Gideon* (Linnaeus, 1767)	Chafer
48.	*Onitis philemon* Fabricius, 1801	Dung beetle
49.	*Onthophagus* (*Colobonthophagus*) *dama* (Fabricius, 1798)	Dungbeetle
50.	Family Elateridae *Agrypnus* sp.	
51.	Family Dermestidae *Anthrenus* sp.	
52.	*Attagenus alfierii* Fabricius, 1787	
53.	Family Coccinellidae *Coccinella septempunctata* (Linnaeus, 1758)	Predator
54.	*Coccinella transversalis* Fabricius, 1781	Predator
55.	*Coelophora unicolor* Fabricius, 1792	Predator
56.	*Halyzia sanscrita* Mulsant, 1853	Predator
57.	*Menochilus sexmaculatus* (Fabricius, 1781)	Predator
58.	*Micraspis discolor* (Fabricius, 1798)	Predator
59.	*Henosepilachna* (Fabricius, 1775)	Chafer
60.	*Henosepilachna indica* (Mulsant 1850)	Chafer
61.	Family Tenebrionidae *Gonocephalum depressum* (Fabricius, 1801)	Chafer
62.	*Gonocephalum hoffmannseggi* (Steven, 1829)	Chafer
63.	*Gonocephalum stoeckleini* Kaszab, 1952	Chafer
64.	*Gonocephalum vagum* planatum (Walker, 1858)	Chafer
65.	*Scleron reitteri* Gebien 1906	Chafer
66.	*Scleropatrum strigatum* Fabricius, 1798	Chafer
67.	*Tribolium castaneum* (Herbst 1797)	Chafer
68.	Family Meloidae *Hycleus phaleratus* (Pallas, 1781)	Chafer
69.	Family Chrysomelidae *Aulacophora almora* Maulik, 1936	Chafer
70.	*Aulacophora lewisii* Baly, 1886	Chafer
71.	*Aulocophora foveicollis* Lucas, 1849	Chafer
72.	*Cassida circumdata* Herbst, 1799	Chafer
73.	*Cassida enervis* Boheman, 1862	Chafer
74.	*Lema* (*Lema*) (Fabricius, 1798)	Chafer
75.	*Lema* (*Lema*) *lacertosa* Lacordaire, 1845	Chafer
76.	*Monolepta signata* (Olivier,1808)	Chafer
77.	*Trichobalya bowringi* bowringi Baly, 1890	Chafer

22. List of Butterflies

Family Hesperiidae
1. *Ampittia dioscorides* (Fabricius)
2. *Barbo cinnara* (Wallace, 1866)
3. *Lambrix salsala* (Moore, 1866)
4. *Matapa aria* (Moore, 1866)

5. *Oriens gola* (Moore, 1877)
6. *Oriens goloides* (Moore, 1881)
7. *Pelopidas agna* (Moore, 1866)
8. *Pelopidas mathias* (Fabricius, 1798)
9. *Suastus gremius* (Fabricius, 1798)
10. *Tagiades japetus* (Stoll, 1781)
11. *Telicota ancilla* (Herrich-Schaffer, 1869)
12. *Udaspes folus* (Cramer, 1775)
Family Lycaenidae
13. *Anthene emolus* (Godart, 1824)
14. *Castalius rosimon* (Fabricius, 1775)
15. *Catochrysops strabo* (Fabricius, 1793)
16. *Chilades lajus* (Stoll, 1780)
17. *Curetis thetis* (Drury, 1773)
18. *Euchrysops cnejus* (Fabricius, 1798)
19. *Euchrysops pandava* (Horsfield, 1829)
20. *Jamides celeno* (Cramer, 1775)
21. *Loxura atymnus* (Stoll, 1780)
22. *Neopithecops zalmora* (Butler, 1870)
23. *Prosotas nora* (C. & R. Felder, 1860)
24. *Pseudozizeeria maha* (Kollar, 1848)
25. *Rapala manea* (Hewitson, 1863)
26. *Rathinda amor* (Fabricius, 1775)
27. *Spindasis vulcanus* (Fabricius, 1775)
28. *Tarucus nara* (Kollar, 1848)
29. *Zizeeria karsandra* (Moore, 1865)
30. *Zizula hylax* (Fabricius, 1775)
Family Nymphalidae
31. *Acraea violae* (Fabricius, 1775)
32. *Ariadne ariadne* (Linnaeus, 1758)
33. *Ariadne merione* (Cramer, 1779)
34. *Charaxes solon* (Fabricius, 1793)
35. *Danaus chrysippus* (Linnaeus, 1758)
36. *Danaus genutia* (Cramer, 1779)
37. *Elymnias hypermnestra* (Linnaeus, 1758)
38. *Euploea core* (Cramer, 1780)
39. *Euploea klugii* (Moore, 1858)
40. *Euthalea aconthea* (Cramer, 1777)
41. *Hypolimnas bolina* (Linnaeus, 1758)
42. *Hypolimnas misippus* (Linnaeus, 1758)
43. *Junonia almana* (Linnaeus, 1758)
44. *Junonia atlites* (Linnaeus, 1763)
45. *Junonia lemonias* (Linnaeus, 1758)
46. *Melanitis leda* (Linnaeus, 1758)
47. *Moduza procris* (Cramer, 1777)
48. *Mycalesis mineus* (Linnaeus, 1758)
49. *Mycalesis perseus* (Fabricius, 1775)
50. *Neptis hylas* (Moore, 1758)
51. *Neptis jumbah* (Moore, 1857)
52. *Phalanta phalanta* (Drury, 1773)
53. *Tirumala limniace* (Cramer, 1775)
54. *Ypthima baldus* (Fabricius, 1775)
55. *Ypthima huebneri* (Kirby, 1871)
Family Papilionidae
56. *Graphium agamemmon* (Linnaeus, 1758)

57. *Graphium doson* (C. & R. Felder, 1864)
58. *Pachliopta aristolochiae* (Fabricius, 1775)
59. *Pachliopta hector* (Linnaeus, 1758)
60. *Papilio clytia* (Linnaeus, 1758)
61. *Papilio demoleus* (Linnaeus, 1758)
62. *Papilio polymnestor* (Cramer, 1775)
63. *Papilio polytes* (Linnaeus, 1758)
Family Pieridae
64. *Anaphaeis aurota* (Fabricius, 1775)
65. *Appias albina* (Boisduval, 1836)
66. *Appias libythea* (Fabricius, 1775)
67. *Catopsilia pomona* (Fabricius, 1775)
68. *Catopsilia pyranthe* (Linnaeus, 1758)
69. *Cepora nerissa* (Fabricius, 1775)
70. *Delias eucharis* (Drury, 1773)
71. *Eurema blanda* (Boisduval, 1836)
72. *Eurema hecabe* (Linnaeus, 1758)
73. *Leptosia nina* (Fabricius, 1793)
74. *Pareronia valeria* (Cramer, 1776)
Family Riodinidae
75. *Abisara echerius* (Stoll, 1790)

23. List of Moths

Family Zygaenidae
1. *Balataea postvitta* Moore, 1879
2. *Gynautocera papilionaria* Guérin- Méneville, 1831
3. *Inope fuliginosa* Moore, 1879
4. *Thyrassia subcordata* Walker, 1854
5. *Trypanophora semihyalina* Kollar, 1844
Family Saturniidae
6. *Actias selene* Huebner, 1806
7. *Antheraea paphia* (Linnaeus)
8. *Cricula trifenestrata* (Helfer)
Family Geometridae
9. *Agathia lycaenaria* Kollar, 1844 10. *Ascotis* sp.
11. *Epipristis minimaria* Guenee, 1857
12. *Gelasma goniaria* Felder, 1875
13. *Metoeca foedalis*

14. *Pelagodes* sp.

15. *Problepsis vulgaris* Butler, 1889

16. *Scopula actuaria* Walker, 1861

17. *Scopula aspilataria* Walker, 1861

18. *Scopula pulchellata* Fabriccius, 1794

19. *Scopula remotata* Guenee, 1858

20. *Scopula* sp.

21. *Scopula emissaria*

22. *Semiothisa pluviata* Fabricius, 1795

23. *Thalassodes quadraria* (Guenee, 1857)

24. *Timandra convectaria* Walker, 1861

25. *Traminda* sp.

Family Sphingidae

26. *Acherontia lachesis* Fabricius 1798

27. *Acherontia styx* Westwood 1848

28. *Acosmeryx naga* Moore 1857

29. *Agrius convolvuli* Linnaeus 1758

30. *Ambulyx substrigilis* Westwood 1848

31. *Callambulyx rubricosa* Walker 1856

32. *Cephonodes shylas* Linnaeus 1771

33. *Daphnis hypothous* Cramer 1780

34. *Daphnis nerii* Linnaeus 1758

35. *Eupana cramydon*

36. *Gurelca hyas*

37. *Leucophlebia lineata* Westwood 1847

38. *Macroglossum assimilis* Swainson 1821

39. *Macroglossum glaucoptera*

40. *Meganoton analis* C. Felder & R. Felder 1874

41. *Nephele didyma*

42. *Psilogramma menephron* Cramer 1780

43. *Sataspes infernalis* Westwood 1848

44. *Theretra alecto alecto* Linnaeus 1758

45. *Theretra clotho clotho* Drury 1773

46. *Theretra nessus* Drury 1773

47. *Theretra pinastrina* Martyn, 1797

48. *Pergesa acteus*

Family Lasiocampidae

49. *Dendrolimus lattipenis* Walker, 1855

50. *Metanastria hyrtaca* Cramer, 1782

51. *Streblote dorsalis* Walker, 1866

52. *Streblote siva* Lefebvre, 1827

53. *Trabala visnou* Lefebvre, 1827

Family Erebidae

54. *Vamuna ramelana* (Moore, 1900)

55. *Mocis frugalis* (Fabricius, 1775)

56. *Amata bicincta* (Kollar, 1844)

57. *Amata cyssea* (Cramer, 1782)

58. *Amata hydatina* (Butler, 1876)

59. *Amata insueta* (Swinhoe, 1892)

60. *Amata lucina* (Butler, 1876)

61. *Amata passalis* (Fabricius, 1781)

62. *Amata fortunei* d'Orza, 1869

63. *Arctornis submarginata* Walker, 1855

64. *Aroa plana* Moore, 1879

65. *Aroa socrus* Geyer, 1837

66. *Miltochrista obsoleta* (Moore, 1878)

67. *Miltochrista congerens* (Felder, 1874)

68. *Caeneressa diaphana* (Kollar, 1844)

69. *Syntomoides imaon* (Butler, 1879)

70. *Chrysorabdia viridata* (Walker, 1865)

71. *Creatonotos gangis* Linnaeus, 1763

72. *Eilema vicaria* (Walker, 1854)

73. *Eressa con□nis* (Walker, 1854)

74. *Euproctis ampala* Walker, 1855

75. *Euproctis asoetria* Huebner, 1818

76. *Euproctis digramma* Guerin, 1829

77. *Euproctis rhoda* (Moore, 1879)

78. *Euproctis lunata* Walker, 1855

79. *Euproctis plana* Fawcett, 1915

80. *Euproctis similis* Moore, 1879

81. *Euproctis subfasciata* Walker, 1865

82. *Euproctis annulata* Hampson, 1900

83. *Lymantriades varians* Walker, 1855

84. *Barsine radians* Moore, 1878

85. *Narosodes punctata* Walker, 1863

86. *Nishada □abifera* Moore, 1878

87. *Orgyia australis* Walker, 1855

88. *Pantana visum* Huebner, 1825

89. *Olepa ricini* (Fabricius, 1794)

90. *Perina nuda* Fabricius, 1787

91. *Psichotoe duvauceli* Boisduval, 1829

92. *Somena scintillans* Walker, 1856

93. *Tigrioides fulveola* Hampson, 1900

94. *Ranghana punctata* Moore, 1878

95. *Thyas honesta* Huebner, 1806

96. *Eudocima* sp.

97. *Ophiusa coronata* Fabricius, 1775

98. *Othreis* sp.

99. *Artena dotata* (Fabricius, 1794)

100. *Asota ficus* Cramer, 1775

101. *Asota caricae* Fabricius, 1775

Family Noctuidae

102. *Chrysodeixis eriosoma* Doubleday, 1843

103. *Pseudaletia unipuncta* Haworth, 1809

104. *Spodoptera litura* Fabricius, 1775

Family Crambidae

105. *Aethaloessa floridalis* Zeller, 1852

106. *Agathodes ostentalis* Geyer, 1837

107. *Agrotera basinotata* Hampson, 1891

108. *Analyta melanopalis* Guenee, 1854

109. *Analyta sigulalis* Guenee, 1854

110. *Ancylolomia chrysographella* (Kollar, 1844)

111. *Antigastra catalaunalis* Duponchel, 1833

112. *Archernis tropicalis* Walker, 1859

113. *Arthroschista hilaralis* Walker, 1859

114. *Autocharis fessalis* Swinhoe, 1887

115. *Bocchoris acamasalis* Walker, 1859

116. *Botyodes asialis* Guenee, 1854

117. *Botyodes flavibasalis* Moore, 1867

118. *Bradina admixtalis* Walker, 1859

119. *Ceratarcha umbrosa* Swinhoe, 1894

120. *Chilo* sp.

121. *Cirrhochrista brizoalis* Walker, 1859

122. *Cnaphalocrocis medinalis* Guenee, 1854

123. *Cnaphalocrocis pauperalis* Strand, 1918

124. *Cnaphalocrocis trapezalis* Guenee, 1854

125. *Cnaphalocrocis trebiusalis* Walker, 1859

126. *Cnaphalocrocis venilialis* Walker, 1859

127. *Crocidolomia binotalis* Zeller,1852

128. *Cryptographis indica* Saunders, 1891

129. *Cydalima laticostalis* Guenee, 1854

130. *Dichocrocis evaxalis* Walker, 1859

131. *Dysallacta negatalis* Walker, 1859

132. *Ercta elutalis* Walker, 1859

133. *Euclasta defamatalis* Walker, 1859

134. *Eurrhyparodes tricoloralis* Zeller,1852

135. *Eurrhyparodes bracteolalis* Zeller,1852

136. *Glyphodes bicolar* Swainson, 1821

137. *Glyphodes bivitralis* Guenee, 1854

138. *Glyphodes caesalis* Walker, 1859

139. *Glyphodes canthusalis* Walker, 1859

140. *Glyphodes pyloalis* Walker, 1859

141. *Glyphodes* sp.

142. *Glyphodes stolalis* Guenee, 1854

143. *Herpetogramma licarsisalis* Walker, 1859

144. *Herpetogramma* sp.

