July 2025

National Mission for Clean Ganga

Ministry of Jal Shakti

Department of Water Resources, River Development &
Ganga Rejuvenation, Government of India

सत्यमेव जयते

RIVER HEALTH ASSESSMENT [RHA]

State-of-the-Art, Challenges, and Coordination Framework

cGanga

Centre for Ganga River Basin
Management and Studies
Indian Institute of Technology Kanpur

National Mission for Clean Ganga (NMCG)

NMCG is the implementation wing of National Ganga Council which was setup in October 2016 under the River Ganga Authority order 2016. Initially NMCG was registered as a society on 12th August 2011 under the Societies Registration Act 1860. It acted as implementation arm of National Ganga River Basin Authority (NGRBA) which was constituted under the provisions of the Environment (Protection) Act (EPA) 1986. NGRBA has since been dissolved with effect from the 7th October 2016, consequent to constitution of National Council for Rejuvenation, Protection and Management of River Ganga (referred to as National Ganga Council).

www.nmcg.in

Centre for Ganga River Basin Management and Studies (cGanga)

cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this it is also responsible for introducing new technologies, innovations and solutions into India.

www.cganga.org

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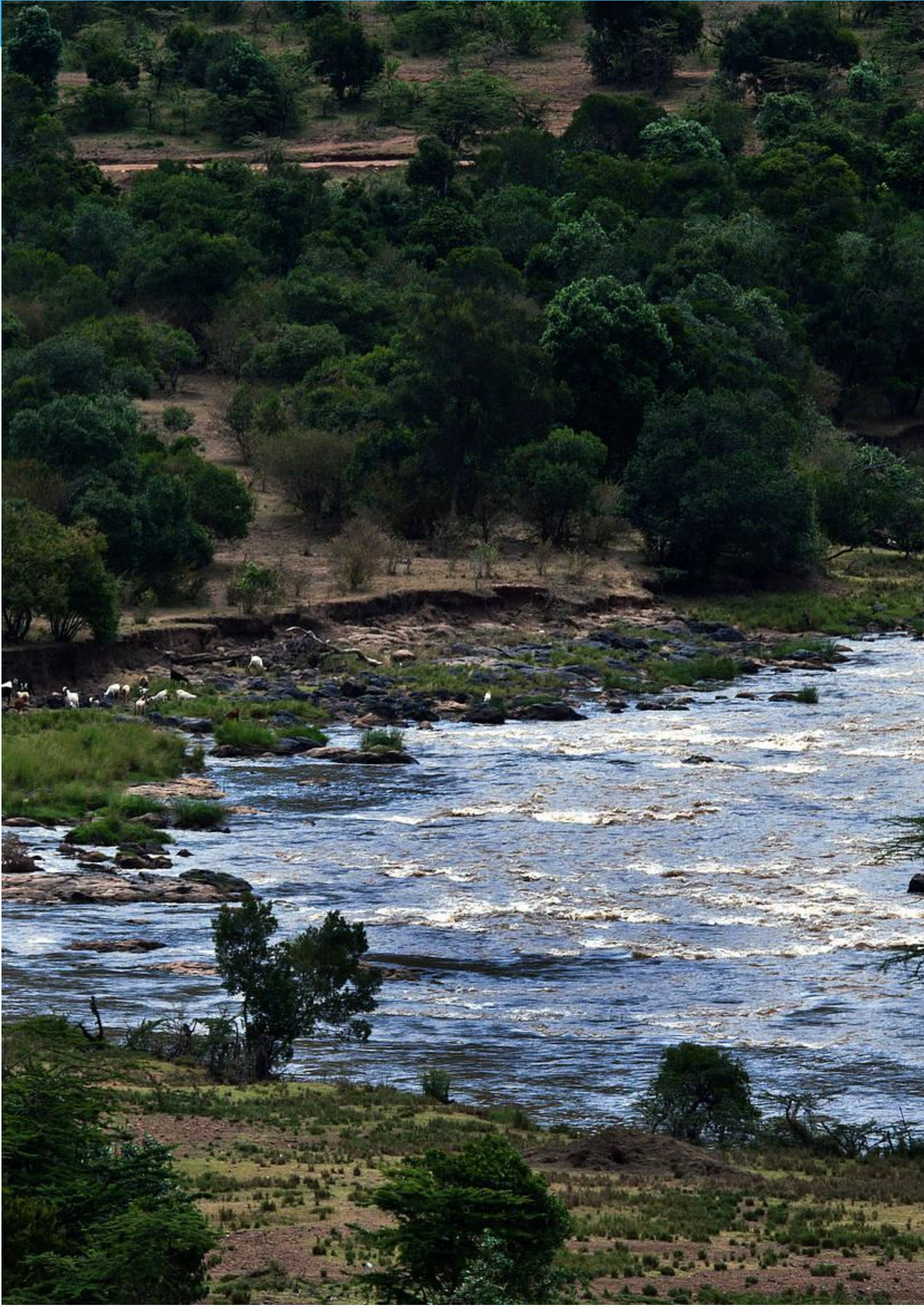

Preface

Rivers are more than waterways; they are the lifelines of our societies, economies, and ecosystems. Their health determines the well-being of millions of people, the sustainability of livelihoods, and the resilience of biodiversity. Yet, rapid industrialization, urban growth, and unsustainable practices have placed unprecedented stress on these fragile systems. Recognizing the urgent need for a comprehensive framework to understand, monitor, and restore our rivers, this report has been prepared as a step toward redefining river health assessment in India.

This report presents a comprehensive approach to river health assessment, combining global best practices with lessons from the Indian context. It emphasizes the need for multi-dimensional indices, standardized monitoring protocols, and institutional coordination across agencies. Importantly, it advocates for a hybrid model that leverages both advanced sensor technologies and participatory community-based monitoring. Such an approach will not only improve the quality and density of data but also foster accountability, transparency, and inclusiveness in river basin management.

cGanga, a think tank created as a knowledge partner to NMCG in 2016 as a follow-up to the Ganga River Basin Management Plan (GRBMP) submitted by the Consortium of 7 IITs (IITC) in 2015, holds the mandate to support the implementation of the GRBMP and dynamically evolve future versions. It is with this background that cGanga, IIT Kanpur and twelve other Indian premier institutions involved in the Condition Assessment and Management Plan (CAMP) project of the National River Conservation Directorate (NRCD), Do WR, RD & GR, MoJs, GoI for six other rivers of India (other than the Ganga) have been brainstorming on this subject.

The report also presents the pioneering River Health Monitoring Pilot, designed to establish an inclusive, four-tier framework that combines citizen science with institutional expertise. By engaging local communities through River Scouts, fostering real-time monitoring through digital platforms, and integrating biological, hydrological, and ecological indicators, this initiative represents a new paradigm in river stewardship.

It is our hope that the insights and frameworks detailed here will not only guide policymakers and practitioners but also inspire collective ownership of rivers as shared heritage. This preface is therefore not an introduction, but a call—to rethink, to reimagine, and to re-engage with our rivers in ways that ensure their vitality for generations to come.

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1. Introduction

Rivers are ecological, social, and economic lifelines. Monitoring their health is vital for water security, biodiversity conservation, and sustainable development. River health refers to the ecological integrity of rivers—the ability to maintain natural structure and functions while continuing to provide ecosystem services and cultural values. It integrates hydrology, geomorphology, water quality, biology, and ecological processes.

