DRAFT URBAN RIVER MANAGEMENT PLAN - GAYAJI

Deliverable 3: Preparation of Urban River Management Plan for Gayaji city, Bihar

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Gaya ji Nagar Nigam

Project Consultants - Consortium of

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ICF Consulting, India Private Limited

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This report is a collaborative effort of NMCG and NIUA along with Gayaji Municipal Corporation for preparation of Urban River Management Plan for cities in Bihar.

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Disclaimer: The interventions proposed in this Draft URMP document (Version1) are prepared in consultation with the city stakeholders, NIUA and NMCG as project concepts. For its implementation, a Detailed Project Report (DPR) needs to be prepared.

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GLOSSARY

Abbreviation	Full Form
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BOD	Biochemical Oxygen Demand
BSDMA	Bihar State Disaster Management Authority
BSPCB	Bihar State Pollution Control Board
BSAPCC	Bihar State Action Plan on Climate Change
BUIDCO	Bihar Urban Infrastructure Development Company
CGWB	Central Ground Water Board
CMMU	City Mission Management Unit
COD	Chemical Oxygen Demand
CPHEEO	Central Public Health and Environmental Engineering Organization
CPCB	Central Pollution Control Board
DGCs	District Ganga Planning Committee
DEP	District Environment Plan
DEWATS	Decentralized Wastewater Treatment System
DO	Dissolved Oxygen
DPR	Detailed Project Report
EO	Executive Officer
FPZ	Flood Plain Zoning
GDDP	Gross District Domestic Product
GNN	Gayaji Nagar Nigam
IHHL	Individual Household Toilets
MoEF&CC	Ministry of Environment, Forest & Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MSL	Mean Sea Level
MSWG	Multi-Stakeholder Working Group
NDVI	Normal Difference Vegetation Index
NGT	National Green Tribunal
NIC	National Informatics Centre
NIUA	National Institute of Urban Affairs
NMCG	National Mission on Clean Ganga
NWIC	National Water Informatics Centre
OHT	Over Head Tank
PHED	Public Health and Engineering Department
RCD	Road and Construction Department
SBM	Swachh Bharat Mission
SDRF	State Disaster Response Force
SPVs	Special Purpose Vehicles
STP	Sewage Treatment Plant

Abbreviation	Full Form
UDHD	Urban Development and Housing Department
ULB	Urban Local Bodies
URMI	Urban River Management Index
URMP	Urban River Management Plan
WRD	Water Resource Department

EXECUTIVE SUMMARY

1. EXECUTIVE SUMMARY

The National Mission for Clean Ganga (NMCG) is advancing the integration of river protection into urban planning and city development through initiatives such as the River Cities Alliance (RCA) and Urban River Management Plans (URMPs). Urban rivers, city drains, groundwater systems, and waterbodies once central to cultural practices, livelihoods, and ecological balance are today severely degraded due to unplanned urbanisation, pollution, and loss of natural drainage systems. This degradation poses serious risks to public health, biodiversity, flood resilience, and the socio-economic fabric of cities. URMPs are designed to address these challenges through sustainable infrastructure augmentation, governance and institutional reforms, community participation, and financial integration.

A river and its city share a deeply symbiotic relationship. While rapid urbanisation has contributed significantly to the degradation of river ecosystems, cities also hold the key to their rejuvenation through informed planning, responsible governance, and citizen stewardship. In this context, the Urban River Management Plan for Gayaji aims to establish a dedicated, city-level strategy for managing the Falgu River (including its seasonal channels) and associated urban water elements such as drains, ghats, ponds, lakes, wetlands, riverine buffers, and groundwater systems in an efficient, inclusive, and sustainable manner.

The URMP for Gayaji follows the *Strategic Framework for Managing Urban River Stretches: Urban River Management Plan* developed by the National Institute of Urban Affairs (NIUA) under the guidance of the National Mission for Clean Ganga (NMCG). The plan is being prepared by the consortium of AIILSG–ICF, appointed as consultants for the preparation of URMPs for six cities in Bihar. Gayaji, a globally significant pilgrimage city, is deeply intertwined with the Falgu River, with ghats such as Vishnupad, Devghat, and numerous sacred kunds and ponds forming an inseparable part of its cultural and ritual landscape. The city's riverfront and waterbodies play a critical role during major religious events such as Pitru Paksha, drawing millions of pilgrims annually.

The baseline assessment for Gayaji highlights persistent challenges including untreated and partially treated sewage discharge, pollution from ritual and solid waste, encroachments within riparian buffers, degradation of ponds and drains, seasonal drying of the river channel, and limited institutional coordination for urban water management. At the same time, the city demonstrates strong cultural stewardship, active religious institutions, and a river-linked local economy, which offer opportunities for participatory rejuvenation. These findings shape the URMP's focus on pollution abatement, restoration of riparian and blue-green assets, eco-sensitive riverfront development, and structured citizen engagement.

Gayaji's composite Urban River Management (URM) Index is assessed at approximately 1.44, indicating an average level of urban river management. While the city shows relative strengths in river-linked cultural economy and citizen-driven initiatives, significant gaps remain in floodplain regulation, pollution control, protection of riparian buffers, and the ecological health of inland waterbodies, drains, and canals. This assessment provides a clear baseline and direction for prioritised interventions.

URMP Gayaji is structured around the ten-point URMP agenda, translating baseline insights into tangible, implementable actions. The plan combines planning and policy-level measures such as zoning regulations, development control guidelines, and institutional arrangements with on-ground projects that can be implemented by multiple line agencies. All actions are phased into short-, medium-, and long-term horizons to ensure pragmatic delivery while strengthening institutional capacity over time.

Key interventions proposed for Gayaji focus on holistic river and water management. Floodplain regulation and riparian buffer protection are to be strengthened through scientific mapping, zoning, and nature-based stabilisation measures to prevent encroachments and reduce erosion. To move towards a pollution-free river, the plan emphasises expansion and optimisation of sewage treatment plants (STPs), faecal sludge and septage management (FSSM), decentralised and nature-based treatment systems, and the design of interceptor sewers for major drains discharging into the Falgu River. An integrated water quality and quantity monitoring framework, with clearly defined discharge standards, is proposed to support evidence-based regulation.

Rejuvenation efforts will prioritise the restoration of riparian buffers, urban ponds, kunds, wetlands, and natural drainage channels as functional blue-green assets that enhance flood mitigation, groundwater recharge, biodiversity, and public open spaces. A citywide strategy for reuse of treated wastewater from proposed and existing

STPs and FSTPs will be developed for urban landscaping, peri-urban agriculture, and waterbody recharge, supported by eco-nalas bioengineered drains that act as treatment and return-flow corridors.

Eco-friendly riverfront development in Gayaji will focus on an Eco-Heritage Riverfront approach, with continuous pedestrian pathways, improved ghats, shaded public spaces, eco-parks, habitat augmentation, and sensitive upgradation of heritage and religious sites. Eco-Ghat Design Guidelines will promote permeable surfaces, local materials, low-impact lighting, inclusive amenities, and systems for ritual and floral waste management, ensuring that religious practices coexist with ecological protection.

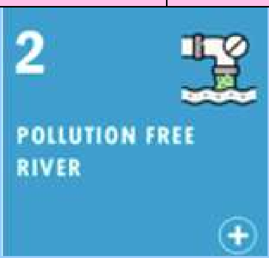
Economic leveraging will centre on heritage- and pilgrimage-based tourism, with river-linked livelihood opportunities such as guided heritage walks, artisanal and ritual markets, cultural events, and eco-tourism initiatives that celebrate Gayaji's unique spiritual identity while safeguarding river ecology. Citizen sensitisation and engagement will be institutionalised through youth clubs, pilgrim outreach programmes, digital grievance and reporting platforms, and regular clean-up, plantation, and monitoring drives, transitioning from sporadic efforts to sustained community stewardship.

Each proposed intervention under URMP Gayaji is assigned a clear implementation phase (short, medium, or long term) and mapped to responsible agencies including Gayaji Municipal Corporation, BUIDCO, PHED, Bihar State Pollution Control Board, Forest, Agriculture, Fisheries, Tourism, Disaster Management Departments, and NMCG ensuring alignment with funding mechanisms, approvals, and DPR preparation. URMP Gayaji is envisaged as a living document that will guide downstream implementation, with periodic monitoring and evaluation using improvements in the URMP Index as the primary performance metric.

Summary of key interventions proposed by Gayaji URMP

Objective 1: Regulation of Activities in the Floodplain

	Intervention	Responsible agency	Potential Funding Source	Estimated budget
1.1	Floodplain Zoning Integration into the Master Plan	Town and Country Planning Department, UDHD-Bihar, Gayaji Municipal Corporation	UDHD Bihar, State funding	NA



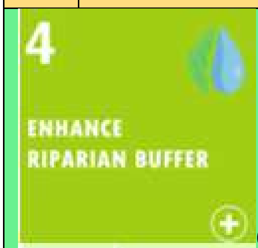
Objective 2: Pollution Free River

	Intervention	Responsible agency	Potential Funding Source	Estimated budget
2.1	Fecal Sludge Treatment Plant (FSTP) for Blackwater Management	Gayaji Municipal Corporation in coordination with PHED / State Urban Development Department	SBM-U 2.0, AMRUT 2.0, State Urban Infrastructure Funds, PPP (O&M model)	₹12–15 Cr (for 50KLD FSTP incl. land, civil works & O&M setup)
2.2	Ritual Waste Management for River Protection	Gayaji Municipal Corporation with Temple Trusts, Forest & Environment Department	NMCG / State River Rejuvenation Funds, CSR (religious trusts, local industries), SBM-U IEC grants	₹50-70 Lakhs (collection centres, composting/processing units, IEC & operations)
2.3	In-Situ Bioremediation & Eco-Restoration of Urban Nalahs	Gayaji Municipal Corporation, PHED, State Pollution Control Board (SPCB)	NMCG, AMRUT 2.0, State Environment Funds, World Bank / ADB assisted urban projects	₹15–25 Cr (bio-enzymes, aeration units, phytoremediation, monitoring & landscaping)

2.4	Ground water regulation policy	District Administration, State Ground Water Directorate, Gayaji Municipal Corporation	State Plan Funds, Jal Jeevan Mission (Urban convergence), NIUA / MoHUA technical assistance	₹1 Cr (policy formulation, GIS mapping, monitoring wells, enforcement & capacity building)

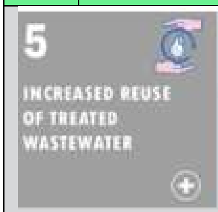
Objective 3: Rejuvenation of inland water bodies

	Intervention	Responsible agency	Potential Funding Source	Estimated budget
3.1	Comprehensive GIS-based inventory and water quality monitoring system for all waterbodies	Gayaji Municipal Corporation (Lead), WRD Bihar (Support)	City's Annual Budget CSR	₹60-80 Lakhs (GIS platform, baseline surveys, sensors, lab testing & capacity building)
3.2	Rejuvenation of Dighi and Haveli talab	Gayaji Ji Municipal Corporation (Lead), WRD Bihar, Forest & Environment Department	Namami Gange, Jal Jeevan Hariyali Mission, Forest Department	₹3-4 Cr (desiltation, embankment strengthening, eco-restoration, access control & O&M)



Objective 4: Enhancing Riparian Buffer

	Intervention	Responsible agency	Potential Funding Source	Estimated budget
4.1	Linear Parks on the Riparian Buffer	Gayaji Ji Municipal Corporation (Lead), with technical support from Forest Department	CAMPA Funds, Gayaji Ji Municipal Corporation (own fund), Forest department	₹ 80 Lakh



Objective 5: Increased Reuse of Treated Wastewater

Objective 6: Maximum Good quality return flow

	Intervention	Responsible agency	Potential Funding Source	Estimated budget
5.1	Real-time water quality monitoring stations	Gayaji Ji Municipal Corporation, BUIDCO	Urban Local body Bihar Pollution Control Board	₹ 50 lakh

Objective 7: Eco-friendly Riverfront Projects

Objective 8: Leveraging Economic Potential of the River

	Intervention	Responsible agency	Potential Funding Source	Estimated budget
7.1	Eco-restore degraded ghats to improve safety and appeal	Gayaji Ji Municipal Corporation (Lead), WRD Bihar, Forest & Environment Department	Namami Gange, AMRUT 2.0, CAMPA (green buffers), State Plan Funds	₹10–15 Cr (eco-edge treatment, riparian plantation, access improvements, safety measures)
7.2	Transform the dry riverbed and riverfront into a seasonal cultural and ecological attraction that celebrates heritage, sustainability, and local livelihoods	GMC (Lead), Tourism Department Bihar, Department of Culture	Swadesh Darshan 2.0, PRASHAD, Namami Gange, CSR	₹15–25 Cr (temporary structures, cultural spaces, riverbed activation, livelihood kiosks, ecological safeguards)
7.3	Create sustainable tourism & cultural circuits along key ghats and temples	Tourism Department (Lead), GMC, Temple Trusts	PRASHAD Scheme, Swadesh Darshan 2.0, State Tourism Grants, CSR	₹5–8 Cr (wayfinding, heritage trails, interpretation signage, last-mile connectivity)
7.4	• Set up a River Economy Cell within the Municipal Corporation • Form Nadi Sevak teams for festivals and visitor management. • Women-led SHGs to manage Nirmalya (ritual waste) collection	GMC (Lead), District Administration, Women & Child Development Dept., NGOs	SBM-U 2.0 (IEC & livelihoods), NRLM/SHG funds, State Capacity-Building Grants	₹2–3 Cr (cell setup, training, uniforms & equipment, IEC, pilot operations)

Objective 9: River Sensitive Behaviour among Citizens

Objective 10: Citizen engagement in river management

	Intervention	**Responsible agency**	**Potential Funding Source**	**Estimated budget**
9.1	River sensitization program for Gayaji city	Gayaji Ji Municipal Corporation (Lead), BSPCB, Education Department, Local NGOs	SBM-U 2.0 (IEC), Namami Gange (Public Awareness), State Urban Development Grants, CSR	₹1–1.5 Cr (citywide IEC campaigns, school & college programs, media outreach, training modules)
9.2	Community engagement programs at the riverfront/ River Day celebration	GMC (Lead), District Administration, Tourism & Culture Department	Namami Gange, Swadesh Darshan 2.0 (CSR), State Culture Grants	₹50 Lakh (River Day events, clean-up drives, cultural programs, volunteer mobilization & logistics)

INTRODUCTION

2. INTRODUCING URBAN RIVER MANAGEMENT PLAN FOR GAYAJI

2.1. Concept, Vision and Pillars of URMP

The core concept of the URMP is to integrate river-sensitive thinking into mainstream urban planning and governance. Rather than treating the river as a residual drain or a standalone beautification project, the URMP positions the river as a living ecological system and a shared urban asset that supports biodiversity, livelihoods, cultural practices, and city resilience. The framework promotes a shift from fragmented, project-based interventions to a holistic, basin-aware, and outcome-oriented approach that aligns with existing statutory plans such as the Master Plan, City Sanitation Plan, and City Development Plan. Importantly, the URMP is designed as a living document, allowing cities to monitor progress, learn from implementation, and recalibrate actions over time. The Urban River Management Plan (URMP) for Gayaji city has been prepared with an intent to manage the Ganga river and the other associated water systems within the city, in a sustainable manner. The URMP framework prepared by the National Institute of Urban Affairs (NIUA) and the National Mission for Clean Ganga (NMCG), has been followed for preparing the URMP Gayaji. The URMP is anchored in the three pillars of sustainable development: Environmental, Economic, and Social. These pillars collectively guide the vision, objectives, and interventions proposed under the plan.

Figure 1: Elements of the URMP Framework

ENVIROMENTAL PILLAR

Focus: Restoring river health by reducing pollution, protecting floodplains and riparian buffers, rejuvenating water bodies, and maintaining ecological flows to support biodiversity and resilience.

.......Responsible

ECONOMIC PILLAR

Aims: Harnessing the river's ecosystem services for sustainable livelihoods and local economic growth through eco-friendly riverfronts, tourism, navigation, and allied activities without compromising river health.

......Beneficial

SOCIAL PILLAR

Seeks: Reconnecting citizens with the river by promoting river-sensitive behavior, cultural engagement, and active public participation in river conservation and management.

.......Inclusive

The Urban River Management Plan envisions a future where urban rivers function as healthy ecological systems, support sustainable economic activities, and are valued and celebrated by citizens. The vision emphasizes river-sensitive urban development that enhances environmental resilience, urban liveability, and socio-economic productivity while maintaining the ecological integrity of the river. The URMP operationalizes this vision through ten objectives covering environmental, economic, and social dimensions. The URMP's vision shall be achieved through a set of ten objectives, six of which are environmental, and two each for the economic and social visions. Each objective is unique and addresses a niche aspect of urban river management.

It is important to note that the URMP is a living document that shall evolve over time as more knowledge and resources become available. The URMP also indicates a phase-wise (short term, medium term, long term) implementation plan for these interventions.

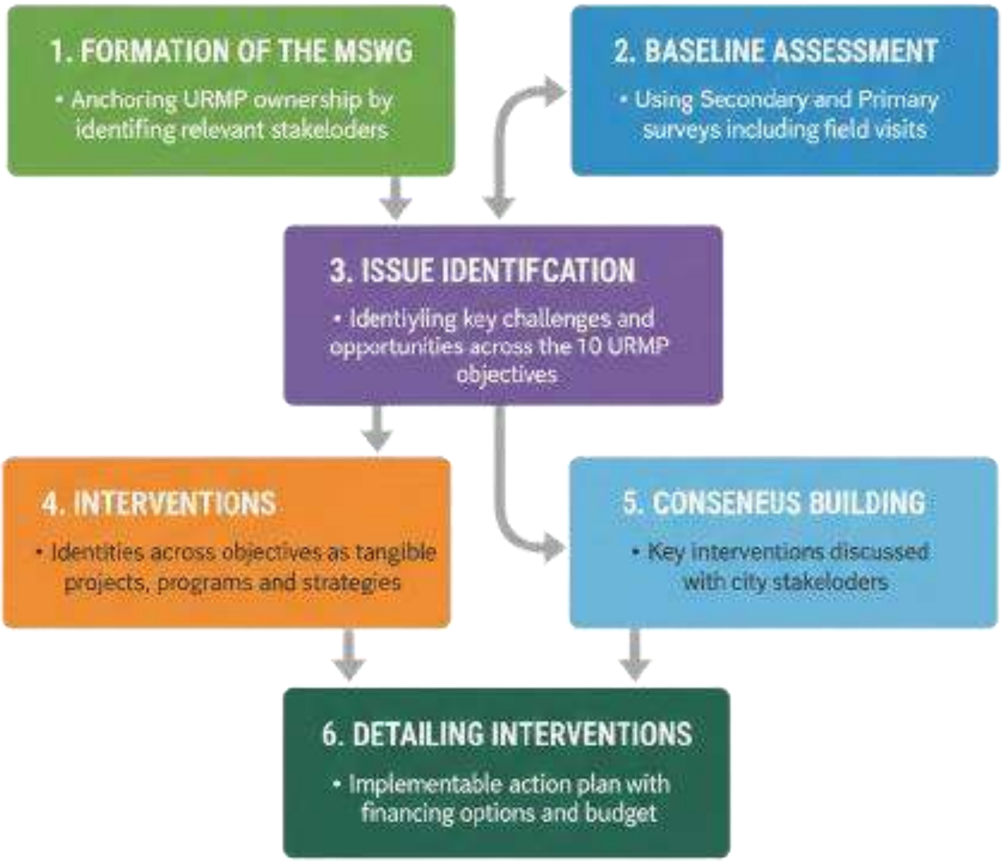
Figure 2: Objectives across the 3 elements of the URMP Framework

2.2. Process for preparation of URMP Gayaji

Following process was followed for the preparation of URMP Gayaji:

- Step 1 –Setting up a core working group of relevant stakeholders to anchor the ownership of the URMP
- Step 2 – Conducting a thorough baseline assessment of the relevant parameters to establish current status and the baseline score
- Step 3 – Identifying key challenges and issues and preparing SWOT
- Step 4 – Identifying tangible interventions for each objective of the URMP framework
- Step 5 – Consensus building on the interventions via stakeholder workshops with City officials
- Step 6 – Preparation of detailed plan for prioritised implementation of the interventions, and linking each intervention to probable institutional and financing option, along with a monitoring framework

Figure 3: Steps for preparation of URMP Gayaji



2.3. URMP Gayaji - Working Group

The preparation of the Urban River Management Plan (URMP) for Gayaji Ji was led by Gayaji Nagar Nigam under the guidance of the Municipal Commissioner, with active support from relevant line departments and stakeholders. The process was guided by the National Mission for Clean Ganga (NMCG) and the National Institute of Urban Affairs (NIUA), with technical facilitation from partner institutions.

To ensure inclusive stakeholder participation and coordinated planning, a Multi-Stakeholder Working Group (MSWG) was constituted, comprising representatives from Gayaji Nagar Nigam, district administration, concerned state departments, and other key agencies. As an initial step, the first in-person MSWG meeting for the URMP of Gayaji Ji was convened on 17 June 2025 at the premises of Gayaji Nagar Nigam.

The meeting was chaired by Shri Kumar Anurag, IAS, Municipal Commissioner, Gayaji Nagar Nigam, and focused on identifying critical river-related challenges faced by the city. Members were introduced to the principles of urban river management and the URMP framework, along with learnings from similar initiatives undertaken in other cities across India. The participating stakeholders shared insights on ongoing and proposed interventions related to river conservation, pollution management, and riverfront development, and collectively expressed their commitment to adopting and implementing the URMP framework for Gayaji Ji.

This baseline assessment report has been prepared as part of the assignment commissioned by the National Institute of Urban Affairs (NIUA) under the National Mission for Clean Ganga (NMCG) via a contract dated 23rd May 2025, the consortium of AIILSG and ICF Consulting have been selected to deliver this project. The primary objective of the assignment is to support urban local bodies (ULBs) in mainstreaming river-sensitive planning by integrating ecological, infrastructural, economic, institutional, and citizen-led priorities into actionable city-level management strategies.

Figure 4: First MSWG Meeting held on 17th June 2025

The meeting brought together representatives from key city departments, state agencies and the URMP project team to introduce the project, deliberate on local river-related challenges and initiate the process of collaborative planning. NIUA presented the objectives and structure of the URMP framework and the consultants shared early insights from field assessments. Stakeholder feedback during this session laid the foundation for a context-sensitive and community-driven URMP for Gayaji.

Departments Represented:

- Nagar Nigam Gayaji (Executive Office, Planning, Sanitation, Solid Waste, and Tax Departments)
- Department of Land Records and Survey
- Public Health Engineering Department (PHED)
- Forest Department, Gayaji
- District Statistical Office
- Water Resource Department
- Public Health and Engineering Department (PHED)
- Bihar Urban Infrastructure Development Corporation Ltd (BUIDCO)

Also Invited: Mayor, Madagh Division, Road Development Department, Agriculture Department, Town Planner, District Land Acquisition Officer, Bihar State Pollution Control Board, Urban Development – Division and Water Board

Key Findings and Discussion Highlights

Pollution Sources Identified: Untreated sewage is currently discharged directly into open drains, prompting BUIDCO to propose an Interceptor and Diversion system under NMCG funding to improve wastewater management. Solid waste is collected door-to-door, but the lack of segregation leads to indiscriminate dumping at the Nalli landfill site, with a Solid Waste Management Facility under consideration. Encroachments along canals and riverbanks continue to obstruct restoration efforts and degrade riparian zones. To address air quality concerns, the Forest Department is conducting plantation drives under the National Clean Air Program (N-CAP), contributing to urban greening and pollution mitigation.

Tourism-Driven Economy: In 2024, Gayaji welcomed over 2.5 crore pilgrims for the Pind Daan rituals, reaffirming its status as a major Hindu spiritual center. Prominent religious sites such as the Falgu River, Vishnupad Temple, Sita Kund, Brahma Kund, and Surya Kund become especially active during Shradh and Chhath Puja, drawing thousands for ceremonial bathing, sun worship, and ancestral offerings. These sacred water bodies serve not only as cultural landmarks but also as key drivers of the local economy through religious tourism. As one of the 12 HRIDAY cities, Gayaji's heritage-focused development is central to its urban planning and river management efforts.

Water Supply Gaps: Gayaji, situated in a drought-prone region, faces recurring water scarcity and significant groundwater depletion due to over-extraction and inadequate recharge mechanisms. While the city is not entirely dependent on groundwater, an ADB-funded piped water supply project is currently being implemented to improve access and reliability. Planning efforts are challenged by fragmented land records maintained across three departments, with river boundaries last mapped in 1982. To address these gaps, a comprehensive Master Plan covering 308 sq. km is under preparation, supported by completed land use mapping from MapmyIndia.

Biodiversity and Riparian Degradation: Riparian vegetation has been cleared for cultivation, prompting active restoration across nine key water bodies. The Forest Department is leading mixed plantation efforts along rivers, canals, and ponds using Kampa funds and departmental budgets. Conservation measures include desilting, installation of dustbins, provision of washrooms, and creation of walking paths to enhance ecological and public utility. A 500-hectare organic farming initiative under PMKSY is being developed along riverbanks to promote sustainable agriculture. Additionally, a 500-meter Riverfront Development Project near Vishnupad Temple is underway, with its Detailed Project Report (DPR) to be shared.

Theme Identification for Gayaji URMP: Gayaji's URMP themes include spiritual integration, focusing on sacred sites like Falgu River and Vishnupad Temple that drive religious tourism. Water resource management addresses drought, groundwater depletion, and infrastructure upgrades through ADB-funded projects. Pollution control targets sewage diversion, solid waste segregation, and riparian encroachment. Biodiversity restoration includes mixed plantations, organic farming, and riverfront development near key cultural zones. Based on these deliberations, the following theme was finalized:

Theme Identified for the Gayaji URMP:

Restoring The Glory Of Falgu River Through Blue Green Infrastructure

This was followed by Baseline assessment phase that involved intensive on-ground data collection, stakeholder consultation and review of available project reports on various initiatives related to managing the river and urban water bodies health including key issues and potential.

Key Challenges Identified

Following key challenges associated with the rivers and waterbody systems in Gayaji were identified during field visits and various stakeholder consultations. These challenges form the backdrop for the Gayaji URMP and form the basis for developing proposals and interventions

Liquid Waste

• Significant discharge of untreated wastewater into drains, nallahs, ponds, and ultimately the Falgu river.

• Delay in commissioning of the Sewage Treatment Plant (STP) and associated network, creating an urgent need for interim measures.

Solid Waste

• Absence of a comprehensive Solid Waste Management (SWM) plan, resulting in widespread pollution across drains, nallahs, ponds, and riverbanks.

Riverfront

• Riverfront potential remains underutilised, with heavy footfall at ghats but inadequate amenities.

• Heritage value of the riverfront is largely untapped.

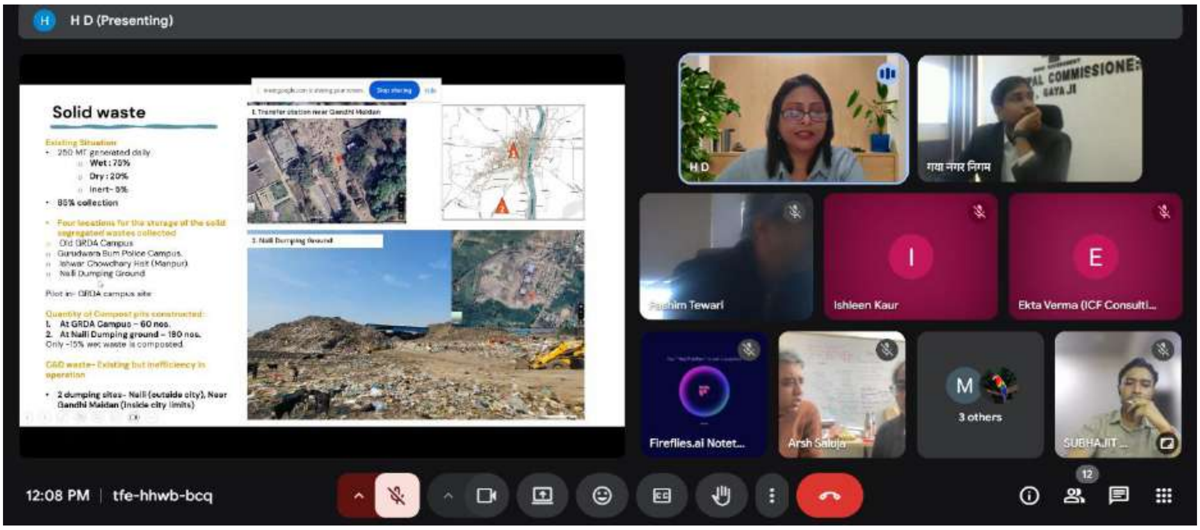
Waterbodies

• Urban ponds and wetlands are severely impacted by pollution and face increasing risk of encroachment.

Based on the key issues identified, interventions were developed across the 10 objectives and aligning with the URMP framework in close consultation with NIUA. Followed by on-ground feasibility check and consensus building amongst the key stakeholders in Gayaji. The 2nd MSWG meeting was held on 30th January 2026 and the meeting was followed up by a online meeting on 3rd February 2026.

Figure 5: Second MSWG Meeting held on 30th January 2026 and Virtual meeting on 3rd February 2026

2nd Multistakeholder Working Group meeting held on 30th January 2026



Followed up 2nd Multistakeholder Working Group online meeting held on 3rd February 2026

GAYAJI – URMP BACKGROUND

3. GAYAJI URMP- BACKGROUND

3.1. City Profile

The Falgu River, flowing through the sacred town of Gayaji, is far more than a geographical feature; it is a living embodiment of faith, memory, and ecology, deeply interwoven with the spiritual fabric of Hindu Dharma. For centuries, the river has shaped Gayaji's religious practices, settlement patterns, livelihoods, and landscapes, making it inseparable from the city's identity. In Hindu tradition, the Falgu is revered not merely as a physical river but as a symbol of devotion, divine action, and karmic consequence. Gayaji itself is among the holiest towns in Hinduism, sanctified by mythological narratives, temples, and sacred sites that draw pilgrims from across India and beyond.

The banks of the Falgu serve as the principal stage for Pind Daan and Shraddha rites, rituals performed for the salvation of ancestors' souls, particularly during the annual Pitru Paksha Mela, when lakhs of devotees gather at ghats near Vishnupad Mandir, Sita Kund, Akshay Vat, and other sacred locations. Festivals such as Chhath Puja, celebrated with immense devotion along the riverbanks, further reinforce the Falgu's spiritual centrality. In this way, the river functions as a ritual corridor, sustaining religious traditions that have endured for millennia.

In ancient Puranic literature, the Falgu is referred to as Mahanadi, meaning "Great River," symbolizing its association with piety and spiritual merit. Sanskrit texts also identify it as Niranjana and Lilagan, reflecting its layered and evolving identity through history. A distinctive feature of the Falgu is its characterization as an "antasalila" river one that flows beneath the ground. Due to its highly porous sandy bed, surface flows often disappear, yet if the sand is dug even slightly, fresh water emerges. This phenomenon has shaped both religious symbolism and practical water use, reinforcing the belief that the river is ever-present, even when unseen.

Hydrologically, the Falgu River is formed by the confluence of two hill streams the Lilajan (also known as Niranjana or Nilanjan) and the Mohana approximately 3 km downstream of the Mahabodhi Temple, or about two miles below Bodh Gayaji. Both streams originate in the Hazaribagh Plateau, a region characterized by undulating terrain and forested hills. The Mohana enters Gayaji district roughly 20 miles southeast of the city, while the Lilajan enters about 11 miles south of Gayaji. These two rivers, each nearly 300 yards wide, unite near Mankosi village, around 5 miles south of Gayaji city, forming the Falgu River.

The Lilajan River rises north of Simaria on the Hazaribagh plateau in present-day Chatra district, Jharkhand. It carves a deep rocky channel through areas such as Jori, before emerging into a broad sandy bed that runs almost dry in summer but swells dramatically during the monsoon. About 10 km south of Gayaji, it joins the Mohana River. The Mohana itself originates from Korambe Pahar near Bendi village, approximately 19.3 km from Hazaribagh town. It drains the northern reaches of the plateau, flows past Itkhori, enters the Gayaji plains, crosses the Grand Trunk Road near the Danua pass, and finally merges with the Lilajan to form the Falgu.

From its confluence, the Falgu flows northward for about 8 km before reaching the outskirts of Gayaji city. During the monsoon season, its channel can expand to over 800 meters in width, spreading across a shallow, braided bed filled with sandbars. Outside the peak rainfall months, much of the surface flow seeps into the sandy substratum, forcing the river underground for stretches of 10–15 km before re-emerging downstream. North of Gayaji, the river veers northeast, passing through agricultural fields and small villages. Over the next 20 km, it gradually narrows, receiving seasonal rivulets and agricultural runoff before dispersing into wetlands and irrigation channels near its confluence with a distributary of the Punpun River in Patna district.

Like its tributaries, the Falgu is highly prone to seasonal flooding, exacerbated by deforestation and land-use changes in its catchment area. During intense monsoon rains, water levels rise sharply, at times approaching road and railway bridges in Gayaji. Across its approximately 70-km course, the river exhibits dramatic seasonal contrasts expansive floods between July and September, and near-invisible flows from December to May. This variability, combined with heavy abstraction for domestic, municipal, and ritual use, renders the Falgu an intermittent yet indispensable urban river.

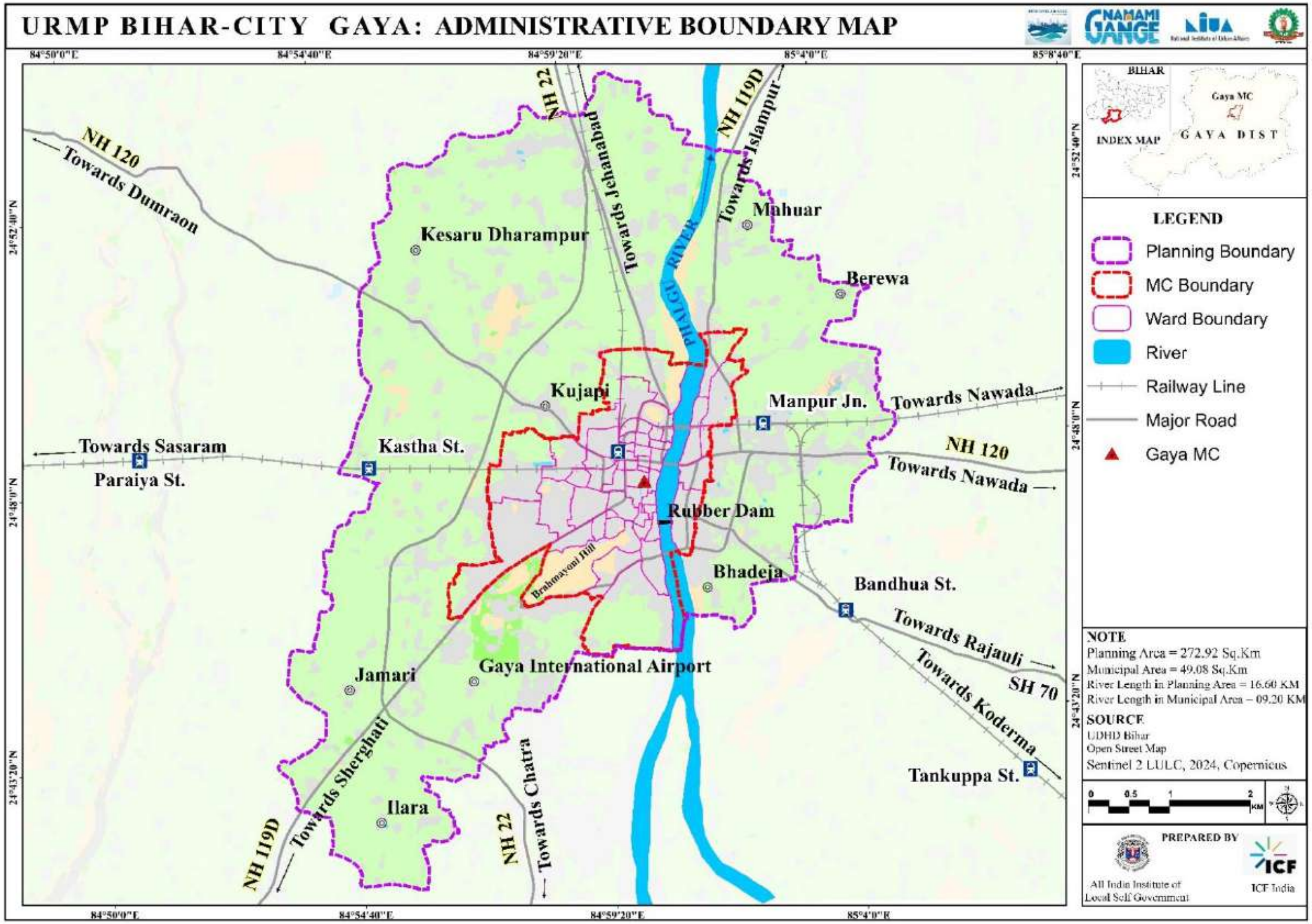
Despite these challenges, the Falgu remains the lifeline of Gayaji. Its monsoon flows recharge aquifers and sustain wells across Gayaji and Manpur, while municipal pumping schemes and the Gayaji Dam draw directly from the river to meet household and industrial demands. When surface flows dry up, residents and vendors ingeniously harvest seepage water from shallow pits in the sand, ensuring water availability for both pilgrims and locals. Ecologically, the river's riparian zones help filter urban runoff, provide breeding habitats for fish, and serve as resting grounds for migratory birds. Its floodplains act as natural buffers, protecting low-lying neighborhoods during peak flows.

The city of Gayaji, the second-largest urban center in Bihar, is governed by the Gayaji Municipal Corporation since 1983. Spread over 49.08 sq km and divided into 53 municipal wards, the city is nestled among hills such as Ramshila, Brahmayoni, and Mangla-Gauri, with the Falgu River forming its central ecological spine. According to the 2011 Census, Gayaji had a population of 468,614 across 72,118 households, with a gross density of 9,548 persons per sq km. Central wards exhibit extremely high densities, while peripheral areas remain sparsely populated. The city lies between 85–120 meters above sea level, with alluvial soils and varied aquifer depths influencing groundwater availability. Climatically, Gayaji experiences a humid subtropical climate, receiving around 1,055 mm of annual rainfall, with temperatures ranging from 8°C in winter to 39°C in summer.

Culturally, Gayaji is recognized as one of India's twelve heritage cities and benefits from its proximity to Bodh Gayaji, a UNESCO World Heritage Site. Its economy is deeply tied to religious tourism, supporting livelihoods through ritual services, boat operations, hospitality, and small-scale vendors. The city is well connected through national highways, a major railway junction, and an international airport serving domestic and Buddhist pilgrimage routes.

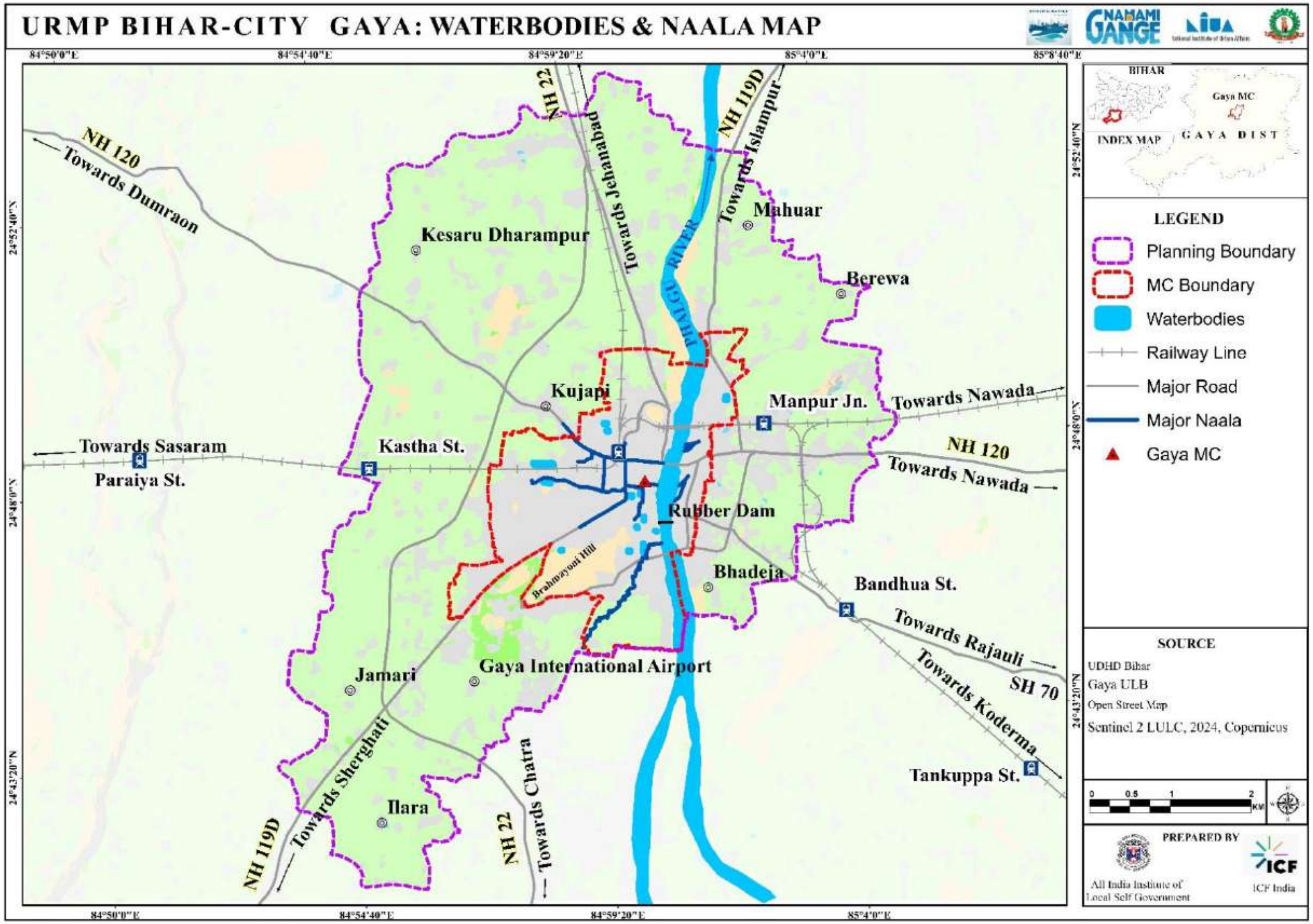
Looking ahead, Gayaji's Urban River Management Plan (URMP) envisions a future where ecological restoration and cultural preservation go hand in hand. Proposed initiatives include a 27-km eco-sensitive riverfront promenade linking eleven ghats, rejuvenation of over 56 traditional ponds and kunds, restoration of riparian buffers through native plantations, improved wastewater reuse, floodplain zoning, and extensive citizen engagement through murals, educational programs, and participatory monitoring. Together, these interventions seek to respect Gayaji's ancient heritage while guiding the city toward a resilient, inclusive, and river-sensitive urban future, anchored firmly around the timeless flow visible or hidden of the Falgu River.

