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INTEGRATED TECHNICAL AND ADMINISTRATIVE FRAMEWORK FOR YAMUNA RIVER REJUVENATION: PRESENT INTERVENTIONS AND FUTURE ROADMAP

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ABSTRACT

The Yamuna River, a major tributary of the Ganga in India, is in bad shape. Years of dumping untreated sewage, toxic industrial waste, piles of trash, and runoff from farms have pushed it to the brink. There's barely any fresh water left flowing through, which just makes things worse. Authorities have rolled out big projects like the Yamuna Action Plan (YAP-I, II, III) and the Namami Gange Programme, but the stretch of river running through Delhi is still dangerously polluted. This research paper lays out a real plan to turn things around. It brings together the latest wastewater treatment tech, real-time monitoring, ecological restoration, and serious changes in how the river is managed. There's also a clear roadmap for the future—complete with system-level block diagrams—focused on keeping the Yamuna healthy for good.

KEYWORDS: Yamuna River, River Rejuvenation, Sewage Treatment Plant (STP), Environmental Flow, Governance, Water Quality Management.

INTRODUCTION

The Yamuna River is a lifeline for over 57 million people living across Uttarakhand, Haryana, Delhi, and Uttar Pradesh. It's pretty shocking—Delhi's stretch covers just about 2% of the river, only 22 kilometers or so, but dumps in nearly 70 to 80% of all the river's pollution. The Central Pollution Control Board says Delhi churns out more than 3,300 million liters of sewage every single day. Treatment plants can't keep up, so a huge amount of

untreated or half-treated sewage just gets dumped straight into the Yamuna. Most of the pollution—over 75% of the biochemical oxygen demand—comes from domestic sewage. The rest? That's from factories, stormwater drains, solid waste, and farm runoff flowing in from upstream. As Delhi's population shot past 16 million, with rapid urban growth and people taking over the floodplains, the river's ability to clean itself has really taken a hit. People have tried to fix this for years—big projects like the Yamuna Action Plan and the Namami Gange Program—but the results just aren't there. Key water quality measures like dissolved oxygen and BOD are still way out of line with what's considered safe. The real problem is clear: building more treatment plants and pipes isn't enough. Without better coordination, real-time monitoring, and leaders who actually take responsibility, the river's not going to recover.

Sources of Pollution in the Yamuna River

Point Sources

Point sources are the biggest and easiest-to-spot polluters in the Yamuna River, especially through Delhi. Most of the problem comes from city sewage—about 70–75% of all pollution starts there. Huge amounts of wastewater from homes, shops, and offices pour into the river, often barely treated or not treated at all. Why? Not enough sewer lines, overloaded treatment plants, and sloppy operations. Then there's the industrial side, mostly small and medium businesses—think electroplating, dyeing, food processing, and chemical factories. They dump heavy metals, oils, and other nasty stuff into the water. Even though big factories follow the rules, smaller ones often don't. You've also got over 20 big drains, like the Najafgarh and Shahdara drains, dumping straight into the Yamuna. These drains bring in the worst loads—high levels of biochemical oxygen demand (BOD) and fecal coliforms—making this stretch through Delhi the most polluted.

Non-Point Sources

Non-point sources just make things worse, and they're much harder to track or control. Upstream farms wash fertilizers, pesticides, and soil into the river, which causes algae blooms and chokes the water. People toss trash—plastic, building rubble, regular household waste—onto the riverbanks, which blocks the flow and ruins the scenery. Religious festivals and rituals add to the mess: idol immersions, mass bathing, flowers, and tons of non-biodegradable stuff all pile up, especially during festival season, causing pollution spikes.

Review of Existing Administrative and Policy Framework

For over thirty years, governments—both at the center and in the states—have launched a bunch of policies and programs to clean up the Yamuna. They've managed to build some infrastructure and put rules in place, but real progress keeps getting stalled by agencies working in silos, weak enforcement, and a lack of accountability.

Yamuna Action Plan (YAP-I, II, III):

The idea sounded solid—outside funding went into building sewage treatment plants, laying new sewer lines, and setting up pumping stations across the big cities. On paper, YAP increased treatment capacity. But in real life, a lot of these new systems just sat there, underused or neglected. Poor maintenance, slow work connecting neighborhoods to the network, and a bunch of other issues meant raw sewage still kept flowing into the river.

Namami Gange Programme:

This one took a step back and looked at the bigger picture, treating the Yamuna as just one part of the whole Ganga river system. It introduced the Hybrid Annuity Model (HAM), so companies would actually get paid for keeping treatment plants running well over time. In theory, that should work. But, honestly, things got tangled. Different agencies couldn't get on the same page, projects kept missing deadlines, and, in the end, water quality barely changed.

