Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 47 No. 05
May 2024

Governance, Policy and Sustainability Evaluation of Yamuna Action Plan

Krish Shokeen[1*], Dr. Anil Kumar Haritash[2]

[1] M. Tech Student in Department of Environmental science and Engineering of Delhi Technological University, Delhi, India

[2] Professor, Department of Environmental science and Engineering of Delhi Technological University, Delhi, India

Abstract

The Yamuna River maintains its position as one of the most polluted water bodies in northern India despite multiple decades of intervention efforts. Recently, the Yamuna River has been subjected to heavy pollution loads caused by the discharge of untreated or partially treated wastewater and industrial effluents. This necessitates the need for managing the pollution caused in the rivers. So, the Yamuna Action Plan is initiated for the effective control of river pollution. The research evaluates Yamuna Action Plans YAP I–III through their policy design elements, their governance systems, and public–private partnership structures. The review uses data from the Central Pollution Control Board (CPCB 2024) and Delhi Pollution Control Committee (DPCC 2025) and academic research to demonstrate that sewage infrastructure development and technological advancements have increased substantially, yet weak governance and insufficient enforcement continue to block environmental restoration. The Delhi section of the Yamuna River maintains Biochemical Oxygen Demand levels exceeding 40 mg/L, which exceeds the required standards for bathing water quality. The paper supports three essential recommendations for Yamuna River sustainability through the establishment of basin-wide governance, performance-based funding, and permanent community engagement. From that, the significance of YAP, importance, and the plans for sustainable river pollution management are explored in this review.

Keywords: Yamuna Action Plan (YAP), Environmental Governance, Public-Private Partnerships, Sustainable River Management.

1. Introduction

Rivers have always been a source of life for civilisations. They are essential to support agriculture and urbanisation as well as culture (Pandey & Pandey 2013). Due to the rapid growth of urbanisation and advanced agricultural activities, rivers are significant in India. India has 14 major rivers that contribute to 85% of the total surface flow, and they signify vital environmental, historical, social, and economic aspects. Among that, the Yamuna River stands significant as it is responsible for over 90% of irrigation practices in India (Jaiswal et al., 2019). The Yamuna River starts from the Yamunotri glacier in Uttarakhand. After running approximately 1370 km, it meets the ocean with its tributary Ganga, at Prayagraj. It flows from the states of Himachal Pradesh, Haryana, Delhi, and Uttar Pradesh, and finally meets the Ganga in Allahabad at Prayagraj. This river sustains more than 50 million people over its course. For decades, rapid urbanization, industrial release, and poor sewage treatment have made this sacred river one of India's most polluted (CPCB 2024). The river receives almost 80 percent of its pollution load from untreated domestic sewage. Furthermore, the short Delhi segment, not exceeding 2 percent of the river's length, contributes almost 75 percent of the total contaminants (DPCC 2025). However, this pollution load from Delhi changes the COD from 70 mg/l at Palla to 430 mg/l at Okhla Barrage (Nehra and Singh, 2020).

Hence, the Government of India launched the Yamuna Action Plan in 1993 to address the crisis through Japanese Government funding from the Japan International Cooperation Agency (JICA). The initiative expanded into YAP II (2003) and YAP III (2015 onwards) under the NMCG. The different phases of the program worked to enhance sewage interception systems and treatment facilities and solid waste management and public education programs (MoEFCC 2018). The total investment of more than ₹5,000 crores has not led to better water quality (Rani & Kumar, 2020). There are still gaps between infrastructure growth and environmental restoration indicate that Indian urban river management faces multiple governance and policy challenges.

Therefore, this review explores the YAP, its significance, and Sustainable River Pollution Control schemes, policies, and governance strategies. Also, this review explores the challenges, legislative frameworks, and policies related to the YAP and its impact on people and the river. This review is undertaken due to the limited exploration of the YAP program, legislative framework, and the evolution of YAP and its impacts on the river Yamuna. Moreover, this review is significant because it highlights the significance and the impacts of the YAP and the government policies, which are underexplored in the existing studies. Along with this, the organizations and institutions helping with the YAP plans are also explored. However, some challenges and limitations in YAP still persist. Some of the challenges are improper governance, improper sewage control, etc..

2. Methodology of the Review

As defined by Singh & Kansal (2018), this review follows the systematic-thematic approach that corresponds with general standards followed by environmental policy journals. The methodology of this review has some stages: i) Literature review and Data Collection, ii) Article Selection Criteria, and iii) Analysis. This is done to effectively classify and select the articles for effective analysis and research. Moreover, the selection and eligibility of the articles are represented as a Preferred Reporting Items for Search Strategy and Meta Analyses (PRISMA) framework in Figure 1.

