National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
River Development & Ganga Rejuvenation
Government of India

Developing Protocol for Initiating Monitoring and Feedback of Various Implementation Strategies/ Plans/ Programmes/ Projects

October 2025

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National River Conservation Directorate (NRCD)

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation, and Ministry of Jal Shakti providing financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of 'National River Conservation Plan (NRCP)'. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

www.nrcd.nic.in

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The Centres for Godavari River Basin Management Studies (cGodavari) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by CSIR-NEERI and IIT Hyderabad, under the supervision of cGanga at IIT Kanpur, the centre serves as a knowledge wing of the National River Conservation Directorate (NRCD). cGodavari is committed to restoring and conserving the Godavari River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.
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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

Acknowledgment

This report is a comprehensive outcome of the project jointly executed by CSIR-NEERI (Lead Institute) and IIT Hyderabad (Fellow Institute) under the supervision of cGanga at IIT Kanpur. It is submitted to the National River Conservation Directorate (NRCD) in 2025.

Disclaimer

This report is a preliminary version prepared as part of the ongoing Condition Assessment and Management Plan (CAMP) project. The analyses, interpretations and data presented in the report are subject to further validation and revision. Certain datasets or assessments may contain provisional or incomplete information, which will be updated and refined in the final version of the report after comprehensive review and verification.

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Preface

Rivers are the lifelines of civilizations, and the Godavari, India's second-longest river, stands as a vital ecological, cultural, and economic resource for the regions it traverses. However, increasing anthropogenic pressures, including pollution, unsustainable water use, and habitat degradation, have threatened its health and resilience. Recognizing the urgent need for systematic conservation efforts, this report presents a Protocol for Initiating Monitoring and Feedback of Various Implementation Strategies, Plans, Programmes, and Projects aimed at restoring and sustaining the Godavari River Basin.

Developed under the guidance of the National River Conservation Directorate (NRCD), cGanga, this protocol establishes a structured framework to ensure effective execution, real-time assessment, and adaptive management of river conservation initiatives. It builds upon the findings of the reports, plans and documents which identified critical challenges such as deteriorating water quality, sedimentation, interstate water disputes, and ecosystem degradation. The protocol emphasizes evidence-based decision-making, leveraging advanced monitoring technologies, stakeholder engagement, and iterative feedback mechanisms to enhance accountability and outcomes.

The approach outlined in this document is designed to be scalable, participatory, and adaptive, ensuring that interventions, whether short-term pollution control measures or long-term climate resilience strategies, are continuously evaluated and refined. Key components include standardized monitoring parameters, multi-tiered governance structures, and transparent reporting systems to track progress against defined targets. By integrating scientific rigor with community involvement, the protocol seeks to bridge the gap between policy formulation and on-ground implementation, fostering a collaborative ecosystem where government agencies, research institutions, industries, and local communities work in unison toward a common goal.

This protocol is more than a procedural document. It is a commitment to sustainable river governance. As the Godavari faces mounting pressures from climate change and development, the need for coordinated, data-driven action has never been greater. We hope this initiative will serve as a blueprint for restoring the Godavari's vitality, ensuring that it continues to nourish ecosystems, economies, and cultures for generations to come.

Centres for Godavari River Basin

Management Studies (cGodavari)

CSIR-NEERI, IIT Hyderabad

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1. Introduction

The Godavari River, as India's second-largest river system, sustains diverse ecosystems, agricultural economies, and millions of livelihoods across its expansive basin (Mishra et al., 1987). However, increasing anthropogenic pressures, including urban and industrial pollution, unsustainable water extraction, sand mining, and climate-induced hydrological variability (Das et al., 2021; Sarkar, 2022), have necessitated a robust, science-driven framework for monitoring and feedback to guide restoration and conservation efforts. This protocol establishes a comprehensive framework for monitoring the Godavari River Basin's ecological health, water quality, and hydrological parameters while implementing robust feedback mechanisms to inform adaptive management strategies. The system integrates scientific data collection, community participation, and advanced analytics to address critical challenges including pollution abatement, flow maintenance, biodiversity conservation, and sustainable water use across the basin's seven states.

The report is structured into chapters to systematically address the monitoring and feedback mechanisms for the Godavari River Basin. The Existing Frameworks examines the current governance and monitoring systems across the seven basin states, highlighting strengths and gaps. The Key Policy Issues and Measurable Indicators identifies critical challenges such as pollution, water scarcity, and biodiversity loss, and proposes quantifiable metrics for impact assessment. The Identification of Key Actors and Institutions maps the stakeholders responsible for monitoring and implementation, emphasizing collaborative governance. The Evidence-Based Monitoring details methodologies for data collection, validation, and application to inform decision-making. The Independent Monitoring in Development Initiatives explores the role of third-party audits and community participation in ensuring transparency. Finally, the Data Analysis Techniques for Evaluation discusses tools and approaches for interpreting monitoring data to drive adaptive management across the Godavari Basin.

This protocol ensures all interventions in the Godavari Basin are effectively tracked, evaluated, and improved through a participatory, evidence-based approach. It provides for efficient resource utilization while maintaining flexibility to address the basin's evolving challenges. Recognizing the basin's ecological significance and the complex challenges it faces - from pollution and over-extraction to biodiversity loss and climate impacts - this protocol creates an integrated framework for evidence-based decision making. It serves as the cornerstone for ensuring that diverse initiatives ranging from government programs to community-led projects contribute effectively to the basin's sustainable development while maintaining alignment with national water policies and Sustainable Development Goals (SDG) targets. This framework aims to be applied universally across the Godavari basin area, encompassing all water resource projects (irrigation, drinking water, hydropower), environmental conservation initiatives (forestry, biodiversity, pollution control), agricultural development programs, rural and urban infrastructure projects, as well as climate adaptation interventions. The protocol mandates compliance regardless of project size (from mega-dams to local watershed programs), funding source (government, private, international), or implementing agency.

2. Existing frameworks

Existing frameworks for river basin management, particularly those under initiatives like the National Mission for Clean Ganga (NMCG) and state-level Godavari rejuvenation programs, emphasize continuous monitoring of three interdependent dimensions namely river-related (hydrological, morphological, and water quality parameters), people-related (socio-economic dependencies and pollution sources), and environment-related (biodiversity, riparian ecosystems, and climate resilience). Participatory monitoring is integral to these frameworks, leveraging local knowledge and community engagement to enhance data accuracy, transparency, and stakeholder ownership. For instance, involving communities in tracking pollution hotspots or deploying citizen science tools for water quality assessments can bridge gaps in conventional monitoring systems.

2.1 Monitoring Frameworks for River Basin Conservation

The Godavari River Basin, spanning seven Indian states, is governed through a combination of national policies and state-specific initiatives tailored to address regional challenges. Each state has developed distinct frameworks for water allocation, pollution control, and ecological conservation, reflecting the basin's diverse geographical and socio-economic conditions. Below is a detailed state-wise breakdown of the existing governance and monitoring frameworks for the Godavari River (See Tables 2.1 to 2.8).

Table 2.1. List of Central Schemes [1]

S.No.	Scheme	Area
1.	Jal Sanchay Jan Bhagidari	A key target of the initiative is the construction of at least one million recharge shafts, with approximately 25,000 already completed.
2.	Accelerated Irrigation Benefit Programme (AIBP)	Ninety-Nine ongoing Major/Medium irrigation projects (and 7 phases) were identified under AIBP during 2016-17. Out of these 99 projects and 62 projects have been reported by States to be completed so far. During 2016-2024, additional irrigation potential of 25.80 Lakh ha. has been created through these projects.
3.	Command Area Development and Water Management (CAD&WM)	Since 2016-17, CADWM Program has been restricted to 99 Prioritized AIBP Projects.
4.	Har khet ko Paani: Surface minor irrigation (SMI)	The target for irrigation potential creation under these schemes is 11.50 lakh hectares, with 3.546 lakh hectares reported to have been created till November 2024.
5.	Har khet ko Paani: Repair, Renovation and Restoration (RRR) of water bodies.	The target for irrigation potential creation in this scheme is 2.41 lakh hectares, with 1.093 lakh hectares reported to be restored till November 2024.
6.	National Mission For Clean Ganga (NMCG)	Government of India approved the Namami Gange Mission on 13th May 2015 as a comprehensive and integrated approach for Ganga River rejuvenation and its tributaries. The programme was subsequently extended up to 31st March 2026 with a budgetary outlay of Rs. 22,500 crores from April 2021 to March 2026.

[1] Source; Report 2024-2025-Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India)

7.	Atal Bhujal Yojana (Atal Jal)	Atal Bhujal Yojana (ATAL JAL) is being implemented since April, 2020 in 8,203 water stressed Gram Panchayats of 229 administrative blocks/ Talukas in 80 districts of seven States, viz. Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh for five years.
8.	Ground Water Management And Regulation (GWMR) Scheme	One of the major activities under the scheme is National Aquifer Mapping & Management (NAQUIM) Programme, under which it was targeted to cover approx..25 lakh sq km of mappable area and it has been covered by 31st March 2023
9.	Flood Management & Border Areas Programme (FMBAP)	The States/UTs are provided promotional central financial assistance through Flood Management Programme (FMP) and River Management Activities & Works related to Border Areas (RMBA) schemes of Department, which have been merged into a single scheme titled FMBAP which is under implementation.
10.	National Hydrology Project (NHP)	National Hydrology Project (NHP), with support from the World Bank, envisages establishing a system for timely and reliable water resources data acquisition, storage, collation and management.
11.	Dam Rehabilitation And Improvement Project (DRIP)	The scheme has provision for rehabilitation of 736 dams located in 19 States (Andhra Pradesh, Chhattisgarh, Goa, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand, West Bengal) and 3 Central Agencies (Central Water Commission, Bhakra Beas Management Board and Damodar Valley Corporation). It is a State Sector Scheme having central component, with duration of 10 years, to be implemented in two Phases i.e. Phase- II and Phase-III, each of six years duration with an overlap of two years.
12.	Development Of Water Resources Information System	DWRIS scheme is a continuing scheme of 12th five-year plan is under implementation during 2021-22 to 2025- 26 with outlay of Rs. 715 crores, for creation of reliable and sound database for policy formulation, planning and designing of water resources projects, timely dissemination of flood forecast.
13.	National River Conservation Plan	The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation is providing financial and technical assistance to the State/UT Governments for conservation of rivers under the Centrally Sponsored Schemes of National River Conservation Plan (NRCP).

The table 2.1 provides a comprehensive overview of key water resource management schemes implemented by the Government of India, highlighting their geographical coverage, targets, and progress achieved. These initiatives collectively address various aspects of water conservation, irrigation development, groundwater management, flood control, and river rejuvenation across multiple states. Beginning with community participation, the Jal Sanchay Jan Bhagidari scheme focuses on groundwater recharge through an ambitious target of constructing one million recharge shafts, with 25,000 already completed. For irrigation infrastructure, the Accelerated Irrigation Benefit Programme (AIBP) has made significant progress, completing 62 out of 99 major/medium irrigation projects since 2016-17, creating an additional irrigation potential of 25.80 lakh hectares. The Command Area Development and

Water Management (CAD&WM) program specifically supports these prioritized AIBP projects.

The Har Khet Ko Paani initiative operates through two components: the Surface Minor Irrigation scheme has created irrigation potential for 3.546 lakh hectares against an 11.50 lakh hectare target, while the Repair, Renovation and Restoration (RRR) of water bodies component has restored 1.093 lakh hectares of its 2.41 lakh hectare goal. River conservation efforts are led by the National Mission for Clean Ganga (NMCG), with a substantial budget of Rs. 22,500 crores allocated until March 2026 for comprehensive Ganga rejuvenation. Groundwater management receives focused attention through the Atal Bhujal Yojana, implemented in 8,203 water-stressed Gram Panchayats across seven states, and the GWMR Scheme, which has successfully completed aquifer mapping of approximately 25 lakh sq km under the NAQUIM program. Flood management is addressed through the FMBAP, merging previous schemes to provide central assistance for flood control and border area river management.

Technological advancement in water resource management is evident in the National Hydrology Project, supported by the World Bank, which establishes systems for robust water data management, and the Development of Water Resources Information System (DWRIS), creating databases for policy formulation with a Rs. 715 crore outlay. Infrastructure safety is ensured through the Dam Rehabilitation and Improvement Project (DRIP), rehabilitating 736 dams across 19 states in a phased manner. Lastly, the National River Conservation Plan extends financial and technical support to states for river conservation efforts. Together, these schemes demonstrate India's multi-pronged approach to water resource management, combining infrastructure development, community participation, technological innovation, and environmental conservation to address the nation's diverse water challenges while ensuring sustainable resource utilization for agricultural and domestic needs.

1. Maharashtra

Table 2.2. Existing Frameworks in Maharashtra

S.No.	Framework	Monitoring Aspects	Participatory Role
1	Maharashtra Irrigation Act, 1976	Regulate irrigation water use, prevent wastage, and resolve water disputes.	Water Regulation & Monitoring, Water Users Associations (WUAs), Drought & Flood Management
2	Maharashtra Water Resource Regulatory Authority Act 2005	Water flow, quality, and usage, water demand, conflicts, and equitable distribution, Groundwater levels, pollution, and ecological flows.	Involves Water User Associations (WUAs) and local stakeholders in data collection. Community-based reporting on water theft and illegal diversions.
3	Maharashtra Management of Irrigation System by Farmers Act 2005	Maintenance of canals (reduces siltation in rivers), monitoring water theft (prevents illegal diversions from rivers), data collection on water usage (supports basin-level planning).	Reducing River Water Exploitation, Pollution & Encroachment Control, Data Sharing with State Agencies
4	Maharashtra Groundwater (Development and Management) Act 2009	Baseflow contribution to rivers. Drinking water security and agricultural dependence. Depletion rates and recharge zones.	Village-level Bhujal Abhiyan (participatory groundwater monitoring). Training farmers to measure well levels and report data to GSDA.
5	National River Conservation Plan	BOD, COD, fecal coliform levels. Sewage treatment and public	Citizen science programs like Jal Mitra for water quality testing. NGOs (e.g.,

	(NRCP) – Godavari & Krishna River Projects	health. Biodiversity and riparian health.	Jeevitnadi) engage locals in monitoring Godavari tributaries.
6	Integrated State Water Plan (ISWP)	Surface water availability, climate resilience.	Consultations with Zilla Parishads and Gram Panchayats.
7	Maharashtra Pollution Control Board (MPCB)	Industrial effluents, sewage treatment plants (STPs). Real-time monitoring of Mula-Mutha, Godavari, Ulhas rivers.	Public complaints via MPCB app and Jal Rakshak Dal (volunteer squads).
8	Namami Gange (for Godavari tributaries)	Industrial pollution, biodiversity.	Ganga Praharis (community guards).
9	Sant Gadge Baba Abhiyan	Improve urban sanitation through cleanliness drives and public toilets	Waste collection, segregation, and public toilet provision
10	Sujal Nirmal Maharashtra Abhiyan (SNMA)	Improve rural water supply and sanitation, Water quality awareness	Consumer survey, water audit, energy audit and leak detection survey, GIS mapping and Hydraulic modelling, installation of bulk flow meters
11	WOTR (Watershed Organisation Trust)	Drought-prone areas (Ahmednagar, Beed).	Farmers collectives track soil moisture.
12	Paani Foundation	Check dam impacts, groundwater recharge.	Shramdaan (community labor for water conservation).
13	AFARM (Action for Agricultural Renewal in Maharashtra)	Agri-water usage in drought zones.	Women's Self-Help Groups (SHGs) monitor wells.
14	Jeevitnadi-Living Rivers Foundation	Urban river health (Mula-Mutha, Indrayani).	Citizens map pollution sources.

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The table 2.2 provides a detailed overview of key frameworks, policies, and programs governing water resource management, river conservation, and participatory monitoring in Maharashtra. It covers 14 distinct initiatives, each addressing different aspects of basin management such as irrigation regulation (Maharashtra Irrigation Act, 1976), groundwater sustainability (Maharashtra Groundwater Act, 2009), pollution control (MPCB monitoring, NRCP), and community-driven water conservation (Paani Foundation, WOTR). The Monitoring Aspects column highlights specific focus areas, including water quality (BOD, COD), groundwater levels, industrial effluents, and ecological flows, while the Participatory Role column emphasizes community involvement through Water Users Associations (WUAs), citizen science programs (Jal Mitra), and volunteer squads (Jal Rakshak Dal). Additionally, schemes like Sujal Nirmal Maharashtra Abhiyan (SNMA) and Sant Gadge Baba Abhiyan integrate sanitation and water supply improvements with public participation. NGOs like Jeevitnadi and AFARM further strengthen grassroots engagement in urban river health and agricultural water management.