Map 1: Gayaji Planning & Administrative Boundary



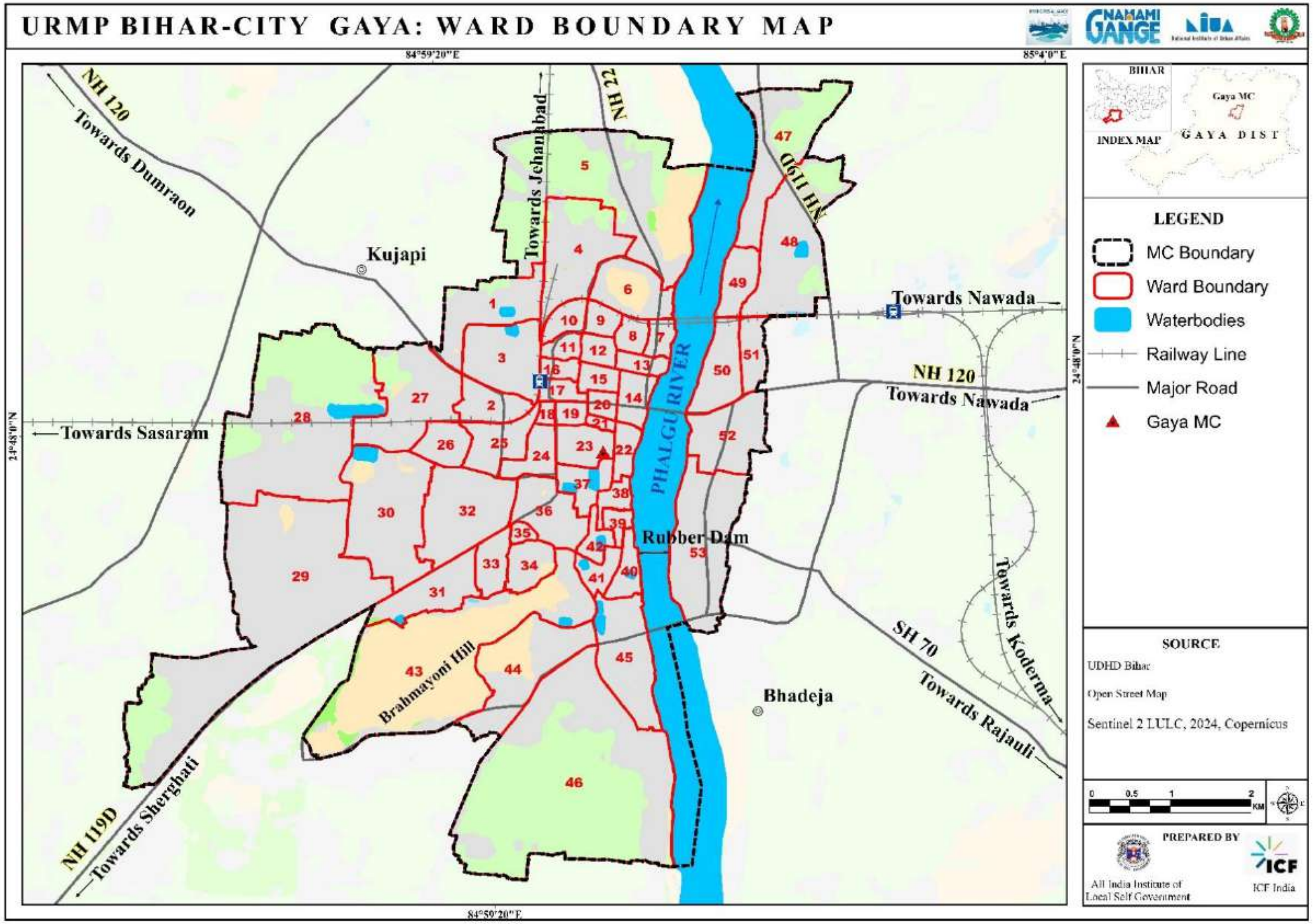
Source: UDHD Bihar

Map 2: Gayaji Water Bodies and River



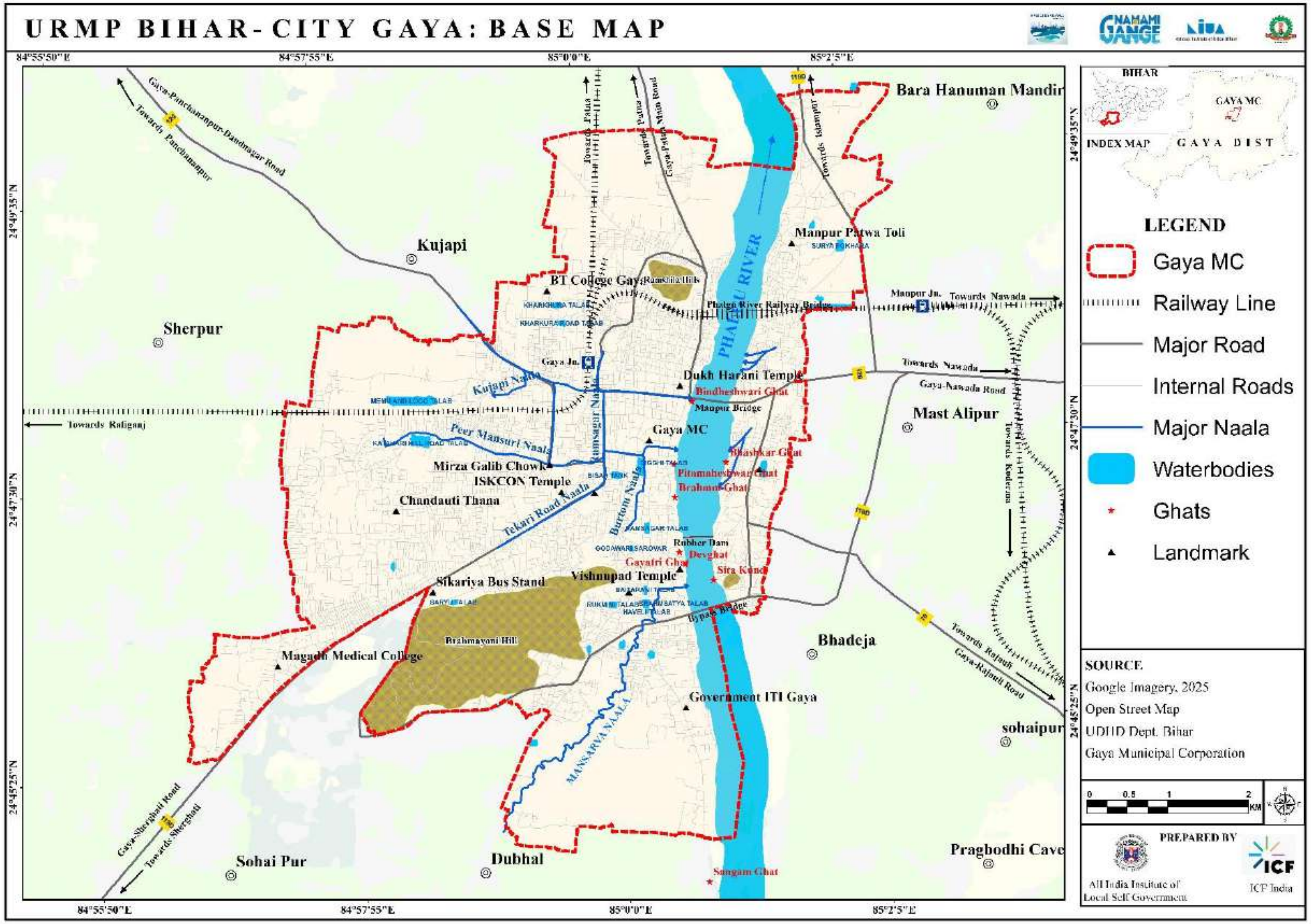
Source: UDHD Bihar

Map 3: Administrative ward boundary-Gayaji city



Source: UDHD Bihar

Map 4: Major Landmarks



Source: UDHD Bihar

Figure 6: Key cultural sites in Gayaji city

Vishnupad Temple, Gayaji

Brahmayoni Hill Temple

Maa Mangala Gauri, One of the 18th Shakti Peeth

Sita Kund Temple

Someshwar Mandir, Gayaji

Surya Mandir

Mukti Dham (crematorium) **Dungeshwari Hills**

3.2. Gayaji and its relationship with Falgu

The Falgu River, coursing through the sacred town of Gayaji, holds profound spiritual significance, intricately interwoven with Hindu Dharma. This river is significant in Hindu tradition as a symbol of devotion, divine actions, and consequences. Gayaji, revered in Hinduism, has long been considered one of the holiest places on earth, with many temples and sacred spots across its landscape. The Chhat puja is celebrated on the bank of the Falgu River. From its source, the river flows north for about 8 km before reaching Gayaji's outskirts, where its channel can expand to over 800 m during monsoon. Here, the Falgu cuts through rocky banks and alluvial plains, creating a shallow, braided bed of sandbars. Outside peak rains, much of the flow Vishnupad Mandir, Sita Kund and countless ghats, drawing hundreds of thousands during Pitru Paksha and weaving ancient myths of Sita's curse and Sujātā's blessing into the city's memory. Along its fertile floodplains, rice, wheat and pulses flourish, while lodging, pandit services, boat rides and ritual-paraphernalia stalls thrive on pilgrimage commerce. The Falgu's riparian strips filter urban runoff, provide breeding grounds for fish and migratory bird sites, and its floodplain buffers low-lying areas during high flows. Gayaji's pulse rises and falls with the Falgu, the city's lifeline.

Gayaji holds historical, etymological, mythological and religious significance. In the Vayu Purana, Gayajisura is described as a demon (Asura) who performed strict penance and received blessings from Lord Vishnu. His body was transformed into rocky hills in the landscape now called Gayaji. Rama, with Sita and Lakshmana, came to Gayaji to offer piṇḍadāna for their father, Dasharatha. Gayaji remains a major Hindu pilgrimage site for piṇḍadāna. Modern scholars identify Gayaji, Bihar, as the location of the ancient Kikata kingdom from the Rigveda.

Figure 7 Key cultural sites and events within the city.

Vishnu Pad Mandir

Vishnu Pad Mandir is a Hindu temple dedicated to Lord Vishnu, often venerating his footprints or iconography in Vishnu's various forms. The temple typically features a sanctum, mandapa, and tower, with rituals like darshan, aarti, and bhajans shaping daily worship and community life. It holds significance as a site for rites, festivals such as Vaikuntha Ekadashi and Janmashtami, and cultural programs that celebrate Vaishnavite traditions. Visiting details vary by location, but modest dress, shoe removal, and respectful participation in puja are customary.

Pitru Paksha Mela

The Pitru Paksha Mela in Gayaji is a sacred yearly event where thousands of Hindu devotees perform Pind Daan (ritual offerings) for the salvation of their ancestors' souls. It occurs during the lunar fortnight of Pitru Paksha, usually in September or October, transforming Gayaji into a spiritual hub. The main rituals take place at Vishnupad Mandir, Akshay Vat, and the Falgu River ghats, with offerings of rice balls, sesame seeds, and prayers. Pilgrims come from across India and abroad, creating a vibrant confluence of faith and community. The mela also places ecological and infrastructural demands on the city, prompting focused riverfront care and waste management efforts.

Sita Kund

Sita Kund is a sacred pond located near Ramshila Hill in Gayaji, deeply rooted in Hindu mythology and revered for its spiritual significance. According to legend, it is associated with Goddess Sita, who is said to have cursed the Falgu River at this site, declaring that it would flow invisibly beneath the sand—a phenomenon still observed today, where water emerges only when the sand is dug.

Maa Mangla Gauri Shakti Peeth

The temple is dedicated to Goddess Durga in her Mangla Gauri form, symbolizing benevolence and maternal strength. Maa Mangla Gauri Shakti Peeth is one of the most revered spiritual landmarks in India, deeply embedded in the city's mythological and cultural fabric. It is recognized as one of the 51 Shakti Peethas, sacred sites where parts of Goddess Sati are believed to have fallen, according to Hindu tradition.

These sacred sites attract pilgrims, especially during festivals like Chhath Puja (October- November), Shivratri, (February) and Kartik Purnima (November), Pitru Paksha, (September or October) reinforcing the city's cultural and spiritual identity.

3.2.1.Issues and Observations:

The religious and cultural site adds vibrancy to the city while impacting the river Falgu and associated waterbodies. Ritual activities like bathing, ablutions, idol immersion and offerings during festivals increase organic load, nutrient enrichment and solid waste in the river. The construction of ghats enables access but accelerates bank erosion and alters riparian ecology. Continuous footfall and rituals cause localized water quality deterioration (e.g., change in Dissolved Oxygen (DO), coliform levels), while pilgrim influx strains aquatic ecosystems and waste management systems. These practices reinforce the river's socio-religious value as a sacred common, highlighting the need for integrated riverfront management balancing cultural continuity with ecological safeguards. It is important to examine river-based religious tourism in Gayaji from an environmental sustainability perspective.

Figure 8: Significance of Falgu River

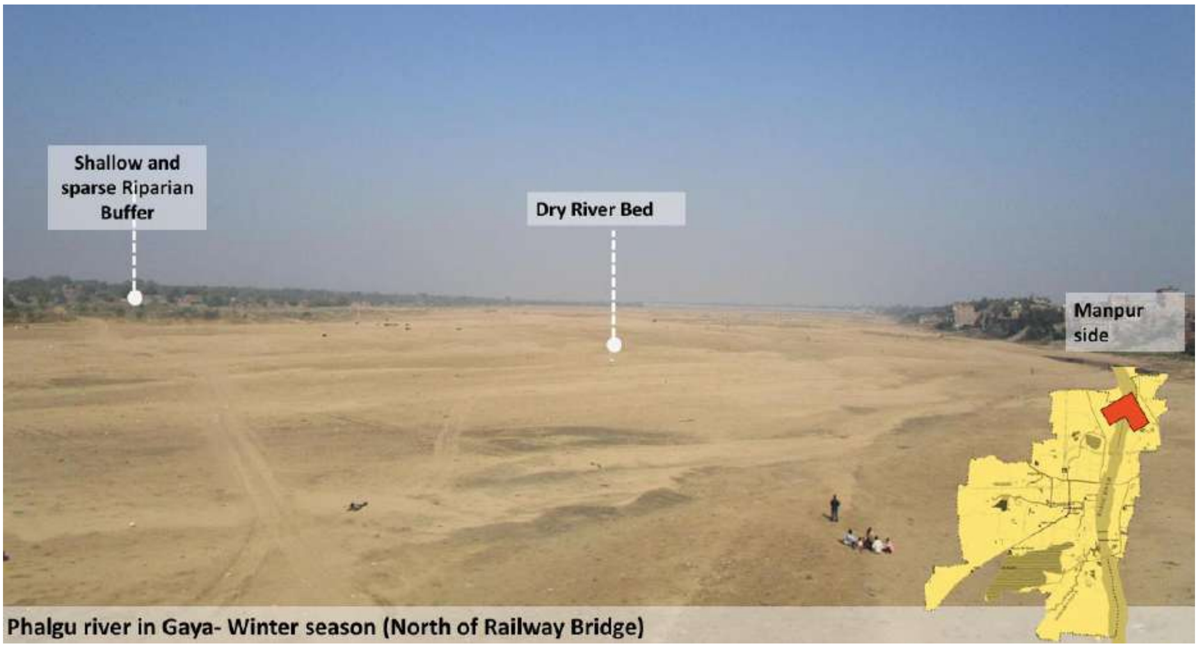
The Falgu River is a rain-fed, seasonal river of immense geographical, ecological, and cultural significance in eastern India, particularly for Gayaji. Unlike perennial rivers, its flow depends on monsoon rainfall, which defines its physical character and interaction with the landscape.

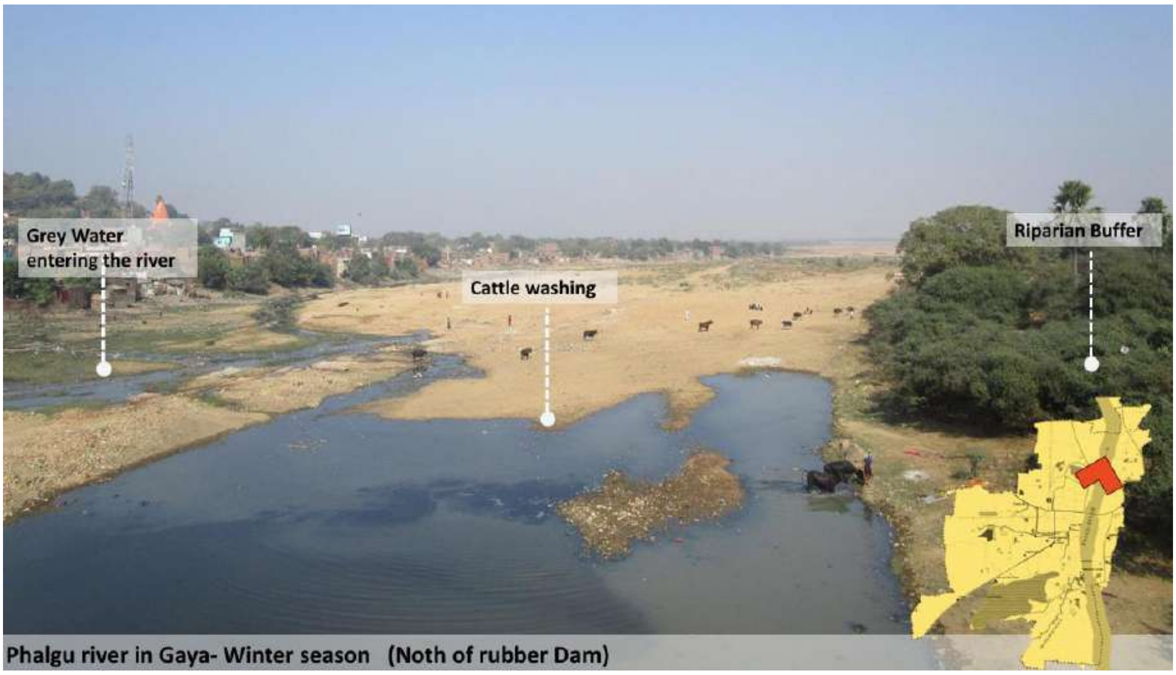
The Falgu River forms at the confluence of two streams—the Lilajan (also known as Niranjana) and the Mohana River near Mankosi village, 3 km south of Gayaji. Both tributaries originate from the Hazaribagh Plateau, a region of undulating terrain and seasonal runoff. After confluence, the Falgu flows northward past Gayaji before dispersing into a distributary of the Punpun River near Patna. The river's length from confluence to dispersal is approximately 70 km.

The seasonal nature of the Falgu River is distinctive. During monsoon months (July to September), intense rainfall leads to high discharge and flooding. The riverbed expands up to 800 metres wide, carrying large volumes of water, silt, and sand. During the dry season (December to May), surface flow nearly disappears. However, water continues beneath the sandy riverbed as subsurface flow, called Antasalila.

This dual nature—visible abundance during monsoon and hidden flow in summer—makes the Falgu River hydrologically unique and challenging to manage for groundwater recharge, urban planning, and riverfront development around Gayaji.

Figure 9: Observation of Falgu River in winter and post monsoon season



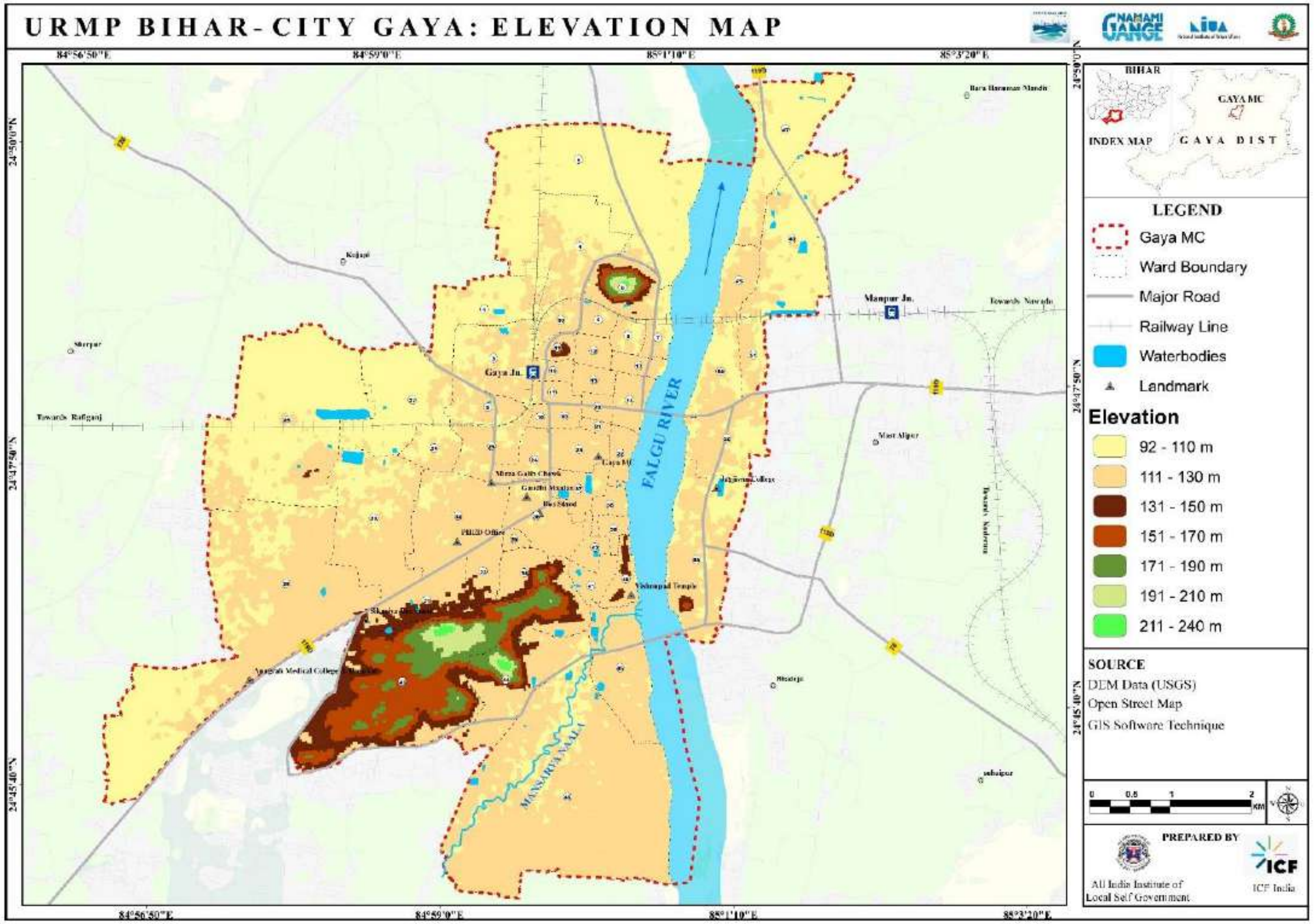


Phalgu river in Gaya- Post monsoon (Vishnu Pad ghat to Rubber Dam)

3.3. Topography

Understanding Gayaji's terrain is fundamental for an effective Urban River Management Plan (URMP). Topographic data helps planners anticipate water flow patterns, erosion hotspots, and flood-prone areas, ensuring site-specific interventions. The topography of Gayaji proper, on the west bank of the Falgu, is defined by rocky outcrops. To the south lies Brahmajoni Hill and smaller elevations along the river at Andar Gayaji. Northward stand Murli and Ramshila Hills, while to the west rise Katari Hill and its plateau, with Pretshila Hill further northwest. These features give the urban area an irregular, broken-saucer profile. Ramshila Hill obstructs the natural north and northeast drainage, making Bairagi Mohalla the lowest-lying sector and prone to waterlogging.

Map 5: Elevation Variation within City of Gayaji



Source: Cartosat 1 (Bhoonidhi-2025)

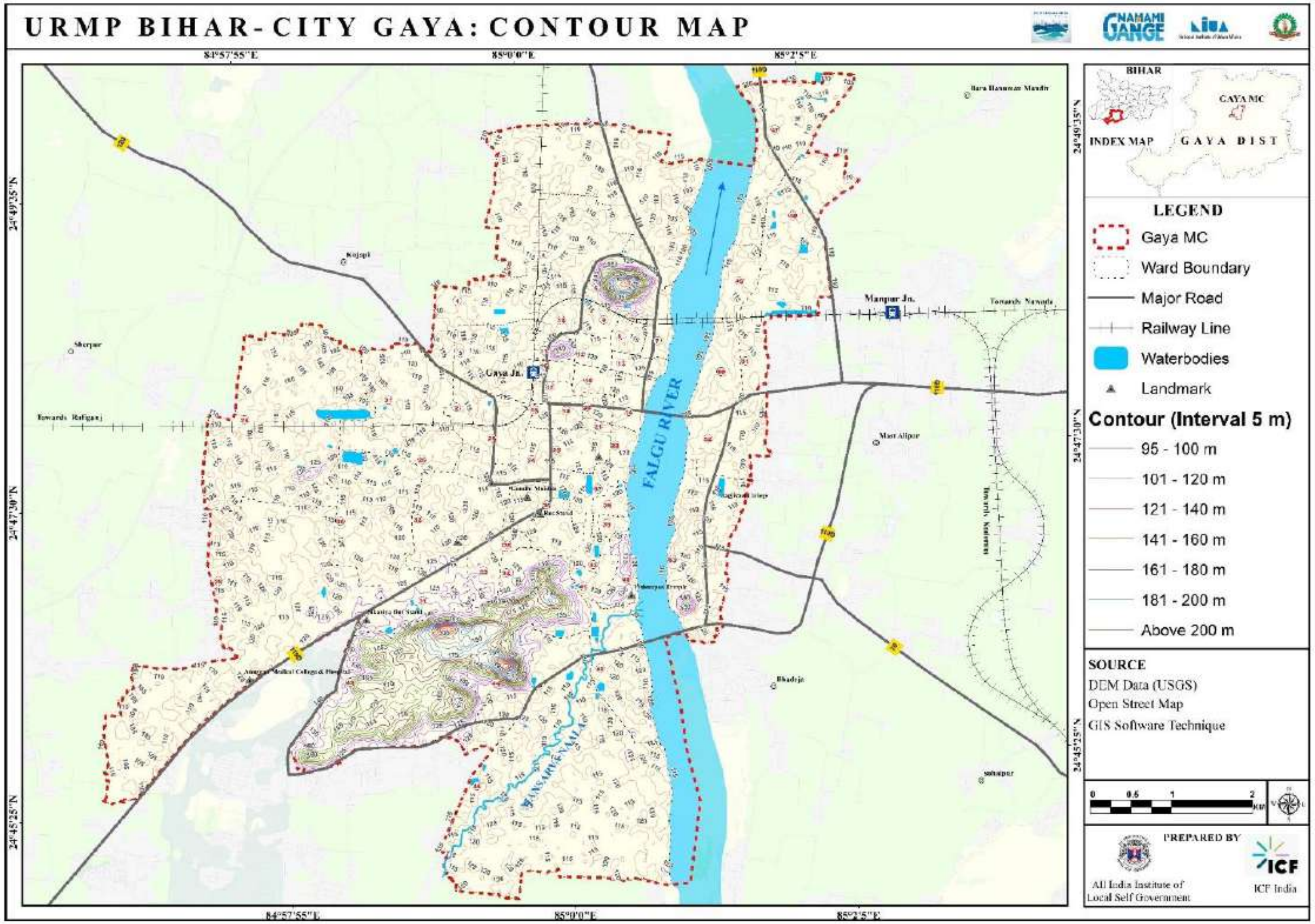
A second, important gradient runs northwest almost parallel to the Gayaji–Tekari road, formed by the depression between the Katari plateau and Pretshila Hill. The lowest elevation on the west bank occurs where this depression meets the Jamunia stream. South of the Vishnupad and Brahmajoni Hills, a small district of Gayaji proper slopes gently toward the south, draining into an extensive lowland that feeds a minor channel of the Falgu River. On the east bank, in the township of Manpur, the terrain falls gradually northward. Although the hills of Manpur and Salempur (Ram Gayaji) are too widely spaced to cause significant local relief, the hill opposite the Vishnupad Rocks creates upstream backwater, deflecting the Falgu toward the opposite bank. Gayaji district is dissected by a network of four roughly parallel streams—Morhar, Falgu, Paimar, and Dhadhar—all of which originate on the southern slopes of the Chotanagpur Plateau and flow northward toward the Ganges basin. The principal river, the Falgu, is itself born of two headstreams: the Lilajan (also known locally as the Niranjana) and the Mohana, which join just north of Gayaji city to form the main Falgu channel A second and equally significant topographic gradient extends northwestward, running almost parallel to the Gayaji–Tekari road. This gradient is shaped by a natural depression lying between the Katari plateau and Pretshila Hill, which acts as a subtle but influential drainage corridor. Along the west bank, the lowest elevation point occurs precisely where this depression converges with the Jamunia stream, making it a critical zone for water accumulation and seasonal flow concentration.

To the south of the Vishnupad and Brahmajoni Hills, a relatively small portion of Gayaji proper exhibits a gentle southward slope. This gradient drains into an expansive low-lying area, which in turn feeds a minor distributary channel of the Falgu River, reinforcing the role of southern lowlands as natural receptacles during monsoon periods. On the eastern bank, within the township of Manpur, the landform contrasts this pattern by sloping gradually northward, directing surface runoff away from the urban core.

Although the hills of Manpur and Salempur (Ram Gayaji) are spaced too far apart to generate sharp local relief, their presence still influences river behavior. Notably, the hill mass located opposite the Vishnupad Rocks creates a backwater effect upstream, subtly obstructing flow and forcing the Falgu River to deflect toward the opposite bank an interaction that has long-term implications for erosion, sediment deposition, and channel migration.

At the district scale, Gayaji is dissected by a system of four roughly parallel rivers Morhar, Falgu, Paimar, and Dhadhar. These streams originate from the southern escarpments of the Chotanagpur Plateau and flow northward, ultimately contributing to the Ganges basin. The Falgu, the principal river of the district, is itself formed by the confluence of two headstreams: the Lilajan (locally known as the Niranjana) and the Mohana. These rivers meet just north of Gayaji city, giving rise to the main Falgu channel that defines the city's hydrology, sacred geography, and flood dynamics.

Map 6: Contour Variation within City of Gayaji



Source: Prepared by Consulta

3.3.1. Geomorphology

Geomorphologically, the Gayaji district is classified into four principal geomorphic units[1] and each unit exhibits characteristic landforms. These area:

(a) **Rocky upland:** the southern hill tracts along the border of the district, the extension of the Rajgir hills on the northeast and the hills around Gayaji constitute this unit. These hills are outcrops of Chotanagpur Plateau and stand as inliers.

(b) **Plateau and the Pediplain:** the southern plateau represent the oldest table land having mature, dissected and rolling topography. The pediplain is covered by residual soil and slope and sheetwash deposits from bordering hills and inliers.

(c) **High level marginal alluvial terrace (Dobhi-Gayaji terrace):** this is the highest and oldest alluvial plain and always lies above the flood level of the present day river because it is the highest and the oldest alluvial plain, made up of the sediments brought from the erosion of the hills. The contact of the terrace and the pediplain is always transitional as the colluvial deposit often overlaps or interfinger with the alluvial sediments.

(d) **Sone-Ganga Plain:** This unit, primarily high level flood plain of the Ganga and the Sone rivers constitutes the intermediate alluvial plain between the terrace and the present day course of the two rivers. This presents flat, depositional topography consisting of unoxidised Quaternary Alluvial deposit. This geomorphic unit, lying 80-100 m above msl lies to the north and northwest of Paraiya-Khizirsarai belt. The Gayaji city has a diverse landscape ranging from hills to flood plains.

While the upland, plateau and the pediplain constitute the erosional landscape, the depositional landscape is portrayed by Dobhi-Gayaji stretch of the terrace and the Sone-Ganga plain.

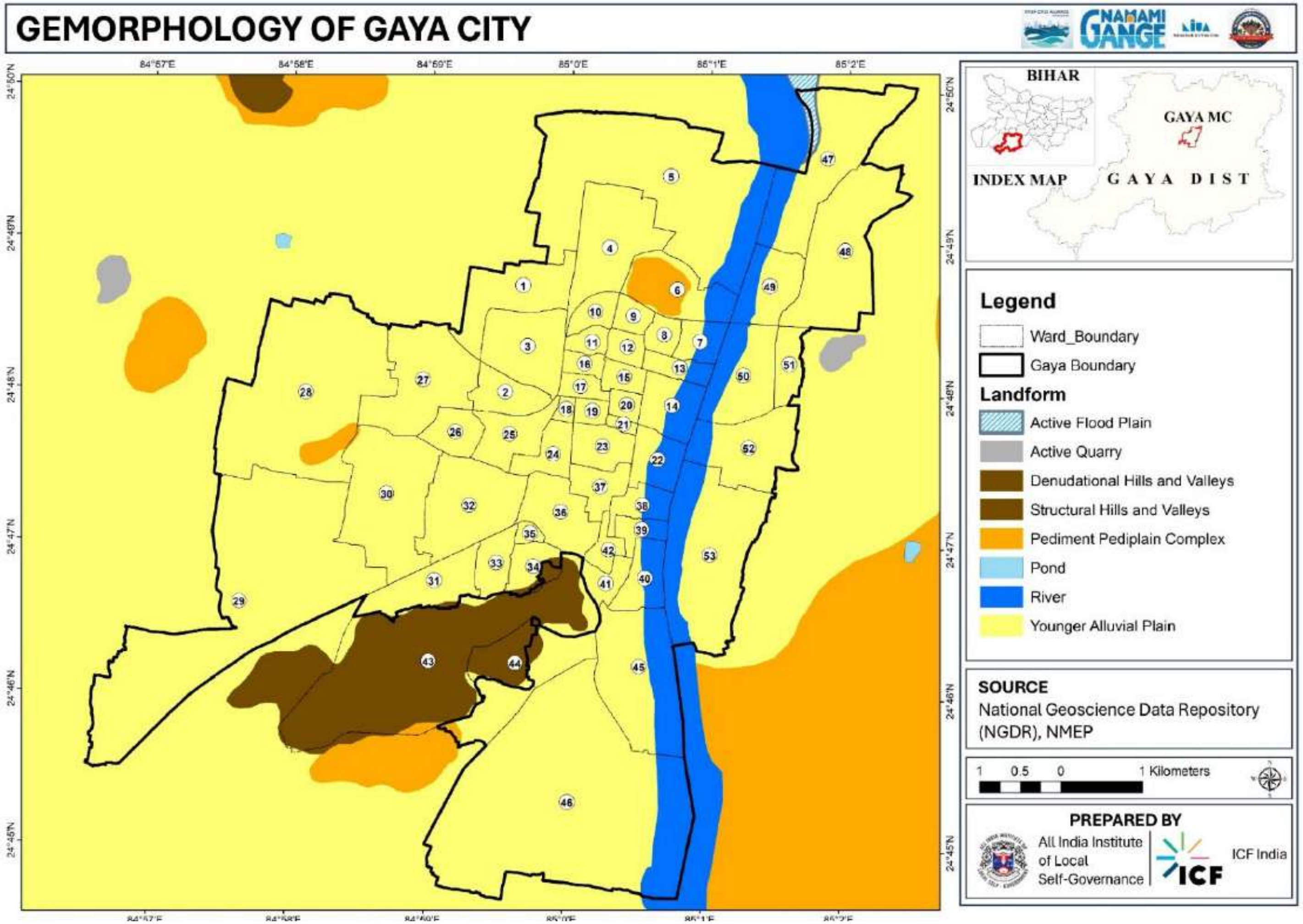
Gayaji and its adjoining Manpur area occupy the central belt where these units interleave. The Gayaji city is surrounded by Ramshila hill (218 m height) on northern side, Katari hill (having 130m height) towards west, and Brahma-yoni hill on the southern side (266 m height). Towards North-West of township at a distance of about 24 Km, there stands the Prêt-shila hill (266 m height) and further north of the town, there exists the

Barabar hill (maximum height of 312 m.) near Balaganj1. Gayaji city sits astride the plateau and pediplain zone, rising gently from 100 m in the floodplain to about 120 m on its western fringes. This pediplain reflects long-continued weathering of the underlying Vindhyan and older formations, leaving a nearly level surface punctuated by isolated residual hills (Mangla Gauri, Ram Shila, Brahmayoni).

Along the eastern margin of town, the ground steps down onto the Dobhi–Gayaji high-level alluvial terrace, formed of older fluvial gravels and sands deposited by ancestral Falgu flows. This bench stands roughly 15–25 m above the modern Falgu floodplain, giving rise to the broad sandy ghats where the river’s intermittent waters spread.

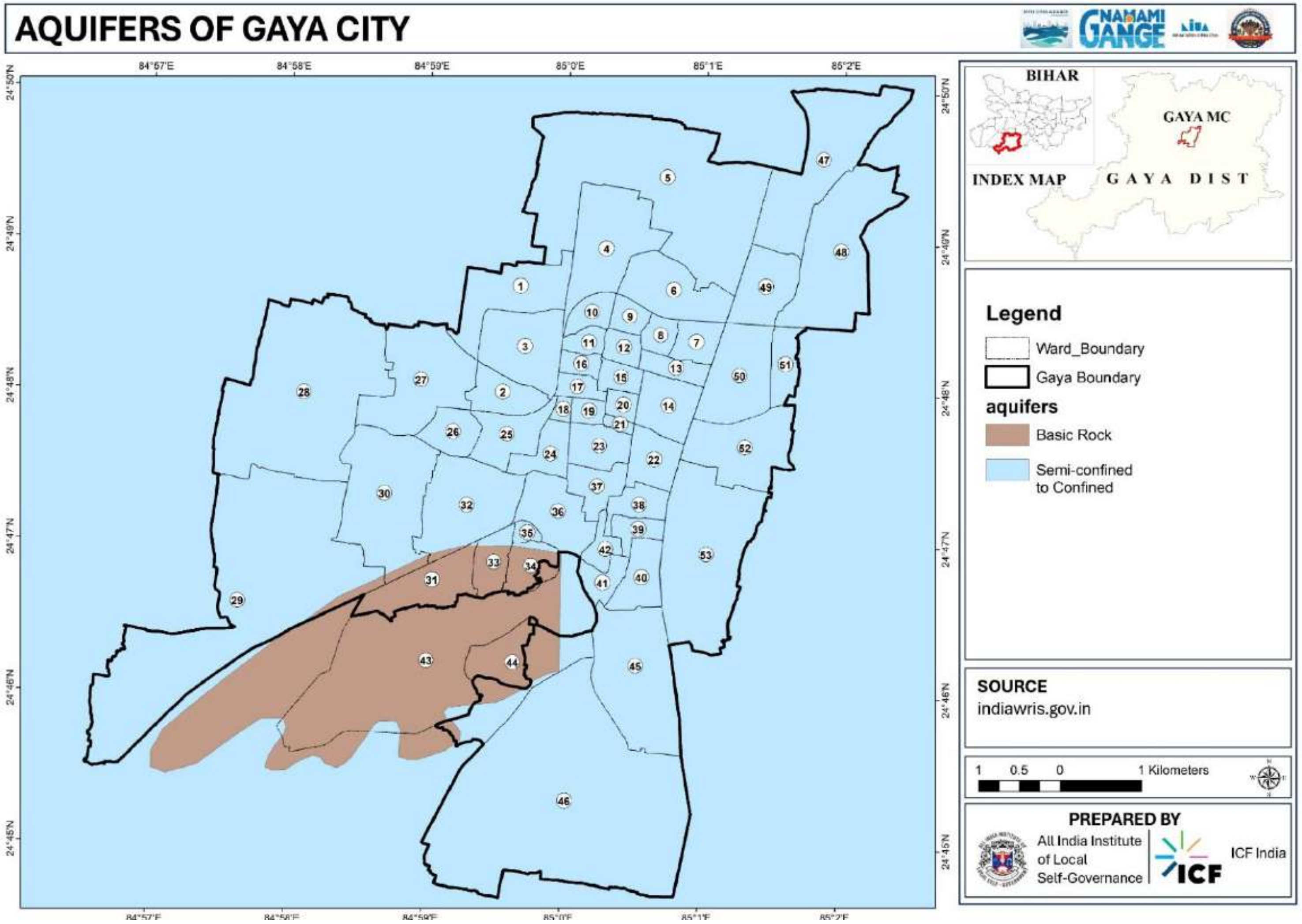
[1] Aquifer Mapping and Management of Ground Water Resources for Gayaji District published by CGWB.