145. *Hyalobathra filalis* Guenee, 1854

146. *Hydriris ornatalis* Duponchel, 1832

147. *Hydrorybina bicolor* Moore, 1888

148. *Hymenoptychis sordida* Zeller, 1852

149. *Lepyrodes geometralis* (Guenee, 1854)

150. *Leucinodes apicalis* Hampson, 1896

151. *Leucinodes orbonalis* Guenee, 1854

152. *Loxoneptera albicostalis* Swinhoe, 1906

153. *Maruca testulalis* Geyer, 1832

154. *Maruca vitrata* Fabricius, 1787

155. *Mimudea leucanalis* Swinhoe, 1890

156. *Nausinoe perspectata* (Fabricius, 1775)

157. *Noorda blitealis* Walker, 1859

158. *Notarcha quaternalis* Zeller, 1852

159. *Palpita vitrealis* (Rossi, 1794)

160. *Paraponyx crisonalis* Walker, 1859

161. *Paraponyx depunctalis* Guenee, 1854

162. *Paraponyx fluctuosalis* Walker, 1852

163. *Parotis marginata* Hampson, 1893

164. *Parotis marinata* (Fabricius 1794)

165. *Parotis vertumnalis* Guenee, 1854

166. *Pleuroptya balteata* (Fabricius 1798)

167. *Polygrammodes sabelialis* Guenee, 1854

168. *Pycnarmon caberalis* Guenee, 1854

169. *Pycnarmon meritalis* Walker, 1859

170. *Pycnarmon virgatalis* Moore 1867

171. *Pygospila tyres* Cramer,1780

172. *Pyrousta incoloralis* Guenee, 1854

173. *Ramila marginella* Moore 1868

174. *Sameodes cancellalis* Zeller, 1852

175. *Schoenobius adjurellus* Walker, 1863

176. *Schoenobius bipunctifer* Walker, 1863

177. *Schoenobius immeritalis* Walker, 1859

178. *Schoenobius incertellus* Walker, 1863

179. *Scirpophaga auriflua* Zeller, 1863

180. *Scirpophaga incertulus* Walker, 1863

181. *Syllepte lunalis* Guenee, 1854

182. *Syllepte derogata* Fabricius, 1775

183. *Synclera trauducalis* Zeller, 1852

184. *Spoladea recurvalis* (Fabricius, 1775)

185. *Talanga sexpunctalis* Moore, 1877

186. *Tatobotys varanesalis* Walker, 1858

187. *Terastia meticulosalis* Guenee, 1854

188. *Tetridia caletoralis* Walker, 1859

Family Elaschitidae

189. *Thudaca obliquella* Walker, 1856

Family Pyralidae

190. *Euzophera particella* Ragonot, 1888

191. *Galleria mellonella* Linnaeus, 1758

192. *Herculia nigrivitta* Walker, 1863

193. *Herculia suffusalis* [Walker, 1866]
194. *Hypsopygia mauritialis* Boisduval, 1833
195. *Oligochroa leucophaeella* Zeller, 1863
196. *Orthopygia igniflualis* Walker, 1859
197. *Phycita hemixanthella* Hampson, 1856
198. *Pyralis manihotalis* Guenee, 1854
199. *Pyralis pictalis* Curtis, 1834
200. *Tamaraca torridalis* Lederer, 1834
201. *Thylacoptila paurosema* Meyrick, 1885
Family Pterophoridae
202. *Hellinsia homodactyla*
Family Uraniidae
203. *Phazaca* sp.
Family Scythrididae
204. *Eretmocera* sp.
Family Stathmopodidae
205. *Atkinsonia* sp.

24. List of Dipterans: True Flies

Taxa
Order DIPTERA
Suborder NEMATOCERA
Family LIMONIIDAE Speiser, 1909
Genus *Limonia* Meigen, 1803
Subgenus *Limnobia* Meigen, 1818
1. *Limonia* (*Limnobia*) *irrorata* (Wiedemann, 1828)
Subgenus *Geranomyia* Haliday, 1833
2. *Limonia* (*Geranomyia*) *flavicosta* (Brunetti,1912)

Family PSYCHODIDAE Bigot, 1854

Genus *Phlebotomus* Loew, 1845

3. *Phlebotomus montana* Sinton, 1924

Subgenus *Euphlebotomus* Theodor, 1948

4. *Phlebotomus* (*Euphlebotomus*) *argentipes* (Annandale, 1908)

Genus *Psychodata* Steyskal, 1974

5. *Psychodatavittata* (Brunetti, 1908)

Family CERATOPOGONIDAE Grassi, 1900

Genus *Culicoides* Latreille, 1809

Subgenus *Avaritia* Fox, 1955

6. *Culicoides* (*Avaritia*) *actoni* Smith, 1929

7. *Culicoides* (*Avaritia*) *orientalis* Macfie,1932

Subgenus *Hoffmania* Fox, 1948

8. *Culicoides* (*Hoffmania*) *innoxius* Sen and Das Gupta, 1959

9. *Culicoides* (*Hoffmania*) *peregrinus* Kieffer, 1910

Subgenus *Oecacta* Poey, 1853

10. *Culicoides* (*Oecacta*) *schultzei* Enderlein, 1908

Subgenus *Trithecoides* Wirth & Hubert, 1959

11. *Culicoides* (*Trithecoides*) *anophelis* Edwards, 1922

Family CHIRONOMIDAE Erichson, 1841

Genus *Clinotanypus* Kieffer, 1913

12. *Clinotanypusvomerus* (Chaudhuri &Debnath), 1984

Family CULICIDAE Stephens, 1829

Genus Anopheles Meigen, 1818

Subgenus *Cellia* Theobald, 1903

13. *Anopheles* (*Cellia*) *stephensi* Liston, 1901

14. *Anopheles* (*Cellia*) *culicifacies* Giles, 1901

Genus *Culex* Linnaeus, 1758

Subgenus *Culex* Linnaeus, 1758

15. *Culex* (*Culex*) *quinquefasciatus* Say, 1823

Genus *Aedes* Meigen, 1818

Subgenus *Stegomyia* Theobald, 1901

16. *Aedes* (*Stegomyia*) *aegypti* (Linnaeus, 1762)

17. *Aedes* (*Stegomyia*) *albopictus* (Skuse, 1894)

Genus *Toxorhynchites* Theobald, 1901

Subgenus *Toxorhynchites* Theobald, 1901

18. *Toxorhynchites* (*Toxorhynchites*) *splendens* (Wiedemann, 1819)

Suborder BRACHYCERA

Family *Tabanidae* Samouelle, 1819

Genus *Chrysops* Meigen, 1803

19. *Chrysopsdispar* (Fabricius, 1798)

Genus *Tabanus* Linnaeus, 1758

20. *Tabanusdorsiger* Wiedemann, 1821

Subgenus *Tabanus* Linnaeus, 1758

21. *Tabanus* (*Tabanus*) *striatus* Fabricius, 1787

22. *Tabanus* (*Tabanus*) *rubidus* Wiedemann, 1821

23. *Tabanus* (*Tabanus*) *brunnipennis* Ricardo, 1911

Family STRATIOMYIDAE Giebel, 1856

Genus *Hermetia* Latreille, 1804

24. *Hermetiaillucens* (Linnaeus, 1758)

Genus *Microchrysa* Loew, 1855

25. *Microchrysa flaviventris* (Wiedemann, 1824)

Family ASILIDAE Kirby & Spence, 1817

Genus *Philodicus* Loew, 1848

26. *Philodicus femoralis* Ricardo, 1921

27. *Philodicusceylanicus* Schiner, 1868

Genus *Astochia* Becker, 1913

28. *Astochiaguptai* Joseph &Parui, 1981

Family DOLICHOPODIDAE Agassiz, 1846

Genus *Chrysosoma* Guerin, 1831

29. *Chrysosomaleucopogon* (Wiedemann, 1824)

Family PHORIDAE Curtis, 1833

Genus *Megaselia* Rondani, 1856

Subgenus *Megaselia* Rondani, 1856

30. *Megaselia* (*Megaselia*) *scalaris* (Loew, 1866)

Family SYRPHIDAE Rondani, 1856

Genus *Sphaerophoria* Le Peletier & Audinet-Serville, 1828

31. *Sphaerophoriaindiana* Bigot, 1884

Genus *Mesembrius* Rondani, 1857

32. *Mesembriusbengalensis* (Wiedemann, 1819)

33. *Mesembriusquadrivittatus* (Wiedemann, 1819)

Genus *Mik*, 1897

Subgenus *Mik,* 1897

34. *Eristalinus* (*Eristalinus*) *arvorum* (Fabricius, 1787)

35. *Eristalinus* (*Eristalinus*) *polychromata* (Brunetti, 1923)

36. *Eristalinus* (*Eristalinus*) *quinquestriatus* (Fabricius, 1794)

Genus *Episyrphus* Matsumura & Adachi, 1917

Subgenus *Episyrphus* Matsumura & Adachi, 1917

37. *Episyrphus* (*Episyrphus*) *balteatus* (De Geer, 1776)

Genus *Eristalis* Latreille, 1804

Subgenus *Eristalis* Latreille, 1804

38. *Eristalis* (*Eristalis*) *tenax* (Linnaeus, 1758)

Genus *Paragus* Latreille, 1804

Subgenus *Paragus* Latreille, 1804

39. *Paragus* (*Paragus*) *serratus* (Fabricius, 1805)

Genus *Syritta* Le Peletier & Audinet-Serville, 1828

40. *Syrittaindica* (Wiedemann, 1824)

Family SEPSIDAE Walker, 1833

Genus *Sepsis* Fallén, 1810

Subgenus *Allosepsis* Ozerov, 1992

41. Sepsis (*Allosepsis*) *indica* Wiedemann, 1824

Family TEPHRITIDAE Newman, 1834

Genus *Bactrocera* Macquart, 1835

Subgenus *Bactrocera* Macquart, 1835

42. *Bactrocera* (*Bactrocera*) *dorsalis* (Hendel, 1912)

Subgenus *Zeugodacus* Hendel, 1927

43. *Bactrocera* (*Zeugodacus*) *cucurbitae* (Coquillett,1899)

Genus *Campiglossa* Rondani, 1870

44. *Campiglossacribellata* Bezzi, 1913

Family SCIOMYZIDAE Fallén 1820

Genus *Sepedon* Latreille, 1804

45. *Sepedonplumbella* Wiedemann, 1830

Family DROSOPHILIDAE Loew, 1862

Genus *Drosophila* Fallén, 1823

46. *Drosophilaananassae* Doleschall, 1858

Subgenus *Sophophora* Sturtevant, 1939

47. *Drosophila* (*Sophophora*) *melanogaster* (Meigen 1830)

Family HIPPOBOSCIDAE Samouelle, 1819

Genus *Hippobosca* Linnaeus, 1758

48. *Hippoboscavariegata* Megerle, 1803

Family MUSCIDAE Latreille, 1802

Genus *Atherigona* Rondani, 1856

Subgenus *Atherigona* Rondani, 1856

49. *Atherigona* (*Atherigona*) *simplex* (Thomas, 1869)

Genus Musca Linnaeus, 1758

Subgenus *Musca* Linnaeus, 1758

50. *Musca* (*Musca*) *domestica* Linnaeus, 1758

Subgenus *Byomya* Robineau-Desvoidy, 1830

51. *Musca* (*Byomya*) *ventrosa* Wiedemann, 1830

Genus *Neomyia* Walker, 1859

52. *Neomyialauta* (Wiedemann,1830)

53. *timorensis* (Robineau-Desvoidy, 1830)

54. *Neomyiaindica* (Robineau-Desvoidy, 1830)

Family SARCOPHAGIDAE Macquart, 1834

Genus *Sarcophaga* Meigen 1826

55. *Sarcophagaruficornis* Macquart, 1851

Subgenus *ParasarcophagaJohnston* & Tiegs, 1921

56. *Sarcophaga* (*Parasarcophaga*) *albiceps* Meigen, 1826

Subgenus *Liosarcophaga* Enderlein, 1928

57. *Sarcophaga* (*Liosarcophaga*) dux Thomson, 1869

Subgenus *Iranihindia* Rohdendorf, 1961

58. *Sarcophaga* (*Iranihindia*) *futilis* Senior-White, 1924
Family RHINIIDAE Brauer and Bergenstamm, 1889
Genus *Stomorhina* Rondani, 1861
59. *Stomorhinadiscolor* (Fabricius, 1794)
Genus *Isomyia* Walker, 1859
60. *Isomyiaviridaurea* (Wiedemann, 1819)
Family CALLIPHORIDAE Townsend, 1915
Genus *Chrysomya* Robineau-Desvoidy, 1830
61. *Chrysomyamegacephala* (Fabricius, 1794)
Genus *Hemipyrellia* Townsend, 1918
62. *Hemipyrellialigurriens* (Wiedemann, 1830)
Genus *Lucilia* Robineau-Desvoidy, 1830
63. *Luciliaporphyrina* (Walker, 1856)
Genus *Bengalia* Robineau-Desvoidy, 1830
64. *Bengaliatorosa* (Wiedemann, 1819)

25. List of Gastropods and bivalves

Taxa
Class: GASTROPODA Cuvier, 1795 Subclass: CAENOGASTROPODA Cox, 1960 Order: ARCHITAENIOGLOSSA Haller, 1890 Superfamily: VIVIPAROIDEA Gray, 1847 Family: VIVIPARIDAE Gray, 1847 Subfamily: BELLAMYINAE Rohrbach, 1937 Genus: *Filopaludina* Habe, 1964
1. *Filopaludina bengalensis* (Lamarck, 1822)
2. *Filopaludina bengalensis* (f. doliaris) (Annandale & Sewell, 1921)
3. *Filopaludina bengalensis* (f. eburnea) (Annandale & Sewell, 1921) Genus: *Idiopoma* Pilsbry, 1901
4. *Idiopoma dissimilis* (O. F. Müller, 1774)