2. Telangana

Table 2.3. Existing Frameworks in Telangana

S.No.	Framework	Monitoring Aspects	Participatory Role
1	The Telangana water, land and trees act, 2002	River water sharing (Krishna & Godavari). Groundwater sustainability.	Water Users Associations (WUAs) involved in decision-making.
2	Mission Kakatiya (2014)	Desilting, bund strengthening. Recharge groundwater linked to rivers.	Village committees monitor tank maintenance.
3	Godavari & Krishna River Management Boards (GRMB & KRMB)	Monitor dam releases (Srisailam, Nagarjuna Sagar).	Stakeholder meetings with Andhra Pradesh.
4	Atal Bhujal Yojana (ABHY) – Telangana	Focus on 7 over-exploited districts (e.g., Nalgonda).	Village Water Committees prepare water budgets.
5	Namami Godavari (under Namami Gange)	STPs, ghat development.	NGOs conduct awareness drives. Local community involvement
6	Jal Jeevan Mission (JJM)	Sources from rivers/tanks.	Village Water & Sanitation Committees (VWSCs) monitor quality.
7	The Swachhata Trailblazer	Promote cleanliness and awareness through community engagement, Awareness drives, cleaning of parks, and community areas	Students, community members, and self-help groups
8	Telangana State Sanitation Strategy (TL-SSS)	Create clean urban environments through sanitation management, Wastewater management, capacity building, and stormwater drainage	Local community involvement
9	Pattana Pragathi - Toilet Monitoring System (PP-TMS)	Track sanitation facility construction and maintenance, ICT tools for real-time monitoring	Urban local bodies

10	Swachh Bharat Mission (Grameen) 2.0 in Telangana	Achieve and sustain ODF Plus villages IHHL construction, waste management	Rural villages
11	Jal Shakti Abhiyaan	water conservation a Jan Andolan through asset creation and extensive communication.	groundwater experts and scientists from the Government of India work together with state and district officials in India's most water-stressed districts for water conservation and water resource management by focusing on accelerated implementation of five target intervention

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The table 2.3 outlines key frameworks, policies, and programs related to water resource management, river conservation, and sanitation in Telangana, highlighting their monitoring aspects and participatory approaches. The Telangana Water, Land, and Trees Act (2002) regulates river water sharing (Krishna & Godavari) and groundwater sustainability, with Water Users Associations (WUAs) playing a key role in decision-making. Mission Kakatiya (2014) focuses on restoring minor irrigation tanks by desilting and strengthening bunds to enhance groundwater recharge, with village committees overseeing maintenance. The Godavari and Krishna River Management Boards (GRMB & KRMB) monitor dam releases (e.g., Srisailam, Nagarjuna Sagar) and facilitate inter-state stakeholder consultations with Andhra Pradesh. For groundwater conservation, Atal Bhujal Yojana (ABHY) targets seven over-exploited districts (e.g., Nalgonda), where Village Water Committees prepare water budgets. Under Namami Godavari (Namami Gange), sewage treatment plants (STPs) and ghat development are monitored, with NGOs and local communities engaged in awareness drives. The Jal Jeevan Mission (JJM) ensures safe drinking water sourced from rivers and tanks, with Village Water & Sanitation Committees (VWSCs) monitoring quality. Sanitation initiatives include The Swachhata Trailblazer, which promotes cleanliness through student and community engagement, and the Telangana State Sanitation Strategy (TL-SSS), which improves urban sanitation via wastewater management and local participation. The Pattana Pragathi - Toilet

Monitoring System (PP-TMS) uses ICT tools for real-time tracking of sanitation facilities, managed by urban local bodies. Swachh Bharat Mission (Grameen) 2.0 aims for ODF Plus villages through rural community-driven waste management, while Jal Shakti Abhiyaan mobilizes government experts, scientists, and local officials for water conservation in stressed districts.

3. Andhra Pradesh

Table 2.4. Existing Frameworks in Andhra Pradesh

S.No	Framework	Monitoring Aspects	Participatory Role
1	The Andhra Pradesh water, land and trees act, 2002	Permits for borewells Declares over-exploited zones.	Farmer groups report illegal drilling.
2	Andhra Pradesh State Water Policy, 2009	Prioritizes drinking water and irrigation. Promotes rainwater harvesting.	Public consultations in drafting.
3	Swatchh Andhra Corporation	Align with SBM to eliminate open defecation and improve sanitation, IHHL, CT, PT construction; partnerships with international agencies	Urban and rural populations
4	Village Health Sanitation & Nutrition Committee	Integrated sanitation strategy for urban areas, Safe excreta disposal, wastewater, and solid waste management	Urban communities participation at local levels
5	Rural Sanitation Strategies	Enhance rural sanitation coverage, Tailored approaches based on geography, infrastructure improvement	Rural households
6	Polavaram Project Authority	directions for establishment, maintenance and operation of an effective system of flood forecasting and flood control including reporting of heavy precipitation and telecommunication systems	obtain all requisite clearances including environmental, forests, and rehabilitation and resettlement norms.
7	Andhra Pradesh - Land Governance Assessment Framework (LGAF)	land tenure recognition; rights to forest and common lands and rural land use regulations; urban land use, planning, and development; public land management; process for transfer of public land to private use; public provision of land information (land administration and information systems); land valuation and taxation; dispute resolution and review of institutional arrangements and policies	gaps in existing evidence, areas for regulatory or institutional change, piloting of new approaches, and interventions to improve land governance on a broader scale (e.g. by strengthening land rights and improving their enforcement); and criteria to assess the effectiveness of these measures.
8	Mission for Clean Krishna and Godavari Canals	protecting and restoring the canals and drains in the state of Andhra Pradesh.	Government interventions, local participation
9	Andhra Pradesh Integrated Irrigation and Agriculture Transformation Project	To enhance agricultural productivity, profitability and climate resilience of small holder farmers in 1000 selected tanks stabilizing an ayacut of 2,26,552 Acres in 12 districts (except Guntur).	World Bank Funded

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The table 2.4 provides a comprehensive overview of key policies, programs, and institutional frameworks governing water resource management, land governance, and sanitation in Andhra Pradesh. The Andhra Pradesh Water, Land and Trees Act (2002) serves as the foundational legislation, regulating groundwater extraction through a permit system for borewells and declaring over-exploited zones, with active participation from farmer groups who help report illegal drilling activities. Complementing this, the Andhra Pradesh State Water Policy (2009) establishes water use priorities, emphasizing drinking water and irrigation while promoting rainwater harvesting, with its formulation involving public consultations to ensure inclusive policy-making. In the sanitation sector, the Swatchh Andhra Corporation aligns with the Swachh Bharat Mission to eliminate open defecation through the construction of individual household latrines (IHHLs), community toilets (CTs), and public toilets (PTs), engaging both urban and rural populations. The Village Health Sanitation & Nutrition Committee and Rural Sanitation Strategies further strengthen sanitation efforts by focusing on safe excreta disposal, wastewater management, and solid waste management, with tailored approaches for different geographical areas and active community participation at local levels.

Water infrastructure and management are addressed through the Polavaram Project Authority, which oversees flood forecasting and control systems while ensuring compliance with environmental and rehabilitation norms. The Mission for Clean Krishna and Godavari Canals focuses on protecting and restoring critical water channels through combined government interventions and local participation. Additionally, the Andhra Pradesh Integrated Irrigation and Agriculture Transformation Project, funded by the World Bank, aims to enhance agricultural productivity and climate resilience for smallholder farmers by stabilizing tank irrigation systems across 12 districts. Land governance is addressed through the Andhra Pradesh - Land Governance Assessment Framework (LGAF), which evaluates various aspects of land tenure, urban planning, public land management, and dispute resolution, identifying gaps and recommending institutional reforms to strengthen land rights and governance systems.

4. Chhattisgarh

Table 2.5. Existing Frameworks in Chhattisgarh

S.No	Framework	Monitoring Aspects	Participatory Role
1	The Community Incentive Model: Towards an Open Defecation Free Chhattisgarh	Innovative and customisable ways ideas and processes needed to ensure community buy-in and achieve greater ownership of the process and high rates of toilet use in an environmentally safe manner.	community-led processes and has seen a number of innovations, Community Incentive Method
2	Community Led Total Sanitation (CLTS)	community mobilization, promoting the health benefits of sanitation, and incentivizing villages to achieve and sustain Open Defecation Free (ODF) status	forming monitoring committees, involving children in monitoring, providing flexibility in toilet technology, and engaging private sanitary ware suppliers to ensure a steady supply chain.
3	Chhattisgarh Environment Conservation Board	control of water pollution and maintaining or restoring the wholesomeness of water by treating sewage, industrial effluents	conserving natural waters to statutory norms and reducing, recycling, reusing and safe-disposing solid wastes
4	Compensatory Afforestation Fund Management and Planning Authority (CAMPA)	restoring natural forests in highly degraded areas (Bastar and Korba)	Wildlife corridors, habitat improvement in protected areas

Source Cited

1. https://sanitationlearninghub.org/resource/the-community-incentive-model-towards-an-open-defecation-free-chhattisgarh/
2. https://www.cltsfoundation.org/clts-champions/
3. https://www.enviscecb.org/func_activ.htm#Activities
4. https://nationalcampa.nic.in/dashboard/monitoring_evaluation_reports/681075e3b5be6.pdf

The table 2.5 presents four key frameworks implemented in Chhattisgarh that address sanitation, environmental conservation, and afforestation through community participation and institutional mechanisms. The Community Incentive Model represents an innovative approach to achieving Open Defecation Free (ODF) status by emphasizing community ownership through customizable processes and behavioural change strategies. This model has demonstrated success by fostering local buy-in and ensuring sustainable toilet usage in an environmentally safe manner. Complementing this, the Community Led Total Sanitation (CLTS) program focuses on grassroots mobilization through health awareness campaigns and village-level incentives, supported by monitoring committees that actively involve children and local stakeholders while collaborating with private suppliers to maintain sanitation infrastructure. For environmental protection, the Chhattisgarh Environment Conservation Board plays a regulatory role in water pollution control by enforcing sewage and industrial effluent treatment standards. Its mandate extends to conserving natural water bodies and promoting sustainable solid waste management through recycling and safe disposal practices. Meanwhile, the Compensatory Afforestation Fund Management and Planning Authority

(CAMPA) focuses on ecological restoration, particularly in degraded regions like Bastar and Korba, by funding afforestation projects and improving wildlife habitats in protected areas.

5. Odisha

Table 2.6. Existing Frameworks in Odisha

S.No.	Framework	Monitoring Aspects	Participatory Role
1	Odisha Rural Sanitation Policy 2020	Sustain sanitation access and hygiene practices, Solid and liquid waste management,	Gram Panchayat involvement, Rural communities
2	Community Led Sanitation (CLS)	Achieve ODF through community empowerment, Toilet construction with subsidies, community awareness	Rural households, tribal communities
3	Decentralized Solid Waste Management	Manage waste through local composting and recycling MCCs, MRFs, and public participation	Urban local bodies
4	Orissa Pani Panchayat Act, 2002	Water distribution and optimizing its use and access to farmers	irrigation participation management by involving farmers directly in the governance, operation, and maintenance of irrigation systems.
5	Odisha Integrated Irrigation Project for Climate Resilient Agriculture (OIIPCRA)	Objective is to intensify and diversify agricultural production, and enhance climate resilience in selected districts of Odisha.	World Bank Funded. Local Community participation

Source Cited

1. https://cprindia.org/wp-content/uploads/2021/12/Odisha-Rural-Sanitation-Policy.pdf
2. https://options.co.uk/article/improving-community-sanitation-in-odisha/
3. https://urban.odisha.gov.in/
4. https://www.indiacode.nic.in/bitstream/123456789/5928/1/the_orissa_pani_panchayat_act_2002.pdf
5. https://nmcg.nic.in/Annual_Reports.aspx

The table 2.6 outlines five key frameworks and policies implemented in Odisha that address rural sanitation, waste management, water governance, and climate-resilient agriculture through participatory approaches. The Odisha Rural Sanitation Policy 2020 serves as the foundational framework for sustaining sanitation access and hygiene practices in rural areas, with a focus on solid and liquid waste management. This policy actively involves Gram Panchayats and rural communities in its implementation, ensuring decentralized governance and local ownership. Complementing this, the Community Led Sanitation (CLS) program adopts a grassroots approach to achieve Open Defecation Free (ODF) status by empowering rural and tribal communities through awareness campaigns, toilet construction subsidies, and behavioural change initiatives. For urban waste management, the Decentralized Solid Waste Management framework promotes local-level solutions such as composting, recycling, and material recovery facilities (MRFs), with Urban Local Bodies (ULBs) leading implementation alongside public participation. In the water sector, the Orissa Pani Panchayat Act, 2002

institutionalizes farmer-led irrigation management by enabling Pani Panchayats (water user associations) to govern, operate, and maintain irrigation systems, ensuring equitable water distribution and optimized agricultural use.

Additionally, the Odisha Integrated Irrigation Project for Climate Resilient Agriculture (OIIPCRA), funded by the World Bank, aims to enhance agricultural productivity and climate resilience in select districts. This project emphasizes local community participation in adopting sustainable farming practices and improving water-use efficiency.

6. Karnataka

Table 2.7. Existing Frameworks in Karnataka

S.No.	Framework	Monitoring Aspects	Participatory Role
1	Safai karamchari Kavalu Samiti (SKKS)	Empower sanitation workers and improve rights	Worker mobilization, accountability advocacy, sanitation workers
2	Rural Sanitation Campaigns	Reduce open defecation and increase toilet coverage	Grama Yojanas, IHHL construction under SBM Rural population
3	State Water Policy Karnataka, 2022	facilitate the water security and optimal utilisation of the State's water resources for health, food, energy, environment and other societal purposes.	Community based integrated Land and Water Management Plans
4	Water Conservation project in Karnataka	assessing the water security status of the village, creating new water harvesting structure to balance the demand and supply side and capacitating farmers on efficient and productive use of water.	meetings with Gram Panchayats, orientation to gram panchayat members and gram panchayat officials
5	The Karnataka Ground Water (Regulation And Control Of Development And Management) Act, 2011	regulate and control the development and management of ground water	Local community monitors the works
6	Karnataka integrated & Sustainable Water Resources Management Investment program-2	Modernization of Vijayanagar Channel System and taking up Integrated Water Resources Management (IWRM) components in K8 sub-basin of Krishna River Basin. Preparation of River Basin Profile for K-2, K-3 & K-4 sub-basinin Karnataka and River Basin Atlas for Ghataprabha and Malaprabha Sub-basin	Funded by Asian Development Bank (ADB)

Source Cited

1. http://www.thamate.org/our-work/safaikarmachari-kavulu-samithi/
2. https://english.swachhamevajayate.org/wp-content/uploads/2021/01/Karnataka-State-Rural-Sanitation-Strategy_Eng.pdf

3. https://aciwrm.karnataka.gov.in/storage/pdf-files/Report%20PDFs/StateWaterPolicy-English.pdf
4. https://afpro.org/ongoing-project-6-project-title-water-conservation-project-in-telangana-and-karnataka/
5. https://dpal.karnataka.gov.in/storage/pdf-files/25%20of%202011%20(E).pdf
6. https://nmcg.nic.in/Annual_Reports.aspx

The table 2.7 presents six key frameworks and initiatives implemented in Karnataka that address sanitation, water security, and sustainable water resource management through participatory governance and policy interventions. The Safai Karamchari Kavalu Samiti (SKKS) focuses on empowering sanitation workers by advocating for their rights and improving accountability mechanisms through worker mobilization. This is complemented by Rural Sanitation Campaigns, which aim to eliminate open defecation and expand toilet coverage under the Swachh Bharat Mission (SBM) by engaging Gram Panchayats and rural communities in Individual Household Latrine (IHHL) construction and behavioral change programs. On water governance, the State Water Policy Karnataka, 2022 provides a strategic framework to ensure water security and optimal utilization of water resources for health, agriculture, energy, and environmental sustainability. It emphasizes community-based integrated land and water management plans, ensuring local stakeholders play a central role in decision-making. Similarly, the Water Conservation Project in Karnataka adopts a participatory approach by conducting village-level water security assessments, constructing water harvesting structures, and training farmers in efficient water use, with active involvement from Gram Panchayats and local officials.

Groundwater regulation is addressed through The Karnataka Ground Water Act, 2011, which controls extraction and promotes sustainable management, with local communities monitoring compliance. For large-scale water infrastructure, the Karnataka Integrated & Sustainable Water Resources Management Investment Program-2, funded by the Asian Development Bank (ADB), focuses on modernizing irrigation systems (e.g., Vijayanagar Channel) and implementing Integrated Water Resources Management (IWRM) in Krishna River sub-basins. This includes preparing river basin profiles and atlases to guide data-driven planning.

7. **Madhya Pradesh**

Table 2.8. Existing Frameworks in Madhya Pradesh

S.No.	Framework	Monitoring Aspects	Participatory Role
1	The Madhya Pradesh Sinchai Prabandhan me Krishkon ki Bhagidari Adhiniyam, 1999	Promote participatory irrigation management (PIM) via Water Users' Associations (WUAs).	WUAs manage canal water distribution and maintenance. Covers major irrigation projects like Indira Sagar, Omkareshwar
2	Swachh Bharat Mission (Grameen); Progress in Madhya Pradesh	Achieve ODF and ODF Plus status in villages, IHHL, CSC construction,	mobile monitoring app, Rural communities
3	Narmada Landscape Restoration Project, Madhya Pradesh India	enhance the quality and quantity of water in these tributaries by promoting sustainable landscape interventions with the help of local communities.	Incentives through soil organic carbon credits

4	Kapil Dhara Yojana	develop irrigation facilities on private land of small and marginal farmers, through the construction of dug wells, farm ponds, check dams	facilities and prioritizes marginalized communities
5	Madhya Pradesh Irrigation Efficiency Improvement Project	Develop 1,25,000 hectares of new, highly efficient micro irrigation network in Rajgarh. Design and construction of a highly efficient and productive new pressurized irrigation system with automated volumetric control for efficient, reliable and flexible water delivery services.	Funded by Asian Development Bank (ADB) to local restoration of irrigation networks in the region

Source Cited

1. https://prsindia.org/files/bills_acts/acts_states/madhya-pradesh/1999/Act%20No.%2023%20of%201999%20Madhya%20Pradesh.pdf
2. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/jul/doc2023717223501.pdf
3. https://gggi.org/project/in12-narmada-landscape-restoration-project/
4. https://www.niti.gov.in/sites/default/files/2023-03/CompositeWaterManagementIndex.pdf
5. https://nmcg.nic.in/Annual_Reports.aspx

The table 2.8 outlines five key frameworks and initiatives implemented in Madhya Pradesh that focus on participatory irrigation management, rural sanitation, and water resource conservation through community engagement and technological interventions. The Madhya Pradesh Sinchai Prabandhan me Krishkon ki Bhagidari Adhiniyam, 1999 serves as the cornerstone for participatory irrigation management (PIM) by establishing Water Users Associations (WUAs) that oversee canal water distribution and infrastructure maintenance in major projects like Indira Sagar and Omkareshwar. This decentralized approach ensures farmer involvement in irrigation governance. Complementing this, the Swachh Bharat Mission (Grameen) drives rural sanitation through toilet construction (IHHLs, CSCs) and community mobilization, supported by a mobile monitoring app to track progress toward ODF and ODF Plus status. For ecological restoration, the Narmada Landscape Restoration Project enhances water quality and availability in tributaries by incentivizing sustainable land-use practices, including soil organic carbon credits for local communities. Similarly, the Kapil Dhara Yojana targets small/marginal farmers by developing on-farm irrigation infrastructure (dug wells, check dams) with a focus on marginalized groups. At a larger scale, the Madhya Pradesh Irrigation Efficiency Improvement Project, funded by the Asian Development Bank (ADB), introduces pressurized micro-irrigation systems with automated controls in Rajgarh to optimize water delivery and expand irrigated area by 1.25 lakh hectares.

2.2. Role of Participatory Monitoring

Participatory monitoring has emerged as a transformative approach in the Godavari River basin's conservation efforts, bridging the gap between government initiatives and grassroots environmental stewardship. The system actively involves Gram Panchayats and local NGOs as key partners in safeguarding the river's ecological integrity, recognizing their intimate knowledge of the basin's micro-environments and socio-cultural dynamics. These partnerships enable systematic tracking of indicator species, including the endangered Gangetic dolphin and migratory birds, whose population trends serve as vital biomarkers of river health.

