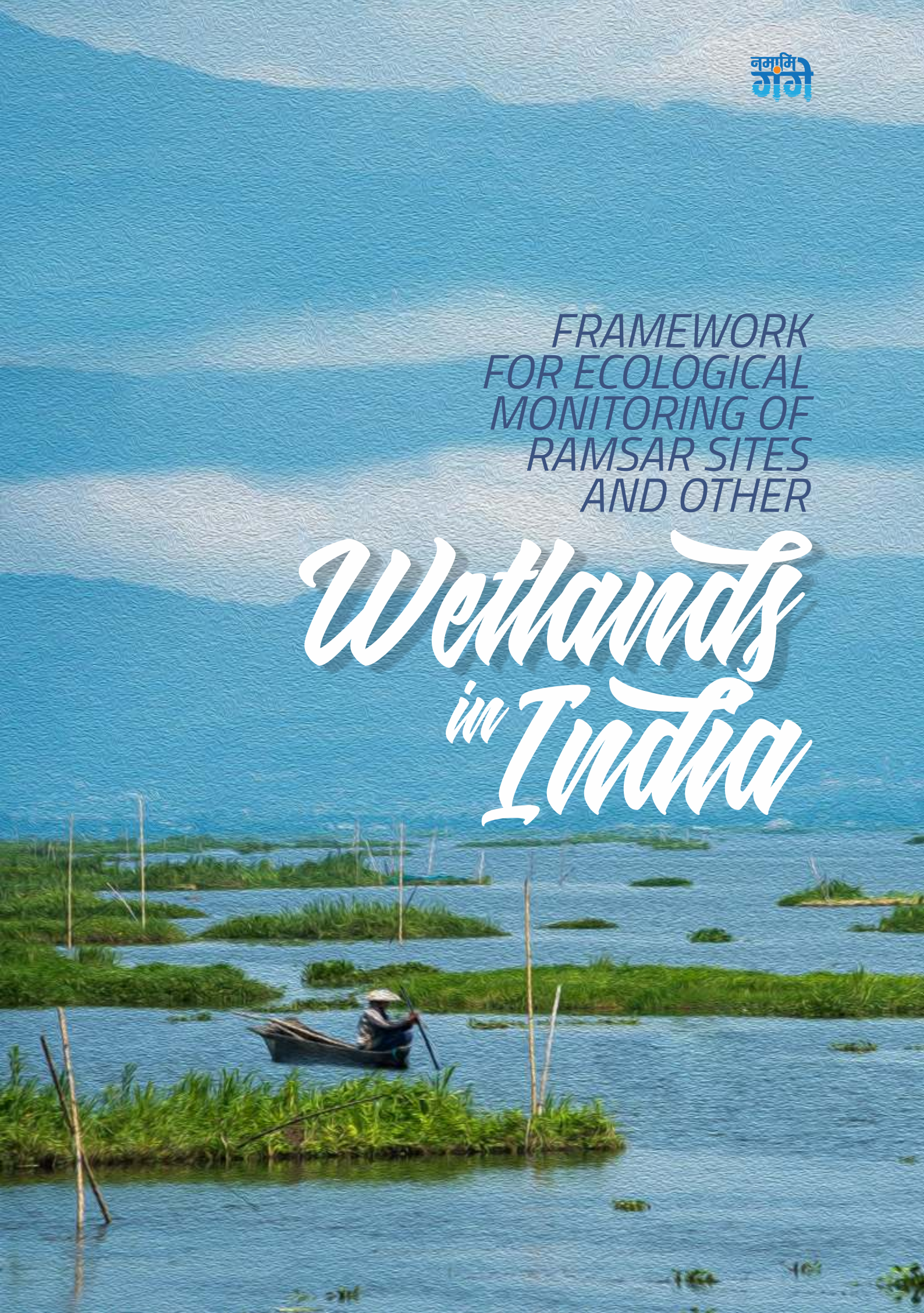
नमामि गंगे

FRAMEWORK FOR ECOLOGICAL MONITORING OF RAMSAR SITES AND OTHER Wetlands in India



FRAMEWORK FOR ECOLOGICAL MONITORING OF RAMSAR SITES AND OTHER Wetlands in India

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Ministry of Environment, Forest and Climate Change
नमामि गंगे
भारतीय वन्यजीव संस्थान
Wildlife Institute of India

FRAMEWORK FOR ECOLOGICAL MONITORING OF RAMSAR SITES AND OTHER Wetlands in India

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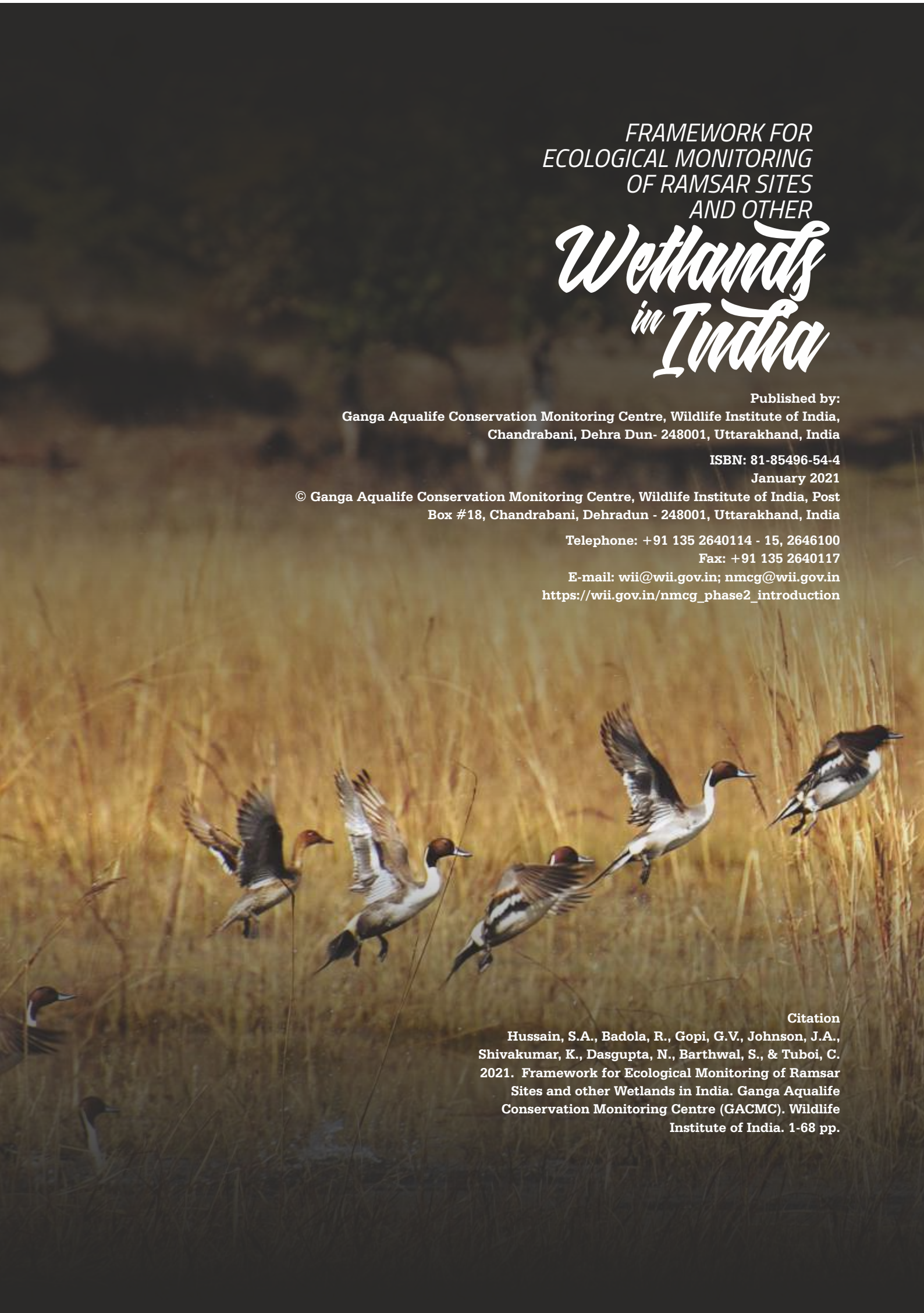

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जल शक्ति मंत्री
भारत सरकार
Minister for Jal Shakti
Government of India

27 JAN 2021

Message

I am pleased to know that the National Mission for Clean Ganga (NMCG) and the Wildlife Institute of India (WII) are bringing out this Publication - 'Framework for Ecological Monitoring of Ramsar sites and other Wetlands in India' under their biodiversity conservation Ganga rejuvenation initiative.

This framework is a reflection of the National Water Policy, India's commitment to the Sustainable Development Goals. This document also aligns with the Ministry of Jal Shakti's water conservation initiative '*Jal Shakti Abhiyan*', which directs participation of stakeholder in water management with scientific inputs from local research and academic institutions. In view of the Government's vision for accelerated implementation of the *Jal Shakti Abhiyan* through five target intervention, and the directives of the National Green Tribunal for preparation of action plans for wetland restoration, this Framework is one stop solution, from condition assessment for prioritization to periodic review of management actions.

This Framework provides guidelines for monitoring of the wetlands, on the basis of the ecological and anthropogenic indicators. The periodic monitoring, as recommended in the document, will aid in informed management decisions, policy support and provide feedback for effective management of the wetlands in the country. I am sure that this document will be of great value to managers, law makers, scientific community and others. I once again congratulate the National Mission for Clean Ganga and Wildlife Institute of India for conceptualizing this document as need of the hour and publishing it.

(Gajendra Singh Shekhawat)

जल शक्ति अभियान

प्रकाश जावड़ेकर
Prakash Javadekar

मंत्री
पर्यावरण, वन एवं जलवायु परिवर्तन,
सूचना एवं प्रसारण और
भारी उद्योग एवं लोक उद्यम
भारत सरकार
MINISTER
ENVIRONMENT, FOREST & CLIMATE CHANGE
INFORMATION & BROADCASTING AND
HEAVY INDUSTRIES & PUBLIC ENTERPRISES
GOVERNMENT OF INDIA

Message

I am happy to note that the Wildlife Institute of India, through its National Mission for Clean Ganga sponsored project 'Biodiversity Conservation and Ganga Rejuvenation' has developed 'Framework for Ecological Monitoring of Ramsar sites and other Wetlands in India'.

Wetlands have always been integral to socio-ecological systems, more so, in country like India, where lives and livelihood of millions are associated with the wetlands, spread across the various biogeographic regions of the country. The wetland wealth of the country is also important in maintaining the biological diversity of the country.

Being a signatory to the Ramsar Convention, India is committed to wise and sustainable use of wetlands. In the past one year we have increased the number of Ramsar sites from 27 to 42. India's initiatives in this direction have been appreciated by the international community. We are in the process of identifying more wetlands of international importance.

The Ministry of Environment, Forest and Climate Change has issued the Wetland (Conservation & Management) Rules in 2017. Further detailed guidelines for implimenting the same have been issued in 2020.

The conservation and monitoring of wetlands are being undertaken in the country by the Ministry of Environment, Forest and Climate Change by adopting scientific & targeted approach. The four-pronged strategy adopted for this purpose includes preparation of health cards for each of the wetlands so as to identify areas of mitigation.

I congratulate the Wildlife Institute of India and NMCG for bringing out the publication.

With best wishes.

29.01.2021

(Prakash Javadekar)

रतन लाल कटारिया
RATTAN LAL KATARIA

सत्यमेव जयते

जल शक्ति
और सामाजिक न्याय एवं अधिकारिता राज्य मंत्री
भारत सरकार
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MINISTER OF STATE FOR
JAL SHAKTI AND SOCIAL JUSTICE & EMPOWERMENT
GOVERNMENT OF INDIA
NEW DELHI - 110001

Message

The wetlands in India are as diverse as are the biogeographic zones. Many of these wetlands serve as the backbone of the local economy and a proper management of these, would be instrumental in tackling water scarcity issues. This Framework published by the National Mission for Clean Ganga (NMCG) and the Wildlife Institute of India (WII) will be a useful document in prioritizing the wetlands for restorative actions and guide the wetland management authorities, including the Gram Panchayats, to prepare action plans for wetland restoration and periodic review of the actions.

The intactness of wetland ecosystem is reflected in its ability to carry out its ecological functions, such as ground water recharge, provisioning of food, fibre, and as habitat for an array of aquatic organisms. This framework captures the essence of the ecological functions through identification of the indicators reflecting the state of the wetland and their subsequent quantification.

I am hopeful that this document will be used widely by the wetland management agencies at local, state and national level. I congratulate the National Mission for Clean Ganga and the Wildlife Institute of India for publishing this Framework.

(Rattan Lal Kataria)

बाबुल सुप्रियो
Babul Supriyo

केन्द्रीय राज्य मंत्री
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
भारत सरकार

Union Minister of State
Ministry of Environment, Forest & Climate Change
Government of India

Message

The multiple functions of the wetlands make them an essential component of the landscapes as well as humanscapes. This is also recognized by the various ministries, which work in coherence for wetland management across the country. This document 'Framework for Ecological Monitoring of Ramsar Sites and other Wetlands in India', is an output of such a coherence, through Wildlife Institute of India's and National Mission for Clean Ganga's biodiversity conservation and Ganga rejuvenation initiative.

The wetlands are key to building resilience and adaptive capacity in wake of the climate change and water scarcity. Taking stock of the wetland resources and evaluation of their condition, is the first step towards wetland management. This document provides guidelines on condition assessment of the wetland resources, through multi-stakeholder participation, including local communities.

I congratulate the team for bringing out this document and wish them good luck for future endeavor.

(Babul Supriyo)

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Message

The wetlands are an important resource when it comes to water cycle and management. This makes wetland as one of the priority areas for intervention to deal with water scarcity. Healthy wetlands are also an indicator of intact ecosystem, which can be determined by simple and scientific methodologies, described in detail in this document "Framework for Ecological Monitoring of Ramsar Sites and other Wetlands in India".

This document would be beneficial for all the stakeholders who are involved in management of wetlands, and particularly the local communities, the primary user of the wetland resources. The framework also concisely outlines the strategies to link the scientific community, managers and the end users. I am hopeful that this document will guide wetland management in the country. I compliment the efforts of the Wildlife Institute of India and National Mission for Clean Ganga's project team for bringing out this publication.