Family: AMPULLARIIDAE Gray, 1824 Genus: *Pila* Röding, 1798 5. *Pila globosa* (Swainson, 1822) Superfamily: CERITHIOIDEA J. Fleming, 1822 Family: THIARIDAE Gill, 1871 (1823) Subfamily: THIARINAE Gill, 1871 (1823) Genus: *Melanoides* Olivier, 1804
6. *Melanoides tuberculate* (O. F. Müller, 1774) Genus *Mieniplotia* Low & Tan, 2014
7. *Mieniplotia scabra* (O. F. Müller, 1774) Genus: *Tarebia* H. Adams & A. Adams, 1854
8. *Tarebia granifera* (Lamarck, 1816)
9. *Tarebia lineata* (Gray, 1828) Family: PACHYCHILIDAE P. Genus: Brotia H. Adams, 1866
10. *Brotia costula* (Rafinesque, 1833) Order: LITTORINIMORPHA Golikov & Starobogatov, 1975 Superfamily: TRUNCATELLOIDEA G Family: BITHYNIIDAE Gray, 1857 Genus: *Bithynia* Leach, 1818
11. *Bithynia pulchella* (Benson, 1836) Genus: *Gabbia* Tryon, 1865
12. *Gabbia orcula* (Frauenfeld, 1862)
13. *Gabbia orcula* (var. *producta*) (Nevill, 1884) Subclass: HETEROBRANCHIA Superorder: HYGROPHILA Superfamily: LYMNAEOIDEA Family: LYMNAEIDAE Subfamily: AMPHIPEPLEINAE Genus: *Radix* Montfort, 1810
14. *Radix rufescens* (Gray, 1822) Genus: *Racesina* Vinarski & Bolotov, 2018
15. *Racesina luteola* (Lamarck, 1822) Superfamily: PLANORBOIDEA Family: PHYSIDAE Fitzinger, 1833 Subfamily: PHYSINAE Tribe: PHYSELLINI Taylor, 2003 Genus: *Physella* Haldeman, 1842
16. *Physella acuta* (Draparnaud, 1805) Family: PLANORBIDAE Rafinesque, 1815 Subfamily: PLANORBINAE Rafinesque, 1815 Genus: *Gyraulus* Charpentier, 1837
17. *Gyraulus barrackporensis* (Clessin, 1886)
18. *Gyraulus convexiusculus* (Hutton, 1849)
19. *Gyraulus euphraticus* (Mousson, 1874) Tribe: SEGMENTININI F.C. Baker, 1945 Genus: *Polypylis* Pilsbry, 1906
20. *Polypylis calathus* (Benson, 1850) Genus: *Trochorbis* Benson, 1855
21. *Trochorbis trochoideus* (Benson, 1836) Family: BULINIDAE P. Fischer & Crosse, 1880 Subfamily: BULININAE P. Fischer & Crosse, 1880 Genus: *Indoplanorbis* Annandale and Prashad, 1921
22. Indoplanorbis exustus (Deshayes, 1833)

Class: BIVALVIA Linnaeus, 1758 Subclass: PALAEOHETERODONTA Newell, 1965 Order: UNIONIDA Gray, 1854 Superfamily: UNIONOIDEA Rafinesque, 1820 Family: UNIONIDAE Rafinesque, 1820 Subfamily: PARREYSIINAE Henderson, 1935 Genus *Lamellidens* Simpson, 1900
23. *Lamellidens corrianus* (Lea, 1834)
24. *Lamellidens marginalis* (Lamarck, 1819)

26. List of Fish

S. No	Taxa	Common Name	IUCN	Remarks
Order ANGUILLIFORMES Family OPHICHTHIDAE Subfamily: Ophichthinae				
1.	*Pisodonophis boro* (Hamilton, 1822) Order OSTEOGLOSSIFORMES Family NOTOPTERIDAE Subfamily: Notopterinae	Rice-paddy eel	LC	Food fish
2.	*Chitala chitala* Hamilton, 1822	Humped, featherback	NT	Food fish
3.	*Notopterus notopterus* (Pallas, 1769)	Grey, featherback	LC	Food fish
Order CYPRINIFORMES Family CYPRINIDAE Subfamily: Labeoninae				
4.	*Cirrhinus mrigala* (Hamilton 1822)	Mrigal	LC	Food fish
5.	*Cirrhinus reba* (Hamilton 1822)	Reba carp	LC	Food fish
6.	*Labeo bata* (Hamilton 1822)	Bata	LC	Food fish
7.	*Labeo boga*(Hamilton 1822)	Boga labeo	LC	Food fish

8.	*Labeo calbasu* (Hamilton, 1822)	Kalbasu	LC	Food fish
9.	*Labeo catla* (Hamilton, 1822)	Catla	LC	Food fish
10.	*Labeo catla* (Hamilton, 1822)	Rohu	LC	Food fish
11.	Subfamily Smiliogastrinae *Pethia conchonius* (Hamilton, 1822)	Rosy barb	LC	Ornamental & food fish
12.	*Pethia phutonio* (Hamilton, 1822)	Spotted sail barb	LC	Ornamental & food fish
13.	*Pethia terio* (Hamilton, 1822)	One spot barb	LC	Ornamental & food fish
14.	*Pethia ticto* (Hamilton, 1822)	Two spot barb	LC	Ornamental & food fish
15.	*Puntius chola* (Hamilton, 1822)	Swamp barb	LC	Ornamental & food fish
16.	*Puntius sophore* (Hamilton, 1822)	Spotfin swamp barb	LC	Ornamental & food fish
17.	*Systomus sarana* (Hamilton, 1822)	Olive barb	LC	Food fish
18.	Subfamily: Cyprininae *Barbonymus gonionotus* (Bleeker 1849)	Silver barb	LC	Food fish, Exotic
19.	*Carassius auratus* (Linnaeus, 1758)	Gold fish	LC	Ornamental fish. Exotic
20.	*Cyprinus carpio* Linnaeus, 1758	Common carp	VU	Food fish. Exotic
21.	Family DANIONIDAE *Amblypharyngodon mola (Hamilton, 1822)*	Mola carplet	LC	Ornamental and food fish
22.	*Danio rerio* (Hamilton, 1822)	Zebra danio	LC	Ornamental fish
23.	*Laubuka laubuca* (Hamilton, 1822)	Indian Glass barb	LC	Ornamental & food fish
24.	*Raiamas bola* (Hamilton, 1822)	Trout barb	LC	Ornamental & food fish
25.	*Rasbora daniconius* (Hamilton, 1822)	Blackline rasbora	LC	Ornamental & food fish

26.	*Salmostoma bacaila* (Hamilton, 1822)	Large razorbelly	LC	Food fish
27.	*Salmostoma phulo* (Hamilton, 1822)	Finescale razorbelly minnow	LC	Food fish
28.	*Esomus danricus* (Hamilton, 1822)	Flying barb	LC	Ornamental & food fish
29.	Family XENOCYPRIDIDAE *Hypophthalmichthys* molitrix	Silver carp	NT	Food fish. Exotic
30.	*Hypophthalmichthys* nobilis (Richardson, 1845)	Bighead carp	DD	Food fish. Exotic
31.	*Ctenopharyngodon Idella* (Valenciennes, 1844)	Grass Carp	NA	Food fish. Exotic
32.	Family COBITIDAE *Lepidocephalichthys* guntea (Hamilton, 1822)	Guntea loach	LC	Widely distributed, food fish
33.	Order CHARACIFORMES Family SERRASALMIDAE *Piaractus brachypomus* (Cuvier 1818)	Red-bellied pacu	NA	Food fish. Exotic
34.	Order SILURIFORMES Family LORICARIIDAE Subfamily: Hypostominae *Pterygoplichthys anisitsi* Eigenmann & Kennedy, 1903	Snow pleco	NA	Ornamental fish. Exotic
35.	*Pterygoplichthys disjunctivus* (Weber, 1991)	Vermiculated sailfin catfish	NA	Ornamental fish. Exotic
36.	*Pterygoplichthys multiradiatus* (Hancock, 1828)	Orinoco sailfin catfish	NA	Ornamental fish. Exotic
37.	*Pterygoplichthys pardalis* (Castelnau, 1855)	Amazon sailfin catfish	NA	Ornamental fish. Exotic
38.	Family CHACIDAE *Chaca chaca* (Hamilton, 1822)	Squarehead chaca	LC	
39.	Family AILIIDAE *Ailia coila* (Hamilton, 1822)	Gangetis ailia	NT	Ornamental & food fish
40.	*Silonia silondia* (Hamilton, 1822)	Silondia vacha	LC	Food & game fish
41.	Family HORABAGRIDAE	Indian potasi	LC	Ornamental & food fish

	Pachypterus atherinoides (Bloch 1794)			
42.	Family BAGRIDAE *Mystus bleekeri* (Day, 1877)	Day,s Mystus	LC	Food fish
43.	*Mystus gulio* Hamilton, 1822	Long whiskered catfish	LC	Food fish
44.	*Mystus tengara* (Hamilton, 1822)	Tengara Mystus	LC	Food fish
45.	*Mystus vittatus* (Bloch 1794)	Striped dwarf catfish	LC	Food fish
46.	*Rita rita* (Hamilton, 1822)	Rita	LC	Food fish
47.	*Sperata aor* (Hamilton, 1822)	Long whiskered catfish	LC	Food fish
48.	Family PANGASIDAE *Pangasianodon hypophthalmus* (Sauvage 1878)	Striped catfish	EN	Food fish. Exotic
49.	*Pangasius pangasius* (Hamilton 1822)	Pungas	LC	Ornamental & food fish
50.	Family SILURIDAE *Ompok pabda* (Hamilton, 1822)	Pabdah	NT	Food fish
51.	Family SILURIDAE *Wallago attu* (Schneider, 1801)	Boal	NT	Food & game fish
52.	Family CLARIIDAE *Clarias gariepinus* (Burchell, 1822)		LC	Food fish. Exotic
53.	*Clarias magur* (Hamilton, 1822)	Magur	EN	Food fish
54.	Family HETEROPNEUSTIDAE *Heteropneustes fossilis* (Bloch, 1794)	Stinging catfish	LC	Food fish
55.	Order GOBIIFORMES Family GOBIIDAE Subfamily Gobiinae *Glossogobius giuris* (Hamilton, 1822)	Tank Goby	LC	Food fish
56.	Order SYNBRANCHIFORMES Family MASTACEMBELIDAE *Macrognathus aral* (Schneider, 1801)	One stripe spinyeel	LC	Food fish

57.	*Macrognathus pancalus* Hamilton, 1822	Barred spiny eel	LC	Food fish
58.	*Mastacembelus armatus* (La Cepède, 1800)	Zig zag eel	LC	Food fish
59.	Family SYNBRANCHIDAE *Monopterus cuchia* (Hamilton, 1822)	Cuchia	LC	Food fish
60.	Order ANABANTIFORMES Family ANA12BANTIDAE *Anabas testudineus* (Bloch, 1792)	Climbing perch	DD	Food fish
61.	*Anabas cobojius* (Hamilton, 1822)	Gangetic koi	DD	Food fish
62.	Family OSPHRONEMIDAE Subfamily Trichogastrinae *Trichogaster fasciata* Bloch & Schneider 1801	Stripled gourami		
63.	*Trichogaster lalius* (Hamilton, 1822)	Dwarf gourami	LC	Ornamental & Food fish
64.	Family CHANNIDAE *Channa gachua* (Hamilton, 1822)	Dwarf snakehead	LC	Ornamental & Food fish
65.	*Channa marulius* (Hamilton, 1822)	Giant snakehead	LC	Food fish
66.	*Channa punctate* (Bloch, 1793)	Spotted snakehead	LC	Food fish
67.	*Channa striata* (Bloch, 1793)	Banded snakehead	LC	Food fish
68.	Family Badidae *Badis badis* (Hamilton, 1822)	Badis	LC	Ornamental fish
69.	Order Pleuronectiformes Family Cynoglossidae *Cynoglossus cynoglossus* (Hamilton, 1822)	Bengal tongue sole	LC	Food fish
70.	Order Cichliformes Family Cichlidae *Oreochromis mossambica* (Peters, 1852)	Mozambique tilapia	VU	Food fish. Exotic
71.	*Oreochromis niloticus* (Linnaeus, 1758)	Nile tilapia		Food fish. Exotic
72.	Order CYPRINODONTIFORMES	Blue panchax		Biological

	Family APLOCHEILIDAE *Aplocheilus panchax* Hamilton, 1822			
73.	Order Mugiliformes Family Mugilidae *Chelon.parsia (Hamilton, 1822)*	Goldspot mullet	NA	Food fish
74.	*Rhinomugil corsula* (Hamilton, 1822)	Corsula mullet	LC	Food fish
75.	Order Tetraodontiformes Family Tetraodontidae *Leiodon cutcutia (Hamilton, 1822)*	Ocellated pufferfish	LC	Ornamental fish
76.	Order Perciformes Family Latidae *Lates Calcarifer (*Bloch 1790)	Barramundi	LC	Food fish
77.	*Chanda nama* Hamilton, 1822	Elongate glass perchlet	LC	Ornamental & Food fish
78.	*Parambassis lala* (Hamilton, 1822)	High fin glassy perchlet	NT	Ornamental & Food fish
79.	*Parambassis ranga* (Hamilton, 1822)	Indian glassy fish	LC	Ornamental & Food fish

*NE: Not Evaluated, DD: Data Deficient, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered, CR: Critically Endangered, EW: Extinct in the Wild, EX:Extinct

27. List of Amphibians and Reptiles

S. No.	**Taxa**	**Common Name**	**Local Name**
Lizards			
1.	FAMILY: AGAMIDAE *Calotes versicolor* (Daudin, 1802) Common Garden Lizard	Girgiti	
2.	FAMILY: GEKKONIDAE *Hemidactylus flaviviridis* Ruppell, 1835 Yellow-Green House Gecko	Tiktiki	
3.	*Hemidactylus frenatus Dumeril*	Asian House Gecko	Chhoto Tiktiki
4.	*Hemidactylus parvimaculatus*	Ground Gecko	Metho Tiktiki
5.	FAMILY: SCINCIDAE *Eutropis carinata* (Schneider, 1799)	Common Grass Skink	Baro Ghaser Anjoni
6.	*Eutropis macularia* (Blyth, 1853) Bronze Grass Skink	Tamate Ghaser Anjoni	
7.	*Riopa albopunctata* (Gray, 1846) White-Spotted Supple Skink	Futkijukto choto anjoni	