The Godavari River Management Board (GRMB) was established on 28th May 2014 under Section 85 of the Andhra Pradesh Reorganisation Act, 2014. Since its inception, the Board has been actively addressing various operational issues related to its mandate through consultations with senior officials from Telangana and Andhra Pradesh. One of the key developments in 2024-25 was the Advisory Committee's approval of five irrigation projects from Telangana, including the Chanaka-Korata Barrage, Choutapally Hanmanth Reddy LIS, Chinna Kaleshwaram LIS, Modikuntavagu Medium Irrigation Project, and Kaddem-Gudem LIS. The Andhra Pradesh government has been requested to submit Detailed Project Reports (DPRs) for these projects following Central Water Commission (CWC) guidelines to facilitate further appraisal and implementation. Another significant issue under discussion is the modernization of the Peddavagu Medium Irrigation Project, an interstate initiative between Andhra Pradesh and Telangana. The matter has been under deliberation since the 8th GRMB meeting, with a project-specific meeting held on 5th August 2024 in Hyderabad. During this meeting, the Board emphasized the urgent need for repairs and modernization due to the deteriorating condition of the project's infrastructure. Both states were advised to seek technical assistance from the National Dam Safety Authority (NDSA) and expedite necessary approvals to ensure timely execution. Additionally, the Central Water Commission conducted a study on water availability and allocations based on the Godavari Water Disputes Tribunal Award, with GRMB working to build consensus between the two states on the findings. To enhance real-time water monitoring, the GRMB has prioritized the installation of telemetry stations at interstate border points across the Godavari Basin. A Telemetry Committee, formed in June 2021, identified 23 locations for sensor installations, including level and velocity monitoring systems. While 22 stations have been installed and are undergoing commissioning, three locations face delays due to logistical constraints. The Board has urged both states to independently complete the telemetry network under the National Hydrology Project (NHP) and develop a robust water accounting system to ensure transparent and efficient water resource management. During the 16th GRMB meeting held on 20th August 2024, the Board reviewed technical clearances for Telangana's Integrated Sita Rama Lift Irrigation Project (SRLIP) and Sitamma Sagar Multipurpose Project (SSMPP)[2]

A particularly successful model of community engagement is the Jal Sevak program operational in Maharashtra's Nashik and Aurangabad districts. These trained local volunteers function as the river's guardians, using smartphone applications to report illegal sand mining activities, industrial effluent discharges, and riverbank encroachments in real-time. Their reports trigger rapid response mechanisms from authorities, significantly reducing the time lag between violation and action. The Jal Sevaks' hyper-local presence allows them to monitor stretches of the river that are logistically challenging for government agencies to patrol

[2] Source; Report 2024-2025-Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India.

regularly. During the 2024 Kumbh Mela in Nashik, this network proved invaluable in managing pilgrim-generated waste, with volunteers coordinating daily clean-up drives and reporting sanitation issues to municipal authorities within hour[3].

The strength of participatory monitoring in the Godavari context lies in its dual benefit - it not only enhances environmental surveillance but also fosters a sense of ownership among riverside communities. Traditional fishermen in Andhra Pradesh's Rajahmundry region, for instance, have begun maintaining water quality diaries that complement official monitoring data, recording observations about fish behaviour, water turbidity, and algal blooms. Women's self-help groups in Telangana's tribal areas monitor drinking water sources, creating pressure for infrastructure improvements. When integrated with formal monitoring systems, these community-generated insights create a more comprehensive understanding of the river's health, capturing nuances that technological systems might miss. However, the full potential of participatory monitoring remains constrained by inconsistent funding, lack of technical training at the grassroots level, and occasional resistance from local stakeholders dependent on river-exploitative livelihoods. Strengthening these community networks through better resource allocation and institutional recognition could transform them into a formidable first line of defense for the Godavari's ecological future.

[3] https://abp.championsofchange.gov.in/content/10595a-life-less-ordinary-ganga-prahari-guardians-of-the-ganga

3. Key Policy Issues & Measurable Indicators for Impact Assessment

The identification of issues that policy can and should monitor is a critical step in effective river basin management, particularly in the context of restoration and conservation. This involves recognizing key challenges across hydrological, ecological, and socio-economic dimensions such as water quality degradation, loss of biodiversity, declining groundwater levels, unsustainable land use, and community vulnerability (See Tables 3.1 to 3.7). Once these issues are identified, the next essential step is to convert them into quantifiable indicators or metrics that can be systematically monitored over time. For example, water pollution can be tracked through parameters like Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and faecal coliform counts, ecosystem health through vegetation cover and aquatic biodiversity indices, and community well-being through access to clean water, incidence of water-borne diseases, and livelihood dependencies on river systems. Establishing such measurable indicators allows policymakers to design evidence-based interventions, set performance benchmarks, evaluate policy outcomes, and ensure accountability in implementation. Moreover, aligning these measures with national and state-level frameworks ensures consistency in data collection and enhances the potential for comparative assessments and integrated action.

3.1. Identifying Issues and Developing Measures

A critical step in this protocol is the identification of policy-monitorable issues and their translation into quantifiable measures. For the Godavari, this could involve measuring minimum environmental flows at key barrages tracking reductions in industrial biochemical oxygen demand (BOD) loads in Nashik, or assessing the recovery of endangered species such as the Gangetic dolphin in the Pranhita tributary. These metrics must be spatially and temporally disaggregated to account for the basin’s heterogeneity.

3.1.1 Threats to the Basin

The Godavari River basin sustains a complex interplay of human activities that significantly impact its hydrological regime and water quality. Agricultural water use dominates the basin's freshwater withdrawals with water-intensive crops like sugarcane in Maharashtra's Marathwada region and paddy in Andhra Pradesh's deltaic districts creating severe demand-supply imbalances. This agricultural dependence has led to unsustainable groundwater extraction, particularly in Telangana's semi-arid zones where the water table has been declining at an alarming rates per year, as documented by the Central Ground Water Board. The basin's religious significance introduces unique pollution challenges, most notably during mass gatherings like the Nashik Kumbh Mela, where temporary infrastructure struggles to manage the wastewater from millions of pilgrims, resulting in documented spikes of fecal coliform levels exceeding in downstream monitoring stations. Groundwater dependency has reached critical levels in drought-prone areas like Beed and Osmanabad districts, where high percentages of drinking water needs are met through deep borewells, many of which show increasing salinity and fluoride contamination. The socio-economic dimensions of water use are particularly evident in the Godavari's tribal belts, where marginalized communities face disproportionate impacts from both water scarcity and pollution, often relying on contaminated surface water sources due to inadequate infrastructure. This complex human-water relationship underscores the need for integrated management approaches that balance agricultural

productivity, cultural practices, and sustainable water use while addressing the growing threats of groundwater depletion and point-source pollution from urban and religious centres. The Godavari River delta, particularly in the Coringa Wildlife Sanctuary of Andhra Pradesh, represents one of India's most ecologically significant yet vulnerable ecosystems. The sanctuary's extensive mangrove forests, serve as critical buffers against coastal erosion, storm surges, and cyclonic activity while supporting rich biodiversity, including the endangered fishing cat, saltwater crocodiles, and over 120 bird species. However, these mangroves face mounting pressures from reduced freshwater flows due to upstream diversions, particularly from the Polavaram Dam project, which has altered the natural sediment and freshwater balance essential for mangrove health. Studies reveal that salinity intrusion has increased in the last decade, stunting the growth of key mangrove species like Avicennia marina and Rhizophora mucronata.

Sedimentation, another critical issue, stems from rampant deforestation in the Godavari's upper catchment areas, especially in the tribal districts of Chhattisgarh and Odisha. The Indravati and Sabari sub-basins, which contribute significant sediment loads, have lost their forest cover since 2000, as per studies (Das et al., 2022). This deforestation, driven by logging, mining, and agricultural expansion, has led to increased siltation in the delta, reducing the Godavari's carrying capacity and exacerbating flood risks during monsoons. Satellite imagery shows that the delta's sediment deposition rate has increased compared to pre-2000 levels, choking vital mangrove nurseries and altering aquatic habitats. The interplay of these factors reduced freshwater flows, rising salinity, and excessive sedimentation threatens not just the Coringa ecosystem but also the livelihoods of delta residents dependent on fishing and aquaculture. While the Andhra Pradesh government has initiated mangrove replantation programs enforcement against upstream deforestation and sustainable dam operations remain weak. Without integrated basin-wide sediment management and freshwater flow guarantees, the Godavari delta's resilience against climate change impacts will continue to erode, mirroring the fate of other degraded Indian delta systems.

The table 3.1 below presents a systematic breakdown of Maharashtra’s critical water-related issues across twelve key categories, highlighting specific problems, affected regions, and underlying policy failures. The state faces severe water pollution from industrial effluents (textiles, sugar mills) and untreated sewage in the Godavari basin (Nashik, Aurangabad), exacerbated by weak enforcement of the Water Act, 1974 and inadequate wastewater infrastructure under schemes like AMRUT. Illegal sand mining in tributaries (Pravara, Manjra) persists due to poor implementation of Sustainable Sand Mining Guidelines (2016), altering riverbeds and causing erosion. In drought-prone Marathwada (Beed, Latur), groundwater over-extraction for water-intensive sugarcane farming remains unregulated despite the Maharashtra Groundwater Act, 2009, while dam projects like Gosikhurd displace tribal communities in Vidarbha without proper rehabilitation under the Land Acquisition Act, 2013. Unplanned dam releases (Jayakwadi) worsen floods in the Godavari belt, revealing gaps in Central Water Commission (CWC) flood forecasting systems. Ecological and governance failures are evident in the decline of riverine biodiversity (e.g., Penganga fish species) due to pollution and barrages, with no action under the Wildlife Protection Act, 1972. Inter-state disputes (e.g., Babli barrage with Telangana) and urban encroachment on Nashik’s Godavari floodplains reflect weak enforcement of River Regulation Zone (RRZ) policies. Tribal communities near dams face water access denials, violating the Forest Rights Act, 2006 and PESA, 1996. Climate vulnerability in Marathwada and Vidarbha, marked by erratic rainfall impacting rivers like Manjra, lacks integration into the State Climate Action Plan.

Table 3.1. Issues in Maharashtra

State	Issue Category	Specific Problem	Affected Areas	Policy/Governance Gaps
Maharashtra	Water Pollution	Industrial effluents (textiles, sugar mills) contaminating Godavari.	Nashik, Aurangabad, Nanded	Weak enforcement of Water (Prevention & Control of Pollution) Act, 1974. No real-time monitoring.
		Untreated sewage discharge into rivers like Godavari, Purna, Manjra.	Major cities: Nagpur, Ahmednagar	Lack of municipal wastewater treatment plants under AMRUT Scheme.
	Sand Mining	Illegal sand mining altering riverbeds, causing erosion.	Tributaries: Pravara, Manjra, Wardha	Poor implementation of Sustainable Sand Mining Guidelines (2016).
	Drought & Water Scarcity	Over-extraction for sugarcane farming depleting groundwater.	Marathwada (Beed, Latur, Osmanabad)	No regulation under Maharashtra Groundwater Act, 2009.
	Dams & Displacement	Tribal displacement due to dams (Gosikhurd, Upper Wardha).	Vidarbha (Bhandara, Wardha)	Inadequate rehabilitation under Land Acquisition Act, 2013. Delayed compensation.
	Floods	Unplanned dam releases (Jayakwadi, Gangapur) worsening floods.	Godavari belt (Pune, Ahmednagar)	No integrated flood forecasting system under CWC guidelines.
	Agriculture Stress	Water-intensive sugarcane in drought-prone areas (Marathwada).	Solapur, Sangli	No crop zoning policy despite Maharashtra Water Resources Regulatory Authority.
	Biodiversity Loss	Decline in fish species due to pollution/barrages (e.g., Penganga, Wainganga).	Yavatmal, Chandrapur	No riverine biodiversity action plan under Wildlife Protection Act, 1972.
	Inter-State Disputes	Maharashtra-Telangana conflicts over Babli barrage (Godavari water sharing).	Nanded	Delays in Godavari Water Disputes Tribunal implementation.
	Urban Encroachment	Illegal constructions on floodplains (Godavari in Nashik).	Nashik, Trimbakeshwar	Weak enforcement of River Regulation Zone (RRZ) policy.
	Tribal Rights	Denial of water access to tribal communities near dams (Gosikhurd).	Gadchiroli	Violation of Forest Rights Act, 2006 and PESA, 1996.

	Climate Vulnerability	Erratic rainfall affecting river flows (Manjra, Purna).	Marathwada, Vidarbha	No climate-resilient water management under State Action Plan on Climate Change.

Table 3.2. Issues in Telangana

State	Issue Category	Specific Problem	Affected Areas	Policy/Governance Gaps
Telangana	Water Sharing Disputes	Maharashtra's Babli barrage reduces inflows into Telangana.	Adilabad, Nirmal, Mancherial	No effective tribunal enforcement (Godavari Water Disputes Tribunal award pending).
	Pollution	Industrial waste (pharma, textiles) polluting Godavari & Manjeera.	Patancheru (Hyderabad), Sangareddy	Weak enforcement of Telangana Pollution Control Board (TSPCB) norms. No penalties.
	Sand Mining	Illegal sand mining in Manair, Kinnerasani rivers causing erosion.	Karimnagar, Warangal	No digital tracking of sand mining as per National Green Tribunal (NGT) orders.
	Drought & Groundwater Depletion	Over-exploitation for paddy & aquaculture.	Nalgonda, Khammam	No strict groundwater regulation despite Telangana Water Resources Act, 2009.
	Dams & Displacement	Kaleshwaram Project displaces tribals without proper rehabilitation.	Medigadda, Eturunagaram	Violation of Land Acquisition Act, 2013 & PESA, 1996 for tribal consent.
	Encroachment & Floods	Illegal constructions on Musi & Manjeera floodplains worsen floods.	Hyderabad, Siddipet	No floodplain zoning under Telangana Urban Development Act.
	Agriculture Stress	Paddy monoculture depleting water (e.g., Mission Bhagiratha overuse).	Warangal, Nizamabad	No crop diversification incentives under Rythu Bandhu scheme.
	Biodiversity Loss	Decline in native fish species due to barrages (e.g., Sriram Sagar).	Nizamabad, Adilabad	No Fisheries Management Plan under Wildlife Protection Act, 1972.
	Urban Water Mismanagement	Hyderabad's sewage enters Musi River, contaminating Godavari tributaries.	Hyderabad, Secunderabad	Incomplete STP projects under AMRUT Mission.
	Tribal Water Rights	Tribal areas (Aswapuram, Bhadrachalam) lack	Bhadradri Kothagudem	Failure of Mission Bhagiratha in tribal zones. No PESA compliance.

		drinking water despite projects.		
	Climate Vulnerability	Erratic rainfall affects Pranahita, Penganga rivers (drying/deluge cycles).	Kumuram Bheem Asifabad	No climate adaptation plan under Telangana State Action Plan on Climate Change.
	Inter-State Conflicts	Karnataka's projects on Bhima River affect Manjeera flows.	Sangareddy, Medak	No inter-state water-sharing agreement under River Boards Act, 1956.

The table 3.2 presents a detailed assessment of Telangana's multifaceted water-related challenges, systematically categorizing twelve critical issues that highlight systemic governance gaps and their socio-environmental impacts. At the forefront are inter-state water disputes, particularly Maharashtra's Babli barrage reducing Godavari inflows into Adilabad and Nirmal districts, exacerbated by delayed implementation of the Godavari Water Disputes Tribunal award. Pollution emerges as a persistent threat, with industrial clusters in Patancheru (Hyderabad) releasing untreated effluents into the Godavari and Manjeera rivers due to lax enforcement by the Telangana State Pollution Control Board (TSPCB) and absent penalties.

Unsustainable resource extraction is evident in rampant illegal sand mining across the Manair and Kinnerasani rivers (Karimnagar, Warangal), where non-compliance with National Green Tribunal (NGT) orders for digital tracking perpetuates ecological degradation. Groundwater depletion in Nalgonda and Khammam, driven by water-intensive paddy cultivation and aquaculture, persists despite the Telangana Water Resources Act (2009), reflecting flawed regulatory mechanisms. Large-scale infrastructure like the Kaleshwaram Project displaces tribal communities in Medigadda without proper rehabilitation, violating the Land Acquisition Act (2013) and PESA (1996) safeguards for tribal consent. Urban water mismanagement compounds these challenges, with Hyderabad's untreated sewage flowing into the Musi River due to delayed AMRUT Mission sewage treatment plants (STPs), while illegal encroachments on floodplains (Musi, Manjeera) amplify flood risks in Hyderabad and Siddipet, underscoring the absence of floodplain zoning regulations. Agricultural policies further strain water resources, as paddy monoculture promoted under schemes like Rythu Bandhu lacks diversification incentives, depleting reserves in Warangal and Nizamabad.

Ecological consequences include biodiversity loss, particularly native fish species in the Sriram Sagar reservoir, with no Fisheries Management Plan under the Wildlife Protection Act (1972). Tribal areas like Bhadradri Kothagudem face drinking water shortages despite Mission Bhagiratha, revealing exclusion in policy implementation and non-compliance with PESA. Climate vulnerability manifests in erratic rainfall disrupting the Pranahita and Penganga rivers, yet the Telangana State Action Plan on Climate Change lacks adaptive strategies. Lastly, inter-state conflicts with Karnataka over Bhima River projects (affecting Manjeera flows) remain unresolved due to inactive River Boards Act (1956) mechanisms.