(U.P. Singh)

आर पी गुप्ता
R P Gupta

सचिव
भारत सरकार
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

Message

The wetlands are lifeline of millions of people world-wide and yet are threatened due to dependency and conversion to other land uses. Wetlands have always been integral to India's socio-ecological system, where lives and livelihoods are associated with the wetlands spread across the various biogeographic regions of the country. Taking cognizance of this, the Government has been strengthening the legislation for wetland conservation, and the most recent Wetland (Conservation & Management) Rules, 2017, provides directives for inventorization of the wetlands and their periodic monitoring.

This document "Framework for Ecological Monitoring of the Ramsar Sites and Wetlands of India" complements the rules and guidelines published earlier by the Ministry of Environment, Forest and Climate Change. The framework is unique in a way that it provides the strategies and opportunity for wetland monitoring and feedback for management, through a trained citizen scientist network. I am hopeful that this document will be used widely and will aid in wetland monitoring and informed decision making. The effort of the Wildlife Institute of India and the National Mission for Clean Ganga to bring out this publication and make it widely available is commendable.

New Delhi
February 1, 2021

(R P Gupta)

Foreword

The wetlands are crucial component for water cycle and aquatic diversity maintenance. Globally, reduction in the wetlands' area and the cascading effect on the reduced water availability, diminished well-being and loss of biodiversity have raised concerns and made the governments to formulate the plans to restore and revitalize the wetlands. The 'Jal Shakti Abhiyan' of the Ministry of Jal Shakti aims to restore the wetlands of the country and manage them efficiently through public participation. This document 'Framework for Ecological Monitoring of Ramsar Sites and other Wetlands in India' would be integral to this Abhiyan, where multiple stakeholders will work together to assess the condition of the wetlands, on the basis of the select indicators. The Monitoring techniques suggested herein are in line with the Ramsar guidelines and address the commitment of the Indian Government to the Ramsar Convention. This document is an initiative of the Wildlife Institute of India (WII) and the National Mission for Clean Ganga (NMCG) to put in place a futuristic wetland monitoring framework that is accessible to technocrats and citizens. The primary goal of this document is to provide easy access to wetland monitoring techniques, to be readily useable by a large number of stakeholders for evidence based wetland monitoring and management. The information thus generated would provide scientific baseline regarding the ecological condition of wetlands, identification of specific cause of degradation and, will aid in prioritizing and planning focussed conservation actions and management decisions. The document is designed for a range of users with various levels of knowledge and understanding of wetlands. It is recommended that the users have a basic understanding of wetlands and aquatic ecosystems and the potential impacts of various factors affecting them at the local level, or they work in association with scientific institutions. The techniques proposed in this document are robust, replicable and strengthen the existing wetland monitoring framework that will allow rapid identification of changes in wetlands for timely implementation of conservation and management plans. This theoretical framework may be adopted by the appropriate agencies after due deliberation and consultation with various stakeholders.

Rajiv Ranjan Mishra
Director General
National Mission for Clean Ganga
New Delhi

01 INTRODUCTION

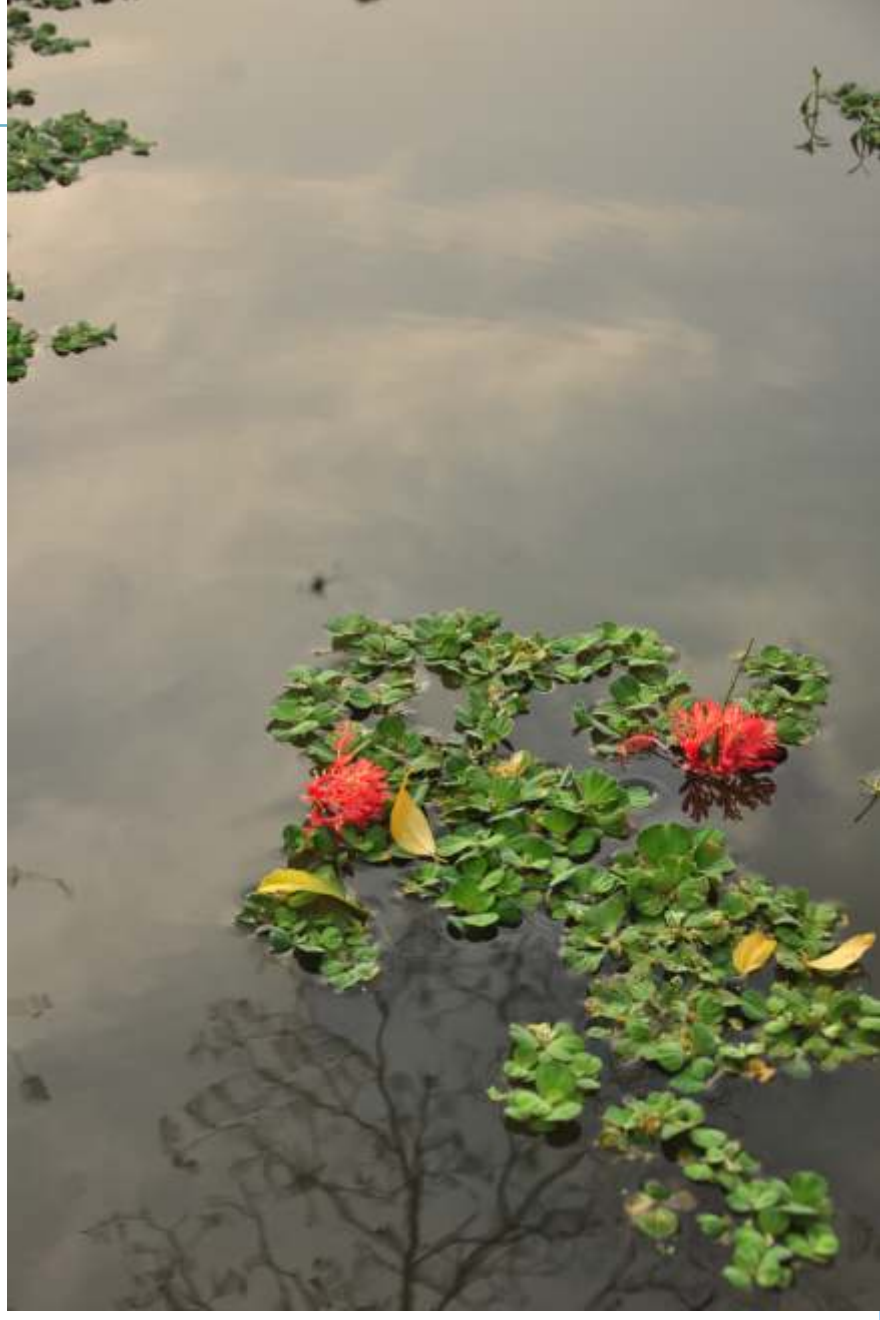
Wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 m', as defined by the Ramsar Convention (1971). By this definition, all water bodies, whether deep or shallow, are considered wetlands. Cowardin et al. (1979), on the other hand, suggested that wetlands are lands that are transitional between terrestrial and aquatic systems in which the water table is usually at or near the surface or in which the land is covered by shallow water. Wetlands as defined thus differ from aquatic ecosystems in terms of the water depth, which is less than 2 m, and they have specific macrophyte communities.

Clause 2 (1) (g) of the Wetlands (Conservation and Management) Rules, 2017, defines wetland as 'an area of marsh, fen, peatland or water; whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters, but does not include river channels, paddy fields, human-made water bodies/tanks specifically constructed for drinking water purposes and structures specifically constructed for aquaculture, salt production, recreation and irrigation purposes'. India has around 7,57,060 wetlands and deep-water aquatic ecosystems with a total extent of 15.26 million ha, roughly equal to 4.6% of its land area. Of this, inland wetlands constitute 69.22% (10.56 million ha). There are 0.556 million wetlands smaller than 2.25 ha in extent (Space Applications Centre, ISRO, 2011). Wetlands vary widely because of regional and local differences in soil, topography, climate, hydrology, water chemistry, vegetation and other factors, including human disturbance. These biodiversity-rich wetland ecosystems support major human settlements by providing goods and services essential for their sustenance.

According to modified National Wetland Classification system wetlands in India are classified into 19 wetland classes which are organized under a Level-III hierarchical system (SAC, 2011) (Table 1). Level-I has two wetland classes such as, inland and coastal. These are further divided into natural and man-made under which 19 wetland classes are placed.

Table 1. Wetland classification and wetland types in India

Wetland classes		
Level I class	Level II class	Level III class
Inland wetlands	Natural	Lake
		Ox-bow lake. Cut-off meander
		High altitude wetland
		Riverine wetland
		Waterlogged
		River/stream
	Man-made	Reservoir/ Barrage
		Tank/ Pond
		Waterlogged
		Salt pan
Coastal wetlands	Natural	Lagoon
		Creek
		Sand/ Beach
		Intertidal mud flat
		Mangrove
		Coral reef
	Man-made	Salt pan
		Aquaculture pond



1.1 ROLE OF WETLANDS

Wetlands and aquatic ecosystems are valuable as sources and sinks and as transformers of a multitude of chemical, biological and genetic materials. Although the value of wetlands as fish and wildlife habitats has been known for millions of years, some of their other benefits have been identified more recently. Wetlands are particularly referred to as 'biological supermarkets' for their extensive food chains and for the rich biodiversity they support. They play major roles in the landscape by providing unique habitats for a wide variety of plants and animals.

Wetlands are described as 'the kidneys of the landscape' because of the functions they perform in hydrologic and chemical cycles and also because they function as sinks of nutrients, silt and pollutants from both natural and human sources. One of the most important functions performed by wetlands is provisioning of water to human society through both groundwater and surface water, whereby water security is ensured. Water security is one of the critical challenges of the century, and is reflected in Sustainable Development Goal 6, through which the availability and sustainable management of water for all by 2030 is envisaged. Presently designated as a water-stressed nation, India is facing the challenge of serving 17% of the world's population with 4% of the world's freshwater resources. Excessive extraction of groundwater and inefficient and a wasteful water management system coupled with years of deficient rains have led to the present water scarcity, with major cities on the verge of zero groundwater levels.

Wetlands are being lost at a faster rate compared with terrestrial ecosystems. Clearance and drainage for agricultural use has been the principal cause of inland wetland loss worldwide. Further, the expanding human use of freshwater has led to less water being available to maintain the ecological character of many inland water systems, leading to the loss and degradation of these systems. Primarily, wetland loss is in the form of a reduction in wetland area or a loss of wetland functions. This loss may be grouped into five main categories viz., loss of riparian buffer, reduction in waterspread area, changes to water regime in terms of quality and quantity, overexploitation of wetland products and introduction of invasive species.

The primary factors causing wetland degradation are water diversion, eutrophication due to wastewater inflow from point and non-point sources, solid waste such as plastics, pesticide and heavy metal pollution from industrial effluents and agricultural runoffs, sedimentation due to the loss of a riparian buffer, low dissolved oxygen and pH levels, salinity, barriers to freshwater inflow and absence of flushing mechanisms, and invasion by exotic species. Wetland loss and degradation is also attributed to a lack of awareness among people about the values of conserved wetlands (information failure), failure of markets to reflect the full or true cost of goods or services provided by conserved wetlands (market failure) and absence of appropriate integrated resource management policies and inter-sectoral policy inconsistencies (intervention failure).

02 STATE OF WETLANDS IN INDIA

According to the Directory of Asian Wetlands (1989), wetlands occupy 58.2 million hectares, 18.4% of the country's area (excluding rivers), of which 40.90 million hectares (70%) were under paddy cultivation. A preliminary inventory by the Department of Science and Technology, recorded a total of 1,193 wetlands, covering an area of about 3,904,543 ha, of which 572 were natural (Scott & Pole, 1989). Later, the Ministry of Environment and Forest and Climate Change (MoEF&CC) estimated wetland area in the country excluding paddy fields, rivers and streams and estimated that wetlands occupy 4.1 million hectares, of which 1.5 million hectares were natural and 2.6 million hectares were manmade (MoEF&CC, 1990). The mangroves occupied 0.45 million hectares. About 80% of the mangroves were distributed in the Sundarbans of West Bengal and Andaman and Nicobar Islands, with the rest in the coastal states of Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Goa, Maharashtra and Gujarat.

The first scientific mapping of wetlands of the country was carried out by Space Applications Centre (SAC), Indian Space Research Organization (ISRO), Ahmedabad, during 1992-93 under the directives of the MoEF&CC, Government of India using remote sensing data from Indian Remote Sensing satellite (IRS-series). The mapping was done at 1:250,000 scale using IRS 1A LISS-I/II data of 1992-93 timeframe under the Nation-wide Wetland Mapping Project and the classification system based on Ramsar Convention definition of wetlands. The classification considers all parts of a water mass including its ecotone area as wetland. In addition, fish and shrimp ponds, saltpans, reservoirs, gravel pits were also included as wetlands. This inventory put the wetland extent (inland as well as coastal) at about 8.26 million ha. (Garg et al, 1998). These estimates (24 categories) do not include rice/paddy fields, rivers, canals and irrigation channels. Further updating of wetland maps of India was carried out by SAC using IRS P6/Resources at AWiFS data of 2004-05 at 1:250000 scale. In recent years, a conservation atlas has been brought out by Salim Ali Centre for Ornithology and Natural History (SACON, 2004), which provide basic information required by stakeholders in both wetland habitat and species conservation.

With better understanding of definition of wetlands and a modified National Wetland Classification system with 19 wetland classes, SAC formulated a National Wetland Inventory and Assessment (NWIA) project. The inventory of wetlands was conducted on 1:50000 scale using two-date (pre- and post-monsoon) IRS LISS III digital data under a Level-III hierarchical system. The entire country including the islands territories has been considered for inventory and assessment of wetlands. Total 2,01,503 wetlands (> 2.25 ha) have been mapped and 5,55,557 wetlands of < 2.25 ha have also been identified. Total wetland area estimated is 15.26 Mha, which is around 4.63% of the geographic area of the country. Wetlands were categorised in to two major categories, 4 sub-categories and 19 classes (Table 1). Area under inland wetlands is 10.56 Mha and area under coastal wetlands is 4.14 Mha (SAC, 2011).