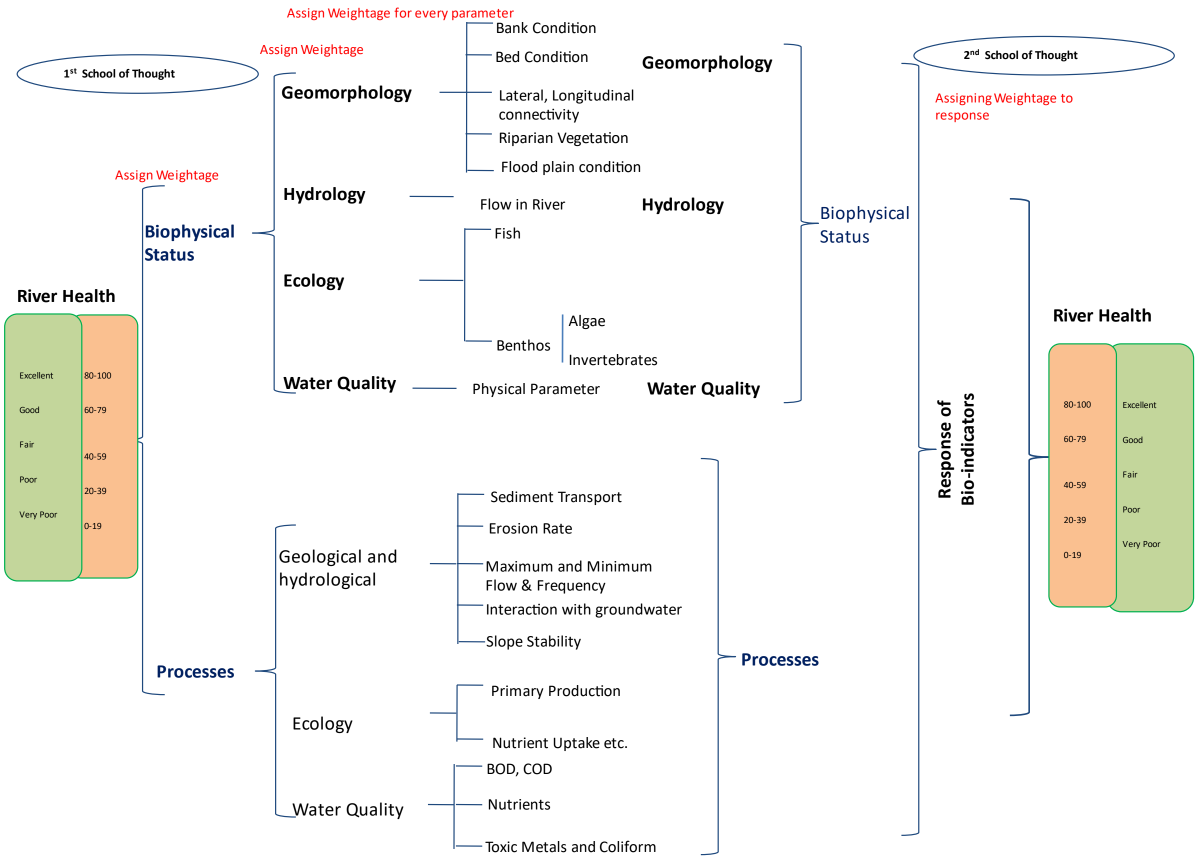

Figure 1: Two Schools of Thought on River Health

While high-end sensor technology is advancing, **River Health Assessment (RHA)** in India must combine **technology-driven methods** with **participatory monitoring**, especially given the diversity of rivers and the gaps in institutional coverage.

2. Dimensions and Indices for RHA

River health assessment uses multiple dimensions, measured by different indices globally, such as the BMWP (macroinvertebrates), IBI (fish), IHA/RVA (hydrology), and WQI variants for water quality. These provide diagnostic and composite perspectives on ecological status.

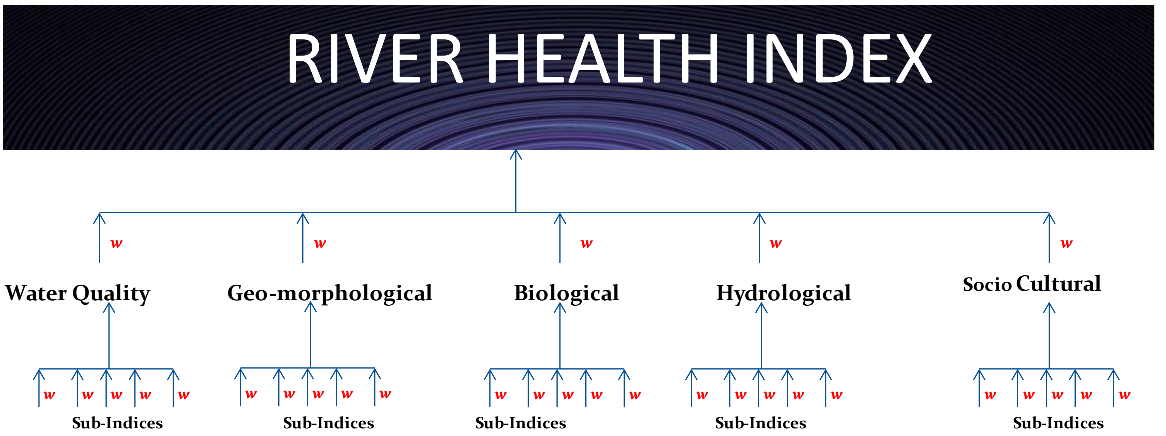

Figure 2: Dimensions of RHA

3. State-of-the-Art Worldwide

Global best practices (EU WFD, US EPA, Australia, South Africa) show that successful RHA relies on:

1. **Multi-dimensional indices** (hydrology, geomorphology, water quality, biology).
2. **Standardized monitoring protocols** for comparability.
3. **Institutionalized coordination** across agencies.
4. **Public-facing dashboards/report cards** for transparency.

4. State-of-the-Art in India

India has **fragmented efforts**:

- CPCB/SPCBs operate water quality stations (>2500), but focus mainly on DO, BOD, pH, EC & Total Coliform/E coli/Fecal coliform.
- CWC runs hydrological and sediment monitoring stations.
- NGOs and academic institutions (IITs, WWF, WII, CIFRI) run pilots on ecology and biomonitoring.
- **cGanga's RHM Pilot** is pioneering integration of **river scouts**, **sensors**, and **indices** across 920 km of the Ganga (Details in Annexure I)

Gap: No single national framework integrates these efforts into a coherent **River Health Index (RHI)**.

5. Challenges in Adopting RHA

- Over-reliance on sensors and water quality only.
- No integration of biology/geomorphology with hydrology and water quality.
- Weak participatory inclusion.
- Turf issues between central, state, and academic agencies.
- Unclear funding model.

6. Real-Time Sensors vs Participatory Monitoring

6.1 Desirability of Sensors

- Real-time sensors are valuable for **transparency** and **continuous data** on parameters like DO, pH, EC, turbidity.
- They are effective for trend detection, event alerts, and public dashboards.

6.2 Limitations of Sensors

- Reliable sensors are **not available** for many crucial parameters: ammonical nitrogen, total nitrogen, nitrate, nitrite, phosphorus, heavy metals, emerging contaminants.
- **Biological aspects** (coliforms, pathogens, macroinvertebrates, keystone species) cannot be measured by sensors.
- Globally, **no regulator or judiciary accepts sensor-only data except for a few parameters** (e.g. temperature, pH, DO, EC) for compliance, contractual, or judicial purposes.

6.3 Why Participatory Monitoring is Unavoidable

The present model of monitoring river health in India—where the Central Water Commission (CWC) measures gauge, discharge, sediment and quality (GDSQ) and the Central Pollution Control Board (CPCB) along with State Pollution Control Boards (SPCBs) monitor water quality—is not scalable and suffers from critical gaps.

- Limited coverage:
  - ➢ For example, CWC maintains a total of 1,014 stations covering seven major river basins namely, Ganga, Mahanadi, Narmada, Godavari, Krishna, Cauvery & Periyar out of over 16,000 major and medium rivers in these basins covering about 53.5 % of India's geographical area. Further about 25 % of these stations measure Gauge (G), Discharge (D), Suspended Sediment (S) and Water Quality (Q) while remaining measure either G, GD, GDQ or GDS.
  - ➢ CPCB/SPCBs monitor water quality at just over 2000 locations for over 30,000 (estimated) rivers whose names are available and where assessment is required.
  - ➢ On an average, there is one CWC station per 350 km of river length and one CPCB/SPCB station per 400 km—far below what is required for meaningful assessment. Many of the CWC and CPCB/SPCBs sampling & monitoring stations are nearby and do not supplement each other in terms of number of locations where monitoring is done.

- Capacity and cost limitations: Expanding the existing model to cover all rivers at sufficient density would require massive investments and institutional capacity, which is unrealistic under current frameworks.

- Credibility concerns: Both CWC and CPCB/SPCBs are government agencies, raising issues of independence and credibility because the same agencies act as regulators, monitors, and implementors of schemes/programmes/projects. Globally, effective monitoring often requires independent or third-party validation, which is missing in the current model.

- Policy recognition: The Samarth Ganga Framework, formally accepted by NMCG (National Mission for Clean Ganga) and NRCD (National River Conservation Directorate), explicitly recognises Jan Ganga (People's Ganga) as one of the five key pillars of river rejuvenation. This framework underscores the importance of Jan Bhagidari (public participation) and Jan Andolan (public movement) as central components of successful river conservation.

Importance of Participatory Monitoring

Given these limitations, participatory monitoring is not optional but a necessity. Its benefits include:

Basic parameters with low-cost kits: Trained River scouts can measure temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), river gauge, and flow velocity reliably and at low cost.

High-frequency observations: Measurements at least twice daily (before sunrise and at sunset) provide dense and frequent datasets, compared to the sparse institutional networks.

Support for biological profiling: Scouts can collect samples for macroinvertebrates, diatoms, fish, pathogens, which academic and research institutions can then analyse—bridging a critical gap in biological assessment.

Employment generation: Each river stretch can support local scouts, create thousands of livelihood opportunities while promoting stewardship.

Community empowerment: Participatory monitoring enhances transparency and accountability, enabling riverside communities to press governments to act.

Cost-effectiveness: Networks of community monitors are significantly cheaper to operate than expanding high-end sensor networks or government stations, while offering far greater spatial and temporal coverage.

Conclusion

Participatory monitoring is indispensable. It is the only scalable, affordable, and credible model to complement government networks and sensor-based systems. It aligns with national frameworks such as Samarth Ganga and embodies the principles of Jan Bhagidari and Jan Andolan, making river health monitoring a people's movement that ensures reliable, frequent, spatially dense, and community-owned data.