Table 3.3. Issues in Andhra Pradesh

State	Issue Category	Specific Problem	Affected Areas	Policy/Governance Gaps
Andhra Pradesh	Inter-State Water Disputes	Telangana's Kaleshwaram Lift Scheme reduces inflows into AP.	Bhadrachalam, Kunavaram	No effective implementation of Godavari Water Disputes Tribunal (GWDT) award.
	Pollution	Industrial effluents (paper mills, distilleries) polluting Godavari & Sabari.	Rajahmundry, Kovvur, Tanuku	Weak enforcement of AP Pollution Control Board (APPCB) norms. No real-time monitoring.
	Sand Mining	Illegal sand mining in Vamsadhara, Tammileru rivers causing erosion.	Srikakulam, Vizianagaram	No enforcement of Sustainable Sand Mining Guidelines (2016).
	Drought & Groundwater Depletion	Over-extraction for paddy & aquaculture in delta regions.	East Godavari, West Godavari	No regulation under AP Water, Land & Trees Act (2002). Over-reliance on free power.
	Dams & Displacement	Polavaram Project displaces tribals without proper rehabilitation.	Rampachodavaram, Chintoor	Violation of Land Acquisition Act (2013) & Forest Rights Act (2006).
	Floods & Drainage Issues	Poor drainage worsens floods in Godavari delta (Kolleru Lake backwaters).	Amalapuram, Mummidivaram	No floodplain zoning under AP Disaster Management Act.
	Agriculture Stress	Water-intensive paddy & shrimp farming depleting freshwater.	Konaseema, Bhimavaram	No crop diversification incentives under Rythu Bharosa Scheme.
	Biodiversity Loss	Decline in mangroves & fish species due to aquaculture & pollution.	Coringa Wildlife Sanctuary	No enforcement of Coastal Regulation Zone (CRZ) norms.
	Urban Encroachment	Illegal constructions on Kolleru Lake & Godavari floodplains.	Eluru, Tadepalligudem	No enforcement of Wetland (Conservation & Management) Rules, 2017.
	Tribal Water Rights	Tribal areas (Paderu, Maredumilli) lack drinking water despite Polavaram promises.	Alluri Sitharama Raju District	No tribal water rights under PESA Act, 1996.
	Saline Intrusion	Seawater ingress into Godavari delta due to over-extraction.	Yanam, Uppada	No coastal aquifer management under AP Groundwater Act.
	Climate Vulnerability	Cyclones & erratic rainfall affecting delta agriculture.	Kakinada, Narsapur	No climate-resilient farming under AP State Action Plan on Climate Change.

The table 3.3 presents a systematic examination of critical water-related challenges facing Andhra Pradesh, highlighting the complex interplay between environmental degradation, policy failures, and socioeconomic impacts. At the core of these issues are persistent inter-state water disputes, particularly concerning Telangana's Kaleshwaram Lift Scheme which reduces Godavari inflows into Bhadrachalam and Kunavaram regions, exacerbated by ineffective implementation of the Godavari Water Disputes Tribunal (GWDT) award. Pollution remains a severe concern, with industrial effluents from paper mills and distilleries contaminating the Godavari and Sabari rivers in Rajahmundry and Kovvur, where weak enforcement by the Andhra Pradesh Pollution Control Board (APPCB) and lack of real-time monitoring perpetuate environmental damage. The state faces significant ecological threats from unsustainable practices, including rampant illegal sand mining in the Vamsadhara and Tammileru rivers (Srikakulam, Vizianagaram) due to non-enforcement of Sustainable Sand Mining Guidelines (2016), leading to severe riverbank erosion. Groundwater depletion in the Godavari delta regions (East and West Godavari) continues unabated, driven by water-intensive paddy cultivation and aquaculture, with no effective regulation under the AP Water, Land & Trees Act (2002) and perverse incentives from free electricity policies. Large infrastructure projects like the Polavaram Dam have displaced tribal communities in Rampachodavaram without proper rehabilitation, violating both the Land Acquisition Act (2013) and Forest Rights Act (2006).

Flood management failures are evident in the Godavari delta, where poor drainage infrastructure worsens flooding in Amalapuram and Mummidivaram, compounded by the absence of floodplain zoning regulations under the state's disaster management framework. Agricultural practices further strain water resources, with paddy monoculture and shrimp farming in Konaseema and Bhimavaram depleting freshwater reserves, while the Rythu Bharosa Scheme fails to incentivize crop diversification. Ecological degradation is particularly severe in coastal areas, with mangrove loss in Coringa Wildlife Sanctuary and declining fish stocks due to unchecked aquaculture expansion and pollution, revealing non-compliance with Coastal Regulation Zone (CRZ) norms. Urban encroachment poses additional threats, with illegal constructions on Kolleru Lake and Godavari floodplains (Eluru, Tadepalligudem) continuing due to non-enforcement of Wetland Conservation Rules (2017). Tribal communities in Paderu and Maredumilli face drinking water shortages despite promises from the Polavaram project, highlighting the exclusion of tribal water rights under PESA Act (1996). Coastal regions like Yanam and Uppada experience saltwater intrusion into aquifers due to excessive groundwater extraction, yet the state lacks proper coastal aquifer management mechanisms. Finally, climate vulnerabilities manifest through cyclones and erratic rainfall in Kakinada and Narsapur, with inadequate adaptation measures under the AP State Action Plan on Climate Change.

Table 3.4. Issues in Karnataka

State	Issue Category	Specific Problem	Affected Areas	Policy/Governance Gaps
Karnataka	Water Sharing Disputes	Reduced inflows due to Maharashtra's dams on Upper Godavari.	Belagavi, Raichur	No inter-state water-sharing agreement under River Boards Act, 1956.
	Pollution	Sugar mill & distillery effluents polluting Bhima & Malaprabha rivers.	Bagalkot, Vijayapura	Weak enforcement of Karnataka State Pollution Control Board (KSPCB) norms.

	Sand Mining	Illegal sand mining in Krishna & Tungabhadra rivers causing erosion.	Raichur, Koppal	No digital tracking as per National Green Tribunal (NGT) orders.
	Drought & Groundwater Depletion	Over-extraction for sugarcane & horticulture.	Kalaburagi, Yadgir	No strict groundwater regulation under Karnataka Groundwater Act, 2011.
	Dams & Displacement	Almatti Dam displaces farmers without adequate compensation.	Bijapur, Bagalkot	Violation of Land Acquisition Act (2013) & R&R Policy delays.
	Encroachment & Floods	Illegal constructions on Krishna & Bhima floodplains worsen floods.	Belagavi, Gadag	No floodplain zoning under Karnataka Urban Development Act.
	Agriculture Stress	Water-intensive sugarcane in drought-prone areas (e.g., Mandya).	Mandya, Hassan	No crop diversification incentives under Krishi Bhagya scheme.
	Biodiversity Loss	Decline in fish species due to dams & pollution (e.g., Tungabhadra Reservoir).	Ballari, Koppal	No Fisheries Management Plan under Wildlife Protection Act, 1972.
	Urban Water Mismanagement	Hubballi-Dharwad's sewage enters Malaprabha River.	Dharwad, Hubballi	Incomplete STP projects under Smart Cities Mission.
	Tribal Water Rights	Tribal areas (Raichur, Yadgir) lack drinking water despite irrigation projects.	Raichur, Yadgir	Failure of Jal Jeevan Mission in tribal zones. No PESA compliance.
	Climate Vulnerability	Erratic rainfall affects Krishna & Bhima rivers (drying/flooding cycles).	Vijayapura, Bidar	No climate adaptation plan under Karnataka State Action Plan on Climate Change.
	Inter-State Conflicts	Andhra Pradesh's projects on Tungabhadra affect Karnataka's inflows.	Koppal, Ballari	No tribunal resolution under Krishna Water Disputes Tribunal (KWDT).

The table 3.4 outlines critical water-related challenges facing Karnataka, revealing a complex web of environmental, agricultural, and governance issues. At the forefront are inter-state water disputes, particularly reduced inflows from Maharashtra's dams on the Upper Godavari affecting Belagavi and Raichur districts, exacerbated by the absence of a formal water-sharing agreement under the River Boards Act, 1956. Pollution emerges as a persistent threat, with sugar mills and distilleries in Bagalkot and Vijayapura contaminating the Bhima and

Malaprabha rivers due to weak enforcement by the Karnataka State Pollution Control Board (KSPCB).

Unsustainable resource extraction is evident through rampant illegal sand mining in the Krishna and Tungabhadra rivers (Raichur, Koppal), where authorities have failed to implement National Green Tribunal (NGT) orders for digital tracking systems. Groundwater depletion in Kalaburagi and Yadgir, driven by water-intensive sugarcane and horticulture, continues unchecked despite the Karnataka Groundwater Act (2011), highlighting regulatory failures. Large infrastructure projects like the Almatti Dam have displaced farmers in Bijapur without adequate compensation, violating provisions of the Land Acquisition Act (2013) and state rehabilitation policies. Urban and flood management challenges compound these issues, with illegal constructions on Krishna and Bhima floodplains (Belagavi, Gadag) worsening floods, as the state lacks floodplain zoning regulations under its urban development framework. Agricultural practices further strain water resources, with sugarcane cultivation persisting in drought-prone Mandya district without crop diversification incentives under the Krishi Bhagya scheme. Ecological consequences include biodiversity loss, particularly fish species in the Tungabhadra Reservoir, where no Fisheries Management Plan exists under the Wildlife Protection Act (1972).

Urban water mismanagement is evident in Hubballi-Dharwad, where untreated sewage enters the Malaprabha River due to delayed Smart Cities Mission projects. Tribal communities in Raichur and Yadgir face drinking water shortages despite irrigation projects, revealing implementation gaps in the Jal Jeevan Mission and non-compliance with PESA provisions. Climate vulnerabilities manifest through erratic rainfall patterns affecting the Krishna and Bhima basins (Vijayapura, Bidar), yet the Karnataka State Action Plan on Climate Change lacks specific adaptation measures. Additionally, inter-state conflicts with Andhra Pradesh over Tungabhadra River projects remain unresolved, with no effective implementation of the Krishna Water Disputes Tribunal (KWDT) award.

Table 3.5. Issues in Chhattisgarh

State	Issue Category	Specific Problem	Affected Areas	Policy/Governance Gaps
Chhattisgarh	Coal Mining Pollution	Acid mine drainage from coal mines pollutes Hasdeo & Indravati rivers.	Korba, Raigarh, Surguja	Weak enforcement of Environmental Impact Assessment (EIA) Notification, 2006.
	Deforestation	Illegal logging in Hasdeo Aranya forests affects river hydrology.	Hasdeo Aranya, Sarguja	Violation of Forest Rights Act (FRA), 2006 & Compensatory Afforestation Fund (CAF) rules.
	Industrial Effluents	Steel plant waste (Bhilai, Raipur) contaminates Sheonath & Mahanadi rivers.	Durg, Raipur	No real-time monitoring under Chhattisgarh Environment Conservation Board (CECB).
	Sand Mining	Illegal sand mining in Shivnath & Kharun rivers causing erosion.	Dhamtari, Balod	No enforcement of Sustainable Sand Mining Guidelines (2016).
	Dams & Displacement	Bodhghat Dam threatens	Bastar, Dantewada	Violation of PESA Act, 1996 for tribal consent in land acquisition.

		tribal lands in Bastar (Indravati basin).		
	Drought & Water Scarcity	Over-extraction for irrigation depletes groundwater in Indravati basin.	Bijapur, Narayanpur	No regulation under Chhattisgarh Groundwater (Regulation) Act, 2012.
	Agriculture Stress	Paddy monoculture in water-stressed regions (e.g., Raipur plains).	Raipur, Mahasamund	No crop diversification incentives under Rajiv Gandhi Kisan Nyay Yojana.
	Biodiversity Loss	Decline in fish species due to dams & pollution (e.g., Indravati River).	Bastar, Kanker	No Fisheries Management Plan under Wildlife Protection Act, 1972.
	Urban Encroachment	Illegal constructions on Kharun & Sheonath floodplains.	Raipur, Durg	No floodplain zoning under Chhattisgarh Urban Development Act.
	Tribal Water Rights	Tribal areas (Bastar, Surguja) lack drinking water despite irrigation projects.	Bastar, Koriya	Failure of Jal Jeevan Mission in tribal zones. No PESA compliance.
	Climate Vulnerability	Erratic rainfall affects Indravati & Sabari rivers (drying/flooding cycles).	Sukma, Bijapur	No climate adaptation plan under Chhattisgarh State Action Plan on Climate Change.
	Inter-State Conflicts	Odisha's projects on Indravati affect Chhattisgarh's inflows.	Bastar, Dantewada	No inter-state water-sharing agreement under River Boards Act, 1956.

The table 3.5 presents a detailed assessment of Chhattisgarh's critical water-related issues. Industrial pollution emerges as a major concern, with acid mine drainage from coal mines in Korba and Raigarh contaminating the Hasdeo and Indravati rivers, exacerbated by weak enforcement of the Environmental Impact Assessment (EIA) Notification, 2006. Similarly, steel plant effluents in Durg and Raipur pollute the Sheonath and Mahanadi rivers due to inadequate real-time monitoring by the Chhattisgarh Environment Conservation Board (CECB). Deforestation and illegal logging in the Hasdeo Aranya forests disrupt river hydrology, violating both the Forest Rights Act (FRA), 2006 and Compensatory Afforestation Fund (CAF) rules. Unsustainable sand mining in the Shivnath and Kharun rivers (Dhamtari, Balod) further degrades river ecosystems, with authorities failing to implement Sustainable Sand Mining Guidelines (2016). Large-scale infrastructure projects, such as the proposed Bodhghat Dam in Bastar, threaten tribal lands without proper consent, disregarding the PESA Act, 1996. Meanwhile, groundwater depletion in the Indravati basin (Bijapur, Narayanpur) persists due to over-extraction for irrigation, despite the Chhattisgarh Groundwater (Regulation) Act, 2012. Agricultural stress is evident in water-intensive paddy monoculture in Raipur plains, lacking crop diversification incentives under state schemes.

Ecological degradation includes declining fish populations in the Indravati River due to dams and pollution, with no Fisheries Management Plan under the Wildlife Protection Act, 1972. Urban encroachment on floodplains (Kharun, Sheonath) in Raipur and Durg worsens flooding, as the state lacks floodplain zoning regulations. Tribal communities in Bastar and Surguja face drinking water shortages despite irrigation projects, reflecting poor implementation of the Jal Jeevan Mission and non-compliance with PESA. Climate vulnerability manifests in erratic rainfall affecting the Indravati and Sabari rivers (Sukma, Bijapur), yet the Chhattisgarh State Action Plan on Climate Change lacks adaptation strategies. Furthermore, inter-state conflicts with Odisha over Indravati water sharing remain unresolved due to the absence of an agreement under the River Boards Act, 1956.

Table 3.6. Issues in Odhisa

State	Issue Category	Specific Problem	Affected Areas	Policy/Governance Gaps
Odisha	Inter-State Water Disputes	Chhattisgarh's projects on Indravati reduce inflows into Odisha	Nabarangpur, Koraput	No effective implementation of Vansadhara Water Disputes Tribunal
	Mining Pollution	Bauxite mining in Eastern Ghats pollutes Kolab & Indravati rivers	Rayagada, Kalahandi	Weak enforcement Odisha Minor Minerals Concession, 2018
	Deforestation	Illegal timber smuggling in Kotia border area affecting river catchments	Koraput, Malkangiri	Poor implementation of Forest Conservation Act, 1980
	Industrial Effluents	Aluminum refinery waste contaminating rivers	Jharsuguda, Sundargarh	Inadequate monitoring by Odisha State Pollution Control Board (OSPCB)
	Sand Mining	Illegal sand mining in Vamsadhara river causing erosion	Gajapati, Rayagada	Violation of Sustainable Sand Mining Management Guidelines, 2016
	Dams & Displacement	Balimela Reservoir displaces tribal communities without rehabilitation	Malkangiri	Non-compliance with Land Acquisition Act, 2013
	Drought & Water Scarcity	Over-extraction for irrigation in drought-prone districts	Kalahandi, Nuapada	No implementation Orissa Ground Water (Regulation, Development and. Management) Act, 2011
	Agriculture Stress	Paddy monoculture in water-stressed regions depleting resources	Bolangir, Subarnapur	No crop diversification under Odisha Agriculture Policy, 2013
	Biodiversity Loss	Decline in hilsa fish due to barrages on Rushikulya	Ganjam, Gajapati	No Fisheries Management Plan under Wildlife Protection Act
	Urban Encroachment	Illegal constructions on Budhabalanga floodplains	Balasore, Mayurbhanj	No floodplain zoning under Odisha Disaster Management Act
	Tribal Water Rights	Tribal areas lack drinking water despite irrigation projects	Koraput, Nabarangpur	Failure of Jal Jeevan Mission in tribal zones
	Climate Vulnerability	Cyclones & erratic rainfall affecting river flows	Puri, Jagatsinghpur	No climate adaptation under Odisha Climate Change Action Plan

The table 3.6 presents an examination of Odisha's multifaceted water-related challenges, revealing critical gaps in environmental governance and resource management. At the core of these issues are inter-state water disputes, particularly reduced inflows from Chhattisgarh's projects on the Indravati River affecting Nabarangpur and Koraput districts, compounded by ineffective implementation of the Vansadhara Water Disputes Tribunal decisions. Mining pollution emerges as a significant threat, with bauxite extraction in the Eastern Ghats contaminating the Kolab and Indravati rivers in Rayagada and Kalahandi, exacerbated by weak enforcement of the Odisha Minor Minerals Concession Rules, 2018.

The state faces severe ecological degradation from deforestation in the Kotia border area, where illegal timber smuggling disrupts river catchments due to poor implementation of the Forest Conservation Act, 1980. Industrial pollution persists as aluminum refineries in Jharsuguda and Sundargarh discharge waste into rivers, with inadequate monitoring by the Odisha State Pollution Control Board (OSPCB). Unsustainable sand mining in the Vamsadhara River (Gajapati, Rayagada) continues unabated, violating Sustainable Sand Mining Management Guidelines (2016) and causing severe erosion. Large infrastructure projects like the Balimela Reservoir have displaced tribal communities in Malkangiri without proper rehabilitation, disregarding provisions of the Land Acquisition Act, 2013. Water scarcity plagues drought-prone districts (Kalahandi, Nuapada) due to over-extraction for irrigation, despite the existence of the Orissa Ground Water Act, 2011 which remains unimplemented. Agricultural stress is evident in water-intensive paddy monoculture in Bolangir and Subarnapur, with no crop diversification incentives under the Odisha Agriculture Policy, 2013.

Biodiversity loss is particularly concerning, with declining hilsa fish populations in the Rushikulya River (Ganjam, Gajapati) due to barrages, and no Fisheries Management Plan under the Wildlife Protection Act. Urban encroachment on Budhabalanga floodplains in Balasore and Mayurbhanj worsens flood risks, as the state lacks floodplain zoning under its disaster management framework. Marginalized communities face acute water insecurity, with tribal areas in Koraput and Nabarangpur lacking drinking water despite irrigation projects, revealing implementation failures in the Jal Jeevan Mission. Climate vulnerabilities manifest through cyclones and erratic rainfall affecting river flows in coastal districts (Puri, Jagatsinghpur), yet the Odisha Climate Change Action Plan lacks specific adaptation measures.