03 WETLAND CONSERVATION IN INDIA

The National Environment Policy (2006) identifies wetlands as important components of 'freshwater resources' and recommends integration in developmental planning, management based on 'wise use' strategies, promotion of ecotourism and implementation of a regulatory framework. The Directory of Indian Wetlands (WWF and Asian Wetland Bureau, 1995) records 147 sites as important, of which 68 are protected under the National Protected Area Network by the Indian Wild Life (Protection) Act, 1972. A major initiative of UNDP to identify conservation strategies for inland wetlands resulted in the identification of 200 wetlands as potential Ramsar sites by Sàlim Ali Centre for Ornithology and Natural History (SACON) (Vijayan et al., 2004). Subsequently, the Bombay Natural History Society (BNHS) built on this list and developed detailed documentation relating to these wetlands (Islam & Rahmani, 2008). The MoEF&CC, under its National Plan for Conservation of Aquatic Ecosystems (NPCA), identified over 180 wetlands of national importance. Conservation of wetlands is also an integral part in 3 of the 12 National Biodiversity Targets, framed by the MoEF&CC in line with the Convention on Biological Diversity's Strategic Plan 2011-2020. India became a signatory in the Ramsar Convention on 1st February, 1982, as a commitment to conserve the wetland resources of the country. As a result of continued conservation commitment by MoEF&CC, 42 wetlands (1,071,861 ha) in India have been designated as Wetlands of International Importance - Ramsar sites, which is highest in the South Asia (Ramsar Sites Information Service, 2020).

The following laws have direct or indirect influence on wetland conservation:

1. Guidelines for implementing Wetlands (Conservation and Management) Rules, 2017, Ministry of Environment, Forest and Climate Change, Government of India, 2020
2. National Plan for Conservation of Aquatic Ecosystems, Ministry of Environment, Forest and Climate Change, Government of India, 2019
3. Wetlands (Conservation and Management) Rules, 2017
4. National Plan for Conservation of Aquatic Ecosystems (NPCA), 2016
5. Guidelines for National Lake Conservation Plan, 2008
6. Provisions under the National Environmental Policy, 2006
7. Water (Prevention and Control of Pollution) Act, 1974
8. Water Cess Act, 1977
9. Environment (Protection) Act, 1986
10. Indian Forest Act, 1927
11. Forest (Conservation) Act, 1980
12. Wild Life (Protection) Act, 1972
13. State Forest Acts
14. Coastal Regulation Zone Notification, 2011
15. Construction and Demolition Waste Management Rules, 2016
16. Manufacture, Storage and Import of Hazardous Chemical Rules, 1989
17. Rules for Manufacture, Use, Import, Export and Storage of Hazardous Micro-organisms Genetically Engineered Organisms or Cells, 1989
18. Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008
19. E-Waste (Management) Rules, 2016

The provisions under these acts range from protection of water quality to conserving, maintaining and augmenting aquatic biodiversity. The primary responsibility for the management and conservation of aquatic ecosystems is in the hands of the Ministry of Environment, Forest and Climate Change and the Ministry of Jal Shakti.

The Ministry of Jal Shakti aims to tackle water issues with a holistic and integrated approach through Jal Shakti Abhiyan, launched on 1st July, 2019. Jal Shakti Abhiyan is inspired by the Hon'ble Prime Minister's emphasis on Jal Sanchay. It is a time-bound, mission-mode water conservation campaign, with the theme Sanchay Jal, Behtar Kal, to undertake conservation, restoration, recharge and reuse of water. The Jal Shakti Abhiyan is being initiated through the cohesion of water related schemes of the Ministry of Jal Shakti, Ministry of Rural Development, Ministry of Agriculture Cooperation and Farmers Welfare and Ministry of Environment, Forest and Climate Change. These ministries are coordinating interventions in water conservation and rainwater harvesting, renovation of traditional and other water bodies, reuse and recharge of borewells, watershed development and afforestation activities.

Jal Shakti Abhiyan was in 255 water-stressed districts across the country. As a part of Jal Shakti Abhiyan, groundwater in the Ganga basin is being recharged through wetland restoration by the National Mission for Clean Ganga (NMCG). The programme will augment the flow in the Ganga River by recharging floodplain aquifers. Towards this cause, the NMCG, in association with the Wildlife Institute of India (WII), Dehra Dun, has initiated a pilot-scale programme, the 'Wetlands and Water Conservation Programme'. This programme aims to restore selected wetlands of great ecological, social and cultural significance of the Ganga basin through community involvement and low-cost interventions.

The wetlands in India are under tremendous stress due to rapid urbanization, industrialization and agricultural intensification. This stress is manifested in a shrinkage of their extent and a decline in the hydrological, ecological and economic functions they perform (Bassi et al., 2014). There has been a significant reduction in the extent of open water, about 32.5%, from post-monsoon to pre-monsoon as assessed by SAC in 2011. Issues of wetland and water conservation are heightened by the multiplicity of stakeholders who use and manage wetlands, often with conflicting land-use priorities and mandates. Wetlands in India are a state subject, and their management is under state authorities (Entry 17 of List-II, i.e. State List, under the Constitution of India, 1950). Various state government agencies are also involved in making decisions about wetland use and management. This multimodal resource use, lack of understanding of functioning of wetland and their ecosystem services, and ecological state demands a holistic monitoring framework that will facilitate a common vision for wetland conservation in India, enable prioritization for conservation and planning of differential management options.

04 EXISTING WETLAND MONITORING FRAMEWORKS

The Ministry of Environment, Forest and Climate Change mapped the number and extent of wetlands in India in 1996 and 2012 on the basis of remote sensed data. The Ramsar guidelines for management of wetlands suggest that wetlands be inventoried and periodically monitored and their status assessed. These guidelines were adapted to the Indian context with the launching of the National Plan for Conservation of Aquatic Ecosystems (NPCA). They are being implemented through collaborative efforts by MoEF&CC and various research organizations. The Central Pollution Control Board (CPCB), in collaboration with the State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) concerned established a nationwide water quality-monitoring network with 2500 stations. This monitoring network covers a wide range of wetland types and sites, including 807 wells. This water quality-monitoring network is operated under a three-tier programme, through Global Environment Monitoring System (GEMS), Monitoring of Indian National Aquatic Resources System (MINARS) and Yamuna Action Plan (YAP). The existing monitoring framework is primarily focussed on assessment of the physio-chemical, microbiological and biological water quality.

Evaluation of biodiversity and other ecosystem service values requires a robust and standardised methodology, regular and periodic assessment, and synergies among monitoring and management agencies.

05 NEED FOR A COMPREHENSIVE ASSESSMENT FRAMEWORK

A holistic and standardized protocol for monitoring the ecological condition of wetlands and aquatic ecosystems across the country has to be futuristic in its approach and should be implementable by various stakeholders. The assessment of wetlands should be inclusive of assessment of ecosystem integrity, resilience capacity in the face of anthropogenic pressure and climate change, and threats (Rapport, 1995). In essence, a healthy wetland should be able to maintain its character and function over time, so that its ecosystem services are sustained, and it should be resilient to the anthropogenic and natural disturbances (Davis et al., 2010).

The scientific literature on the cause and impact of water quality deterioration, reduction in fish catches, and reduction in migratory waterbird congregation in wetlands is sparse and disconnected. A futuristic framework needs to include hydrological, ecological and anthropogenic influence parameters in the monitoring process so as to evaluate the ecological condition of the wetland ecosystems, which is fundamental for providing decision support in conservation and management processes. Given the complexity of the factors that affect the integrity of a wetland, a combination of narrative and numeric criteria may be most cross-cutting, adaptive and preferable for wetland monitoring and status assessment. Therefore, the assessment protocol should be based on established ecological knowledge and systematic evaluation of relevant, scientifically sound, site-specific, comprehensive, manageable, adaptive and easy-to-use indicators. Generally, a suite of parameters is required to address the full range of wetland functions and/or ecological conditions. The objective of developing this protocol is to simplify the methods used to monitor wetlands so that large numbers of wetlands can be covered with the least investment.

06

ECOLOGICAL MONITORING FRAMEWORK FOR WETLANDS

Waterbird congregation at Chilka Lake, Odisha

The Wetland Monitoring Framework is an integrated framework that incorporates wetland categorization and assessment of ecological condition. The Ramsar Classification System for Wetland Types is recommended for categorization of wetlands. The framework follows a systems approach which assumes that a wetland is a complex system of related and dependent elements within a catchment. Thus, hydrology, biota and anthropogenic influences, which, when in interaction forms a unitary whole. Therefore, the framework identified indicators that comprehensively address integrity of these elements.

Northern pintail in Chandpata Jheel at Madhav National Park in Madhya Pradesh

6.1 CATEGORIZATION OF WETLANDS

The Ramsar Convention, classifies wetland types through a broad framework to aid in rapid identification of the main wetland habitats represented at each Ramsar site. Wetland types are identified for each site on the relevant Ramsar Information Sheet. The codes used to define the wetland types of Ramsar sites are based upon the Ramsar Classification System for Wetland Type, as approved by Recommendation 4.7 and amended by Resolutions VI.5 and VII.11 of the Conference of the Contracting Parties (Table 2).

Loktak Lake in Manipur

Table 2. Wetland types identified by the Ramsar Convention

Type code	Description
Inland wetlands	
L	Permanent inland deltas
M	Permanent rivers/streams/creeks, including waterfalls
N	Seasonal/intermittent/irregular rivers/streams/creeks
O	Permanent freshwater lakes (over 8 ha in extent), including large oxbow lakes
P	Seasonal/intermittent freshwater lakes (over 8 ha in extent), including floodplain lakes
Q	Permanent saline/brackish/alkaline lakes
R	Seasonal/intermittent saline/brackish/ alkaline lakes and flats
Sp	Permanent saline/brackish/alkaline marshes/pools
Ss	Seasonal/intermittent saline/brackish/ alkaline marshes/pools
Tp	Permanent freshwater marshes/pools, ponds (less than 8 ha in extent) and marshes and swamps on inorganic soils with emergent vegetation that are water-logged for at least most of the growing season
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils (includes sloughs, potholes, seasonally flooded meadows and sedge marshes)
U	Non-forested peatlands, including shrub or open bogs, swamps and fens

Type code	Description
Inland wetlands	
Va	Alpine wetlands, including alpine meadows and temporary waters from snowmelt
Vt	Tundra wetlands; includes tundra pools, temporary waters from snowmelt
W	Shrub dominated
Xf	Freshwater, trees species
Xp	Forested peat lands, peat swamp forests
Y	Freshwater springs, oases
Zg	Geothermal wetlands

Note: Floodplain is a broad term used to refer to one or more wetland types, which may include wetlands with type codes R, Ss, Ts, W, Xf, Xp or others. Seasonally inundated grasslands (including natural wet meadows), shrublands, woodlands and forests are examples of floodplain wetlands. Floodplain wetlands are not listed as a specific wetland type herein.

Type code	Description
Marine/coastal wetlands	
A	Permanent shallow marine waters (in most cases less than 6 m deep at low tide), including sea bays and straits
B	Marine subtidal aquatic beds, including kelp beds, sea-grass beds and tropical marine meadows)
C	Coral reefs
D	Rocky marine shores, including rocky offshore islands and sea cliffs
E	Sand, shingle or pebble shores, including sand bars, spits, sandy islets, dune systems and humid dune slacks
F	Estuarine waters; permanent water of estuaries and estuarine systems of deltas
G	Intertidal mud, sand or salt flats
H	Intertidal marshes, including salt marshes, salt meadows, saltings, raised salt marshes and tidal brackish and freshwater marshes
I	Intertidal forested wetlands, including mangrove swamps, Nipa swamps and tidal freshwater swamp forests
J	Coastal brackish/saline lagoons (brackish to saline lagoons with at least one relatively narrow connection to the sea)
K	Coastal freshwater lagoons, including freshwater delta lagoons
Human-made wetlands	
1	Aquaculture (e.g., fish/shrimp) ponds
2	Ponds, including farm ponds, stock ponds and small tanks (generally less than 8 ha in extent)
3	Irrigated land, including irrigation channels and rice fields
4	Seasonally flooded agricultural land (including intensively managed or grazed wet meadows or pastures)
5	Salt exploitation sites: salt pans, salines, etc.
6	Water storage areas: reservoirs/barrages/dams/ impoundments (generally over 8 ha in extent)
7	Excavations: gravel/brick/clay pits, borrow pits, mining pools
8	Wastewater treatment areas: sewage farms, settling ponds, oxidation basins, etc.
9	Canals, drainage channels, ditches

The Wetlands Rule, 2017 on India categorized wetlands under Clause 2, Section (1), Sub-section (g) to assist the state governments/UT administrations in the preparation of a brief document for wetlands. Any natural or man-made wetland can be proposed for notification under the Wetlands Rules. Proposals for notification would, however, not be considered for the following:

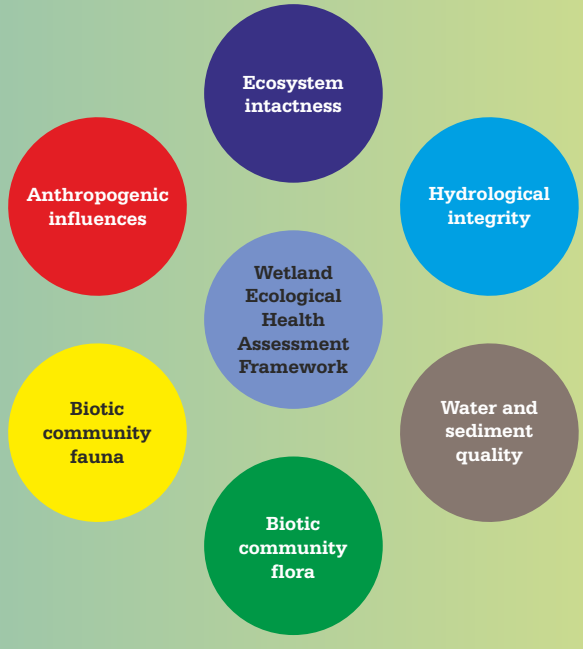
a) River channels
b) Paddy fields
c) Coastal wetlands within the purview of Coastal Regulation Zone 2011
d) Wetlands with permanent agriculture in the Rabi and Kharif seasons
e) Waterlogged areas created due to fragmentation of hydrological regimes within the last three decades, which do not possess any significant biodiversity or ecosystem service value
f) Ash ponds of a thermal power plant, equalization tanks, polishing ponds that are part of an effluent treatment plant, sewage treatment plants or water treatment plants.