7. Coordinating Efforts Across Agencies

Neither government agencies alone nor community groups alone can cover all RHA needs. A **layered model** is required:

- **CWC:** Hydrology, sediment load, hydraulics.
- **CPCB/SPCBs:** Water quality (routine + extended).
- **WII, CIFRI, WWF-India:** Biodiversity, keystone species, ecosystem monitoring.
- **cGanga/IITs/Universities:** Index design, QA/QC, integration, and training.
- **Schools & Colleges:** Biological sampling (macroinvertebrates, diatoms) under supervision.
- **NGOs & CSOs:** Community mobilization and scout training.
- **ISRO/NRSC:** Remote sensing for connectivity, floodplain dynamics, land use.

National Coordinator: A central technical body (such as **cGanga with network of most national institutes of eminence**, under DoWR,RD&GR, MoJS in coordination with CPCB) would be most appropriate to integrate protocols, data flows, and reporting for a unified national River Health Assessment (RHA) in the country.

8. Developing Indices

- **Component indices**: Separate for water quality, hydrology, geomorphology, biology.
- **Integration:** RPCT/AHP for weighting, check consistency ratio.
- **Dashboard approach:** Publish both **separate indices for diagnostics** and **composite indices for communication**.

9. Funding RHA

- **Government of India (MoWR, MoEFCC, Jal Jeevan Mission):** Core funding for baseline monitoring.
- **State Governments & ULBs:** Co-financing local scouts and stations.
- **Polluter-pays Principle:** Industries should co-fund monitoring where they discharge.
- **CSR & Philanthropy:** To support participatory and educational outreach.
- **International Partners:** Development banks, climate funds for basin-scale pilots.

10. Strategic Importance

A robust RHA framework is essential for:

- **River-centric development** and restoration.
- **Water security and climate resilience.**
- **Attaining SDG-6** (clean water and sanitation, healthy ecosystems).
- **Making governments accountable** through participatory monitoring and public reporting.
- **Creating green jobs** by employing local scouts and citizen monitors.

11. Conclusion

India's RHA must be built on a **hybrid model**:

- **Sensors** for real-time visibility of limited core parameters.
- **Participatory monitoring** for dense, frequent, and ecological data that sensors cannot provide.
- **Agencies, academia, and communities must collaborate under a coordinated framework.**
- Funding should combine public resources, polluter contributions, and CSR.

Such a model is not just desirable but **necessary for river-centric development, national water security, and achieving SDG-6 goals**.

Policy Brief

River Health Assessment (RHA)

Towards a Coordinated, Participatory, and Technology-Enabled Framework for India

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"The rejuvenation of rivers requires Jan Bhagidari and Jan Andolan — the active participation of citizens as partners in river conservation."

— Samarth Ganga Framework,
cGanga & NMCG, 2021

Executive Summary

India's rivers are vital for ecological integrity, water security, and sustainable development. Yet, existing monitoring systems managed by CWC and CPCB/SPCBs remain fragmented, limited in scope, and inadequate for basin-scale management. The Samarth Ganga Framework emphasizes 'Jan Ganga' as one of its five pillars, recognizing citizen participation (Jan Bhagidari) as essential. A National River Health Assessment (RHA) framework combining institutional, technological, and participatory monitoring is therefore indispensable. This policy brief proposes a four-tier hybrid model anchored at cGanga/IIT Kanpur, integrating River Scouts, academic institutions, and national coordination through MoJS. It recommends establishing a National RHA Coordination Authority, a unified digital portal, participatory monitoring networks, and annual River Health Report Cards to guide evidence-based river rejuvenation efforts.

1. Background & Context

Rivers form the ecological and cultural foundation of India's heritage and economy. The Government of India has prioritized river rejuvenation through the National Mission for Clean Ganga (NMCG) and the National River Conservation Directorate (NRCD). However, the current system of monitoring river flow, sediment, and water quality—managed primarily by the Central Water Commission (CWC) and the Central/State Pollution Control Boards (CPCB/SPCBs)—is inadequate for comprehensive River Health Assessment (RHA).

2. Current Issues & Gaps

The existing monitoring framework faces several limitations:

- Sparse coverage: Only ~1,500 CWC stations and approximately 2000+ CPCB/SPCB water quality sites across India's 30,000+ major and medium rivers.
- Limited parameters: Most stations measure only a few physicochemical indicators (DO, BOD, pH, EC, coliforms) without ecological context.
- High operational cost and limited manpower.
- Credibility and independence concerns, as monitoring and implementation agencies are often the same.
- Absence of a unified River Health Index (RHI) and integrated national portal.

Table1A: Basin Wise Details of Hydrological Observation Sites (as on 01.01.2025) by CWC

S No	Basin Name	G	GD	GDQ	GDS	GDSQ	GQ	Total
1	Barak and Others	6	23	6	6	18	7	66
2	Brahmani and Baitarani	9	-	1	-	11	3	24
3	Brahmaputra	12	6	35	-	44	77	174
4	Cauvery	-	13	17	-	24	-	54
5	EFR between Pennar & Cauvery	-	17	8	-	4	-	29
6	EFR between Krishna & Pennar	-	1	-	-	1	-	2
7	EFR Between Mahanadi & Godavari	8	-	1		4	5	18
8	EFR South Cauvery	-	2	2	-	4	-	8
9	Ganga	226	148	50	12	116	6	558
10	Godavari	45	44	12	-	33	4	138
11	Indus (Up to International Border)	21	16	2	11	9	-	59
12	Krishna	8	14	12	-	29	3	66
13	Mahanadi	27	-	3	-	22	3	55
14	Mahi	8	4	2	-	3	-	17
15	Narmada	15	33	8	-	11	4	71
16	Pennar	-	4	4	-	4	-	12
17	Rivers Draining into Bangladesh Basin	1	6	-	-	1	-	8
18	Rivers Draining into Myanmar Basin	1	4	-	3	2	-	10
19	Sabarmati	7	4	1	-	1	-	13
20	Subernaekha	5	1	2	-	6	1	15
21	Tapi	14	18	1	-	5	-	38
22	WFR of Kutch and Saurashtra including Luni Basin	3	10	2	-	3	-	18
23	WFR South of Tapi	7	22	11	-	31	1	72
	Total	**423**	**390**	**180**	**32**	**386**	**114**	**1525**

Table1B: State Wise Details of Water Quality Observation Sites (Source: WQMN_list.pdf) by CPCB/SPCBs

S No	State	No. of Stations
1	Andhra Pradesh	41
2	Assam	100
3	Goa	32
4	Gujarat	66
5	Punjab	59
6	Haryana	22
7	Himachal Pradesh	141
8	Karnataka	109
9	Kerala	75
10	Maharashtra	162
11	Manipur	41
12	Meghalaya	64
13	Odisha	128
14	Puducherry	6
15	Tamil Nadu	86
16	Rajasthan	35
17	Tripura	38
18	Arunachal Pradesh	29
19	Bihar	96
20	Chhattisgarh	29
21	Diu, Dadra and Nagar Haveli	13
22	Delhi	9
23	Jammu & Kashmir	64
24	Jharkhand	65
25	Madhya Pradesh	158
26	Mizoram	46
27	Nagaland	19
28	Sikkim	16
29	Telangana	55
30	Uttar Pradesh	113
31	Uttarakhand	40
32	West Bengal	59
	Grand Total	**2016**

Table1C: Basin Wise Details of Water Quality Observation Sites (Source: WQMN_list.pdf) by CPCB/SPCBs

S No	Basin	WQMN Stations
1	Ganga	475
2	Narmada	77
3	Godavari	109
4	Mahanadi	83
5	Krishna	138
6	Cauvery	104
7	Periyar	9
	Total	**995**

Table1D: Details of Real Time Water Quality Monitoring (WQM) Project in Ganga Basin by CPCB/SPCBs [Source: National Ganga River Basin Authority (NGRBA)]

WQM Budget and Duration			
S. No.	**WQM Project Phase**	**Sanction Cost**	**Duration**
1	Phase I	Rs. 94.45 crores	June, 2013 – July 2020
2	Phase II	Rs. 126.17 crores	2020 – 2026
Installation Details			
	WQM Project Phase	**Monitoring Method**	**Details**
1	Phase I	Real Time Water Quality# Monitoring (RTWQM)	36 stations were commissioned w.e.f. 11.03.2017
2	Phase II		Installation of 40 new stations completed in October, 2021
Bio-assessment Study Details			
1	Total of 42 locations of river Ganga (34 locations are on main stream and 08 locations are on tributaries) and 12 locations in river Yamuna		

Reliable Data is yet not available in Public Domain. Studies carried out by cGaga, IIT Kanpur (refer report titled: “Novel Sensor-Based Water Quality Measurements for Public Purposes: How Reliable are They?” cGanga & NMCG (2022)) points out limitations of state-of-the-art on Real Time Water Quality Monitoring and usefulness of such monitoring under Indian Context for River Monitoring.

3. Policy Rationale: Why Participatory Monitoring is Unavoidable

Expanding the existing institutional networks is financially and logistically unviable. Participatory monitoring, supported by digital tools, offers scalability, transparency, and inclusiveness. The Samarth Ganga Framework (NMCG, 2021) explicitly identifies Jan Ganga and Jan Bhagidari as central to sustainable river rejuvenation.