Table 3.7. Issues in Madhya Pradesh

State	Issue Category	Specific Problem	Affected Areas	Policy/Governance Gaps
Madhya Pradesh	Inter-State Water Disputes	Maharashtra's dams (Upper Godavari) reduce inflows into MP.	Betul, Chhindwara	No effective implementation of Godavari Water Disputes Tribunal (GWDT) award.
	Industrial Pollution	Textile & paper mill effluents polluting Wainganga & Wardha rivers.	Balaghat, Seoni	Weak enforcement by Madhya Pradesh Pollution Control Board (MPPCB). No real-time monitoring.
	Sand Mining	Illegal sand mining in Tapti & Purna rivers causing erosion.	Betul, Khandwa	Poor implementation of Sustainable Sand Mining Management Guidelines (2016). Local corruption.

	Drought & Groundwater Depletion	Over-extraction for soybean & wheat farming.	Harda, Hoshangabad	No regulation under Groundwater (Regulation) Act. Free electricity policy worsens overuse.
	Dams & Displacement	**Pench Dam** displaces tribal communities without proper rehabilitation.	Chhindwara, Seoni	Violation of Land Acquisition Act (2013) & Forest Rights Act (FRA), 2006.
	Encroachment & Floods	Illegal constructions on Narmada & Tapti floodplains worsen floods.	Khargone, Barwani	No floodplain zoning under MP Urban Development Act.
	Agriculture Stress	Water-intensive soybean farming in water-scarce regions.	Vidisha, Raisen	No crop diversification incentives under Krishi Unnati Yojana.
	Biodiversity Loss	Decline in fish species due to dams & pollution (e.g., Pench River).	Chhindwara, Seoni	No Fisheries Management Plan under Wildlife Protection Act, 1972.
	Urban Water Mismanagement	Bhopal & Indore's sewage contaminates Betwa & Chambal tributaries.	Bhopal, Indore	Incomplete STP projects under AMRUT Mission.
	Tribal Water Rights	Tribal areas (Betul, Alirajpur) lack drinking water despite irrigation projects.	Betul, Alirajpur	Failure of Jal Jeevan Mission in tribal zones. No PESA compliance.
	Climate Vulnerability	Erratic rainfall affects Tapti & Wainganga rivers (drying/flooding cycles).	Burhanpur, Khandwa	No climate adaptation plan under MP State Action Plan on Climate Change.
	Forest Degradation	Deforestation in Satpura ranges affects river catchments (Tawa, Denwa).	Pachmarhi, Pipariya	Weak enforcement of Compensatory Afforestation Fund (CAF) Act,2016

The table 3.7 presents a detailed examination of critical water-related challenges in Madhya Pradesh. At the forefront are inter-state water disputes, particularly reduced inflows from Maharashtra's dams on the Upper Godavari affecting Betul and Chhindwara districts, exacerbated by ineffective implementation of the Godavari Water Disputes Tribunal (GWDT) award. Industrial pollution poses a significant threat, with textile and paper mill effluents contaminating the Wainganga and Wardha rivers in Balaghat and Seoni, where weak enforcement by the Madhya Pradesh Pollution Control Board (MPPCB) and lack of real-time monitoring perpetuate environmental degradation.

Unsustainable resource extraction is evident through rampant illegal sand mining in the Tapti and Purna rivers (Betul, Khandwa), facilitated by poor implementation of Sustainable Sand Mining Management Guidelines (2016) and local corruption. Groundwater depletion in Harda and Hoshangabad, driven by water-intensive soybean and wheat farming, continues unchecked due to the absence of regulation under the state's Groundwater Act and counterproductive free electricity policies. Large infrastructure projects like the Pench Dam have displaced tribal communities in Chhindwara without proper rehabilitation, violating both the Land Acquisition Act (2013) and Forest Rights Act (FRA), 2006. Urban and flood management challenges compound these issues, with illegal constructions on Narmada and Tapti floodplains (Khargone, Barwani) worsening floods, as the state lacks floodplain zoning regulations under its urban development framework. Agricultural practices further strain water resources, with soybean monoculture persisting in water-scarce regions like Vidisha without crop diversification incentives under the Krishi Unnati Yojana. Ecological consequences include biodiversity loss, particularly fish species in the Pench River, where no Fisheries Management Plan exists under the Wildlife Protection Act (1972).

Urban water mismanagement is evident in Bhopal and Indore, where untreated sewage contaminates Betwa and Chambal tributaries due to delayed AMRUT Mission projects. Tribal communities in Betul and Alirajpur face drinking water shortages despite irrigation projects, revealing implementation gaps in the Jal Jeevan Mission and non-compliance with PESA provisions. Climate vulnerabilities manifest through erratic rainfall patterns affecting the Tapti and Wainganga basins (Burhanpur, Khandwa), yet the Madhya Pradesh State Action Plan on Climate Change lacks specific adaptation measures. Additionally, forest degradation in the Satpura ranges (Pachmarhi, Pipariya) disrupts river catchments like Tawa and Denwa, with weak enforcement of the Compensatory Afforestation Fund (CAF) Act, 2016.

3.2. Aviral, Nirmal, and Ecological Restoration: A Holistic Framework for River Rejuvenation

The cGanga initiative's three-pronged approach of Aviral (uninterrupted flow), Nirmal (pollution-free waters) and Ecological Restoration was originally conceived for the Ganga basin but holds equal relevance for all major river systems across India, including the Godavari, Krishna, Narmada and other vital basins. This comprehensive framework addresses the universal challenges facing India's rivers through adaptable, science-based solutions tailored to each basin's unique ecological and hydrological needs

Aviral’s focus on maintaining natural river flows is critical for basins like the Godavari where excessive dam construction and water diversions have disrupted seasonal flow patterns. The mission's emphasis on environmental flows (e-flows) and sustainable water allocation can help restore the Godavari's ecological integrity while balancing irrigation and drinking water needs. Similar flow management strategies are equally applicable to peninsular rivers that face over-extraction pressures.

The Nirmal mission's pollution abatement strategies directly address contamination threats in industrial and urban river stretches nationwide. For the Godavari, this means tackling textile and pharmaceutical effluents in Andhra Pradesh and municipal sewage in Nashik. The same monitoring frameworks, sewage treatment upgrades and industrial compliance mechanisms developed for Ganga can be adapted to other polluted rivers.

Ecological Restoration components including floodplain rejuvenation, riparian buffer zones and biodiversity conservation have universal applicability. The Godavari delta's degrading

mangroves, the Krishna's shrinking wetlands, and the Narmada's endangered aquatic species all require similar habitat restoration approaches. cGanga's successful models of community-led afforestation and wetland revival can be replicated with local modifications across basins.

What makes this framework particularly powerful is its integrated systems approach - recognizing that flow, water quality and ecosystem health are interdependent. A Nirmal (clean) Godavari requires Aviral flows to dilute pollutants, while Ecological Restoration enhances the river's natural purification capacity. This holistic perspective is essential for all Indian rivers facing mounting pressures from urbanization, agriculture and climate change.

The cGanga model provides a scalable blueprint that state governments and river basin organizations can adapt to their specific contexts. While implementation details may vary - accounting for differences in hydrology, pollution sources and governance structures - the core principles of maintaining flows, controlling pollution and restoring ecosystems remain universally relevant for India's fight to revive its dying rivers.

While each mission has a distinct focus, their success depends on integrated implementation. Aviral's uninterrupted flow ensures pollutants are diluted, aiding Nirmal's pollution control efforts. Ecological Restoration revives wetlands that naturally filter contaminants, further supporting Nirmal's goals. Simultaneously, Nirmal's success in reducing pollution allows aquatic life to thrive, fulfilling Ecological Restoration's objectives. Without Aviral, stagnant stretches become pollution hotspots; without Nirmal, even a flowing river remains toxic; and without Ecological Restoration, the river loses its natural resilience.

3.2.1. Framework for Successful Implementation

The success of Aviral Dhara (Uninterrupted Flow), Nirmal Dhara (Pollution-Free Flow), and Ecological Restoration in the Godavari Basin must be assessed through a structured, multi-dimensional approach. To determine whether these objectives have been achieved, a combination of scientific monitoring, policy compliance checks, and community-driven feedback mechanisms should be implemented. To ensure the Godavari maintains a sustainable flow, real-time hydrological monitoring should be prioritized. Central Water Commission (CWC) gauging stations must track discharge rates at critical points such as Nashik, Rajahmundry, and the Sriram Sagar Dam. Compliance with minimum environmental flows (e-flows) should be verified through automated sensors and dam release logs. If the river's flow remains uninterrupted, key indicators such as stable groundwater levels (measured via piezometers) and reduced siltation in reservoirs (assessed through sediment load surveys) will demonstrate success.

Additionally, feedback from farmers and fisherfolk, particularly in drought-prone can validate whether water availability meets their needs. Interstate coordination through the Godavari River Management Board will ensure that upstream releases align with downstream requirements, preventing artificial water scarcity. Achieving a pollution-free Godavari requires stringent water quality monitoring at industrial, urban, and agricultural discharge points. Continuous BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) sensors should be installed in high-risk zones, including Nashik's industrial belt and Rajahmundry's urban stretches. Success will be evident if 90% of samples meet CPCB's standards. Industrial compliance must be audited through third-party inspections and mandatory Zero Liquid Discharge (ZLD) certifications. Sewage treatment efficiency can be tracked via real-time STP dashboards, ensuring no untreated wastewater enters the river. To curb agricultural runoff, nutrient load sensors should measure reductions in nitrate and phosphate levels, while farmer adoption of organic practices can be incentivized and verified

through local cooperatives. Public participation via pollution reporting apps will further enhance accountability. The revival of the Godavari's ecosystems can be assessed through biodiversity surveys, habitat mapping, and invasive species control. Annual fish diversity audits by institutions like Indian Council of Agricultural Research - Central Inland Fisheries Research Institute (ICAR-CIFRI) can track the return of native species. Mangrove restoration in the delta should be monitored via satellite imagery and ground-level drone surveys, with success defined by a net increase in mangrove cover. Riparian buffer zones can be evaluated using NDVI (Normalized Difference Vegetation Index) analysis, ensuring native vegetation thrives along riverbanks. Community-driven initiatives, such as hyacinth removal programs, should show a measurable decline in invasive species coverage. The return of bioindicator species like otters or migratory birds would further confirm ecosystem recovery. To ensure continuous improvement, transparent reporting systems must be established. Public dashboards displaying real-time water quality, flow data, and project milestones will keep stakeholders informed. Independent third-party audits by organizations can provide unbiased progress assessments. Local communities should contribute through participatory scorecards, rating the effectiveness of conservation efforts based on their lived experiences. Policy adjustments should be made annually, incorporating insights from these evaluations to refine strategies.

3.2.2. Need for Multi-stakeholder Participation

The Aviral Dhara (Continuous Flow) component of the cGanga initiative represents a critical intervention for maintaining the Godavari River's ecological and hydrological integrity. Implementation of this mission requires rigorous monitoring of environmental flows (e-flows) throughout the basin, particularly at strategic locations like the Polavaram Dam in Andhra Pradesh and the Jayakwadi Dam in Maharashtra. Scientific assessments determine that maintaining a minimum of percentage of the monsoon flow during dry seasons is essential to sustain aquatic ecosystems, support groundwater recharge, and preserve the river's natural purification capacity. The Central Water Commission (CWC) has established a network of automated gauging stations that continuously measure discharge rates at these critical nodes, comparing real-time data against mandated e-flow benchmarks. During drought periods, when water demand for agriculture peaks, compliance is verified through a combination of satellite-based discharge measurements and ground observations from river monitoring stations operated by state irrigation departments.

A key challenge in assessing Aviral Dhara's success lies in differentiating between natural flow variations and anthropogenic disruptions. Advanced modelling tools, including the Soil and Water Assessment Tool (SWAT), help isolate the impacts of upstream diversions and dam operations from climatic factors. For instance, in the Godavari's Pranhita tributary, which frequently experiences water stress, these models correlate reservoir release patterns with downstream flow measurements to evaluate compliance. However, true success of Aviral Dhara requires going beyond technical measurements to address governance challenges. The Godavari River Management Board faces difficulties enforcing e-flow standards across state boundaries, particularly when water demands for irrigation and drinking compete with environmental needs. Independent audits by institutions like the Indian Institute of Technology Hyderabad can provide crucial third-party verification of compliance data, while community-based monitoring through Jal Sevaks offers ground-level flow observations. The integration of these diverse data streams, technological, ecological, and participatory creates a comprehensive framework for evaluating whether the Godavari maintains its aviral (continuous) character throughout the year, fulfilling the mission's promise of a perennial, living river system. Future enhancements to the monitoring system will require real-time data

integration across all dams and stricter accountability mechanisms to ensure drought-season compliance when pressures on the river are most severe.

The Nirmal Dhara (Clean Flow) mission represents a critical commitment to restoring the Godavari's water quality through systematic pollution control measures. Achieving this vision requires comprehensive monitoring of both point and non-point pollution sources across the basin, with particular emphasis on urban wastewater management and agricultural runoff. In major cities like Nashik, the mission's success can be measured through rigorous evaluation of sewage treatment plant (STP) performance, where key parameters including Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and fecal coliform levels are tracked against national water quality standards. The Nashik Municipal Corporation's recent upgrade to tertiary treatment systems has shown measurable improvements at the upstream Gangapur STP (source; https://www.eawater.com/regulars/waternews/nashik-municipal-corporation-to-set-up-another-stp-at-gangapur/). However, challenges persist in older colonial-era drainage systems where untreated sewage still enters the river during monsoon overflows, necessitating continuous sensor-based monitoring at intervals across all outfall points.

In the Godavari's agricultural belt, particularly the cotton-growing regions of Maharashtra's Vidarbha and Telangana's Adilabad district, Nirmal Dhara's effectiveness can be assessed through pesticide contamination studies. The Central Pollution Control Board needs to conduct water sampling during the Kharif season, analyzing residues of toxic pesticides that frequently exceed permissible limits. Recent initiatives promoting organic farming along the river's buffer zones have demonstrated promising results, with a substantial reduction in pesticide loads documented in the Wardha tributary over three years. Advanced monitoring techniques, including gas chromatography-mass spectrometry for pesticide detection and biosensors using freshwater mussels as bioindicators, provide robust data on chemical pollution trends. The true measure of Nirmal Dhara's success extends beyond laboratory numbers to ecological recovery.

The return of pollution-sensitive aquatic species in the upper Godavari and improved dissolved oxygen levels downstream of major cities serve as biological validation. Citizen science initiatives complement official data, with local colleges and NGOs conducting monthly water quality tests at community-designated points along the river. While progress is evident, sustaining these gains requires addressing emerging challenges like pharmaceutical pollution from Nashik's drug manufacturing units and seasonal spikes in agricultural chemical loads. The integration of real-time digital dashboards displaying water quality parameters at all major monitoring stations can enhance transparency, enabling both regulators and citizens to track the river’s journey toward true nirmalta (purity). Future success will depend on expanding wastewater treatment coverage to smaller towns, enforcing stricter pesticide regulations, and maintaining the basin-wide water quality monitoring network that forms the backbone of this transformative mission.

The Ecological Restoration component of the Godavari River management strategy focuses on reviving critical aquatic ecosystems and indicator species that reflect the river's overall health. In the middle stretches near Bhadrachalam, the resurgence of the endangered Gangetic dolphin (*Platanista gangetica*) population serves as a key biological metric for evaluating restoration success. Systematic monitoring by the Wildlife Institute of India can be achieved through targeted measures including the removal of illegal fishing nets, regulation of sand mining activities, and establishment of seasonal no-go zones during calving periods. Dolphin sightings are now meticulously recorded through a combination of acoustic monitoring devices that track their ultrasonic clicks and community-based observation networks involving local ferry operators and fishermen, creating a robust dataset that maps population recovery against habitat

improvement initiatives. In the Godavari delta, mangrove ecosystem restoration demonstrates another critical dimension of ecological recovery. The Coringa Wildlife Sanctuary's mangrove cover, which had shrunk due to upstream dams altering freshwater flows, has expanded through strategic replantation of salt-tolerant *Avicennia marina* and *Rhizophora mucronata* species. The return of mangrove-dependent species, including the reintroduction of breeding pairs of the rare fishing cat (*Prionailurus viverrinus*), further validates the habitat's recovery. These ecological indicators are complemented by systematic water quality improvements that enable species recovery - dissolved oxygen levels in dolphin habitats now consistently exceed and salinity gradients in the delta have stabilized within the range optimal for mangrove growth. However, long-term success depends on maintaining balanced environmental flows from upstream dams and continued community engagement, particularly in reducing plastic waste that threatens both dolphins and mangrove ecosystems. The integration of traditional ecological knowledge with scientific monitoring has proven particularly valuable, with local fishermen helping identify critical dolphin feeding zones and women's self-help groups participating in mangrove nursery management. This multidimensional approach to ecological restoration demonstrates how targeted interventions, when combined with continuous monitoring of keystone species and habitats, can gradually reverse decades of ecosystem degradation in the Godavari basin.

4. Identifying Key Actors and Institutions for Monitoring Relevant Research

The effectiveness of monitoring and restoration efforts in the Godavari River basin hinges on the coordinated involvement of specialized agencies and local stakeholders, each playing distinct yet complementary roles in evidence generation and validation. At the foundational level, data provision is primarily handled by technical institutions such as the Central Water Commission's Godavari Basin Office in Hyderabad, which maintains the basin-wide network of hydrological monitoring stations tracking flow parameters and sediment loads. These efforts are complemented by state pollution control boards including the Maharashtra Pollution Control Board (MPCB) and Andhra Pradesh Pollution Control Board (APPCB), which operate water quality testing laboratories at strategic locations like Nashik, Rajahmundry, and the delta region, generating crucial data on industrial effluents and urban sewage impacts. The efficacy of monitoring hinges on identifying the right nodes and agencies for evidence commissioning. Institutional actors such as the Central Water Commission (CWC) for hydrological data, state pollution control boards (MPCB, TSPCB) for discharge compliance, and research bodies like the IIT Hyderabad for pollution studies form the backbone of data collection. Local entities, including Gram Panchayats and farmer cooperatives, play a complementary role in ground-truthing data, particularly in remote stretches like the Indravati sub-basin. For rigorous scientific validation of collected data, specialized research institutions bring critical expertise. The IIT Hyderabad can conduct independent water quality audits and develop pollution remediation protocols, particularly for complex industrial contaminants from Telangana's textile hubs. There should be the nodal agency for biodiversity-related validation, assessing ecological restoration outcomes through standardized protocols for monitoring flagship and evaluating mangrove conservation success in the Coringa sanctuary.