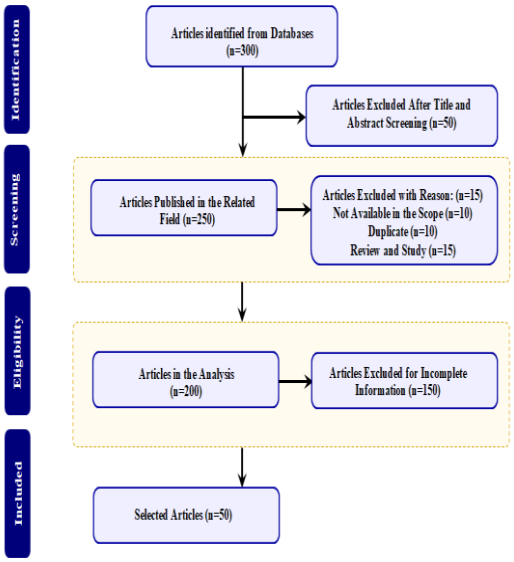

Figure 1: PRISMA Framework

Literature Review and Data Collection:

In this review, articles, journals, and reports from governmental agencies like CPCB 2024, DPCC 2025, MoEFCC 2018, NMCG 2024, and JICA progress documents and news updates from "The Indian Express" 2025 were used throughout the review.

Selection Criteria:

Studies that centered on either of the Yamuna Action Plans or other Indian river-cleaning projects, or dealt with policy, governance, or institutional mechanisms where there was empirical data on implementation, were included. Purely chemical or site-specific papers with no policy insight were excluded. Also, the literature from the significant databases like "Science Direct, Web of Science, IEEE, etc.," was selected between the years 2016 and 2026. Also, the keywords like "Yamuna Action Plan (YAP), Environmental Governance, Public–Private Partnerships, and Sustainable River Management" were used for the search strategy.

Analysis:

All data were qualitatively coded for emergent themes: policy design, governance gaps, stakeholder engagement, and sustainability. Additional reliability was provided in the reliability coding process effort due to utilizing multiple data sources. Trends expressed in older studies, for instance, were validated by using CPCB readings from 2024 and DPCC readings from 2025.

3. Policy and Governance Analysis

Policy Design and Objectives

The evolution of policy thinking reveals a gradual but steady broadening in scope from YAP I to YAP III. Policies and reports that address the socio-ecological condition are policy documents of the Central Pollution Control Board (CPCB), Delhi Development Authority (DDA), and Yamuna Monitoring Committee (Singhal and Gupta, 2024).

- **YAP I (1993-2003):** project-oriented, an end-of-pipe model focused on sewage-treatment infrastructure and pollution-load reduction (NRCD 2014)
- **YAP II (2003-2015):** introduced public awareness, solid-waste management, and non-point-source controls. There is recognition that technical solutions cannot reverse ecological decline (Rao & Singh 2015).

- **YAP III (2015-present):** Re-framed in the lens of NMCG and SDG 6 - as part of Integrated River Basin Management; with growing attention to re-use, efficiency, etc. Despite the maturity of this concept, policy fragmentation continues. For example, pollution abatement in Delhi is also undermined by untreated discharges from upstream industrial clusters in Haryana (DPCC 2025). The absence of a basin-wide coordination mechanism makes policies state-centric rather than ecosystem-centric.

The funding is erratic. For example, it was approximately 5 crore in 2019 and nearly ₹400 crore in 2021, which is impacting the continuity of project works (DJB 2024). The latest reforms include online dashboards of progress and third-party audits to enhance transparency. Nevertheless, the monitoring is still based on outputs - e.g., number of STPs built - rather than outcomes - actual improvement in water quality. Number of STPs built, rather than outcome-based, actual improvement in water quality. It was also found that the water quality of the river Yamuna was affected by agriculture as well as the discharge of various untreated water from sewage and industrial waste (Sharma et al., 2021).

Institutional Coordination and Administrative Mechanisms

several agencies: NMCG for planning, CPCB/SPCBs for regulation, and ULBs for operations. This sounds comprehensive on paper, but it actually brings about duplication and blurred accountability.

For instance, sewer infrastructure in Delhi comes under the purview of both DJB and PWD; this leads to a web of overlapping contracts with ensuing delays. CPCB and SPCBs sometimes release conflicting data on water quality because sampling protocols are not standardized. These regulating authorities, i.e., CPCB and DPCC, must monitor river water quality at regular intervals and pass the instructions to the concerned authorities appropriately. Thus, this concept can be replicated anywhere globally. However, the success of the interceptor sewer depends on the lateral coordination and cooperation of various Stakeholders (Tyagia et al., 2024). Though YAP III instituted PMUs at the national and state levels, there are still problems of coordination. Disbursal of funds is the policy and governance framework of the Yamuna Action Plans, which epitomizes how ambitious environmental programs go astray when institutional coordination and enforcement lag behind investment in infrastructure. Whereas major engineering milestones have been achieved under the YAPs, weak governance and fragmented accountability persist as binding constraints to outcomes (Singh & Kansal 2018; CPCB 2024).