National Green Tribunal (NGT):

The NGT keeps pushing—setting deadlines, handing out fines, demanding real action. But on the ground? It's all pretty uneven. There just aren't enough people or resources to make sure any of it actually happens.

CPCB and SPCBs:

These agencies are supposed to keep an eye on things and make sure everyone follows the rules. In reality, they're understaffed, they can't use real-time data the way they need to, and honestly, they just don't have the authority to make anyone listen.

Gap Identified: There are too many agencies, not enough muscle, and nobody faces real consequences when things go wrong. That's why any real effort to clean up the Yamuna keeps stalling.

Technical Interventions for Yamuna Rejuvenation

If we want to bring the Yamuna back to life, we need solid, reliable technology—stuff that

actually works, not just on paper, but out in the real world. It has to tackle pollution from the source, through treatment, all the way to discharge.

Sewage and Wastewater Management

Upgrading the old sewage treatment plants to tertiary-level is a must if we want to meet tougher discharge rules. Advanced systems like Membrane Bioreactor (MBR), Moving Bed Biofilm Reactor (MBBR), and Sequencing Batch Reactor (SBR) can pull out a lot more BOD, nutrients, and germs. But central plants aren't the whole answer. In unsewered colonies and the outskirts, we need Decentralized Wastewater Treatment Systems (DEWATS) to pick up the slack. Those massive drains dumping raw sewage into the Yamuna? We have to intercept and reroute them— now—before they make things worse.

Industrial Effluent Control

Industries that pollute the most? They need to stick to Zero Liquid Discharge (ZLD) rules, no exceptions. And let's be real, the Common Effluent Treatment Plants (CETPs) need a serious upgrade, especially since they're dealing with a mix of waste from all sorts of small factories. When we connect Online Continuous Effluent Monitoring Systems (OCEMS), we can actually see what's going on, the moment it happens, and step in as soon as someone tries to break the rules.

Solid Waste and Sludge Management

Letting sewage sludge pile up isn't an option. We need to treat it properly—whether that's co-processing, composting, or turning it into energy—so we don't create even bigger problems down the road. Stopping people from dumping plastic and construction waste along the riverbanks is just as important if we want to keep the river flowing and healthy.

Environmental Flow (E-Flow) Restoration

The Yamuna needs a guaranteed minimum flow from upstream barrages, or it won't have a chance to clean itself. On top of that, reusing treated wastewater—whether for industry, landscaping, or cooling—cuts down on how much fresh water we pull from the river, helping restore its flow.

Administrative and Governance Reforms

Technical fixes alone won't cut it—you need strong governance and real institutional change if you want lasting results.

- Set up a Unified Yamuna River Authority (UYRA). Give this group the power to plan, get things done, keep an eye on progress, and work across state lines—no more scattered efforts.
- Make contracts with STP operators performance based. Tie their payments to how well they treat wastewater and run their plants. That way, they're actually accountable.
- Share water quality data in real time. Put it out there on digital dashboards so anyone can see what's happening with the river. It keeps things honest.
- Build up urban local bodies. Give them better tools, more funding, and train their people so they're ready to handle the job.
- Get the community involved. Encourage people to take care of the river, set up programs where citizens help monitor, and spread the word so everyone understands why the Yamuna needs protecting for the long haul.

System-Level Block Diagram (Proposed Integrated Model)

Figure1: Integrated Technical–Administrative Framework for Yamuna Rejuvenation

Proposed Future Roadmap for Yamuna Rejuvenation (2025–2040)

Fixing the Yamuna is not a weekend affair. It takes years with a solid plan and real change of heart. Pollution has to be stopped; restoring the river's natural flow, making sure that these improvements actually last. In simple words: upgrade the basics—think better sewage systems and treatment plants. Get serious about reviving the river's own ecosystem. And don't shy away from using smart tech to keep things on track.