On the implementation front, the Godavari River Management Board can operate as the key interstate coordinating body, translating monitoring data into actionable policies for water allocation and quality control across basin states. At the grassroots level, local Jal Boards in urban centres and Panchayat-led water committees in rural areas shall serve as implementation partners, executing pollution control measures and habitat restoration activities informed by the collected evidence. This multi-tiered governance framework ensures that data flows seamlessly from collection points to decision-making bodies, with each stakeholder category data providers, validators, and implementers, maintaining clear accountability while contributing specialized knowledge to the basin's integrated management system. The system's strength shall lie in its combination of technical expertise from national institutions with contextual knowledge from local agencies, creating a robust evidence chain that supports adaptive management of the Godavari's complex socio-ecological system. Below is a detailed list of potential commissioning organisations and contact persons for the management of Godavari Basin (See Table 5.1 and Table 5.2)

Table 5.1. List of Organisations

S/ No.	State	Agency	
		Government	Non-government
1.	**Karnataka**	1. Water Resources Department Government of Karnataka[4]	1. Water Literacy Foundation[5]
		2. Karnataka State Pollution Control Board[6]	2. Vasudha Foundation[7]
		3. Ecology and Environment Department, Karnataka[8]	3.Prawarda foundation[9]
		4. Industries and Commerce Department, Karnataka[10]	4.Reshine organisation[11]
		5. Minor Irrigation Department, Karnataka	5. Dakshin Foundation[12]
		6. Watershed Development Department, Karnataka	6. Ashoka Trust for Research in Ecology and the Environment (ATREE)[13]
		7. Indian Institute Of Technology Dharwad	7.Karuna Trust[14]
		8. Indian Institute of Science (Bengaluru)	8.Diya Foundation[15]
		9. University of Agricultural Sciences (UAS) Bangalore.	9. Sankalpa Rural Development Society[16]
		10. Central University Of Karnataka	
2.	**Telangana**	1. Godavari River Management Board	1.Grow Billion Trees Foundation[17]
		2. Telangana Ground Water Department (TG GWD)	2.Urban Waters[18]
		3. Telangana Remote Sensing Applications Centre (TGRAC)	3.Watershed Organisation Trust[19]
		4. National Remote Sensing Centre (NRSC)	4. Prakriti Environment Society[20]
		5. Telangana Pollution Control Board (TGPCB)	5.Abhaya Foundation[21]

[4] https://waterresources.karnataka.gov.in/english
[5] https://www.waterliteracyfoundation.com/home
[6] https://kspcb.karnataka.gov.in/
[7] https://www.vasudha-foundation.org/
[8] https://forest.karnataka.gov.in/
[9] https://prawarda.1ngo.in/
[10] https://industry.karnataka.gov.in/
[11] https://reshineorg.com/
[12] https://dakshin.org/
[13] https://www.atree.org/
[14] https://www.karunatrust.org/
[15] https://www.diyafoundation-india.org/
[16] https://srdsindia.org/
[17] https://growbilliontreesfoundation.com/
[18] https://urbanwaters.in/about-us/
[19] https://wotr.org/
[20] http://prakritipes.org/
[21] https://www.abhayafoundation.org/

		6. Telangana Forest Department	6.Akshara Foundation[22]
		7. Telangana Biodiversity Board[23]	7. BAIF Livelihoods[24]
		8. Institute of Forest Biodiversity[25]	8.Dhruvansh[26]
		9. Commissioner And Director Of Municipal Administration[27]	9.Dharti Foundation[28]
		10. Greater Hyderabad Municipal Corporation	10.Good Universe[29]
		11. Indian Institute of Technology, Hyderabad	11. Ashray Akruti Telangana[30]
		12. CSIR – National Geophysical Research Institute (NGRI)	
3.	**Odisha**	1.Water Resource Department	1.Pragati Koraput[31]
		2. Forest, Environment and Climate Change Department	2.Harsha Trust[32]
		3. Panchayati Raj & Drinking Water[33]	3.Ekta Foundation, Koraput[34]
		4. Revenue & Disaster Management	4.Pani Panchayat, Kalahandi[35]
		5.Rural Development[36]	5. Aaina[37]
		6.State Pollution Control Board, Odisha	6. Saunta Gaunta Foundation[38]
		7. Central Ground Water Board (CGWB)(Odisha)[39]	7.Agragamee[40]

[22] https://akshara.org.in/
[23] http://www.tsbiodiversity.org/
[24] https://baif.org.in/baif-livelihoods/
[25] https://ifb.icfre.gov.in/
[26] https://dhruvansh.org/
[27] https://emunicipal.telangana.gov.in/
[28] https://www.dhaatri.org/
[29] https://gooduniverse.org/
[30] https://ashrayakruti.org/
[31] https://pragatikoraput.org/
[32] https://harshatrust.org/
[33] https://panchayat.odisha.gov.in/
[34] https://www.ekta.org.in/
[35] https://panchayat.odisha.gov.in/about-us/field-officials/DPO
[36] https://rd.odisha.gov.in/
[37] https://www.aaina.org.in/
[38] https://sgfoundation.org.in/
[39] https://cgwb.gov.in/old_website/District_Profile/Orissa_districtprofile.html
[40] https://www.agragamee.org/

			8.AJSA India[41]
			9.Prastutee[42]
4.	Maharashtra	1.Godavari Conservation Cell Nashik	1.The Applied Environmental Research Foundation (AERF)[43]
		2. Maharashtra Water Resources Regulatory Authority	2. Green Yatra[44]
		3. Maharashtra Pollution Control Board	3.Prayas Youth Foundation[45]
		4.CSIR-NEERI	4.Nelda Foundation[46]
		5. Indian Institute of Science Education and Research, Pune(IISER pune)	5. Environmental Forum Of India[47]
		6.Tata Institute of Fundamental Research (TIFR), Mumbai	6. KALPAVRIKSH[48]
		7. Indian Institute of Technology Bombay	7. Vanashakti[49]
		8. Agharkar Research Institute, Pune	8.Waatavaran[50]
		9. Forest Development Corporation Of Maharashtra Limited	9. Environmentalist Foundation of India[51]
		10. Directorate of Municipal Administration	10. Wildlife Conservation Trust[52]
			11. Satpuda Foundation[53]
			12. The Godavari Initiative (TGI)[54]
			13.EARTH5R[55]

[41] https://www.ajsaindia.org/
[42] https://www.prastutee.org/
[43] https://www.aerfindia.org/
[44] https://greenyatra.org/
[45] https://prayasgroup.org/
[46] https://nelda.org.in/
[47] https://evfindia.org/
[48] https://kalpavriksh.org/
[49] https://vanashakti.org/
[50] https://waatavaran.org/
[51] https://indiaenvironment.org/
[52] https://www.wildlifeconservationtrust.org/
[53] https://satpuda.org/
[54] https://thegodavariinitiative.in/
[55] https://earth5r.org/

5.	**Chhattisgarh**	1.Goevrnment of Chhattisgarh Water Resource Department	1.Chhattisharh Environment Conservation Board[56]
		2. Revenue and Disaster Management Department	2. Ambuja Foundation[57]
		3. Forest & Climate Change Department Chhattisgarh Government	3.Samarthan-Centre for Development Support[58]
		4. Chhattisgarh Government Panchayat and Rural Development Department	4. Help and Helps Samiti[59]
		5. Housing and Environment Department, Govt. of Chhattisgarh	5. Self Reliant Initiatives through Joint Action (SRIJAN)[60]
		6. National Institute of Technology, Raipur	6.
6.	**Madhya Pradesh**	1.Water Resources Department http://mpwrd.gov.in/	1.Vanvasi Kalyan Ashram[61]
		2. Panchayat and Rural Development Department Madhya Pradesh	2.Samarthan-Centre for Development Support[62]
		3.Narmada Valley Development Authority, Government of M.P.	3. Card office Centre for Advanced Research & Development[63]
		4. Housing and Environment Department	4. RAWS India[64]
		5. Forest Department, Madhya Pradesh	5.Action for Social Advancement[65]
		6. Directorate of Economics & Statistics, Madhya Pradesh	6. National Centre for Human Settlements and Environment (NCHSE)[66]
		7. Public Works Department Government of Madhya Pradesh	7. Neenv Social Welfare Association[67]
		8.MANIT, Bhopal	8. Centre for Aquatic Livelihood Jaljeevika[68]
		9.ICAR- Central Institute of Agricultural Engineering, Bhopal	9. Self Reliant Initiatives through Joint Action (SRIJAN)[69]

[56] https://www.enviscecb.org/
[57] https://www.ambujafoundation.org/ngo-chhattisgarh
[58] https://www.samarthan.org/
[59] http://www.helpandhelps.org/
[60] https://srijanindia.org/
[61] https://vanvasi.org/
[62] https://www.samarthan.org/
[63] https://www.cardindia.org/
[64] https://rawsindia.org/
[65] https://asaindia.org/
[66] https://www.nchse.org/
[67] https://www.nswa.co.in/
[68] https://jaljeevika.org/
[69] https://srijanindia.org/

		10.Indian Institute of Science Education and Research, Bhopal	10.
7.	**Andhra Pradesh**	1. Rural Water Supply & Sanitation Government Of Andhra Pradesh	1. Watershed Support Services and Activities Network (WASSAN)[70]
		2. Water Resources Department, Andhra Pradesh	2.Centre for Environment Education[71]
		3. Planning Department, Andhra Pradesh	3.ASSIST India[72]
		4. Forests Department, Andhra Pradesh	4. Association for Social and Humanize Action[73]
		5. Agriculture Department, Andhra Pradesh	5. Peoples Charitable Trust[PCT)[74]
		6 Andhra Pradesh Pollution Control Board	6. Chaitanya Educational and Rural Development Society (CERDS)[75]
		7. Indian Institute Of Technology (IIT) Tirupati	7. Ken Foundation[76]
		8. Indian Institute of Science Education and Research Tirupati	8. Sam and Jane Foundation[77]
		9. National Atmospheric Research Laboratory Tirupati	
		10. Andhra University	

[70] https://www.wassan.org/
[71] https://www.ceeindia.org/andhra-pradesh
[72] https://www.assist-india.org/
[73] https://ashachintur.org/
[74] https://peoplescharitabletrust.in/
[75] https://www.cerds-india.org/
[76] https://kenfoundation.org/
[77] https://www.samandjane.org/

Table 5.2. List of potential commissioning persons

S No	Full Name	Designation	Department	Address	State	E Mail Address	Contact Number
1	K. Lakshmana Rao	Director	AP, Ground Water & Water Audit Department	4th & 5th Floor, Vysya Bhavan, Namboori Gopalrao Street, Vijayawada-520013	Andhra Pradesh	andhragw@gmail.com	91-8662574673
2	Sri Kantilal Dande	Principal Secretary/ Secretary	Andhra Tribal Welfare Department	Principal Secretary to Government , Tribal Welfare Department, Room No. 214(West) Block-III, Ist Floor , Andhra Pradesh Secretariate, Velagapudi, Amaravati, Andhra Pradesh.	Andhra Pradesh	prlsecy_tw@ap.gov.in, prlsecytwpeshi@gmail.com	8632443146, 7093930002
3	Sri S. Sri Saravanan, IFS	Member Secretary (FAC)	AP Pollution Control Board	Andhra Pradesh Pollution Control Board, Paryavaran Bhavan, APIIC Colony Road,Gurunanak Colony, Autonagar,Vijayawada-520007.	Andhra Pradesh	membersecy@appcb.gov.in	0866-2463204
4	Sri M. Rajashekar	Joint Chief Environmental Engineer, Water (FAC)	AP Pollution Control Board	Andhra Pradesh Pollution Control Board, Paryavaran Bhavan, APIIC Colony Road,Gurunanak Colony, Autonagar,Vijayawada-520007.	Andhra Pradesh	unit1-jcee@appcb.gov.in	0866-2463208

5	Sri Ramashankar Naik IAS	Commissioner of Fisheries	Department of Fisheries	Office of Commissioner of Fisheries, Bandar Road, Poranki, Vijayawada - 521137, Andhra Pradesh	Andhra Pradesh	comfishap@gmail.com, comfish-ap@ap.gov.in	
6	Dr. P. Koteswara Rao	Principal	State Institute of Fisheries Technology(SIFT)	Kakinada SIFT, Jagannaikpur, Kakinada, East Godavari Dist., -533 002	Andhra Pradesh	siftkkdap@gmail.com	0884-2378552, 9440814723
7	Sri Ajaya Kumar Naik, IFS	Principal Chief Conservator of Forests & (Head of Forest Force)	AP Forest Department	Aranya Bhavan, P.V.S.Land Mark, Near APIIC Towers, Mangalagiri, Guntur District-522503, Andhra Pradesh.	Andhra Pradesh	contactapfd@gmail.com	(0863) 2377500, 599
8	G. Anantha Ramu	Secretary	AP State Biodiversity Board	FLAT 210 & 311, WALLNUT BLOCK, NH16, opp. Nagarjuna University, Guntur, Andhra Pradesh 522510	Andhra Pradesh	apsbiodiversityboard@gmail.com	0863 229 3777
9	Shri Ahmad Nadeem	Principal Secretary	Environment, Forests, Science & Technology	Aranya Bhavan,, NH 44, Opposite Safabad, Saifabad, Khairtabad, Hyderabad, Telangana 500004	Telangana	prlsecy_efst@telangana.gov.in	040-23453111
10	Dr. A. Sharath, IAS	Secretary to Government	Tribal welfare department, TS	Aranya Bhavan,, NH 44, Opposite Safabad, Saifabad, Khairtabad, Hyderabad, Telangana 500004	Telangana	secretary_tw@telangana.gov.in, secretary.tw.ts@gmail.com	040-23453401, 23453403

11	Commissioner	Commissioner of Tribal Welfare/Ex - Officio Managing Director	Tribal welfare department, TS	Tribal Welfare Department Ground Floor, DSS Bhavan, Masab Tank, Hyderabad	Telangana	ctwtgs@gmail.com	040-23317126
12	V. Sarveshwar Reddy	Director	Tribal Cultural Research & Training Institute (TCR&TI), TS Tribal Welfare department	Tribal Welfare Department Ground Floor, DSS Bhavan, Masab Tank, Hyderabad	Telangana	directortrits@gmail.com	9490957118
13	Ms. Farida Tampal	State Director	Ramboll and WWF-India	WWF-India Hyderabad Office 1-2-288/42 Plot No. 21, 1st Floor SBH Colony, Domalguda Hyderabad- 500029	Telangana	ftampal@wwfindia.net	040-27614151
14	A NAGESWAR ARAO	SECRETARY	Remote Tribal Mission (RTM)	Regd. Office: H.No.76, Rama Gopalapuram (Village), Nellipaka (Post), BHADRACHALAM – 507111, Khammam (Dist)Admin Office: D.N. 15-1-42/3. S.R.N. Colony, BHADRACHALAM(Post)-507111,Bhadradri Kothagudem (Dist), Telangana State	Telangana	vimalartm2011@gmail.com	9948845497

15	MADDELA SREENIVAS	SECRETARY	THE SOCIETY OF GOD IN CHRIST TRUST	432, ISRAJPALLY PO RAPALLI, MADL. GOLLAPALLI, DISTRICT JAGTIYAL, TG03, TELANGANA, PIN- 505532	Telangana	antharpuladavid123@gmail.com	9908794207
16	SIMRAN SAGAR SINGH	OPERATIONS DIRECTOR	GENESIS FOUNDATION	HNO 4-33 DUDEPUDI VILLAGE PALLIPADU POST KONIJERLA MANDAL KHAMMAM DISTRICT	Telangana	gf1142014@gmail.com	9032003213
17	Mr. P. Kiran Kumar	Secretary	Centre for Rural Development	MANDAL NIRMAL, H.No.1-3-23, Shastrinagar,504106, Nirmal District.	Telangana	crd.org@rediffmail.com	9440001272
18	JAYASREE MOOGA	CHIEF EXECUTIVE OFFICER	Prakriti Environment Society	H.No.5-3-182 Ashok Nagar Karimangar Andhra Pradesh 505001	Telangana	prakritipes@yahoo.com	9848053830
19	Sri Rahul Bojja, IAS	Secretary to Government	Irrigation & CAD Department	JalaSoudha, Irrigation & CAD Department, Erram Manzil Colony, Punjagutta, Hyderabad, Telangana 500082, India	Telangana	secy-irg@telangana.gov.in	040-23450606
20	Mohd. Amjad Hussain	Chief Engineer, Enquires, Hyderabad	Irrigation & CAD Department	JalaSoudha, Irrigation & CAD Department, Erram Manzil Colony, Punjagutta, Hyderabad, Telangana 500082, India	Telangana	ceenquiries.irr@gmail.com	9849582650
21	G.KRUPAKAR REDDY	Engineer-in-Chief (Mission Bhagiratha)	Department of Mission Bhagiratha	Mission Bhagiratha, . SRTGN Bhavan, Errumanzil Colony Hyderabad-500082.	Telangana	eic_rwss@telangana.gov.in	040-23396655; 040-23319676

22	Satyanarayana Reddy.	IAS, Member Secretary, T.S	TS pollution control board	Pollution Control Board, A-3, Industrial Estate, Sanath Nagar, Hyderabad	Telangana	ms-tspcb@telangana.gov.in	040-23887518
23	K Laxma	Director	Government of Telangana Ground Water Department	Director, Ground Water Department, D.No.6-2-916/1, Opp: Govt., Degree College, Chintal Basthi, Khairatabad, Hyderabad-500004	Telangana	director.tsgwd@gmail.com	7032982001
24	Dr. C.Suvarna, IFS	Prl.Chief Conservator of Forests (HoFF), Telangana	Head of Forest Force	PRL. CHIEF CONSERVATOR OF FORESTS (HoFF), TELANGANA, ARANYA BHAVAN, SAIFABAD,HYDERABAD	Telangana	pccftelangana@gmail.com	040-23231404, Fax: 23231851,9440816295
25	Sri B. Raghu	Chief Environmental Engineer	Telangana Pollution Control Board	Pollution Control Board, A-3, Industrial Estate, Sanath Nagar, Hyderabad	Telangana	cee-tspcb@telangana.gov.in	040-23887505, 9866776707
26	Sri Kalicharan S Khartade, IAS	Secretary	Telangana Biodiversity Board	4th floor, Aranya Bhavan, opp. RBI Bank, Saifabad, Khairtabad, Hyderabad, Telangana 500004	Telangana	telanganabiodiversity@gmail.com	040–24602345 Fax: 24602873
27	Smt. K. Nikhila, IAS,	Director	Commissioner of Fisheries	Rd Number 4, Shantinagar Colony, Masab Tank, Hyderabad, Telangana 500457	Telangana	dftelangana@gmail.com	040-23376251 Fax: 23300263