Legislative and Regulatory Framework

YAPs have a legal basis in the Water (Prevention and Control of Pollution) Act 1974 and the Environment (Protection) Act 1986. These empower CPCB / SPCBs to set standards and prosecute non-compliance. The legislative frameworks included the implementation of sewage control laws, prohibiting sewage disposal in the sewerage, and the use of surveillance and sanctions. Despite the legislative framework and available technical facilities, water was still not provided to everyone in the city (Patel and Gautam, 2025). The NGT has ensured better enforcement since 2010 through 100 percent sewage treatment and effluent reuse orders. In 2023, the NGT directed that Okhla STP's treated water be used for horticulture and flow maintenance. (NMCG 2024). However, urges are fickle; only a small percentage are penalized for non-compliance, while litigations seem to stalemate compliance. There is a Ganga River Basin Authority, but there is no Yamuna River Basin Authority. No single body has been empowered so as to integrate land-use, industrial, and water-management decisions across the basin. The CPCB 2024 report shows that 23 of the 33 monitoring stations still fall under priority I–II with BOD > 40 mg/l. It is evident that the policy and legal measures are yet to show any tangible ecological recovery (CPCB 2024).

Governance Challenges and Accountability Gaps

Governance for water reuse is felt necessary in all water management-related deliberations across the world. In recent years, global transitions in water governance, including promotion of Integrated Water Resources Management (IWRM), river basin approaches, and inclusion of participation, are also reflected in the Indian government's policy (Chattopadhyay, 2018). Yamuna is still polluted after spending more than ₹5,000 crores (DPCC 2025). The main structural governance issues are.

1. Fragmented responsibility – different agencies for design, implementation, and monitoring cause weak ownership.

2. Financial discontinuity – O&M budgets left to under-funded municipalities reduce plant efficiency (Singh & Sharma 2016).
3. Low public engagement – awareness drives are sporadic; citizen participation in monitoring is minimal (MoEFCC 2018).
4. Upstream–downstream disconnect – untreated effluents from Haryana and Uttar Pradesh undermine Delhi's investments (CPCB 2024).

Experts are now telling us that basin governance should be integrated, and ring-fenced O&M financing should be provided to remedy this ongoing accountability gap. Further, the Policy and Governance Analysis related to the YAP is tabulated in Table 1

Table 1: Policy and Governance Analysis related to the YAP

Author	Duration/ Timeline	Policies	Governance	Findings					Challenges
				Regions Covered	BOD	Drains analysed	Coliform	Area	
(Singhal and Gupta, 2024)	5 Years	Water Policy, Rezoning Policy, Spatial Policy	National Institute of Urban Affairs, the Delhi Jal Board, and CPCB	Delhi	Nil	Nil	Nil	7.42%	DDA acquired large agricultural lands and the commons and "modernized" them.
(Sharma et al., 2021)	1999 to 2010	Climate Change Mitigation Policy	CPCB, CCME	Delhi	2.65 mg/L	22	Nil	3.25%	No standard frequency level.
(Tyagia et al., 2024)	2006 to 2021	Nil	CPCB, DPCC	Uttar Pradesh, Haryana, Madhya Pradesh	32 ppm to 11 ppm	45 to 50	2.4 107	8%	No adequate freshwater was left to maintain the ecological flow.
(Patel and Gautam, 2025)	2018 to 2024	Nil	CPCB, NGT	Haryana, Agra, Delhi	16mg/L	24	40 to 100 MPN/100 mL	Nil	Limited improvements were measurable through years of sustained improvements.
(Chattopadhyay, 2018)	1995 to 2011	UNICEF, NWP, CWFL	CPCB	Delhi	Nil	Nil	Nil	7%	Emissions from the diffuse sources could not be mentioned directly.
(Rao and Singh, 2015)	1990	National River Conservation Plan (NRCP)	CPCB	Haryana, Uttar Pradesh	3mg/L	Nil	550 MPN/100ml	7%	High water tarrifs
(Singh and Kansal, 2018)	1985-1993	NCRP, GAP	YAP	Bihar, West Bengal, Delhi	20 mg/L	Kanpur, Varanasi (major sewages)	100MPN/100 ml	6%	Insufficient data for analysis
(Singh and Sharma, 2018)	1993	Sewage Treatment Plants (STP)	Delhi Jal Board	Delhi, Agra, Haryana	Nil	43	Nil	8.7%	Limited focus on sector reforms

From the above table, it was found that governance and policies were involved in the water quality analysis and YAP. The research study (Tyagia et al., 2024) reported the highest BOD of 32 ppm to 11 ppm. Subsequently, the research study (Patel and Gautam, 2025) reported the BOD value of 16mg/L. However, the limited improvements were measurable through years of sustained improvement. Subsequently, in the research study (Sharma et al., 2021), the policies like CPCME and CCME were analysed. The results showed that it had a lower BOD with no standard frequency level.

4. Outcomes and Challenges

The Yamuna Action Plans (YAPs) span over a period of over three decades and are the longest and most active river restoration programme in India. The YAPs have achieved high infrastructural and institutional milestones with the support of the Japan International Cooperation Agency (JICA), coordinated by the National Mission for Clean Ganga (NMCG). Despite such funding, Yamuna is still one of the most contaminated rivers in India, especially in the Delhi section (CPCB 2024) (DPCC 2025).