8.	FAMILY: VARANIDAE *Varanus salvator* (Laurenti, 1768)	Water Monitor Lizard	Jal Godhika, Tarkel, Gorkel
9.	*Varanus flavescens* (Hardwicke & Gray, 1827)	Yellow Monitor Lizard	Sonali Godhika, Sonali Gui
Turtle			
10.	FAMILY: TRIONYCHIDAE *Lissemys punctata* (Bonnaterre, 1789) Indian Flap-Shell Turtle	Chiti Kachim	
Snake			
11.	FAMILY: COLUBRIDAE *Amphiesma stolatum* (Linnaeus, 1758)	Buff-Striped Keelback	Hele
12.	*Atretium schistosum* (Daudin, 1803) Olive Keelback Water Snake	Kerul	
13.	*Cerberus rynchops* (Schneider, 1799) Dog-Faced Water Snake	Kukur Mukho	
14.	*Enhydris enhydris* (Schneider, 1799)	Common Smooth	Metuli
15.	*Lycodon aulicus* (Linnaeus, 1758) Common Wolf Snake	Gharchiti	
16.	*Ptyas mucosus* (Linnaeus, 1758)	Indian Rat Snake	Daras, Dhamna
17.	*Fowlea piscator* (Schneider, 1799)	Checkered Keelback	Jaldhora
18.	*Fowlea schnurrenbergeri* (Kramer, 1977)	Bar-Necked Keelback	Jaldhora
19.	*Xenochrophis cerasogaster* (Cantor, 1839)	Painted Keelback	Khorichonch
20.	*Chrysopelea ornata* (Shaw, 1802)	Ornamental Flying Snake	Kalnagini
21.	*Oligodon arnensis* (Shaw, 1802)	Banded Kukri Snake	Udaykal
22.	*Ahaetulla anomala* Annandale, 1906	Common Vine Snake	Laudaga
23.	*Dendrelaphis tristis* (Daudin, 1803)	Common Bronze-Back	Betanchra
24.	*Dendrelaphis pictus* (Gmelin, 1789	Painted Bronze-back	Kharichur
FAMILY: ELAPIDAE			
25.	*Bungarus caeruleus* (Schneider, 1801)	Common Krait	Kalaj
26.	*Bungarus fasciatus* (Schneider, 1801)	Banded Krait	Sankhamuthi
27.	*Naja kaouthia* Lesson, 1831 Monocellate Cobra	Keute	
FAMILY: VIPERIDAE			
28.	*Daboia russellii* (Shaw &Nodder, 1797)	Russell's Viper	Chandrabora
FAMILY: TYPHLOPIDAE			
29.	*Indotyphlops braminus* (Daudin, 1803)	Common Blind	Puye saap
Amphibians			
1.	*Duttaphrynus melanostictus* (Schneider, 1799)	Common Indian Toad	
2.	*Duttaphrynus stomaticus* (Lutken, 1864)	Marbled Toad	
3.	*Microhyla ornata* (Dumeril & Bibron, 1841)	Ornate Narrow-Mouthed Frog	
4.	*Kaloula taprobanica* (Parker, 1934)	Indian Painted Frog	
5.	*Euphlyctis cyanophlyctis* (Schneider, 1799)	Skittering Frog	

6.	*Euphlyctis hexadactylus (Lesson, 1834)*	Green Pond Frog	
7.	*Hoplobatrachus tigerinus* (Daudin, 1802)	Indian Bull Frog	
8.	*Fejervarya syhadrensis* (Annandale, 1919)	Syhadra Cricket Frog	
9.	*Hylarana tytleri* (Theobald, 1868)	Reed Frog	
10.	*Polypedates maculatus* (Gray, 1834)	Common Indian Tree Frog	

28. List of Birds

S. No.	Common Name	Species	Status
1.	Little Grebe	*Podiceps ruficollis*	R/f
2.	Grey Pelican	*Pelecanus philippenis*	Ix
3.	Cormorant	*Phalacrocorax Carbo*	M/u
4.	Indian Shag	*Phalacrocorax*	R/f
5.	Little Cormorant	*Phalacrocorax niger*	R/c
6.	Darter	*Anhinga Rufa*	Ix
7.	Grey Heron	*Andea cinerea*	R/u
8.	Purple Heron	*Ardea purpurea*	R/u
9.	Pond Heron	*Ardeola grayii*	R/u
10.	Cattle Egret	*Bubulcus ibis*	
11.	Large Egret	*Ardea alba*	R/u
12.	Smaller Egret	*Egretta intermedia*	R/u
13.	Little Egret	*Egretta garzetta*	R/u
14.	Night Heron	*Nycticorax nycticorax*	
15.	Chestnut Bittern	*Lxobrychus*	
16.	Yellow Bittern	*Lxobrychus sinensis*	
17.	Black Bittern	*Lxobrychus*	
18.	Openbill Stork	*Anastomus oscitans*	
19.	Spoonbill	*Platalea leucorodia*	
20.	Greylag Goose	*Anser anser*	
21.	Bar-headed Goose	*Anser indicus*	
22.	Lesser Whistling Teal	*Dendrocygna javanica*	

23.	Ruddy Shelduck	*Tadorna ferruginea*	
24.	Common Shelduck	*Tadona fadoma*	
25.	Pintail	*Anas acuta*	
26.	Common Teal	*Anas Crecca*	M/u
27.	Spot-billed Duck	*Anas Poecilorhyncha*	
28.	Mallard	*Anas platyrhynchos*	
29.	Gadwall	*Anas srepera*	M/f
30.	Wigeon	*Anas Penelope*	
31.	Garganey	*Anas querquedula*	
32.	Shoveler	*Anas clypeata*	
33.	Red-crested Pochard	*Netta rufina*	
34.	Common Pochard	*Aythya ferina*	
35.	White Eyed Pochard	*Aythya nyroca*	
36.	Baer's Pochard	*Aythya baeri*	
37.	Tufted Pochard	*Aythya fuligula*	M/f
38.	Cotton Teal	*Nettapus coromandelianus*	R/r
39.	Comb Duck	*Sakidiomis melanotos*	
40.	Red-breasted merganser	*Mergus serrator*	
41.	Marsh Harrier	*Circus aeruginosus*	M/u
42.	Crested Serpent Eagle S	*Spilornis cheela*	
43.	Osprey	*Pandion heliaetus*	M/r
44.	Common Bastard Quail	*Tumix suscicator*	
45.	Water Rail	*Rallus Aquaticus*	
46.	Blue-breasted Banded Rail	*Rallus striatus*	
47.	Banded Crake	*Rallina eurizonoides*	
48.	Baillon's Crake	*Porzana pusilla*	
49.	Spotted Crake	*Porzana porzana*	
50.	Ruddy Crake	*Porzana fusca*	
51.	Brown Crake	*Amauromis akool*	
52.	White-breasted waterhen	*Amauromis hoenicurus*	R/f

53.	Watercock	*Gallicrex cineres*	
54.	Moorhen	*Gallicrex cineres*	R/f
55.	Purple Moorthen	*Porphyrio porphyrio*	R/u
56.	Coot	*Fulica atra*	M/u
57.	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	
58.	Bronze-winged Jacana	*Metropidius indicus*	R/u
59.	Grey-headed Lapwing	*Vanellus cinereus*	
60.	Red-wattled Lapwing	*Vanellus indicus*	R/u
61.	Spur-winged Lapwing	*Vanellus spinosus*	
62.	Yellow-wattled Lapwing	*Vanellus malabaricus*	
63.	Grey Plover	*Pluvialis Squatarola*	
64.	Eastern Golden Plover	*Pluvialis dominica*	
65.	Ringed Plover	*Charadrius hiaticufa*	
66.	Little Ringed Plover	*Charadrius dubius*	
67.	Kentish Plover	*Chandrius*	
68.	Curlew	*Numenius arquata*	
69.	Black-tailed Godwit	*Limosa limosa*	
70.	Spotted Redshank	*Tringa erythropus*	
71.	Marsh Sandpiper	*Tringa stagnatilis*	
72.	Greenshank	*Tringa nebularia*	
73.	Blue-throated	*Megalaima asiatica*	
74.	Lineated Barbet	*Megalaima lineata*	M
75.	Coppersmith Barbet	*Megalaima haemacephala*	
76.	Indian Roller	*Coracias benghalensis*	M
77.	Common Kingfisher	*Alcedo atthi*	
78.	White-throated Kingfisher	*Halcyon smyrnensis*	
79.	Stork-billed Kingfisher	*Halcyon capensis*	
80.	Pied Kingfisher	*Ceryle rudis*	M
81.	Common Hawk-Cuckoo	*Hierococcyx varius*	
82.	Grey-bellied Cuckoo	*Cacomantis passerinus*	

83.	Asian Koel	*Eudynamys scolopacea*	
84.	Greater Coucal	*Centropus sinensis*	
85.	Rose-ringed Parakeet	*Psittacula krameri*	
86.	House Swift	*Apus affinis*	
87.	Asian Palm-Swift	*Cypsiurus balasiensis*	
88.	Rock Pigeon	*Columba livia*	
89.	Spotted Dove	*Streptopelia chinensis*	
90.	Common Snipe	*Gallinago gallinago*	
91.	Wood Sandpiper	*Tringa glareola*	M
92.	Green Sandpiper	*Tringa ochropus*	M
93.	Common Sandpiper	*Tringa hypoleucos*	M
94.	Little Stint	*Calidris minuta*	M
95.	Small Pratincole	*Glareola lactea*	M
96.	Pacific Golden Plover	*Pluvialis fulva*	M
97.	Black Kite	*Milvus migrans*	
98.	Black-headed Ibis	*Threskiornis melanocephalus*	
99.	Brown Shrike	*Lanius cristatus*	M
100.	Long-tailed Shrike	*Lanius schach tricolor*	
101.	Rufous Treepie	*Corvus macrorhynchos*	
102.	House Crow	*Corvus splendens*	
103.	Black Drongo	*Dicrurus leucophaeus*	
104.	Chestnut-tailed Starling	*Sturnus malabaricus*	
105.	Asian Pied Starling	*Sturnus contra*	
106.	Common Myna	*Acridotheres tristis*	
107.	Barn Swallow	*Hirundo rustica*	
108.	Oriental Magpie- Robin	*Copsychus saularis*	
109.	Black Redstart	*Phoenicurus ochruros*	
110.	Red-vented Bulbul	*Pycnonotus cafer*	
111.	Plain Prinia	*Prinia inornata*	
112.	Zitting Cisticola	*Cisticola juncidis*	

113.	Blyth's Reed- Warbler	*Acrocephalus*	M
114.	Clamorous Reed-Warbler	*Acrocephalus dumetorum*	M
115.	Striated Grassbird	*Megalurus stentoreus*	
116.	Common Tailorbird	*Orthotomus palustris*	
117.	Purple Sunbird	*Nectarinia sutorius*	
118.	White-browed Wagtail	*Motacilla asiatica*	
119.	White Wagtail	*Motacilla alba maderaspatensis*	M
120.	Yellow Wagtail	*Motacilla fiava*	M
121.	Grey Wagtail	*Motacilla cinerea*	M
122.	Paddyfield Pipit	*Anthus rufulus*	
123.	House Sparrow	*Passer domesticus*	

[Status: c = common; seen in very high numbers and/or on many occasions in suitable habitat. f = fairly common; seen on more than one occasion or in fairly high numbers; u = uncommon; seen on one /two occasions and / or one or two individuals; v = vagrant; lx = locally extinct; ? = unknown; R = Resident; M = Migrant; P = Partly migrant]

29. List of Mammals

Taxa	**Occurrence**	**IUCN Status**
Order Carnivora Family Viverridae 1. Asian Palm Civet *Paradoxurus hermaphrodites* (Pallas, 1777)	Rare	LC
Family Herpestidae 2. Bengal Marsh Mongoose *Herpestes palustris* Ghose, 1965	Rare	LC
Family Canidae 3. Asiatic Jackal *Canis aureus* Linnaeus, 1758 Order Rodentia	Rare	LC
Family Sciuridae 4. Northern Palm Squirrel *Funambulus pennantii* Wroughton, 1905	Common	LC
Family Muridae 5. Greater Bandicoot Rat *Bandicota indica* (Bechstein,1800)	Common	LC
6. Common House Rat *Rattus rattus* (Linnaeus,1758)	Common	LC

7. House mouse *Mus musculus* Linnaeus,1758	Common	LC
Order Eulipotyphla Family Soricidae 8. Asian House Shrew *Suncus murinus* (Linnaeus, 1766)	Rare	LC
Order Chiroptera Family Pteropodidae 9. Indian Flying Fox *Pteropus giganteus* (Brünnich, 1782)	Common	LC
10. Greater Short nosed Fruit Bat *Cynopterus sphinx* (Vahl, 1797)	Common	LC
11. Lesser Short nosed Fruit Bat *Cynopterus brachyotis* (Müller, 1838)	Common	LC
12. Leschenault's Rousette *Rousettus leschenaultii* (Desmarest, 1820)	Common	LC
Family Vespertilionidae 13. Indian Pipistrelle *Pipistrellus coromandra* (Gray, 1838)	Common	LC

*NE: Not Evaluated, DD: Data Deficient, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered, CR: Critically Endangered, EW: Extinct in the Wild, EX:Extinct

30. List of Fungi

	Family	**Species**
Bracket Macrofungi	Bondarzewiaceae	*Amylosporus campbellii* (Berk.) Ryvarden
	Ganodermataceae	*Ganoderma australe* (Fr.) Pat. *Ganoderma curtisii* (Berk.) Murrill *Ganoderma colossus* (Fr.) C.F. Baker *Ganoderma mediosinense* J.D. Zhao
	Hymenochaetaceae	*Fuscoporia senex* (Nees & Mont.) Ghob. -Nejh. *Inonotus pachyphloeus* (Pat.) T. Wagner & M. Fisch.

		Phellinus allardii (Bres.) S. Ahmad *Phellinus gilvus* (Schwein.) Pat.
	Meripilaceae	*Rigidoporus lineatus* (Pers.) Ryvarden
	Polyporaceae	*Cellulariella acuta* (Berk.)Zmitr. & Malysheva *Coriolopsis occidentalis* (Klotzsch) Murrill *Earliella scabrosa* (Pers.) Gilb. & Ryvarden *Favolus grammocephalus* (Berk.) Imazeki *Funalia caperata* (Berk.) Zmitr. & Malysheva *Leiotrametes lactinea* (Berk.) Welti & Courtec. *Leiotrametes menziesii* (Berk.) Welti & Courtec. *Pycnoporus sanguineus* (L.) Murrill *Truncospora tephropora* (Mont.) Zmitr.
Pseudogilled Macrofungi	Schizophyllaceae	*Schizophyllum commune* Fr.
	Serpulaceae	*Serpula similis* (Berk. & Broome) Ginns
Gilled Macrofungi	Agaricaceae	*Agaricus* sp.
	Hymenogastraceae	*Gymnopilus purpureosquamulosus* Høil.
	Lyophyllaceae	*Termitomyces striatus* (Beeli) R. Heim
	Pluteaceae	*Pluteus chrysaegis* (Berk. & Broome) Petch
		Volvariella volvacea (Bull.) Singer
	Polyporaceae	*Lentinus polychrous* Lév.
		Lentinus sajor-caju (Fr.) Fr.