28	Dr. Dhriti Banerjee	Director	Zoological Survey of India	Zoological Survey of India Freshwater Biology Regional Centre Plot No 366/1, PVNR express way Pillar No 162 Hyderguda,Attapur,Hyderabad	Telangana	fbrc@zsi.gov.in; fbrczsi@gmail.com	040-24002200
29	Sri K. Suresh Kumar	THE ENGINEER-IN-CHIEF,	Telangana Public Health & Municipal Engineering Department	Public Health, A.C. Guards, Hyderabad - 500004 Telangana (India).	Telangana	enc_gen_phmed@telangana.gov.in, eicphts@gmail.com	(040) 23391208, (040) 23302234
30	Sri. Vijay Mohan Raj V, IFS	Principal Secretary	Karnataka Biodiversity Board	Ground Floor, 'Vanavikas Building', 18th Cross, Malleshwaram, Bengaluru-560003	Karnataka	kbb-ka@nic.in and kbb.ka.ms@gmail.com	080 23448783, 080 23448784
31	Shri. Sumitkumar Subashrao Patil ,IFS	Deputy Conservator of Forests, Kalaburagi	Kalaburagi Forest Division	Aranya Bhavan, SB Temple Road, Opposite Satya Hospital, Kalaburagi 585102	Karnataka	dcf_tgulbarga@yahoo.co.in	8472256601
32	Shri. Anjum Parwez	Additional Chief Secretary (FEE)	Forest, Ecology and Environment Department	Karnataka Government Secretariat, Room No. 448, 4th Floor, Gate No. 2, M. S. Building, Bengaluru-560001	Karnataka	prs-fee@karnataka.gov.in	8022256722
33	Shri. Prabhash Chandra Ray, IFS	Principal Secretary (Forests)	Forest, Ecology and Environment Department	Karnataka Government Secretariat, Room No. 448, 4th Floor, Gate No. 2, M. S. Building, Bengaluru-560001	Karnataka	secyforestfee@gmail.com secyforest-fee@karnataka.gov.in	080-22254434/ 22032570

34	Shri Suryakanth Male	Chief Engineer KNNL, Irrigation Project Zone	Karnataka Water Resources department	The Chief Engineer, KNNL, IPZone, Kalaburagi	Karnataka	ceg_ipz@rediffmail.com , ceipzklb@gmail.com	9486289650
35.	Prof. Asif Qureshi	Professor	Department of Civil Engineering,	IIT Hyderabad, Kandi, 502285	Telangana	asif@ce.iith.ac.in	9030367216
36.	Dr. Anindita Majumdar	Associate Professor	Department of Liberal Arts	IIT Hyderabad, Kandi, 502285	Telangana	anindita@la.iith.ac.in	9911857759
37.	Prof. Debraj Bhattacharyya	Professor	Department of Civil Engineering,	IIT Hyderabad, Kandi, 502285	Telangana	debrajb@ce.iith.ac.in	6300617001
38	Dr. Satish Regonda	Associate Professor	Department of Civil Engineering,	IIT Hyderabad, Kandi, 502285	Telangana	satishr@ce.iith.ac.in	9581118374
39	Dr. Pritha Chatterjee	Associate Professor	Department of Civil Engineering	IIT Hyderabad, Kandi, 502285	Telangana	pritha@ce.iith.ac.in	8420199639
40	Prof. Prabheesh KP	Professor	Department of Liberal Arts	IIT Hyderabad, Kandi, 502285	Telangana	prabheesh@la.iith.ac.in	9493329635

5. Evidence-Based Monitoring for River Basin Management

The Godavari River Basin spans 7 Indian states (Maharashtra, Telangana, Andhra Pradesh, Chhattisgarh, Odisha, Madhya Pradesh, Karnataka) and requires multi-agency coordination for evidence-based policymaking. To conduct a comprehensive assessment of the Godavari River Basin, a multi-dimensional evidence base must be developed, covering hydrological, ecological, socio-economic, and climatic aspects.

5.1. Areas of Possible Interventions for River Basin Management

The flow dynamics of the Godavari must be studied through discharge measurements at key stations to understand seasonal variations and the impact of dams. Groundwater monitoring is critical, particularly in over-exploited zones like Marathwada and Telangana, where aquifer depletion threatens water security. Water quality assessments must track pollutants such as industrial effluents, agricultural runoff (pesticides), and urban sewage (BOD/COD levels). Sedimentation studies are needed to evaluate reservoir siltation and its impact on storage capacity. The riparian ecosystem must be mapped, including forest cover loss in tributaries like the Pranhita and Indravati, and wetland degradation in the Godavari delta.

Aquatic biodiversity surveys should document endangered species (e.g., the hump-backed mahseer) and the effects of barrages and invasive species (water hyacinth, African catfish). Mangrove health in the Coringa Wildlife Sanctuary must be assessed for climate resilience. Water-use patterns must be quantified, including agricultural demand (sugarcane in Maharashtra, paddy in AP), industrial consumption (thermal plants in Chhattisgarh), and urban supply (Hyderabad, Nashik). Land-use changes such as sand mining in the Manjira, deforestation and urbanization in Hyderabad should be analysed. Stakeholder conflicts, including inter-state disputes (AP-Telangana over Polavaram), tribal water rights (Adivasis in Bastar), and farmer-industry tensions, require documentation. Flood vulnerability must be modelled, particularly in low-lying areas of Rajahmundry and Nanded, while drought risk assessments should focus on Marathwada and Vidarbha. Climate change impacts, such as shifting monsoon patterns and rising temperatures, must be projected to forecast long-term water availability.

To establish baseline conditions and monitor dynamic changes across the Godavari Basin, high-resolution remote sensing needs to be deployed through a multi-sensor approach. The satellite data providing organisations need to provide 2-10m resolution imagery for land-use classification, supplemented by Sentinel-2 multispectral data (10m) for vegetation health monitoring. We recommend implementing a comprehensive, multi-tiered monitoring system for the Godavari Basin that combines advanced technologies with grassroots participation. For hydrological monitoring, we propose upgrading key gauge stations with Acoustic Doppler Current Profilers (ADCPs), with priority installation at critical locations like Polavaram for inter-state water allocation monitoring, Peddagattu for assessing mining impacts on the Pranhita tributary, and Bhadrachalam for flood forecasting. These should be complemented by state-level installations of multi-parameter sondes measuring water quality indicators at 15-minute intervals, with data transmission through state of art networks to ensure real-time decision-making capability.

For groundwater assessment, we suggest deploying telemetric piezometers in critically over-exploited blocks, with particular focus on Jalna's basalt aquifers, Nalgonda's fluoride-affected areas, and Korba's mining zones. This should be integrated with the Atal Bhujal Yojana's community-based approach, implementing participatory aquifer mapping using electromagnetic induction surveys and maintaining detailed farmer logbooks of irrigation patterns to create accurate block-level water budgets. The ecological monitoring program should employ cutting-edge techniques like eDNA metabarcoding at strategic locations to track both endangered species like the Deccan mahseer and invasive threats like African catfish, combined with thermal drone surveys for crocodile habitat mapping.

The protocol recommends state forest departments adopt standardized riparian health indices and hydrogeomorphic wetland assessment protocols to ensure consistent monitoring across jurisdictions. For socio-economic data collection, we advocate for a stratified sampling approach covering agricultural households with detailed water use monitoring and fisherfolk interviews to document changing catch patterns. Tribal communities should be actively engaged through participatory mapping of traditional water systems and seasonal resource calendars to incorporate indigenous knowledge into management plans. Pollution monitoring requires sophisticated instrumentation including high-frequency mass spectrometers for pharmaceutical and heavy metal detection, complemented by bioassay testing and historical sediment core analysis. We strongly recommend implementing blockchain-enabled effluent monitoring systems for industries to ensure data integrity and transparency. For effective governance of the Godavari Basin, we recommend establishing a clear institutional structure with well-defined roles for state and central agencies.

Each of the seven basin states should designate their primary implementing agencies: Maharashtra Water Resources Regulatory Authority (MWRRA) and Groundwater Surveys and Development Agency (GSDA) for Maharashtra; Telangana State Pollution Control Board (TSPCB) and Irrigation Department for Telangana; Andhra Pradesh Water Resources Department and AP Pollution Control Board for Andhra Pradesh; and corresponding agencies in Chhattisgarh, Odisha, Madhya Pradesh and Karnataka. These state agencies would work under the overarching coordination of three central bodies: the Godavari River Management Board (GRMB) for technical oversight, the Ministry of Jal Shakti for policy guidance, and the National Mission for Clean Ganga (NMCG) for pollution control expertise. This multi-level institutional arrangement ensures both state-specific implementation and basin-wide coordination. A robust administrative data ecosystem must be established to support evidence-based decision making across the Godavari River Basin. This requires systematic collection and integration of critical datasets from multiple governance tiers, with clearly defined protocols for data sharing, validation, and application.

The framework mandates standardized reporting of water allocation records through formalized inter-state agreements coordinated by the Godavari River Management Board (GRMB). This includes reservoir release data from major projects canal distribution logs maintained by state irrigation departments, and water withdrawal permits issued to industries and urban utilities. These datasets must be complemented by legal documents including inter-state water sharing awards, environmental clearances for infrastructure projects, and judicial orders related to water disputes. For effective data commissioning, the system should implement binding MoUs between states and central agencies, requiring real-time sharing of operational data through API-based linkages between existing platforms like WRIS India and Pro Active and Responsive Facilitation by Interactive and Virtuous Environmental Single-window Hub (PARIVESH). Blockchain technology should be deployed to maintain immutable

records of industrial compliance and resource extraction permits. The framework must incorporate rigorous validation mechanisms, including third-party technical audits coupled with community-level social audits through Gram Sabhas and water user associations.

A quality control architecture should be institutionalized, beginning with automated validation checks at data entry points, followed by monthly inter-departmental reconciliation meetings chaired by GRMB, and culminating in annual public disclosure of basin management data. This structure will be supported by clearly designated lead agencies for each data domain state water resources departments for surface water data, CGWB and state groundwater agencies for aquifer monitoring records, and pollution control boards for industrial compliance data. The implemented framework should deliver three key outcomes such as unified decision-making through integrated data dashboards that align water availability, demand and quality metrics; transparent dispute resolution supported by auditable allocation records; and predictive governance capabilities linking hydro-meteorological forecasts with operational protocols. This administrative data infrastructure will transform fragmented state-level records into a cohesive knowledge base for basin-wide water governance, while ensuring accountability across all seven riparian states through systematic monitoring and public disclosure mechanisms.

A robust evidence-gathering framework is essential for informed decision-making in the Godavari River basin, combining diverse data sources and collection methodologies tailored to the river's unique challenges. Primary surveys form a critical component, particularly in assessing the impact of mass religious gatherings along the sacred Nashik-Trimbakeshwar corridor. These intensive field studies employ water quality sampling before, during, and after major pilgrimage events, tracking parameters such as fecal coliform counts, biochemical oxygen demand, and chemical contaminants from ritual offerings. Survey teams comprising hydrologists, sociologists, and public health experts should conduct longitudinal studies that correlate pilgrim density with ecological impacts, while also documenting the effectiveness of temporary sanitation infrastructure deployed during events like the Kumbh Mela. Administrative records would serve as another vital evidence stream, particularly for monitoring regulated activities like sand mining. The compilation and analysis of sand mining permits issued by district authorities would reveal patterns of legal extraction, while cross-referencing these with satellite imagery helps identify unauthorized mining hotspots. This paper trail, maintained by state mining departments and the Godavari River Management Board, shall provide crucial evidence for enforcing environmental flow maintenance and riverbed conservation policies.

The space-based monitoring is particularly effective for identifying thermal plumes from sugar mills and pharmaceutical units, where conventional water sampling might miss intermittent discharges. The thermal anomaly data, when combined with ground-truthing by pollution control boards, creates a compelling evidence base for regulatory action against violators. The sustainable management of the Godavari River basin relies on a combination of advanced technological tools and community-based monitoring systems to track environmental changes and human impacts. Remote sensing technology plays a pivotal role in basin-wide observation, providing critical satellite data for analyzing land-use changes, deforestation patterns, and sedimentation dynamics. The high-resolution imagery, including data from resources like Cartosat and RISAT satellites, would enable precise mapping of mangrove cover fluctuations in the Coringa delta, illegal sand mining activities along riverbanks, and the expansion of agricultural land in water-stressed regions. These satellite-based tools are particularly valuable for detecting large-scale ecological shifts that ground surveys might miss, such as gradual silt

deposition in reservoirs or the encroachment of urban areas on floodplains. Complementing these technological approaches is the invaluable role of community participation, particularly through fishermen cooperatives that serve as frontline observers of river health. These cooperatives, which operate along the entire length of the Godavari from Nashik to Rajahmundry, provide real-time reports on pollution incidents, illegal dumping, and unusual fish mortality events. Their traditional knowledge of river ecosystems allows them to identify subtle changes in water quality or aquatic biodiversity that automated systems might overlook. The integration of remote sensing with community observations creates a robust, multi-layered monitoring framework.

This multi-layered approach addresses the limitations of any single methodology, ensuring that policy decisions benefit from both scientific precision and contextual ground reality. The challenge lies in effectively synthesizing these disparate data sources into a unified knowledge platform that can inform adaptive management strategies for the entire basin ecosystem. Future enhancements should focus on developing interoperable data systems that can seamlessly combine administrative records, sensor data, and community observations while maintaining strict quality control protocols for each evidence type.

6. Independent Monitoring in Development Initiatives

The Godavari Basin audit framework must incorporate approaches to capture community perceptions and traditional ecological knowledge. Following the model pioneered by IIT Hyderabad in this report, we propose establishing Community River Councils (CRCs) that employ ethnographic methods to document local observations and cultural relationships with the river system. These councils should conduct periodic perception surveys using mixed-method approaches combining structured questionnaires about water quality observations with narrative interviews capturing generational knowledge about hydrological changes. The methodology should particularly focus on marginalized riparian communities, including fisherfolk along the Dowleswaram barrage and tribal agriculturalists in the Indravati sub-basin, whose lived experiences provide critical ground-truthing for technical data. For institutional models of data auditing, India's Comptroller and Auditor General (CAG) has to set global benchmarks through its performance audit of the National Mission for Clean Ganga. This audit shall innovatively combine financial expenditure tracking with ecological outcome assessments, using GIS mapping to correlate sewage treatment plant investments with actual water quality improvements.

6.1. Comprehensive Data Audit Framework

The monitoring and feedback mechanism's implementation should be driven by a GRMB-led Multi-Stakeholder Task Force comprising representatives from all seven basin states, supported by technical experts from premier institutions like IITs (for engineering solutions), Wildlife Institute of India (for ecological aspects), and Central Ground Water Board (for aquifer management). A centralized Digital Data Hub should be established to integrate real-time monitoring data from all states, with open access to authorized stakeholders. At the grassroots level, Village Water Committees should be empowered for local monitoring, while tribal councils in forested regions should be involved in conservation planning. For sustainable financing, we recommend leveraging Compensatory Afforestation Fund Management and Planning Authority (CAMPA) funds for afforestation and pursuing international funding from World Bank/ADB for advanced hydrological modelling infrastructure. This comprehensive framework is expected to deliver three key transformative outcomes for the Godavari Basin. First, a scientifically-grounded, basin-wide water allocation plan that equitably addresses inter-state disputes while considering environmental flows. Second, an actionable pollution control strategy with targeted interventions for industrial effluents and urban wastewater, particularly in critically polluted stretches. Third, development of climate-resilient water management systems incorporating advanced drought and flood forecasting capabilities. The nature of commissioned evidence must align with the basin's challenges.

Similarly, the European Environment Agency's "State of Water" assessments demonstrate best practices in integrating satellite data with national monitoring reports across transnational basins like the Danube. The US Geological Survey's quality assurance protocols for its National Water-Quality Assessment (NAWQA) provide another robust model, featuring blind sample re-testing, blockchain-secured data chains for critical parameters, public-facing data quality scoring for each monitoring station[78]. The framework should mandate similar verification

[78] https://www.usgs.gov/mission-areas/water-resources/science/national-water-quality-assessment-nawqa

mechanisms for Godavari data, including cross-validation of government discharge data with community rainfall records in the upper basins, tribal youth fellowships to document traditional flood prediction methods, triangulation of official groundwater data with farmer well logs in drought-prone areas These approaches would create India's first truly participatory river audit system, blending bureaucratic accountability with democratic participation. The Maharashtra Groundwater Surveys and Development Agency's (GSDA) citizen science program, which trained village volunteers to collect and verify piezometric data, offers a proven template for scaling community-based validation.

To ensure scientific rigor and impartiality in monitoring efforts, an independent Technical Audit Consortium should be formally constituted under the Godavari Basin Monitoring Authority. This consortium must bring together the specialized capabilities of premier institutions for water quality expertise, ecological assessments, and for hydrological modelling validation. The consortium should implement a rigorous three-tier verification system. First, annual water quality audits must incorporate blind sampling protocols of monitoring locations, where samples are collected without prior notice to operators and analysed at certified independent laboratories. Second, biodiversity assessments should be verified through replicate surveys conducted by separate field teams using identical methodologies to confirm result consistency. Third, sediment transport models require validation through advanced tracer studies using rare earth element tagging and mineralogical fingerprinting techniques at key sediment source areas. The consortium must maintain complete operational independence from implementing agencies, with direct reporting lines to the GBMA governing council. A critical component of this oversight system should be mandatory trigger-based evaluations following major basin events. Within hours of flood events exceeding danger levels or industrial accidents with potential water quality impacts, rapid response teams comprising hydrologists, ecologists and public health experts must be mobilized to conduct comprehensive impact assessments. These teams should be pre-identified and trained in standardized rapid assessment protocols, with mobile laboratories and field equipment maintained in readiness at strategic locations across the basin.