Environmental and Technical Outcomes

Started with YAP I in 1993, sewage treatment capacity in the Yamuna basin grew to around 1,900MLD by 2024, as compared to its initial state of less than 300MLD. The refurbishment of large plants at Okhla, Kondli, and Rithala with 564MLD, 204MLD, and 182MLD capacities, respectively, using technology of Sequencing Batch Reactor (SBR) and Membrane Bioreactor (MBR), was undertaken by YAP alone and improved the treatment process and energy savings. Parameters were monitored in real-time by means of real-time monitoring systems installed at 33 locations on the river track and included Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), and Total Coliform. In spite of this advancement, the CPCB report in 2024 shows that BOD in the Yamuna segment in Delhi ranges between 3050mg L -1 and DO is more often under 2mg L -1, implying minimal biological activity. Therefore, grappling with substantial environmental challenges, paradoxically, witnesses an exacerbation of drainage and wastewater treatment issues alongside the rise in water supply and water-borne sanitation facilities. There has been significant evidence that decentralized systems are feasible on many fronts, encompassing socioeconomic, administrative, planning, technological, and environmental aspects, provided that shortcomings are diligently monitored (Ramadhan et al., 2024).

About 70-80 percent of the pollution load is taken up in the Wazirabad-Okhla stretch that covers about 2 percent. of the river length. The report has put this burden on untreated domestic wastewater. The city produces 3,400ml of sewage, with approximately 800-1000ml going untreated through incomplete sewer systems and poor performing STPs (DPCC 2025). Although the use of modern technologies and the provision of high-level monitoring have been implemented, the gap between the amount of sewage discharge and the treatment process is a fundamental ecological limitation. Periodic power cuts, poor maintenance, and uneven financing remain a hindrance to performance (Rani and Kumar 2020). Therefore, various measures should be adopted to ensure proper and efficient management of wastewater to avoid Yamuna River pollution. Some measures include: i) Waste water may be used in agriculture only if it is treated up to the tertiary level, and ii) A comprehensive treatment scheme needs to be envisioned for substantial removal of soluble and insoluble pollutants (Parween et al., 2017)

Institutional and Policy Outcomes

At an institutional level, the YAPs transformed the river-management system in India, which encouraged inter-agency cooperation between NRCD, the SPCBs, Urban Local Bodies (ULBs), and international collaborators. Project Management Units (PMUs) under YAP III professionalised the delivery of projects and facilitated the oversight by data (NMCG 2024). The adoption of Hybrid Annuity Models (HAM) and Public-Private Partnerships (PPP) also updated the wastewater governance. The performance-based contracts in the Okhla and Kondli STPs are currently based on payments that rely on effluent-quality standards (CPCB 2024). Furthermore, the YAPs have shaped national programmes, including Namami Gange (2014) and Swachh Bharat Mission (2015), hence enhancing the linkage of sanitation and river restoration (MoEFCC 2024). Nevertheless, amidst such policy benefits, it lacks a Yamuna Basin Authority to facilitate basin-wide coordination. Industrial effluents in Panipat and Sonipat (Haryana) and urban effluents in Mathura - Vrindavan (Uttar Pradesh) continue to affect the downstream water quality (DPCC 2025). So, emphasis has also been placed on strengthening institutional and organizational capacity for executing cost-effective capital works and operation and maintenance (O&M) activities (Deepika et al., 2017).

Socio-Economic and Community-Level Outcomes

The research study (Kumar, 2023) reported that the experiences of toxicity were embedded in the social, political, and economic context of the urban ecology of the Yamuna khaddar, such as the social relationships with the landowners, river, soil, and the city. This influences the social ecology of this space and vice versa in YAP. The YAPs also created job opportunities in the building and running of plants and community participation in sanitation efforts. The cheap toilets and sanitation units developed with YAP I and II enhanced hygiene in the informal settlements (NRCD 2014). YAP III reuse of treated water in industries and horticulture generated small-scale opportunities for a circular economy (NMCG 2024). However, there is a peripheral community involvement. According to the survey conducted in the city in 2025 by DPCC, 70 per cent of the residents of Delhi did not know anything about the goals of YAP, nor where the treatment plants are

located. Projects like Yamuna Mitra, in collaboration with NGOs like INTACH, have raised awareness of the locals, but these efforts are not large-scale (MoEFCC 2024). Failure to engage citizens on a continuous basis simply means that the environmental awareness efforts rarely result in behavioural change. As an example, solid waste and domestic effluent are illegally dumped along drains, including Najafgarh and Shahdara (DPCC 2025). This resulted in the negative correlation of DO with other parameters when there was an increase in the pollution (Kaur et al., 2021).