Map 7: Geomorphology Map of Gayaji City



Source: National Geoscience Data Repository (NGDR), NMEP

Map 8: Aquifer Map of Gayaji City



Source: indiawris.gov.in

Manpur lies immediately east and southeast of central Gayaji, perched atop the Falgu River's Dobhi–Gayaji alluvial terrace rather than within the plateau–pediplain unit. This terrace bench, ranging from about 100 to 115 meters above mean sea level, consists of fine to medium sands and silts overlain by a thin veneer of clay–silt. Scattered across its western and southwestern fringes are isolated remnants of the higher plateau and pediplain, where resistant quartzite and shale hillocks rise 10–20 meters above the terrace. These knolls, with their thin silty-clay cover and gentle concave slopes, offer subtle topographic relief against the otherwise flat, very gently sloping surface of the terrace.

Drainage across Manpur is dominated by shallow, ephemeral channels that dissect the terrace surface and funnel storm runoff into tributaries of the Falgu. The well-drained loamy sands of the terrace support intensive plow agriculture and tubewell irrigation, while the slightly elevated terrace margins and old gravel deposits host ceremonial ghats and clustered village settlements. Overall, the geomorphic setting—with its stable terrace platform, discrete upland knolls, and efficient natural drainage—offers a solid foundation for both cultivation and light-weight construction, provided that site-specific subsurface layering is taken into account during planning.

Key Features:

- Elevation band: 100–120 m (pediplain), 85–100 m (terrace)
- Dominant unit: Dobhi–Gayaji alluvial terrace (100–115 m)
- Secondary upland: remnant plateau–pediplain knolls (115–130 m) at the western and southwestern fringes.
- Residual hills: Mangla Gauri, Shringa Sthan, Ram Shila, Brahmayoni.
- Terrace soils: fine gravel and loamy sands over compacted alluvium.
- Modern floodplain (below 85 m) hosts Falgu channels and ghats.
- Drainage: shallow, ephemeral channels dissect terrace surface; knoll runoff drains into Falgu tributaries.
- Land use: intensive plow agriculture and tubewell irrigation on the terrace; ceremonial ghats and settlement clusters occupy the slightly elevated terrace margins.

In both Gayaji town and Manpur, the interplay of ancient pediplanation and Quaternary fluvial processes shapes soil depth, groundwater prospects, and land-use patterns—underpinning the region's hydrology, settlement layout, and ritual landscapes.

Gayaji lies atop the vast Quaternary alluvial deposits of the Middle Ganga Plain. Surface soils (0–0.5 m) in the municipal area are dominated by five major types: black soils, sandy soils, sandy loam soils, alkali soils, and diara (floodplain) soils[2].

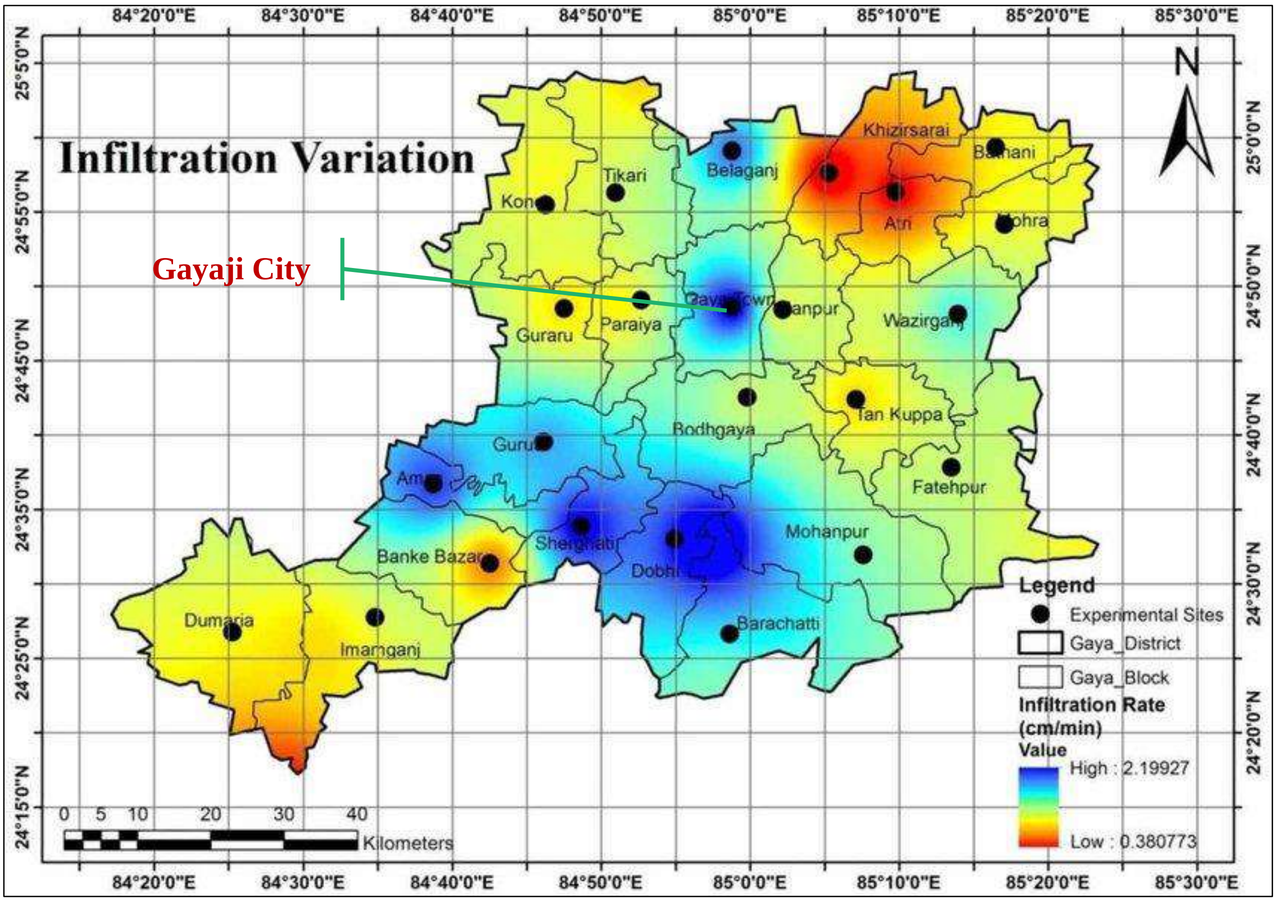
Beneath the topsoil, the alluvial sequence grades from fine silty clays to coarse sands and gravels. This layered profile reflects repeated depositional cycles driven by shifting river courses and monsoon floods.

- 0.5–2 m: Silty clay loam to clay; rich in organic matter from flood-borne sediments.
- 2–10 m: Clayey silt and silty clay, with occasional thin sand lenses. Low permeability zones here slow vertical water movement.
- 10–30 m: Predominantly silty sand; medium permeability supports perched water tables during monsoons.
- 30–60 m: Fine to medium sand layers form the principal phreatic aquifer. Sand thickness can exceed 20 m locally, yielding 10–20 m^3/hr in bore wells.
- 60–100 m: Coarse sand and gravel horizons alternate with silty interbeds. These units constitute a semi-confined aquifer with static water levels typically 15–25 m below ground and transmissivity of 200–800 m^2/day in pumping tests.

[2] https://bausabour.ac.in/Contingency-Plan-pdf/Gayaji.pdf

This stratigraphy underpins Gayaji's groundwater regime: rapid recharge into upper sands during the monsoon, sustained yield from deeper coarse zones in the dry season, and natural filtering through successive fine-grained layers that improve water quality before extraction.

Map 9: Water Infiltration Rate of Gayaji City



Source: https://www.researchgate.net/figure/Prepared-infiltration-map-of-Gayaji-district_fig3_351338229

Investigation of soil infiltration characteristics plays a crucial role in the field of water resource management and environmental protection. Infiltration measurement helps in predicting the runoff from the surface of city after the precipitation and how the soil and water can be conserved. The average infiltration rate of the Gayaji city is up to 2.00 cm/min and the infiltration rate of Manpur is up to 1.04 cm/ min.

3.3.2.Hydrogeology

The occurrence and movement of ground water in the area is variable, which depends on geomorphology, structure, geological setting, hydraulic properties, tectonic setup etc. The hydrogeological condition of Gayaji is complex due to diverse geological terrain vide variability of topography, drainage, etc. Gayaji is situated on the western bank and Manpur on the eastern bank of the Falgu river, which is a non-perennial river because the water flows for a few months during and after the rainy season; the rest of the year remains dry, but the river is the lifeline of the city.

The Gayaji falls under Jamuna sub sub-basin of the Punpun sub-basin of the Ganga basin, whereas Manpur area falls under Mohana-Falgu sub sub-basin of the Kiul sub-basin of the Ganga basin. The drainage network in the Gayaji district is composed by four parallel streams, the Morhar, the Falgu, the Paimar and the Dhadhar. The drainage network in the city is represented by the Falgu, emanating from the southern plateau. The river Falgu flows from south to north through the city where its width is nearly 825m.

The Gayaji district can be divided into two main units viz, (A) Fissured formations and (B) Porous formations. Hydrogeologically, the Gayaji city falls under both the Fissured formations as well as Porous formation. The quaternary recent alluvium occurring in central valley (Dobhi – Gayaji terrace) as well as Sone – Ganga plain constitute the porous hydrological unit. It consists of alluvial sediments made up of gravel, sand, silt and clay. The formation of gravel and medium to coarse sand layers are good ground water repositories. The thickness of the alluvium deposit is nearly 30 to 50m but actual thickness of water bearing zone varies from 15m to 20m. In these alluvium the ground water is in phreatic condition. The subsurface explorations indicate increase in thickness of sandy horizon eastward towards river Falgu. The Quaternary unconsolidated alluvium that blankets the Falgu floodplain and skirts Gayaji city's western bank consists of recent alluvial deposits—clay, silt, sand, and gravel—and exhibits a moderate groundwater yield potential of 50–100 m^3/hr. This aquifer zone underpins the city's shallow tube wells and hand pumps. Most of the water pumping stations of city are installed along the river bank for water supply to the town.

Fissured formation aquifer is shallow and Porous formation is deeper. The shallow aquifers are chiefly constituted by the alluvial overburden, weathered residuum. The alluvium comprises of clay of different grades of sand. Shallow aquifers are chiefly constituted by alluvium overburden, weathered residumm, and shallow fractures within 30-40 m depth. Deeper Porous formation aquifer is characterized by fractures beyond the depth of 30-40m. The exploratory well data of CGWB, reveals that tube wells of 120-150 m depth discharge at 3.00 m^3/hr with drawdown 9.49 m.

Table 1: Discharge Rate of Ground Water in the City

Sl. No.	Location of Borehole	Type of Well	Drilled Depth (m)	Casing Depth (m)	Zone encountered (mbgl)	Depth to Water Level (mbgl)	Formation	Discharge (m^3/hr)	Drawdown (m)
1	Gayaji College	EW	123.92	31.50	42-43	26.02	Granite Gneiss	3.00	9.49

Source: Aquifer Mapping and Management of Ground Water Resources for Gayaji District published by CGWB.

The geology of Gayaji city is described under Quaternary sediments comprising younger and older alluvium. Recent alluvial deposits, clay, silt, sand and gravel are all found in the city of Gayaji. Older Alluvium occupies the topographic high position within the valley. The Present Day flood plain has been developed as small discontinuous patches along the river Falgu. The landforms constitute point bars, lateral bars and channel bars.

PHED wells supplying water to people at Gayaji town close to Brahmayoni Pahar in the south is 19.8 to 21.3 m deep sunk in the western bank of the river Falgu. They tap nearly 12 m of aquifer consisting of coarse sand. There is 6.0 m thick clay between 6.0 to 12.0 depth ranges. Otherwise, it is overlain and underlain by the coarse sand. The basement has been encountered at the bottom of the wells.

Central Ground Water Board has carried out hydrogeological surveys and ground water exploration in the district. Ground water regime monitoring is carried out 4 times annually from 15 HNS wells in the district. Water samples are collected during the month of May to study the changes in water quality along with monitoring of pre-monsoon water level.

As part of the quality of Gayaji water supply, water sampling is done on 15 June 2015 and the laboratory analysis was carried out by SGS India Pvt. Ltd. under contract with PMC. The results are shown in below Table. With the results, it is concluded that the water currently abstracted from the aquifer to be used for this water supply project is safe for drinking.

Table 2: Ground Water Quality of Gayaji City in 2015

Sl. No.	Parameters	Panchayati Akhara (Sample 1)	Dandibagh (Sample 2)	Acceptable Limit*	Permissible Limit*
Physicochemical					
1	BOD (27°C for 3 days) mg/L	BDL	BDL	–	–
2	COD mg/L	< 5.0	< 5.0	–	–
3	Calcium as Ca mg/L	56.7	26.7	75	200
4	Chloride as Cl mg/L	55.8	14.0	250	1000
5	Residual free Chlorine mg/L	BDL	BDL	0.2	1
6	Colour in Hazen unit	10	10	5	15
7	Fluoride as F mg/L	0.3	0.3	1.0	1.5
8	Total hardness as $CaCO_3$ mg/L	210.1	99.0	200	600
9	Magnesium (Mg) mg/L	16.7	7.9	30	100
10	Nitrate as NO_3 mg/L	5.29	2.20	45	No Relaxation
11	pH at 25°C	7.58	7.84	6.5–8.5	No Relaxation
12	Sulphates as SO_4 mg/L	9.6	6.3	200	400
13	TDS mg/L	311.2	165.6	500	2000
14	Arsenic as As mg/L	BDL	BDL	0.01	0.05
15	Total Chromium as Cr mg/L	BDL	BDL	0.05	No Relaxation
16	Copper (Cu) mg/L	BDL	BDL	0.05	1.5
17	Lead (Pb) mg/L	0.010	BDL	0.01	No Relaxation
18	Manganese (Mn) mg/L	BDL	BDL	0.1	0.3
19	Cadmium (Cd) mg/L	BDL	BDL	0.003	-
20	Amoniacal Nitrogen as N mg/L	BDL	BDL	–	–
21	Dissolved Oxygen (DO) mg/L	3.4	4.5	–	–
22	Conductivity at 25°C µS/cm	497	266	–	–
23	Oil and Grease mg/L	BDL	BDL	–	–
24	Iron (Fe) mg/L	0.06	0.07	0.3	No Relaxation
25	Zinc (Zn) mg/L	0.02	0.02	5	15
26	Sodium (Na) mg/L	47.49	21.28	–	–
27	Potassium (K) mg/L	2.78	BDL	–	–
28	Total Phosphates as PO_4 mg/L	0.37	BDL	–	–
29	Total Suspended Solids (TSS) mg/L	BDL	BDL	–	–
30	Temperature °C	30.6	30.5	–	–
Pesticides					
31	Methyl parathion µg/L	< 0.01	< 0.01	-	0.3
32	Malathion µg/L	< 0.01	< 0.01	-	190
33	Chlorpyriphos µg/L	< 0.01	< 0.01	-	30
34	DDT (o,p & p,p isomers of DDT, DDE, DDD) µg/L	< 0.01	< 0.01	-	1
35	Gamma HCH µg/L	< 0.01	< 0.01	-	2
36	Alpha HCH µg/L	< 0.01	< 0.01	-	0.01
37	Beta HCH µg/L	< 0.01	< 0.01	–	0.04
38	Delta HCH µg/L	< 0.01	< 0.01	–	0.04

Sl. No.	Parameters	Panchayati Akhara (Sample 1)	Dandibagh (Sample 2)	Acceptable Limit*	Permissible Limit*
39	Endosulfan Sulphate (α, β & sulphate) µg/L	< 0.01	< 0.01	–	0.4

*Note: BDL = Below Detectable Limit; *IS 10500: 2012 Standard*
Source: Detailed Project Report – Gayaji WS – Pack1, 2016.

Table 3: Quality of Ground Water Underlying Agriculture Fields of Gayaji City in 2015

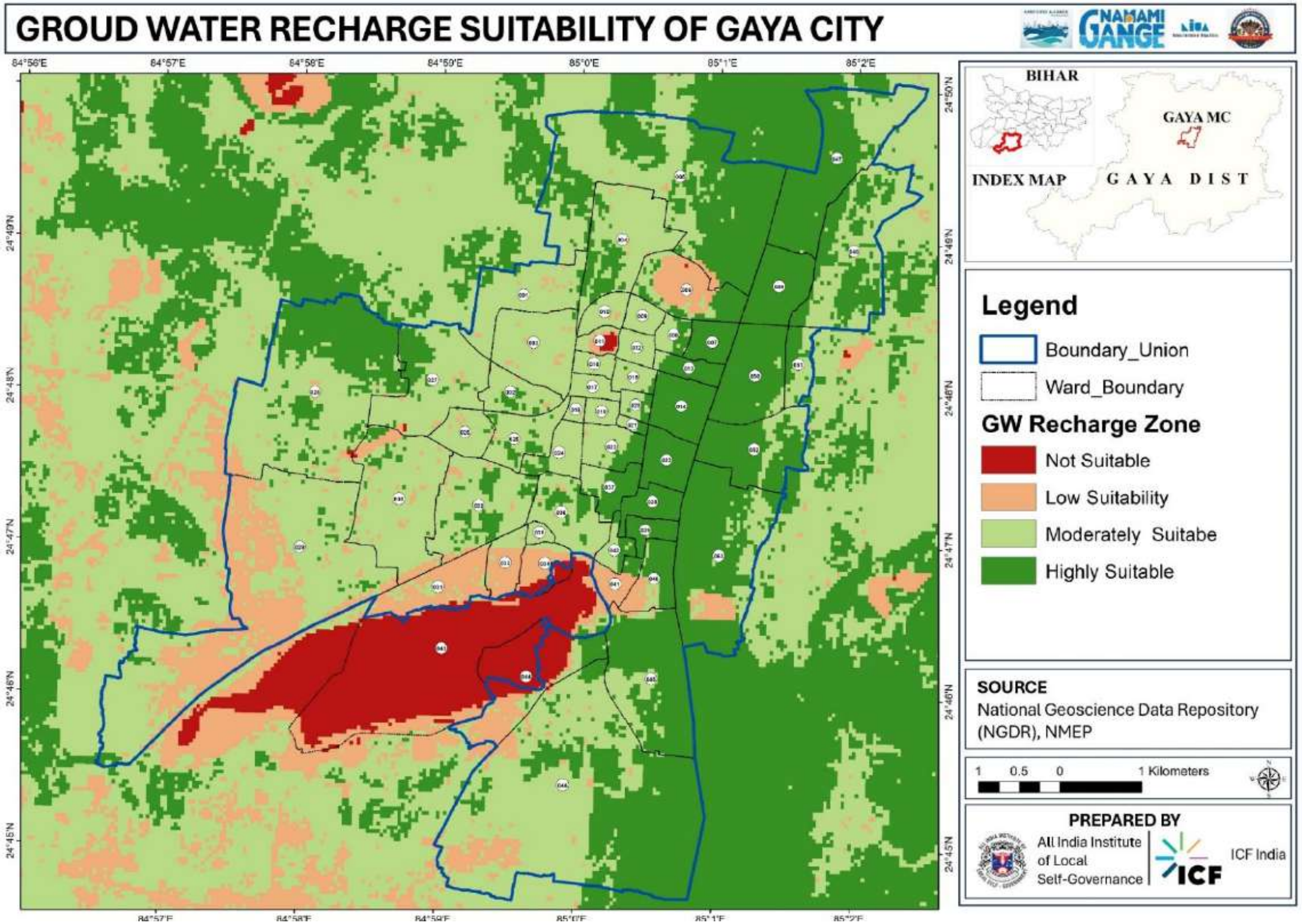
Sl. No.	Parameter	Khiriyawa Village	Amwan Village	Acceptable Limit	Permissible Limit
1	Methyl parathion µg/L	< 0.01	< 0.01	–	0.3
2	Malathion µg/L	< 0.01	< 0.01	–	190
3	Chlorpyriphos µg/L	< 0.01	< 0.01	–	30
4	DDT (o,p- and p,p- isomers of DDT, DDE, DDD) µg/L	< 0.01	< 0.01	–	1
5	Gamma HCH µg/L	< 0.01	< 0.01	–	2
6	Alpha HCH µg/L	< 0.01	< 0.01	–	0.01
7	Beta HCH µg/L	< 0.01	< 0.01	–	0.04
8	Delta HCH µg/L	< 0.01	< 0.01	–	0.04
9	Endosulfan Sulphate (α-, β- and sulphate) µg/L	< 0.01	< 0.01	–	0.4

*Note: BDL = Below Detectable Limit; *IS 10500: 2012 Standard*
Source: Detailed Project Report – Gayaji WS – Pack1, 2016.

Seasonal ground water level fluctuation: Water level fluctuations between May 2019 and November 2019 have been analysed. Observation wells are dug wells and piezometer of minor irrigation department, Government of Bihar.

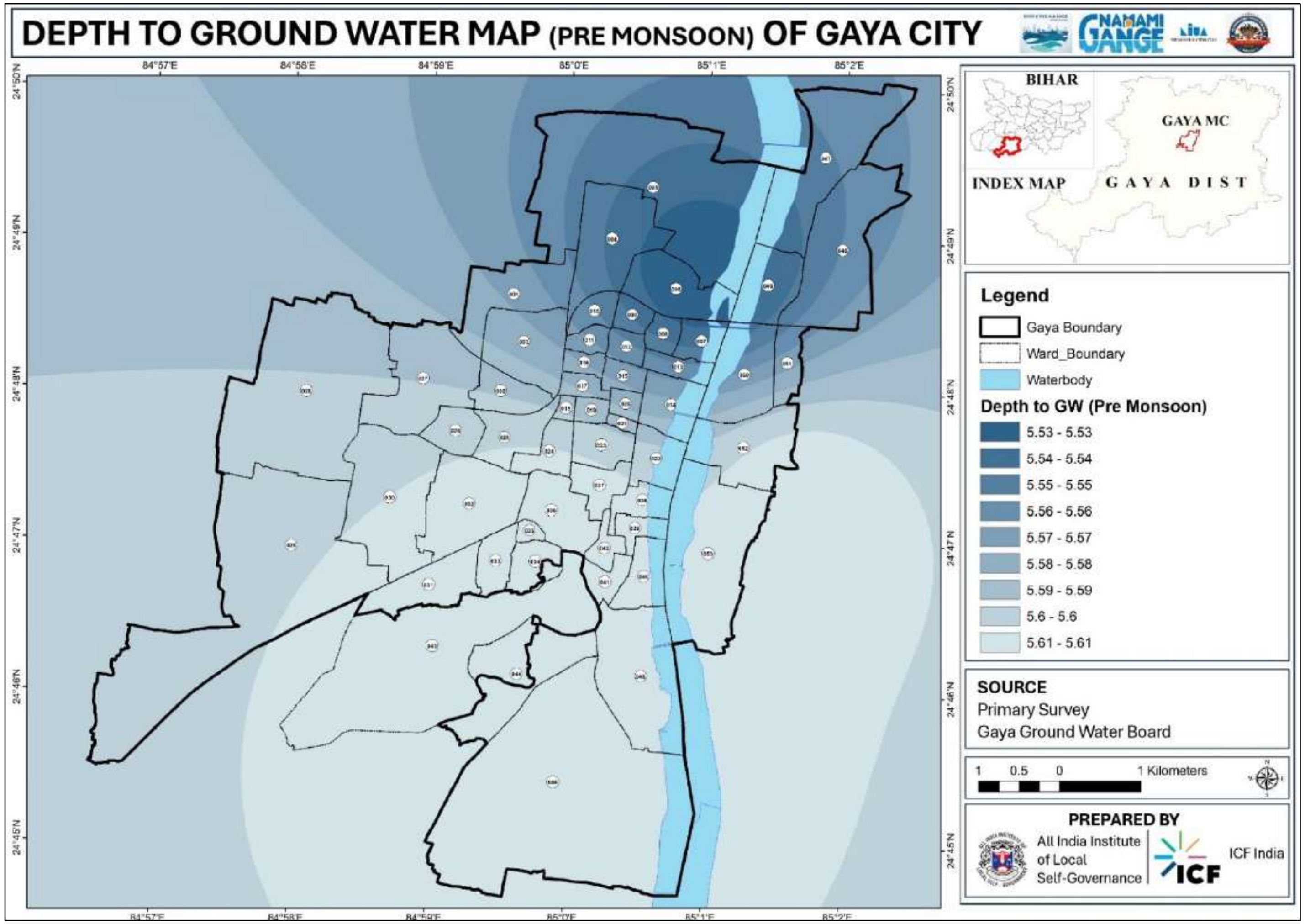
The groundwater-recharge suitability map of Gayaji highlights clear spatial variation driven by topography, soil characteristics, land use, and drainage conditions. Areas classified as not suitable are largely confined to dense built-up zones, rocky hill slopes, and paved surfaces where impervious cover and rapid runoff severely limit infiltration. Low-suitability zones occur mainly in compacted soils and transitional urban areas, where some recharge is possible but constrained by poor permeability and surface sealing. Moderately suitable **areas** are typically found in open lands and agricultural tracts with relatively permeable soils and gentle slopes, allowing partial percolation during monsoon periods. The highly suitable zones are concentrated along riverine alluvium and low-lying floodplain pockets of the Falgu system, where sandy soils, shallow groundwater tables, and natural depressions create favorable conditions for effective groundwater recharge. From the study of the depth to water map, it is evident that average ground water level during pre-monsoon period mainly varies between 5-10 mbgl below ground level in the major part of the city. From the study of the depth to water map, it is conspicuous that average ground water level during post-monsoon period mainly varies between 5-10 mbgl below ground level in the major part of the city.

Map 10: Ground water recharge suitability of Gayaji city



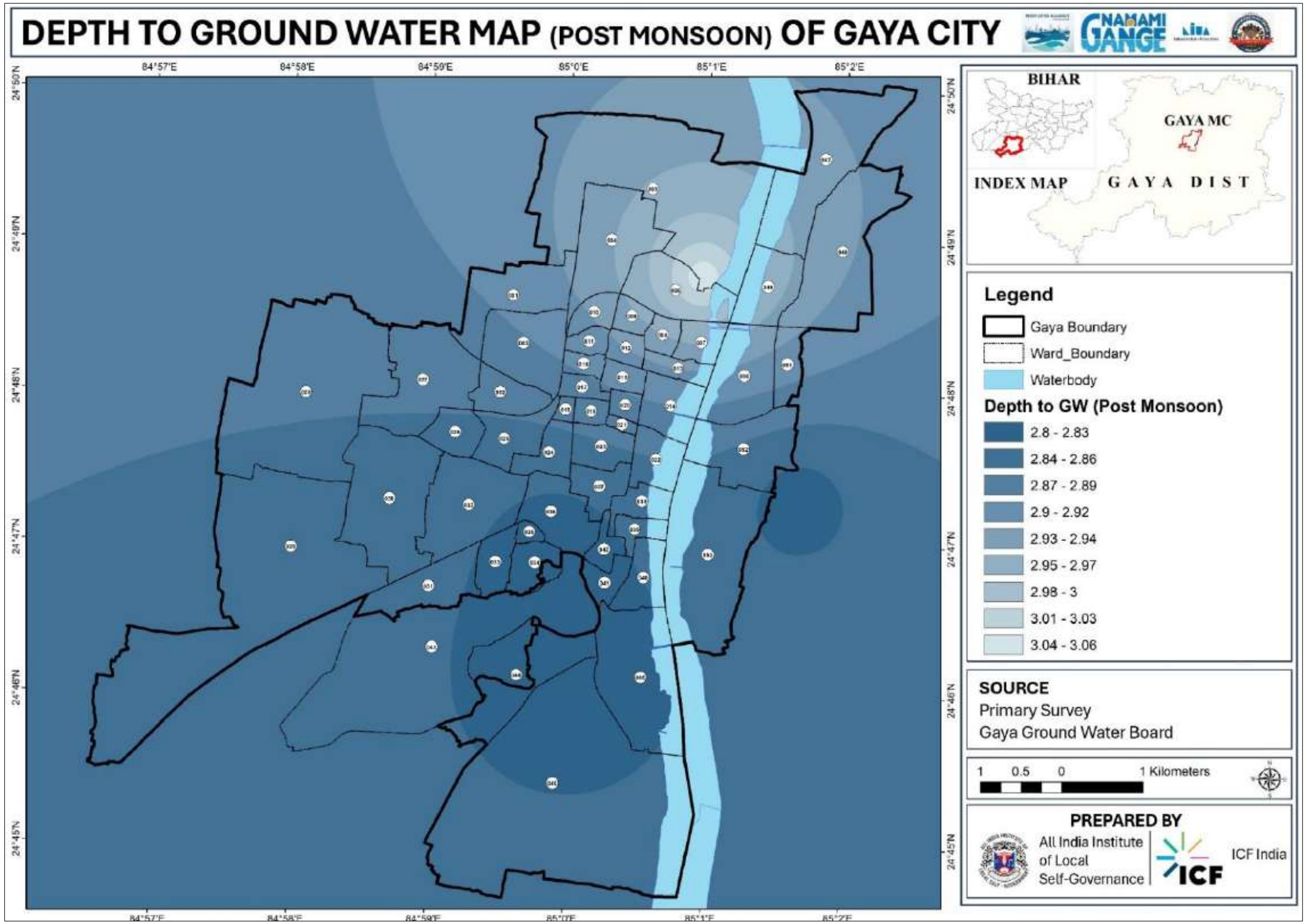
Source: National Geoscience Data Repository(NGDR), NMEP

Map 11: Depth of Ground Water Level during Pre-monsoon in 2025 of City



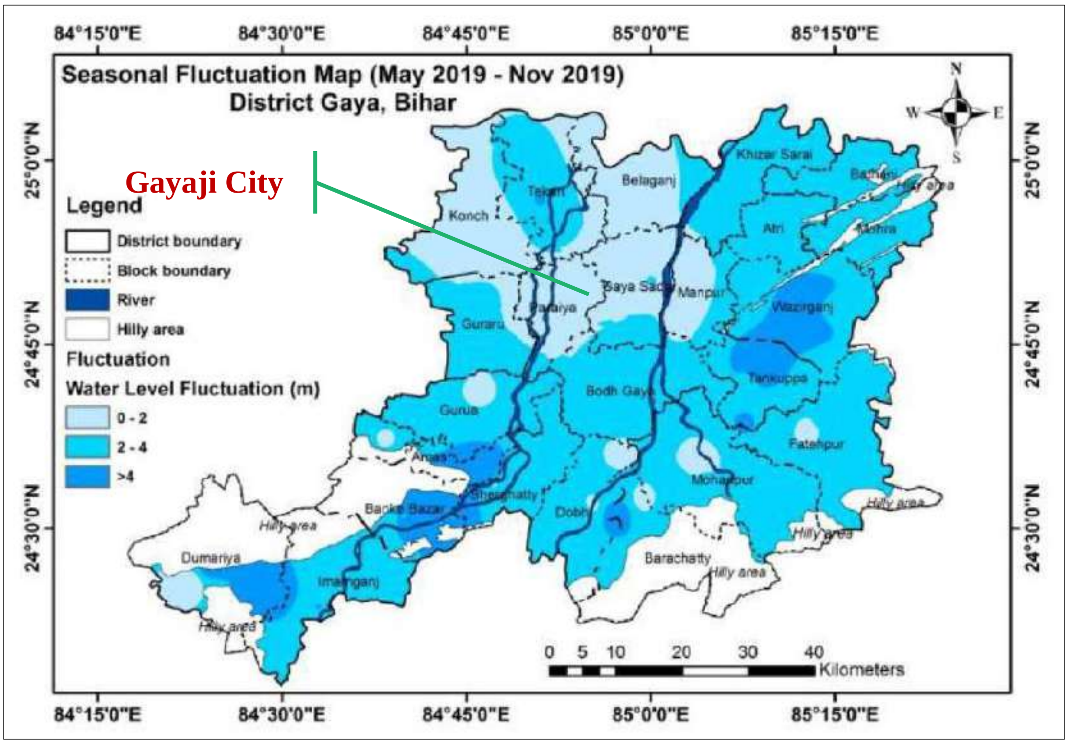
Source: Primary Survey and Gayaji ground water Board

Map 12: Depth of Ground Water Level during Post-monsoon in 2025 of City



Source: Primary Survey and Gayaji ground water Board

Map 13: Seasonal Ground Water Level Fluctuation of the City in 2019



Source: Aquifer Mapping and Management of Ground Water Resources for Gayaji District published by CGWB.

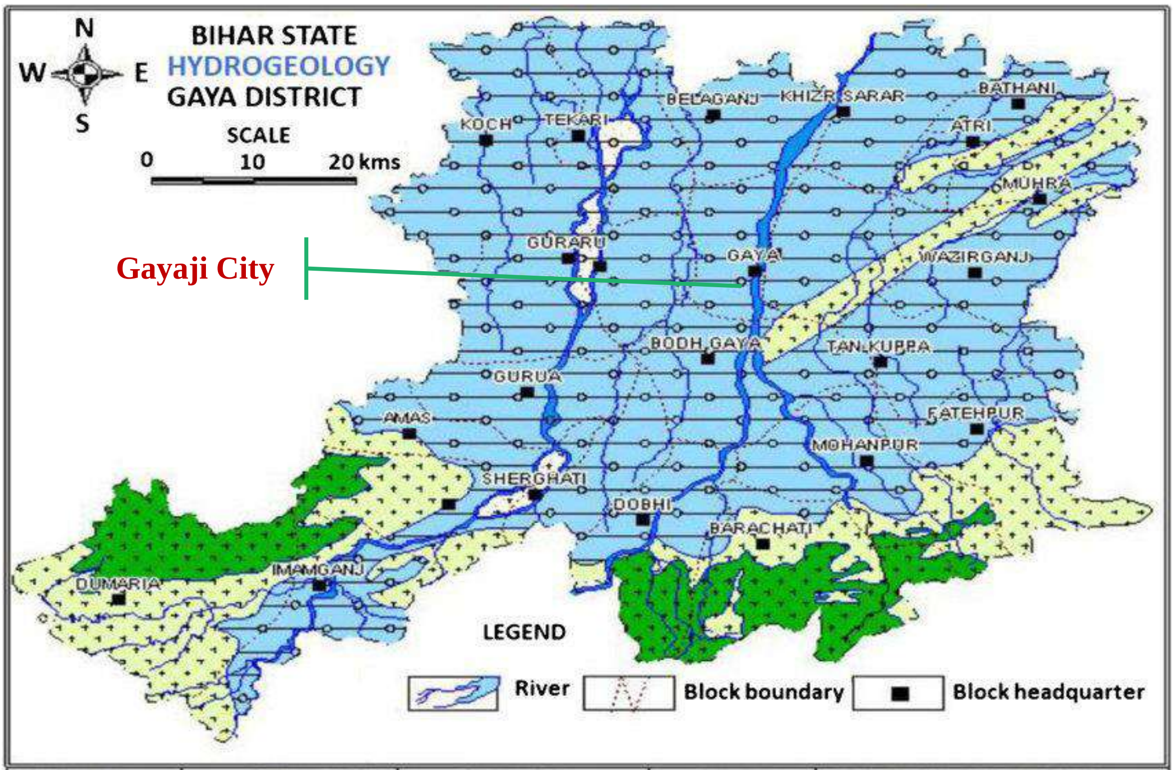
Table 4: Depth of Water Level of Pre-Monsoon and Post-Monsoon of the City

Location of Well	Type of Well	Depth of Well (m)	RL (m)	Depth to Water Level (mbgl		Fluctuation (m)	Water Table (amsl)	
				Pre-Monsoon	Post-Monsoon		Pre-Monsoon	Post-Monsoon
Gayaji City	PZ	55	117.9	27.27	20.43	6.84	90.63	97.47
Manpur	PZ	55	105.8	8.49	7.44	1.05	97.31	98.36

Source: Aquifer Mapping and Management of Ground Water Resources for Gayaji District published by CGWB.

The Quaternary unconsolidated alluvium that blankets the Falgu floodplain and skirts Gayaji city's western bank consists of recent alluvial deposits—clay, silt, sand, and gravel—and exhibits a moderate groundwater yield potential of 50–100 m³/hr. This aquifer zone underpins the city's shallow tube wells and hand pumps.

Map 14: Hydrogeological Map of the City



FORMATION	AGE GROUP	LITHOLOGY	SYMBOL	GROUND WATER POTENTIAL
Unconsolidated	Quaternary	Recent alluvium, clay, silt, sand, gravel etc.		Moderate yield 50-100 cu.m./hr
Consolidated	Pre-cambrian	Quartzite / Mica schist Granite gneiss		Poor yield prospect 20-50 cu.m./hr

Source: Aquifer Mapping and Management of Ground Water Resources for Gayaji District published by CGWB.

Table 5: Dynamic GW resources, availability, utilisation and GW extraction (March, 2020) in City

Assessment Unit Name	Recharge from Rainfall – Monsoon Season (Ham)	Recharge from Other Sources – Monsoon Season	Recharge from Other Sources – Non-Monsoon	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Domestic and Industrial	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025	Net Ground Water Availability for Future Use	Stage of Ground Water Extraction (%)	Categorization
MANPUR	2,653.97	618.46	679.27	4,021.69	402.17	3,619.52	3,310.53	426.69	3,737.22	287.22	0	103.25	Over Exploited

Assessment Unit Name	Recharge from Rainfall – Monsoon Season (Ham)	Recharge from Other Sources – Monsoon Season	Recharge from Other Sources – Non-Monsoon	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Domestic and Industrial	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025	Net Ground Water Availability for Future Use	Stage of Ground Water Extraction (%)	Categorization
GAYAJI	4,113.09	222.19	282.26	4,726.00	4,726.00	4,253.40	1,163.82	2,655.85	3,819.67	2,619.39	146.19	89.80	Semi Critical

Source: Aquifer Mapping and Management of Ground Water Resources for Gayaji District published by CGWB.

3.3.3.Morphometry

Beyond its spiritual significance, the river's morphometric characteristics like form, structure, length, drainage density are central to understanding both its geomorphic evolution and the multiple anthropogenic and climatic pressures that have driven substantial change in recent decades.

In the dry months (November–June), the Falgu's main channel between the Bodh Gayaji confluence and Gayaji's northern boundary—about 32–35 km within the municipal limit shrinks to a shallow trickle across its wide, sandy bed, then reactivates in the monsoon, often inundating nearby villages and farmland. Across the entire basin, the mapped network of tributaries and distributaries exceeds 1000 km in a dendritic to semi-dendritic pattern.

Table 6: Key Channel Widths (at peak monsoon)

Location	River Width (m)
Gayaji (Vishnupad area)	820+
Bodh Gayaji Confluence	500–600
Downstream Ghats	60–450

At peak monsoon, widths surpass 820 m at Vishnupad in Gayaji, 500–600 m at the Bodh Gayaji confluence, and range from 60 to 450 m along downstream ghats, whereas pre-monsoon measurements can drop below 100 m at some sites. Urban bank reinforcement and accelerated siltation have reshaped the cross section, in places intensifying erosion where the channel was once broader.

The total length of all streams per unit basin area is a fundamental indicator of drainage efficiency, runoff potential and infiltration capacity. In the Falgu basin, drainage density is inherently shaped by lithology, slope and anthropogenic alteration over time.

Table 7: Morphometric Parameter Evolution

Parameter	1980s–1990s	1994–2000	2010–2015	2018–2025	Explanation
Main Channel Length	Approx. 34 km	Approx. 34 km	Approx. 32.5 km	Approx. 32 km	Slight contraction due to channelization, sand extraction
Drainage Density (Km/Km^2)	2.0	1.9	1.89	1.87 (urban core)	Minor loss of branch lines, canalization effects

Source: Ranjan, R.K., Ramanathan, A., Parthasarathy, P. et al. Hydrochemical characteristics of groundwater in the plains of Falgu River in Gayaji, Bihar, India. Arab J Geosci 6, 3257–3267 (2013).