Phase I (2025–2030): Stabilization

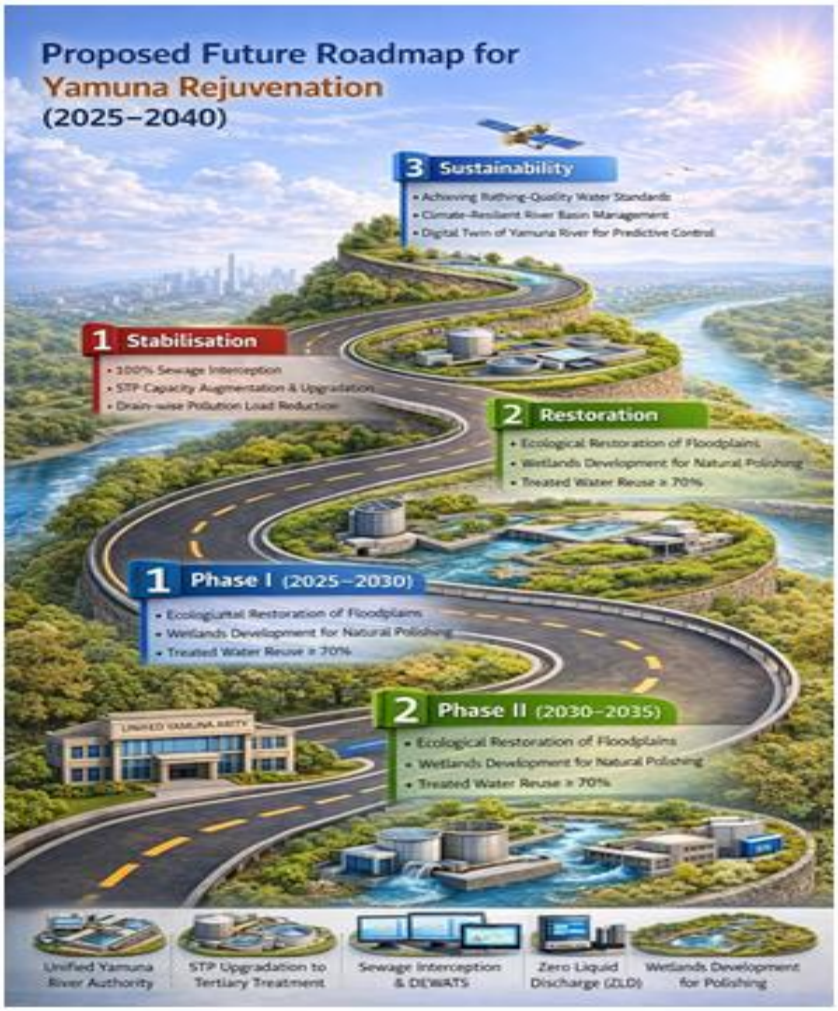
Begin by stopping damage. Not a single drop of sewage shall be allowed to flow into the Yamuna until captured and treated. This involves achieving full coverage of the area with sewers, intercepting all major drains, and upgrading old treatment plants so they can actually function properly. Teams will identify every drain and focus on the main polluters to reduce things like BOD and bacteria. By 2030, throwing raw sewage into the river? That's over.

Phase II (2030–2035): Restoration

After ensuring pollution is under control, we can do the restoration of the river. The eviction of informal settlers along the banks of a river constitutes part of floodplains management wherein native trees and plants help in bringing back natural areas along rivers. Part of this includes wetlands and oxidation ponds since water gets another round of treatment through nature itself. Not less than 70% of this water is reused for industrial uses or irrigation purposes replacing the use of potable water such that even during dry seasons the river still has flow maintained.

Phase III (2035–2040): Sustainability

Now the focus is on actually keeping the Yamuna clean, not just tidying it up once and walking away. The real aim? People should be able to swim in the stretch that runs through Delhi, not just stare at it from the banks. So, river management has to get smarter. That means handling crazy weather, sudden floods, or dry spells when water runs low upstream. With things like a digital twin of the river, teams can spot trouble early, act fast, and stop new pollution before it even starts. Stick with this approach, and the Yamuna stays healthy year after year—for everyone who relies on it.



Gap Study: Present Ground-Level Reality vs. Rejuvenation Objectives

The Yamuna River's condition through Delhi still looks grim, no matter how many programs or how much money gets thrown at it. On paper, Delhi's sewage treatment plants can handle over 3,600 million liters a day, but about 700–800 million liters still flow out untreated or only half- treated. Why? The city's sewer network is patchy, plants get overloaded, and things break down way too often. Even when sewage does reach a treatment plant, a lot of them don't hit the required standards for BOD and fecal coliform. So, pollution just keeps pouring into the river. Then there's the problem with drains. The big ones—Najafgarh and Shahdara—dump more than 60% of Delhi's pollution into the Yamuna. Their wastewater is loaded, mainly because of poor interception, illegal hookups, and shoddy maintenance. Industrial waste is another headache. Small factories, especially informal ones, pretty much fly under the radar, and rules like Zero Liquid Discharge barely make a dent. Administratively, it's a mess. Too many agencies—DJB, ULBs, DPCC, CPCB, irrigation, and development authorities—all have a piece of the pie, but nobody really owns the

problem. This splits accountability and slows everything down. Monitoring systems just check boxes for compliance; they don't focus on real outcomes. Hardly anyone uses real-time data to fix issues on the fly. And good luck finding up-to-date water quality info—public access is still lacking, which means there's little transparency or community pushback. On the ecological side, the floodplains are still encroached, the connection between groundwater and river gets ignored, and releases of environmental flows from upstream are all over the place. So, what's really missing? Not plans or technology—those exist. It's about how things actually get done: better execution, agencies working together, real accountability, and sticking with operations and maintenance for the long haul. Until that happens, the river won't see much of a turn around.