Challenges

In spite of infrastructure and institutional improvement, there are still some challenges that persist:

1. **Infrastructure-Operation Gap:** Sewage treatment plants are less efficient due to a lack of a complete sewerage network and inadequate operation and maintenance budgets, which leads to most of the units operating below 70 per cent (CAG 2013; DJB 2024).
2. **Financial Shortfalls:** There are a total of 23 drains discharging wastewater into the river Yamuna. Out of 23, a total of 16 drains are discharging wastewater in the river Yamuna between Wazirabad downstream to Okhla upstream, 04 drains meet the Yamuna in the downstream of Okhla Barrage, and 03 remaining drains discharge their wastewater further down at Agra Canal and Gurgaon Canal (Arif et al., 2020). So, while total investment exceeds 5,400 crore for analysing these drains, municipal authorities are faced with the problems of covering operation and maintenance, which is limiting the efficiency of the systems.
3. **Fragmented Governance:** PCB, SPCBs, and local authorities have overlaps that hinder coordinated execution and create a lack of accountability (Rao & Singh 2015).
4. **Weak Enforcement:** There are regulatory measures, but they are not enforced regularly, and penalties are seldom imposed, resulting in inconsistent compliance (NGT 2017). The research study (Karvouni, 2025) indicated that the pollution in the river was not managed properly due to weak law enforcement, a lack of environmental regulations, and the failure of the responsible authorities to locate specific polluting industries.
5. **Upstream-Downstream Disconnect:** Haryana and Uttar Pradesh contribute to the pollution of the inflows to Delhi by undermining the investment made in water purification in Delhi (CPCB 2024).
6. **Limited Public Awareness:** Even though various missions and NGO's initiative the awareness is still not as widespread among the population.
7. **Ecological Imbalance:** Overuse of water in irrigation dampens ecological flows, which prolongs foaming and eutrophication (Rani & Kumar 2020). Also, from the research study (Bhutiani et al., 2019), it was found that the discharge of industrial, sewage wastes, and agricultural runoff were major cause of ecological damage and posed serious health hazards. Hence, controlling water pollution is urgent for the ecological sustainability of water resources as well as for underlying economic reasons and human health.

Recent government initiative (NMCG 2025) emphasises the need for an Integrated Basin Management Strategy that combines governance reforms, technology upgrades, and community participation to overcome these challenges.

5. Conclusion and Policy Recommendations

One of the biggest and most ambitious projects in the area of environmental governance and international cooperation in India is the Yamuna Action Plans (YAP I, II, and III). As a conceptualization of the National River Conservation Plan and with financial assistance from the Japan International Cooperation Agency, the YAPs have produced significant wastewater infrastructural advancements, policy learning, and governance capacity. Starting with a treatment capacity of less than 300MLD in 1993, the total capacity has since reached over 1,900 MLD (NMCG 2024). The Okhla (564-MLD) and Kondli (204-MLD) sewage treatment installations use the modern technologies of the Sequencing Batch Reactor (SBR) and Anaerobic Digester (DJB 2024). However, in the presence of these technological and institutional improvements, the Yamuna still records high levels of critical pollution, especially the 22-km stretch of the Yamuna in Delhi, where almost 80 percent of the total pollution is recorded (CPCB 2024).

Policy Recommendations

Based on the three decades of operation, the following strategies are put forward in an effort to realize true and long-term rejuvenation of the rivers:

1. **Establish a Statutory Authority**: A legally mandated body should be appointed under the Ministry of Jal Shakti for the Yamuna basin to provide a legally binding framework to manage the critical water issues. This authority incorporates various schemes like basin-wide planning, equitable water allocation, and water pollution control schemes. These schemes can establish a transparent repository of flow and quality metrics, enabling evidence-based decisions. Hence, these policy harmonisations under the Ministry of Jal Shakti coordinate interstate planning and data sharing across the Yamuna basin (NMCG 2025).
2. **Adopt Basin-Scale Integrated Management:** The present morphology of the Yamuna basin in the Garhwal Himalaya, India, is a result of continuing crustal deformation, erosion, and deposition in the area with active tectonics influencing the topography and drainage. The drainage systems and geomorphic expression of topography have been significantly influenced by the active tectonics in this Yamuna basin (Gahlaut et al., 2021). So, an integrated basin management approach is essential to address the impacts of urban sewage, industrial effluents, and agricultural runoffs.
3. **Ensure Sustainable Financing and O&M Support:** A performance-linked funding model should be introduced to deliver substantial outcomes rather than just the infrastructure, where the central grants are tied to water-quality outcomes. These approaches enhance accountability and ensure long-term effectiveness. Additionally, prompting the treated-water reuse markets can generate a revenue system to cover O&M costs. In conclusion, these measures promote efficiency, resilience, and self-resilience in the basin management (DJB 2024).
4. **Expand Long-Term PPP Frameworks**: The long term PPP frameworks can be expanded through the standardized Hybrid Annuity Model (HAM) contracts to transform the Yamuna basin management. In Yamuna basin management, HAM combines government support with private investments, ensuring risk-sharing and financial sustainability. These mandatory transparency audits strengthen accountability, public trust, and the prevention of fund misuse. This enhances development impacts through wide-ranging partnerships and co-creation with development partners through the promotion of the JICA Global Agenda (JICA 2024).
5. **Institutionalise Community Monitoring:** Establishing the ward-level watch communities empowers local residents to track pollution sources, report violations, and participate in the conservation efforts. This decentralised model builds accountability, which ensures community-driven interventions. Integrating this environmental education into the school syllabus promotes awareness among the younger generations, thereby improving the sense of ownership and responsibility towards the river's health (DPCC 2025).
6. **Incorporate Nature-Based Solutions (NBS):** Engineer interventions on constructed wetlands, restoration of riparian vegetation, and bio-remediation to improve the self-purification of the river (Rani and Kumar 2020). Moreover, a combination of decentralized and in-situ treatment systems can be planned through Nature based Solutions. This will help to tackle the issue of wastewater generation-treatment gap in a way that urban farming is practised on the river banks (Srivastava et al., 2023). The DRRWG recognizes the importance of Nature-based Solutions and Ecosystem-based Approaches for Disaster Risk Reduction and aims to generate and collate a robust evidence base (including cost-benefit analyses) for the effective implementation of these approaches (Satsangi, 2024).
7. **Strengthen Legal and Regulatory Oversight**: The implementation of compliance regarding the Yamuna water management follows the Water Act (1974) and the Environment Protection Act (1986). The CPCB informs that the damage assessment due to non-compliance with the directions of the tribunal is being done in consultation with all the stakeholders after assessing the level of non-compliance and the continuing pollution of the Yamuna River through the obedience of the National Green Tribunal (NGT) (NGT 2017).