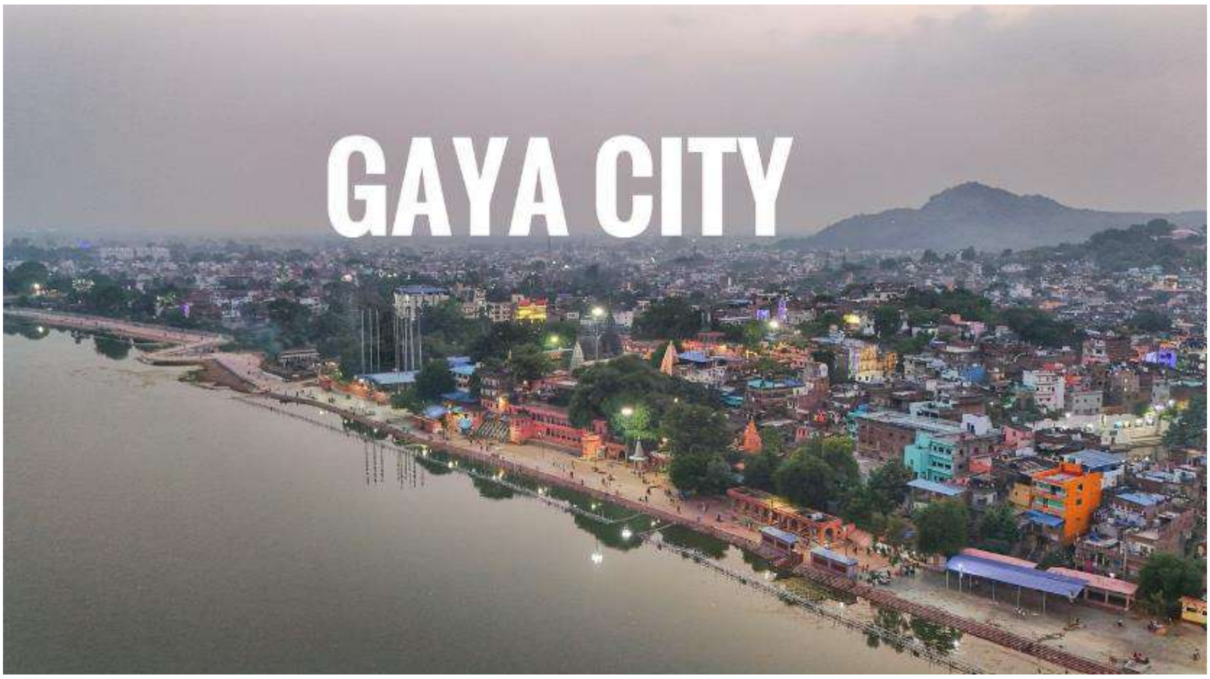
The longitudinal gradient is negligible through Gayaji, elevation drops very gradually and the riverbed is mostly level. Relief between banks at heavily mined locations (e.g., Sultanpur Ghat) can vary by 3–4 m due to extraction pits, contributing to local dereliction and bank erosion. Relief and cross-sectional profiles taken in the last five years document ongoing channel flattening and reduction in natural levee development.

3.4. Biodiversity Status

1. **Flora:** Native riparian vegetation includes Madhuca longifolia, Ficus racemose, Ficus religiosa[3] (Peepal), Madhuca longifolia (Mahua), Terminalia arjuna and Tamarix dioica[4]. However, invasive species like Salvinia molesta and Eichhornia crassipes dominate disturbed stretches and floodplain ponds.
2. **Aquatic Fauna:** Aquatic fauna is primarily found in its various ponds and the sacred Falgu River which support diverse native fish species including Rohu, Catla, Mrigal, walking catfish and snakehead Channa striata.
3. **Terrestrial Biodiversity:** Inventories of 12 urban open spaces and five temple groves in Gayaji recorded 85 native plant species[5] (e.g., Ficus religiosa, Terminalia Arjuna) and 35 resident and migratory bird species (e.g., Asian koel, Indian paradise flycatcher). These green patches serve as invaluable biodiversity refuges but remain isolated by roads, built-up areas, and sprawling developments. Encroachment into adjacent agricultural lands has severed ecological linkages between these groves, open spaces, and the Falgu River hinterland, disrupting wildlife movement and genetic exchange.

Figure 10: Types of flora and fauna

[3] District Gazetteer of Gayaji (1907; revised 1979)
[4] https://actascientific.com/ASAG/pdf/ASAG-03-0595.pdf
[5] Department of Botany, Magadh University, in collaboration with Bihar State Biodiversity Board and Gayaji Municipal Corporation (2017–2019)



BASEMENT ASSESSMENT-SUMMARY

4. BASELINE ASSESSMENT-SUMMARY

4.1. URMP Index for Gayaji City

Move Summarizing the score achieved across the 10 objectives:

Sl. No	URMP Objective	Indicator/ score	Score achieved
1	Regulation of activities in Flood planning and	Flood plain management score	1
2	Pollution Free River	Net dissolved oxygen score	awaited
3	Rejuvenation of Waterbodies	Waterbody revival score	1
4	Enhancing riparian buffer	Riparian buffer score	1
5	Increased reuse of treated used water	Wastewater reuse score	1
6	Maximum Good Quality return Flow	Return flow score	1
7	Eco-friendly riverfront projects	Eco friendly riverfront score	2
8	Leveraging on economic potential of river	River economy score	4
9	River Sensitive Behaviour Among citizens	Citizen sensitization score	2
10	Engage Citizens in River management	Citizen engagement score	5

URM index = (1+0+1+1+1+1+2+4+2+5) /9* = 18/9 = 2

***In this case, as we do not have DO Score, we will average it by 9**

URM Index for Gayaji city = 2 (Average Level of river management)

As per URMP Framework, Gayaji city has an Elementary level of urban river management

Overall, Gayaji's baseline assessment indicates a city at a critical inflection point: one where ecological risk, if left unmanaged, could intensify rapidly, but where strategic planning, regulatory clarity, and integrated investments could unlock significant environmental, economic, and social gains under the URMP. Gayaji's score profile highlights a high-risk, high-opportunity city. With targeted interventions in floodplain zoning, wastewater reuse, waterbody restoration, and structured citizen engagement, the city has the potential to significantly improve its URM performance in subsequent assessment cycles.

4.2. SWOT analysis

Based on the baseline assessment and consultations with city stakeholders, the following SWOT analysis has been prepared for the Falgu and its associated water bodies in Gayaji. This provides a diagnostic basis for identifying intervention areas under the URMP.

ENVIRONMENTAL

Key focus: Treatment of wastewater, groundwater quality improvements, trunk infrastructure creation, flood plain management, pollution control, rejuvenation of inland water bodies and drains

STRENGHTS
- Natural drainage
- Wide riverbed
- Cultural identity

WEEKNESS
- Sewer deficit
- Industrial pollution
- Low vegetation

OPPORTUNITIES
- Sewer upgrade
- Constructed wetlands
- Green buffer

THREATS
- Encroachment
- Hydrological instability
- Lean flows


Natural Drainage


Encroachment

Water pipeline


Drainage outfall

ECONOMIC

Key focus: Leveraging the economic potential of the riverfront and other economic activities

STRENGHTS
- Pilgrimage tourism
- Successful Projects

WEEKNESS
- Seasonal income
- Informal economy

OPPORTUNITIES
- Year-round economy
- Tourism capture
- Redevelpment of ghats
- Rejuvenation of waterbodies

THREATS
- Infra mismanagement


Household industries


Rejuvunated waterbodies


Vishnupad Temple


Pitra paksh mela

SOCIAL

Key focus: Citizen sensitization and awareness on the importance of the river and mobilisation of community led efforts in managing river's health

STRENGHTS

-Community participation
-Cultural attachment
- Support networks

WEEKNESS

- Behaviour change
- Livelihood gaps

OPPORTUNITIES

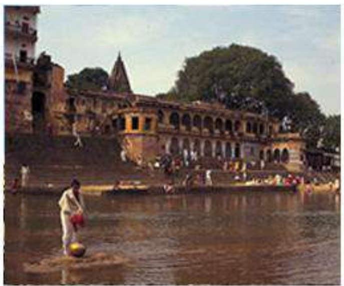
- Public awareness
- Sanitation literacy

THREATS

- Development Pressure

Active Ghats

Open dumping



landmark religious sites

Encroachments

INTERVENTIONS

5. INTERVENTIONS

5.1 Objective 1: Regulation of Activities in the Floodplain

Objective 1 *aims to regulate activities within the floodplain to safeguard river health. This includes ensuring land-use compliance, preventing encroachment, and aligning development with river-sensitive planning and zoning norms*

Element :ENVIRONMENTAL

Significance:

Floodplains act as nature's **safety valves, absorbing excess floodwater, replenishing groundwater, and providing fertile land for biodiversity.** When these zones are encroached upon by settlements, industries, or unsustainable farming, both people and ecosystems face increased risks. Poor regulation often leads to **amplified flood damage, erosion, and long-term river degradation.** Protecting floodplains is therefore not only an ecological necessity but also an urban resilience strategy that safeguards life, infrastructure, and economic activity.

Scope as per URMP:

- River and flood plain zoning, policies and regulations
- River-sensitive urban planning
- Enforcing no-development zones
- Strengthening law enforcement within the floodplain

5.1.1.Exisiting Situation

Gayaji Ji City is located directly along the banks of the Falgu River, which flows through the urban core and historically functioned as the city's primary riverfront. However, for a significant part of the year—particularly during the lean season the Falgu remains dry or carries minimal surface flow, resulting in a fragmented and inactive riverfront condition. Despite the river's central alignment with the city and its immense religious significance, large stretches of the riverbed remain underutilized and disconnected from everyday urban life. Land along the riverbanks and within the riverbed is largely classified as public or riverine land under state jurisdiction, though portions have experienced informal occupation and encroachment over time. While some ghats and religious precincts, particularly near the Vishnupad Temple, are actively used, much of the river edge lacks structured development, clear access, or ecological buffering. Topographically, Gayaji Ji City and the Falgu river corridor are predominantly flat, with limited elevation variation between the urban edge and the riverbed. The river's wide sandy bed and seasonal flow regime are a result of high sediment deposition and reduced upstream discharge. This geomorphological condition, combined with altered natural drainage channels and encroachments, constrains effective stormwater conveyance. Consequently, the city remains vulnerable to localized flooding during intense rainfall events, even as the river remains dry for much of the year.

Figure 11: Exisiting riverriver edge analysis

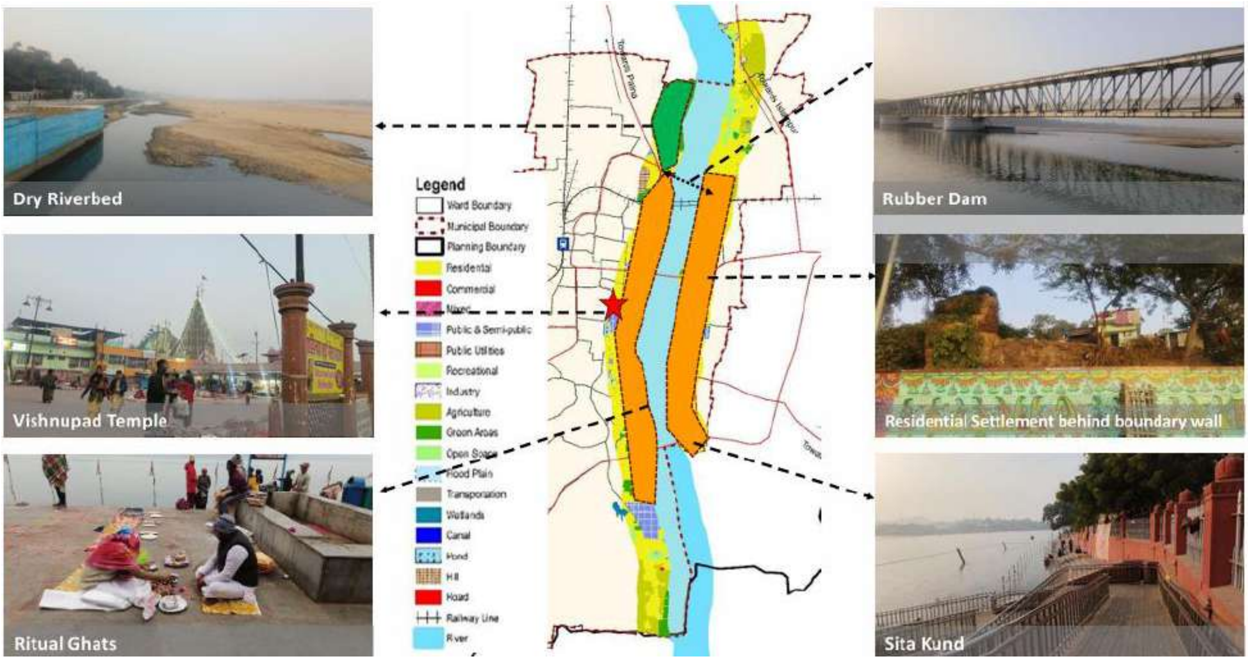
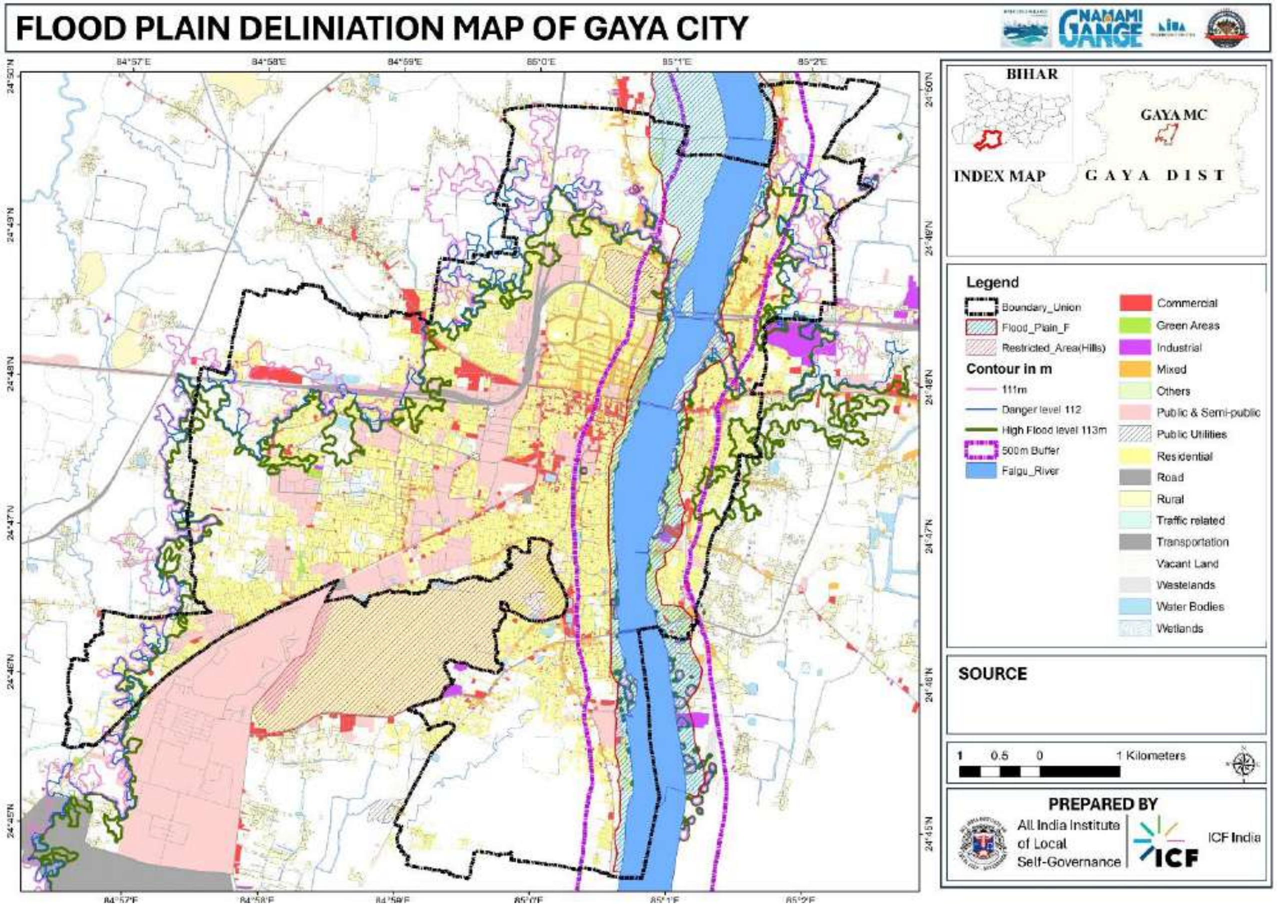


Figure 12: Exisiting Riverfront development

5.1.2.Floodplain Characteristics and Land Use Dynamics

Figure 13: Flood plain delineation map of Gayaji City



Source: AIILSG and ICF Analysis for URMP Bihar, URMP Report, 2026

Introduction and Conceptual Framework

Flood susceptibility refers to the intrinsic tendency of a terrain to experience inundation based on its physical, hydrological, environmental and anthropogenic characteristics. The approach adopted in this study follows a multi-criteria decision analysis (MCDA) framework using the Analytical Hierarchy Process (AHP) integrated with GIS-based weighted overlay analysis. The methodology is structured in two sequential components:

1. Preparation of Flood Susceptibility Map using terrain, hydrological, land surface and proximity-based parameters.
2. Delineation of Floodplain by combining the susceptibility output with High Flood Level (HFL) contour and modification using hydraulic barriers such as roads, railway embankments, dams and ghats.

The entire workflow is designed to be technically defensible and suitable for use in EIA studies, urban planning, disaster management plans and regulatory submissions.

Data Used and Sources

The study utilizes only authoritative and standard datasets to ensure reliability of outputs.

Dataset	Source	Resolution / Scale	Purpose
Digital Elevation Model (DEM)	SRTM Arc 1 Second Global	~30 m	Terrain analysis, slope, elevation, drainage, TWI
Satellite Imagery	Landsat 9 OLI, dated 15 November 2025	30 m	NDVI and LULC preparation
Soil Data	WRIS India Portal	Vector thematic	Soil texture and infiltration characteristics
River, Road, Railway layers	AIILSG	Vector GIS layers	Proximity analysis and hydraulic barrier identification
Contour Data	Derived from DEM	1 m / 5 m interval	Identification of 112 m HFL contour

All datasets were projected to a common coordinate system (UTM, WGS 84 datum) and resampled to a uniform spatial resolution of 30 m to maintain consistency in raster-based analysis.

Pre-processing of Datasets

The DEM obtained from SRTM Arc 1 Second Global was subjected to sink filling to remove spurious depressions using hydrological correction tools. This step is critical for ensuring reliable derivation of hydrological parameters such as flow direction, flow accumulation, drainage network and TWI.

Landsat 9 imagery was radiometrically corrected and atmospherically normalized. Cloud-free scenes were selected and clipped to the study area boundary. Soil and vector layers (river, road, railway) were cleaned for topology errors and clipped to the study area.

All thematic layers were converted into raster format at 30 m resolution for integration in the weighted overlay stage.

Derivation of Flood Conditioning Parameters

Elevation

Elevation was directly derived from the DEM. Lower elevation areas generally exhibit higher flood susceptibility due to gravitational flow accumulation. The elevation raster was classified into five susceptibility classes using natural breaks, where lower elevation zones were assigned higher susceptibility ranks.

Slope

Slope was generated from the DEM using standard slope algorithms in degrees. Gentle slopes favor water stagnation and prolonged inundation, whereas steep slopes promote rapid runoff. Accordingly, slope values were reclassified such that low slope classes received higher flood susceptibility ranks.

Drainage Density

Drainage density represents the ratio of total stream length to the area of a drainage basin. Flow direction and flow accumulation were derived from the DEM, followed by stream network extraction using a suitable accumulation threshold. Sub-watersheds were delineated and drainage density was calculated for each sub-watershed. The resulting drainage density map was then interpolated and rasterized for spatial analysis. Higher drainage density zones were considered more flood-prone due to increased runoff concentration.

Topographic Wetness Index (TWI)

TWI was derived from the DEM using the equation:

$$TWI = \ln (As / \tan \beta)$$

Where as represents the upslope contributing area and β represents the local slope. Flow accumulation and slope layers were used to compute TWI. Areas with high TWI values indicate zones of water convergence and saturation potential and were therefore assigned higher susceptibility ranks.

Buffer from River

The river network obtained from AIILSG was used to generate multiple buffer zones (e.g., 0–100 m, 100–250 m, 250–500 m, >500 m). Proximity to river channels directly influences flood exposure. Areas closer to rivers were assigned higher susceptibility rankings.

Land Use Land Cover (LULC)

LULC classification was performed using supervised classification on Landsat 9 imagery. Major classes such as built-up, agricultural land, barren land, water bodies, vegetation and wetlands were identified. Impervious surfaces such as built-up areas and barren land were ranked higher due to reduced infiltration and increased surface runoff, while dense vegetation areas were ranked lower.

NDVI

NDVI was computed using Landsat 9 bands:

$$NDVI = (NIR - Red) / (NIR + Red)$$

Lower NDVI values represent sparse vegetation and higher runoff potential, thus receiving higher flood susceptibility ranks. Higher NDVI areas indicate dense vegetation and improved infiltration, therefore receiving lower ranks.

Soil

Soil texture data from WRIS was reclassified based on infiltration characteristics. Clayey soils with low infiltration capacity were assigned higher susceptibility ranks, while sandy and loamy soils with better drainage characteristics were assigned lower susceptibility ranks.

Buffer from Road and Buffer from Railway

Road and railway layers from AIILSG were used to generate proximity buffers. These parameters were included not only for susceptibility but also because transport corridors influence surface drainage, obstruct natural flow paths and create artificial embankments.

Analytical Hierarchy Process (AHP) and Weight Assignment

AHP was used to assign scientifically justified weights to each flood conditioning parameter.

The factors used are given weightages using AHP Method. The matix is as follows:

	Drainage Density	TWI	Buffer from River	Elevation	Slope	LULC	NDVI	Soil	Buffer from Road	Buffer from Railway
Drainage Density	1	1.07	1.07	1.25	1.5	1.67	1.88	1.88	3	3
TWI	0.93	1	1	1.17	1.4	1.56	1.75	1.75	2.8	2.8
Buffer from River	0.93	1	1	1.17	1.4	1.56	1.75	1.75	2.8	2.8
Elevation	0.8	0.86	0.86	1	1.2	1.33	1.5	1.5	2.4	2.4
Slope	0.67	0.71	0.71	0.83	1	1.11	1.25	1.25	2	2
LULC	0.6	0.64	0.64	0.75	0.9	1	1.13	1.13	1.8	1.8
NDVI	0.53	0.57	0.57	0.67	0.8	0.89	1	1	1.6	1.6
Soil	0.53	0.57	0.57	0.67	0.8	0.89	1	1	1.6	1.6
Buffer from Road	0.33	0.36	0.36	0.42	0.5	0.56	0.63	0.63	1	1
Buffer from Railway	0.33	0.36	0.36	0.42	0.5	0.56	0.63	0.63	1	1

The parameters considered are normalized to assign the final weights for flood susceptibility as follows:

Criterion	Weight	Percentage Weight
Drainage Density	**0.15**	15
TWI	**0.14**	14
Buffer from River	**0.14**	14
Elevation	**0.12**	12
Slope	**0.1**	10
LULC	**0.09**	9
NDVI	**0.08**	8
Soil	**0.08**	8
Buffer from Road	**0.05**	5
Buffer from Railway	**0.05**	5
Total		**100**

The pairwise comparison matrix provided was used to confirm internal consistency and ensure methodological robustness. The consistency ratio was found to be within acceptable limits (< 0.1), validating the reliability of expert judgments.

Flood Susceptibility Map Generation

Each thematic raster layer was reclassified into five classes representing Very Low, Low, Moderate, High and Very High susceptibility. The standardized layers were then integrated using Weighted Linear Combination (WLC) in GIS as per the following expression:

Flood Susceptibility Index (FSI) = $\Sigma (W_i \times R_i)$

Where Wi is the weight of the criterion and Ri is the reclassified rank of each pixel for that criterion.

The final Flood Susceptibility Index raster was classified into five categories: Very Low, Low, Moderate, High and Very High susceptibility zones using natural breaks (Jenks) classification.

This map represents the intrinsic susceptibility of the landscape to flooding based on environmental and physical parameters.

Floodplain Delineation Using HFL and Hydraulic Barriers

Identification of Preliminary Floodplain Using HFL

From the DEM, contour lines were generated and the **113m (112.36m) contour was extracted and treated as the High Flood Level (HFL) and 112m (111.69m) was identified as Danger Levels.** All areas lying below the 112 m elevation and simultaneously falling within the High and Very High Flood Susceptibility classes were considered as the Preliminary Floodplain. This approach integrates both terrain-controlled inundation potential and hydrological susceptibility.

Incorporation of Hydraulic Barriers

Floodplain delineation was further refined by incorporating anthropogenic and structural barriers that significantly alter surface flow dynamics. These included:

- Road embankments
- Railway embankments
- Dams and bunds
- Ghats and riverfront protection structures

These features were mapped using AIILSG vector data and validated through high-resolution imagery interpretation. These structures were treated as flow obstructions or flow controllers and used to modify the preliminary floodplain boundaries. Areas located behind continuous elevated embankments or protected by hydraulic structures were excluded from the final floodplain where appropriate, while low-lying areas adjacent to barrier openings or culverts were retained within floodplain zones.

Final Floodplain Demarcation

The final floodplain map was produced after spatially refining the preliminary floodplain through barrier overlay analysis. The final floodplain thus represents a more realistic inundation extent reflecting both natural topography and anthropogenic modifications to the hydrological system.

The zonation could be done so that the identified High Flood Susceptibility Zone could be marked as **Zone 1: Flood Plain Zone.** 500m buffer from Falgu River in consideration with flood plain in the norther portion of the city could be the **Zone 2: Buffer Zone** and rest of the city would fall under **Zone 3: Safe Zone.**

Conclusion

The adopted GIS–AHP based framework integrates terrain analysis, hydrological behaviour, land surface characteristics and infrastructure influence to produce a scientifically robust flood susceptibility map. The additional refinement using HFL and hydraulic barriers ensures that the final floodplain delineation reflects realistic ground conditions rather than purely theoretical terrain thresholds. This provides a reliable technical basis for planning, regulation and disaster risk reduction interventions.

Flowchart of Methodology

The overall methodological framework adopted for flood susceptibility mapping and floodplain delineation follows a structured GIS-based workflow as described below.

The process begins with collection of all spatial datasets including DEM, Landsat imagery, soil data and vector layers for river, road and railway. This is followed by data preprocessing which includes projection standardization, clipping to study area and resampling to a common spatial resolution.

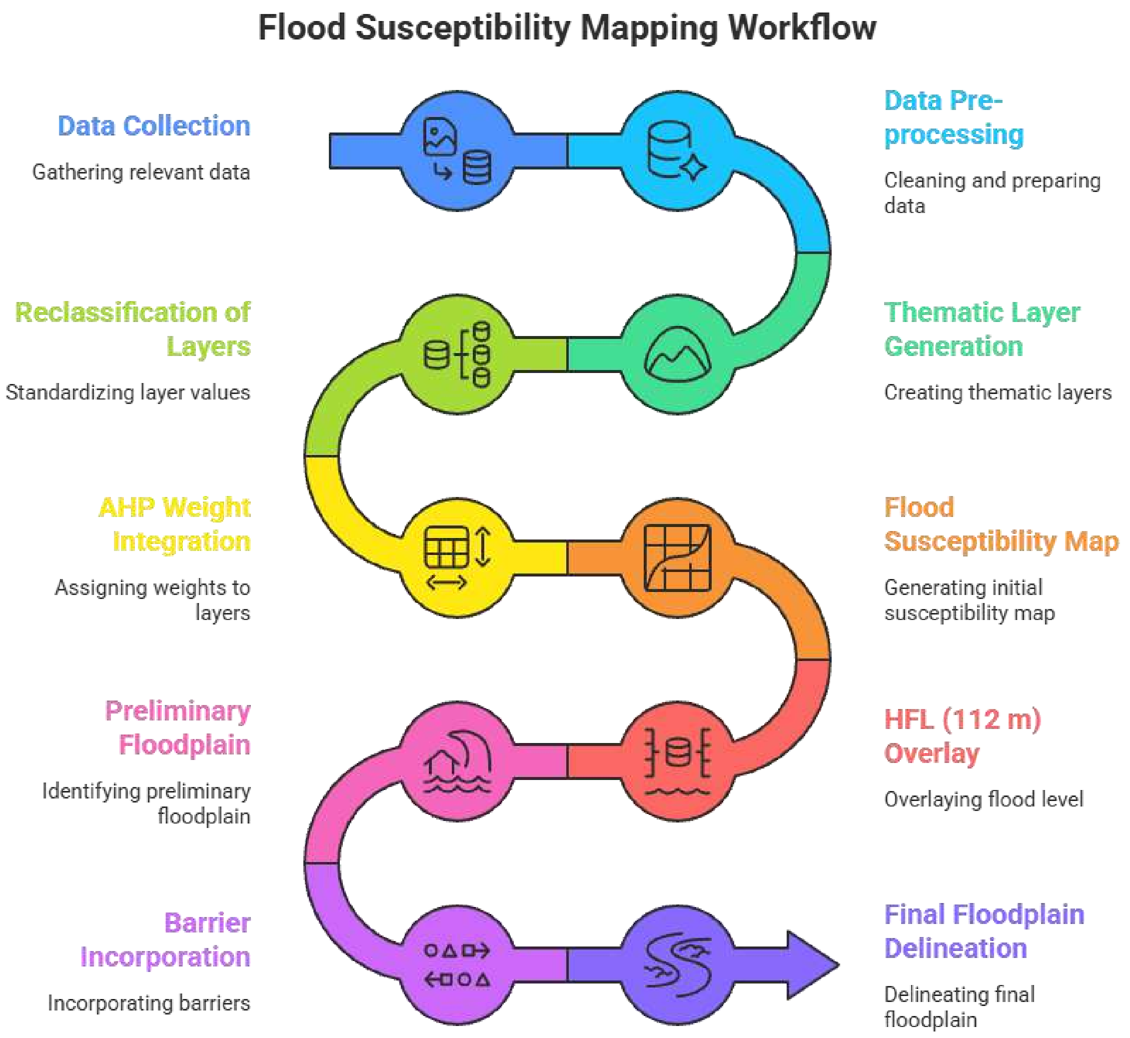
From the DEM, primary terrain derivatives such as elevation, slope, flow direction and flow accumulation are generated. These are further used to derive drainage density, drainage network and Topographic Wetness Index. Simultaneously, Landsat imagery is processed to generate NDVI and classified to prepare the LULC map. Soil and proximity layers are converted into raster thematic layers through reclassification and buffer analysis.

All derived thematic layers are then reclassified into standardized susceptibility ranks. The AHP-based weights are applied using a weighted overlay model to generate the Flood Susceptibility Index. This index is further classified into five flood susceptibility zones.

Subsequently, the 112 m contour is extracted from the DEM and overlaid on the susceptibility output to delineate preliminary floodplain areas. Finally, hydraulic barriers such as roads, railways, dams and ghats are incorporated to refine the floodplain boundaries and produce the final floodplain map.

This logical workflow can be visually represented in project documentation as the following sequence:

Figure 14: Flood susceptibility mapping workflow



Data Processing Environment and GIS Tools Used (ArcGIS Framework)

All spatial analysis was carried out using ArcGIS Desktop / ArcGIS Pro environment with Spatial Analyst and Hydrology toolsets. The processing environment was standardized to ensure reproducibility and technical rigor.

The key tools and functions used are described below.

DEM preprocessing involved the use of the Fill tool (Spatial Analyst → Hydrology) to remove sinks, followed by Flow Direction and Flow Accumulation tools to derive hydrological flow characteristics. Stream extraction was carried out using conditional raster thresholding on flow accumulation, and Stream Order was derived using the Stream Order tool. Watershed and Basin tools were used for sub-watershed delineation. Drainage density was computed using Line Density and Zonal Statistics functions.

Slope and elevation layers were derived using the Slope and Raster Calculator tools. Contours, including the 112 m HFL contour, were generated using the Contour tool from the Spatial Analyst toolbox.

Topographic Wetness Index (TWI) was generated using a combination of Flow Accumulation, Slope and Raster Calculator applying the logarithmic TWI expression.

Landsat 9 imagery was processed using the Raster Calculator for NDVI generation. Image classification for LULC was performed using the Image Classification toolbar with supervised classification techniques. Post-classification refinement was carried out using Majority Filter and Reclassify tools.

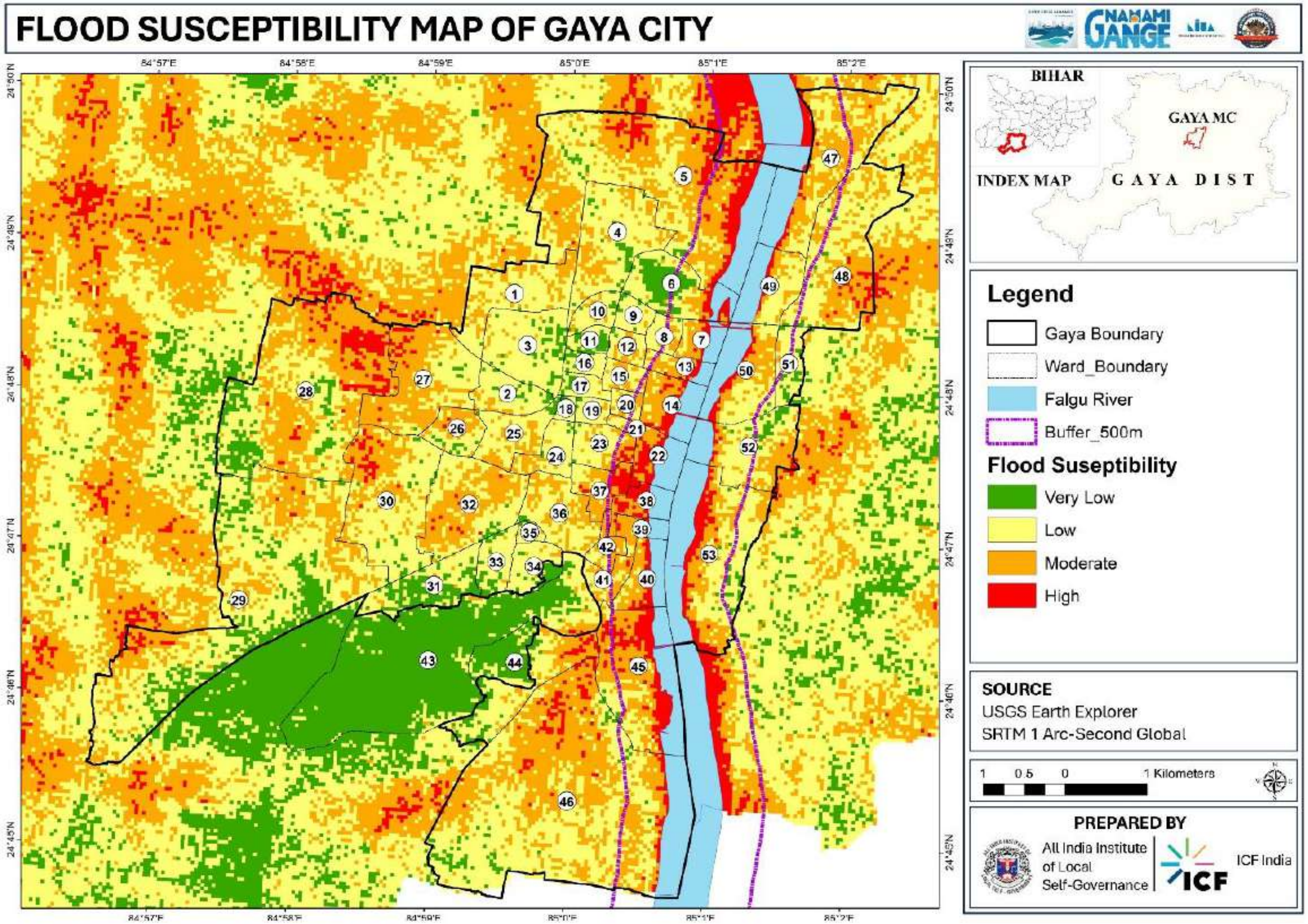
Buffer zones for river, road and railway were generated using the Buffer tool (Analysis toolbox). These buffers were then converted to raster format using the Feature to Raster tool and reclassified for susceptibility ranking.

Soil data processing involved vector-to-raster conversion followed by Reclassify based on soil texture characteristics.

The final integration of all thematic layers was performed using the Weighted Overlay tool under Spatial Analyst. Reclassification of flood susceptibility into Very Low, Low, Moderate, High and Very High categories was carried out using the Reclassify tool with Natural Breaks (Jenks) classification.