Participatory monitoring through River Scouts and community networks enables:

- High-frequency measurements (twice daily) at minimal cost.
- Broader geographic coverage across all river stretches.
- Employment and skill development for local communities.
- Enhanced data credibility through independent citizen engagement.
- Cost-effective complementarity with advanced sensor-based systems.

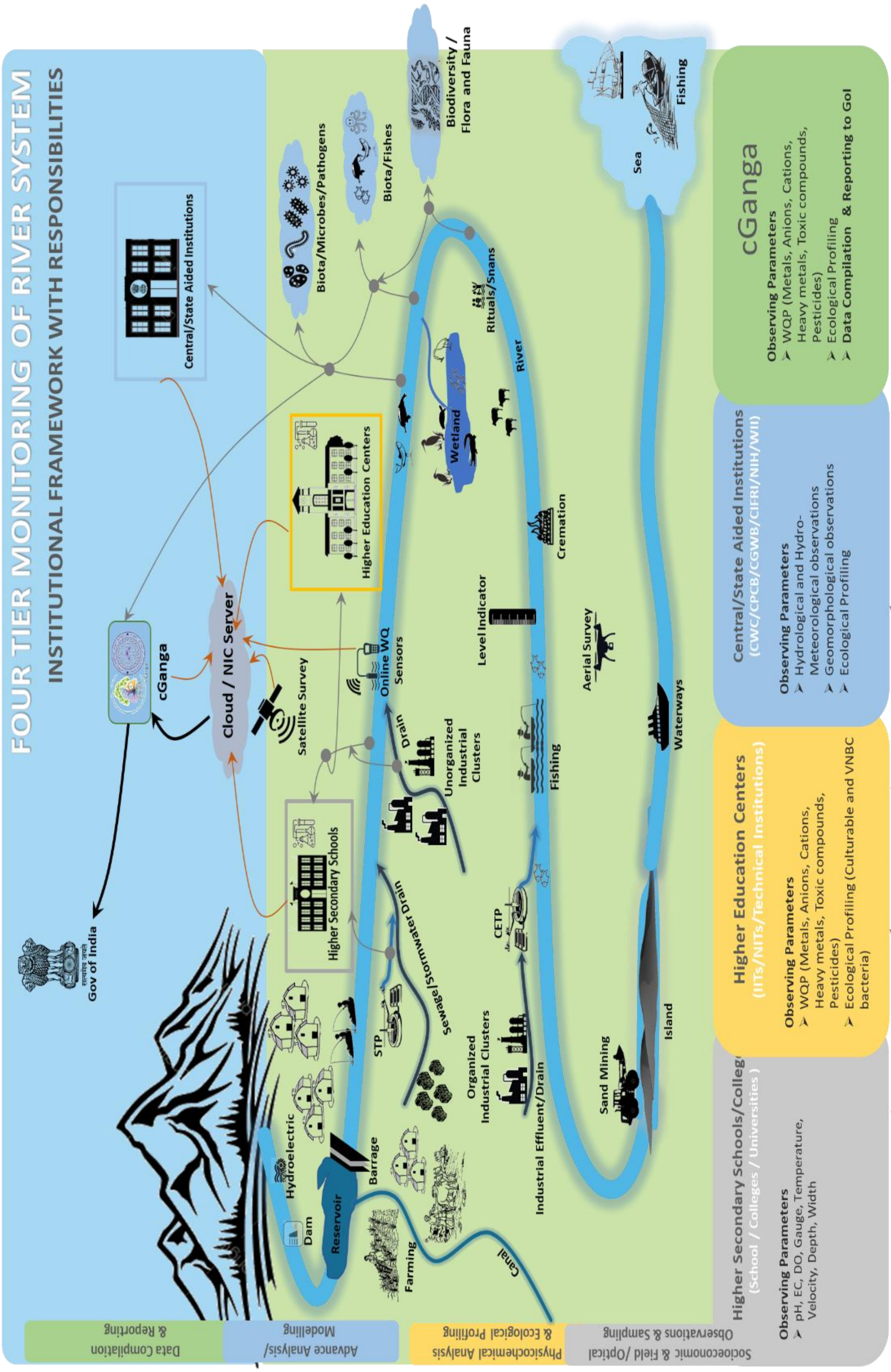


Figure 1: Integration of Institutional and Participatory Monitoring

Table 2: Four-Tier Hybrid Monitoring Framework#

Tier / Level	Actors / Institutions	Key Responsibilities	Monitoring Frequency	Funding Responsibility / Support	Expected Outputs
Tier I – Community Monitoring	*River Scouts / Local Communities / Schools / NGOs*	Measure temperature, pH, DO, EC, river gauge & flow velocity using low-cost kits; collect samples for biological profiling (macroinvertebrates, diatoms, fish, pathogens).	Twice daily (pre-sunrise & sunset); biological sampling Quarterly	State Govts & ULBs (wages, kits); CSR & local industries for training / equipment	Dense spatial & temporal data; community engagement; green jobs
Tier II – Zonal Academic Centres	*IITs, Universities, Engineering Colleges & Research Labs*	Sample validation, QA/QC, chemical & biological analysis; training and supervision of River Scouts; data upload and verification.	Weekly to monthly review cycles	MoJS / NMCG core funds; research grants; State Govts for local labs	Reliable validated datasets; capacity building; quality control
Tier III – Regional Expert Institutions	*WII, CIFRI, WWF-India, cGanga Partners, IIT Consortium*	Advanced biological & ecological assessment; keystone species monitoring; integration of hydrological, geomorphological & ecological data; development of River Health Index (RHI) sub-components.	Quarterly / seasonal	MoJS / NRCD; international funds for ecosystem services studies	Regional RHI reports; ecological baselines; technical guidelines
Tier IV – National Coordination & Integration	*cGanga / IIT Kanpur Network with MoJS & CPCB / NIWR*	Data integration and analytics; dashboard development; training and capacity building; annual River Health Report Cards; policy advisory to GoI and States.	Data integration and analytics; dashboard development; training and capacity building; annual River Health Report Cards; policy advisory to GoI and States.	Continuous real-time integration + annual reporting	Central Govt (MoJS, MoEFCC); multilateral & climate finance for digital systems

 # This Framework is to supplement, strengthen, expand and enhance the existing monitoring by CWC & CPCB/SPCBs to adopt the Samarth Ganga Concept of Comprehensive River Basin Management using River Health Assessment

4. Strategic Framework for National River Health Assessment (RHA)

A hybrid four-tier monitoring framework is proposed, combining institutional rigor with participatory engagement. This model is being demonstrated in the River Health Monitoring (RHM) Pilot by cGanga over a 920 km Ganga stretch (178 stations).

5. Funding & Implementation Strategy

A blended funding model is essential to sustain participatory RHA:

- Core funding by GoI (MoWR, MoEFCC, Jal Jeevan Mission) for baseline monitoring.
- State Governments and Urban Local Bodies (ULBs) for local scout networks.
- CSR, Polluter-Pays Principle, and International Climate Funds for technology and capacity building.

Implementation should be coordinated through cGanga/IIT Kanpur, leveraging digital data management and QA/QC systems.

6. Key Policy Recommendations

- Establish a National RHA Coordination Authority under MoJS, anchored at cGanga.
- Mandate participatory monitoring as a policy instrument in river rejuvenation.
- Integrate RHA within the Samarth Ganga Framework under Jan Bhagidari and Jan Andolan.
- Develop a unified national digital RHA Portal and publish annual River Health Report Cards.
- Ensure third-party validation and public accessibility of monitoring data.
- Provide sustained blended financing (GoI, CSR, Polluter Pays, and international sources).

7. Way Forward

The National River Health Assessment must transition India from fragmented data collection to a coordinated, transparent, and participatory governance framework. Immediate steps should include the expansion of the RHM Pilot, establishment of the coordination authority, and integration of participatory monitoring with institutional networks. In the long term, RHA should evolve into a national platform informing river basin management, policy decisions, and SDG-6 implementation.

Annexure I

Pilot on Evolving Comprehensive River Health Monitoring Program

1) Introduction

River monitoring and conservation in India are anchored by the dedicated efforts of several key institutions. The Central Water Commission (CWC) and Central Pollution Control Board (CPCB) have long been at the forefront of assessing the condition of surface water bodies, with the Wildlife Institute of India (WII) and WWF-India providing crucial insights into ecological aspects. However, the scale and complexity of India's river systems necessitate a more integrated and comprehensive framework. The proposed four-tier monitoring program is designed to enhance these existing efforts by creating a collaborative ecosystem that engages not only central and state-aided institutions but also local communities. This initiative aims to establish a denser network of monitoring locations and a higher frequency of data collection, thereby providing more granular and real-time insights than the existing frameworks alone.

2) Genesis

The genesis of this four-tier program stems from the critical need for a paradigm shift in how India assesses and manages river health, a need extensively detailed in the policy paper titled *"Evolving River-Centric Criteria for Sustainable Management of Surface Waterbodies in India"*. The policy paper highlights the limitations of current methodologies, which are often anthropocentric and rely on outdated parameters like BOD and Total Coliforms, which can lead to misleading information. The document argues that India's unique cultural relationship with its rivers and the immense ecological diversity of its river systems render a "one-size-fits-all" approach fundamentally inadequate. Based on this policy paper a committee constituted by CPCB has prepared a report to evolve norms for assessing the health of water bodies in line with the existing monitoring programmes (cGanga & CPCB, 2025).