All audit reports and evaluation findings must undergo technical peer review before being made publicly available through the Godavari Data Hub within minimum days of completion, ensuring transparency while maintaining data integrity. The consortium should also develop standardized ecological health indices that simplify complex technical data for policymakers and the public. The monitoring system must institutionalize meaningful community engagement through multiple complementary channels. A network of trained Jal Sevaks (water stewards) should be deployed across the basin, selected from local communities and equipped with portable water testing kits capable of measuring basic parameters (pH, turbidity, conductivity) along with smartphone-based digital reporting tools. These community monitors would serve as the first line of detection for pollution incidents and ecological changes, with their observations feeding into the central monitoring system. Water Parliaments should be established at sub-basin levels, serving as permanent platforms for community oversight and grievance redressal. These forums would convene monthly, bringing together elected representatives, government officials, technical experts and community members to review monitoring data, discuss emerging concerns, and validate official findings. Traditional ecological knowledge must be systematically documented through participatory mapping exercises led by anthropologists, particularly focusing on flood prediction methods, drought coping strategies, and historical hydrological patterns. This knowledge should be digitized and integrated with scientific datasets through geospatial platforms, creating hybrid knowledge systems that enhance the basin's adaptive capacity.

A transparent, predictable compliance regime must be established with clearly defined consequences for violations and incentives for exemplary performance. The graded penalty system should escalate enforcement actions based on violation severity and recurrence. First violations would trigger corrective action orders specifying remediation measures and timelines, coupled with mandatory public disclosure of the violation through the Godavari Data Hub. Second violations within a three-year period would incur financial penalties scaled to the operator's turnover with funds directed to local conservation projects. Third violations would result in temporary operational suspension and referral to statutory authorities for legal action under relevant environmental laws. Concurrently, a robust incentive program should recognize and reward compliance excellence. Districts maintaining consistent parameter compliance over three consecutive years should qualify for preferential funding allocation under basin development programs. Industries adopting beyond-compliance standards should receive Green Certification with associated benefits like fast-tracked permit renewals and public recognition.

An annual “Godavari Guardian” awards program should highlight outstanding community monitoring initiatives and innovative conservation efforts by local stakeholders. The Godavari Monitoring Academy should be established as a permanent capacity-building institution, operating through a hub-and-spoke model with its headquarters and regional centres in each basin state. The academy would deliver training programs such as intensive technical courses for professionals (covering advanced monitoring methodologies, data analysis and reporting standards); certification programs for community monitors (with modules on basic hydrology, pollution identification and digital literacy); and policy workshops for decision-makers (focusing on data interpretation and evidence-based policymaking). Training should incorporate hands-on field components and scenario-based simulations to build practical skills. Concurrent with cleaning the river is the imperative to manage its water wisely and equitably. A key focus here is on decentralized water harvesting. Data from initiatives like the Jal Shakti Abhiyan demonstrates the high impact of localized structures such as check dams, percolation tanks, and rejuvenated traditional water bodies for groundwater recharge, particularly in the rain-fed regions of the basin. Furthermore, a large-scale project for canal lining in the extensive Godavari Delta system is crucial. Lining canals with concrete or geo-synthetic materials can reduce seepage losses, conserving a massive volume of water for extended irrigation and drinking needs without the ecological disruption of new large dams.

A comprehensive Digital Knowledge Repository should be developed as the basin's central information clearinghouse, featuring: searchable databases of technical manuals and standard operating procedures; interactive case study libraries documenting successful interventions and lessons learned; geospatial tools for data visualization; and e-learning modules for continuous professional development. Quarterly Knowledge Exchange Workshops should bring together monitoring teams from across the basin to share innovations and problem-solve common challenges, with proceedings systematically documented and incorporated into the repository. The framework must institutionalize regular review and adaptation cycles to ensure the system evolves with changing basin conditions. Monthly technical review meetings at zonal levels would examine monitoring data trends, equipment performance, and field implementation challenges, producing actionable recommendations for operational improvements. Biannual state-level policy dialogues would convene senior officials, technical experts and civil society representatives to review aggregate findings and adjust implementation strategies. Every five years, a Comprehensive Basin Assessment should evaluate the entire monitoring framework's effectiveness, incorporating statistical analysis of long-term parameter trends; independent evaluation of system outputs by international experts; and broad stakeholder consultations.

This assessment would inform major framework revisions and strategic reorientation as needed. Pre-approved trigger-based action plans would enable rapid response to emergencies, with clear protocols for immediate water quality crisis management (including alternative water supply arrangements), drought period flow maintenance, and ecological rescue operations for endangered species. A fast-track policy amendment process would allow timely regulatory adjustments in response to monitoring findings, with provisions for pilot testing innovations before basin-wide implementation. The system’s effectiveness should be periodically evaluated by the Comptroller and Auditor General of India, with findings presented to state legislatures and the National Green Tribunal to ensure accountability. By combining cutting-edge monitoring technologies with deep community engagement and robust governance mechanisms, the framework would deliver sustained improvements in basin health while supporting sustainable development across the Godavari's diverse socio-ecological landscape.

7. Data Analysis Techniques for Evaluation

The analysis must be conducted through a structured institutional framework involving specialized agencies, academic institutions, and local communities, employing methodologies tailored to the basin's complex challenges. A Godavari Basin Data Consortium (GBDC) should be established under the auspices of the Godavari River Management Board (GRMB), comprising representatives from each state's water resources department, pollution control boards, groundwater agencies, and technical institutions. This consortium should oversee the standardization of data collection protocols, ensure quality control, and facilitate cross-state data sharing. Each state should establish a State Data Analysis Unit (SDAU) responsible for processing regional datasets, while a Central Analytics Hub at GRMB headquarters would integrate findings for basin-wide assessments. Hydrological data analysis should be spearheaded by the Central Water Commission (CWC) in collaboration with state irrigation departments. Time-series analysis of discharge records from gauging stations should assess long-term flow trends, seasonal variations, and the impact of dam operations. Spatial interpolation techniques should map groundwater depletion patterns using data from the Central Ground Water Board (CGWB) and state groundwater agencies.

7.1. Institutional Data Analysis for Evaluation and Feedback

IIT Hyderabad should lead hydraulic modelling using SWAT (Soil & Water Assessment Tool) to simulate basin-wide water balance, incorporating climate projections from the Indian Institute of Tropical Meteorology (IITM). Machine learning algorithms should predict flood and drought risks by analysing historical rainfall, reservoir storage, and land-use data. State Pollution Control Boards (PCBs) should conduct multivariate statistical analysis (e.g., Principal Component Analysis) to identify pollution sources from industrial, agricultural, and urban wastewater. Mass balance models should quantify pollutant loads, while geospatial hot-spot analysis should pinpoint critical zones. Institutions should oversee toxicity assessments using bioassays and chemical fingerprinting to trace heavy metal sources. Citizen science data from Jal Sevaks should be incorporated to validate official monitoring through Bayesian inference techniques, improving accuracy in remote areas. The forest departments should lead occupancy modelling for endangered species, analysing acoustic and visual survey data to estimate population trends. NDVI (Normalized Difference Vegetation Index) analysis of satellite imagery should assess riparian health, while eDNA metabarcoding should monitor aquatic biodiversity shifts due to pollution or flow alterations.

State forest departments should implement landscape-level habitat connectivity models to evaluate fragmentation impacts from dams and urbanization. Community-reported data on fish catches and wetland health should be integrated using participatory GIS to validate scientific findings. NITI Aayog, in partnership with state rural development departments, should conduct panel data analysis of household surveys to correlate water access with agricultural productivity and health outcomes. Agent-based modelling should simulate farmer decision-making under water stress, incorporating crop choice, market prices, and climate variability. Tribal councils should contribute ethnographic data on traditional water management, analysed through qualitative coding techniques to identify adaptive strategies. Network analysis should map stakeholder conflicts (inter-state water disputes) and governance bottlenecks. Sediment fingerprinting using radionuclides to quantify erosion sources, while remote sensing analysis should track land-use changes and siltation in reservoirs. SWAT-coupled sediment models should predict future scenarios under climate change and land degradation. This framework

ensures that data analysis progresses from descriptive profiling to causal attribution and predictive modelling, enabling evidence-based policymaking across the Godavari states. By leveraging institutional expertise, advanced analytics, and community knowledge, the basin can transition from reactive crisis management to proactive, adaptive governance. Regular inter-state technical workshops and public data dashboards will maintain transparency, while third-party audits by CAG and academic consortia will validate the system's integrity. The result will be a scientifically rigorous, socially inclusive approach to sustaining India's vital Godavari River system.

A healthy river is defined by its ecosystem, necessitating the allocation the budget to biodiversity and rejuvenation. This involves large-scale afforestation and catchment area treatment using native species along the riverbanks and in its source regions to combat erosion and siltation, using the funding and expertise framework of the Compensatory Afforestation Fund Management and Planning Authority (CAMPA). Alongside this, a dedicated program for aquatic biodiversity conservation is essential, focusing on rehabilitating critical wetlands, which act as natural water filters, and on conservation programs for key species like turtles, dolphins, and native fish. Underpinning all these efforts must be the establishment of a comprehensive network of real-time water quality monitoring stations to provide transparent, reliable data on the river's health, enabling data-driven decision-making and public accountability.

A dedicated team of anthropologists and sociologists needs to be deployed across the Godavari Basin to conduct in-depth ethnographic studies. These researchers can spend 6-12 months living in representative communities, including tribal villages, farming communities, and fishing settlements in the delta region. The research would employ rigorous participant observation methodologies, with daily logs documenting water-related behaviours, rituals, and traditional ecological knowledge. Structured oral history interviews need to be conducted with three generations of community members to track changes in water access and quality perceptions over time. The findings will be systematically coded and analyzed with particular attention to identifying, community-developed early warning systems for droughts and floods, local innovations in water conservation, and emerging conflicts over water resources. These qualitative insights will be georeferenced and integrated with quantitative monitoring data through the Godavari Data Hub, ensuring traditional knowledge informs modern water management decisions. Primary surveys are indispensable for capturing socio-economic impacts, such as water access disparities in tribal areas of Odisha's Godavari districts. Administrative data, including sand mining permits and industrial discharge records, provide regulatory insights, while remote sensing enables large-scale tracking of deforestation, siltation, and thermal pollution. The long-term sustainability of any river conservation effort hinges on the support of its surrounding communities. Therefore, significant budget needs to be dedicated to community livelihoods and governance. This includes promoting a transition to organic farming through incentives and training, which would significantly reduce the chemical runoff from agriculture that pollutes the river. Supporting fishery cooperatives to adopt sustainable practices and develop alternative livelihoods is also critical for economic resilience. Furthermore, continuous public awareness campaigns and community engagement programs are needed to foster a sense of collective ownership, turning local residents into active guardians or "Godavari Mitras."

Emerging technologies like drone-based hyperspectral imaging can further enhance resolution in critical zones To ensure objectivity, independent audits and third-party monitoring need to be institutionalized. Agencies can audit biodiversity outcomes, while academic institutions can

validate hydrological models. These audits should be event-triggered such as post-flood assessments of embankment breaches and periodic, ensuring accountability in long-term projects ecological offsets. Finally, data analysis must distinguish between descriptive trends (e.g., decade-long salinity intrusion in the delta) and causal inference (e.g., the impact of sugarcane effluents on mid-basin water quality). Advanced statistical tools (multivariate regression, machine learning) and spatially explicit models are essential to isolate drivers of degradation and prioritize interventions. By integrating these elements, this protocol aims to transform the Godavari's management from reactive to predictive, ensuring the basin's resilience for future generations. A robust third-party monitoring system must be formally established as an integral component of the Godavari River Basin's governance framework. The mandate should encompass comprehensive ecological audits conducted at predetermined intervals, employing standardized methodologies that allow for longitudinal comparison of ecosystem health indicators across the basin's diverse reaches. For aquatic biodiversity monitoring, the framework should institutionalize biannual surveys of flagship species like the Gangetic dolphin, utilizing both traditional boat-based counts and advanced acoustic monitoring technologies. These surveys must follow strict scientific protocols to ensure data consistency, with particular focus on critical habitats in the middle reaches near Bhadrachalam and the deltaic regions. The mangrove ecosystems in the Godavari estuary require specialized monitoring protocols that combine ground-level vegetation sampling with satellite-based change detection analysis, creating a multi-scale assessment system for evaluating restoration efforts in the Coringa Wildlife Sanctuary and surrounding wetlands. Hydrological and geomorphological monitoring should be formally assigned to academic institutions with specialized expertise. Their work must incorporate both field measurements and advanced modelling to track sediment dynamics throughout the basin, with particular attention to reservoir sedimentation patterns and tributary erosion processes. These models should be regularly updated with new field data and calibrated against actual measurements to maintain predictive accuracy, serving as essential tools for infrastructure planning and soil conservation program design.

Additionally, the Central Water Commission needs to establish a basin-wide network of automated monitoring stations equipped with advanced sensors for measuring water quality parameters (pH, dissolved oxygen, turbidity, heavy metals) and hydrological variables (discharge, water temperature, conductivity). These stations will transmit data in real-time to the central data hub using secure networks. Monthly sediment sampling should be conducted at strategic locations using USGS-approved protocols, with samples analyzed for particle size distribution and contaminant loading at regional laboratories. Ecological monitoring teams from the Wildlife Institute of India need to implement standardized protocols for aquatic biodiversity assessments, including quarterly dolphin population surveys using both visual census methods and acoustic monitoring equipment. All field data collection will follow strict chain-of-custody procedures to ensure data integrity, with 10% of samples subjected to blind duplicate analysis for quality control. A stratified random sampling framework shall be implemented to administer structured household surveys across the basin, ensuring proportional representation of all major stakeholder groups (farmers, fishers, urban residents, tribal communities).

The survey instrument has to be developed through an iterative participatory process, with questions tested and refined through focus groups in each sub-region. Trained enumerators will collect data using tablet-based applications with built-in logic checks and geotagging capabilities. The survey will capture water access and quality perceptions, adaptation strategies to water stress, trust in water institutions, and willingness to participate in conservation

programs. Industrial facilities will be required to complete detailed water use and discharge questionnaires, with responses cross-verified through unannounced site inspections. All collected data will undergo rigorous cleaning and validation before being incorporated into the central database.

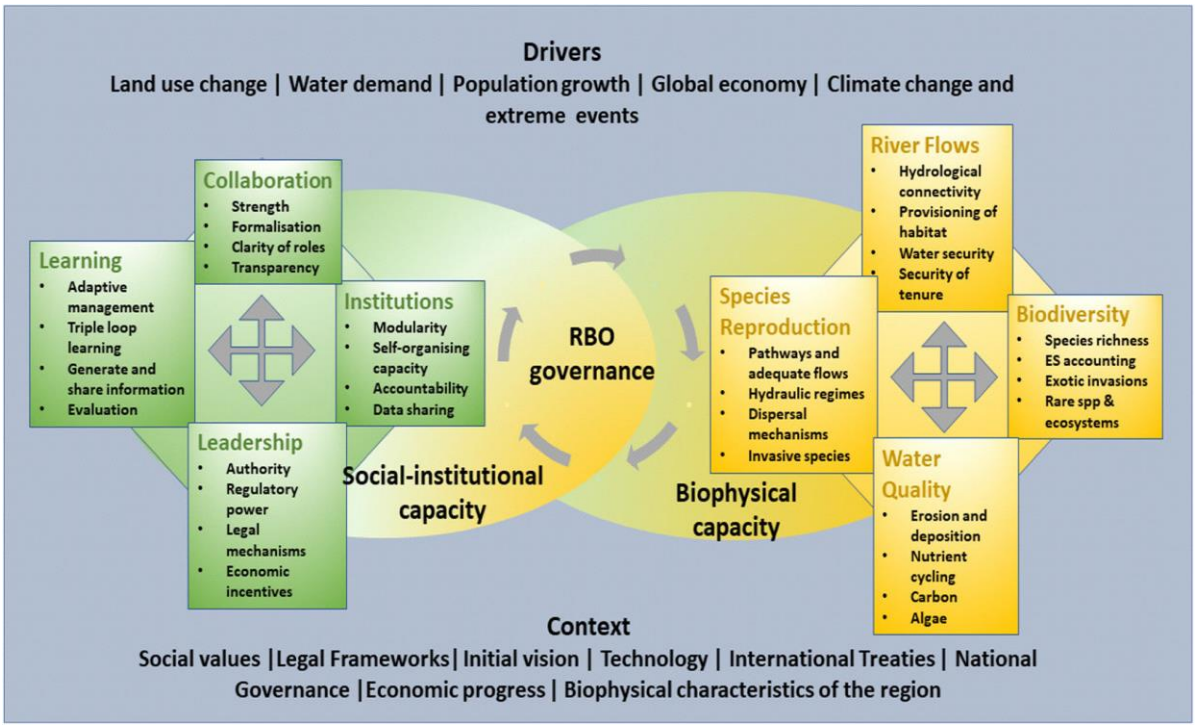

Fig. 7.1. Conceptual framework for river basin management (adopted from Bouckaert et al., 2018)

Operationalization of feedback mechanism can generate feedback outputs tailored to different user groups. A conceptual framework to assess the capacity of river basin governance and management adopted from Bouckaert et al. (2018) (Fig.7.1.) can also be tested for the regional basin wise management in India. For local communities, simplified River Health Report Cards can be produced quarterly, presenting key indicators through culturally appropriate visual formats (e.g., color-coded maps, pictorial representations). These will be disseminated through village meetings, local radio broadcasts, and mobile messaging platforms. For technical staff and policymakers, the system will generate automated anomaly alerts when parameters exceed predefined thresholds, accompanied by preliminary diagnostic analysis. Monthly technical briefs will synthesize emerging trends across monitoring domains, while annual State of the Basin reports will provide comprehensive assessments. Decision-support will need to be developed to allow stakeholders to simulate the potential impacts of management interventions before implementation.

Additionally, a multi-layered quality assurance system needs to be implemented to ensure data reliability. All monitoring equipment should undergo quarterly calibration against certified reference standards, with calibration records maintained in blockchain-secured logs. Field duplicate samples need to be analysed to quantify measurement precision, while certified reference materials will be used to assess accuracy. Community validation workshops shall be held biannually to review preliminary findings and incorporate local knowledge. An independent Technical Advisory Panel comprising experts from IITs, research institutes and

international institutions shall need to conduct annual audits of the entire monitoring system, assessing both data quality and operational effectiveness. Their recommendations will inform continuous improvement of protocols and procedures. The Godavari Basin Management Authority shall have to establish specialized working groups for each monitoring domain (hydrology, water quality, ecology, socio-economics), with representation from all stakeholder agencies. Annual training programs need to be conducted to build technical capacity across implementing institutions, covering standardized monitoring protocols, data analysis techniques, and maintenance of field equipment.

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