	Tricholomataceae	*Macrocybe gigantea* (Massee) Pegler & Lodge
	Psathyrellaceae	*Coprinopsis* sp. *Psathyrella* sp.
Crust Macrofungi	Lachnocladiaceae	*Scytinostroma duriusculum* (Berk. & Broome) Donk
	Meripilaceae	*Rigidoporus vinctus* (Pers.) Ryvarden
	Peniophoraceae	*Duportella tristicula* (Berk. & Broome) Reinking
	Phanerochaetaceae	*Porostereum spadiceum* (Pers.) Hjortstam & Ryvarden
	Polyporaceae	*Grammothele fuligo* (Berk. & Broome) Ryvarden
Stereoid Macrofungi	Meruliaceae	*Stereopsis dimiticum* (Rehill & B.K. Bakshi)
	Stereopsidaceae	*Gyrodontium sacchari* (Spreng.) Hjortstam
Toothed Macrofungi	Coniophoraceae	*Gyrodontium sacchari* (Spreng.) Hjortstam
	Meruliaceae	*Flavodon □avus* (Klotzsch) Ryvarden
Jelly Macrofungi	Auriculariaceae	*Auricularia auricula-judae* (Bull.) Quél. *Auricularia nigricans* (Sw.) Birkebak, Looney & Sánchez-García
	Dacrymycetaceae	
	Tremellaceae	
Stink horn	Phallaceae	
Carbon and Cushion Macrofungi	Hypoxylaceae	*Daldinia bambusicola* Y.M. Ju, Macrofungi J.D. Rogers & F. San Martín *Daldinia concentrica* (Bolton) Ces. & De Not. *Hypoxylon haematostroma* Mont.

	Xylariaceae	*Xylaria multiplex* (Kunze) Fr. *Xylaria polymorpha* (Pers.) Grev.

31. List of Freshwater Algae

S. No.	Taxa	Family	Mode of occurrence
Cyanophyceae			
1	*Limnococcus limneticus* (Lemmerm.) Komárk. & al.	Merismopediacea	Planktonic
2	*Merismopedia minima* Beck	Merismopediaceae	Planktonic
3	*Merismopedia tenuissima* Lemmerm.	Merismopediaceae	Planktonic
4	*Merismopedia tranquilla* (Ehrenb.) Trevis.	Merismopediaceae	Planktonic
5	*Synechocystis aquatilis Sauv.*	Merismopediaceae	Planktonic
6	*Microcystis aeruginosa* (Kütz.) Kütz.	Microcystaceae	Planktonic
7	*Lemmermanniella pallida* (Lemmerm.) Geitler	Synechococcaceae	Planktonic
8	*Rhabdoderma irregulare* (Naumann) Geitler	Synechococcaceae	Planktonic
9	*Synechococcus elongatus* (Nägeli) Nägeli	Synechococcaceae	Planktonic
10	*Chroococcus disperses* (Keisll.) Lemmerm.	Chroococcaceae	Planktonic; Attached
11	*Chroococcus turgidus* (Kütz.) Nägeli	Chroococcaceae	Planktonic
12	*Pseudanabaena catenate* Lauterb.	Pseudanabaenaceae	Planktonic
13	*Leptolyngbya subtilis* (West) Anagn.	Leptolyngbyaceae	Attached
14	*Planktolyngbya limnetica* (Lemmerm.) Komárk. -Legn. & Cornberg	Leptolyngbyaceae	Planktonic
15	*Spirulina major Kütz. ex Gomont*	Spirulinaceae	Planktonic
16	*Spirulina subsalsa Oerst.* ex Gomont	Spirulinaceae	Planktonic
17	*Spirulina gigantea* Schmidle	Spirulinaceae	Planktonic
18	*Microcoleus autumnalis* (Gomont) Strunecky & al.	Microcoleaceae	Attached
19	*Planktothrix isothrix* (Skuja) Komárek & Komárk.	Microcoleaceae	Planktonic
20	*Planktothrix rubescens* (DC. ex Gomont) Anagn. & Komárk	Microcoleaceae	Planktonic
21	*Kamptonema chlorinum* (Kütz. ex Gomont) Strunecky & al.	Oscillatoriaceae	Attached
22	*Kamptonema formosum* (Bory ex Gomont) Strunecky & al.	Oscillatoriaceae	Attached
23	*Lyngbya hieronymusii* Lemmerm.	Oscillatoriaceae	Attached
24	*Oscillatoria limosa C.Agardh* ex Gomont	Oscillatoriaceae	Planktonic; Attached
25	*Oscillatoria ornata* Kütz. ex Gomont	Oscillatoriaceae	Attached

26	*Oscillatoria crassa* (C.B.Rao) Anagn.	Oscillatoriaceae	Attached
27	*Oscillatoria subbrevis* Schmidle	Oscillatoriaceae	Planktonic; Attached
28	*Oscillatoria princeps* Vaucher ex Gomont	Oscillatoriaceae	Attached
29	*Phormidium tergestinum* (Rabenh ex Gomont) Anagn. & Komárek	Oscillatoriaceae	Planktonic
30	*Phormidium chalybeum* (Martens ex Gomont) Anagn. & Komárek	Oscillatoriaceae	Planktonic
31	*Scytonema pseudohofmanni* Bharadwaja	Scytonemataceae	Attached
32	*Anabaena iyengarii* Bharadwaja	Nostocaceae	Planktonic
33	*Anabaena catenula* Kütz. ex Bornet & Flahault	Nostocaceae	Planktonic
34	*Cylindrospermum* stagnale Bornet & Flahault	Nostocaceae	Attached
Chlorophyceae			
1	*Chlamydomonas mucicola* Schmidle	Chlamydomonadaceae	Planktonic
2	*Edaphochlamys debaryana* (Gorozh.) Pröschold & Darienko	Chlamydomonadaceae	Planktonic
3	*Eudorina elegans* Ehrenb.	Volvocaceae	Planktonic
4	*Pandorina morum* (O.F.Müll.) Bory	Volvocaceae	Planktonic
5	*Oocystis borgei* J.Snow	Oocystaceae	Attached
6	*Chlorococcum infusionum* (Schrank) Menegh.	Chlorococcaceae	Attached
7	*Lacunastrum gracillimum* (West & G.S.West) McManus	Hydrodictyaceae	Planktonic
8	*Goniochloris mutica* (A.Braun) Fott	Hydrodictyaceae	Attached
9	*Pediastrum boryanum* var. cornutum (Racib.) Sulek	Hydrodictyaceae	Planktonic; Attached
10	*Pediastrum duplex* Meyen	Hydrodictyaceae	Planktonic
11	*Pediastrum sarmae* Keshri & Mullick	Hydrodictyaceae	Planktonic
12	*Pediastrum subgranulatum* (Racib.) Komárek & Jánkovska	Hydrodictyaceae	Attached
13	*Pseudopediastrum boryanum* (Turpin) E.Hegew.	Hydrodictyaceae	Attached
14	*Stauridium privum* (Printz) E.Hegew.	Hydrodictyaceae	Planktonic; Attached
15	*Stauridium tetras* (Ehrenb.)E.Hegew.	Hydrodictyaceae	Planktonic; Attached
16	*Tetraedron caudatum*(Corda) Hansg.	Hydrodictyaceae	Attached
17	*Tetraedron gracile* (Reinsch) Hansg.	Hydrodictyaceae	Planktonic
18	*Tetraedron minimum* (A.Braun) Hansg.	Hydrodictyaceae	Planktonic
19	*Tetraedron trigonum* (Nägeli) Hansg.	Hydrodictyaceae	Planktonic
20	*Coelastropsis costata* (Korshikov) Fott & Kalina	Scenedesmaceae	Attached
21	*Coelastrum microporum* Nägeli	Scenedesmaceae	Attached
22	*Desmodesmus brasiliensis* (Bohlin) E.Hegew.	Scenedesmaceae	Planktonic

23	*Desmodesmus pannonicus* (Hortob.) E.Hegew.	Scenedesmaceae	Planktonic
24	*Desmodesmus hystrix* (Lagerh.) E.Hegew.	Scenedesmaceae	Planktonic
25	*Scenedesmus armatus* (Chodat) Chodat	Scenedesmaceae	Planktonic
26	*Scenedesmus ecornis* (Ehrenb.) Chodat	Scenedesmaceae	Planktonic
27	*Scenedesmus lafevrii* var.manguinii M.Lafévre & Bourr.	Scenedesmaceae	Planktonic
28	*Tetradesmus dimorphus* (Turpin) M.J.Wynne	Scenedesmaceae	Planktonic
29	*Tetradesmus incrassatulus* (Bohlin) M.J.Wynne	Scenedesmaceae	Planktonic
30	*Tetradesmus lagerheimii* M.J. Wynne & Guiry	Scenedesmaceae	Planktonic
31	*Tetradesmus obliquus* (Turpin) M.J.Wynne	Scenedesmaceae	Planktonic; Attached
32	*Kirchneriella lunaris* (Kirchn.) K.Möbius	Selenastraceae	Planktonic; Attached
33	*Kirchneriella obesa* (West) West & G.S.West	Selenastraceae	Planktonic; Attached
34	*Monoraphidium convolutum* (Corda) Komárk.-Legn.	Selenastraceae	Planktonic
35	*Monoraphidium contortum* (Thur.) Komárk.-Legn.	Selenastraceae	Planktonic
36	*Monoraphidium grifithii* (Berk.) Komárk.-Legn.	Selenastraceae	Planktonic
37	*Monoraphidium pseudobraunii* J.H.Belcher & Swale) Heynig"	Selenastraceae	Planktonic
38	*Monoraphidium pusillum* (Printz) Komárk.-Legn.	Selenastraceae	Planktonic
39	*Ulothrix* sp.	Ulotrichaceae	Attached
40	*Trentepohlia aurea* (L.) C.Mart.	Trentepohliaceae	Attached
41	*Trentepohlia willei* (Tiffany) Printz	Trentepohliaceae	Attached
42	*Cladophora glomerata* (L.) Kütz.	Cladophoraceae	Attached
43	*Oedogonium varians* Wittr. & P.Lundell ex Hirn	Oedogoniaceae	Attached
44	*Closterium costatum* Corda ex Ralfs	Closteriaceae	Planktonic
45	*Closterium littorale* F.Gay	Closteriaceae	Planktonic; Attached
46	*Spirogyra* sp.	Zygnemataceae	Attached
Xanthophyceae			
1	*Characium angustum* A.Braun	Characiaceae	Attached
Euglenophyceae			
1	*Cryptoglena skujae* Marin & Melkonian	Euglenaceae	Attached
2	*Euglena deses* Ehrenb.	Euglenaceae	Planktonic
3	*Euglena gracilis* G.A.Klebs	Euglenaceae	Planktonic
4	*Euglena granulata* (G.A.Klebs) F.Schmitz	Euglenaceae	Planktonic

5	*Euglena sanguinea* Ehrenb.	Euglenaceae	Planktonic
6	*Euglena tuberculata* Swirenko	Euglenaceae	Planktonic
7	*Euglena viridis* (O.F.Müll.) Ehrenb.	Euglenaceae	Planktonic
8	*Euglenaria anabaena* (Mainx) Karnkowska & E.W.Linton	Euglenaceae	Planktonic
9	*Euglenaria clavata* (Skuja) Karnkowska & E.W.Linton	Euglenaceae	Planktonic
10	*Euglenaformis proxima* (P.A.Dang.) M.S.Benn. & Triemer	Euglenaceae	Planktonic
11	*Monomorphina pyrum* (Ehrenb.) Mereschk.	Euglenaceae	Attached
12	*Strombomonas triquetra* (Playfair) Deflandre	Euglenaceae	Planktonic; Attached
13	*Trachelomonas abrupt var.* minor Deflandre	Euglenaceae	Planktonic
14	*Trachelomonas intermedia* P.A.Dang.	Euglenaceae	Planktonic
15	*Trachelomonas volzii* var. intermedia Playfair	Euglenaceae	Planktonic
16	*Peranemopsis trichophora* (Ehrenb.) L.S.Péter□	Peranemidae	Planktonic
17	*Lepocinclis acus* (O.F.Müll.) Marin & Melkonian	Phacaceae	Planktonic
18	*Lepocinclis fusca* (Klebs) Kosmala & Zakry	Phacaceae	Planktonic
19	*Lepocinclis fusiformis* (H.J.Carter) Lemmerm.	Phacaceae	Planktonic
20	*Lepocinclis ovum* (Ehrenb.) Lemmerm.	Phacaceae	Planktonic
21	*Lepocinclis salina* F.E.Fritsch	Phacaceae	Planktonic
22	*Phacus acuminatus* A.Stokes	Phacaceae	Planktonic
23	*Phacus caudatus* K.Hübner	Phacaceae K.Hübner	Planktonic
24	*Phacus curvicauda* Svirenko	Phacaceae	Planktonic
25	*Phacus glaber* Pochm.	Phacaceae	Planktonic
26	*Phacus hamatus* Pochm.	Phacaceae	Planktonic
27	*Phacus helikoides* (Ehrenb.) Dujard.	Phacaceae	Planktonic
29	*Phacus tortus* (Lemmerm.) Skvortzov	Phacaceae	Planktonic
30	*Phacus triqueter* Perty (Ehrenb.)	Phacaceae	Planktonic
Bacillariophyceae			
1	*Aulacoseira sp.*	Aulacosieraceae	Planktonic
2	*Cyclotella meneghiniana* Kütz.	Stephanodiscaceae	Planktonic
3	*Diadesmis confervacea* Kütz.	Diadesmidiaceae	Planktonic; Attached
4	*Achnanthidium minutissimum* (Kütz.) Czarnecki	Achnanthidiaceae	Attached
5	*Anomoeoneis sphaerophora* Pfitzer	Anomoeoneidaceae	Attached
6	*Cymbella lanceolata* (C.Agardh) C.Agardh	Cymbellaceae	Planktonic
8	*Gyrosigma acuminatum* (Kutz.) Rabenh.	Naviculaceae	Attached

9	*Navicula cryptocephala* Kütz.	Naviculaceae	Attached
10	*Navicula peregrina* (Ehrenb.) Kütz.	Naviculaceae	Attached
11	*Navicula phyllepta* Kütz.	Naviculaceae	Attached
12	*Navicula tripunctata* (O.F.Müll.) Bory	Naviculaceae	Planktonic; Attached
13	*Craticula cuspidate* (Kütz.) D.G.Mann	Stauroneidaceae	Attached
14	*Craticula halophila* (Grunow) D.G.Mann	Stauroneidaceae	Attached
15	*Halamphora coffaeformis* (C.Agardh) Mereschk.	Amphipleuraceae	Planktonic
16	*Nitzschia acicularis* (Kütz.) W.Sm.	Bacillariaceae	Planktonic
17	*Nitzschia frustulum* (Kütz.) Grunow	Bacillariaceae	Attached
18	*Nitzschia fruticose* Hust.	Bacillariaceae	Attached
19	*Nitzschia palea* (Kütz.) W.Sm.	Bacillariaceae	Attached