The pilot designed and executed for monitoring river health is a direct response to these challenges. It is conceived as a dynamic framework for smart river health monitoring, aiming to address the current absence of a national river health assessment system. By integrating citizen science with regional technical institutes, the program directly implements the policy paper's core philosophy: a new approach that is scientifically sound, simple, reproducible, and, most importantly, people centric. The program will generate the critical data needed to develop the "river-centric criteria" and "reference conditions" advocated in the policy paper, ensuring a truly holistic approach to river rejuvenation and conservation (Kuehne, 2023).

Team cGanga has initiated a comprehensive river monitoring pilot program, establishing a four-tier monitoring framework that integrates citizen science with institutional expertise. The program, designed to collect critical data on key river health indicators, is being conducted on a 920 km stretch of the Ganga River from Kachhla Bridge to the Ghaghara River confluence, a stretch identified as one of the most impacted due to urban and industrial activities. This report outlines the milestones achieved and the progress made to date.

3) Milestones and Progress against Timeline

a) Training and Program Launch:

- **River Scout Training:** Two batches of River Scouts were trained at IIT Kanpur in September 2024. These over 75 trained individuals are now actively involved in monitoring the 900 km pilot stretch.
- **Inception:** The program's objectives were discussed at a brainstorming session titled: "River Monitoring - Real Time Sensor Based vis-à-vis Participative in 9th IWIS held in December 2024 (reference: A Consolidated Report on 9th India Water Impact Summit & 2nd Climate Investments & Technology Impact Summit). Following this, site screening was conducted between December 2024 and March 2025. The program started on April 1, 2025.

b) Data Collection and Analysis:

- **Water Quality Monitoring:** Daily data on parameters like pH, EC, and Temperature were collected from April to July 2025, and have been successfully uploaded to the real-time data portal. Monthly parameters were also surveyed during the same period, with analysis completed up to July 2025.
- **Quarterly Monitoring:** The first-quarter survey for heavy metals, pesticides, and other chemical parameters was conducted from May 25 to June 2, 2025. The analysis of these samples is currently in progress.
- **Biomonitoring:** The first two quarterly surveys for macroinvertebrates were completed in March and June 2025, with Q1 identification already complete. Fish sampling for the pre-monsoon period was also completed in June 2025, and the identification and analysis are in progress.

c) Digital Platform Development:

- A web portal for real-time data collection was developed between February and March 2025. A data analysis platform was subsequently developed in July 2025. These platforms enable continuous data collection and analysis, which facilitates timely decision-making and fosters collaboration across institutions. A sample report from this platform is shown in Figures 7a and 7b.

In conclusion, the pilot program has established a functional four-tier monitoring system. It has trained and engaged citizen scientists, collected a significant volume of data on various parameters, and developed the necessary digital infrastructure to support a data-driven approach to river management. This initiative is expected to generate essential data to inform future policies and enhance environmental sustainability.

4) Salient Features of the RHM Pilot in Progress

The assessment of ecological integrity has increasingly incorporated political, social, and economic factors, recognizing these elements as essential to understanding river health. Reviews of international river health monitoring frameworks have highlighted the need for more frequent and accessible data, as well as efforts to reduce uncertainty. This shift underscores the importance of improved methods for data aggregation, standardization, and classification.

Simultaneously, advancements in technology—now accessible to communities across diverse social and cultural contexts—have enabled greater public participation in monitoring activities. This growing involvement offers substantial benefits in terms of time efficiency and cost-effectiveness.

However, the current absence of a national river health assessment system presents a major obstacle to the effective preservation of river ecosystems. To address this, Team cGanga proposes a comprehensive river monitoring program designed to collect critical data on key parameters such as water level (gauge), velocity, dissolved oxygen (DO), temperature, and electrical conductivity (EC) (cGanga &NMCG, 2025). The program will also monitor indicators including micro-invertebrates, coliform bacteria, heavy metals, ions, nutrients, and insecticides/pesticides, with increased spatial and temporal resolution.

This pilot study aims to establish a dynamic framework for smart river health monitoring by integrating citizen science initiatives with the capabilities of regional technical institutes.

a) Four-tier Monitoring Program

The four-tier monitoring program envisages engagement of scientific and non-scientific organizations, local stakeholders, primary schools, and colleges, fostering a collaborative approach to river health assessment (Figure 1). By involving a wide range of participants, the program will not only support data collection but also enhance infrastructure and build knowledge within local communities.

This initiative will generate essential data for assessing river health and contribute to mapping, integration, and scenario analysis—helping us better understand the current conditions and the rate of change in our rivers and streams.

In addition, the program will establish a robust data backup system, create employment opportunities, strengthen the water-based economy, and promote stronger connections between communities and their local water systems. It will also support the development of reference conditions to inform future policymaking and ensure the sustainable management of our river ecosystems.

Objectives:

- **Enhance river monitoring methods by integrating local observations with regional institutional resources.**
  Leverage community-based inputs and existing institutional infrastructure to create a more responsive and context-specific monitoring system.
- **Develop extensive databases and advanced data visualization tools for key components of river health.**
  Ensure accessible, real-time insights into river conditions by building scalable digital platforms that aggregate and display critical environmental parameters.
- **Empower citizens to function as a distributed sensor network for river health monitoring.**
  Promote citizen science by equipping communities with tools and training to collect, report, and interpret river data, thereby expanding coverage and fostering environmental stewardship.

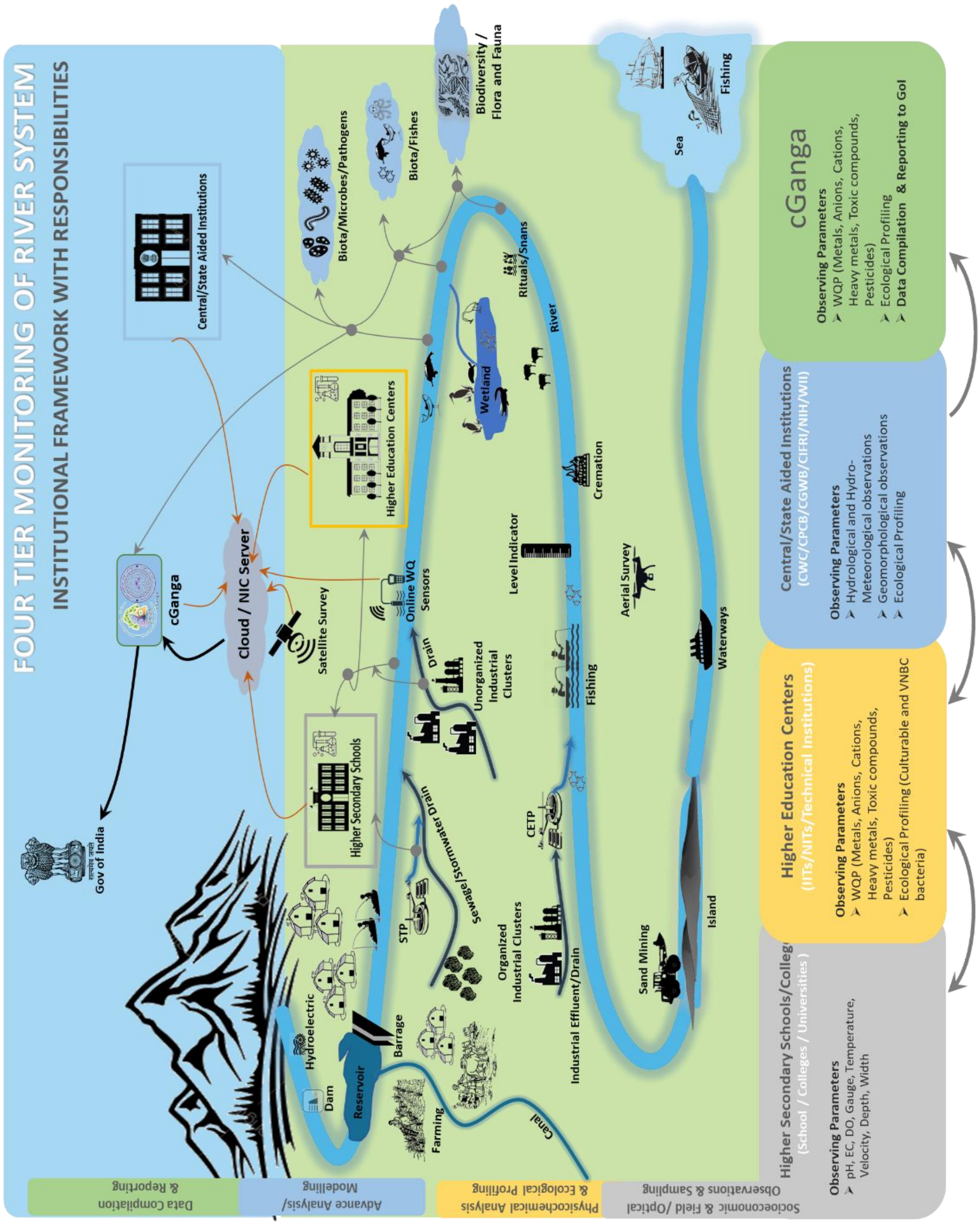


Figure 1: Schematic Representation of the Concept of Four-tier River Monitoring

Alignment with Existing Monitoring Framework:

The proposed four-tier monitoring program closely aligns with the current framework implemented by the Central Pollution Control Board (CPCB) for assessing the condition of surface water bodies. Both programs share common objectives and methodologies aimed at ensuring water quality and environmental sustainability.