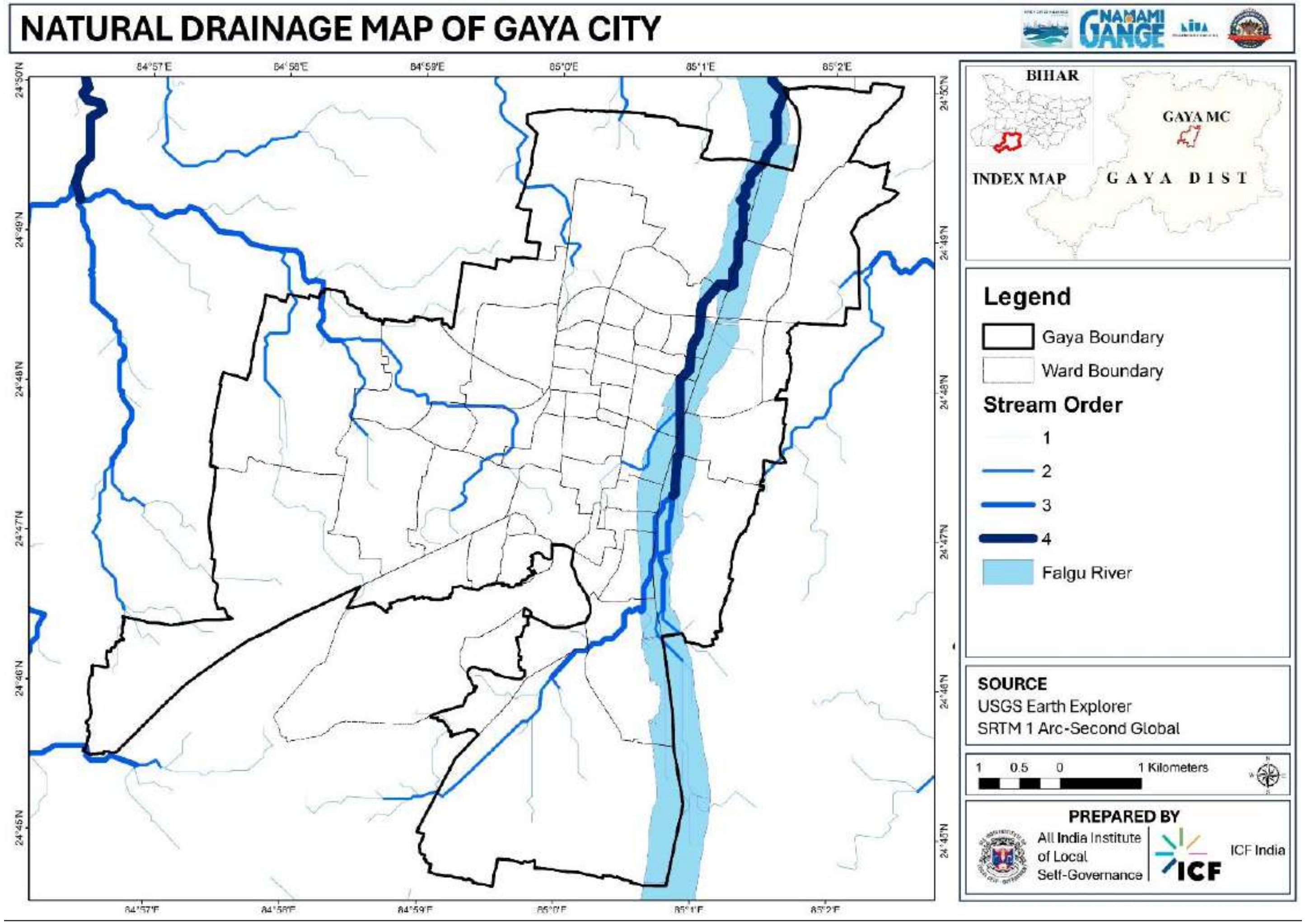
Map layouts, legends, symbology and cartographic outputs were prepared using the Layout View to ensure professional-quality outputs suitable for inclusion in technical reports and regulatory submissions

Map 15: Flood Susceptibility Map Of Gayaji City



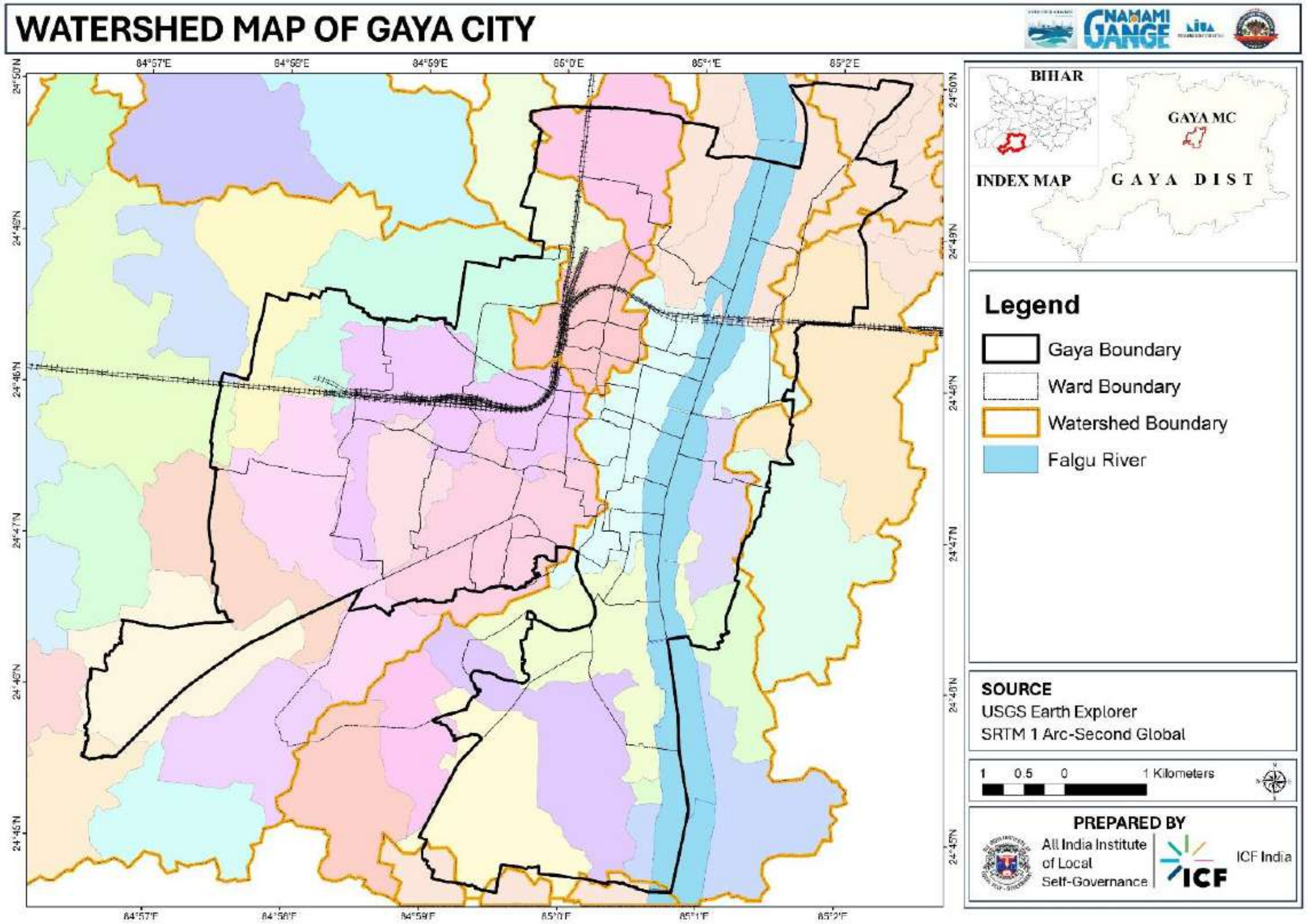
Source: USGS Earth Exlporer, SRTM 1 Arc-Second Global

Map 16: Natural Drainage Map of Gayaji City



Source: USGS Earth Exlporer, SRTM 1 Arc-Second Global

Map 17: Watershed Map of Gayaji City



Source: USGS Earth Exlporer, SRTM 1 Arc-Second Global

Table 8: Observed Changes in Land Cover in the River buffer zone

Floodplain Feature	Present Condition	Observed Changes /Trends	Key Issues
Developed Riverfront	Primarily ghats and other religious uses	Hard construction development such as stairs and paved MUZs	Waste disposal, crowding during festivals
Floodplain without embankment	Seasonal cropping, farming Residential encroachment	Construction of large houses in sensitive areas	Surface Runoff pollution, Risk of unplanned sprawl, reduced flood capacity
Nalas and Outfall locations	Encroachments, solid waste dumping, open discharge	Increasing informal housing and blockage of drains	Reduced conveyance, local flooding

Based on municipal reports, field surveys and observed patterns along the Falgu River embankments in Gayaji, the 10-meter buffer zone is currently occupied by a mix of informal, municipal, cultural and non-compliant activities. Encroachments are common, with small temporary kiosks, tea stalls and households, alongside religious shrines and ritual platforms near the ghats, particularly close to the Vishnupad Temple. Municipal infrastructure also runs through this zone, including drainage channels, sewer lines, inspection pathways for flood management and occasional utility poles or pump houses. The buffer further accommodates community and cultural practices such as ritual bathing and offerings at the ghats, seasonal fairs and gatherings during festivals and heavy pedestrian movement, often accompanied by informal parking of two-wheelers and auto-rickshaws. However, several problematic activities persist, including the dumping of solid waste and construction debris, vehicle parking that obstructs inspection access, and the storage of building materials by local contractors, all of which compromise the embankment's intended protective and ecological functions.

Key Takeways

The floodplain/ river buffer zone in Gayaji is functionally occupied and heavily contested, balancing ecological importance with cultural traditions and economic dependence. While the embankment offers protection, it is not a substitute for scientific zoning and enforcement of floodplain regulations. Despite the legal restrictions under NGT orders and national/state policies, field assessments indicate limited enforcement on the ground. Demarcation of the floodplain remains incomplete, with cadastral maps and flood hazard zonation not consistently integrated into municipal land management. Waste management and encroachment control are immediate priorities to prevent further degradation. The embankment system defines the perceived boundary but masks the true extent of flood vulnerability, especially in the south. Immediate priorities include demarcation of floodplain zones (per NGT/WRD norms), waste management and nala clearance.

Long-term resilience depends on integrating floodplain zoning with local land use planning and providing safer alternatives for vulnerable groups currently inhabiting these areas.

5.1.3.URMP Score

As per the URMP frameworks parameters for the regulation of activities in flood plain, Gayaji city scores Flood management score 1. This is mainly due to absence of a master plan that defines permissible and non-permissible uses in the flood plain and absence of a river edge/ boundary. Further, new development in the river buffer was observed.

5.1.4.Interventions

5.1.4.1 Intervention 1-1: Floodplain Zoning Integration into the Master Plan

The Master Plan for Gayaji Ji City is currently under preparation/proposal stage and does not explicitly outline comprehensive measures for the protection, management, or ecological restoration of the Falgu River and its associated floodplain. While the river holds immense religious and cultural significance, river-specific planning interventions remain limited and fragmented within the statutory planning framework.

At present, large stretches of the Falgu River within the city lack formally notified floodplain zoning or riparian buffer regulations. Flood protection is not achieved through continuous embankments; instead, the river edge is largely defined by paved ghats and localized hard structures developed primarily for ritual and religious functions. Beyond these ghats, the river corridor remains mostly open and natural, particularly along the wide sandy riverbed.

Although this semi-natural condition allows the river to safely accommodate seasonal flows, the absence of an integrated river management strategy exposes the floodplain to gradual encroachment, unregulated construction, and ad-hoc hardscaping. The lack of clear policy guidance within the Master Plan limits opportunities to leverage the Falgu River as an ecological asset while ensuring long-term flood resilience and cultural continuity.

Figure 15: Process for Floodplain Zoning Integration into the Master Plan

Key Planning Components:

Step 1: Delineate and Zone the Floodplain

Zone 1 – No Development Zone (NDZ): Active Riverbed

The active riverbed shall be delineated based on existing ghats, rubber dam markers, and observed seasonal flow patterns. This zone will function as a strict no-development area, with no permanent structures permitted under any circumstances.

However, non-intrusive, zero-impact dry-season uses may be allowed on a regulated basis to retain cultural and social continuity. Permissible activities include temporary cultural events such as nukkad nataks and limited recreational uses like informal sports, provided they involve no hardscaping, excavation, or ecological alteration. All installations must be fully removable prior to the monsoon season.

Zone 2 – Regulated Development Zone (RDZ): 100 m Riparian Buffer

A 100 m buffer from the river edge shall be designated as the Regulated Development Zone, excluding areas falling under Zone 3. This buffer broadly corresponds to the historical Highest Flood Level (HFL) extent and currently contains pockets of dense, pre-existing development.

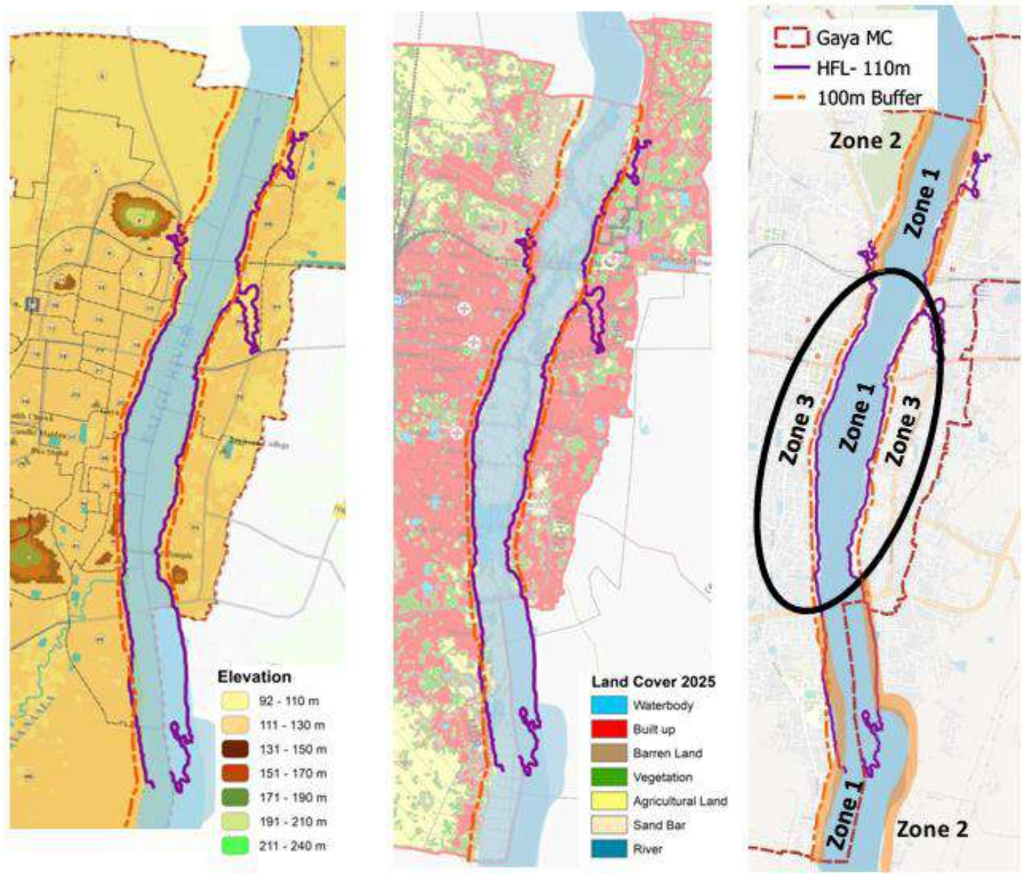
The planning approach for this zone focuses on arresting further urbanization and preventing the introduction of new permanent structures. Development control shall prioritize regulation rather than expansion, with clear guidelines for land use, building retrofits, drainage improvements, and activity management. The objective is to prevent the compounding of flood risks over time while improving environmental performance within existing built areas.

Zone 3 – Special Regulation Zone (SRZ): Strategic Urban Interface

Zone 3 shall be designated as a Special Regulation Zone requiring Master Plan–level interventions. This zone will be governed through customized Development Control Regulations (DCRs), including controls on FAR, ground coverage, building height, built form, and permissible versus non-permissible uses.

Infrastructure enhancement, climate-responsive urban design, and flood-compatible development typologies shall be mandated within this zone. The SRZ will act as a transition interface between the river system and the urban fabric, balancing development needs with long-term flood resilience and ecological sensitivity.

Figure 16: Proposed zoning in the floodplain



Step 2: Modify relevant Development Control Regulations (DCRs)

The DCRs accompanying the Master Plan should clearly articulate land-use controls within each floodplain zone. A list of suggested activities for each zone is given below. They are derived from applicable national and state policy frameworks on floodplain management and river-sensitive planning. These include the Model Bill for Flood Plain Zoning (CWC, 1975); relevant NGT orders, including the order dated 13.07.2017 in M.C. Mehta vs Union of India, which mandates no-development buffers and prohibits waste dumping and large-scale construction in floodplains; the Draft River Regulation Zone Notification, MoEF&CC (2016); the Technical Guidelines on Flood Plain Zoning issued by CWC (2025); and the Flood Plain Zoning Notification of the Water Resources Department, Government of Bihar (March 2025). A detailed summary of these orders is given in Annexure 1.

Table 9: Suggested Permissible Activities in the NDZ and RDZ

Activity Type	No Development Zone (100 m)	Regulated Development Zone (500 m)
Permanent residential housing	✕ Prohibited	✕ Prohibited
Agriculture (organic / natural)	✓ Permitted	✓ Permitted
Chemical-intensive farming	✕ Prohibited	△ Strongly discouraged
Grazing / pasture	✓ Permitted	✓ Permitted

Activity Type	No Development Zone (100 m)	Regulated Development Zone (500 m)
Religious activities (Chhath, rituals)	✓ Permitted (temporary, non-monsoon)	✓ Permitted
Permanent religious structures	✕ Prohibited / △ Regulated	✕ Prohibited
Ghats (eco-sensitive design)	✓ Permitted	✓ Permitted
Cremation grounds	✓ Permitted	✓ Permitted
Parks, open spaces, playgrounds	✓ Permitted	✓ Permitted
Commercial / industrial activity	✕ Prohibited	✕ Prohibited
Solid waste dumping / landfills	✕ Prohibited	✕ Prohibited
STPs / river conservation works	✕ Prohibited	△ Strongly discouraged

Legend:

✓ Permitted △ Regulated / Conditional ✕ Prohibited

The following should be permitted across zones, subject to safeguards:

- Bridges, embankment repairs, flood protection works
- Water supply pipelines, power transmission lines
- Outfalls, river conservation works under NMCG

Gayaji Ji City, urban flooding driven by altered natural drainage patterns, encroachment along nalas and river edges, and inadequate regulation within flood-influenced zones, rather than extreme congestion alone. To address these challenges, development regulations must be strengthened and contextualized to the city's riverine and geomorphological setting.Building regulations and setback norms should be strictly applied in accordance with road widths as prescribed in the prevailing Building Bye-laws, particularly in areas abutting primary and secondary drains to ensure unobstructed stormwater flow. In addition, groundwater recharge zones, natural drainage channels, and catchment areas feeding into the Falgu River must be clearly identified, mapped, and earmarked within the Master Plan. Mandatory buffers should be enforced around all drains, nalas, ponds, and water bodies, with these buffer areas designated as "no solid waste zones" to prevent blockage and pollution. Any form of construction, dumping, or informal use within these buffers should be explicitly prohibited. Further, differential Development Control Regulations (DCRs) must be introduced for construction within floodplain and river-influenced zones. This includes regulating plinth heights, ground coverage, and built form based on flood susceptibility, to reduce flood damage risks while maintaining urban functionality.

<u>Step 3: Physically Demarcate the floodplain Boundaries</u>

Once the floodplains are demarcated, they should be physically demarcated, as done in the case of the Bandh road, to improve on-ground enforceability. This can be done via:

- Installation of boundary pillars, signage, and visual markers along NDZ and RDZ edges.
- Use of embankment crests as reference lines where embankments exist, supplemented by signage clarifying regulatory status.
- Periodic verification of demarcation using GIS and field surveys.

5.2. Objective 2: Pollution Free River

Objective 2** aims to assess the existing situation of citywide waste management systems with a focus on both liquid and solid waste streams and their impact on river health. The scope of this assessment covers the entire value chain, starting from sources of generation to final disposal, while also considering institutional arrangements, service* *delivery mechanisms, and ongoing or planned interventions. The central premise of this indicator is that, at the least, the city should ensure that the* ***quality of water leaving the city should be the same as entering the city*.*

Element : ENVIRONMENTAL

Significance:

Urban rivers often bear the brunt of inadequate **waste management, receiving untreated sewage, industrial effluents, and solid waste** through informal dumping and poorly maintained drainage systems. Assessing the **full waste management cycle from generation and containment to treatment, reuse, and disposal** helps pinpoint critical failures that contribute to river pollution. **Spatial hotspot analysis** identifies where mismanagement leads to concentrated pollution along river stretches.

Scope as per URMP:

- City liquid waste management -assessment
- City solid waste management & assessment
- Water quality assessment
- Pollution hotspot analysis

5.2.1.Existing Situation

<u>Status of water supply</u>

Gayaji's urban water supply system has undergone a gradual transition from a surface-water–based scheme to one that is overwhelmingly dependent on groundwater. The city's piped water supply was first commissioned in 1924, drawing directly from the Falgu River. However, by the mid-1950s, seasonal variability in river flows and increasing urban demand necessitated the development of a groundwater-based supply scheme at Dandibagh along the riverbank. Subsequent decades witnessed incremental expansion of the network to serve newly urbanizing areas. A major augmentation was sanctioned in 2007 under the 12th Finance Commission, envisaging the drilling of multiple tube wells along the Falgu River and within the city, along with expansion of transmission and distribution infrastructure to areas such as Manpur and AP Colony. These works are implemented by the Public Health Engineering Department on behalf of the Gayaji Municipal Corporation.

At present, groundwater constitutes the sole source of water supply for Gayaji, extracted through 39 high-yielding tube wells located across Manpur, Dandibagh, Panchayati Akhara, and the main city. Despite this extensive infrastructure, actual water production is only about 27.6 MLD, reflecting significant underutilization of both pumping capacity and operating hours. The piped water network covers approximately 80–90% of the city, yet service reliability remains low. Intermittent supply, absence of chlorination at tube wells or reservoirs, and aging transmission and storage assets have resulted in poor water quality perception among consumers, leading many households to depend on private wells and hand pumps.

The system's total storage capacity of about 43 MLD is undermined by the poor condition of several old reservoirs, many of which remain idle due to insufficient pumping capacity and deteriorated structural health. While water is supplied for 8 hours a day through direct pumping and 4 hours through reservoirs, high non-revenue water losses estimated at over 20 MLD further reduce effective supply. Losses arise from leakage, unauthorized connections, and the lack of comprehensive metering and monitoring.

Equity concerns are pronounced, particularly in slum areas, where access to piped water remains limited and dependence on public stand posts and hand pumps is widespread. The system also lacks mechanisms for aquifer recharge, real-time monitoring, and climate resilience, increasing vulnerability to droughts and future demand pressures.

<u>Existing status of Solid waste Management</u>

Solid waste management plays a critical role in safeguarding urban environmental quality and protecting the Falgu River in Gayaji Ji, as improperly handled waste directly contributes to land and water pollution. Solid waste in the city comprises household, commercial, institutional, market, street sweeping, and ritual-related waste. Under the Environmental Protection Act, 1986, the 12th Schedule of the Constitution, and the Solid Waste Management Rules, 2016, the responsibility for managing municipal solid waste lies with the Gayaji Ji Municipal Corporation (GMC).

Gayaji Ji generates approximately 250 metric tonnes of solid waste per day, consisting of about 75% wet waste, 20% dry waste, and 5% inert material. The waste stream is dominated by organic matter, sand- and silt-mixed organics, plastics, garden waste, paper, and coconut shells. Chemical analysis indicates moderate moisture content, a favorable C/N ratio for composting, and a calorific value suitable for resource recovery, though heavy metals are present in trace amounts. The domestic sector is the primary contributor, followed by commercial establishments, markets, hotels, and street sweeping operations.

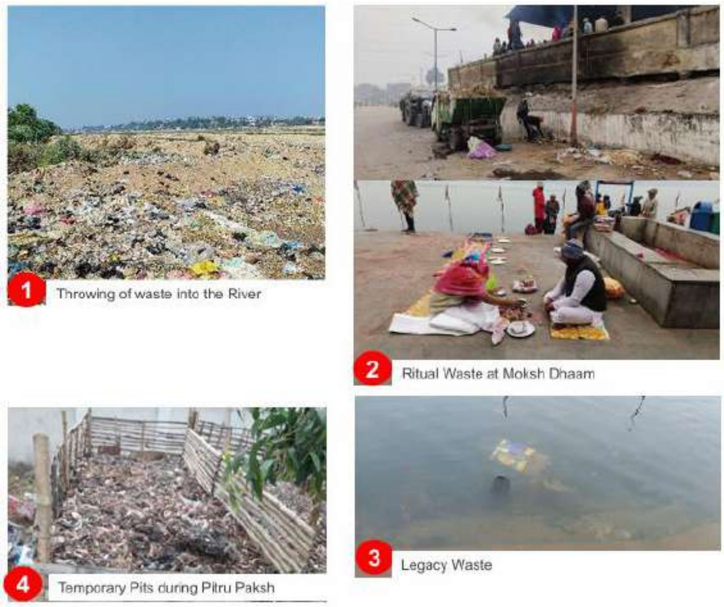
Earlier, the city lacked door-to-door collection and segregation systems, leading to widespread littering and unregulated dumping, particularly along riverbanks and water bodies, including the Falgu River. Waste was disposed of at the Naili dumping ground without scientific processing, resulting in environmental degradation. In response, GMC has initiated reforms focused on source segregation, primary collection, transportation efficiency, and public awareness. Households have been provided with green and blue bins for wet and dry waste, respectively, and segregated waste is collected using tricycles and auto tippers based on road width. Door-to-door collection efficiency has improved to about 70%, while overall waste collection efficiency stands at nearly 85%.

Gayaji Ji operates secondary collection points and transfer stations across four waste-management zones. Dry waste is further segregated into multiple material streams, enhancing recovery value, while wet waste is treated through composting pits at GRDA Campus and Naili, converting around 15% of wet waste into bio-compost. Remaining residual waste is transported to the Katari Hills dumping site, with GPS-based vehicle tracking improving operational monitoring.

A unique challenge in Gayaji Ji is waste generation during the *Pinda Daan* rituals performed along the Falgu River during *Pitru Paksha*. Large volumes of organic offerings, flowers, oils, cloth, and plastics estimated at 20–30 tonnes over the fortnight enter the river, leading to sharp declines in dissolved oxygen, increased BOD, nutrient loading, turbidity, and reduced aquatic biodiversity. These impacts underscore the need for ritual-waste management systems, designated collection points, biodegradable offerings, and river-sensitive IEC campaigns.

Overall, while Gayaji Ji Municipal Corporation's recent initiatives have strengthened solid waste management, gaps remain in achieving 100% segregation, universal door-to-door coverage, and river-centric waste control. Sustained public engagement, improved processing capacity, and integration with URMP objectives are essential to protect the Falgu River and ensure a cleaner, resilient Gayaji Ji.

Figure 17: Solid waste source



Gayaji currently generates about 250 MT of solid waste daily, comprising 75% wet, 20% dry, and 5% inert waste, with an overall collection efficiency of 85%. Segregated waste is stored at four locations, while composting is piloted at GRDA Campus and Naili, treating only 15% of wet waste. Two inefficient dumping sites remain in use.

Figure 18: Location of dumping site

Despite ongoing collection and limited processing efforts, no new solid waste management projects are in the pipeline, highlighting critical gaps in long-term planning, disposal infrastructure, and sustainable waste treatment solutions. unsegregated and uncollected waste remains a major concern. Limited processing capacity leaves large quantities of wet and dry waste unmanaged**.** C&D and inert waste dumping blocks drains and contributes to sedimentation, increasing flood risk. Ritual and festival-related waste, especially during Pitru Paksha, adds significant pressure on the system. Weak enforcement, low public awareness, and the presence of an active dumping spot within city limits further aggravate environmental and sanitation challenges.

Figure 19: Solid waste efforts in wet waste treatment

Auto Tipper dumping the wastes on the open platform at GRDA

GRDA Campus

Segregation of minor mixes in wastes on the open platform at GRDA

Naili Dumping Ground

Existing Drainage Status

Gayaji's drainage system is shaped by its unique topography, with the Mangla Gauri, Shringa Sthan, Ramshila and Brahmayoni hills enclosing the city on three sides and the Falgu River forming the fourth boundary. Drainage naturally follows gravity, flowing from the surrounding hillocks toward the river. A major road west of the Collectorate divides the city into eastern and western drainage zones. While this gradient supports natural drainage, it also concentrates runoff in low-lying pockets, causing stress during intense monsoon rainfall.

The formal drainage network extends about 62 km, covering nearly 40% of the road length. This includes 46 km of pucca drains and 16 km of kutcha drains. Western nallahs such as Kujapi, Karimganj and Katari Hill Road channel flows toward Gandhi Maidan and the railway station, while eastern drains like Mansarva, Mashanghat and Nadwaganj discharge directly into the Falgu River. However, only around 30% of households are connected to formal sewerage, leading to frequent clogging of open drains by solid waste. As a result, chronic waterlogging affects Gandhi Maidan, Manpur, Dhobi Road, Katari Hill Road and several newer colonies.

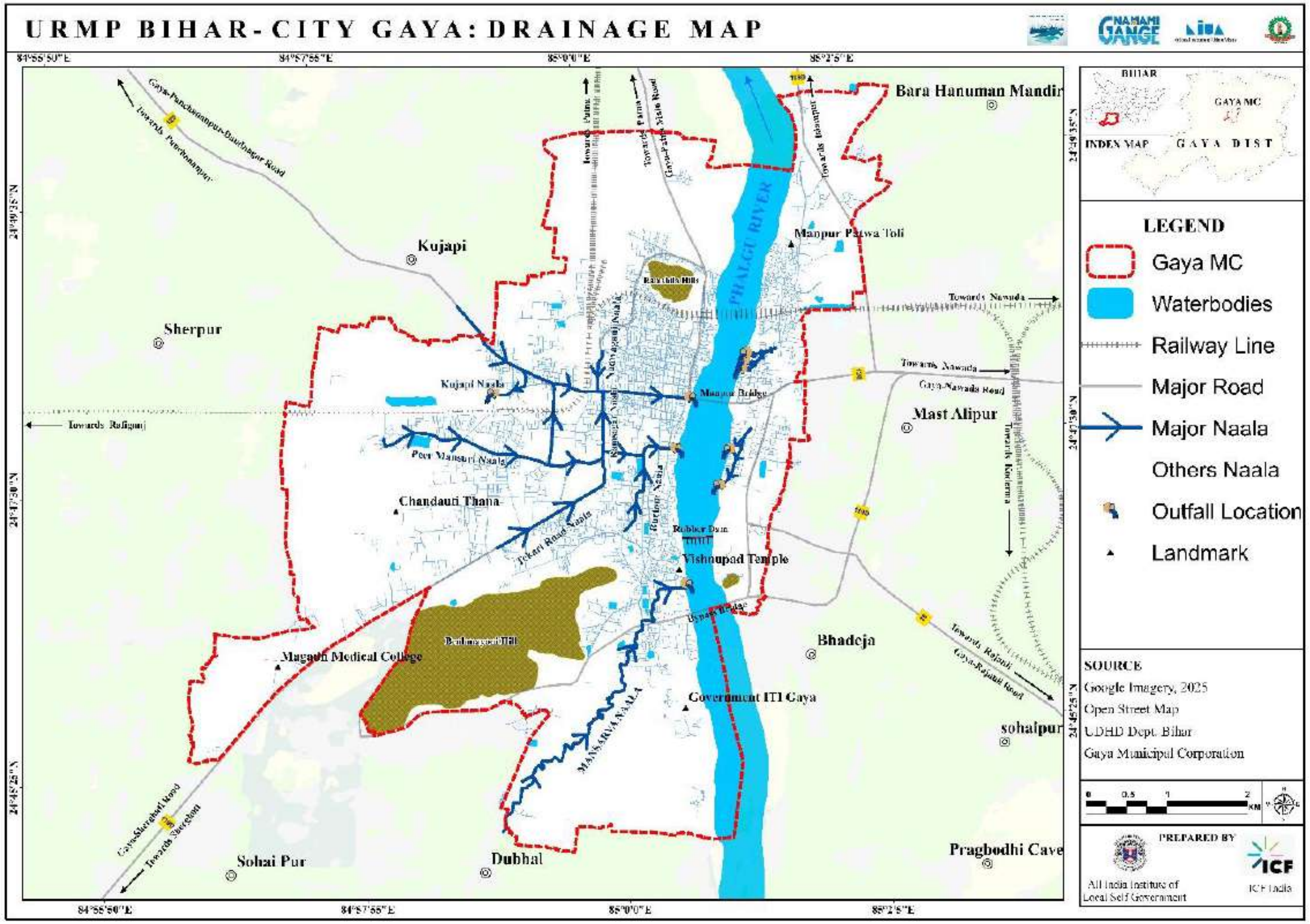
To improve the situation, GMC has deployed Quick Response Teams for desilting, while BUIDCO's mid-2024 master plan proposes micro-catchment based drainage planning, drain upgradation, new STPs with pumping stations, and systematic realignment of outfalls to the Falgu River, backed by an investment of ₹4,230 crore.

Table 10: Status of Existing Natural Drains

Sl. No.	Name of Drain	Length (m)	Coverage (Ward No.)	Section (mxm)	Drainage Area (Ha)	Discharge Point	Status
1	Mansar Nallah	5234	40, 44, 45, 46 (Part)	4.6 x3.3	558.179	Falgu River	Kuchcha
2	Peer Mansur Nalla	632	37, 38, 46(Part)	1.2x1.3	14.09	Falgu River	Good Condition
3	Tekari Road Nalla	630.5	20 and Part of 14, 21, 22 & 23	1.2 x 1.3	30.47	Falgu River	Good Condition
4	Burtom Nalla	511	Part of 14, 21, 22 &23	1.2x1.3	11.89	Falgu River	Good Condition
5	Jai Prakash Nalla	1343	24, 25 & part of 2	2.0x1.8	81.616	Open Field	Partially Damaged
6	Kujapi Nalla	1343	3,17,18,19 & Part of 2	3.7 x 1.7	180.714	Open Field	Damaged
7	Nadwaganj Nallah	2411	38, 39, 36, 37, 42, 32 & 33	3.0x1.7 1.3x1.3	199.13	Falgu River	Damaged
9	Ramsagar Nalla	842	39,42	2.5x2.1	90.1	Falgu River	Damaged

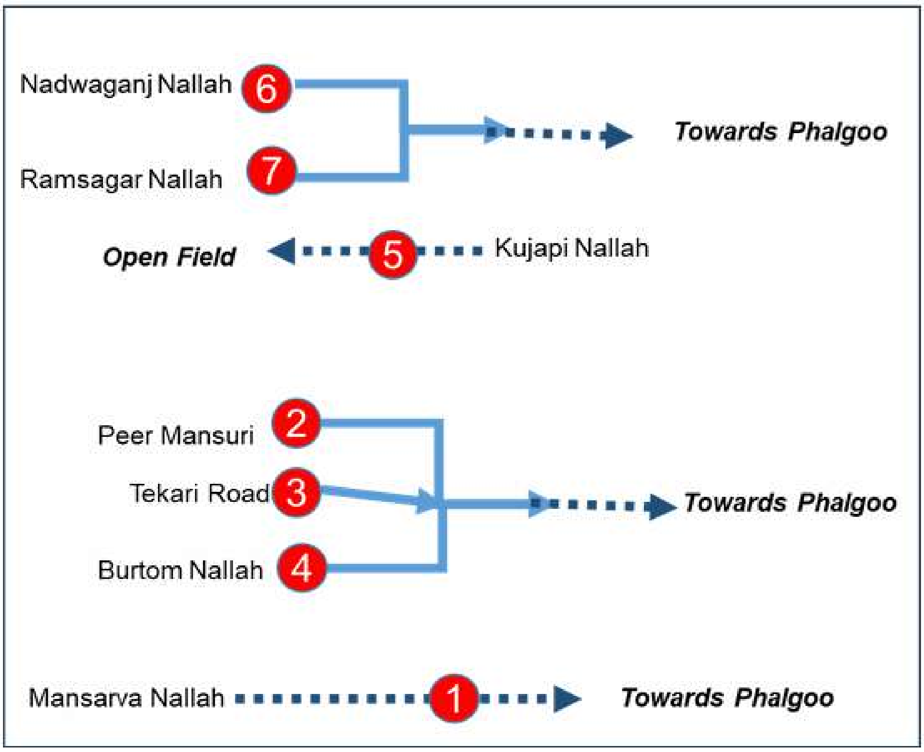
Source: DPR for Storm Water Drainage, 2022

Map 18 Location of Outfalls to the River Falgu



Source: Portrayed by Agency

Figure 20: Network alignment of the major nallahs



Source: Portrayed by Agency

Figure 21: Seewage network issues

Existing Status of sewerage and sanitation

In Gayaji’s core urban area, the absence of an organized underground sewerage system and limited solid waste disposal infrastructure results in the discharge of untreated household wastewater into open drains. These drains carry a mixture of sewage and storm water directly into the Falgu River, causing severe surface-water pollution and facilitating groundwater contamination through infiltration. During the monsoon, flooding of waste-laden riverbanks exacerbated by indiscriminate dumping and open defecation further degrades river ecology, intensifies flood risks, and heightens public health concerns. Small-scale industries scattered across the city also discharge untreated effluents into the same drainage network, adding to the cumulative pollution load.

Most households in Gayaji rely on onsite sanitation systems, primarily septic tanks and soak pits. However, many installations do not comply with technical standards. Larger and deeper septic tanks, unlined pits, and direct connections to open drains are common, particularly in slum areas, driven by cost considerations and limited awareness. A field survey under the FSM DPR revealed that 96% of households have toilets, with nearly 95% using septic or holding tanks, yet only 6% have soak pits for proper effluent treatment. The city lacks a sewerage network and sewage treatment facilities, and fecal sludge is often manually emptied and disposed of into drains or open land without treatment, posing serious environmental and health risks.

To address these challenges, a comprehensive Faecal Sludge and Septage Management (FSSM) plan is proposed. The system begins with vacuum tankers—both GMC-operated and private—collecting sludge from onsite systems and transporting it to a dedicated treatment facility. Incoming sludge is screened to remove debris and treated through vertical flow constructed wetlands for dewatering and stabilization, followed by horizontal flow wetlands for further reduction of organic load and pathogens. Dewatered sludge is co-composted with segregated organic waste to produce nutrient-rich compost, while treated effluent is safely reused or discharged through soak pits.

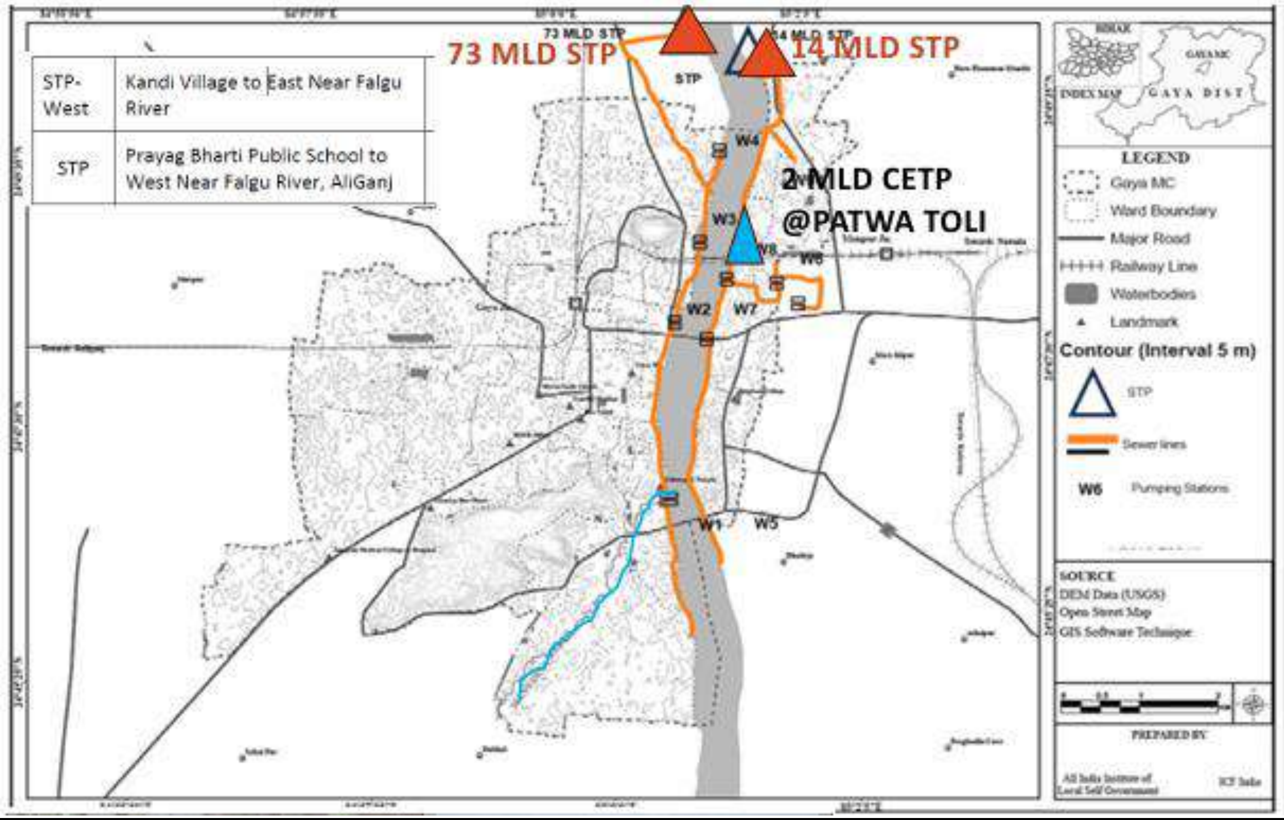
This integrated FSSM approach offers a sustainable, low-energy solution that protects the Falgu River, reduces groundwater contamination, improves sanitation outcomes, and promotes resource recovery for Gayaji's long-term urban resilience.

<u>Existing proposal of STP and CETP</u>

Under the National Mission for Clean Ganga (NMCG), an integrated sewerage and treatment proposal has been planned for Gayaji, comprising 87 MLD of STP capacity under Interception and Diversion (I&D) works. The plan includes two STPs of 73 MLD and 14 MLD capacity, supported by two main pumping stations and eight intermediate pumping stations, with an associated sewer network of approximately 16.8 km. The system has been designed for the horizon year 2057, catering to an estimated sewage generation of 109 MLD and a projected population of 9.5 lakh. The proposal also includes 12 outfall points equipped with sluice gates to regulate discharge into the river. Although the DPR has been prepared, the project has not yet progressed to the execution stage.

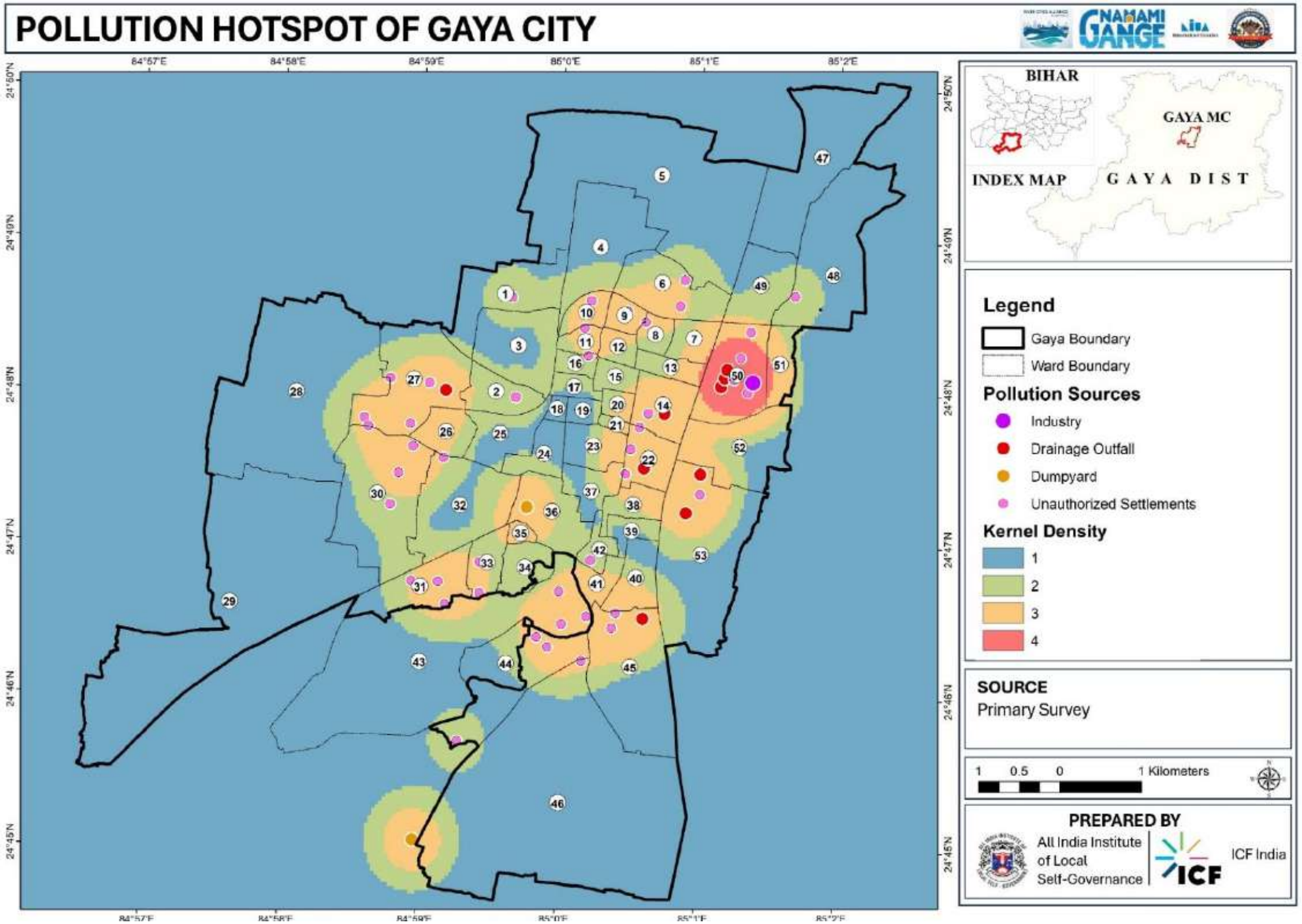
In addition, a 2 MLD Common Effluent Treatment Plant (CETP) has been proposed at Patwa Toli, Manpur, along with a dedicated 1.8 km effluent conveyance network to serve the Manpur industrial cluster. The cluster consists of over 12,000 power looms and around 1,000 production units, employing more than 20,000 people in weaving, dyeing, and finishing activities. The CETP will support the Manpur power loom and household industries, with three BIADA industrial areas also proposed to strengthen organized industrial wastewater management.