32. List of Bryophytes

Species	Family
Marchantiophyta (Liverworts)	
1. *Cyathodium cavernarum* Kunze ex Lehm.	Cyathodiaceae
2. *Lejeunea alata* Gottsche	Lejeuneaceae
3. *Lejeunea devendrae* (Sushil K. Singh) P.K.Verma & K.K.Rawat	Lejeuneaceae
4. *Lopholejeunea sikkimensis* Steph.	Lejeuneaceae
5. *Riccia billardierei* Mont. & Nees	Ricciaceae
6. *Riccia discolor* Lehm. & Lindenb.	Ricciaceae
7. *Spruceanthus minutilobulus* (Udar & U.S.Awasthi) Sushil K. Singh	Lejeuneaceae
Bryophyta (Mosses)	
8. *Bryum plumosum* Dozy & Molk.	Bryaceae
9. *Entodontopsis tavoyensis* (Hook.) W.R. Buck & Ireland	Stereophyllaceae
10. *Erpodium mangiferae* Müll. Hal.	Erpodiaceae
11. *Fissidens crenulatus* Mitt.	Fissidentaceae
12. *Fissidens sylvaticus* Griff.	Fissidentaceae
13. *Hydrogonium arcuatum* (Griff.) Wijk & Margad.	Pottiaceae
14. *Hydrogonium consanguineum* (Thwaites & Mitt.) Hilp.	Pottiaceae
15. *Hyophila involuta* (Hook.) A. Jaeger	Pottiaceae
16. *Hyophila nymaniana* (M. Fleisch.) M. Menzel	Pottiaceae

33. List of Agro-Flora (Cultivation crops)

S. No.	Local Name	Scientific Name	Family
1.	Bhindi	*Abelmoschus esculentus* (L.) Moench	Malvaceae
2.	Bel	*Aegle marmelos* (L.) Corrêa	Rutaceae
3.	Lalsag	*Amaranthus cruentus* L.	Amaranthaceae
4.	Kanta Note	*Amaranthus spinosus* L.	Amaranthaceae
5.	Dengua	*Amaranthus tricolor* L.	Amaranthaceae
6.	Note	*Amaranthus viridis* L.	Amaranthaceae
7.	Ol	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Araceae
8.	Supari	*Areca catechu* L.	Arecaceae

9.	Kathal	*Artocarpus heterophyllus* Lam.	Moraceae
10.	Bramhi	*Bacopa monnieri* (L.) Wettst.	Scrophulariaceae
11.	Pui	*Basella alba* L.	Basellaceae
12.	Taal	*Borassus fiabellifer* L.	Arecaceae
13.	Phul Kophi	*Brassica oleracea* var. botrytis L.	Brassicaceae
14.	Lanka	*Capsicum annuum* L.	Solanaceae
15.	Pepe	*Carica papaya* L.	Caricaceae
16.	Karamcha	*Carissa carandas* L.	Apocynaceae
17.	Bethu	*Chenopodium album* L.	Chenopodiaceae
18.	Lebu	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae
19.	Pati Lebu	*Citrus limon* (L.) Osbeck	Rutaceae
20.	Batabi Lebu	*Citrus maxima* (Burm.) Merr.	Rutaceae
21.	Kundri	*Coccinia grandis* (L.) Voigt	Cucurbitaceae
22.	Narkel	*Cocos nucifera* L.	Arecaceae
23.	Kochu	*Colocasia esculenta* (L.) Schott	Araceae
24.	Pat	*Corchorus olitorius* L.	Tliaceae
25.	Kumro	*Cucurbita maxima* Duchesne	Cucurbitaceae
26.	Holud	*Curcuma longa* L.	Zingiberaceae
27.	Aans	*Dimocarpus longan* Lour.	Sapindaceae
28.	Lombu	*Dysoxylum alliaceum* (Blume) Blume	Meliaceae
29.	Surjamukhi	*Helianthus annuus* L.	Asteraceae
30.	Kulekhara	*Hygrophila schulli* M.R. Almeida & S.M. Almeida	Acanthaceae
31.	Kalmi	*Ipomoea aquatica* Forssk.	Convolvulaceae
32.	Sim	*Lablab purpureus* (L.) Sweet	Fabaceae
33.	Lau	*Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae
34.	Katbel	*Limonia accidissima* L.	Rutaceae
35.	Tometo	*Lycopersicon esculentum* Mill.	Solanaceae
36.	Aam	*Mangifera indica* L.	Anacardiaceae
37.	Safeda	*Manilkara zapota* (L.) P. Royen	Sapotaceae
38.	Susni	*Marsilea minuta* L.	Marsileaceae
39.	Uchhe	*Momordica charantia* L.	Cucurbitaceae
40.	Sojne	*Moringa oleifera* Lam.	Moringaceae
41.	Kari Pata	*Murraya koenigii* (L.) Spreng.	Rutaceae
42.	Kola	*Musa paradisiaca* L.	Musaceae
43.	Shaluk	*Nymphaea pubescens* Willd.	Nymphaeaceae
44.	Tulsi	*Ocimum tenuifiorum* L.	Lamiaceae
45.	Dhan	*Oryza sativa* L.	Poaceae
46.	Khejur	*Phoenix sylvestris* (L.) Roxb.	Arecaceae
47.	Hari fal	*Phyllanthus acidus* (L.) Skeels	Euphorbiaceae
48.	Pyara	*Psidium guajava* L.	Myrtaceae
49.	Bedana	*Punica granatum* L.	Punicaceae
50.	Mulo	*Raphanus sativus* L.	Brassicaceae
51.	Til	*Sesamum indicum* L.	Pedaliaceae
52.	Begun	*Solanum melongena* L.	Solanaceae
53.	Palak	*Spinacia oleracea* L.	Amaranthaceae
54.	Aamra	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae
55.	Jam	*Syzygium cumini* (L.) Skeels	Myrtaceae
56.	Golap jam	*Syzygium samarangense* (Blume) Merr. & L.M. Perry	Myrtaceae
57.	Tetul	*Tamarindus indica* L.	Caesalpiniaceae
58.	Pani fal	*Trapa natans* L.	Trapaceae
59.	Ghatkanchu	*Typhonium fiagelliforme* (Lodd.) Blume	Araceae
60.	Bhutta	*Zea mays* L.	Poaceae

34. List of Floristic Diversity

S. No.	Name	Family	Habit
1	*Ranunculus sceleratus* L.	Ranunculaceae	Herb
2	*Magnolia champaca* (L.) Baill. ex Pierre	Magnoliaceae	Tree
3	*Annona reticulata* L.	Annonaceae	Tree
4	*Polyalthia longifolia* (Sonn.) Thwaites	Annonaceae	Tree
5	*Cissampelos pareira* L.	Menispermaceae	Climber
6	*Tinospora cordifolia* (Willd.) Miers	Menispermaceae	Climber
7	*Stephania japonica* (Thunb.)	Menispermaceae	Climber
8	*Nymphaea nouchali* Burm.f.	Nymphaeaceae	Herb
9	*Nymphaea pubescens* Willd.	Nymphaeaceae	Herb
10	*Nelumbo nucifera* Gaertn.	Nelumbonaceae	Herb
11	*Argemone mexicana* L.	Papaveraceae	Herb
12	*Brassica juncea* (L.) Czern.	Brassicaceae	Herb
13	*Rorippa indica* (L.) Hiern	Brassicaceae	Herb
14	*Capparis zeylanica* L.	Capparaceae	Scandent shrub
15	*Cleome gynandra* L.	Capparaceae	Herb
16	*Cleome rutidosperma* DC.	Capparaceae	Herb
17	*Cleome viscosa* L.	Capparaceae	Herb
18	*Portulaca oleracea* L.	Portulacaceae	Herb
19	*Abelmoschus esculentus* (L.) Moench	Malvaceae	Undershrub
20	*Abutilon indicum* (L.) Sweet	Malvaceae	Undershrub
21	*Hibiscus mutabilis* L.	Malvaceae	Shrub
22	*Hibiscus rosa-sinensis* L.	Malvaceae	Shrub
23	*Hibiscus vitifolius* L.	Malvaceae	Undershrub
24	*Malachra capitata* (L.) L.	Malvaceae	Undershrub
25	*Malvastrum coromandelianum* (L.) Garcke	Malvaceae	Undershrub
26	*Sida acuta* Burm.f.	Malvaceae	Undershrub
27	*Sida cordata* (Burm.f.) Borss. Waalk.	Malvaceae	Undershrub
28	*Sida rhombifolia* L.	Malvaceae	Undershrub
29	*Urena lobata* L.	Malvaceae	Herb
30	*Urena sinuata* L.	Malvaceae	Herb
31	*Ceiba pentandra* (L.) Gaertn.	Bombacaceae	Tree
32	*Abroma augusta* (L.) L.f.	Sterculiaceae	Shrub
33	*Melochia corchorifolia* L.	Sterculiaceae	Undershrub
34	*Corchorus aestuans* L.	Tiliaceae	Undershrub
35	*Oxalis corniculata* L.	Oxalidaceae	Herb
36	*Averrhoa bilimbi* L.	Averrhoaceae	Tree
37	*Aegle marmelos* (L.) Corrêa	Rutaceae	Tree
38	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae	Tree
39	*Citrus limon* (L.) Osbeck	Rutaceae	Tree
40	*Citrus maxima* (Burm.) Merr.	Rutaceae	Tree
41	*Glycosmis pentaphylla* (Retz.) DC.	Rutaceae	Undershrub
42	*Limonia accidissima* L.	Rutaceae	Tree
43	*Murraya koenigii* (L.) Spreng.	Rutaceae	Shrub
44	*Murraya paniculata* (L.) Jack	Rutaceae	Tree
45	*Azadirachta indica* A. Juss.	Meliaceae	Tree
46	*Melia azedarach* L.	Meliaceae	Tree
47	*Swietenia mahogani* L.	Meliaceae	Tree
48	*Ziziphus oenopolia* (L.) Mill.	Rhamnaceae	Shrub
49	*Cayratia trifolia* (L.) Domin	Vitaceae	Climber
50	*Cardiospermum halicacabum* L.	Sapindaceae	Climber
51	*Dimocarpus longan* Lour.	Sapindaceae	Tree

52	*Anacardium occidentale* L.	Anacardiaceae	Tree
53	*Mangifera indica* L.	Anacardiaceae	Tree
54	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae	Tree
55	*Moringa oleifera* Lam.	Moringaceae	Tree
56	*Bauhinia acuminata* L.	Caesalpiniaceae	Tree
57	*Caesalpinia bonduc* (L.) Roxb. (Roxb.) K. Larsen & S.S. Larsen	Caesalpiniaceae	Shrub
58	*Cassia fistula* L.	Caesalpiniaceae	Tree
59	*Cassia javanica* subsp. nodosa	Caesalpiniaceae	Tree
60	*Delonix regia* (Bojer ex Hook.) Raf.	Caesalpiniaceae	Tree
61	*Peltophorum pterocarpum* (DC.) Baker ex K. Heyne	Caesalpiniaceae	Tree
62	*Senna alata* (L.) Roxb.	Caesalpiniaceae	Shrub
63	*Senna obtusifolia* (L.) Irwin & Barneby	Caesalpiniaceae	Undershrub
64	*Senna occidentalis* (L.) Link	Caesalpiniaceae	Undershrub
65	*Senna siamea* (Lam.) H.S. Irwin & Barneby	Caesalpiniaceae	Tree
66	*Senna tora* (L.) Roxb.	Caesalpiniaceae	Undershrub
67	*Tamarindus indica* L.	Caesalpiniaceae	Tree
68	*Acacia auriculiformis* A.Cunn. ex Benth.	Mimosaceae	Tree
69	*Acacia nilotica* (L.) Willd. ex Delile ssp. *indica* (Benth.) Brenan	Mimosaceae	Tree
70	*Albizia lebbeck* (L.) Benth.	Mimosaceae	Tree
71	*Albizia saman* (Jacq.) Merr.	Mimosaceae	Tree
72	*Lysiloma latisiliquum* (L.) Benth.	Mimosaceae	Tree
73	*Neptunia oleracea* Lour.	Mimosaceae	Herb
74	*Pithecellobium dulce* (Roxb.) Benth.	Mimosaceae	Tree
75	*Aeschynomene aspera* L.	Fabaceae	Herb
76	*Aeschynomene indica* L.	Fabaceae	Herb
77	*Alysicarpus vaginalis* (L.) DC.	Fabaceae	Herb
78	*Butea monosperma* (Lam.) Taub.	Fabaceae	Tree
79	*Dalbergia latifolia* Roxb.	Fabaceae	Tree
80	*Desmodium gangeticum* (L.) DC.	Fabaceae	Herb
81	*Desmodium triflorum* (L.) DC.	Fabaceae	Herb
82	*Erythrina variegata* L.	Fabaceae	Tree
83	*Sesbania sesban* (L.) Merr.	Fabaceae	Shrub
84	*Smithia sensitiva* Aiton	Fabaceae	Herb
85	*Teramnus labialis* (L.f.) Spreng.	Fabaceae	Climber
86	*Myriophyllum tetrandrum* Roxb.	Haloragaceae	Herb
87	*Combretum indicum* (L.) DeFilipps	Combretaceae	Climber
88	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Combretaceae	Tree
89	*Terminalia catappa* L.	Combretaceae	Tree
90	*Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson	Myrtaceae	Tree
91	*Callistemon lanceolatus* (Sm.) Sweet	Myrtaceae	Tree
92	*Psidium guajava* L.	Myrtaceae	Tree
93	*Syzygium cumini* (L.) Skeels	Myrtaceae	Tree
94	*Syzygium samarangense* (Blume) Merr. & L.M. Perry	Myrtaceae	Tree
95	*Ammannia baccifera* L.	Lythraceae	Herb
96	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	Tree
97	*Lawsonia inermis* L.	Lythraceae	Shrub
98	*Punica granatum* L.	Punicaceae	Shrub
99	*Ludwigia adscendens* (L.) H. Hara	Onagraceae	Herb
100	*Ludwigia hyssopifolia* (G. Don) Exell	Onagraceae	Herb