8. **Adopt Global Best Practices**: Adopt lessons learned with the Thames (UK), Rhine (Europe), and Cheonggyecheon (South Korea) rivers restorations that show how adaptive governance, cross-sectoral integration, and inclusion of the general population work (Singh and Kansal 2018). With the help of these ventures, the government could seek to inspire its own constituencies, NGOs, other companies, and customers in the region to shape the social environment of which they are a part. In doing so, this opens up new frontiers for positive social change (Mulloth and Rao, 2018).

In conclusion, the future of rejuvenation of the Yamuna lies in technological innovation in a system along with support in governance, economic sustainability, and civic accountability. The restoration of the river is not just an environmental project but also a challenge to India to put sustainable development into practice.

References

[1] Arif, M., Kumar, R., & Parveen, S. (2020). Reduction in Water Pollution in Yamuna River Due to Lockdown Under COVID-19 Pandemic. International Journal of Chemical Studies, 1–15. https://doi.org/10.26434/chemrxiv.12440525.v1

[2] Bhutiani, R., Khanna, D. R., Kumar, R., Ram, K., Ahamad, F., Science, E., & Vishwavidyalaya, K. (2019). Impact Assessment of Sewage Treatment Plants' Effluent Discharge on The Quality of Ganga River at Haridwar, Uttarakhand. Journal of Mountain Research, 14(2), 77–83. https://rakeshbhutiani.in/wp-content/uploads/National Publications/Publications/1.pdf

[3] Central Pollution Control Board (CPCB). (2024). Status of Water Quality in India: Monitoring Results of Yamuna River (2023–2024). Ministry of Environment, Forest and Climate Change, Government of India.

[4] Chattopadhyay, S. (2018). Challenges of water governance in the context of water quality problem : Comparative study of India, Indonesia and Germany. Transactions, 40(2), 171–183. https://iigeo.org/IIG journals Vol 36 year 2014 to 46 year 2024/vol 40-2/2-Challenges-of-water-governance-in-the-context-of-water-quality-problem-Comparative-study-of-India-Indonesia-and-Germany.pdf

[5] Comptroller and Auditor General of India (CAG). (2013). Performance Audit on Conservation of Rivers (Including Yamuna, Ganga, and Others): Report No. 21 of 2013. Government of India, New Delhi.

[6] Deepika, Kumar, R., & McMasters, F. (2017). Planning and Design of Sewerage Infrastructure for a Congested Area in Delhi: A Case Study Towards Pollution Abatement in River Yamuna. Pipelines, 249–260. https://ascelibrary.org/doi/abs/10.1061/9780784480878.024

[7] Delhi Jal Board (DJB). (2024). Budget and Annual Reports: Water and Sewage Treatment Performance 2023–24. Government of NCT of Delhi.

[8] Delhi Pollution Control Committee (DPCC). (2025). Annual Report on Water Quality Monitoring of River Yamuna (2024–2025). Government of NCT of Delhi.

[9] Gahlaut, P., Patel, R. C., Ayyamperumal, R., Sati, M., & Nainwal, D. C. (2021). Assessment of Recent Tectonic Activity along the Yamuna Basin, Garhwal Region, NW-Himalaya, India: Based on Morphotectonic Analysis. Open Journal of Geology, 11, 734–755. https://doi.org/10.4236/ojg.2021.1112036

[10] Gosain, A. K., & Sharma, D. (2008). Development of River Water Quality Management Plan Using Qual2E Simulation Model: Yamuna River, India. Environmental Monitoring and Assessment, 144(1–3), 143–154.

[11] India–Japan Cooperation Office (JICA). (2019). Yamuna Action Plan Phase III: Progress and Impact Evaluation Report. Japan International Cooperation Agency, New Delhi.