Figure 22: Proposal of STP and CETP



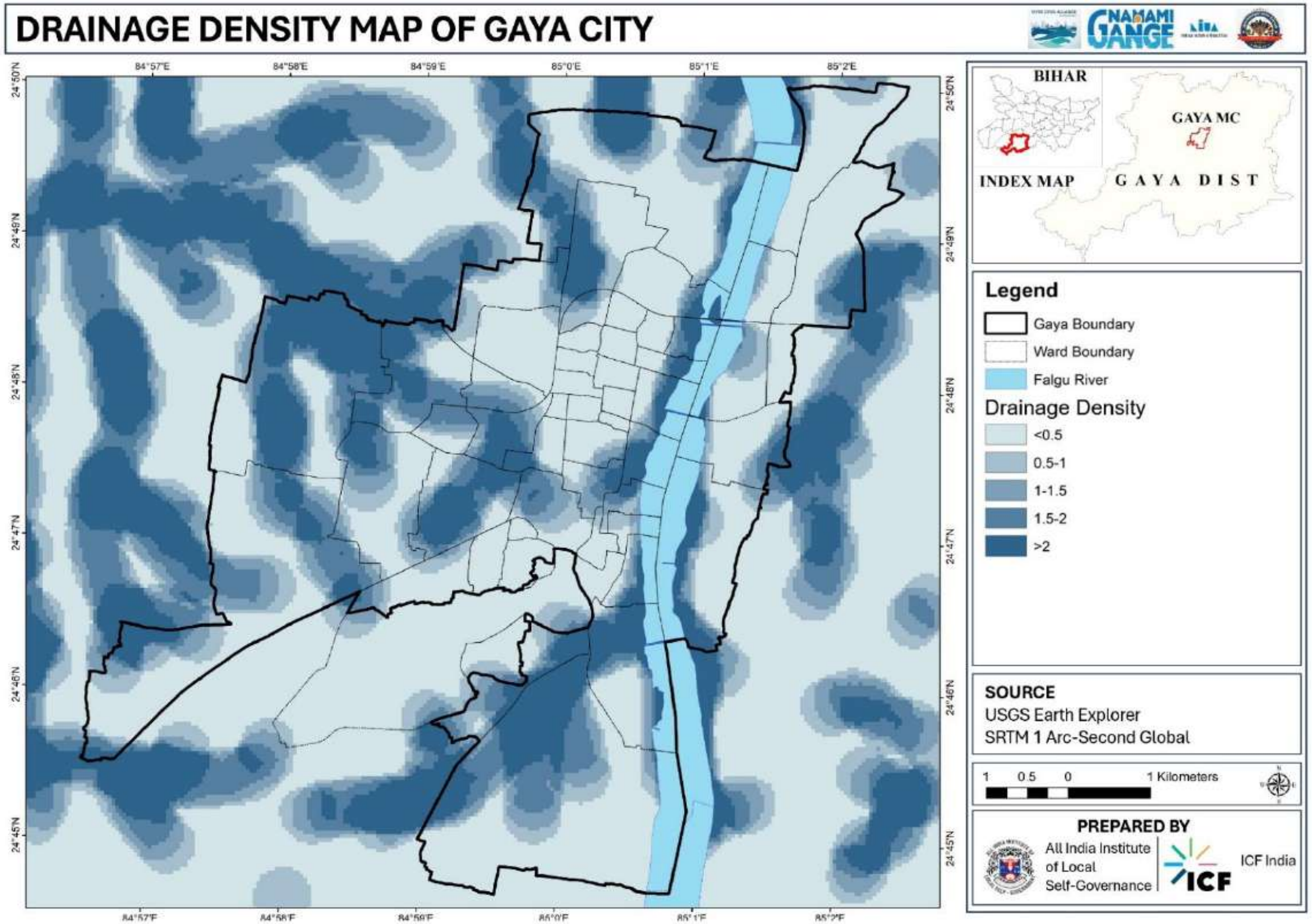
Source: BUIDCO, 2026

Map 19: Pollution hotspot map of Gayaji City



Source: Primary Survey

Map 20: Drainage Density Map of Gayaji City



Source: USGS Earth Explorer, SRTM 1 Arc-Second global

5.2.2. URMP Score

As per URMP framework to understand the pollution levels in the river the Net Dissolved Oxygen Score is measured. Since the SPCB- Bihar has published data of Dos. The net DO is DO outlet (-) DO inlet / DO inlet x 100. DO difference is 2.3, indicating very high score of 5. This may not show the true nature of the water quality due to the high flow rate of water; the water quality is diluted.

5.3.3. Interventions

5.2.3.1 Intervention 2.1: Fecal Sludge Treatment Plant (FSTP) for Blackwater Management (Interim Measure)

Gayaji City is a historic, religious, and rapidly urbanizing city with complex sanitation challenges arising from its settlement pattern, population growth, tourism inflow, and existing infrastructure gaps. While long-term plans for development of a comprehensive underground sewerage network and centralized Sewage Treatment Plant (STP) are envisaged for the city, the present sanitation reality indicates a predominant dependence on on-site sanitation systems such as septic tanks and pits. In this context, the proposal of a Faecal Sludge Treatment Plant (FSTP) is envisaged not as a temporary or transitional intervention, but as a critical and complementary component of the city's overall sanitation ecosystem**,** both in the interim and in the long term.

At present and in the foreseeable future, a significant proportion of Gayaji's households and establishments rely on on-site sanitation systems due to factors such as low sewer network coverage, mixed land use, narrow streets, organic urban growth, and peri-urban expansion. Even after commissioning of a sewerage network and STP, experience from Indian cities indicates that universal sewer connectivity is achieved only over extended timeframes, and on-site systems continue to coexist with centralized sewerage for decades. Therefore, faecal sludge management remains an indispensable urban service, independent of the existence of an STP.

The proposed FSTP addresses this structural sanitation gap by providing a scientifically designed, environmentally compliant, and operationally sustainable solution for the treatment of faecal sludge collected from septic tanks and pits. Its role is not limited to bridging a time lag until the STP becomes operational, but rather to ensure that faecal sludge generated across non-sewered and partially sewered areas is treated safely, thereby preventing indiscriminate dumping, environmental contamination, and public health risks.

It is important to recognize that even after the commissioning of an STP, faecal sludge will continue to be generated from multiple sources, including households not yet connected to the sewer network, institutions with independent septic systems, commercial establishments, informal settlements, peri-urban areas, and temporary or seasonal developments. Additionally, decentralized sanitation systems are increasingly promoted under national and state policies as resilient and cost-effective solutions, especially in areas where sewer extension may be technically challenging or economically unviable. In such a scenario, the FSTP becomes a permanent and parallel sanitation asset, supporting inclusive and citywide sanitation.

From a planning and infrastructure phasing perspective, the FSTP allows Gayaji City to adopt a modular, scalable, and adaptive sanitation strategy. While the STP caters primarily to liquid sewage conveyed through the sewer network, the FSTP caters to concentrated faecal sludge collected periodically. These two systems serve different waste streams with different operational dynamics, and one does not substitute the other. Rather, they function synergistically to ensure that all forms of human waste are treated in compliance with environmental standards.

The proposed FSTP also aligns with the principles of the National Faecal Sludge and Septage Management (FSSM) Policy, AMRUT guidelines, and SBM-Urban framework, which emphasize the need for safe treatment of faecal sludge irrespective of sewerage coverage. Policy experience across India has shown that cities with only STPs but without FSTPs often face uncontrolled dumping of septage into drains, water bodies, or even sewer manholes, leading to overloading of STPs and degradation of receiving water bodies. Establishing an FSTP therefore strengthens the performance and longevity of the future STP by preventing shock loads and untreated inflows.

In the case of Gayaji, the presence of the River Phalgu and the city's religious and cultural significance further underscore the importance of comprehensive sanitation solutions. The FSTP contributes directly to river protection, groundwater safety, and improved environmental quality by ensuring that faecal sludge is treated through appropriate biological and physical processes rather than entering the environment untreated. This supports broader objectives of river rejuvenation, ritual waste management, and sustainable urban development.

Operationally, the FSTP provides flexibility to integrate with future infrastructure. As sewerage coverage increases over time, the proportion of faecal sludge may gradually stabilize or reduce, but it will not disappear entirely. The FSTP can be operated at optimized loads, expanded modularly if required, or integrated with co-treatment strategies, such as treating septage alongside sewage sludge where feasible. Thus, the investment in an FSTP remains relevant and valuable over the long term.

Economically, decentralized and semi-centralized treatment systems such as FSTPs offer cost advantages in terms of lower capital expenditure, reduced network costs, and faster implementation timelines compared to large sewerage projects. They enable immediate improvements in sanitation outcomes without waiting for full sewer network roll-out, which often spans multiple years. At the same time, the FSTP does not preclude or undermine future investments in sewerage and STPs; instead, it ensures that sanitation services remain functional, safe, and inclusive throughout the transition period and beyond.

In conclusion, the proposal of an FSTP for Gayaji City is a strategic sanitation intervention designed to complement, not replace, future sewerage and STP infrastructure. It acknowledges the realities of mixed sanitation systems in Indian cities and adopts a pragmatic, phased, and resilient approach to urban sanitation. The FSTP will continue to play a vital role even after the commissioning of the STP by managing faecal sludge from non-sewered areas, safeguarding environmental resources, and supporting public health outcomes. Together, the FSTP and STP form an integrated sanitation framework that enables Gayaji City to move steadily towards the goal of safe, sustainable, and citywide sanitation.

Table 11: Calculation of 2041 FSTP requirement.

Sl. No.	Calculation Component	Formula	Value	Unit
1	Daily Faecal Sludge Generation	Population × Rate	8,52,667 × 0.14	1,19,373
2	Annual Faecal Sludge Generation	Daily × 365	1,19,373 × 365	43,571,284
3	Sludge Collected per Year (Desludging once in 3 years)	Annual ÷ 3	43,571,284 ÷ 3	14,523,761
4	Average Daily Sludge Load to FSTP	Annual ÷ 365	14,523,761 ÷ 365	39,789
5	Average Daily Load	Converted	39.79	KLD
6	Additional Capacity (25%)	39.79 × 0.25	9.95	KLD
7	Total Required FSTP Capacity	39.79 + 9.95	49.74	KLD

8	**TOTAL**		**49.74**	**KLD**

Source: Consultant

Based on the projected population of 8,52,667 (2041) and 100% sanitation coverage**,** with 95% households dependent on on-site sanitation systems, faecal sludge generation has been estimated using CPHEEO norms of 0.14 LPCD and a desludging frequency of once in three years**.** After applying a 25% safety factor, the required treatment capacity has been assessed accordingly. As per standard planning norms, an FSTP requires approximately 1 hectare (≈2.5 acres) of land for every 50 KLD of treatment capacity**,** which has been considered while assessing land requirements for the proposed facility.

5.2.3.2 Intervention 2.2: Ritual Waste Management for River Protection

Gayaji City, owing to its religious significance, growing population, and expanding urban footprint, is witnessing a steady increase in municipal solid waste and ritual waste generation. Projections indicate a solid waste treatment capacity gap of approximately 315 MT by 2045, which, if not addressed in a planned and timely manner, may exacerbate environmental degradation, public health risks, and pollution of drains and the River Phalgu. In this context, schemes such as AMRUT and Swachh Bharat Mission (Urban) provide a critical opportunity for Gayaji Municipal Corporation (GMC) to strengthen its waste management systems through decentralized, sustainable, and environmentally compliant interventions.

To bridge the projected capacity gap, it is imperative that GMC seeks support under these schemes for the development of decentralized waste processing facilities. Decentralized systems reduce transportation costs, lower dependency on large centralized dumpsites, and enable efficient handling of waste at or near the point of generation. Such facilities may include ward-level or cluster-based composting units, material recovery facilities (MRFs), and localized processing units for wet and dry waste streams. This approach not only improves operational efficiency but also enhances resilience of the waste management system against future growth and seasonal variations.

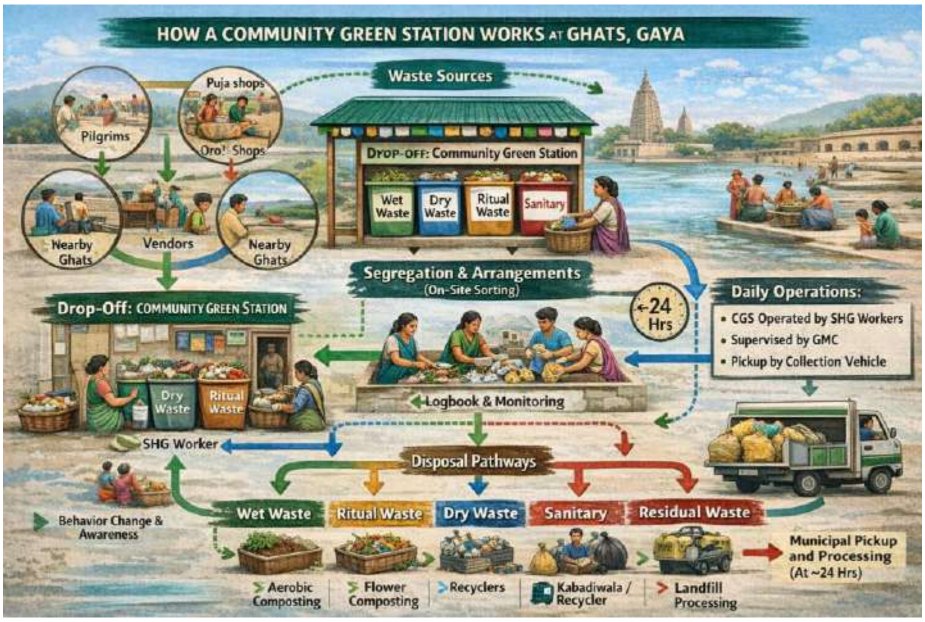
In parallel, urgent attention is required for bio-mining and scientific closure of existing dump sites. Legacy waste dumps pose a significant environmental hazard due to leachate generation, which often finds its way into nearby drains, groundwater, and ultimately the river system. Bio-mining enables systematic excavation, segregation, and processing of legacy waste, recovering recyclable materials and stabilizing inert fractions. Scientific closure of dumpsites, including capping, leachate management, and landscaping, is essential to prevent further contamination and to reclaim valuable urban land. These interventions directly align with SBM guidelines and contribute to long-term environmental restoration.

Given Gayaji's religious and cultural context, ritual waste management forms a crucial component of the overall waste strategy. Large quantities of flower waste, organic offerings, and materials used for idol immersion are generated daily, particularly around ghats, temples, and during festivals. In the absence of dedicated systems, such waste often ends up being dumped directly into drains and the river, leading to water pollution and ecological stress. Establishing dedicated collection, segregation, and treatment systems is therefore essential.

Specific interventions may include flower waste composting units to convert biodegradable offerings into useful manure, designated immersion tanks for idols and ritual materials, and controlled collection points near religious sites. These facilities not only prevent direct river dumping but also promote environmentally responsible religious practices through community participation and awareness. Integration of informal workers, temple committees, and local NGOs can further strengthen the sustainability of these systems.

Overall, a coordinated approach combining decentralized waste processing, bio-mining of legacy dumps, and structured ritual waste management will enable GMC to address current deficiencies while preparing for future demand. Support under AMRUT and SBM will be instrumental in translating these interventions into implementable projects, ensuring protection of the river ecosystem, improvement of urban sanitation, and enhancement of environmental quality in Gayaji City.

Figure 23: Concept of ritual waste management



Source: Ai generated image produced by consultant

Source: Ai generated image produced by consultant

Self-Sustainable model of Ritual Waste Management

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5.2.3.3 Intervention 2.3: In-Situ Bioremediation & Eco-Restoration of Urban Nallas

The proposed Eco-Nallah intervention in Gayaji City is conceived as a nature-based, in-situ wastewater treatment approach that deploys Green Bridge technology and microbial dosing directly within existing drain channels, enabling treatment of polluted flows during conveyance rather than relying exclusively on end-of-pipe solutions such as centralized sewage treatment plants. In the present urban context of Gayaji, several natural drains and nallahs effectively function as open sewers, receiving untreated domestic wastewater from households, small establishments, and informal networks, and conveying this pollution load directly toward the River Phalgu. While long-term plans for comprehensive sewerage networks and centralized treatment facilities are being envisaged, immediate implementation is constrained by dense urban development, limited right-of-way, land availability challenges, and the presence of encroachments along drain corridors. In such a scenario, the Eco-Nallah approach offers a pragmatic and environmentally responsive solution that addresses pollution at its source and along its flow path, rather than deferring treatment until centralized infrastructure becomes operational.

Field observations and site assessments of Gayaji's nallahs indicate physical and hydraulic conditions that are particularly conducive to in-channel, nature-based treatment systems. During non-monsoon months, flow velocities are typically low and water depths remain shallow, creating extended hydraulic retention times that are favorable for biological degradation processes. These conditions support the effective application of constructed wetland elements, phytoremediation belts, and floating treatment systems, which rely on sustained contact between wastewater, microbial biofilms, and plant root zones. The gradual movement of water through these systems allows for progressive reduction of organic matter, suspended solids, and nutrient concentrations, thereby improving water quality before discharge into downstream water bodies. Such low-energy, passive treatment processes are especially suitable for drains that experience variable flows and limited maintenance capacity.

The dense urban edges that characterize many stretches of Gayaji's drains significantly limit the feasibility of conventional engineering interventions such as widening, deepening, or realignment. Encroachments, built structures, and narrow access corridors make large-scale civil works both socially disruptive and financially prohibitive. The Eco-Nallah intervention responds to these constraints by prioritizing soft, modular, and reversible interventions that can be installed within existing channel geometries without extensive structural modification. Green Bridge technology, which utilizes biologically active media such as fibrous biomass, gravel, sand, and microbial consortia, is designed to fit within the hydraulic profile of the drain while enhancing treatment performance. These installations partially obstruct flow to increase contact time, but are engineered to avoid backwater effects or flooding during peak flows.

An important site observation supporting the Eco-Nallah concept is the presence of existing vegetation along several drain banks. Although currently unmanaged, this vegetation already performs limited filtration, bank stabilization, and micro-habitat functions. The proposed intervention seeks to formalize and enhance this natural capacity through managed planting, stabilization of banks using bio-engineering techniques, and development of root-zone treatment areas. By leveraging the regenerative potential of these green banks, the drains can be gradually transformed from degraded channels into functional ecological corridors that contribute to both pollution control and urban environmental quality. Such interventions also offer co-benefits in terms of improved aesthetics, reduced odour nuisance, and enhanced public perception of urban water bodies.

The Green Bridge system operates on the principles of filtration, biodegradation, and biosorption, combining physical media and biological processes to treat wastewater in situ. Selected microbial cultures are introduced to accelerate the breakdown of organic pollutants, and over time these microorganisms colonize the media surfaces, forming stable biofilms that adapt to local wastewater characteristics. Unlike chemical treatment systems, microbial-based processes are self-sustaining, resilient to fluctuations in load, and require relatively low operational inputs. This makes them particularly suitable for decentralized applications in urban drains where continuous monitoring and intensive maintenance may not be feasible.

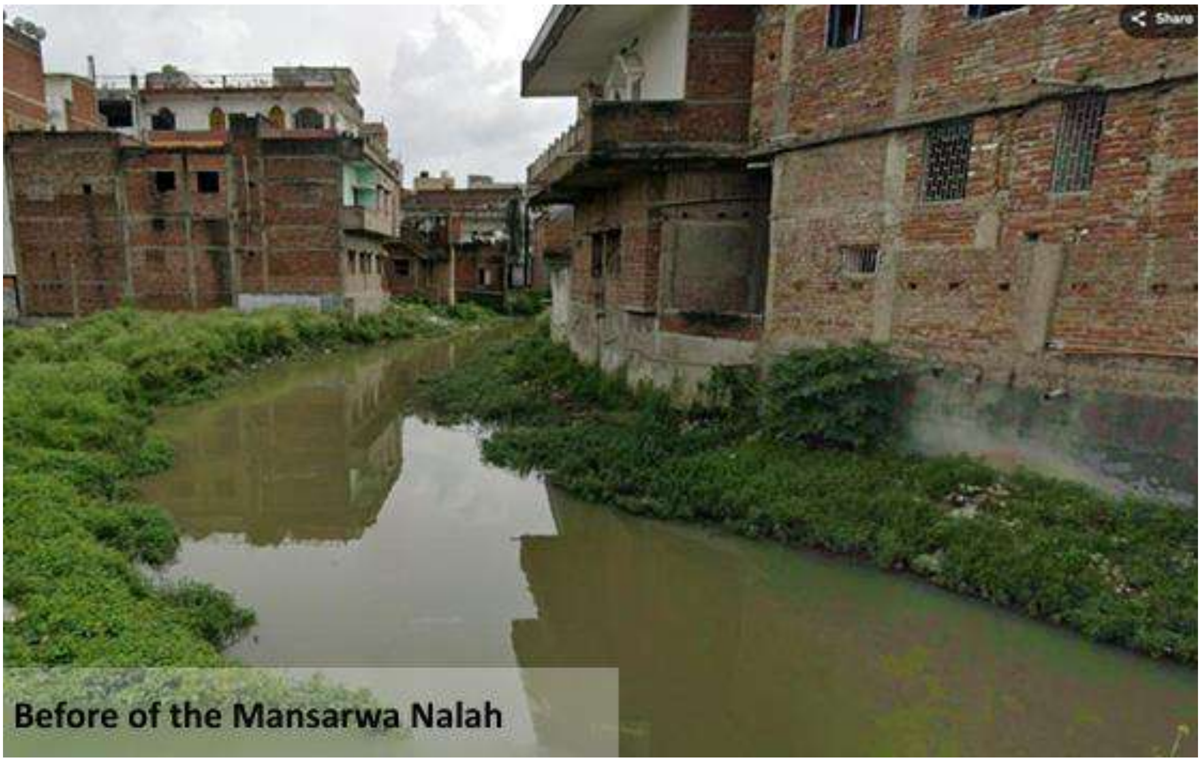
Direct inflows of wastewater from households and local networks into the nallahs are a defining characteristic of Gayaji's drainage system. In addition to liquid waste, these inflows often carry floating debris, plastics, and coarse solids that can impair treatment performance if left unmanaged. The Eco-Nallah approach therefore integrates upstream interception chambers, trash traps, and coarse screening mechanisms at strategic locations. These elements serve as pre-treatment measures, removing solids before wastewater enters the biological treatment zones, protecting downstream systems from clogging, and improving overall efficiency. The visible removal of solid waste also contributes to immediate aesthetic improvement and reinforces public confidence in the intervention.

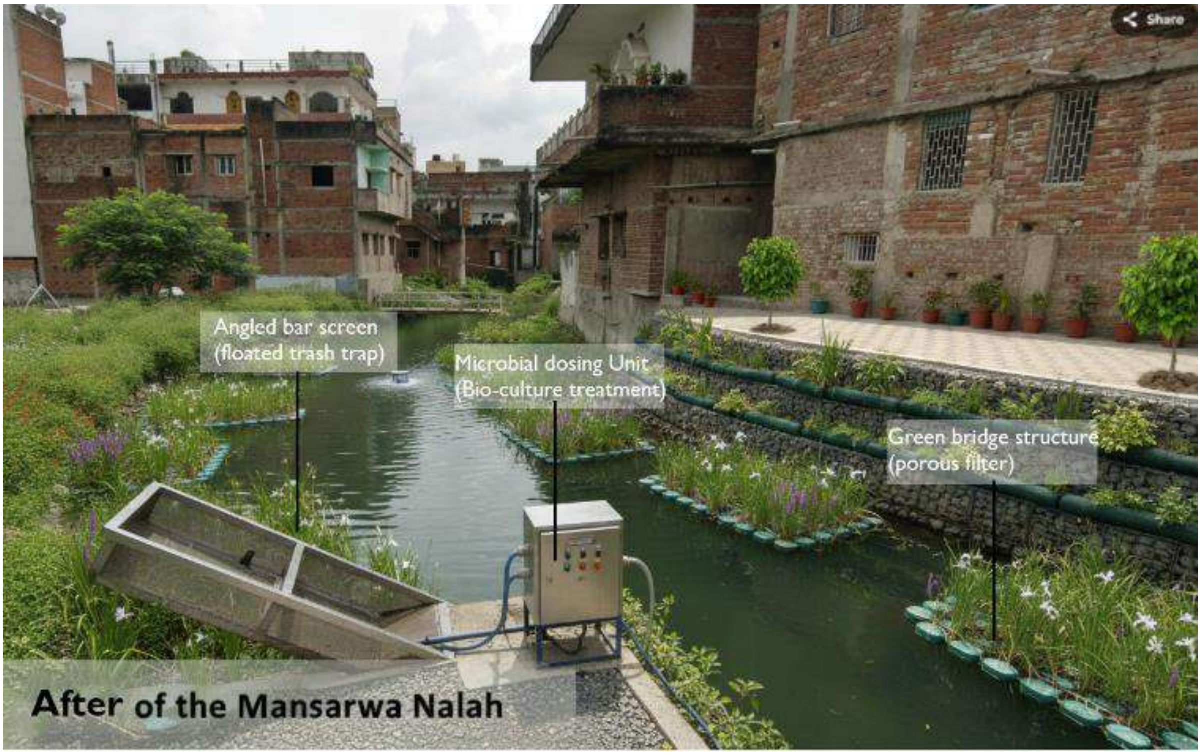
Another critical factor informing the Eco-Nallah proposal is the interaction between wastewater flows and groundwater in unlined or partially lined drain sections. In such areas, untreated sewage can infiltrate surrounding soils, posing a risk to groundwater quality and public health, particularly where shallow aquifers are used for domestic or ritual purposes. By reducing pollutant concentrations within the drain itself, the Eco-Nallah system acts as a protective barrier, limiting the extent of contamination before infiltration occurs. This preventive function is especially important in the absence of full sewerage coverage and underscores the environmental urgency of in-situ treatment.

The Eco-Nallah intervention is not envisioned as a replacement for future sewerage and centralized treatment infrastructure, but rather as a complementary and transitional solution that delivers immediate pollution reduction while supporting long-term planning objectives. Even after sewer networks and STPs are developed, such in-channel systems can continue to function as polishing units, buffers during peak flows, or decentralized solutions for unsewered pockets. Their modular nature allows for adaptation over time, ensuring that investments remain relevant as urban infrastructure evolves.

In conclusion, the observed physical, hydraulic, and ecological conditions of Gayaji's nallahs strongly validate the adoption of nature-based, in-situ treatment systems such as the proposed Eco-Nallah intervention using Green Bridge technology. By treating wastewater during conveyance, leveraging existing green banks, and integrating microbial processes within the drain channel, the approach offers a space-efficient, resilient, and environmentally sustainable solution to reduce pollution loads entering the River Phalgu. It aligns with contemporary urban water management principles that emphasize decentralization, ecological restoration, and adaptive infrastructure, while responding directly to the spatial, social, and environmental constraints of Gayaji City.

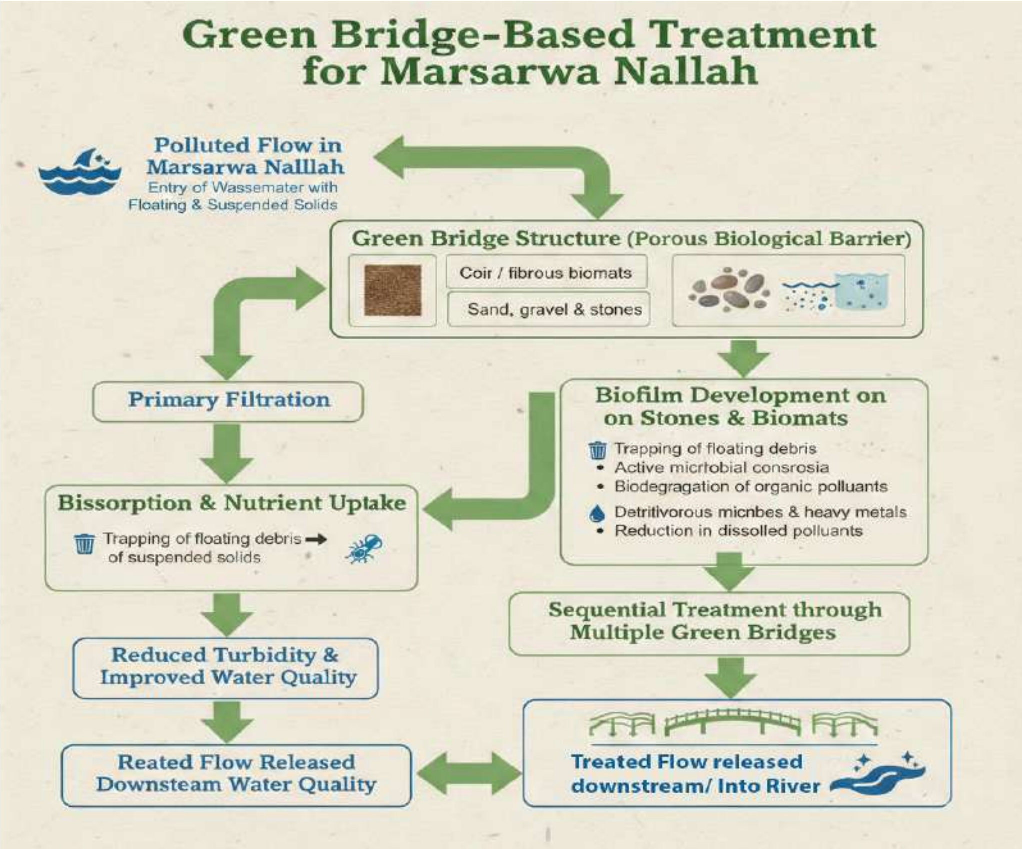
Figure 24: Before and After intervention of Mansarwa Nallah





Source: Consultant

Figure 25: Concept of Mansarwa Nallah



Source: Consultant

Table 12 : Parameters for Green Bridge Technology System of Mansarwa Nallah

Parameter	Value	Unit	Remarks
Name of Nallah	Mansarwa Nallah		
Total Length	5234	m	
Drainage Area	558.179	ha	
Wastewater Generation Rate	5	m³/ha/day	As per CPCB / AMRUT DPRs
Design Flow	2791	m³/day	≈ 2.8 MLD
Green Bridge Spacing	500	m	From case studies (Ahar River, urban nallah pilots)
Number of Green Bridges	11	Nos	
Capacity per Green Bridge	2800 / 11	255 KLD	

Source: Consultant

5.2.3.4 Intervention 2.4: Guideline on Groundwater protection and recharge zoning

Sustainable groundwater management is essential for urban resilience, public health, and water security in cities like Gayaji, where stressed surface water makes aquifers a critical supplementary source. Rapid urbanization, unregulated extraction, poor sanitation, and surface sealing have increased risks of groundwater depletion and contamination. The notification of groundwater protection and recharge zones, supported by aquifer vulnerability zoning and enforceable regulations, is crucial.

Aquifer vulnerability zoning provides a scientific basis for differentiating areas based on contamination risk and recharge potential, as groundwater conditions vary across the city. The framework classifies Gayaji into four zones—Very High, High, Moderate, and Low Vulnerability—each with specific planning and regulatory controls to balance environmental protection and development.

Very High Vulnerability Zones (Red Zones) have shallow water tables, permeable soils, and high contamination risk. These areas require strict controls, including bans on unlined septic tanks and soak pits, restrictions on excessive paving, and new development only where advanced sanitation systems are ensured. Recharge must be regulated to avoid pollutant entry.

High Vulnerability Zones (Orange Zones) have good recharge potential but remain sensitive to contamination. Managed recharge through rainwater harvesting should be promoted with strict design standards. Sanitation systems must follow enhanced construction norms, while industrial activities should be subject to permits and monitoring.

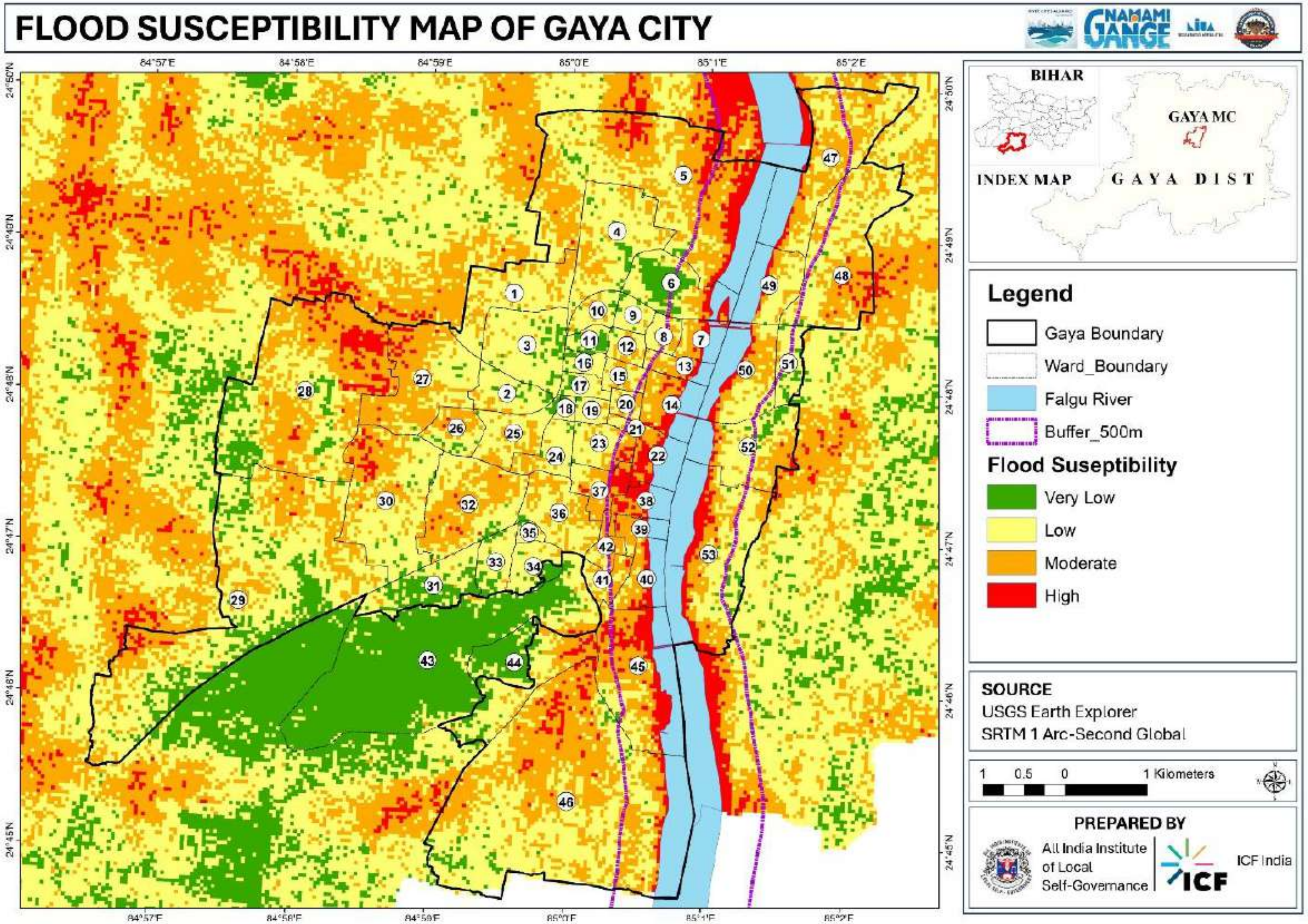
Moderate Vulnerability Zones (Yellow Zones) have limited recharge potential and moderate sensitivity. Controls can be flexible, focusing on preventing cumulative impacts, promoting controlled rainwater harvesting, and maintaining balance between built-up areas and open spaces.

Low Vulnerability Zones (Green Zones) have deeper aquifers and low recharge potential. Planning controls should focus on regulating groundwater abstraction and promoting efficient water use, rather than large-scale recharge interventions.

To operationalize this framework, aquifer vulnerability zoning should be integrated into building regulations and development rules. Key measures include banning unlined sanitation systems in high-risk zones, maintaining 10 percent permeable plot area, mandating zone-specific rainwater infiltration systems, and introducing permit-based groundwater extraction for non-domestic users. Regular water quality testing for bulk users should be mandatory to enable monitoring and adaptive management.

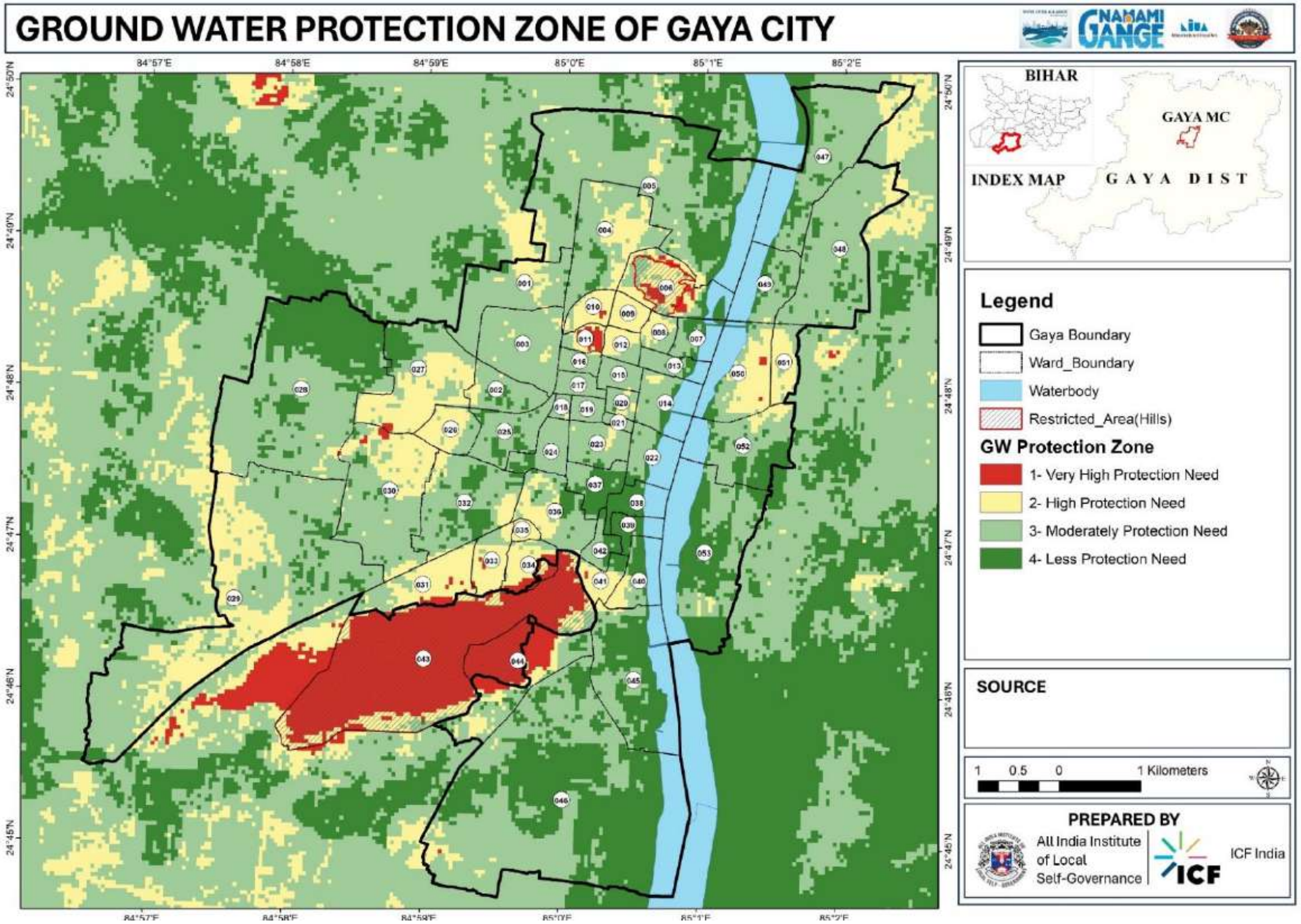
Overall, notifying groundwater protection zones based on aquifer vulnerability offers a practical approach for sustainable groundwater management in Gayaji. By aligning land use, sanitation, construction practices, and extraction controls with aquifer sensitivity, the city can safeguard groundwater resources while supporting sustainable urban development.growth.