6.2 ESTABLISHMENT OF WETLAND MONITORING CRITERIA (WMC)

The proposed Wetland Monitoring Criteria framework includes both quantitative and qualitative assessment of indicators to define the ecological condition of wetlands in India for integrated conservation planning. This framework has been divided into six broad ecological criteria, viz.,

(1) Ecosystem intactness,
(2) Hydrological integrity,
(3) Water and sediment quality,
(4) Biotic community-flora,
(5) Biotic community-fauna, and
(6) Anthropogenic influences (Figure 1, Table 2).

Figure 1. Wetland monitoring framework



Khajjiar lake in Himachal Pradesh

(1) Ecosystem intactness

Species and habitats cannot persist in isolation. Often, natural and intact large wetlands are more resilient to environmental changes compared to smaller wetlands. Thus, the ecological condition of a wetland ecosystem depends greatly on its size of wetlands as well as the nature of the land use in the surrounding areas and the connectivity between habitat patches in the landscape (Amezagaa et al., 2002). Indicators of structural connectivity are a measure of the number of physical connections between habitats, which act as corridors, such as ditches or streams. Indicators of functional connectivity represent how easily species can move through the landscape outside their ideal habitat (Morris, 2012). Intactness can be measured by monitoring encroachments in the catchment and shoreline, changes in the riparian vegetation cover, changes in the waterspread area, and the extent of alteration of the water flow regime (Table 3).

Bharatpur Bird Sanctuary in Rajasthan

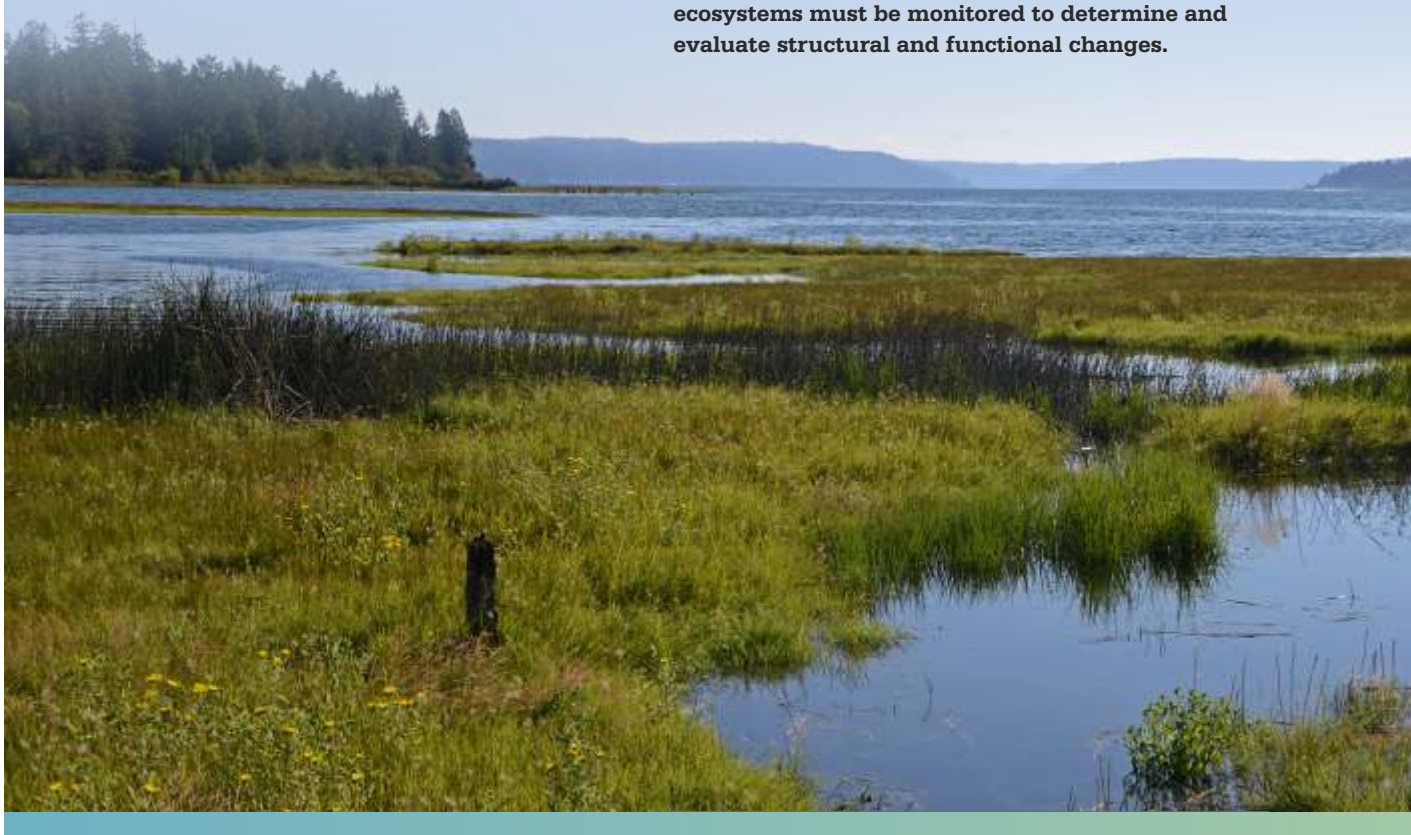
Vembanad lake, Kerala

(2) Hydrological integrity

The existence of wetlands solely depends on the availability of water for maintaining ecological processes. While development activities such as building of dams, reservoirs, barrages and other structures are essential, the impacts of such structures on rivers, wetlands and aquatic life, if these are not carefully planned, can have irrecoverable impacts (McLaughlin et al., 2019). Therefore, careful monitoring of the extent of degradative changes to aquatic and wetland ecosystems by such structures should be a priority in the assessment protocol. The hydrological parameters of an aquatic ecosystem, both qualitative and quantitative, shape its productivity and biotic assemblage and determine the use of resources for the benefit of human society (McLaughlin & Cohen, 2013).

The hydrology regime show natural seasonal fluctuation and simultaneously influence and are influenced by land use practices. Therefore thorough knowledge of the waterspread area, water depth, flow and functionality of flow regulation structure is needed to assess the status and maintain a healthy ecosystem. Flooding and drought will both be common features of future climate shifts, and their influence on rivers and wetland ecosystems must be monitored to determine and evaluate structural and functional changes.

Hydrological connectivity of river and wetland ensure exchange of nutrient and migration of biota



Hydrology monitoring

(3) Water and sediment quality

The water and sediment chemistry of wetlands are influenced by the type of soil in the catchment, geology, vegetation cover, topography, hydrological connectivity, climate, groundwater and surface water interaction, and, most importantly, pollution from point and non-point sources. The physio-chemical water quality is a determinant of the biotic composition and nutrient cycles in an aquatic ecosystem and influences the sustainability of the ecosystem and resource use by the local community. In consideration of this factor, the Water Quality Assessment Authority (WQAA) exercises power under Section 5 of the Environment (Protection) Act, 1986 to issue directions and take measures with respect to the water quality of inland surface waters. The physio-chemical characteristics of wetlands can be assessed by following the prescribed Designated-Best-Use criteria (DBU) as defined by EPA, 1986.

Persistent pollutants such as pesticides and heavy metals pose a threat to aquatic ecosystems and their biota through manifestation of hormonal disruption, molecular-level changes and, diminished reproductive success and survival (Feist et al., 2005). Assessment of the concentration of these xenobiotic compounds in the water as well as in sediments is necessary to formulate prevention and mitigation measures to restrict the release of these compounds in the aquatic environment.

The physio-chemical characteristics of water alone do not always answer certain management questions. To know the species' responses to alterations in the hydrology and water chemistry is important in making decisions about how much alteration should be allowed in a freshwater ecosystem. In this regard, CPCB has developed Biological Water Quality Criteria (BWQC) on the basis of the community structure of the benthic macro-invertebrates as indicators of water quality. This system is based on the range of saprobic values and the diversity of the aquatic benthic macro-invertebrate families with respect to water quality. The BWQC, in addition to physio-chemical water quality parameters, may provide the information necessary to assess and mitigate anthropogenic alterations (Table 3).

Weed infestation deteriorate wetland habitat

Water lily is native flora in wetlands of northern and peninsular India

(4) Biotic community-Flora

The trophic structure and abundance of producers, consumers, and detritivores determine the ecological condition of an aquatic ecosystem and its functioning. The biotic communities vary considerably across wetlands in different geographic locations. The wetland vegetation, comprising the producers, performs diverse functions such as nutrient recycling, sediment trapping, shoreline stabilization, removal of pollutants, and regulation of dissolved oxygen in the waterbody (Barko & James, 1998). On the other hand, invasive species pose a threat to the wetland through clogging, reduction of the interface with the atmospheric, modification of the photoperiod, reduction of the habitats of native species, and acceleration of succession. Invasive species are also indicators of degradation of the wetland and the catchment (Keller et al., 2018). Information related to the state of the native and invasive floral species is important in assessing the condition of the wetland (Table 3).

Herpetofauna are indicators of wetland status

(5) Biotic community-Fauna

The diversity of aquatic species in a wetland is often determined by extent of fish catch

Wetlands provide important habitats for key aquatic vertebrate species such as fishes, amphibians, reptiles, birds, and mammals, and the presence and congregation of such species are, in turn, indicators of healthy wetlands and river ecosystems. The criteria for designation of wetlands of international importance - Ramsar Site, is based on biodiversity and representativeness and uniqueness of wetland ecosystems. Therefore, assessment of occurrence and population trend of such indicator species can provide important insight about the state of biodiversity of a wetland and can influence conservation decision.

Wetlands are particularly susceptible to invasive non-native species, which compete with native species and possibly lead to decline in their populations and local extirpation (Mills et al., 2004). Thus, monitoring the occurrence of invasive species should be an integral part of wetland monitoring and status evaluation (Table 3).

Otters often use wetland habitats that are connected with rivers

(6) Anthropogenic influences

It is well established that human activities have significant impacts on ecosystems and their functions. Rivers and wetlands have been the lifelines of human populations, providing not only clean water but also fertile sediments, food, fuel, and other provisions (Clarkson et al., 2013). However, the rising population and subsequent increase in demands have resulted in over exploitation of these aquatic and wetland resources. Expansion of agriculture and linear infrastructure and other developmental activities have led to degradation and loss of wetlands (Ramsar Convention on Wetlands, Global Wetland Outlook, 2018). Therefore, the impacts of these changes need to be monitored carefully by measuring the extents of the impacts of various human activities, viz., wastewater discharge, solid waste dumping, destructive fishing activities, biomass extraction, grazing, sand and boulder mining, reclamation, and encroachment (Table 3). The information gathered will be crucial in prioritization of corrective and preventive measures for the conservation of these ecosystems.

Over-exploitation of resources

Agricultural drainage
leads to loss of wetland

Pollution from point and
non-point sources degrade
water and habitat quality

07 EVALUATION STRATEGY

Through an extensive literature survey, 48 indicators were identified, under six criteria, for ecological assessment (Table 3). The indicators were selected on the basis of (i) their ecological importance, (ii) the relevance and representativeness of the condition of the criterion, (iii) the availability of data and information at local, regional and national scales, (iv) the availability of a standard methodology, (v) the ease of determining thresholds, (vi) their robustness (comparable standard indicators on an international scale), (vii) the reproducibility and replicability of the information, (viii) their ease of assessment, and (ix) their applicability in predicting long-term trends and ecological changes.

The thresholds of each of the indicators were divided into a three-point scoring matrix, assigning a simple score ranging between 1 (poor) and 3 (good). The thresholds are representative of the existing national and international standards (Table 3).

The indicators are divided into the following priority categories.

a) Primary: Essential indicator

b) Secondary: Optional indicator, may be assessed according to data availability and feasibility of assessment

c) Specific: Indicator(s) specific to wetlands or river stretches, to be identified on a case-to-case basis.

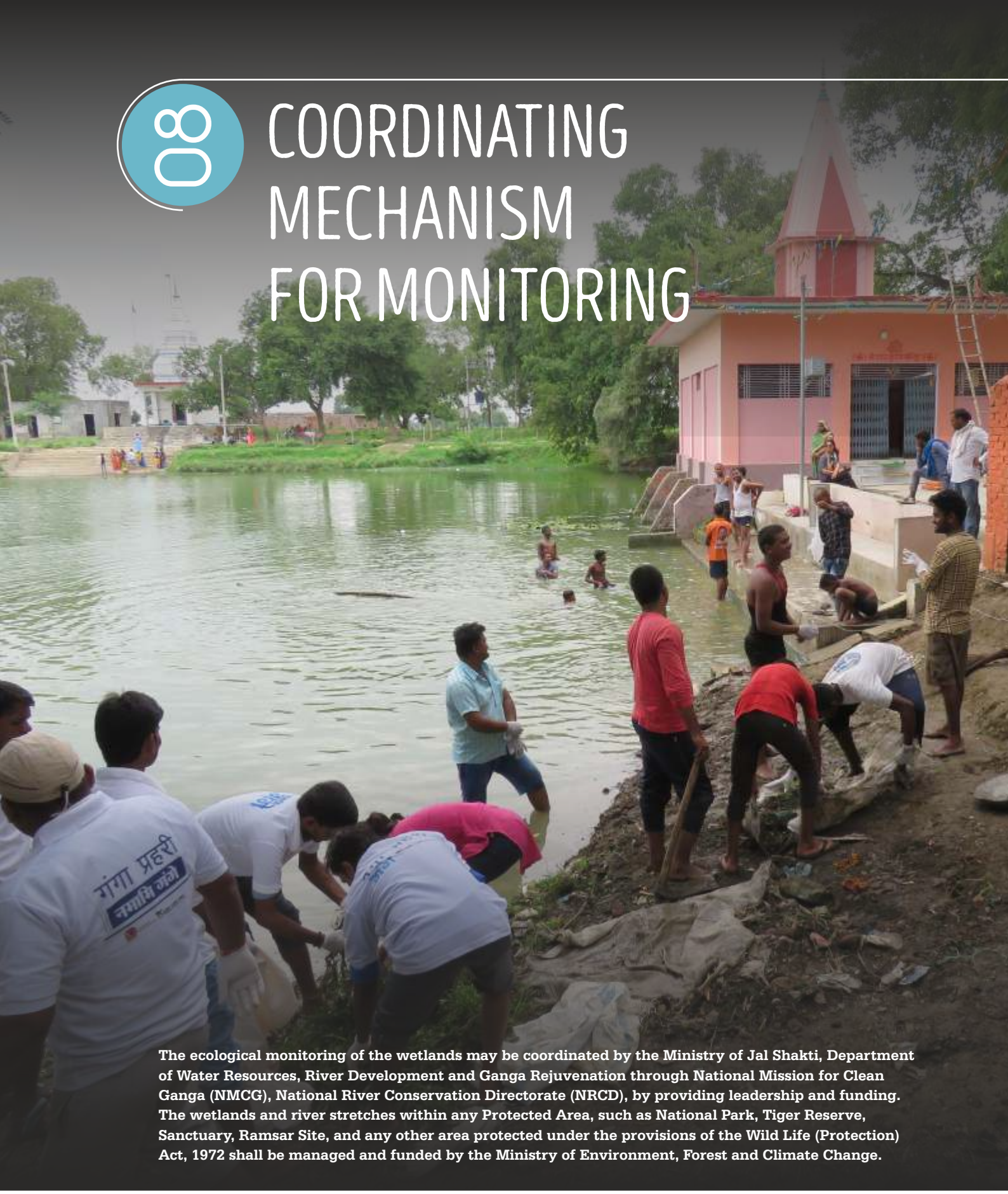
Different combination of parameters are designated (Boxes 1 & 2) for assessment of rivers, freshwater wetlands and brackish water wetlands. The strategy for the monitoring is as follows;