[12] Jaiswal, M., Hussain, J., Gupta, S. K., Nasr, M., & Nema, A. K. (2019). Comprehensive evaluation of water quality status for entire stretch of Yamuna River, India. Environmental Monitoring and Assessment, 191, 1–17. https://doi.org/10.1007/s10661-019-7312-8

[13] Japan International Cooperation Agency (JICA). (2024). Urban Water Reuse and Sewage Management in Delhi: YAP III Technical Evaluation Update. Tokyo: JICA Research Department.

[14] Kandula, S. N. (2018). Journal of Governance & Public Policy. Institute of Public Enterprise, 8(2), 1–120. https://www.researchgate.net/publication/353417136_A_Study_on_Growth_of_Capital_Adequacy_Profitability_and_Liquidity_Analysis_of_Indian_Public_and_Private_Sector_Banks_in_the_Post_Financial_Crises_Period

[15] Karvouni, R. (2025). Limiting the Consequences of the Recovery of Polluted Rivers in Megacities. The American College of Greece Model United Nations, 1–26. https://www.acgmun.gr/wp-content/uploads/2025/03/EC.1.RK_.pdf

[16] Kaur, H., Shashi, Warren, A., & Kamra, K. (2021). Spatial variation in ciliate communities with respect to water quality in the Delhi NCR stretch of River Yamuna, India. European Journal of Protistology, 79, 125793. https://doi.org/10.1016/j.ejop.2021.125793

[17] Kumar, R. (2023). Political Ecology of Urban Agricultural Pollution: Cultivating the Yamuna Floodplains in Delhi. Ecology, Economy, and Society–the INSEE Journal, 6(2), 237–252. https://doi.org/10.37773/ees.v6i2.1052

[18] Kumar, R., Deepika, & McMasters, F. (2017). River Rejuvenation along Heritage Site: Drainage and Sewerage Infrastructure Condition Assessment, Planning, Design, and Upgradation. Pipelines, 213–225. https://ascelibrary.org/doi/abs/10.1061/9780784480885.021

[19] Kumari, S., & Biswas, R. (2022). Decoding Delhi' s water governance through multi-level governance approach. H2Open Journal, 5(4), 1–13. https://doi.org/10.2166/h2oj.2022.048

[20] Lokhande, S., & Tare, V. (2021). Spatio-temporal trends in the flow and water quality: response of river Yamuna to urbanization. Environmental Monitoring and Assessment, 193, 1–14. https://doi.org/10.1007/s10661-021-08873-x

[21] Ministry of Environment, Forest and Climate Change (MoEFCC). (2018). Compendium of River Cleaning Projects in India: Lessons from Yamuna and Ganga Action Plans. Government of India.

[22] Ministry of Environment, Forest and Climate Change (MoEFCC). (2024). National River Conservation Plan Progress Report 2023–24. Government of India, New Delhi.

[23] Ministry of Jal Shakti. (2024). National Mission for Clean Ganga (NMCG): Monthly Progress Report (Delhi – May 2024). Government of India.

[24] Mulloth, B., & Rao, B. (2018). Revitalizing the Yamuna River: Social Entrepreneurship Approaches. 2018 Proceedings of PICMET '18: Technology Management for Interconnected World, 1–9. https://doi.org/10.23919/PICMET.2018.8481862

[25] National Green Tribunal (NGT). (2017). Order in O.A. No. 6/2012: Manoj Mishra v. Union of India & Ors. (Yamuna Pollution Case). National Green Tribunal, New Delhi.

[26] National Mission for Clean Ganga (NMCG). (2024). Delhi Sewerage and Yamuna River Rejuvenation: Project Status and Data Dashboard. Ministry of Jal Shakti, Government of India.

[27] National Mission for Clean Ganga (NMCG). (2025). Integrated Basin Management Policy Proposal for the Yamuna River. Ministry of Jal Shakti, New Delhi.

[28] National River Conservation Directorate (NRCD). (2014). Achievements and Challenges under Yamuna Action Plan Phases I & II. Ministry of Environment and Forests, Government of India.

[29] Nehra, V., & Singh, S. K. (2020). Assessment of water quality of Najafgarh drain and its impact on river Yamuna. International Conference of Advance Research and Innovation (ICARI), 1–4. https://dx.doi.org/10.2139/ssrn.3577270

[30] Pandey, J., & Pandey, R. (2013). Impact of Urbanization and Industrialization on River Yamuna Water Quality in Delhi, India. Journal of Environmental Sciences, 25(3), 575–586.

[31] Parween, M., Ramanathan, A. L., & Raju, N. J. (2017). Waste water management and water quality of river Yamuna in the megacity of Delhi. International Journal of Environmental Science and Technology, 1-16. https://doi.org/10.1007/s13762-017-1280-8

[32] Patel, S., & Gautam, B. (2025). Urbanisation and Environmental Degradation: A Geographical Perspective on Yamuna River Pollution in NCT Delhi. International Journal of Leading Research Publication (IJLRP), 6(11), 1–6. https://www.ijlrp.com/papers/2025/11/1846.pdf

[33] Ramadhan, A. J., Yadav, S., Anand, S., Singh, A. P., Atta, K., Abotaleb, M., Alkattan, H., & Albadran, Z. (2024). Assessment of Municipal and Industrial Wastewater Impact on Yamuna River Water Quality in Delhi. BIO Web of Conferences, 97, 1–14. https://doi.org/10.1051/bioconf/20249700124

[34] Rani, M., & Kumar, R. (2020). Assessment of Spatio-Temporal Variations in Water Quality of River Yamuna Using Multivariate Analysis. Environmental Monitoring and Assessment, 192(2), 125.