Figure 26 : Flood Susceptibility Map of Gayaji City



Source: USGS Earth Explorer, SRTM 1 Arc-Second global

Map 21: Ground water protection zone of Gayaji City



Source: Consultant

5.3. Objective 3: Rejuvenation of Waterbodies

***Objective 3** aims to gauge the existing condition of inland water bodies within the city to assess their potential for rejuvenation and their "acceptable" condition. All water bodies more than 1 acre are considered for study, as otherwise advised by the city.*

Element : ENVIRONMENT

Significance:

Waterbodies and wetlands are intrinsically connected to rivers either through their drainage patterns or groundwater flow. Rejuvenating water bodies aid in **reducing the burden on rivers**. They **improve groundwater recharge,** which in **turn helps augment the water supply of a city**, and reduces the stress on rivers. Similarly, rejuvenated wetlands are **natural "wastewater treatment plants"** that can significantly **mitigate the pollution** load entering a river. Waterbodies also add to **recreational significance** to the city

Scope as per URMP:

Qualitative Assessment -

- No presence of solid waste in or around the water body
- No discharge of untreated wastewater in the water body
- Presence of a boundary protection around a water body
- No visible eutrophication in the water body
- Minimum DO of 4 mg/l
- No reduction in volume of water from previous year

5.3.1.Existing Situation

Water bodies have multiple uses and nomenclatures based on their purpose. The classification in this report was done by resources, comprising ponds, tanks, irrigation tanks, lake, reservoirs, beels, river and stream. Gayaji has 26 officially recognized ponds, tanks and kunds as reported by the Gayaji Nagar Nigam. Water bodies can be perennial, containing water throughout the year, or seasonal, containing water only post monsoon. Many water bodies hold cultural, historical, ecological, social, and religious significance. Water bodies are classified into two groups: less than 1.0 acre and greater than 1.0 acre. This report analyzes water bodies with spread area greater than 1.0 acre for URMP preparation. The 17 water bodies (greater than 1.0 acre) occupy about 764.05 hectares maximum and 416 hectares minimum water spread area. Most water bodies have a spread area less than 1 acre.

No database exists for these 26 water bodies regarding depth, capacity, ownership, uses, spread area, and quality. However, data for 17 water bodies are from the Open Government Data (OGD) Platform India and listed below. Surface water bodies are essential for domestic, cultural, and commercial uses like pisciculture, livestock, recreation, and agriculture. They serve ecological purposes and are vital for groundwater recharge. Thus, maintaining and knowing these resources is necessary. As Gayaji's urban development expands pilgrim infrastructure, commercial zones, and residential enclaves, encroachment on pond margins and wetlands has intensified. Untreated sewage, solid waste dumping, and seasonal siltation from rocky hills are increasing pollution and diminishing hydrological functions of these vital urban water bodies.

Ramsagar Pond is a Semi-Permanent type pond in densely populated Jaiprakash Nagar Colony. Surya Kund is located on the west side of the "Vishnupad Temple" and is regarded as one of the most prominent ponds for pilgrim rituals. Bisar Talab is located on the southern side of Gandhi Maidan and is a semi-permanent type pond.

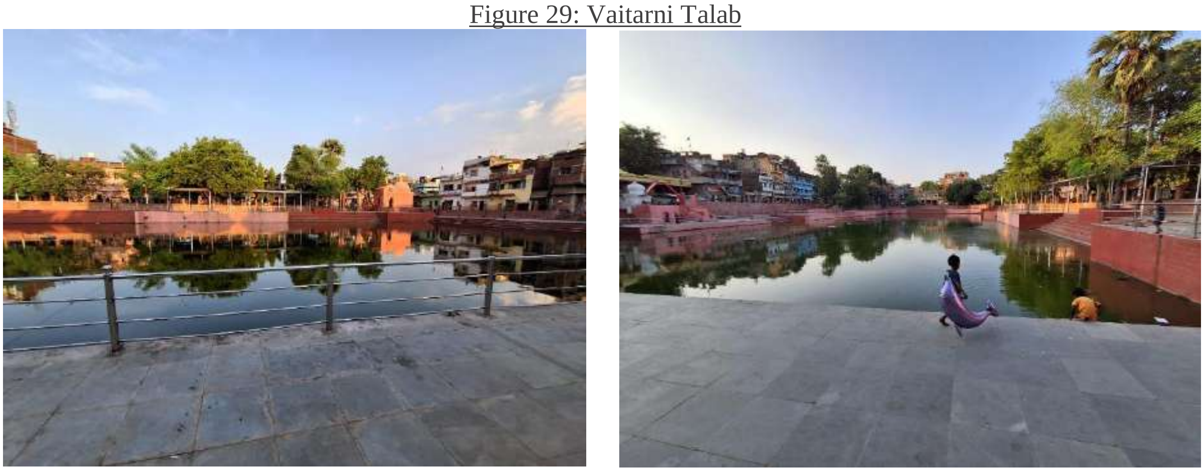
Figure 27: Ramsagar Pond

Source: Primary Survey, 2025

Figure 28: Saryu Talab

Source: Primary Survey, 2025

Figure 29: Vaitarni Talab



Source: Primary Survey 2025

Table 13: List of Water Bodies with Area greater than 1 acre

Sl. No.	Name of Water Body	Ward No.	Ownership	Nature of Water Body	Present Status	Water Spread Area (acre)	Fully Filled Max. Depth of Water Bodies (m)	Original Storage Capacity (Sq. m)	Present Storage Capacity (Sq. m)	Filled-up Storage Space	City & Villages Benefited (No.)	Water in Use	Renovation Year
1	KHARKHURA ROAD POND	3	Co-operative	Natural	-	1.9	8	840000	420000	Usually filled up	City - 1; Vill. - 4	Pisciculture, Ground Water Recharge & Industrial	2019
2	SURYA POKHARA, SURYAMANDIR, MANPUR	47	Other Govt. Agency	Natural	-	4.25	7	240000	120000	Usually filled up	City - 2; Vill. - 2	Religious, Ground Water Recharge & Other	2016
3	GODAWARI SAROWAR RAJENDRA MADHYA VIDHAYALAYA	43	Co-operative	Natural	-	5.81	7	23520	12520	Usually filled up	City - 1; Vill. - 1	Religious, Ground Water Recharge & Other	2016
4	BISAR TANK	37	Co-operative	Natural	-	3.5	7	560000	280000	Usually filled up	City - 1; Vill. - 4	Pisciculture, Ground Water Recharge & Industrial	2019
5	GANDHI MAIDAN POND	37	Co-operative	Natural	-	1.86	7	550000	270000	Usually filled up	City - 1; Vill. - 4	Pisciculture, Ground Water Recharge & Industrial	2018
6	DIGGHI TALAB	37	Co-operative	Natural	-	5.5	6	560000	30000	Usually filled up	City - 1; Vill. - 4	Pisciculture, Ground Water Recharge & Industrial	2019

Sl. No.	Name of Water Body	Ward No.	Ownership	Nature of Water Body	Present Status	Water Spread Area (acre)	Fully Filled Max. Depth of Water Bodies (m)	Original Storage Capacity (Sq. m)	Present Storage Capacity (Sq. m)	Filled-up Storage Space	City & Villages Benefited (No.)	Water in Use	Renovation Year
7	MEMU & LOCO TALAB	28	Private Body	Earthen, Man Made in 1960	-	24.46	5	495000	495000	Filled up every year	City - 1; Vill. - 1	Industrial, Ground Water Recharge & Religious	2019
8	KATARI HILL ROAD TALAB	27	Co-operative	Natural	Dried-up	1.86	5	460000	-	-	-	-	-
9	BRAHMSATYA TALAB OR BRAHSAROWAR TALAB	45	Co-operative	Natural	-	2.5	8	800000	600000	Filled up every year	City - 2; Vill. - 2	Pisciculture, Religious & Ground Water Recharge	2016
10	BAITARANI TALAB	45	Co-operative	Natural	-	2	2	75000	55000	Filled up every year	City - 6; Vill. - 5	Pisciculture, Religious & Ground Water Recharge	2019
11	SARYA TALAB OR SINGARA STHAN TALAB	31	Co-operative	Natural	-	2.75	8	400000	300000	Usually filled up	City - 1; Vill. - 2	Religious, Recreation & Ground Water Recharge	2016
12	SINGRA ASTHAN TALAB OR POLICE LINE TALAB	33	Co-operative	Natural	-	6.5	7	540000	270000	Usually filled up	City - 1; Vill. - 4	Pisciculture, Ground Water Recharge & Recreation	2019
13	KHARKHURA TALAB DEVI ASTHAN	1	Co-operative	Natural	-	1.88	6	480000	240000	Usually filled up	City - 1; Vill. - 4	Pisciculture, Ground Water Recharge & Industrial	2019
14	RAMSAGAR TALAB	42	Co-operative	Natural	-	2.55	4	213000	173250	Usually filled up	City - 2; Vill. - 2	Pisciculture, Religious &	2013

Sl. No.	Name of Water Body	Ward No.	Ownership	Nature of Water Body	Present Status	Water Spread Area (acre)	Fully Filled Max. Depth of Water Bodies (m)	Original Storage Capacity (Sq. m)	Present Storage Capacity (Sq. m)	Filled-up Storage Space	City & Villages Benefited (No.)	Water in Use	Renovation Year
												Ground Water Recharge	
15	RUKMINI TALAB OR KHANMANI TALAB AKSHAYA VATA	44	Co-operative	Natural	-	2.3	8	384000	384000	Filled up every year	City - 1; Vill. - 2	Pisciculture, Religious & Ground Water Recharge	2016
16	HAVELI TALAB	44	Co-operative	Natural	-	3.5	6	480000	240000	Usually filled up	City - 1; Vill. - 2	Pisciculture, Recreation & Ground Water Recharge	2013
17	SURYA KUND	40	Co-operative	Natural	-	3.5	6	540000	270000	Usually filled up	City - 1; Vill. - 4	Religious, Pisciculture & Ground Water Recharge	2016

Source: Open Government Data (OGD) Platform India

Figure 30: Brahmsatya Talaav

Source: Primary Survey, 2025

Figure 31: Digghi Talab

Source: Primary Survey, 2025

Digghi Talab in Gayaji is being positioned as a central wetland node, ideal for supporting seasonal waterfowl, stabilizing soil and enhancing scenic greenery, while also serving as an anchor for nature-based tourism and environmental education initiatives. It functions as a focal water body within the Women for Trees plantation program led by Gayaji Nagar Nigam. The 2025 AMRUT estimate allocates roughly INR 2.18 lakh for planting and maintaining 100 native tree saplings at Digghi Talab, signalling an early investment that could help shape the site into a green corridor and wetland habitat within Gayaji's alluvial landscape.

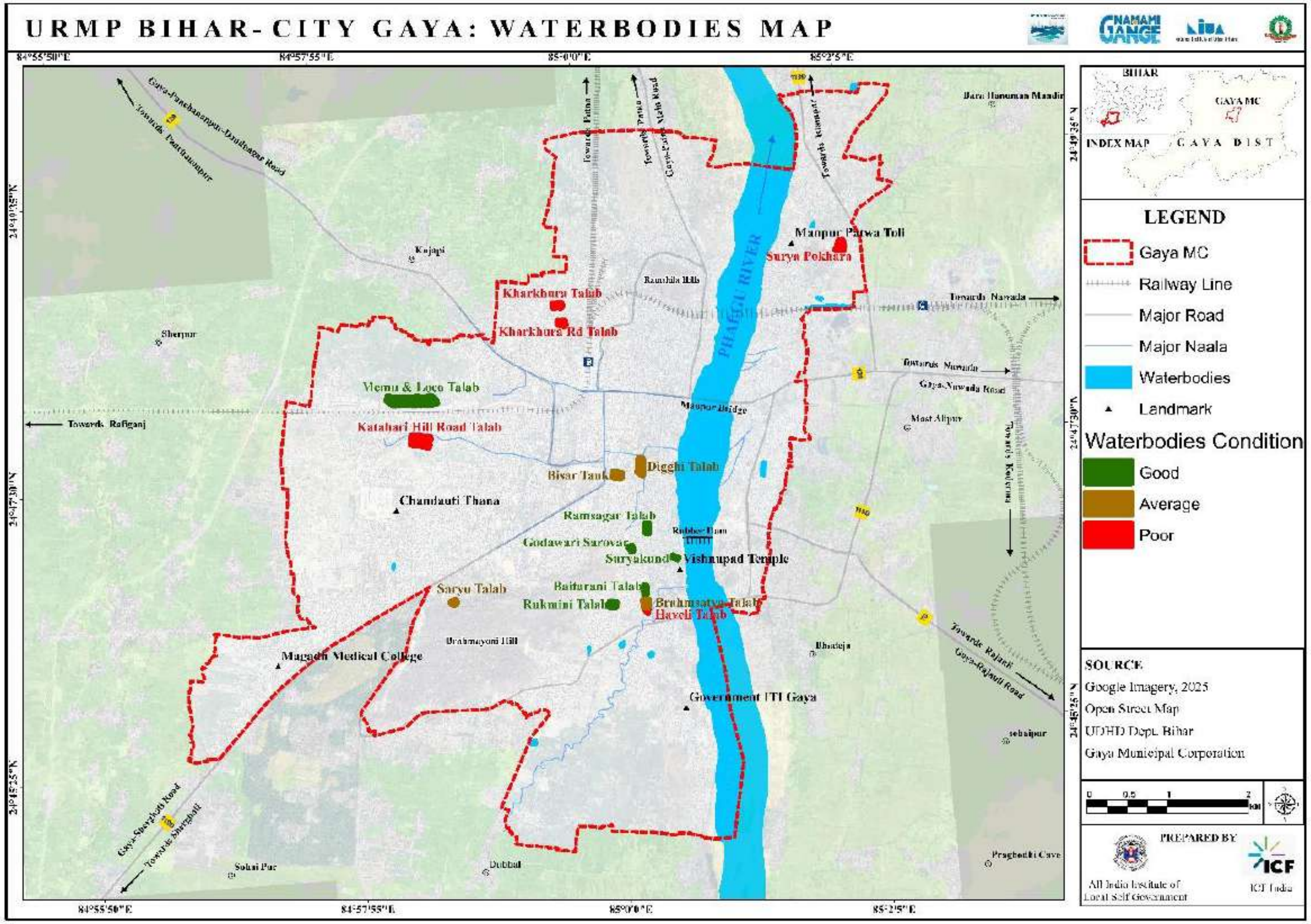
A field-based qualitative ecological assessment was conducted between June and August 2025, across 17 water bodies in Gayaji city to evaluate their current environmental status. The assessment focused on six key indicators: absence of solid waste, lack of untreated wastewater discharge, presence of boundary protection, absence of visible eutrophication, minimum dissolved oxygen (DO) levels of 4 mg/L and no reduction in water volume compared to the previous year. These indicators were selected to reflect both ecological health and basic infrastructure safeguards. The surveyed water bodies are tabulated below.

Table 14: Qualitative Assessment of the Waterbodies on Conditions based on Six Key Indicators

Sl. No.	Water Body / Site	Solid Waste Present	Untreated Wastewater Discharge	Boundary Protection Present	Visible Eutrophication	Minimum DO (mg/L)	Water Volume Change vs. Last Year
1	Needed	Yes	Yes	No	Yes	≥ 4	No Reduction
2	SURYA POKHARA, SURYAMANDIR, MANPUR	Yes	Yes	No	Yes	≥ 4	No Reduction
3	GODAWARI SAROWAR RAJENDRA MADHYA VIDHAYALAYA	No	No	Yes	No	≥ 4	No Reduction
4	BISAR TANK	No	Yes	No	Yes	≥ 4	No Reduction
5	GANDHI MAIDAN POND	Yes	Yes	No	Yes	≥ 4	No Reduction
6	DIGGHI TALAB	Yes	Yes	No	Yes	≥ 4	Yes
7	MEMU & LOCO TALAB	No	Yes	No	Yes	≥ 4	No Reduction
8	KATARI HILL ROAD TALAB	Yes	Yes	No	No	NA	No Reduction
9	BRAHMSATYA TALAB OR BRAHSAROWAR TALAB	No	No	Yes	No	≥ 4	No Reduction
10	BAITARANI TALAB	No	No	Yes	No	≥ 4	No Reduction
11	SARYA TALAB OR SINGARA STHAN TALAB	Yes	Yes	No	Yes	≥ 4	No Reduction
12	SINGRA ASTHAN TALAB OR POLICE LINE TALAB	Yes	Yes	No	Yes	≥ 4	No Reduction
13	KHARKHURA TALAB DEVI ASTHAN	Yes	Yes	No	Yes	≥ 4	No Reduction
14	RAMSAGAR TALAB	No	No	Yes	No	≥ 4	No Reduction
15	RUKMINI TALAB OR KHANMANI TALAB AKSHAYA VATA	No	No	Yes	No	≥ 4	No Reduction
16	HAVELI TALAB	Yes	Yes	No	Yes	≥ 4	No Reduction
17	SURYA KUND	No	No	Yes	No	≥ 4	No Reduction

NA – Not Applicable; Source: Primary Survey, 2025

Map 22: Waterbodies of Gayaji City



Source: Portrayed by Agency

Figure 32: Presence of Solid Waste in or around the Water Body – Falgu River

Source: Primary Survey, 2025

Figure 33: Discharge of Untreated Wastewater in the Water Body – Falgu River

Source: Primary Survey, 2025

Figure 34: No Presence of a Boundary Protection around the Water Body – Mansarovar Naala

Figure 35: Visible Eutrophication in the Water Body - Brahmsatya Talav

Source: Primary Survey, 2025

Figure 36: Presence of Minimum DO (4 mg/L) - Digghi Talab

Source: Primary Survey, 2025

Figure 37: Encroachment of Water Bodies at Naili

Source: Primary Survey, 2025

Key initiatives for the rejuvenation of water bodies in Gayaji Municipal Corporation are being implemented under various government schemes, most notably the state-level Jal-Jeevan-Hariyali Mission and the national Atal Mission for Rejuvenation and Urban Transformation (AMRUT).

The ₹1.62 crore rejuvenation project for the Singra Asthan Sarovar was undertaken in 2018–2019 under the central government's Atal Mission for Rejuvenation and Urban Transformation (AMRUT). The project was led by the Urban Development Department. The Magadh Jal Jamaat, a network of individuals in Gayaji, has successfully revived over a dozen abandoned water sources, including the Saryu talab and Jamune Dasain in Gayaji city. Their work has inspired the restoration of traditional ahar-pyne systems and promoted community-led water conservation. The Guardian of the Falgu, Mr. Ashok Verma, together with the GDA and partner NGOs such as Arghyam and DISHA, is spearheading rejuvenation efforts on over five key water bodies. These include Brahmayoni Kund, Sita Kund, Mangla-Gauri Spring, Shringa-Sthan Pond and Ram-Shila Tank. Although these agencies are making steady progress in desilting embankments, repairing inlet channels and restoring historic steps but there remains no consolidated, publicly accessible database capturing each water body's bathymetry, aerial extent, total storage capacity, legal ownership patterns or up-to-date water-quality metrics.

The Bihar State Pollution Control Board (SPCB) undertakes systematic monitoring of river water quality in accordance with the protocols prescribed by the Central Pollution Control Board (CPCB). At designated monitoring stations, water samples are collected on a monthly basis and subjected to laboratory analysis for DO, BOD, COD, pH and a range of other physico-chemical and biological parameters. For Gayaji city, this study draws upon data recorded between 2019 and 2024 across two officially monitored water bodies stations namely Digghi Talab and Surya Kund.

Between 2019 and 2024, water quality monitoring of Dighi Talab and Surya Kund in Gayaji revealed persistent ecological stress, with COD frequently spiking far above the desirable limit of 10 mg/L (up to 56 mg/L at Dighi and 92 mg/L at Surya Kund), BOD often exceeding the CPCB Class-B standard of 3 mg/L (peaking at 12 mg/L and 11 mg/L respectively) and DO fluctuating between near-zero hypoxic conditions and abnormally high values caused by algal blooms. These patterns, most pronounced during the monsoon and post-monsoon months, reflect untreated sewage inflows, ritual waste, and runoff, leaving Surya Kund more polluted due to its intense religious use. The absence of consistent improvement over the six-year period underscores that current rejuvenation measures have not stabilized water quality, with frequent BOD >5 mg/L and DO <4 mg/L episodes posing risks to aquatic biodiversity, groundwater recharge, and the overall ecological resilience of Gayaji's urban water bodies. Refer annexure.

5.3.2.URMP Score

Water body revival score = (Total number of water body in "acceptable" condition/ Total number of water bodies) X 100 . Out of the 17 water bodies evaluated, 5 were in acceptable condition scoring 37.5 as per the parameters defined in the framework. As per URMP, if water body revival factor is 1.

5.3.3.Interventions

5.3.3.1 Intervention 3.1: Create a comprehensive GIS-based inventory and water quality monitoring system for all waterbodies

A comprehensive GIS-based inventory and water quality monitoring system is essential for the sustainable management, protection, and rejuvenation of urban and peri-urban waterbodies. Rapid urbanization, encroachment, pollution, and hydrological alterations have significantly degraded lakes, ponds, rivers, wetlands, and other surface water resources. To address these challenges, a centralized, spatially enabled decision-support system is proposed to map, monitor, and manage all waterbodies within the city jurisdiction.

The proposed system shall involve the creation of a geo-referenced digital inventory of all waterbodies using high-resolution satellite imagery, drone surveys, and ground-truthing. Each waterbody will be assigned a unique identification code and mapped within a GIS platform, capturing attributes such as location, surface area, storage capacity, ownership, hydrological connectivity, catchment characteristics, inflow and outflow structures, surrounding land use, and encroachment status. Seasonal variations in water spread area will also be monitored to assess hydrological health and climate resilience.

In line with national best practices promoted by the National Institute of Urban Affairs (NIUA), the inventory shall be integrated with a digital waterbody management platform/app, similar to NIUA-supported GIS tools developed under AMRUT and urban water programs. Such platforms enable standardized data collection, visualization, and real-time updating by urban local bodies (ULBs), ensuring transparency and institutional accountability. The system will allow field officials to upload geo-tagged photographs, inspection reports, and status updates through a mobile-based interface.

A critical component of the system is water quality monitoring. Regular sampling shall be conducted for key physico-chemical and biological parameters such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, nutrients, fecal coliform, and heavy metals, depending on waterbody use and sensitivity. Monitoring stations—both manual and sensor-based—will be strategically located to capture pollution sources, inflow points, and downstream impacts. The collected data will be linked to the GIS database, enabling spatial and temporal analysis of water quality trends.

The system will also support risk-based classification of waterbodies based on pollution levels, ecological importance, and vulnerability to encroachment or contamination. This classification will guide prioritization of interventions such as desilting, bioremediation, constructed wetlands, sewage interception, buffer zone development, and catchment treatment. Integration with land-use plans, stormwater drainage maps, and sanitation infrastructure will ensure coordinated urban planning and water-sensitive design.

Furthermore, the GIS-based platform will facilitate public disclosure and citizen engagement, allowing selected waterbody information to be shared through dashboards or mobile apps. This promotes community stewardship, grievance reporting, and awareness regarding waterbody protection.

Overall, the proposed GIS-based inventory and water quality monitoring system will serve as a robust planning and governance tool, enabling data-driven decision-making, regulatory enforcement, and long-term conservation of urban waterbodies, fully aligned with NIUA's digital urban water management framework and national missions such as AMRUT 2.0.

5.3.3.2 Intervention 3.2: Rejuvenation of Dighi Talab and Haveli Talab

Issues and observation

The city has 26 officially recognized waterbodies, of which 17 are larger than one acre, indicating a substantial blue infrastructure base. However, their current condition is a matter of concern. Solid-waste dumping affects nearly 53% of the waterbodies, while about 35% receive untreated wastewater, leading to severe degradation of water quality. Boundary protection is absent in 47% of cases, making these assets vulnerable to encroachment and misuse. Visible eutrophication is observed in nearly 59% of the waterbodies, reflecting excessive nutrient loading and stagnation. Alarmingly, 94% show no improvement in water volume, highlighting chronic issues of siltation, disrupted catchments, and poor groundwater recharge.

Ongoing efforts

Despite these challenges, several rejuvenation initiatives are underway. Digghi Talab has been included under the Women for Trees programme through AMRUT 2025, integrating ecological restoration with community participation. Singra Asthan Sarovar has already been rejuvenated under AMRUT, serving as a demonstrative success. Beyond government-led initiatives, local groups and individuals have revived more than 12 abandoned talabs, including Saryu and Jamune Dasain, through collective action. Additionally, focused efforts are ongoing to rejuvenate over five culturally significant kunds and tanks, such as Brahmayoni, Sita Kund, Mangla-Gauri, Shringa Sthan, and Ram-Shila Tank, reinforcing the link between heritage conservation and waterbody restoration.

Digghi Talav: Context and Existing Conditions

Digghi Talav is one of the prominent urban waterbodies in the city, with a water spread area of approximately 5.5 acres. Owing to its size and strategic location, the talav plays a significant role in pisciculture, groundwater recharge, and industrial water support, making it an important component of the city's blue-green infrastructure network. Beyond its functional role, Digghi Talav also serves as a public open space, contributing to urban livability and recreation.

The waterbody is currently protected by a defined boundary on all sides, with controlled, gated access, which has helped limit large-scale encroachment. The presence of walking pathways, ghat steps, and a viewing deck along the periphery indicates earlier investments aimed at integrating the talav with public life. These features encourage recreational use such as walking, leisure, and informal gatherings, and provide visual and physical access to the water.

However, despite its physical infrastructure, the existing environmental condition of Digghi Talav is deteriorating. A major concern is the discharge of untreated wastewater directly into the waterbody, which has resulted in declining water quality and poses risks to aquatic life, especially pisciculture activities. This inflow of sewage contributes to nutrient loading, leading to algal growth and reduced dissolved oxygen levels. In addition, solid waste accumulation is observed along the edges and near inflow points, further degrading the ecological health and aesthetic value of the talav.

While the protected boundary restricts indiscriminate dumping, gaps in waste, management and inadequate interception of drains continue to undermine conservation efforts. The existing pathways and ghat steps, though functional, require regular maintenance to prevent deterioration and ensure user safety. The viewing deck, if properly maintained, has the potential to function as an educational and recreational node, promoting awareness about waterbody conservation.

In its current state, Digghi Talav represents a partially protected but environmentally stressed urban waterbody. Its large water spread area and existing public infrastructure provide a strong foundation for rejuvenation. With targeted interventions such as wastewater diversion and treatment, solid waste control, desilting, and ecological restoration, Digghi Talav can be transformed into a resilient urban asset that balances environmental sustainability, community use, and economic functions such as fisheries and groundwater recharge.

Figure 38: Existing Water Spread Area of Digghi Talav

Source: Consultant

Figure 39: Existing walking pathway & steps of Digghi Talav

Source: Consultant

Figure 40: Existing wastewater discharge & water edge of Digghi Talav

Source: Consultant

Proposed Strategy of Digghi Talav

Digghi Talav is envisioned as a multi-functional urban waterbody that balances ecological restoration, cultural significance, and public recreation. Given its role as a key city-level recreational space, particularly during Pitru Paksh, the proposed strategy aims to enhance environmental quality while strengthening the spiritual and social character of the talav.

A continuous compound wall is proposed along the periphery, softened with climber and creeper plantations to create a green buffer and reduce visual harshness. The wall will also serve as a cultural narrative surface, depicting the story and rituals of Pind Daan through murals and interpretative panels, reinforcing the talav's spiritual identity and promoting heritage awareness among visitors.

A dedicated walking and jogging track will be developed along the embankment, designed with permeable materials to allow rainwater infiltration and minimize surface runoff. Strategically placed decks and viewing points will offer safe access to the water edge, encouraging passive recreation, bird watching, and social interaction without disturbing aquatic habitats.

To improve water quality, Floating Treatment Wetlands (FTWs) will be introduced within the pond. These FTWs, planted with flowering and aromatic species, will act as natural bio-filters by absorbing nutrients and pollutants from the water, while simultaneously attracting birds, pollinators, and aquatic life. This intervention will enhance biodiversity and create visually appealing ecological zones within the talav.

The embankments will be stabilized and landscaped using native flowering plants, shrubs, and grasses to prevent erosion, improve aesthetics, and create a seasonal visual experience. Along the water edge, stone and gravel-based edge treatments are proposed to naturally filter runoff, trap sediments, and reduce direct pollutant inflow into the waterbody.

For active water management, surface aerators will be installed to increase dissolved oxygen levels, prevent stagnation, and support aquatic life, particularly pisciculture. At the nala outlet points, trash boom barriers will be installed to intercept floating solid waste before it enters the waterbody, reducing pollution load and maintenance requirements.

To support public use and ensure long-term sustainability, basic urban infrastructure will be systematically provided. This includes adequate lighting for safety, seating areas, segregated waste bins, directional and interpretative signages, and drinking water points. Dedicated collection points for flowers and puja waste will be established to prevent ritual waste from entering the water, with provisions for composting or safe disposal.

Overall, the proposed strategy seeks to transform Digghi Talav into a clean, vibrant, and culturally rooted urban commons, integrating nature-based solutions, community engagement, and infrastructure upgrades. The approach not only addresses existing environmental issues but also ensures that Digghi Talav functions as a resilient recreational and spiritual space throughout the year, with heightened capacity to manage peak footfall during Pitru Paksh.

Figure 41: Proposed Strategy of Digghi Talav

Source: Consultant

Figure 42: Present situation of Digghi Talab

Source: Consultant

Figure 43: Digghi Talav Reimagined

Source: Consultant

Existing condition of Haveli Talav

Haveli Talav is a medium-sized urban waterbody with a water spread area of approximately 3.5 acres, playing an important role in pisciculture, recreation, and groundwater recharge. Located within the urban fabric, the talav has the potential to function as a neighborhood-level blue–green open space while contributing to local livelihoods and ecological balance. However, its current condition reflects significant institutional and physical challenges that threaten its sustainability.

The most critical issue affecting Haveli Talav is encroachment along its periphery. Gradual occupation of the buffer zone for informal activities and structures has reduced the effective water spread area and disrupted natural inflow patterns. Encroachment has also limited public access to certain stretches of the waterbody, creating fragmented and poorly managed edges that are vulnerable to further degradation.

Eutrophication is widely evident, driven by nutrient inflow from surrounding areas and stagnation of water. The excessive growth of aquatic weeds and algal blooms has led to reduced dissolved oxygen levels, adversely impacting pisciculture and overall water quality. This condition also results in foul odour and visual deterioration, discouraging recreational use and increasing public health concerns.

A major gap is the absence of any gating or fencing around the talav. Unrestricted access has enabled indiscriminate dumping of solid waste, washing activities, and unregulated human and animal movement along the banks. The lack of controlled entry points has also made monitoring and maintenance difficult for local authorities.

In its present state, Haveli Talav remains highly vulnerable to further degradation, despite its functional importance. Without immediate interventions such as demarcation of boundaries, removal of encroachments, access control, and ecological restoration, the talav risks losing its role as a recharge zone and recreational asset. Targeted rejuvenation measures can help reclaim Haveli Talav as a safe, productive, and environmentally resilient urban waterbody supporting both community use and ecological health.

Figure 44: Existing condition of Haveli Talav (100% Eutrophication)

Source: Consultant

Proposed Strategy of Haveli Talav

The proposed rejuvenation strategy for Haveli Talav aims to restore the ecological health of the waterbody while ensuring controlled public access and long-term sustainability. The approach integrates nature-based solutions with minimal physical interventions to enhance water quality, biodiversity, and community engagement without disturbing the natural character of the pond.

To begin with, the physical boundaries of Haveli Talav will be clearly demarcated using low-impact edge markers such as stone bollards, wooden posts, or natural rope fencing. This will prevent encroachment and unregulated access while maintaining visual permeability. In addition, hedges composed of native shrub species will be planted along the periphery, with limited and clearly designated entry points. These controlled access points will help regulate human movement, reduce littering, and protect sensitive ecological zones.

Desiltation and re-profiling of the pond bed form a critical component of the strategy. Accumulated silt will be removed to restore the original holding capacity of the waterbody. The pond bed will be re-profiled to create shallow zones suitable for macrophyte growth and deeper refuge zones to retain water during summer months. This depth variation will support aquatic biodiversity and improve the resilience of the pond during dry periods.

To improve water quality, floating treatment wetlands (FTWs) will be introduced. These FTWs will be planted with native phytoremediation species such as Typha, Phragmites, and Vetiver, which are effective in nutrient uptake and removal of pollutants. The FTWs will help reduce biochemical oxygen demand (BOD), suspended solids, and nutrient loading in the water. Surface aerators will be installed at strategic locations to enhance dissolved oxygen levels, prevent anaerobic conditions, and reduce foul odour, especially during lean flow periods.

Reed beds will be developed along the embankments to act as bio-filters for surface runoff entering the pond. These reed beds will trap sediments, absorb nutrients, and prevent direct inflow of pollutants, thereby strengthening the pond’s self-purification capacity.

To support community use and stewardship, basic public infrastructure such as solar lighting, seating, waste bins, and designated collection points for flower and puja waste will be provided. This will discourage ritual waste dumping into the waterbody. Viewing decks will be constructed at select locations to allow people to enjoy the pond without disturbing the embankments or aquatic habitat.

Overall, the proposed strategy balances ecological restoration with cultural and social needs, ensuring Haveli Talav functions as a healthy, resilient, and community-friendly urban waterbody.

Figure 45: Proposed Strategy of Haveli Talav

Source: Consultant

Figure 46: Existing and Proposed Image of Haveli Talav

Source: Consultant

5.4. Objective 4: Enhancing Riparian Buffer

***Objective 4** seeks to restore and strengthen riparian buffers as natural shields that protect rivers from urban pressures and flooding. By developing continuous stretches of native vegetation along riverbanks, cities can stabilize soils, filter pollutants, and create ecological corridors.*

Element : ENVIRONMENT

Significance:

Riparian zones are ecological shields that maintain water quality, prevent erosion, and provide a refuge for biodiversity. When urban development encroaches on these zones, the river loses its natural protection, making it vulnerable to pollution and floods. Establishing riparian buffers helps cities mitigate disasters while promoting biodiversity corridors that strengthen ecosystem services. They also improve the aesthetics of urban rivers, making them spaces for both nature and people.

Scope as per URMP:

- Continuous Vegetative Buffer
- Native Species

5.4.1.Existing Situation

Within the Gayaji Municipal Corporation limits, the Falgu (Falgu) River runs roughly 9.6 km of urban frontage, yet barely 0.9 km of naturally vegetated riparian buffer remains which comprising scattered sandbars, scrub thickets and remnant floodplain grasslands. This acute shortfall underscores the imperative of Objective 4 in Gayaji's Urban River Management Plan, which calls for systematic restoration and enhancement of riparian corridors. Although the Bihar Forest Department and Gayaji Municipal Corporation have sponsored piecemeal plantation drives most visibly around the Vishnupad temple precincts, these efforts are confined to isolated patches and are negated by impermeable ghats, embankments, informal settlements, agricultural encroachment and invasive Prosopis juliflora stands. As a result, native riparian species such as Madhuca longifolia, Ficus racemosa and Tamarix dioica[6] are in decline, both in number and compositional diversity. The current saplings are chiefly sourced from the Gayaji nursery or roadside hawkers. Securing the Falgu's capacity for bank stabilization, sediment trapping and wildlife habitat provision will require re-establishing a continuous, multi-tiered vegetative buffer which extending well beyond existing fragments to reconnect the river with its floodplain and restore its ecological functions.

Historically, the Manpur stretch of the Falgu's floodplain supported a continuous, multi-storied riparian forest that extended from the active channel to the backswamp margins. Early 20th century land-use records and travellers' accounts describe a mosaic of Ficus religiosa[7] (Peepal), Madhuca longifolia (Mahua) and Terminalia arjuna lining the banks, with dense mid-story growth of Hibiscus spp. and native grasses such as Saccharum spontaneum on point bars. Aquatic fringes teemed with Nelumbo nucifera (lotus) in monsoon ponds, while overhanging branches harboured Common Kingfishers (Alcedo atthis) and Little Egrets (Egretta garzetta). Large-bodied fish—rohu (Labeo rohita), catla (Catla catla) and freshwater turtles like Nilssonia gangetica—used the vegetated margins as spawning and nursery grounds. Oral histories from local fishers and the first botanical surveys (1950s) attest to a seamless transition from wetland to riparian woodland, supporting a diverse assemblage of birds, reptiles and mammals including Smooth-coated Otter (Lutrogale perspicillata).

The Manpur riparian buffer is now highly degraded, fragmented by embankments and encroachments. Native vegetation has been replaced by invasive species, aquatic habitats are choked, and fish spawning has sharply declined. Herpetofauna and bird diversity have collapsed, with generalist species dominating. This reflects a major loss of ecological functions once provided by the riparian zone.