Expected Outcomes

Policy Recommendations for Yamuna Rejuvenation

A. Recommendations for Delhi Government

1. Connect Every Home to the Sewer—and Make Sure It Works

Don't just lay pipes and move on. Every home, even in unauthorized colonies and outskirts, needs to hook up to the main sewer. Set real deadlines and actually stick to them. Once that's done, check if the sewage treatment plants are really working. Go out, run solid audits—don't just push papers around.

2. Pay STP Operators for Results, Not Just Infrastructure

Tie STP operator payments and drain agency contracts to real water quality numbers—BOD, COD, faecal coliform, all of it. If the water quality drops, so does their paycheck. Clean water is the goal, not just fancy new buildings.

3. Fix Drains One at a Time

Pick big drains like Najafgarh and Shahdara and go all in. Stop the dirty water before it reaches the river, use in-situ treatment, and keep tracking the numbers. Don't scatter effort everywhere— focus on one drain at a time until it's sorted.

4. Make Local Bodies and DPCC Stronger

Urban Local Bodies and the Delhi Pollution Control Committee need more muscle. Hire more people, train them properly, and give them up-to-date digital tools so they can actually monitor and enforce the rules.

5. Push for Treated Wastewater Reuse

Set strict targets for industries, construction, and landscaping to switch to treated wastewater. The less fresh water we pull, the better the Yamuna gets**.**

B. Recommendations for Central Government

1. Establish a Unified Yamuna River Authority (UYRA)

Stop just talking about it—set up a real authority with legal power to manage the entire Yamuna basin. Get all the states on board, pool the money, and focus on what actually helps the river, not more endless meetings.

2. Assure Environmental Flows (E-Flows)

Lock in minimum flows for upstream barrages, and write it into law. The river needs a fair share every season, no excuses.

3. Integrate Yamuna under Outcome-Oriented River Basin Governance

Big schemes like Namami Gange, AMRUT, SBM, and industrial policies need to focus on actual river health. Judge success by cleaner water, not just by counting new projects.

4. Scale Digital Governance and Real-Time Monitoring

Roll out more sensors, go online with monitoring, and build a national data portal. This way, everyone can spot problems early and fix them fast.

5. Incentivise State Performance

Put real money behind states that actually clean up the river, reuse water, and keep things running well. Progress should get rewarded—simple as that.

Overall, Policy Direction:

Big picture: We need to move away from scattered, project-based fixes and start managing the Yamuna at the basin level. That means focusing on real outcomes and holding institutions responsible, with decisions grounded in solid data. It's the only way we'll see lasting change for the river.

CONCLUSION AND REMARKS

Fixing the Yamuna River—especially the stretch running through Delhi—takes more than just building new treatment plants or writing stricter rules. Yes, there's been a lot of money spent on sewage plants, drain work, and new regulations. Still, the river stays dirty. The real trouble? Not everyone's connected to the sewers. Treatment plants get overloaded. Industries keep breaking the rules. Too many government bodies pass the buck.

This study makes it clear: technical fixes only go so far. If we want the Yamuna to bounce back, we need solid leadership, agencies that actually talk to each other, real-time tracking, and a system where results matter. The plan's laid out in phases—first, stabilize things by 2030, then push for real ecological recovery by 2035, and finally, keep the momentum going with sustainable management up to 2040. That way, we don't just patch things up; we actually restore water quality, bring back life to the river, and rebuild public trust one step at a time.

At the end of the day, what do we want to see? Lower BOD and COD levels that finally meet CPCB standards, higher dissolved oxygen, fish and other river life making a comeback, and government agencies that work together instead of getting in each other's way. New tech helps, too—better STPs, constructed wetlands, even digital twins to predict problems before they happen. All of this makes lasting change more likely.

In the end, it's going to take real commitment from both state and national leaders, strict

enforcement, and people getting involved. When infrastructure, policy, and community effort all come together, the Yamuna can turn into a clean, resilient, and thriving river—a model for every city in India looking to bring its rivers back to life.

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