[35] Rao, P. G., & Singh, S. (2015). Governance and Institutional Challenges in India's River Rejuvenation Programmes: The Case of the Yamuna Action Plan. International Journal of Water Resources Development, 31(4), 687–702.

[36] Said, S., & Hussain, A. (2019). Pollution mapping of Yamuna River segment passing through Delhi using high-resolution GeoEye-2 imagery. Applied Water Science, 9(3), 1-8. https://doi.org/10.1007/s13201-019-0923-y

[37] Samui, S., Mallik, A., Kumar, D., Rao, S., Dhanya, C. T., & Gosain, A. K. (2025). Identifying the pollution sources of River Yamuna through B eld observations and participatory approach. Journal

of Earth System Science, 134, 1–15. https://doi.org/10.1007/s12040-024-02498-7

[38] Satsangi, P. S. (2024). Restoration/Rejuvenation of ater in the River Yamuna, Agra. Journal of Systems Science and Engineering, 28(1), 1–94. https://www.dei.ac.in/dei/edei/files/2024/Paritantra Jan 2024 V3_1.pdf

[39] Sharma, B., Ram, S., & Vyas, S. (2025). Characterization of Yamuna River water quality and its remediation by Phytoremediation technique. South African Journal of Chemical Engineering, 53, 49–59. https://doi.org/10.1016/j.sajce.2025.04.006

[40] Sharma, B., Ram, S., & Vyas, S. (2025a). Evaluation of water quality of Yamuna River: A study conducted on Delhi Stretch using CCME WQI and HACA methods. IOP Conf. Series: Earth and Environmental Science, 1489. https://doi.org/10.1088/1755-1315/1489/1/012008

[41] Sharma, V. R., Bisht, K., Sanu, S. K., Arora, K., & Rajput, S. (2021). Appraisal of Urban Growth Dynamics and Water Quality Assessment along River Yamuna in Delhi, India. Journal of Indian Water Works Association, 1–10. https://www.researchgate.net/profile/Shubham-Sanu/publication/357419885_Appraisal_of_Urban_Growth_Dynamics_and_Water_Quality_Assessment_along_River_Yamuna_in_Delhi_India/links/61cd791ed450060816789528/Appraisal-of-Urban-Growth-Dynamics-and-Water-Quality-Assessment-along-River-Yamuna-in-Delhi-India.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail&_rtd=e30%3D

[42] Singh, G., & Kansal, M. L. (2018). Comparative Evaluation of River Action Plans in India: A Case Study of Yamuna and Ganga. Water Policy, 20(3), 479–494.

[43] Singh, R. P., & Sharma, M. (2016). Urban Wastewater Management and River Pollution in Delhi: Evaluating Yamuna Action Plan Outcomes. Environmental Policy and Governance, 26(5), 432–445.

[44] Singhal, S., & Gupta, M. (2024). Critically analyzing nature-based solutions: A political ecology framework of planning for the Yamuna River floodplains, Delhi. Journal of Urban Affairs, 1–21. https://doi.org/10.1080/07352166.2024.2413587

[45] Srivastava, A., & Prathna, T. C. (2022). Yamuna Action Plan-III: Impact on Water Quality of River Yamuna,. Fine Chemical Engineering, 3(1), 1–10. https://wiserpub.com/uploads/1/20211112/a8558b4d143bb818037e2c56335a3ad3.pdf

[46] Srivastava, R., Malhotra, R., & Sachdeva, R. (2023). Wastewater Pollution, Declining River Water Quality, and Its Socio-Economic Impact in NCT of Delhi. Urban India, 43, 179–204. https://gyanganga.ai/admin/fileupload/STC/RUP AL SRIVASTAVA_Declining River water quality, NCT DELHI.pdf

[47] The Indian Express. (2025). Yamuna Pollution Worsens: Bacteria Levels and BOD Fluctuations Raise Alarm. The Indian Express

[48] Times of India. (2025, April 12). Delhi Spent Over Rs 1,500 Crore on Yamuna Cleaning, But Water Still Toxic. Times News Network.

[49] Tyagia, R. S., Singha, S. K., & Goyal, P. K. (2024). Interceptor sewer for abatement of pollution in surface water. Water Practice & Technology, 19(2), 532–545. https://doi.org/10.2166/wpt.2024.005

[50] Yamuna Monitoring Committee (YMC). (2022). Report on Implementation of NGT Directives for Rejuvenation of River Yamuna. National Green Tribunal, New Delhi. Yamuna Monitoring Committee (YMC)