However, a key distinction lies in the proposed program's enhanced design, which features a denser network of monitoring locations and a higher frequency of data collection. This increased granularity is expected to provide more comprehensive and real-time insights into water quality trends.

Moreover, the integration of local stakeholders into the monitoring process adds significant value to the program. Their engagement not only fosters community ownership but also contributes to the consistency, reliability, and contextual relevance of the monitoring outcomes.

Inclusion of Citizen Science:

A notable feature of the proposed four-tier monitoring program is the integration of citizen science, which plays a critical role in strengthening environmental governance (IWMI, 2024; Earth5R, 2025). In the existing surface water monitoring program, citizen participation is already being leveraged through the engagement of over 75 trained individuals, referred to as River Scouts. These individuals are actively involved in monitoring activities along approximately 900 km of river stretch. The training program was conducted at IIT Kanpur in two consecutive phases, on 27–28 September 2024 and 29–30 September 2024, respectively. Glimpses of this training program are available in Figure 2.

Their participation supports the collection of critical on-ground data, facilitates early detection of pollution incidents, and strengthens the feedback loop between communities and regulatory authorities. This model demonstrates the practical benefits of citizen science in large-scale environmental monitoring and underscores the value of expanding such engagement under the proposed four-tier monitoring framework.

Monitoring Roles and Responsibilities:

Monitoring of various river health parameters are assigned to different stakeholders residing in the vicinity of river:

i. **River Scouts:**
   - Gathering crucial data on key but routine parameters (e.g. Temperature, pH, Conductivity, DO, Gauge & Surface Velocity)
   - Collection of samples for analysis of Monthly and Quarterly Parameters
   - Reporting of events related to extreme and disaster conditions

ii. **Zonal Centers:**
   - Collection of samples from River Scouts
   - Analytical support and supervision for River Scouts
   - Regular monitoring and meetings with personals of River Scouts

iii. **Regional Centers:**
   - Engage scientific and non-scientific organizations, local stakeholders, primary schools, and colleges, creating a collaborative approach to river health assessment
   - Capacity & skill development of River Scouts for assigned activities
   - Provide financial and instrumentation support
   - Conduct training programs
   - Analysis of specific parameters (e.g. Heavy Metals, Pesticides, Insecticides, Cations & Anions, Emerging Contaminants, etc.)
   - Documentation and digitization of the collected information
   - Evaluation of river health which contribute to mapping, integration, and assessment of different scenario
   - Development of real time data evaluation platform

Figure 2: Glimpses of River Scout Training Program

b) Pilot for Monitoring

i. **Monitoring Sites and Data Collection:** After thorough discussions with experts, it was decided to conduct a pilot study on River Health Monitoring between Badaun and Bijnor, upstream of the Ganga-Ghaghara River confluence, covering the most polluted stretch of the Ganga. The study also aimed to analyze the impact of 12 tributaries and 49 drains on water quality and native biota. The details are presented in Figure 3 and 4.

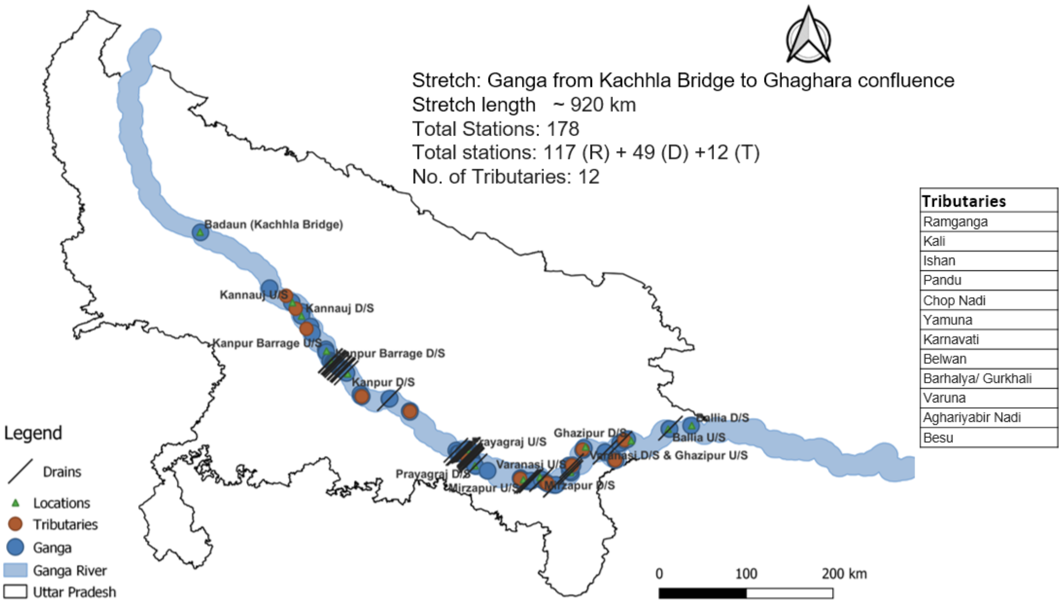


Figure 3: Pilot on Ganga River Health Basin Monitoring: Kachhla Bridge up to Ghaghara River Confluence

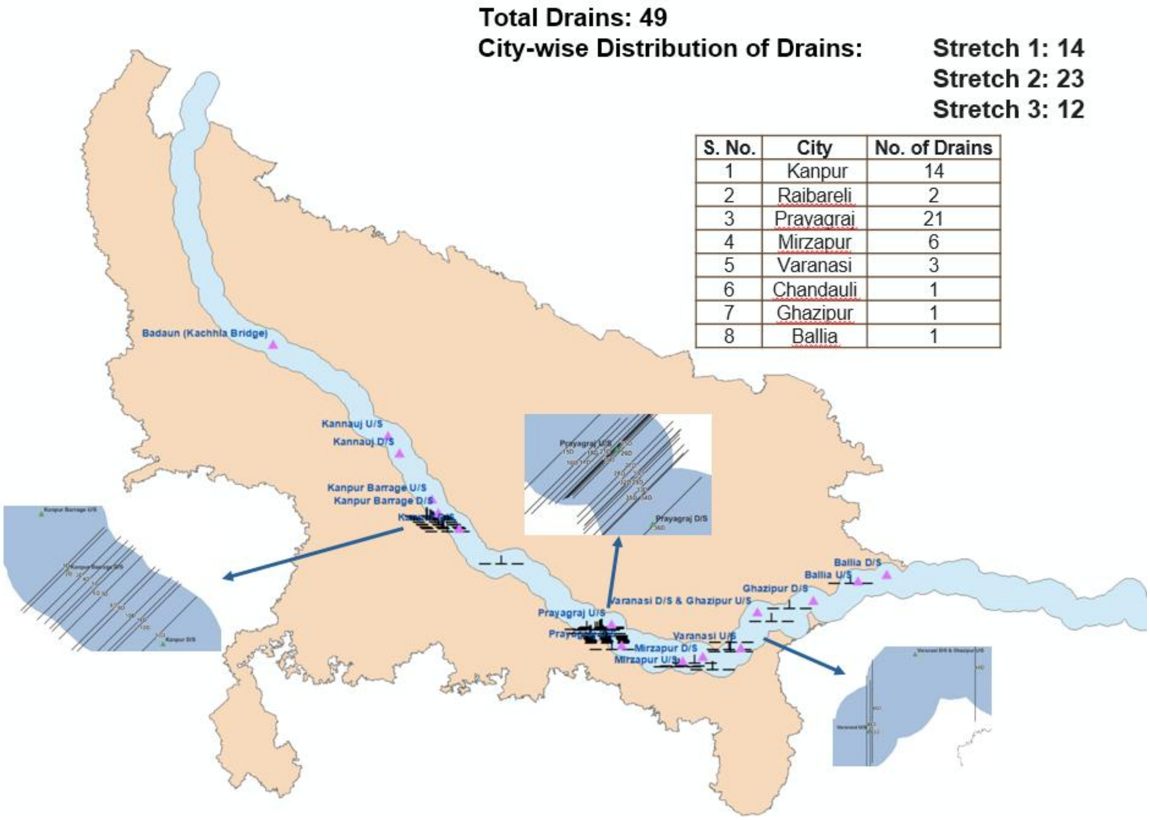


Figure 4: Distribution of drains covered under RHMP

ii. **Monitoring Indicators and Relevant Details:** Across all bio-physical and chemical components, we identified a comprehensive yet parsimonious set of indicators for river health. These indicators were selected based on input from expert members across various forums (IWIS 2024). Both short-term and long-term indicators of river health and habitat conditions were considered.