- Assessors should collect baseline information about salient features and state of wetlands in terms of Ramsar criteria for the wetlands to be evaluated. This basic data need to be compiled prior to the commencement of the monitoring activities. Information that are not available at initial evaluation stage, can be strengthened after assessment (Annexure 1).
- A digital map should be prepared to delineate the wetland boundary, water spread area and Zone of Influence.
- Information regarding forest cover, linear structures, connectivity with other water bodies, and other land use should be demarcated in a 500-1000 m buffer from the wetland boundary (according to the size and zone of influence of the wetland).
- Sampling sites/plots for measurement of water depth, assessment of water quality and inventory of aquatic and riparian vegetation should be demarcated on the basis of grid. Grid size should be calculated on the basis of the size of the wetland.
- The sampling sites/plots/transects for river stretches should be delineated according to habitat mosaic, hydrology regime and biodiversity.
- A reconnaissance survey should be carried out to confirm the sampling sites/plots.
- For assessment of the biodiversity of a wetland or a river stretch, sampling time/duration shall cover the migratory season of waterbirds, summer season (lean hydroperiod) and post-monsoon season in accordance with the climatic conditions of the region. Where possible, the waterbird monitoring may be carried out in conjunction with the Asian Waterbird Census, which is coordinated every year by Wetlands International.
- Sampling should be performed within the framework of standard wildlife monitoring techniques used for conducting population censuses and habitat assessment (Annexures 1-13). Guidelines and a checklist of the equipment, field gear, and sampling containers used for field monitoring should be drawn up for ready reference. The guidelines must be adaptations of the Guidelines for Water Quality Monitoring (MINARS/27/2007-08) of the Central Pollution Control Board (CPCB, 2008).

The data sheets to be used in the assessment are as follows,

1. Data sheet for habitat survey (Annexure 2)
2. Data sheet for bathymetric survey (Annexure 3)
3. Guideline for sampling water and sediment quality parameters (Annexure 4)
4. Data sheet for water sampling and field assessment of water and sediments (Annexure 5)
5. Data sheet for aquatic vegetation survey (Annexure 6)
6. Protocol for biomonitoring (BWQC) (Annexure 7)
7. Data sheet for fish survey (Annexure 8)
8. Data sheet for amphibian survey (Annexure 9)
9. Data sheet for turtle survey (Annexure 10)
10. Data sheet for crocodile survey (Annexure 11)
11. Data sheet for water bird and water-associated bird survey (Annexure 12)
12. Data sheet for otter survey (Annexure 13)

08 COORDINATING MECHANISM FOR MONITORING



The ecological monitoring of the wetlands may be coordinated by the Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation through National Mission for Clean Ganga (NMCG), National River Conservation Directorate (NRCD), by providing leadership and funding. The wetlands and river stretches within any Protected Area, such as National Park, Tiger Reserve, Sanctuary, Ramsar Site, and any other area protected under the provisions of the Wild Life (Protection) Act, 1972 shall be managed and funded by the Ministry of Environment, Forest and Climate Change.

Citizen science initiatives usually involve individuals, teams or networks of volunteers and often partner with professional scientists to achieve common goals. Large volunteer network of local communities, educational institutions, NGOs and trained nature enthusiasts often allow scientists to accomplish tasks that would be too expensive or time consuming to complete otherwise. This approach will be effective in ecological monitoring of wetlands with a wider reach, less amount of time and minimum investment. It will also create a larger constituency, stake and sustained involvement of the local communities in the conservation process.

The coordinating mechanism for ecological monitoring of wetlands should adhere to the guidelines proposed by the Ministry of Environment, Forest and Climate Change viz., Guidelines for implementing Wetlands (Conservation and Management) Rules, 2017, Ministry of Environment, Forest and Climate Change, Government of India, 2020 and National Plan for Conservation of Aquatic Ecosystems, Ministry of Environment, Forest and Climate Change, Government of India, 2019.

The following is a list of sources of secondary information for wetland monitoring:

1. National Wetland Atlas
2. State Wetlands Authority or Union Territory Wetlands Authority
3. Lake Development Authority (LDA)
4. Lake Conservation Authority (LCA)
5. Central and state pollution control boards
6. Forest departments/wildlife departments
7. Irrigation and water resource departments
8. Department of Science and Technology
9. Central Water Commission (CWC)
10. Groundwater boards
11. State statistical departments
12. State biodiversity boards
13. Biodiversity management committees (BMCs)
14. People's biodiversity registers (PBRs)
15. Village panchayat, blocks and tehsil office

A basic training programme on how to use this framework may be arranged by WII and other agencies mentioned in the foregoing section. The state and Union Wetland Management Authority wherever it exists, could coordinate the collection, analysis and reporting of data.

Table 2. Ecological indicators of wetland ecosystem assessment

Indicator no.	Indicator [priority categories]	Justification	Methods of assessment
Criterion 1: Ecosystem intactness			
1.1	Riparian vegetation buffer [Primary]	The natural capital in terms of the extent of the natural vegetation cover and its intactness will ensure the sustainability of an ecosystem and improve its resilience against anthropogenic and natural functional degradation.	Assessment of secondary data from forest departments. Examination of Survey of India maps and higher-resolution remote-sensing images. Field observations.
1.2	Upland land-use other than forest [Primary]	The land-use practices in the adjacent uplands have a strong influence on the condition of a wetland. Intense human activities and encroachments in the surrounding lands indicate low connectivity and a disturbed ecosystem. Encroachment causes loss of riparian vegetation, the floodplains and the catchment and negatively affects the ecosystem value.	Assessment of land use through village surveys, participatory mapping, secondary information from local governing bodies such as revenue departments and panchayats, high-resolution remote-sensing images and observations in the field.
1.3	Permanent structure (Embankments, construction and linear infrastructure in or around the wetland) [Primary]	Embankments, construction of infrastructures, dykes, roads and railway tracks in or along the wetlands cause loss of percolation area, reduce the runoff and hamper the water flow from the catchment to the wetland.	Field observations. Secondary information from the government agencies concerned. Examination of Survey of India maps and higher-resolution remote-sensing images.
1.4	Waterspread area [Primary]	Disturbance in the upland catchment due to loss of forest cover and land use change increase the siltation rate and in turn reduce the waterspread area and depth of a wetland.	Designation of water spread area through high-resolution remote-sensing images. Bathymetric assessment using an acoustic Doppler current profiler (ADCP) or depth meter.
1.5	Littoral zone (shallow water zone, <2 m deep) percentage area [Secondary]	This is a measure of the intactness of the wetland as this zone is most productive.	Examination of Survey of India maps and higher-resolution remote-sensing maps. Field surveys. Bathymetry.
Criterion 2: Hydrological integrity			
2.1	Flow regime[Specific]	Connectivity barriers such as dams and barrages reduce the flow, disrupt the natural flushing mechanism and fragment wildlife populations.	Examination of Survey of India maps and higher-resolution remote-sensing images. Field surveys.
2.2	Environmental water availability [Primary]	This is the quantity of water that is needed for sustained functioning of a wetland, mimicking the natural hydro-period of every month that enables the continuity of its ecological services.	Monitoring inflow and outflow, water depth, water spread area. This can be done through flow measurement (using a flow gauge or acoustic based flow measuring device), bathymetric assessment (depth meter) and mapping of water spread area using Survey of India maps, higher-resolution remote-sensing images and field observations. The volume of water can be calculated from the bathymetry and water spread area.

	Range of score		
	1 (Poor)	**2 (Fair)**	**3 (Good)**
	<50% area remaining under natural vegetation cover within 100 m from the wetland boundary.	50-70% area remaining under natural vegetation cover within 100 m of the wetland boundary.	70-100% area remaining under natural vegetation cover within 100 m from the wetland boundary.
	>70% built-up area, agricultural land encroachment within 100 m of the wetland boundary and intensive human activities.	30-70% built-up area and agricultural land beyond 200-500 m of the wetland boundary, with moderate human activities.	<30% built-up area and agricultural land beyond 500 m from the wetland boundary, with negligible human activities.
	Embankments, dykes, roads and railway tracks crisscross the wetland Or, Extensive construction of a permanent nature except for boat jetties within 50 m from the mean highflood level.	Dykes, roads and railway tracks with adequate open land and adequate numbers of culverts or bridges that allows recharging crisscross the wetland. Or, Moderate construction of a permanent nature except for boat jetties within 50 m from the mean high flood level.	Free flow from the catchment to the wetland without dykes, roads, etc. in between. Or, No construction of a permanent nature except for boat jetties within 50 m from the mean high flood level.
	Substantial silt deposition in the wetland, causing a general reduction (>5%) of wetland area, average depth or hydroperiod.	Moderate silt deposition but no significant reduction (2-5%) in wetland area, average depth or hydroperiod.	Minor reduction (<2%) in wetland area, average depth or hydroperiod due to siltation.
	Littoral zone (shallow water zone <2 m), perceived or actually reduced by more than 25% or got disturbed due to other land use in last 10 years.	Littoral zone (shallow water zone, <2 m depth) perceived to be or actually reduced by 25% or less or disturbed due to other land use in the last 10 years.	Negligible/ No reduction in the original littoral zone in the last 10 years.
	Barriers present upstream. Inflow almost negligible to low during dry season.	Barriers present with fish passes and adequate environmental flow.	No barriers present. Flow regime and natural flushing mechanism intact.
	<60% of the natural mean monthly water volume is available at human-used wetlands, as a result of which ecosystem-level processes are disrupted. Or, <80% of the natural mean monthly water volume is available in notified wetlands in protected areas, as a result of which ecosystem-level processes are disrupted.	60-75% of the natural mean monthly water volume available at human-used wetlands, as a result of which ecosystem-level processes are moderately disturbed. Or, 80-90% of the natural mean monthly water volume is available in notified wetlands in protected areas, as a result of which ecosystem-level processes are moderately disturbed.	Flow regime is intact and >75% of the natural mean monthly water volume is available at human-used wetlands for maintenance of ecosystem-level processes. Or, >90% of the natural mean monthly water volume is available in notified wetlands in protected areas for maintenance of ecosystem-level processes.

Indicator no.	Indicator [priority categories]	Justification	Methods of assessment
2.3	Hydrological connectivity [Primary]	The connectivity among the surrounding aquatic, riparian and forest habitats in the floodplains and catchment area as well as the inter- and intra-basin connectivity. Connectivity enhances habitat variability and biodiversity values and provides a buffer against habitat alteration.	Assessment of land use through village surveys and participatory mapping. Examination of Survey of India maps and higher-resolution remote-sensing images. Field observations.
2.4	Water depth [Primary]	Natural seasonal depth variations provide habitat variability and support biodiversity. Any deviation would cause a change in the hydro-period, habitat loss and biodiversity loss.	Assessment of bathymetry using a depth meter or acoustic based flow measuring device. Consultation with local communities.
Criterion 3: Water and sediment quality			
3.1	Water Quality Criteria (WQC; only for freshwater wetlands) [Primary]	The WQC is an indicator of the physio-chemical water quality in natural water bodies. WQC A represents a drinking water source without conventional treatment but after disinfection; WQC B represents outdoor bathing (organized); WQC C represents a drinking water source after conventional treatment and disinfection; WQC D represents a water body for propagation of wild life and fisheries; and WQC E represents water to be used for irrigation, industrial cooling and controlled waste disposal.	The sampling and analysis should be done as prescribed in IS:3025-Part I (1987).
3.2	Concentration of pesticides in water [Primary]	Pesticide residues in high concentrations in the water and sediment may lead to bioaccumulation and 22iomagnification in the food chain and may cause acute and chronic toxic effects such as death, endocrine disruption and hormonal stress.	Surveys of agricultural lands around wetlands and rivers. Pesticide analysis using standard sampling and analytical methods as prescribed in the CPCB guidelines and USEPA series.
3.3	Concentration of pesticides in sediment [Primary]		
3.4	Concentration of heavy metals (HM) in water [Primary]	HM in high concentrations in the water and sediment may lead to bioaccumulation and 22iomagnification in the food chain and may cause acute and chronic toxic effects such as death, endocrine disruption and hormonal stress.	Assessment of HM such as cadmium (Cd), chromium (Cr+6), lead (Pb), mercury (Hg) and arsenic (As) using the methods prescribed in IS:3025.
3.5	Concentration of HM in sediment [Primary]		

Range of score		
1 (Poor)	**2 (Fair)**	**3 (Good)**
Connectivity with other wetlands/rivers, forests and grasslands disrupted wholly. Or, there is linear connectivity between the upstream and downstream sections of a river or stream, and there are fish passes disturbed by barriers. Connected only during extreme flooding.	There is connectivity only in the rainy season. Otherwise there is no connectivity with other wetlands/rivers/forests. Or, the linear connectivity between the upstream and downstream sections of a river or stream is disturbed by barriers, but these are connected during high floods, and there are fish passes.	There is connectivity with other wetlands/rivers, forests and grasslands in all seasons. Or, the linear connectivity between the upstream and downstream sections of a river or stream are not disturbed by barriers.
Substantial change (>10% deviation from the mean annual depth) in water depth.	Moderate change (5-10% deviation from the mean annual depth) in water depth.	Negligible change (<5% deviation from the mean annual water depth) in water depth.
WQC D or E. pH between 6.5 and 8.5, dissolved oxygen 4 mg/L or more, free Ammonia (as N) 1.2 mg/L or less. Or pH between 6.0 and 8.5, maximum electrical conductivity at 25°C 2250 micromhos/cm, maximum sodium absorption ratio 26, maximum boron level 2 mg/L	WQC C. Total coliform organism MPN/100 mL shall be 5000 or less, pH between 6 and 9, dissolved Oxygen 4 mg/L or more, biochemical oxygen demand (5 days at 20°C) 3 mg/L or less.	WQC B or A. Total coliform organism MPN/100 mL shall be between 50 and 500, pH between 6.5 and 8.5, dissolved oxygen 5-6 mg/L or more, biochemical oxygen demand (5 days at 20°C) 2 -3 mg/L or less.
Pesticide use in more than 25% of the catchment area. Most of the pesticides present in the water are above the permissible limits.	Pesticide use in 10-25% of catchment area. Most of the pesticides present in the water are within the permissible limits.	Negligible (<10%) pesticide used in the catchment. All the pesticides present in very low concentrations in the water, lower than the permissible limits or not detected.
Presence of pesticides in the sediment in higher concentrations than in the water in all seasons.	Presence of pesticides in the sediment in low concentrations.	Pesticides not detected in the sediment.
Most of the HM present in the water are above than the permissible limits.	Most of the HM present in the water are within the permissible limits.	All the HM present in very low concentrations in the water, below the permissible limits or not detected.
HM concentration higher than the concentration in the water in all seasons.	Presence of HM in the sediment in low concentrations.	HM not detected in the sediment.