101	*Ludwigia perennis* L.	Onagraceae	Herb
102	*Trapa natans* L.	Trapaceae	Herb
103	*Passifiora foetida* L.	PassiLoraceae	Climber
104	*Passifiora suberosa* L.	PassiLoraceae	Climber
105	*Carica papaya* L.	Caricaceae	Tree
106	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Climber
107	*Cucurbita coccinea* G.Don	Cucurbitaceae	Climber
108	*Momordica charantia* L.	Cucurbitaceae	Climber
109	*Glinus lotoides* L.	Aizoaceae	Herb
110	*Glinus oppositifolius* (L.) Aug. DC.	Aizoaceae	Herb
111	*Trianthema portulacastrum* L.	Aizoaceae	Herb
112	*Centella asiatica* (L.) Urb.	Apiaceae	Herb
113	*Foeniculum vulgare* Mill.	Apiaceae	Herb
114	*Oenanthe javanica* (Blume) DC.	Apiaceae	Herb
115	*Alangium salvifolium* (L.f.) Wangerin	Alangiaceae	Tree
116	*Dentella repens* (L.) J.R. Forst. & G. Forst.	Rubiaceae	Herb
117	*Ixora chinensis* Lam.	Rubiaceae	Shrub
118	*Morinda angustifolia* Roxb.	Rubiaceae	Shrub
119	*Mussaenda philippica* A. Rich.	Rubiaceae	Shrub
120	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae	Tree
121	*Oldenlandia bifiora* L.	Rubiaceae	Herb
122	*Oldenlandia corymbosa* L.	Rubiaceae	Herb
123	*Paederia foetida* L.	Rubiaceae	Climber
124	*Ageratum conyzoides* (L.) L.	Asteraceae	Herb
125	*Blumea lacera* (Burm.f.) DC.	Asteraceae	Herb
126	*Caesulia axillaris* Roxb.	Asteraceae	Herb
127	*Cyanthillium cinereum* (L.) H. Rob.	Asteraceae	Herb
128	*Eclipta prostrata* (L.) L.	Asteraceae	Herb
129	*Eleutheranthera ruderalis* (Sw.) Sch. Bip.	Asteraceae	Herb
130	*Enydra fiuctuans* DC.	Asteraceae	Herb
131	*Grangea maderaspatana* (L.) Poir.	Asteraceae	Herb
132	*Helianthus annuus* L.	Asteraceae	Undershrub
133	*Laphangium luteoalbum* (L.) Tzvelev	Asteraceae	Herb
134	*Mikania micrantha* Kunth	Asteraceae	Climber
135	*Parthenium hysterophorus* L.	Asteraceae	Herb
136	*Pluchea indica* (L.) Less.	Asteraceae	Herb
137	*Pseudelephantopus spicatus* (B. Juss. ex Aubl.) Rohr ex C.F. Baker	Asteraceae	Herb
138	*Sonchus arvensis* L.	Asteraceae	Herb
139	*Tridax procumbens* (L.) L.	Asteraceae	Herb
140	*Xanthium strumarium* L.	Asteraceae	Undershrub
141	*Synedrella nodifiora* (L.) Gaertn.	Asteraceae	Herb
142	*Sphagneticola calendulacea* (L.) Pruski	Asteraceae	Herb
143	*Sphenoclea zeylanica* Gaertn.	Sphenocleaceae	Herb
144	*Manilkara zapota* (L.) P. Royen	Sapotaceae	Tree
145	*Nyctanthes arbor-tristis* L.	Oleaceae	Tree
146	*Allamanda cathartica* L.	Apocynaceae	Climber
147	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Tree
148	*Cascabela thevetia* (L.) Lippold	Apocynaceae	Tree
149	*Carissa carandas* L.	Apocynaceae	Tree
150	*Catharanthus roseus* (L.) G. Don	Apocynaceae	Herb
151	*Kopsia fruticosa* (Roxb.) A. DC.	Apocynaceae	Tree
152	*Nerium oleander* L.	Apocynaceae	Shrub
153	*Rauvolfia tetraphylla* L.	Apocynaceae	Undershrub

154	*Tabernaemontana divaricata* (L.) R. Br. ex Roem. & Schult.	Apocynaceae	Shrub
155	*Calotropis gigantea* (L.) R. Br.	Asclepiadaceae	Shrub
156	*Pergularia daemia* (Forssk.) Chiov.	Asclepiadaceae	Climber
157	*Dregea volubilis* (L.f.) Benth. ex Hook.f.	Asclepiadaceae	Climber
158	*Nymphoides cristata* (Roxb.) Kuntze	Menyanthaceae	Herb
159	*Nymphoides indica* (L.) Kuntze	Menyanthaceae	Herb
160	*Heliotropium curassavicum* L.	Boraginaceae	Herb
161	*Heliotropium indicum* L.	Boraginaceae	Herb
162	*Heliotropium ovalifolium* Forssk.	Boraginaceae	Herb
163	*Cuscuta campestris* Yunck.	Convolvulaceae	Climber
164	*Evolvulus alsinoides* (L.) L.	Convolvulaceae	Herb
165	*Evolvulus nummularius* (L.) L.	Convolvulaceae	Herb
166	*Hewittia malabarica* (L.) Suresh	Convolvulaceae	Climber
167	*Ipomoea aquatica* Forssk.	Convolvulaceae	Herb
168	*Ipomoea carnea* Jacq. subsp. *fistulosa* (Mart. ex Choisy) D.F. Austin	Convolvulaceae	Undershrub
169	*Ipomoea obscura* (L.) Ker Gawl.	Convolvulaceae	Climber
170	*Ipomoea marginata* (Desr.) Verdc.	Convolvulaceae	Climber
171	*Ipomoea triloba* L.	Convolvulaceae	Climber
172	*Operculina turpethum* (L.) Silva Manso	Convolvulaceae	Climber
173	*Capsicum annuum* L.	Solanaceae	Herb
174	*Cestrum diurnum* L.	Solanaceae	Shrub
175	*Datura metel* L.	Solanaceae	Herb
176	*Lycopersicon esculentum* Mill.	Solanaceae	Herb
177	*Nicotiana plumbaginifolia* Viv.	Solanaceae	Herb
178	*Physalis minima* L.	Solanaceae	Herb
179	*Solanum americanum* Mill.	Solanaceae	Herb
180	*Solanum indicum* L.	Solanaceae	Herb
181	*Solanum melongena* L.	Solanaceae	Herb
182	*Solanum sisymbriifolium* Lam.	Solanaceae	Herb
183	*Solanum torvum* Sw.	Solanaceae	Herb
184	*Bacopa monnieri* (L.) Wettst.	Scrophulariaceae	Herb
185	*Limnophila heterophylla* (Roxb.) Benth.	Scrophulariaceae	Herb
186	*Lindernia oppositifolia* (Retz.) Mukherjee	Scrophulariaceae	Herb
187	*Mazus pumilus* (Burm.f.) Steenis	Scrophulariaceae	Herb
188	*Mecardonia procumbens* (Mill.) Small	Scrophulariaceae	Herb
189	*Scoparia dulcis* L.	Scrophulariaceae	Herb
190	*Utricularia aurea* Lour.	Lentibulariaceae	Herb
191	*Utricularia stellaris* L.f.	Lentibulariaceae	Herb
192	*Tabebuia aurea* (Silva Manso) Benth. & Hook.f. ex S. Moore	Bignoniaceae	Tree
193	*Spathodea campanulata* P. Beauv.	Bignoniaceae	Tree
194	*Sesamum indicum* L.	Pedaliaceae	Herb
195	*Acanthus ilicifolius* L.	Acanthaceae	Undershrub
196	*Andrographis paniculate* (Burm. f.) Wall. ex Nees	Acanthaceae	Herb
197	*Asystasia gangetica* (L.) T. Anderson	Acanthaceae	Herb
198	*Barleria prionitis* L.	Acanthaceae	Undershrub
199	*Hemigraphis hirta* (Vahl) T.Anderson	Acanthaceae	Herb
200	*Hygrophila schulli* M.R.Almeida & S.M. Almeida	Acanthaceae	Herb
201	*Hygrophila trifiora* (Roxb. ex Nees) Fosberg & Sachet	Acanthaceae	Herb
202	*Justicia adhatoda* L.	Acanthaceae	Undershrub

203	*Justicia gendarussa* Burm.f.	Acanthaceae	Undershrub
204	*Justicia simplex* D. Don	Acanthaceae	Herb
205	*Ruellia prostrata* Poir.	Acanthaceae	Herb
206	*Ruellia tuberosa* L.	Acanthaceae	Herb
207	*Clerodendrum indicum* (L.) Kuntze	Verbenaceae	Undershrub
208	*Clerodendrum infortunatum* L.	Verbenaceae	Undershrub
209	*Duranta erecta* L.	Verbenaceae	Shrub
210	*Gmelina arborea* Roxb.	Verbenaceae	Tree
211	*Lantana camara* L.	Verbenaceae	Shrub
212	*Lippia alba* (Mill.) N.E. Br. ex Britton & P. Wilson	Verbenaceae	Undershrub
213	*Phyla nodiflora* (L.) Greene	Verbenaceae	Herb
214	*Tectona grandis* L.f.	Verbenaceae	Tree
215	*Vitex negundo* L.	Verbenaceae	Shrub
216	*Volkameria inermis* L.	Verbenaceae	Shrub
217	*Anisomeles indica* (L.) Kuntze	Lamiaceae	Undershrub
218	*Leonurus sibiricus* L.	Lamiaceae	Undershrub
219	*Leucas aspera* (Willd.) Link	Lamiaceae	Herb
220	*Hyptis suaveolens* (L.) Poit	Lamiaceae	Herb
221	*Ocimum tenuiflorum* L.	Lamiaceae	Herb
222	*Boerhavia diffusa* L.	Lamiaceae	Herb
223	*Boerhavia repens* L.	Lamiaceae	Herb
224	*Mirabilis jalapa* L.	Lamiaceae	Herb
225	*Achyranthes aspera* L.	Amaranthaceae	Herb
226	*Aerva lanata* (L.) Juss.	Amaranthaceae	Herb
227	*Alternanthera ficoidea* (L.) Sm.	Amaranthaceae	Herb
228	*Alternanthera paronychioides* A.St.-Hil.	Amaranthaceae	Herb
229	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	Herb
230	*Alternanthera sessilis* (L.) R.Br. ex DC.	Amaranthaceae	Herb
231	*Amaranthus cruentus* L.	Amaranthaceae	Herb
232	*Amaranthus hybridus* L.	Amaranthaceae	Herb
233	*Amaranthus spinosus* L.	Amaranthaceae	Herb
234	*Amaranthus tricolor* L.	Amaranthaceae	Herb
235	*Amaranthus viridis* L.	Amaranthaceae	Herb
236	*Celosia argentea* L.	Amaranthaceae	Herb
237	*Gomphrena globosa* L.	Amaranthaceae	Herb
238	*Chenopodium album* L.	Chenopodiaceae	Herb
239	*Suaeda maritima* (L.) Dumort.	Chenopodiaceae	Herb
240	*Basella alba* L.	Basellaceae	Climber
241	*Persicaria barbata* (L.) H. Hara	Polygonaceae	Herb
242	*Persicaria glabra* (Willd.) M. Gómez	Polygonaceae	Herb
243	*Persicaria hydropiper* (L.) Delarbre	Polygonaceae	Herb
244	*Persicaria orientalis* (L.) Spach	Polygonaceae	Herb
245	*Polygonum plebeium* R. Br.	Polygonaceae	Herb
246	*Rumex dentatus* L.	Polygonaceae	Herb
247	*Peperomia pellucida* (L.) Kunth	Piperaceae	Herb
248	*Litsea glutinosa* (Lour.) C.B. Rob.	Lauraceae	Tree
249	*Acalypha indica* L.	Euphorbiaceae	Herb
250	*Chrozophora rottleri* (Geiseler)	Euphorbiaceae	Undershrub
251	*Codiaeum variegatum* (L.) Rumph. ex A. Juss.	Euphorbiaceae	Shrub
252	*Croton bonplandianus* Baill.	Euphorbiaceae	Undershrub
253	*Euphorbia antiquorum* L.	Euphorbiaceae	Shrub
254	*Euphorbia heterophylla* L.	Euphorbiaceae	Undershrub
255	*Euphorbia hirta* L.	Euphorbiaceae	Herb
256	*Euphorbia indica* Lam.	Euphorbiaceae	Herb

257	*Euphorbia nivulia* Buch. -Ham.	Euphorbiaceae	Shrub
258	*Euphorbia prostrata* Aiton	Euphorbiaceae	Herb
259	*Euphorbia thymifolia* L.	Euphorbiaceae	Herb
260	*Euphorbia tithymaloides* L.	Euphorbiaceae	Undershrub
261	*Excoecaria agallocha* L.	Euphorbiaceae	Tree
262	*Flueggea virosa* (Roxb. ex Willd.) Voigt	Euphorbiaceae	Shrub
263	*Jatropha curcas* L.	Euphorbiaceae	Shrub
264	*Jatropha gossypiifolia* L.	Euphorbiaceae	Shrub
265	*Trewia nudiflora* L.	Euphorbiaceae	Tree
266	*Putranjiva roxburghii* Wall.	Euphorbiaceae	Tree
267	*Phyllanthus acidus* (L.) Skeels	Euphorbiaceae	Tree
268	*Phyllanthus amarus* Schumach. & Thonn.	Euphorbiaceae	Herb
269	*Phyllanthus emblica* L.	Euphorbiaceae	Tree
270	*Phyllanthus reticulatus* Poir.	Euphorbiaceae	Shrub
271	*Phyllanthus urinaria* L.	Euphorbiaceae	Herb
272	*Ricinus communis* L.	Euphorbiaceae	Shrub
273	*Pilea microphylla* (L.) Liebm.	Urticaceae	Herb
274	*Pouzolzia zeylanica* (L.) Benn.	Urticaceae	Herb
275	*Cannabis sativa* L.	Cannabaceae	Shrub
276	*Trema orientalis* (L.) Blume	Cannabaceae	Tree
277	*Artocarpus heterophyllus* Lam.	Moraceae	Tree
278	*Ficus benghalensis* L.	Moraceae	Tree
279	*Ficus hispida* L.f.	Moraceae	Tree
280	*Ficus racemosa* L.	Moraceae	Tree
281	*Ficus religiosa* L.	Moraceae	Tree
282	*Streblus asper* Lour.	Moraceae	Shrub
283	*Casuarina equisetifolia* L.	Casuarinaceae	Tree
284	*Ceratophyllum demersum* L.	Ceratophyllaceae	Herb
285	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitaceae	Herb
286	*Nechamandra alternifolia* (Roxb. ex Wight) Thwaites	Hydrocharitaceae	Herb
287	*Ottelia alismoides* (L.) Pers.	Hydrocharitaceae	Herb
288	*Vallisneria spiralis* L.	Hydrocharitaceae	Herb
289	*Vanda tessellata* (Roxb.) Hook. ex G. Don	Orchidaceae	Herb
290	*Curcuma longa* L.	Zingiberaceae	Herb
291	*Musa paradisiaca* L.	Musaceae	Herb
292	*Canna indica* L.	Cannaceae	Herb
293	*Dioscorea bulbifera* L.	Dioscoreaceae	Climber
294	*Eichhornia crassipes* (Mart.) Solms	Pontederiaceae	Herb
295	*Monochoria hastata* (L.) Solms	Pontederiaceae	Herb
296	*Monochoria vaginalis* (Burm.f.) C. Presl	Pontederiaceae	Herb
297	*Commelina benghalensis* L.	Commelinaceae	Herb
298	*Commelina diffusa* Burm.f.	Commelinaceae	Herb
299	*Commelina longifolia* Lam.	Commelinaceae	Herb
300	*Commelina paludosa* Blume	Commelinaceae	Herb
301	*Murdannia vaginata* (L.) G.Brückn.	Commelinaceae	Herb
302	*Cyanotis axillaris* (L.) D. Don ex Sweet	Commelinaceae	Herb
303	*Areca catechu* L.	Arecaceae	Tree
304	*Borassus flabellifer* L.	Arecaceae	Tree
305	*Cocos nucifera* L.	Arecaceae	Tree
306	*Dypsis lutescens* (H. Wendl.) Beentje & J. Dransf.	Arecaceae	Shrub
307	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	Tree
308	*Typha angustifolia* L.	Typhaceae	Herb
309	*Typha domingensis* Pers.	Typhaceae	Herb