Table 1: Details of Water Quality Sampling Stretches, Sample Density, River Scouts and Sampling Frequency

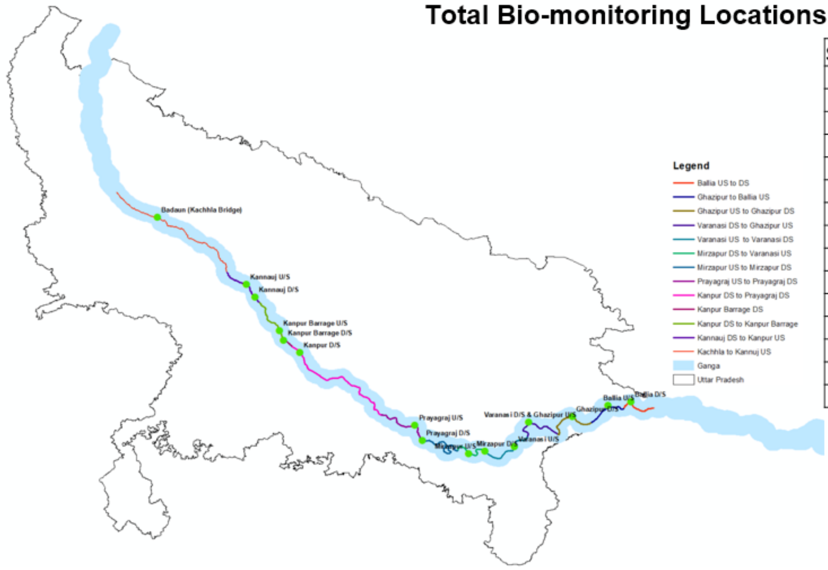
S. No.	Stretch	No. of Samples	No. of River Scouts in Daily Monitoring	Water Quality Parameters		
				Daily (Twice in a day: Morning and Evening)	Monthly	Quarterly
1	Kachhla to Fatehpur	39 (R) + 14 (D)	26	pH, EC, Temperature, DO, Gauge*, Velocity	pH, EC, DO, BOD, Ammoniacal Nitrogen (NH4-N), TKN, Phosphorous, Total Coliform, Fecal Coliform	Heavy Metal, Insecticide, Pesticide, Anions, Cations
2	D/S Fatehpur to Sirsa	42 (R) + 23 (D)	26			
3	D/S Sirsa to Ballia	48 (R) + 12 (D)	22			

**** At selected sites***

The selected indicators and their corresponding measurement frequencies are presented in Table 1 for water quality and hydrological parameters. The details of biological indicators, along with their assigned monitoring stretches, are depicted in Figure 5. Daily parameters are measured by River

Scouts, while monthly and quarterly samples are analyzed by regional centers (cGanga IIT Kanpur, MNNIT Allahabad, and NIT Patna) and zonal centers (cGanga, IIT Kanpur), respectively (see Table 2a and b). Biological parameters, such as macroinvertebrates and fish, are analyzed through expert surveys conducted by Team cGanga.

Total Bio-monitoring Locations: 15



Stations	Km
Kachhla Bridge, Badaun	0
Kusumkhor, Kannauj	155
Mehndi Ghat, Kannauj	180
Bithoor (U/S Kanpur Barrage)	226
Kanpur (D/S Kanpur Barrage)	242
D/S Kanpur	267
Prayagraj (before Yamuna Confluence)	459
Mawaiya Ghat (after Yamuna Confluence)	475
Mirzapur-cum-Vindhyachal (U/S Vindhyachal)	579
Mirzapur-cum-Vindhyachal (D/S Vindhyachal)	596
U/S Varanasi	661
D/S Varanasi U/S Ghazipur	711
D/S Ghazipur	788
U/S Ballia	850
Rudrapur, D/S Ballia	877

Figure 5: Details of Bio-profiling Stretches, Sampling Frequency and Participating Institutes

Table 2a: Analysis Schedule for Water Quality Parameters

Stretch	Daily	Monthly Analysis	Quarterly Analysis
Kachhla to Fatehpur	River Scouts	cGanga, IITK	cGanga, IITK
D/S Fatehpur to Sirsa		MNNIT Allahabad	
D/S Sirsa to Ballia		NIT Patna	

Table 2b: Analysis Schedule for Bio-Monitoring Parameters (MI and Fish)

Parameters	Frequency	Task & Institutes
MI	Quarterly	Sampling, Identification & Analysis: cGanga, IITK
Fish	Pre & Post monsoon	Sampling & Analysis: cGanga, IITK Identification: cGanga, IITK + CIFRI

c) Timeline and Work Progress

The entire pilot project is scheduled to be completed within one year, from April 2025 to March 2026. However, sampling and data sharing at certain locations may be affected by unavoidable circumstances such as the Kumbh Mela and high river flows during the monsoon season. Detailed progress for each analytical component is presented in Tables 3a and 3b.

Table 3a: Sampling and Analysis Schedule with Progress for Water Quality Parameters

Month	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Remarks
Daily	Trial													Data Uploaded on the Portal
Monthly	Trial													Analysis Completed
Quarterly*														Analysis in Progress

Completed | **Pending** | **Partly Completed**

** Quarterly Samples in Pre-monsoon season were 168 as remaining channels were dry on a particular sampling day*

Table 3b: Sampling and Analysis Schedule with Progress for Biological Parameters

Month	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Remarks
MI	Q1			Q2				Q3			Q4			Q1 Identification Completed
Fish (Pre & Post)				Pre Monsoon				Post Monsoon						Pre Monsoon Identification in Progress

Completed | **Pending**

d) Analytical Procedures

The analysis of water quality parameters was conducted using standardized methodologies. Macroinvertebrate samples were identified, followed by a comprehensive diversity assessment employing the Shannon-Wiener diversity index (H'). Additionally, other general macroinvertebrate community indices (Pielou's evenness index (J'), Biological Monitoring Working Party) were calculated to evaluate biodiversity and water quality (Saprobic score) at each monitoring station (CPCB 2021; Friedrich et al., 1996; Pielou 1966; Shannon 1948). Fish sampling was done by local fishermen along with morphometric and quantitative fish catch measurements for subsequent analysis.

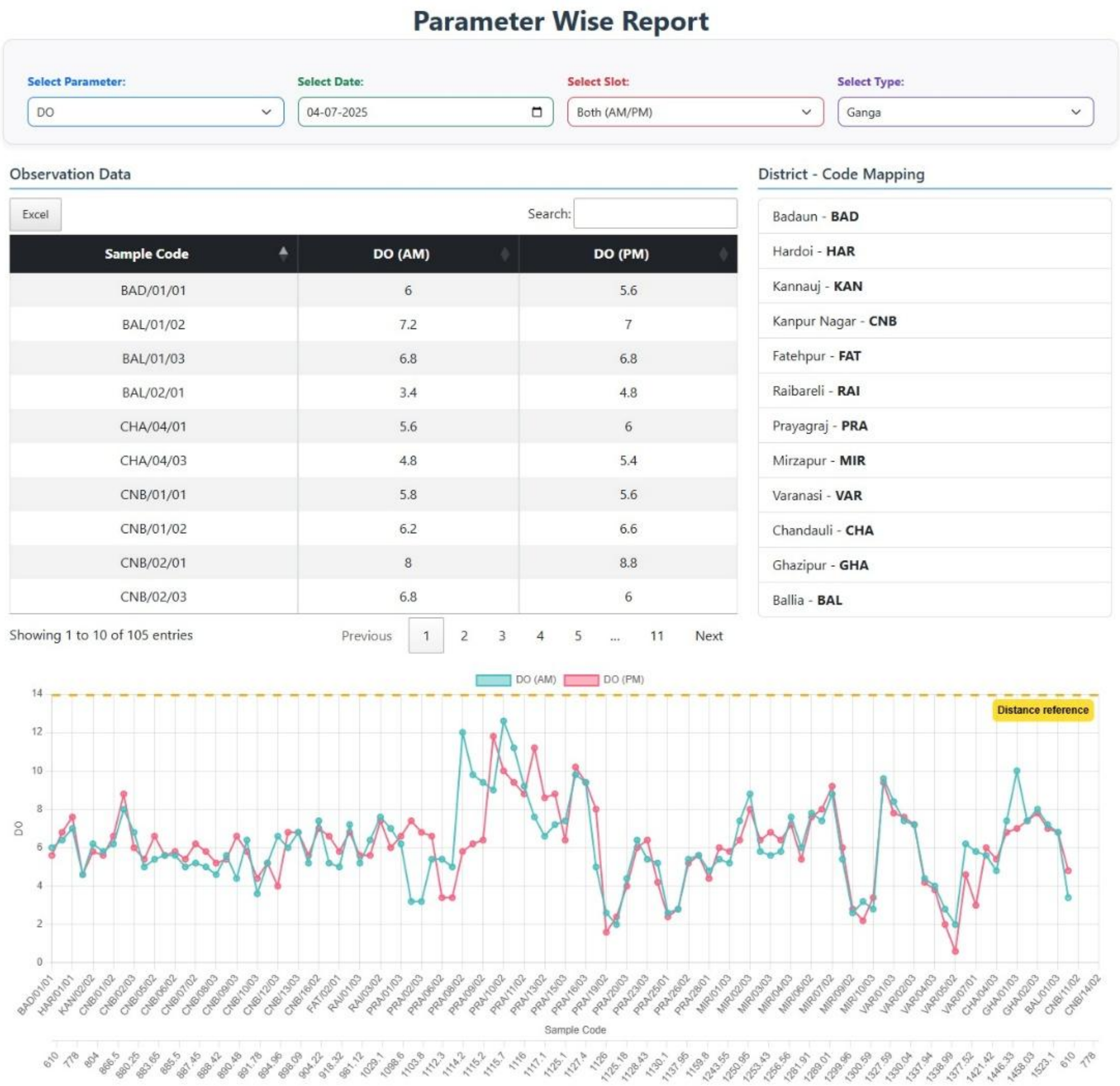
Figure 6: Benthic Macroinvertebrates of Ganga, A Valuable Water Quality Indicators

e) RHMP Web-based Data Evaluation Platform

A Web Based Data Evaluation Platform for river health monitoring offers numerous advantages that significantly enhance the efficiency and accuracy of river management programs. First and foremost, it enables the continuous, real-time collection and analysis of data from various monitoring stations, providing immediate insights into water quality, and hydrological parameters.