Indicator no.	Indicator [priority categories]	Justification	Methods of assessment
3.6	Trophic status (Only for freshwater wetlands) [Primary]	Nutrients such as nitrogen and phosphorus tend to be limiting resources in standing water bodies, and so increased concentrations tend to result in increased algal and macrophyte growth, followed by corollary increases in subsequent trophic levels.Higher trophic states represents cultural eutrophication.	Assessment of Carlson's Trophic State Index (TSI) based on total phosphorus or Secchi depth. The parameters may be analysed as described in IS:10500:2012.
3.7	Biological water quality assessment through benthic macro-invertebrates (only for fresh water) [Secondary]	Biological Water Quality Classes were developed by CPCB on the basis of the response of benthic macro-invertebrates towards changes in physio-chemical water quality. This BWQC provides a comprehensive idea about the anthropogenic alteration of an inland freshwater ecosystem.	Field surveys carried out according to the "Bio-monitoring Protocol" of CPCB. The locations may coincide with the water-sampling locations.
3.8	Algal bloom[Secondary]	An algal bloom affects the dissolved oxygen (DO) available for ecological processes and affects the aesthetic value.	Fluorometer. Periphyton abundance surveys based on site-level inspections.
3.9	Visible water pollution [Secondary]	Reduced water transparency, a greenish/greyish colour and an obnoxious odour are indicators of pollution. Presence of floating waste debris also indicates a poor aesthetic value and poor wetland condition.	Observer's perception based on site-level inspections.
4: Biotic community-flora			
4.1	Free-floating invasive species (percentage of wetland area) [Primary]	These affect native biotic communities.	Visual estimation.
4.2	Rooted invasive species (percentage of wetland area) [Primary]	These affect native biotic communities.	Plot method (1 m x 1 m).
4.3	Percentage of flood plain area covered with native vegetation [Primary]	This indicates the integrity of the floodplain, which traps nutrients and sediment from runoff and provides shelter for riparian animals.	Visual estimation
4.4	Percentage of shoreline covered with native vegetation [Primary]	This indicates the integrity of the wetland, which traps nutrients and sediment from runoff, stabilizes banks and provide shelter to aquatic animals.	Visual estimation
Criterion 5: Biotic community-fauna (vertebrate)			
5.1	Richness of native fish species [Specific]	This indicates the intactness of a site-specific native biotic community.	Netting, fish traps where possible (catch per unit effort, CPUE). Secondary data from fishermen on percentage fish catch and surveys of local fish markets.

	Range of score		
	1 (Poor)	**2 (Fair)**	**3 (Good)**
	Eutrophic	Mesotrophic	Oligotrophic
	BWQC D or E,heavy to severe pollution.	BWQC C, moderate pollution.	BWQC B or A, slight pollution or clean water.
	Accumulation of microalgae layer >1 cm thick is evident.	Accumulation of microalgae layer 0.1-1 cm thick is evident.	Accumulation of microalgae layer <0.1 cm thick is evident.
	Pungent odour in water, brownish colour, presence of floating solid non-biodegradable waste. Or, floating and submerged macrophytes covering >50% of the wetland area present. Or, active sewage/industrial effluent discharge present.	No odour. Greenish colour. Presence of floating macrophytes covering 20-50% of the wetland area.	No odour, no colour, presence of very few floating macrophytes, covering <20% of the wetland area.
	>50% of the wetland is colonized by weeds/invasive species.	Some weed incursion into the wetland resulting from edge colonization; however, 50-95% of the wetland remains free of weeds/invasive species.	No weeds. Or invasive species present in ?5% of the wetland.
	More than 50% of the wetland area covered with weeds or invasive plants.	Some weed incursion into the wetland resulting from edge colonization and/or incursion from roads and tracks; however, 50-95% of the wetland remains free of weeds.	Less than 5% of the wetland and its boundary is affected by weeds and invasive species.
	<50% of the area covered with native vegetation.	50-70% of the area covered with vegetation.	>70% of the area covered with native vegetation.
	No vegetation.Or < 75% of shore vegetation intact.	75-80% of the shore vegetation intact.	> 80% of the shore vegetation intact.
	Highly declining.	Very little or no decline.	Stable/increasing.

Indicator no.	Indicator [priority categories]	Justification	Methods of assessment
5.2	Abundance of native fish species [Specific]		
5.3	Richness of amphibian species [Specific]	This indicates the intactness of a site-specific native biotic community.	Standard survey methodology for amphibians
5.4	Abundance of amphibian species[Specific]		
5.5	Abundance of crocodile species [Specific]	This indicates the intactness of a site-specific native biotic community.	Standard crocodile surveys, questionnaire surveys in adjacent villages and purposive surveys.
5.6	Richness of turtle species [Specific]	This indicates the intactness of a site-specific native biotic community.	Standard turtle surveys, questionnaire surveys in adjacent village and purposive surveys.
5.7	Abundance of turtle species [Specific]		
5.8	Richness of water bird and water-associated bird species [Specific]	Water birds and water-associated birds are indicators of the integrity of a wetland. Birds are one of the important criteria in designating wetlands of international importance (Ramsar sites).	Standard water bird surveys.
5.9	Abundance of water bird and water-associated bird species [Specific]		
5.10	Richness of breeding birds [Specific]	Abundance/nesting of water birds indicates that a wetland is healthy.	Breeding bird surveys/monitoring colonial breeding birds and nests.
5.11	Nest count of breeding birds [Specific]		
5.12	Abundance of otters [Specific]		Standard river otter survey techniques.
5.13	Abundance of exotic/invasive animals [Primary]	These affect native biotic communities.	Netting, traps where possible. Secondary data from fishermen.
Criterion 6: Anthropogenic disturbance			
6.1	Water withdrawal from the wetland [Primary]	This may affect the hydro-period of the wetland and reduce the area and depth in a wetland and, in turn, will affect the functioning of the ecosystem.	Examination of irrigation and other water withdrawal facilities/ activities through field surveys.
6.2	Groundwater withdrawal in the surrounding uplands [Primary]	This may affect the wetland hydro-period over time and accelerate the loss of the wetland.	Examination of irrigation and other water withdrawal facilities/ activities through field surveys and secondary information.

	Range of score		
	1 (Poor)	**2 (Fair)**	**3 (Good)**
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Highly declining.	Very little or no decline.	Stable/increasing.
	Increasing.	Decreasing. Or,exotic/ invasive species present.	No exotic/invasive species in the wetland.
	Scoring criteria for first assessment: Withdrawal of water increased from wetland due to urbanization, agricultural expansion and other development activities in the last 10 years. More pump sets installed. Scoring criteria for successive assessments: More water withdrawal structures than previous assessment.	Scoring criteria for first assessment: Withdrawal of water constant from wetland constant in the last 10 years. Number of water diversion channels/pumps fairly constant. Scoring criteria for successive assessments: No new water withdrawal structure since previous assessment.	Scoring criteria for first assessment: Perceived or actual withdrawal of water declined in the last 10 years due to creation of alternate sources such as canals and water tanks. Scoring criteria for successive assessments: No water withdrawal from wetland.
	Scoring criteria for first assessment: Withdrawal of water within 200 m radius of the boundary of the wetland drawdown zone increased due to urbanization and agricultural expansion in the last 10 years. More bore wells installed. Scoring criteria for successive assessments: More bore wells than previous assessment within 200 m radius of the boundary of the wetland drawdown zone.	Scoring criteria for first assessment: Withdrawal of water within 200 m radius of the boundary of the wetland drawdown zone increased due to urbanization and agricultural expansion in the last 10 years. Number of water abstractions remained fairly constant. Scoring criteria for successive assessments: No new bore well within 200 m radius of the boundary of the wetland drawdown zone.	Scoring criteria for first assessment: Withdrawal of water in the last 10 years declined due to availability. of alternate sources. Or, no groundwater extraction within 200 m radius of the boundary of the wetland drawdown zone. Scoring criteria for successive assessments: No bore well within 200 m radius of the boundary of the wetland drawdown zone.

Indicator no.	Indicator [priority categories]	Justification	Methods of assessment
6.3	Numbers of active untreated sewage and industrial wastewater discharge points (effluent outlets/overflows/ drains) [Primary]	Sewage and industrial effluents directly influence the water quality and degrade wetland condition.	Field surveys along the boundary of the wetland. Secondary data from CPCB/SPCB/PCCs.
6.4	Quality of sewage inflow [Primary]	Sewage directly affects water quality and degrades wetland and river condition.	Sampling and analysis as proposed in IS:3025-Part I (1987). The standard limit is identified in the Environment (Protection) Rules, 1986, Rule 3A and Schedule VI, General Standards for Discharge of Environmental Pollutants, Part A: Effluents, Discharge Limit for Inland Surface Water.Specific parameters are pH, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total nitrogen (TN), total phosphorus (TP) and faecal coliform (FC) counts.
6.5	Quality and quantity of industrial discharge [Specific]	Industrial discharges directly affect water quality and degrade wetland condition.	Field surveys and sample analyses using IS:3025-Part I (1987). Effluent standards are industry-specific, and CPCB's "Standards for Emission or Discharge of Environmental Pollutants from Various Industries" should be strictly followed.
6.6	Draining/reclamation of wetland [Primary]	Draining changes the plant composition and reduces the ability of wetlands to perform their hydrological functions.	Field surveys.
6.7	Extent of fishing[Primary]	Overfishing may affect the biodiversity and availability of resources.	Field observations and questionnaire surveys.
6.8	Extent of extraction of other biomass and poaching [Primary]	This affects the provisioning service value reduce the biodiversity and causes disturbances in the trophic level.	Field surveys, household interviews. Perception of the observer.
6.9	Extent of grazing[Primary]	Grazing can cause intensive disturbance on the banks and along the shoreline, changes the composition of the plant community, increase bank erosion/siltation and damage nests of island and shore nesting birds.	Field surveys to check the number of livestock grazing in the wetland area. Availability of alternative grazing grounds and fodder sources.
6.10	Sand mining, stone quarrying [Specific]	These affect natural shoreline features, enhance siltation and alter habitats for nesting birds and reptilians such as turtles and crocodiles.	Field surveys. Perception of the observer.
6.11	Boat waves or wakes [Secondary]	Boat waves or wakes are caused by the movement of boats through the water. When the speed is greater, the effect of the wash on the river banks and shoreline is greater and more damaging. Boat waves have the potential to erode and undercut banks, causing severe damage to the riparian zone.	Field observations.

	Range of score		
	1 (Poor)	**2 (Fair)**	**3 (Good)**
	More than two active untreated sewage discharge points/overflows/drains at the wetland.	Not more than two active treated sewage discharge points at the wetland.	No wastewater (treated or untreated) discharge into the wetland.
	Concentrations of designated parameters are higher than the limits specified in the standards.	Concentrations of parameters just fulfilling the specified standards.	No sewage coming into the wetland. Or concentrations of all parameters well below the specified limits.
	Concentrations of designated parameters are higher than those specified in the standards.	Concentrations of parameters just fulfilling the specified standards.	No industrial waste coming into the wetland. Orall effluents well below the specified limits.
	Presence of well-established drainage infrastructure such as canals that completely drains the wetland for other land use.	Presence of drainage infrastructure such as canals that partially drains the wetland.	Only natural drainage and spillover.
	Extensive commercial fishing, with destructive fishing practices.	Limited seasonal commercial fishing activity.	Fishing using traditional fishing gear by fishing community for personal consumption.
	Substantial biomass extraction from the wetland for sale as well as consumption. Substantial removal/poaching of rare, endangered or threatened animal/plant species.	Occasional biomass extraction from the wetland for consumption only. Occasional removal/poaching of rare, endangered or threatened animal/plant species.	Minimal/negligible/ sustainable biomass extraction from wetland. Biomass extraction is regulated by local administration. No poaching.
	Grazing animals have access to >50% of the wetland, established tracks throughout the wetland, dung widespread, major damage to bank and shoreline vegetation.	Grazing animals have access to 25-50% of the wetland, some established tracks, few dung deposits, moderate damage to bank and shoreline vegetation.	Grazing animals have partial access (less than 25%) to the wetland, little damage to bank and shoreline vegetation, no current signs of grazing.
	Substantial sand or boulder mining on the banks and in the water for commercial purposes both manually and using mechanized tools.Intensive mining.	Sand and boulder mining on the banks and in the water using traditional methods, primarily for local subsistence.	No sand or boulder mining on the banks and in the water.
	Powered vessels move frequently in the wetland. Erosion and undercutting of banks is severe in places.	Few small powered vessels in the wetland. Negligible erosion of the banks.	Paddle boats used for tourism or by local fishermen. No erosion or undercutting of the banks is evident at any location in the study site.