310	*Alocasia macrorrhizos* (L.) G. Don	Araceae	Herb
311	*Colocasia esculenta* (L.) Schott	Araceae	Herb
312	*Cryptocoryne spiralis* (Retz.) Fisch. ex Wydler	Araceae	Herb
313	*Pistia stratiotes* L.	Araceae	Herb
314	*Typhonium fiagelliforme* (Lodd.) Blume	Araceae	Herb
315	*Lemna minor* L.	Lemnaceae	Herb
316	*Lemna perpusilla* Torrey	Lemnaceae	Herb
317	*Spirodela polyrrhiza* (L.) Schleid.	Lemnaceae	Herb
318	*Wolffia globosa* (Roxb.) Hartog & Plas	Lemnaceae	Herb
319	*Sagittaria guayanensis* Kunth	Alismataceae	Herb
320	*Sagittaria montevidensis* Cham. & Schltdl.	Alismataceae	Herb
321	*Sagittaria sagittifolia* L.	Alismataceae	Herb
322	*Najas graminea* Delile	Najadaceae	Herb
323	*Aponogeton natans* (L.) Engl. & K. Krause	Aponogetonaceae	Herb
324	*Potamogeton crispus* L.	Potamogetonaceae	Herb
325	*Bolboschoenus maritimus* subsp. af□nis (Roth.) T. Koyama	Cyperceae	Herb
326	*Bulbostylis densa* (Wall.) Hand. -Mazz.	Cyperceae	Herb
327	*Cyperus alopecuroides* Rottb.	Cyperceae	Herb
328	*Cyperus articulatus* L.	Cyperceae	Herb
329	*Cyperus compressus* L.	Cyperceae	Herb
330	*Cyperus corymbosus* Rottb.	Cyperceae	Herb
331	*Cyperus difformis* L.	Cyperceae	Herb
332	*Cyperus distans* L.f.	Cyperceae	Herb
333	*Cyperus kyllingia* Endl.	Cyperceae	Herb
334	*Cyperus nutans* Vahl	Cyperceae	Herb
335	*Cyperus pangorei* Rottb.	Cyperceae	Herb
336	*Cyperus pilosus* Vahl	Cyperceae	Herb
337	*Cyperus polystachyos* Rottb.	Cyperceae	Herb
338	*Cyperus pumilus* L.	Cyperceae	Herb
339	*Cyperus rotundus* L.	Cyperceae	Herb
340	*Eleocharis spiralis* (Rottb.) Roem. & Schult.	Cyperceae	Herb
341	*Fimbristylis eragrostis* (Nees) Hance	Cyperceae	Herb
342	*Fimbristylis polytrichoides* (Retz.) Vahl	Cyperceae	Herb
343	*Fimbristylis schoenoides* (Retz.) Vahl	Cyperceae	Herb
344	*Kyllinga brevifolia* Rottb.	Cyperceae	Herb
345	*Mariscus aristatus* (Rottb.) T. Tang & F.T. Wang	Cyperceae	Herb
346	*Pycreus polystachyos* (Rottb.) P. Beauv.	Cyperceae	Herb
347	*Schoenoplectiella articulata* (L.) Lye	Cyperceae	Herb
348	*Brachiaria reptans* (L.) C.A. Gardner & C.E. Hubb.	Poaceae	Herb
349	*Chloris barbata* Sw.	Poaceae	Herb
350	*Chrysopogon aciculatus* (Retz.) Trin.	Poaceae	Herb
351	*Coix aquatica* Roxb.	Poaceae	Herb
352	*Cynodon dactylon* (L.) Pers.	Poaceae	Herb
353	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	Herb
354	*Echinochloa colona* (L.) Link	Poaceae	Herb
355	*Echinochloa crus-galli* (L.) P.Beauv.	Poaceae	Herb
356	*Eleusine indica* (L.) Gaertn.	Poaceae	Herb
357	*Eragrostis amabilis* (L.) Wight & Arn.	Poaceae	Herb
358	*Hygroryza aristata* (Retz.) Nees ex Wight & Arn.	Poaceae	Herb
359	*Imperata cylindrica* (L.) Raeusch.	Poaceae	Herb
360	*Isachne globosa* (Thunb.) Kuntze	Poaceae	Herb

361	*Leersia hexandra* Sw.	Poaceae	Herb
362	*Leptochloa chinensis* (L.) Nees	Poaceae	Herb
363	*Panicum paludosum* Roxb.	Poaceae	Herb
364	*Paspalidium fiavidum* (Retz.) A. Camus	Poaceae	Herb
365	*Paspalidium punctatum* (Burm.) A. Camus	Poaceae	Herb
366	*Paspalum conjugatum* P.J. Bergius	Poaceae	Herb
367	*Paspalum scrobiculatum* L.	Poaceae	Herb
368	*Phragmites karka* (Retz.) Trin. ex Steud.	Poaceae	Herb
369	*Phyllostachys aurea* Rivière & C. Rivière	Poaceae	Herb
370	*Vetiveria zizanioides* (L.) Nash	Poaceae	Herb
371	*Zoysia matrella* (L.) Merr.	Poaceae	Herb
372	*Azolla imbricate* (Roxb. ex Griff.) Nakai	Salviniaceae	Herb
373	*Salvinia molesta* D.S. Mitch.	Salviniaceae	Herb
374	*Salvinia natans* (L.) All.	Salviniaceae	Herb
375	*Marsilea minuta* L.	Marsileaceae	Herb
376	*Ceratopteris thalictroides* (L.) Brongn.	Pteridaceae	Herb
377	*Adiantum* sp.	Pteridaceae	Herb
378	*Pteris vittata* L.	Pteridaceae	Herb
379	*Asplenium nidus* L.	Aspleniaceae	Herb
380	*Drynaria quercifolia* (L.) J. Sm.	Polypodiaceae	Herb
381	*Platycladus orientalis* (L.) Franco	Cupressaceae	Herb

35. List of Invasive Alien Species (Vascular Plants)

S. No.	Plant Name	Family	Common Name	Habit at	Nativity
1	*Ageratum conyzoides* (L.) L.	Asteraceae	Goat weed	Herb	Tropical America
2	*Alternanthera paronychioides* A.St.-Hil.	Amaranthaceae	Smooth joy weed	Herb	Tropical America
3	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	Alligator weed	Herb	Tropical America
4	*Argemone mexicana* L.	Papaveraceae	Prickly poppy	Herb	Tropical Central & South America
5	*Blumea lacera* (Burm.f.) DC.	Asteraceae	Lettuce-leaf Blumea	Herb	Tropical America
6	*Calotropis gigantea* (L.) R. Br.	Asclepiadaceae	Crown flower	Shrub	Tropical Africa
7	*Celosia argentea* L.	Amaranthaceae	Wool flower	Herb	Tropical Africa
8	*Chloris barbata* Sw.	Poaceae	Peacock plume grass	Herb	Tropical America
9	*Chrozophora rottleri* (Geiseler) A. Juss. ex Spreng.	Euphorbiaceae	Suryavarti	Under shrub	Tropical Africa
10	*Cleome gynandra* L.	Capparaceae	Wild Spider flower	Herb	Tropical America

11	*Cleome rutidosperma* DC.	Capparaceae	Fringed spider flower	Herb	Tropical America
12	*Cleome viscosa* L.	Capparaceae	Dog mustard	Herb	Tropical America
13	*Corchorus aestuans* L.	Tiliaceae	East Indian mallow	Under shrub	Tropical America
14	*Croton bonplandianus* Baill.	Euphorbiaceae	Bonpland's Croton	Under shrub	Temperate South America
15	*Cyperus difformis* L.	Cyperaceae	Rice sedge	Herb	Tropical America
16	*Datura metel* L.	Solanaceae	Thorn apple	Herb	Tropical America
17	*Echinochloa colona* (L.) Link	Poaceae	Shama millet	Herb	Tropical South America
18	*Echinochloa crus-galli* (L.) P. Beauv.	Poaceae	Barnyard millet	Herb	Tropical South America
19	*Eclipta prostrata* (L.) L.	Asteraceae	False daisy	Herb	Tropical America
20	*Eichhornia crassipes* (Mart.) Solms*	Pontederiaceae	Water hyacinth	Herb	Tropical America
21	*Euphorbia heterophylla* L.	Euphorbiaceae	Wild Poinsettia	Under shrub	Tropical America
22	*Euphorbia hirta* L.	Euphorbiaceae	Snake weed	Herb	Tropical America
23	*Euphorbia indica* Lam.	Euphorbiaceae	Snake weed	Herb	Tropical South America
24	*Evolvulus nummularius* (L.) L.	Convolvulaceae	Round leaf bind weed	Herb	Tropical America
25	*Grangea maderaspatana* (L.) Poir.	Asteraceae	Madras carpet	Herb	Tropical South America
26	*Hyptis suaveolens* (L.) Poit	Lamiaceae	American mint	Herb	Tropical America
27	*Imperata cylindrica*(L.) Raeusch.*	Poaceae	Cogon grass	Herb	Tropical America
28	*Ipomoea carnea Jacq. subsp. fistulosa* (Mart. ex Choisy)	Convolvulaceae	Bush morning glory	Shrub	Tropical America
29	*Ipomoea obscura* (L.) Ker Gawl.	Convolvulaceae	Obscure morning glory	Climber	Tropical Africa
30	*Lantana camara* L.*	Verbenaceae	Wild sage	Shrub	Tropical America
31	*Ludwigia adscendens* (L.) H. Hara	Onagraceae	Water primrose	Herb	Tropical America
32	*Ludwigia perennis* L.	Onagraceae	Paddy clove	Herb	Tropical Africa
33	*Lysiloma latisiliquum* (L.) Benth. *	Mimosaceae	Horse tamarind	Tree	Tropical America
34	*Malachra capitata* (L.) L.	Malvaceae	Brazil jute	Under shrub	Tropical America
35	*Malvastrum coromandelianum* (L.) Garcke"	Malvaceae	False mallow	Under shrub	Tropical America
36	*Mecardonia procumbens* (Mill.) Small	Scrophulariaceae	Baby jump-up	Herb	Tropical North America
37	*Melochia corchorifolia* L.	Sterculiaceae	Chocolate weed	Under shrub	Tropical America
38	*Mikania micrantha* Kunth*	Asteraceae	Mile-a-minute	Climber	Tropical America

39	*Monochoria vaginalis* (Burm.f.) C. Presl	Pontederiaceae	Oval leaf pond weed	Herb	Tropical America
40	*Nicotiana plumbaginifolia* Viv.	Solanaceae	Tex-mex tobacco	Herb	Tropical America
41	*Oxalis corniculata* L.	Oxalidaceae	Indian sorrel	Herb	Europe
42	*Parthenium hysterophorus* L.	Asteraceae	Congress weed	Herb	Tropical North America
43	*Passifiora foetida* L.	PassiLoraceae	Stinking passion flower	Climber	Tropical South America
44	*Peperomia pellucida* (L.) Kunth	Piperaceae	Rat's ear	Herb	Tropical South America
45	*Pilea microphylla* (L.) Liebm.	Urticaceae	Gun powder plant	Herb	Tropical South America
46	*Pistia stratiotes* L.	Araceae	Water lettuce	Herb	Tropical America
47	*Portulaca oleracea* L.	Portulacaceae	Purslane	Herb	Tropical South America
48	*Ruellia tuberosa* L.	Acanthaceae	Menow weed	Herb	Tropical America
49	*Salvinia molesta* D.S. Mitch. *	Salviniaceae	Kariba weed	Herb	Brazil
50	*Scoparia dulcis* L.	Scrophulariaceae	Sweet broom weed	Herb	Tropical America
51	*Senna alata* (L.) Roxb.	Caesalpiniaceae	Roman candle	Shrub	West Indies
52	*Senna obtusifolia* (L.) Irwin & Barneby	Caesalpiniaceae	Sickle senna	Under shrub	Tropical America
53	*Senna occidentalis* (L.) Link	Caesalpiniaceae	Coffee weed	Under shrub	Tropical South America
54	*Sida acuta* Burm.f.	Malvaceae	Morning mallow	Under shrub	Tropical America
55	*Solanum americanum* Mill.	Solanaceae	Nightshade	Herb	Tropical America
56	*Solanum torvum* Sw.	Solanaceae	Turkey berry	Under shrub	West Indies
57	*Synedrella nodifiora* (L.) Gaertn.	Asteraceae	Node weed	Herb	West Indies
58	*Tridax procumbens* (L.) L.	Asteraceae	Mexican daisy	Herb	Tropical Central America
59	*Typha domingensis Pers.* (T. angustata Bory.)	Typhaceae	Cat tail	Herb	Tropical America
60	*Urena lobata* L.	Malvaceae	Bur mallow	Herb	Tropical Africa
61	*Xanthium strumarium* L.	Asteraceae	Cocklebur	Under shrub	Tropical America

** - Species included in the list of 100 of the world's worst invasive alien species (Lowe et. al., 2000).*

Save Wetlands to Save Life

Department of Environment
Government of West Bengal