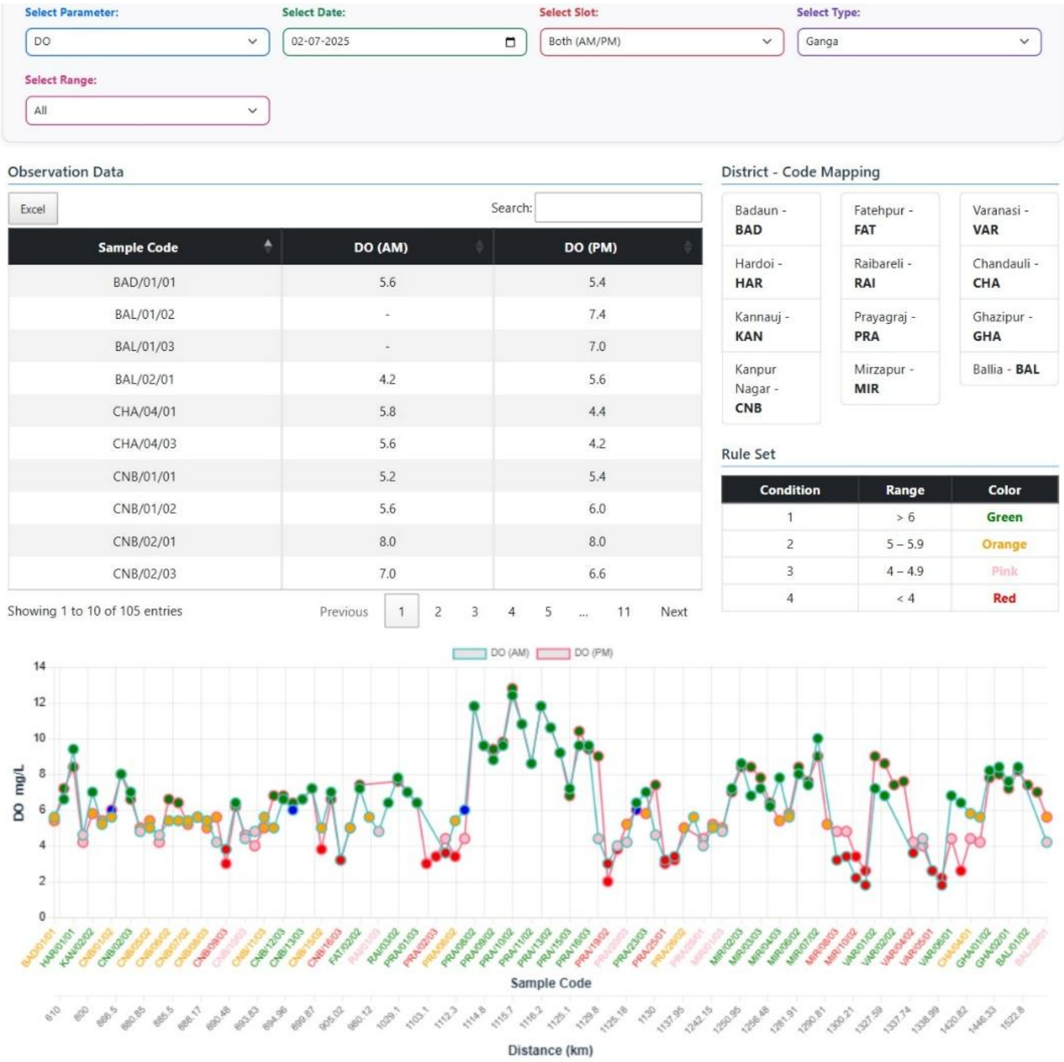
This dynamic approach allows for rapid identification of anomalies, such as pollution spikes or water flow irregularities, which can be addressed proactively, minimizing environmental risks. Additionally, the platform facilitates timely decision-making by providing stakeholders with up-to-date information for policy formulation and intervention planning.

It also fosters collaboration among different regional and zonal centres, ensuring that data is seamlessly shared and analysed across institutions. Furthermore, the real-time nature of the platform supports adaptive management strategies, allowing for the modification of monitoring protocols based on emerging trends. Overall, this platform enhances transparency, accountability, and responsiveness in river health management, ultimately contributing to more sustainable and effective conservation practices.



Sample Code	DO (AM)	DO (PM)
BAD/01/01	6	5.6
BAL/01/02	7.2	7
BAL/01/03	6.8	6.8
BAL/02/01	3.4	4.8
CHA/04/01	5.6	6
CHA/04/03	4.8	5.4
CNB/01/01	5.8	5.6
CNB/01/02	6.2	6.6
CNB/02/01	8	8.8
CNB/02/03	6.8	6

Figure 7a: Real Time Data Evaluation Platform * Development of Rulesets are under progress



Sample Code	DO (AM)	DO (PM)
BAD/01/01	5.6	5.4
BAL/01/02	-	7.4
BAL/01/03	-	7.0
BAL/02/01	4.2	5.6
CHA/04/01	5.8	4.4
CHA/04/03	5.6	4.2
CNB/01/01	5.2	5.4
CNB/01/02	5.6	6.0
CNB/02/01	8.0	8.0
CNB/02/03	7.0	6.6

Condition	Range	Color
1	> 6	Green
2	5 – 5.9	Orange
3	4 – 4.9	Pink
4	< 4	Red

Figure 7 b: Real Time Data Evaluation Platform * Development of Rulesets are under progress

f) Expected outcome of the program:

The Comprehensive River Monitoring Program is expected to deliver the following outcomes:

i. <u>Enhanced River Health Assessment</u>

- Establishment of a robust, four-tier monitoring framework that integrates citizen science with institutional expertise.
- High-resolution and frequent data collection enabling accurate assessment of water quality, hydrological, and biological parameters.

ii. <u>Real-Time Monitoring and Decision Support</u>

- Deployment of a digital, real-time data evaluation platform providing continuous updates on river conditions.
- Early detection of pollution incidents and environmental risks, enabling timely interventions and adaptive management.

iii. Community Engagement and Capacity Building

- Active participation of local stakeholders, River Scouts, schools, and colleges in river health monitoring.
- Strengthening of community ownership, environmental stewardship, and knowledge sharing.
- Skill development, employment opportunities, and enhanced water-based economy in the region.

iv. Scientific and Policy Advancements

- Creation of a comprehensive national-level database on river health indicators.
- Development of standardized reference conditions and methodologies to inform future environmental policies.
- Support for scenario analysis, long-term planning, and sustainable river basin management.

v. Environmental and Social Benefits

- Improved ecological integrity of rivers through proactive management and conservation practices.
- Strengthened linkages between communities and their water systems, fostering cultural and ecological resilience.

References:

cGanga & NMCG (2025). निर्मलता / Nirmalta: Evolving River-Centric Criteria for Sustainable Management of Surface Waterbodies in India.

CBCB (2021). An Introduction to Aquatic Bio-Monitoring using Macro-Invertebrates. New Delhi, India.

Earth5R (2025). Earth5R's River Health Index: A Community-Based Monitoring Tool. https://earth5r.org/earth5rs-river-health-index-a-community-based-monitoring-tool/

Friedrich G, Chapman D, Beim A (1996) The use of biological material. In: Chapman D (ed) Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring - Second Edition, Chapman & Hall, London, pp. 175-234.

IWIS-CITIS (2024). Post Proceedings of IWIS "River Rejuvenation and Conservation- Learnings from the Past and Strategizing the Future". Dec. 4-6, 2024. Bharat Mandapam, New Delhi, India.

IWMI (2024). Join the citizen science movement for healthy rivers. https://www.iwmi.org/news/join-the-citizen-science-movement-for-healthy-rivers/

Kuehne LM, Dickens C, Tickner D, Messager ML, Olden JD, O'Brien G, et al. (2023) The future of global river health monitoring. PLOS Water 2(9): e0000101.

Pielou EC (1966). The measurement of diversity in different types of biological collections. Journal of Theoretical Biology, 13, pp. 131–144.

Shannon CE (1948). A mathematical theory of communication. The Bell System Technical Journal, 27, pp. 379-423.

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