Indicator no.	Indicator [priority categories]	Justification	Methods of assessment
6.12	Oil and grease from motorized boats (ferries and tourist boats) [Secondary]	Leakage of oil and grease from motorized boats could lead to mortality of planktonic biota and suffocate fish and other aquatic life forms.	Sampling and analysis as proposed in IS:3025-Part I (1987). The standard limit is identified in the Environment (Protection) Rules, 1986, Rule 3A and Schedule VI, General Standards for Discharge of Environmental Pollutants, Part A : Effluents, Discharge Limit for Inland Surface Water.
6.13	Any other activity that may degrade the ecosystem or affect the integrity of the wetland (Washing of clothes, vehicles near the wetland, landfill construction, defaecation, wallowing of cattle, drying of cow-dung cakes, passing of overhead power lines across the wetland) [Primary]	These degrade the water quality and modify the habitat.	Field surveys.

BOX 1: ASSESSMENT SCORING SYSTEM

There are 27 Primary, 6 Secondary and 15 Specific indicators. A minimum of 34 indicators including all 27 Primary indicators should be assessed. Coastal wetlands have a set of 31 specific indicators.

The scores for all individual indicators in Table 1 that have been assessed should be summed up, and the sum of the indicator scores needs to be expressed as a percentage of the maximum score. The actual percentage shows the degree of deviation of a wetland from its natural condition.

The Ecological Condition Score for wetland = (Sum of the indicator scores /(Number of indicators assessed × 3)) × 100

BOX 2: INDICATORS FOR DIFFERENT TYPES OF WETLANDS

River segments under Ramsar site:
1.1-1.3, 2.1, 2.4, 3.1-3.5, 3.7, 3.9, 4.3, 4.4, 5.1-5.13, 6.1-6.5, 6.7-6.13

Freshwater wetlands
1.1-1.5, 2.2-2.4, 3.1-3.9, 4.1-4.4, 5.1-5.11, 5.13, 5.14, 6.1-6.13

Coastal wetlands (estuaries and lagoons)
1.1-1.5, 2.2-2.4, 3.2-3.5, 3.9, 5.1-5.9, 5.14, 6.1, 6.3-6.5, 6.7, 6.8, 6.12, 6.13

Range of score		
1 (Poor)	**2 (Fair)**	**3 (Good)**
>10 mg/L	Maximum 10 mg/L	Well below 10 mg/L
Substantial human pressure.	Fairly low human pressure.	No human pressure.

Annexure 1

MONITORING WETLAND: BASELINE INFORMATION

A. Salient features

S. no.	Parameter	Explanation	Description/note
1	Name of wetland	Write the name of the wetland.	
2	Coordinates of site	Use a GPS to note the coordinates. If needed, note the GPS coordinates at specified intervals along the boundary of the wetland.	
3	State	Write the name of the state.	
4	District	Write the name of the district.	
5	Taluka	Write the name of the taluka/block.	
6	Closest village	Write the names of the closest villages	
7	Ownership of land	Please write down who owns the wetland: government, community, private	
8	Management category	National Park / Sanctuary / Community Reserve / Conservation Reserve / Ramsar site / Nationally Notified Wetland / Reserve Forest / Protected Forest / Community managed or others. If a wetland falls under multiple categories, write down all the categories.	
9	Nodal management department/agency	Information regarding wetlands under protected areas can be obtained from forest departments. Information about wetlands under non-protected areas can be obtained from municipal corporations or any other state agencies.	
10	Biogeographic zone	Write down the biogeographic zone.	
11	Name of catchment	Write the name of the catchment name as in toposheets from the Survey of India.	
12	Name of sub-catchment	Write the name of the sub-catchment as in toposheets from the Survey of India.	
13	Wetland types	Write the wetland type as given in the Ramsar list.	
14	Source of water	Mention the source of the water (river/stream/other wetland/runoff/rain-fed/ storm water/sewage)	
15	Listed in Asian Wetland Directory	Mention if the wetland is listed in the Asian Wetland Directory.	
16	Listed as Important Bird Area (IBA)	Mention if the wetland is listed as an IBA site. If it is listed, provide the reference number.	
17	Approach	Mention how to reach the wetland by road and rail.	
18	Size	< 2.5 ha 2.5-50 ha > 50 ha	
19	Water spread area (ha)	Mention the date of the image used for the assessment. A comparison of older and recent images will help detect changes.	

B. Description of the wetland ecosystem and biodiversity
(brief review of the status of the wetland and its biodiversity; this will be used to define a specific survey strategy)

Site-specific assessment sheets need to be prepared on the basis of these preliminary data.			
1	Wetland map	A digital map should be prepared to delineate the wetland boundary, water spread area and Zone of Influence. Information regarding forest cover, linear structures, connectivity with other water bodies, and other land use shall be demarcated in a 500-1000 m buffer from the wetland boundary (according to the size and zone of influence of the wetland). Sampling sites/plots for measurement of water depth, assessment of water quality and inventory of aquatic and riparian vegetation should be demarcated on the basis of grid. Grid size shall be calculated on the basis of the size of the wetland. The sampling sites/plots/ transects for river stretches should be delineated according to habitat mosaic, hydrology regime and biodiversity.	
2	Biodiversity	Checklist of riparian vegetation	List table and total numbers
		Checklist of aquatic vegetation	List table and total numbers
		Checklist of plans with medicinal value	List table and total numbers
		Checklist of fishes	List table and total numbers
		Checklist of amphibians	List table and total numbers
		Checklist of turtles	List table and total numbers
		Checklist of crocodiles	List table and total numbers
		Checklist of birds	List table and total numbers
		Waterbird and water associated bird congregation	Total numbers
		Checklist of mammals	List table and total numbers
		Species listed in the Wildlife (Protection) Act, 1972, and total numbers	Provide species-wise table
		Species listed in IUCN Red List, and total numbers	Provide numbers of species

3. Whether the wetland fulfils the criteria for the designation of Wetlands of International Importance - Ramsar Site

[If prior information to evaluate the criteria is not available, the data can be filled after comprehensive monitoring]

Criteria			If the criteria is fulfilled, provide description
A. Group A of the Criteria. Sites containing representative, rare or unique wetland types		Criterion 1: Whether it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	
Group B of the Criteria. Sites of international importance for conserving biological diversity	Criteria based on species and ecological communities	Criterion 2: Whether it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	
		Criterion 3: Whether it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.	
		Criterion 4: Whether it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	
	Specific criteria based on waterbirds	Criterion 5: Whether it regularly supports 20,000 or more waterbirds.	
		Criterion 6: Whether it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.	
	Specific criteria based on fish	Criterion 7: Whether it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	
		Criterion 8: Whether it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	
	Specific criteria based on other taxa	Criterion 9: Whether it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.	

Note: Site-specific assessment sheets need to be prepared on the basis of these preliminary information.

Annexure 2

DATA SHEET FOR HABITAT SURVEY

(This data sheet should be carried along with Annexure 1 (Salient Features) when the field survey is being conducted. A common code (alpha-numerical) should be generated for the surveyed wetland for uniformity amongst the other datasheets. The water quality samples should also use the same code.)

Name of wetland:	**Date:**	**Code:**
Team:		
Perceived pollution:		
Odour (please tick multiple): Decaying/pungent/chemical/none		
Colour (please tick multiple): Greenish/brownish /no colour		
Floating debris (visual estimate, please tick multiple):		
Thermocol: None/low/medium/high		
Plastic: None/low/medium/high		
Other: None/low/medium/high		
Floating macrophyte cover (visual estimate, please tick): <20% /20-50%/>50%		
Inflow point(s):		
(Please write the number of points. Code them according to the wetland code, take samples for laboratory analysis, and record the pH and conductivity at each point before and after the confluence):		
Sewage/industrial		
Storm water/none		
Litter in and around the wetland (visual estimate): No waste/negligible/high		
Barriers to connectivity (please tick multiple):		
Barriers upstream: Dam/barrage/check-dam/sluice		
Barriers downstream: Dam/barrage/check-dam/sluice		
None		
Fish pass/ladder (please tick multiple): Present/non-functioning/functioning/absent/NA		
Hydrological connectivity [with any surface water] (please tick):		
Regular/seasonal (local knowledge)/connectivity lost/non-existent		
Groundwater withdrawal [numbers of bore wells, dug wells and hand pumps within 500 m of the boundary of the wetland]:		
Active (nos.):	Dried (nos.):	
Contaminated (nos.):		
Use of pesticide:		
(Estimate the extent of the agricultural area and enquire about local practices. Also write the names of frequently used pesticides. Please tick.)		
<10%/ 10-25%/>25%	Pesticides:	
Native vegetation cover in floodplain (visual estimation, please tick): >70%/50-70%/<50%		
Native vegetation cover along shoreline (visual estimation, please tick): >80%/75-80%/<75% / no vegetation		
Littoral zone (depth <2 m) (visual estimate and information from the local community):		

Change in last 10 years: >25% disturbed and increasing/< 25% disturbed and decreasing/no change
Micro-algae layer (please tick): <0.1 cm/0.1-1 cm/>1 cm
Free-floating invasive species (visual estimation, please tick): None/<50%/>50%
Reclamation of wetland (Field observation/secondary information from local community, please tick):
Completely drained/partially drained/only natural water level fluctuation
Fishing:
(Field observation/secondary information from local community/market survey. Please tick.)
Extensive, commercial, destructive
Seasonal, commercial
Traditional (subsistence consumption)
Biomass extraction:
(Field observation/secondary information from local community/market survey. Please tick.)
Extensive, removal of rare, endangered, threatened (RET) species/
Occasional, no removal of RET species/Negligible
Grazing:
(Visual assessment of number of cattle, dung and tracks. Please tick.)
Throughout, severe damage to vegetation/ Access to 25-50% of the area, moderate damage to vegetation/
Access to <25% of the area, little damage to vegetation/
Mining:
(Visual estimate, please tick)
Extensive, mechanized, commercial/ Traditional mining for local subsistence/
No mining activity
Washing/bathing (visual estimate, please tick): Regular/occasional/none
Other:
[Landfills, defaecation, wallowing of cattle, drying of cow-dung cakes, overhead power lines crossing the wetland, etc., affecting the integrity of the wetland. Please tick.]
Substantial human pressure/
Fairly low human pressure/
No human pressure

Annexure 3

DATA SHEET FOR BATHYMETRIC SURVEY

Wetland code: **Date:**

Team:

Instrument used* (please tick): Acoustic based flow meter/depth meter

*If an Acoustic based flow meter is used, a depth profile will be generated automatically and can be interpolated in the GIS domain to produce a bathymetry map. If a depth meter is used, the following data should be collected by boat.

Site**	GPS location		Depth (m)	Remarks
	Lat.	Long.		

**The sites should be predetermined during a preliminary GIS-based assessment. Sites (number and location) may change if they are found to be inaccessible or unsuitable during reconnaissance survey of the wetland.

Annexure 4

GUIDELINES FOR SAMPLING OF WATER AND SEDIMENT QUALITY PARAMETERS

[The following guidelines are an adaptation of the Guidelines for Water Quality Monitoring, MINARS/27/2007-08 prepared by the Central Pollution Control Board. For details of the methodology, kindly refer to that document.]

1. Planning for sampling

It is necessary to select the sampling points of a survey location in such a manner that all the locations can be covered and the samples delivered to a designated laboratory on the same day. If required, more teams may be deployed for a synchronous sampling effort.

2. Sampling guideline

A checklist of the essential items that need to be carried to the field is presented in Table 1. The list is tentative and may be changed according to the sampling strategy.

Table 1. Checklist of items to be carried to the field

S.No.	Items			
1.	Itinerary for the trip (location, route, permission for sampling, if any)			
2.	Sampling site location map			
3.	Data sheet for sampling			
4.	Labels for sample containers			
5.	Equipment and necessary tools	Distilled water (sufficient amount for rinsing sampling bottles, probes)		
6.	If probes are used, separate pH, total dissolved solids (TDS), conductivity and dissolved oxygen (DO) meters need not be taken.	pH meter		
7.		TDS/conductivity meter		
8.		DO meter		
9.		Secchhi disc		
10.		Thermometer (0° to 50°C with a resolution of 0.1°C)		
11.		Polyethylene (PE) beaker (500 mL) for on-site assessment		
12.		PE pipettes of 1 mL, 2 mL, and 5 mL capacity for adding chemical preservative/fixative		
13.		Measuring tape (30-50 m)		
14.		Field notebook, pen/pencil/marker, knife, scissors		
15.		Aluminium foil		
16.		Rope (Nylon, minimum 10 m)		
17.		Gloves and eye protection		
18.		First-aid box		
19.	Sample containers	Icebox (4050 L capacity)		
Specifications for sampling bottles				
20.	Sampling bottles	Parameter	Volume (mL)	Container type
		DO	300	Glass
		General (suspended solids, total dissolved solids, major ions)	1000	Wide-mouth PE
		Chemical oxygen demand (COD), ammonia, nitrate, nitrite	500	Narrow-mouth PE

Sampling bottles	Parameter	Volume (mL)	Container type
	Biochemical oxygen demand (BOD)	1000	Narrow-mouth PE
	Phosphate	100	Wide-mouth PE
	Heavy metal (water)	500	PE
	Heavy metal (sediment)	500	PE zip pouch
	Pesticides (water)	1000	Brown glass
	Pesticides (sediment)	500	PE zip pouch

Specifications for sample preservation			
21.	Sample preservation	Parameter	Preservation
		General	Ice preserve at 4°C
		DO	Manganous sulfate and sodium iodide-azide
		BOD	Ice preserve at 4°C in the dark (can be wrapped with aluminium foil)
		COD, ammonia, nitrate, nitrite	Concentrated Sulfuric acid, preserved to a pH < 2 and maintained at 4°C until analysis
		Heavy metal in water	Concentrated Nitric acid, preserve to a pH < 4
		Heavy metal in sediment	Ice preserve at 4°C
		Pesticides in water	Ice preserve at 4°C
		Pesticides in sediment	Ice preserve at 4°C

General guidelines

- Rinse the sample container three times with the sample before it is filled.
- Leave a small air space in the bottle to allow mixing of the sample at the time of analysis.
- Label the sample container properly, preferably by attaching an appropriately inscribed tag or label. The sample code and the sampling date should be clearly marked on the sample container or the tag.
- Samples will be representative of different hydrology regimes (depth, flow) of the wetland and river stretch. The sampling points shall cover the regimes before (upstream) and after (downstream) confluences with rivers or drains. The downstream samples should be collected from a well-mixed section.
- The sampling depth shall be 30 cm below the water surface. Avoid floating particles/algae during sampling.
- The DO in the sample must be fixed immediately after collection, using chemical reagents. The DO concentration can then be determined in the field or, later, in a laboratory.
- If hand-held water testing probes are used, the sample should be collected in a PE beaker and the probe shall be inserted in the beaker for the reading. Avoid introducing the probes directly into the water. The probes should be rinsed with distilled water before and after sampling.
- Care should be taken to avoid damaging submersible probes when they are introduced into the water. The probes shall not touch the bottom of the water body. The probes should be rinsed with distilled water before and after sampling.
- Samples for BOD analyses shall be stored at a temperature below 4°C and in the dark as soon as possible after sampling by being placed in an insulated ice box with ice or ice packs. Once in the laboratory, the samples should be transferred as soon as possible to a refrigerator.
- Samples taken for COD analysis should be preserved below pH 2 by addition of concentrated sulfuric acid. This procedure should also be followed for samples taken for ammonia, nitrate, and nitrite analysis.

- Samples taken for heavy metals in water should be preserved by adding concentrated nitric acid at a pH value below 2. Such samples can then be kept up to 6 months. Samples taken for mercury should be collected separately in a brown narrow-mouth glass bottle, and analysis shall be carried out within 5 weeks.
- After labeling and preservation, the samples should be placed in an insulated ice box for transportation.
- Samples should be transported to the laboratory as soon as possible, preferably within 48 hours.

Note:

- Precautions shall be taken during the collection and handling of samples, their preservation and their storage. Carelessness during these activities may result in erroneous results and may not provide the actual environmental conditions.
- Where the tasks of sampling (and preservation) and chemical analysis belong to different groups, lack of communication may easily lead to erroneous results. Therefore, it is essential to circulate standard operating procedures, the sampling strategy, the number of samples and the schedule of the sampling to all the groups concerned.

Annexure 5

DATA SHEET FOR SAMPLING AND FIELD ASSESSMENT OF WATER AND SEDIMENTS

['Guidelines for Water Quality Monitoring, 2017', published by the Central Pollution Control Board (CPCB), Ministry of Environment, Forest & Climate Change, Government of India, should be followed during sampling, sample preservation and transportation of samples to the laboratory.]

Wetland code: **Date:** **Team:**

Weather (please tick multiple): Windy/ rain (steady)/ showers (intermittent)/ clear-sunny/ overcast

Has there been heavy rain in the last 7 days? (Y/N):

About the wetland

Sampling site code	GPS location		Sampling depth (m)	AT*	WT*	pH	Cond. (mS/cm)	TDS (mg/L)	DO (mg/L)	NO3-N (mg/L)	Secchi depth (cm)
	Lat.	Long.									

*AT: Air temperature, WT: Water temperature

Ensure that samples are collected for the following.

Please tick	Parameters	Sampling site code(s)	Preservation method
	Oil & Grease		
	BOD		
	SAR		
	Boron		
	Po4		
	NH3-N		
	Heavy metal (water and sediment)		
	Pesticide (water and sediment)		
	Faecal Coliform		

About wastewater inflow points

Sampling site code	GPS location		Sampling depth (m)	WT	pH	Cond. (mS/cm)	TDS (mg/L)
	Lat.	Long.					

Ensure that samples are collected for the following.

Please tick	Parameters	Sampling site code	Preservation method
	General (TS*, TSS*, TDS*, Turbidity)		
	BOD		
	COD		
	Total nitrogen		
	Total phosphorus		
	Faecal Coliform		

*TS: Total solids, TSS: Total suspended solids, TDS: Total dissolved solids

Note: Take samples of industrial discharges according to the type of industry. Follow the guidelines in 'Pollution Control Law Series: PCLS/4/ 2000-2001, Environmental Standards for Ambient Air, Automobiles, Fuels, Industries and Noise', published by the Central Pollution Control Board (CPCB), Ministry of Environment, Forest & Climate Change, Government of India.

Annexure 6

DATA SHEET FOR AQUATIC VEGETATION SURVEY

Wetland code: Date:

Observer:

Plot no.*	GPS location		Species**	Nos.
	Lat.	Long.		

*The plots may be predetermined during a preliminary GIS-based assessment. The plots (number and location) may change if they are found to be inaccessible or unsuitable during reconnaissance survey of the wetland.

**The species, if not identified at the site, may be coded and brought back to the laboratory/institute for identification.

Annexure 7

PROTOCOL FOR BIOMONITORING (BWQC)

[Please follow the methodology described in 'De Zwart, D. and Trivedi, R. C. (1995). Manual on Integrated Water Quality Evaluation. RIVM, Bilthoven, The Netherlands. RIVM report 208023003.' An introduction to BWQC and the data sheets to be used for assessment are as follows.]

Biological Water Quality Criteria (BWQC)

When evaluating the biological water quality, the diversity of the benthic biota is compared with the saprobity score (oxygen demand) in the Biological Water Quality Criteria (BWQC) assessment method. The BWQC have been developed by the Central Pollution Control Board (CPCB). These criteria are based on a range of saprobic values and diverse benthic macro-invertebrate families and their relation with water quality. The 'Manual on Integrated Water Quality Evaluation' (de Zwart & Trivedi 1995) has details of the assessment methodology for reference.

Sampling criteria

1. The sampling should be done by first evaluating the nature of the bed material of the wetland.
2. In rocky segments of fast-flowing channels, grab samples of the bed materials should be collected using shovels. Large stones should be hand-picked and collected on a tray. The hand net (pore size 0.6 mm) should also be used and placed firmly in the bed while sand and pebbles are scraped along the riverbed against the current. All the shoveled and scraped materials should be collected in the tray. Organisms attached under rocks should be collected cautiously to avoid physical damage.
3. When the bed is sandy, nets (pore size 0.6 mm) should be placed facing the current in the riverbed. The bed material should be scraped to catch benthos in the net. Organisms should be collected using forceps. In a wetland, the bed material should be scraped along with the aquatic vegetation.
4. In a muddy or silt bed, the bed material should be collected along with the aquatic vegetation using a shovel and placed into a sieve (Number 30 US Standard sieve with pore size 0.6 mm). The materials should be washed in the water, and organisms should be picked up using forceps.
5. The sampling exercise should be repeated at different points in the sampling location so that at least 150 organisms are assessed for diversity.
6. The organisms should be identified up to the family level according the guidelines. The saprobity data sheet (Table 1) should be filled.
7. The collected animals should be kept in a separate white tray for identification and scoring. The taxonomic key of de Zwart and Trivedi (1995) should be used. Each family should be given a biological monitoring working party (BMWP) score in a scale from 1 to 10 (Table 1). The score should then be multiplied by the number of families encountered in the group. The Saprobic Score should be estimated using the following formula:

$$\text{Saprobic Score} = \frac{\text{Grand total multiplied BMWP Score}}{\text{Grand total number of families encountered}}$$

8. The Diversity Score should be estimated by pair-wise comparison of the sequentially encountered individuals or run. The first animal is given a score of 1. The next similar organism is given a score of 0, a dissimilar organism is given a score of 1 and so on. The run is estimated according to Table 2.
9. The Diversity Score should be calculated using following formula:

$$\text{Diversity Score} = \frac{\text{Number of Runs}}{\text{Number of Organisms}}$$

10. Using the Saprobic Score and Diversity Score, the Biological Water Quality Criteria (BWQC) should be estimated as proposed by de Zwart and Trivedi (1995) (Table 3).

Table 1. Data sheet for BMWP scoring

Taxonomical class	BMWP score	Families	Present (1A, 1B, 1C)	Aggregate score
Ephemeroptera	10	Siphlonuridae, Heptageniidae, Leptophlebiidae, Ephemerellidae, Potaminthidae, Ephemeridae		
Plecoptera		Taeniopterygidae, Leuctridae, Capniidae, Perlodidae, Perlidae, Chloroperlidae		
Hemiptera		Aphelocheiridae		
Trichoptera		Phryganeidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Lepidostomatidae, Brachycentridae, Sericostomatidae		
		Total number of families =	… × 10	
Odonata	8	Lestidae, Argidae, Gomphidae, Cordulegastridae, Aeshnidae, Corduliidae, Libellulidae		
Trichoptera		Psychomyiidae, Philopotamidae		
		Total number of families =	… × 8	
Ephemeroptera	7	Caenidae		
Plecoptera		Nemouridae		
Trichoptera		Rhyacophilidae, Polycentropodidae, Limnephilidae		
		Total number of families =	… × 7	
Mollusca	6	Neritidae, Viviparidae, Ancylidae, Unionidae		
Trichoptera		Hydroptilidae		
Crustacea		Corophiidae, Gammaridae, Palaemonidae		
Polychaeta		Nereidae, Nephthyidae		
Odonata		Platycnemididae, Coenagriidae		
		Total number of families =	… × 6	
Hemiptera	5	Mesoveliidae, Hydrometridae, Gerridae, Nepidae, Naucoridae, Notonectidae, Pleidae, Corixidae		
Coleoptera		Haliplidae, Hygrobiidae, Dytiscidae, Gyrinidae, Hydrophilidae, Helodidae, Dryopidae, Elminthidae, Chrysomelidae, Curculionidae		
Trichoptera		Hydropsychidae		
Diptera		Tipulidae, Simuliidae		
Rhabditophora		Planariidae, Dendrocoelidae		
		Total number of families =	… × 5	
Ephemeroptera	4	Baetidae		
Megaloptera		Sialidae		
Hirudinea		Piscicolidae		
		Total number of families =	… × 4	

Taxonomical class	BMWP score	Families	Present (1A, 1B, 1C)	Aggregate score
Mollusca	3	Valvatidae, Hydrobiidae, Lymnaeidae, Physidae, Planorbidae, Sphaeriidae		
Hirudinea		Glossiphoniidae, Hirudinidae, Erpobdellidae		
Crustacea		Asellidae		
		Total number of families =	… × 3	
Diptera	2	Chironomidae		
		Total number of families =	… × 2	
Oligochaeta	2	All families		
		Total number of families =	… × 1	
		Grand total score =		

Table 2. Data sheet for estimation of Run and Diversity Score

Organisms															Total Runs	Total organisms	Diversity Score
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
															15		
															30		
															45		
															60		
															75		
															90		
															105		
															120		
															135		
															150		

Table 3. Biological Water Quality Criteria (BWQC)

Range of Saprobic Score	Range of Diversity Score	Water quality characteristics	Biological Water Quality Class	Indicator color
7 and more	0.2-1	Clean	A	Blue
6-7	0.5-1	Slight pollution	B	Light blue
3-6	0.3-0.9	Moderate pollution	C	Green
2-5	0.4 and less	Heavy pollution	D	Orange
0-2	0-0.2	Severe pollution	E	Red

Annexure 8

DATA SHEET FOR FISH SURVEY

Wetland code: Observers:

Site no. GPS location: Start time: End time:

Water temperature (°C): Air temperature (°C):

Site code	Net type	Total effort	Fish species	Nos.	Length (cm) (each individual)	Weight (gm) (each individual)
1.						
2.						
3.						
4.						
5.						

Caution: Release fishes as soon as they are identified and measurements have been taken. For Schedule I species, extra precautions should be taken during handling.

Annexure 9

DATA SHEET FOR AMPHIBIAN SURVEY

Wetland code: Observers:

GPS location: Start time: End time:

Water temperature (°C): Air temperature (°C):

Visual encounter method

#	GPS location		Time	Species (if not identified, take photograph and write the photo ID)	Nos.	Basking substrate*
	Lat.	Long.				
1						
2						
3						
4						
5						

Basking substrate:

W: Water, P: Pebbly, S: Sandy, Si/C: Silt-clayey, Vgl.: Vegetation on land, Vga.: Vegetation aquatic

Annexure 10

DATA SHEET FOR TURTLE SURVEY

Wetland code: Observers:

GPS location: Start time: End time:

Water temperature (°C): Air temperature (°C):

Visual encounter method

S. no.	GPS location		Species (if not identified, write hardshell or softshell)	Age class			Basking substrate*	Suitable for nesting (Y/N)
	Lat.	Long.		Adult	Juvenile	Hatchling	Unidentified	
1								
2								
3								
4								

Basking substrate
P: Pebbly, S: Sandy, Si/C: Silt-clayey, Vg.: Vegetation

Nesting** (if any):
Numbers of nests:

Species:

*Note: During a survey, record probable nesting sites, if any, or get information about nesting activity from the local community.

Annexure 11

DATA SHEET FOR CROCODILE SURVEY

Wetland code: Observer:

GPS location: Start time: End time:

Water temperature (°C) Air temperature (°C)

#	Time	GPS location		Species	Hatchling (<60 cm)	Juvenile I (>60 cm to <1.2 m)	Juvenile II (>1.2 to <1.8 m)	Sub-adult (>1.8 to <2.7 m)	Adult (>2.7 m)	Water depth (m)	Shoreline feature (multiple)	Human activities (multiple)
		Lat.	Long.									
1												
2												
3												
4												

Shoreline feature
P: Pebbly, S: Sandy, Si/C: Silt-clayey, Vg.: Vegetation

Human activities
M: Mining, W/B: Washing-bathing, F: Fishing, T: Tourism, D: Drain, A: Agriculture

Annexure 12

DATA SHEET FOR WATER AND WATER ASSOCIATED BIRD SURVEY

Wetland code: Observer:

Site no. GPS location: Start time: End time:

Water temperature (°C) Air temperature (°C)

A. Water and water associated birds

Obs.	Time	Distance (m)	Bearing (°of angle)	Species	Numbers
1.					
2.					
3.					

B. Nest count

Obs.	Site no.	Nest code	Clutch size	Species
1.				
2.				
3.				

Annexure 13

DATA SHEET FOR OTTER SURVEY

Wetland code: Observers:

GPS location: Start time: End time:

Water temperature (°C): Air temperature (°C):

Site	GPS location		Wetland type	Type of sign	No. of otters seen	Water depth (m)	River width (m)	Bank land use	Shoreline substrate	Remarks
	Lat.	Long.								
1.										
2.										
3.										
4.										

Wetland Type
NSR: Narrow (<200m) straight river, WSR: Wide (>200m) straight river, NMR: Narrow meandering river, WMR: Wide meandering river, B: Braided, I: Island, MF: Marshy freshwater, Mg: Mangrove, OB: Ox-bow lake, MM: Man-made

Type of signs
Fp: Foot prints, Sp: Spraint, Gro: Grooming site, Ho: Holt, Oth: Others

Bank land use
F: Forested, Ag: Agriculture, U: Urban, R: Rural

Shoreline substrate:
P: Pebbly, S: Sandy, Si/C: Silt-clayey, Vg.: Vegetation

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