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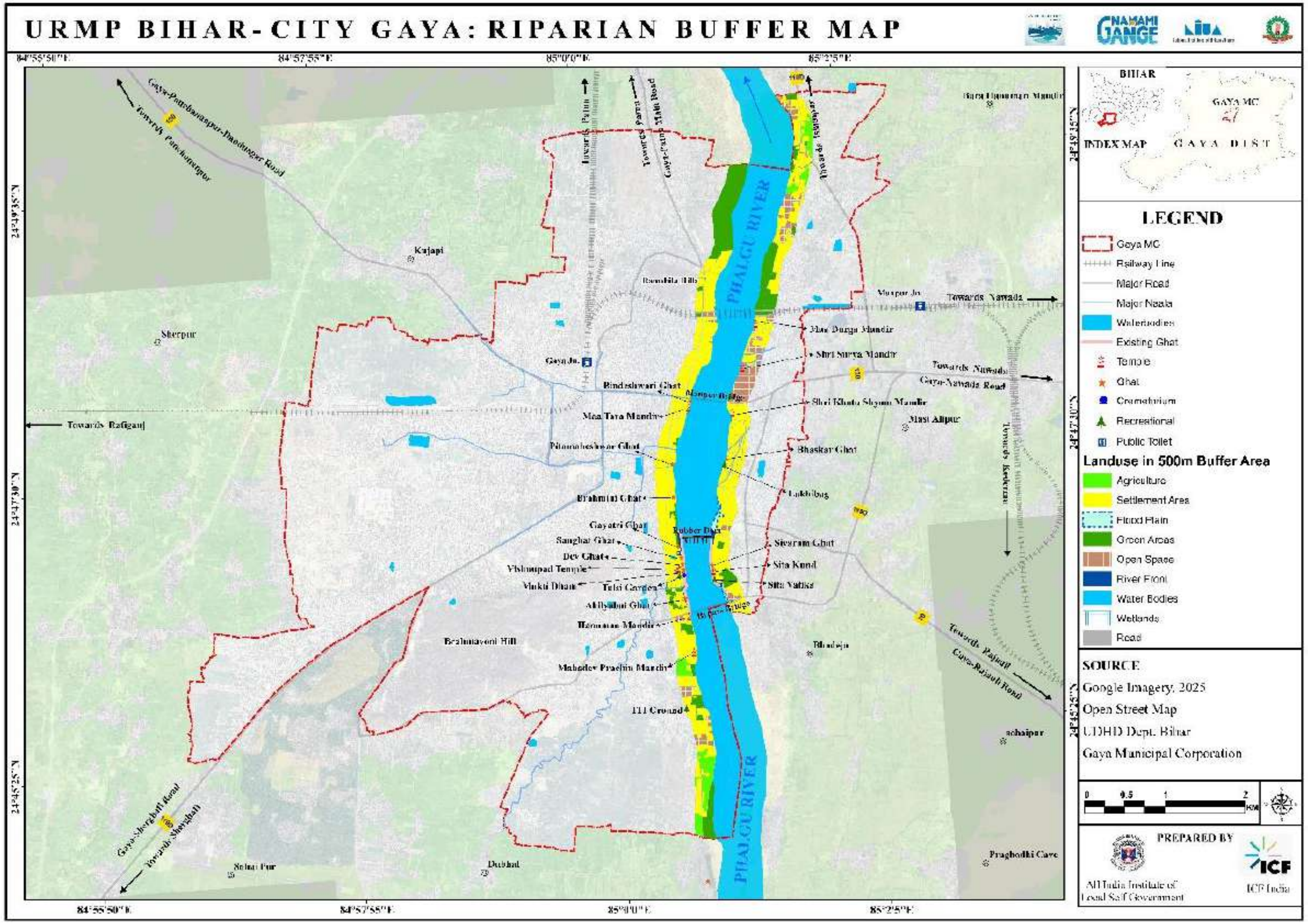
[6] https://actascientific.com/ASAG/pdf/ASAG-03-0595.pdf

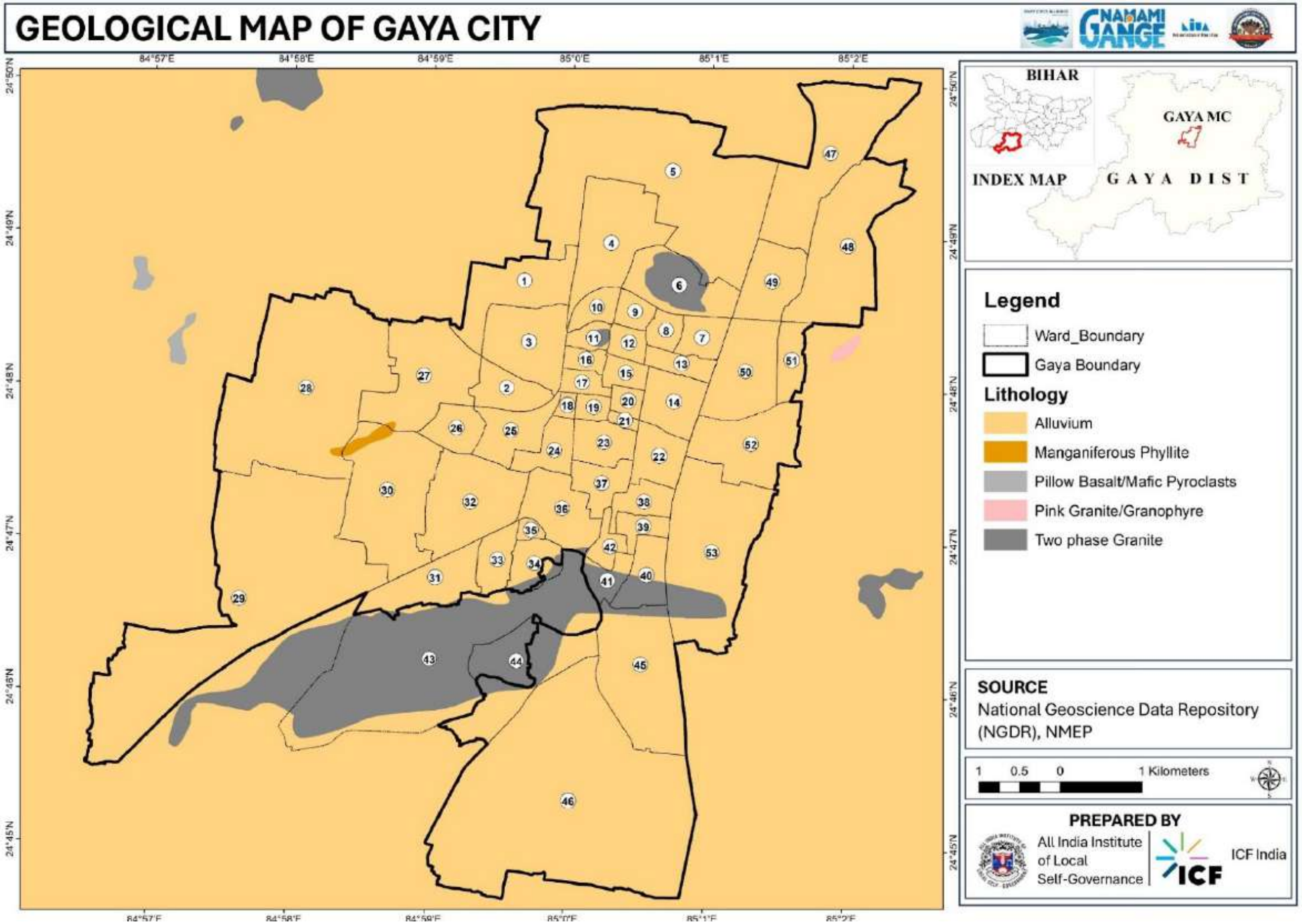
[7] District Gazetteer of Gayaji (1907; revised 1979)

Map 23: Riparian Stretch along Falgu River



Source: Portrayed by Agency

Map 24: Geological Map of Gayaji City



Source: National Geoscience data repository (NGDR), NMEP

Between 2017 and 2019, surveys (led by the Department of Zoology, Magadh University, in partnership with the Bihar State Biodiversity Board and Gayaji Municipal Corporation's Environment Division) across eight ponds, one lake, two canals and three seasonal wetlands within the Gayaji municipal area documented rich aquatic fauna. Ponds hosted 46 fish species (e.g., (Labeo Rohita) Rohu, Catla, (Cirrhinus Mrigala) Mrigal, Snakehead Channa Striata, (Clarias Batrachus) Walking Catfish) and 11 amphibian species, while Ramsagar Lake supported 20 fish (dominated by Clarias Batrachus and Indian major carps Labeo Rohita and Catla) and 5 amphibians. Canals recorded 15 fish (including Nile Tilapia Oreochromis niloticus and silver carp Hypophthalmichthys molitrix) and 2 amphibians, constrained by erratic flows and concrete banks. Seasonal wetlands yielded 28 fish (such as Channa punctata, Puntius sophore and bronze featherback Notopterus notopterus) and 8 amphibian species, demonstrating high evenness and serving as core breeding sites. Amphibian diversity was assessed between July 2017 and June 2019 via nocturnal visual-encounter and acoustic-call surveys.

Habitat heterogeneity underpins these distinct assemblages: ponds and wetlands excel for amphibian diversity, lakes favor larger fish and canals require structural enhancements to foster breeding niches. Invasive macrophytes like water hyacinth and urban runoff threaten water quality across all habitats. Prioritized removal of dense mats, restoration of riparian buffers and reconnection of water bodies will bolster gene flow and ecosystem resilience. Integrating seasonal physico-chemical monitoring with species inventories, alongside macroinvertebrate and water bird surveys, can inform a comprehensive aquatic ecosystem–health index.

Figure 47: Distance View of Concretisation of the Bank along Falgu River on Manpur side

Source: Primary Survey, 2025

Figure 48: Naturally Occurring Riparian Buffer along the edge of the Falgu River

Source: Primary Survey, 2025

Figure 49: River Front Development near Vishnupad Temple

Source: Primary Survey

Figure 50: Naturally Occurring Riparian Buffer along the edge of the Falgu River

Source: Primary Survey

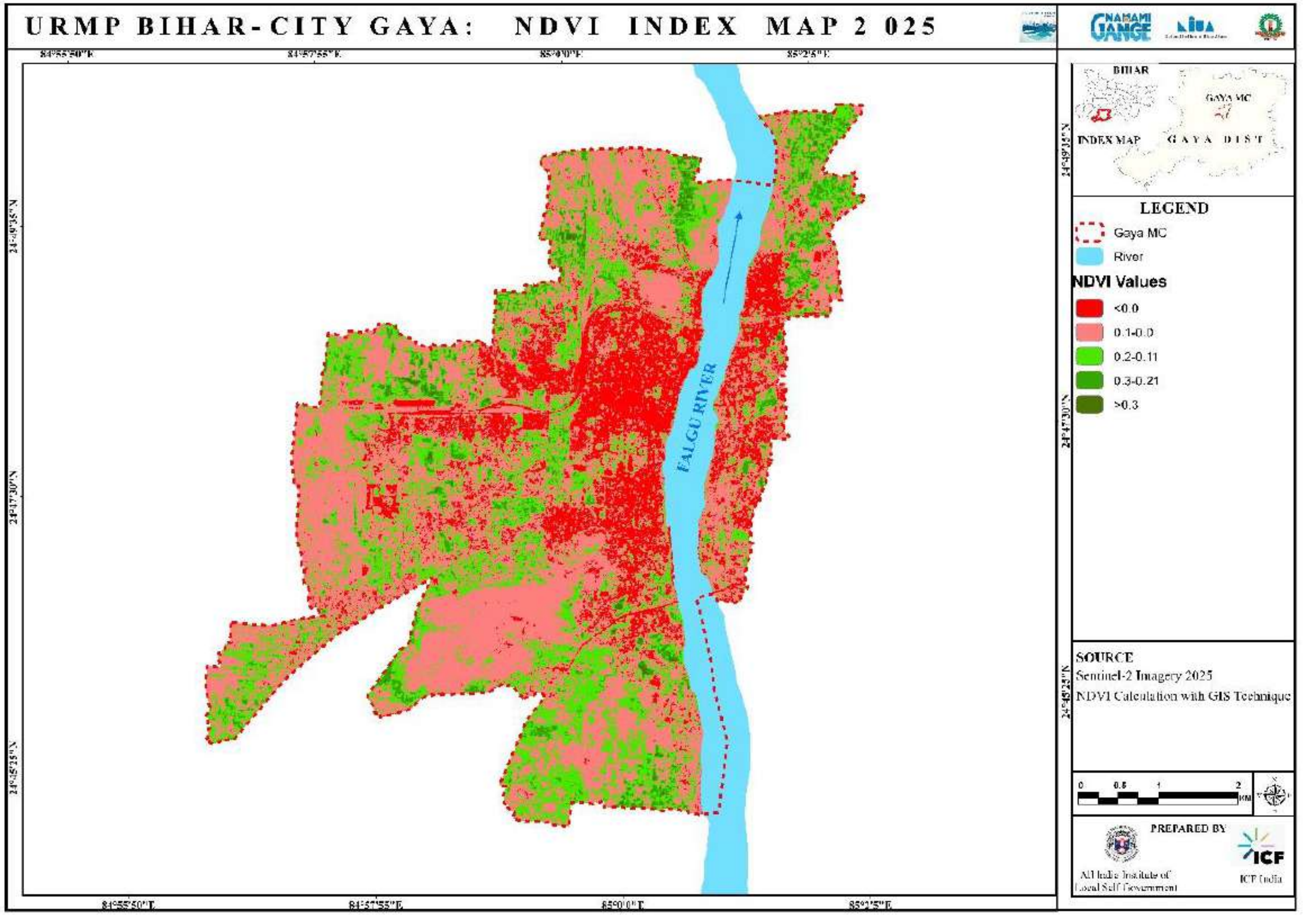
The Remote-sensing indices such as NDVI are widely used to quantify vegetation cover, detect degradation and evaluate restoration success over time. NDVI quantifies live green biomass by comparing near-infrared and red reflectance like higher values indicate denser, healthier vegetation, while low or negative values point to sparse vegetation, bare soil or water. In riparian zones, NDVI tracks tree canopy, shrub cover and seasonal herbaceous growth. Sustained low NDVI along a bank typically signals buffer loss, invasive-dominated scrub or recent clearing and increasing NDVI suggests successional recovery or successful planting. Also, riparian forest target NDVI > 0.6 (depending on local species and sensor) and shrub/herbaceous buffer NDVI 0.3–0.6.

The below maps show NDVI-derived vegetation density across Gayaji city with values.

Figure 51: Various Tree Species along Falgu River

Source: Primary Survey, 2025

Map 25: NDVI-derived Vegetation Density in 2025



Source: Sentinel-2 Imagery 2025

Table 15: Strategic Planting Zones

Zone	Recommended Species Types	Purpose
Riparian Buffer (0–100m)	*Terminalia arjuna*, *Syzygium cumini*, *Pongamia pinnata*	Bank stabilization, shade, filtration
Flood Fringe (100–500m)	*Mangifera indica*, *Madhuca longifolia*, *Jamun*	Biodiversity, fruiting, canopy cover
Urban Parks & Green Belts	*Callistemon citrinus*, *Bottle Brush*, *Ashok*	Aesthetic, pollution control
Slum Pockets & Community Spaces	*Zizyphus mauritiana*, *Khejri*, *Mahua*	Hardy, low-maintenance, culturally relevant

Here's a structured framework for Strategic Planting Zones in Gayaji city, integrating species from the Gayaji Urban Biodiversity List, Green Belt Guidelines, and Forest Division Working Plan. This approach balances ecological restoration, flood resilience and cultural relevance.

1. Develop and maintain a continuous **riparian buffer at least 7.5 to 15** meters wide along the entire river corridor, prioritizing gaps especially in urban core zones.
2. Remove **encroachments and solid waste** in buffer areas to prevent degradation and promote vegetation growth.
3. Implement **embankment vegetation management**, allowing natural grasses to grow on sandbag embankments for slope stabilization.
4. Promote **zoned planting strategies** with distinct vegetation layers like river edge grasses, middle shrubs, and taller canopy trees away from water for enhanced ecological function.
5. Leverage multi-agency coordination for buffer maintenance, including urban local bodies, forest departments, and irrigation authorities.
6. Use **annual satellite monitoring (NDVI**) to track riparian vegetation health and detect declines early.
7. Integrate riparian buffer restoration goals with city master plans and climate resilience strategies to ensure long-term protection.

5.4.2.URMP Score

Adding the cumulative scores of the Riparian buffer factor is 68.65, translating to a score of 3 as per URMP framework

5.4.3.Interventions

5.4.3.1 Intervention 4.1: Linear Parks on the Riparian Buffer Restoration of Outfalls

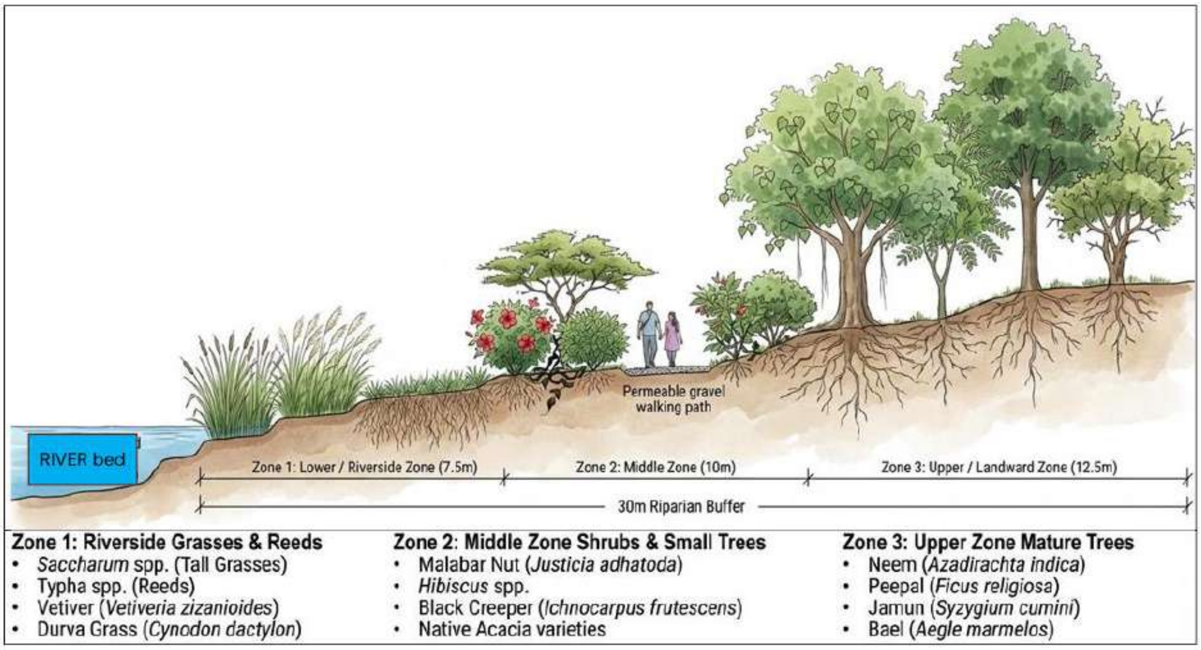
The proposal envisions the development of linear parks within a defined riparian buffer along the Falgu River, structured into three ecological and functional zones. This zoning approach balances river protection, ecological restoration, flood resilience, and public access, while addressing pollution from untreated outfalls.

Zone 1: Lower Riverside Zone (7.5 m): This zone lies closest to the river edge and is primarily designated as an eco-sensitive buffer. It will remain largely non-built, allowing for seasonal inundation and sediment deposition. Native riparian vegetation, grasses, and bioengineering measures such as coir rolls and live staking will be introduced to stabilize riverbanks and reduce erosion. Public access will be restricted to controlled pathways and ghats where culturally essential, ensuring minimal disturbance to river ecology.

Zone 2: Middle Zone (10 m): The middle zone functions as an ecological transition and treatment zone. It accommodates nature-based solutions such as bioswales, constructed wetlands, and phytoremediation strips to intercept surface runoff and partially treat wastewater from restored outfalls before it reaches the river. This zone can include permeable walking trails, seating, and shaded areas, designed to withstand periodic flooding. It plays a crucial role in improving water quality and enhancing groundwater recharge.

Zone 3: Upper Zone (12.15 m): The uppermost zone serves as the public interface and recreational linear park. It supports pedestrian and cycling tracks, viewing decks, cultural interpretation spaces, and landscaped open areas. This zone also acts as a buffer between urban development and the river system, with strict land-use controls to prevent encroachment and direct discharge into the river.

Figure 52: Zone wise enhancement of riparian buffer



Source: Consultant

5.5. Objective 5 & 6: Increased Reuse of Treated Used Water & Maximum Good Quality Return Flow

Objective 5 *aims to reduce dependency on freshwater withdrawals and ease stress on rivers by maximizing reuse of treated wastewater. The wastewater treated must conform to the quality standards prescribed by CPCB for that stretch of the river flowing through the city.*

Objective 6 *promotes the city's responsibility to contribute to maintaining environmental flow in the river. Return flows must be proportional to withdrawals and treated to meet quality standards before release. Key actions include assessing urban drains, balancing reuse with discharge, and ensuring that stormwater and wastewater outfalls enhance rather than degrade river health.*

Element : ENVIRONMENTAL

Significance:

Cities consume vast amounts of freshwater and release most of it back as wastewater. If **untreated, this becomes a pollutant;** if treated and reused, it becomes a vital resource. Reusing wastewater

reduces the stress on rivers, lowers dependence on groundwater, and supports a circular water economy. It also ensures environmental flows in the river are not sacrificed for urban consumption.

Most cities only take from rivers but rarely give back, creating **ecological imbalance**. Ensuring that a portion of good quality treated water returns to the river **maintains its ecological flow and resilience**

Scope as per URMP:

- Targets the use of treated wastewater
- Groundwater recharge
- Replenishing waterbodies.
- Regulating storm water and treated effluent releases
- Balancing reuse with river contributions

5.5.1.Existing Situation

Within Gayaji's urban limits there is currently no formal model for reusing treated municipal wastewater. Between the two operational sewage treatment plants at Jethian (4 MLD) and Keshopur (9 MLD), the city produces about 37 MLD of treated effluent, yet only around 10 percent of this—roughly 1.3 MLD—is sporadically used for purposes such as street cleaning and park irrigation. As the sewer network expands to achieve full household connectivity, treated wastewater generation is projected to climb to nearly 70 MLD by 2030. The Gayaji Municipal Corporation did explore supplying treated effluent to local brick kilns and small-scale industries, but found that laying the over 20 km of dedicated pipeline required would entail prohibitive capital costs.

The Gayaji Wastewater Project (GWWP) upgrades and expands Gayaji's sewerage network and sewage treatment capacity through a mix of item-rate and DBO contracts into two phases to reduce untreated discharges, improve public health and strengthen municipal service delivery. The project comprises a 36-month construction phase and a parallel 60-month operation and maintenance phase with O&M costs funded by the project during implementation and thereafter borne by Gayaji Municipal Corporation.

Key Gaps:

Gayaji City currently lacks any operational sewage treatment plant (STP), resulting in the discharge of untreated domestic wastewater into open drains, ponds, and the Falgu River. Although two STPs have been proposed, the absence of interim treatment and reuse planning has led to continued environmental degradation and public health risks.

The existing drainage network carries a mix of sewage and stormwater due to incomplete sewerage coverage and informal connections. Unengineered and open secondary drains are heavily silted, encroached upon, and clogged with solid waste, reducing conveyance capacity and increasing flood risk during monsoon periods.

Additionally, poor integration between urban drains, natural drainage systems, and water bodies limits groundwater recharge and ecological functions. Fragmented institutional responsibilities between state agencies and the Municipal Corporation further constrain effective wastewater and drainage management.

Key issues related to wastewater and drainage infrastructure include:

- Absence of treatment infrastructure: Gayaji has no functional STP at present; although two STPs are proposed, wastewater treatment and reuse mechanisms are currently absent.
- Mixed sewage and stormwater flows: Drains carry combined household sewage, greywater, and stormwater due to lack of a sewerage system and informal connections, leading to direct discharge into natural water bodies.
- Incomplete sewer coverage: Large parts of the city and peri-urban areas remain unsewered, increasing pollution loads in drains and the Falgu River.
- Secondary drain degradation: Unengineered, open drains are silted, encroached, and clogged with solid waste, reducing conveyance and increasing flooding and sanitation risks.
- Flood-prone drainage network: Low-lying drains are vulnerable to monsoon flooding and river backflow, causing overflow of untreated wastewater.

5.5.2.URMP Score

The city formally does not reuse the treated wastewater (,20%) Hence the water reuse score is 1 as per URMP framework.

5.5.3.Interventions

Major drains discharging into the Falgu River should be intercepted and routed to strategically located decentralized wastewater treatment systems (DEWATS) as an interim and complementary solution to the proposed STPs. Phased interception of high-pollution catchments will reduce untreated wastewater inflow into the river while enabling localized treatment and reuse until the centralized system becomes operational. Establish a city-level monitoring system to regularly assess the health of the Falgu River and urban water bodies through defined physical, chemical, and biological indicators. Monitoring data should be publicly disclosed through dashboards and periodic reports to enhance transparency, support evidence-based decision-making, and enable early identification of pollution hotspots, thereby strengthening accountability and community participation in river and water body management.

5.5.3.1 Intervention 5.1: Preparation of a City-Level Treated Wastewater Reuse Strategy how to do it in Gayaji city

1. Baseline Assessment of Wastewater Generation and Treatment: Assess current and projected wastewater generation at ward and catchment levels, considering population growth, tourism-related inflows, and institutional demand. Map the two proposed STP locations, their planned capacities, timelines, and potential zones of influence. Until commissioning, identify locations suitable for interim decentralized wastewater treatment systems (DEWATS).

2. Mapping Reuse Demand Nodes: Identify potential non-potable reuse areas within and around Gayaji, including riverfront plantations and ghats along the Falgu River, public parks and green buffers, institutional campuses, bus stands, railway areas, construction activities, and peri-urban agricultural zones. Quantify seasonal and daily water demand for each reuse category.

3. Matching Supply with Demand: Link treated wastewater availability from proposed STPs and DEWATS with identified demand nodes based on proximity, elevation, and conveyance feasibility. Prioritize gravity-based or low-energy reuse options such as nearby irrigation, landscaping, and riverfront ecological restoration to reduce operational costs.

4. Quality Standards and End-Use Classification: Define treated water quality standards for different reuse applications (e.g., irrigation, landscaping, construction, groundwater recharge) in line with CPCB, CPHEEO, and state guidelines. Ensure reuse plans avoid sensitive zones identified under aquifer vulnerability mapping.

5. Infrastructure Planning for Reuse: Plan dedicated reuse infrastructure, including storage tanks, pumping systems, dual piping networks, and distribution lines from STPs and DEWATS to reuse zones. Reserve and protect land near treatment facilities for reuse-related infrastructure and prevent encroachment.

6. Phased Implementation Strategy: Adopt a phased approach short term (DEWATS-based reuse in high-pollution drain catchments), medium term (partial reuse from commissioned STPs), and long term (full-scale reuse with expanded sewer coverage). This ensures early environmental gains while transitioning to a centralized system.

8. Monitoring, Reporting, and Public Disclosure: Establish a monitoring system to track treated water quality, reuse volumes, and environmental benefits such as reduced river pollution and groundwater abstraction. Publish reuse performance through public dashboards and annual reports to build transparency and trust.

Intervention	Responsible Agency	Intervention Type	Estimated Budget	Potential Funding Sources	Timeline
Preparation of a City-Level Treated Wastewater Reuse Strategy	Gayaji Municipal Corporation (Lead), with technical support from State Urban Development Department and PHED	Policy / Planning	INR 60 lakh	NMCG (Policy & Planning Component), AMRUT 2.0 – City Action Plans	Long-term (5–10 years)

5.5.3.2 Intervention 5.2: River Health and water bodies Monitoring and Public Reporting System

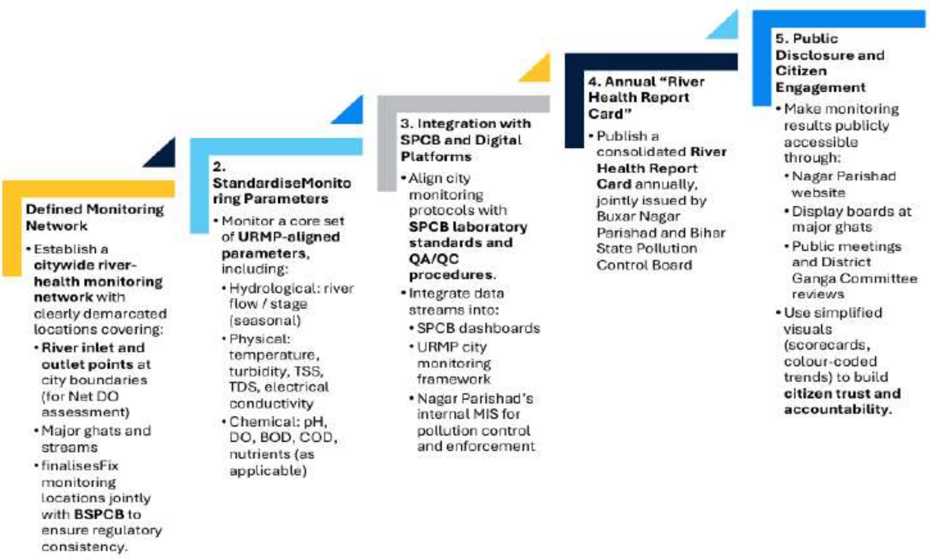
This intervention recommends institutionalising a robust, transparent, and repeatable river and water body health monitoring system for Gayaji City to enable evidence-based decision-making, strengthen regulatory enforcement, and track long-term improvements in the health of the Falgu River and associated water bodies through an annual River Health Report Card.

At present, water quality monitoring in Gayaji is fragmented, infrequent, and largely agency-driven, with limited integration into city-level planning and municipal decision-making. Existing SPCB datasets are not systematically translated into actionable indicators for the Urban Local Body (ULB) nor effectively communicated to citizens. The absence of a consolidated monitoring and reporting framework weakens enforcement, delays corrective action at identified pollution hotspots, and limits the city's ability to demonstrate progress under URMP indicators, particularly Net Dissolved Oxygen, overall Water Quality, and Eco-friendly Riverfront scores.

<u>This intervention should be developed in convergence with the GIS-based inventory of all water bodies and integrated with the Urban Water Dashboard (UWD) tool, enabling spatial tracking of water quality trends, identification of priority restoration areas, and transparent public reporting to support adaptive river and water body management in Gayaji City.</u>

Intervention	Responsible Agency	Intervention Type	Estimated Budget	Potential Funding Sources	Timeline
River Health Monitoring and Public Reporting System	Gayaji Municipal Corporation (Lead); Water Resources Department (Monitoring); Bihar State Pollution Control Board – BSPCB (Regulatory Oversight)	Project	INR 50 lakh	Gayaji Municipal Corporation (Own Funds), NMCG (Monitoring & Evaluation Support)	Short to Medium Term (1–2 years)

Key Strategy Components



5.6. Objective 7 & 8 : Eco-Friendly Riverfront Projects & Leveraging Economic Potential of River

Objective 7 *- Eco-friendly riverfronts reconnect citizens with rivers while promoting recreation, culture, and sustainable tourism. Objective 7 encourages the development of people-centric spaces without compromising ecological integrity. The emphasis is on smaller, scalable interventions that improve aesthetics, enhance access, and stimulate local economies.*

Objective 8 *focuses on assessing and promoting sustainable river-linked economic activities while ensuring that interventions respect the carrying capacity of the ecosystem. It highlights the potential of rivers as economic assets that can drive inclusive urban growth.*

Element : Economy

Significance:

Riverfronts are the most visible spaces where people connect with rivers. When poorly designed, they invite encroachment and over-commercialization, harming ecology. Eco-friendly riverfronts, however, can rejuvenate both rivers and urban life by blending ecology with recreation and aesthetics. They reconnect citizens to the river, support local economies, and build civic pride while safeguarding the river's natural character.

At the same time, rivers are engines of local economies supporting agriculture, transport, tourism, and fisheries. When managed responsibly, river-based economies can generate livelihoods and investment without degrading ecosystems. Together, sustainable riverfronts and river-sensitive economic activities create a balanced model of urban growth where development and conservation reinforce each other.

Scope as per URMP:

- Development of green spaces, parks, ghats, eco-tourism sites, and small-scale amenities
- River-based economic ventures
- Carrying capacity and sustainability principles

5.6.1. Existing Situation

The stretch of the Falgu River as it courses through Gayaji city spans approximately 27 km and is lined by eleven formal ghats and numerous heritage sites. Along its western bank you'll find structures such as the Vishnupad Mandir and its adjacent ghat, the subterranean Sita Kund shrine, and the immortal Akshaya Vat, as well as a scattering of dharamshalas and pilgrim lodges that support ritual bathing and pind dān ceremonies. Among all the ghats, Vishnupad Ghat—situated at the foot of the Vishnupad Mandir—draws the greatest daily influx of devotees performing ancestral rites, especially during the Pitru Paksha period when thousands come to offer pinda dān.

The 575 m × 12 m riverfront promenade has been paved with red sandstone blocks and underlain by a 370 m hume-pipe drain with efficient storm water conveyance.

The Gayaji Municipal Corporation is now preparing to interlink all eleven ghats[8] to form a continuous 27 km riverfront promenade. This corridor will feature a motorable service road, pedestrian pathways and river-edge viewing platforms, enabling tourists and pilgrims alike to traverse the entire Falgu frontage and experience its ritual heritage and hidden-river mystique in a single, seamless stretch.

[8] https://Gayaji.nic.in/culture-heritage

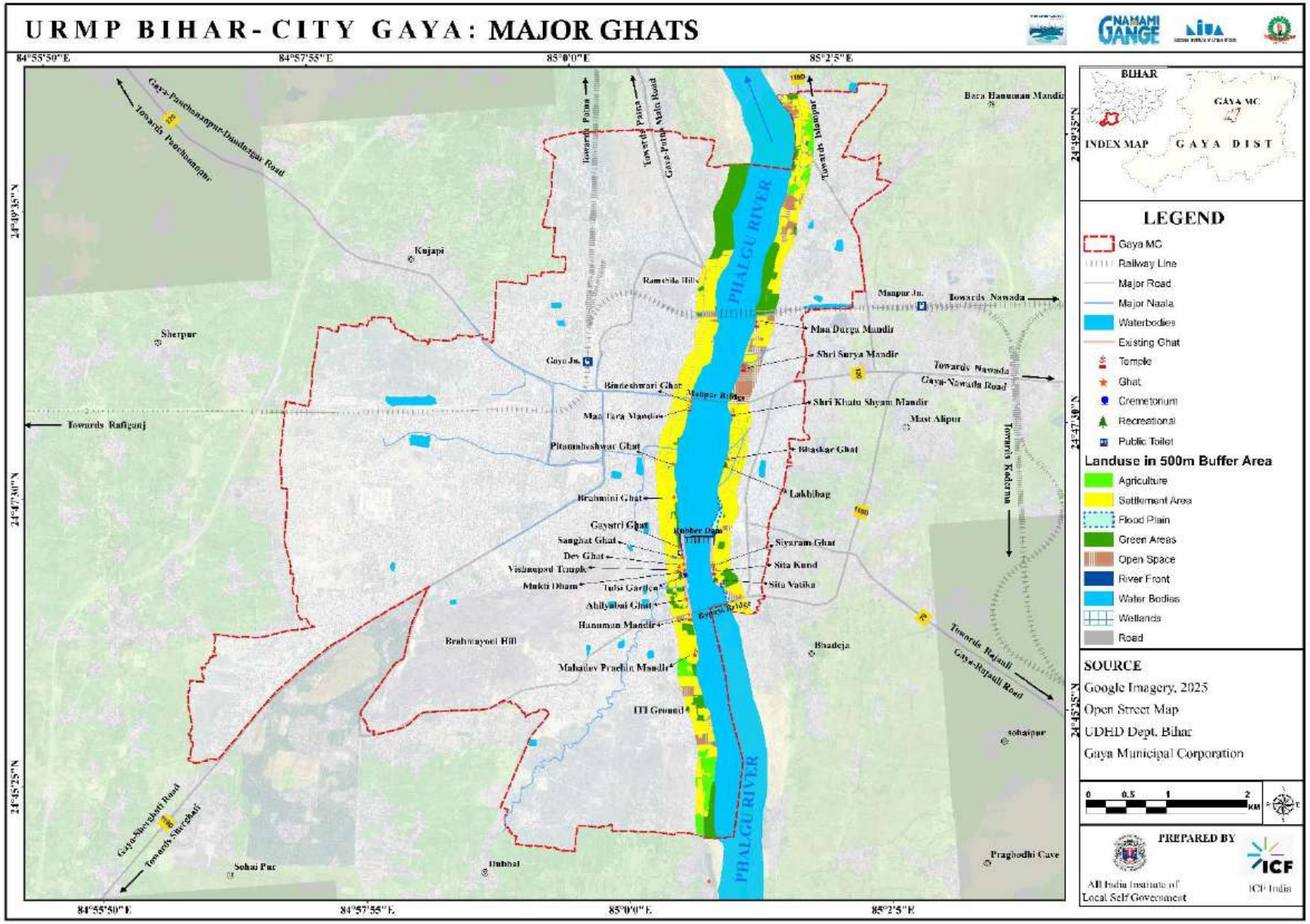
Figure 53: Vishnupad Ghat

Source: Primary Survey

Figure 54: Sita Kund

Source: Primary Survey

Map 26: Location of Major Ghats along Falgu River



Source: Portrayed by Agency

5.6.2.URMP Score

Objective 7: Eco friendly Riverfront project score Since there are no riverfront projects under Gayaji Municipal corporation's jurisdiction, the defined parameters, , that translates to a score of 2

Objective 8: River Economy Score Total river economy score is calculated by considering the number of economic uses that city utilizes the river for. As per URMP framework, then the score is 5

5.6.3.Interventions

5.6.3.1 Intervention 7.1: Eco-restore degraded ghats to improve safety and appeal.

Riverfront Profile

The riverfront forms one of the most significant natural and cultural spines of the city, shaping its physical growth, ecological balance, and socio-religious life. Extending along both banks, the riverfront covers a total stretch of approximately 15.3 km, comprising 6.0 km on the eastern side at Manpur and 9.3 km on the western side, which includes the historic core of the city. This continuous river edge holds immense potential for ecological restoration, cultural integration, public recreation, and climate-resilient urban development.

The eastern riverfront at Manpur, stretching for 6.0 km, is relatively less urbanized and retains semi-natural characteristics in several stretches. The land use along this side is predominantly residential with pockets of open land, agricultural patches, and informal settlements. The riverbank here is vulnerable to erosion, encroachment, and unregulated waste disposal, largely due to the absence of continuous riverfront infrastructure and defined access points. However, this stretch presents strong opportunities for low-impact development such as green buffers, pedestrian trails, ecological parks, and controlled ghat development that can enhance both environmental quality and community access.

The western riverfront, extending over 9.3 km, represents the historic, cultural, and religious heart of the city. This stretch accommodates major pilgrimage activities, heritage structures, and high-intensity urban uses. The river here plays a central role in daily rituals, tourism, and ceremonial events, resulting in heavy seasonal footfall and pressure on riverbank infrastructure. While the western edge is more active and built-up, it also faces challenges related to pollution, crowd management, aging infrastructure, and limited public open spaces.

At present, riverfront development is limited to specific nodes rather than a continuous, integrated system. On the eastern side at Manpur, Sita Kund represents the only developed riverfront stretch, covering approximately 0.8 km. This area has religious significance and functions as a localized activity node. While basic access and ritual use are present, the development remains fragmented, lacking comprehensive pedestrian connectivity, landscape treatment, and flood-resilient design. The surrounding areas still experience inadequate sanitation facilities and insufficient buffer zones between urban activity and the river edge.

On the western side, the Vishnupad riverfront, extending about 1.2 km, constitutes the most prominent and intensively used riverfront segment. This stretch is closely associated with pilgrimage activities and ritual practices, particularly during peak religious periods. The development here includes ghats, paved promenades, and access infrastructure; however, the focus has largely remained functional rather than holistic. Issues such as overcrowding, surface runoff, direct discharge of waste, and limited ecological considerations continue to impact river health.

Overall, the existing riverfront development accounts for only 2.0 km, which is a small fraction of the total 15.3 km riverfront length. The remaining stretches remain largely unstructured, environmentally stressed, and disconnected from the urban fabric. There is a clear imbalance between high-intensity use zones on the western bank and underutilized, vulnerable stretches on the eastern bank.

A comprehensive riverfront strategy must therefore move beyond isolated beautification projects and adopt a continuous, zone-based approach that integrates ecological restoration, public access, cultural functions, and flood resilience. By strengthening the riverfront as a linear public asset, the city can transform the river from a stressed back-end space into a central, inclusive, and sustainable urban corridor.

Figure 55: Image showing existing ghat conditions

Source: Consultant

Riverfront Zones – Existing Condition

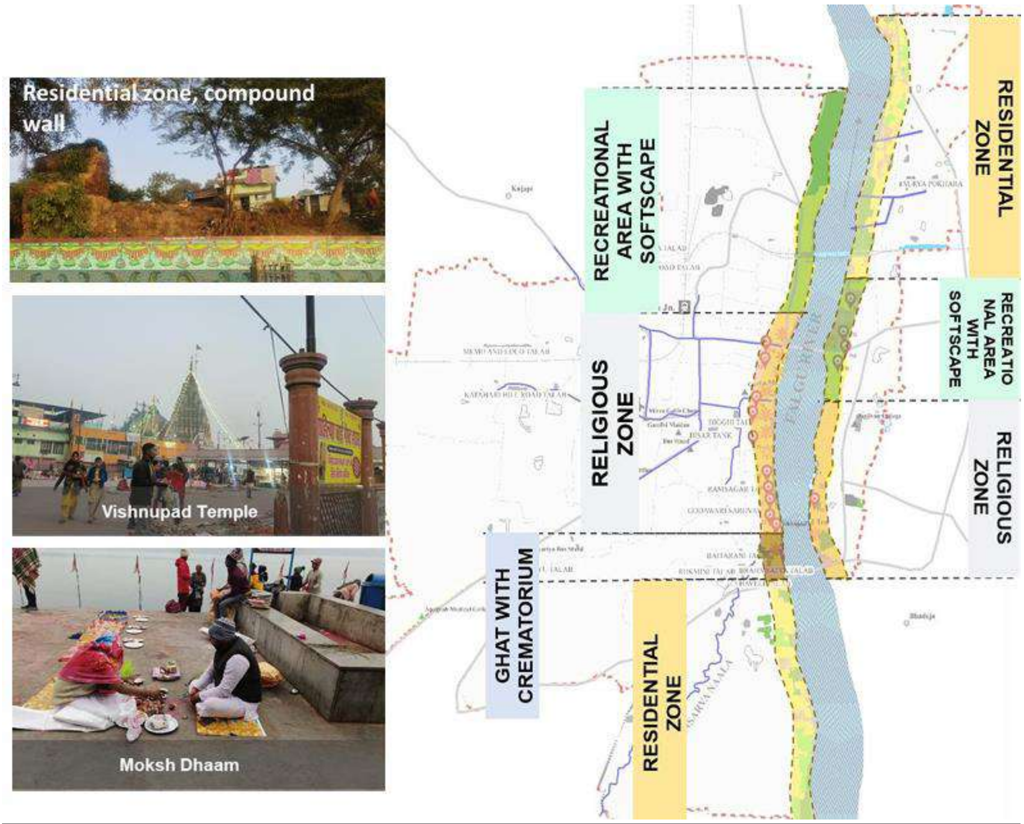
The existing condition of the riverfront reflects a predominantly hard-engineered and ritual-centric development pattern, particularly along the western bank. Large stretches of the river edge are highly concretized, with continuous ghats constructed to facilitate religious activities. While these ghats play an important cultural and ceremonial role, their uninterrupted nature has significantly reduced the natural river edge, limiting the river's ability to adapt to seasonal fluctuations and ecological processes.

The concentration of ritual ghats has resulted in the near absence of riparian buffers or transitional zones between the river and the urban fabric. Dense built-up areas, including religious structures, residential buildings, and commercial establishments, extend up to the river's edge, leaving minimal space for soft landscaping or flood absorption. This condition increases vulnerability to erosion, surface runoff, and direct pollutant inflow into the river, particularly during monsoon periods.

Public open spaces along the riverfront are extremely limited and largely confined to localized pockets near the Vishnupad area. Even within these areas, green or soft-scaped spaces are minimal, with most surfaces being paved or built-up. The lack of vegetated buffers and permeable surfaces restricts the riverfront's ecological resilience, reduces groundwater recharge potential, and limits habitat availability for aquatic and riparian species.

Furthermore, the dominance of hard infrastructure has constrained opportunities for river-sensitive public use, such as informal recreation, shaded pedestrian movement, and nature-based activities. Access to the river is largely functional and ritual-oriented, rather than inclusive or environmentally responsive. Overall, the existing riverfront zoning prioritizes built and ceremonial uses over ecological balance, highlighting the need for a more integrated zoning approach that reintroduces green buffers, soft edges, and multi-functional transition zones to support both cultural activities and river health.

Figure 56: Image showing the current zones of the existing riverfront



Source: Consultant

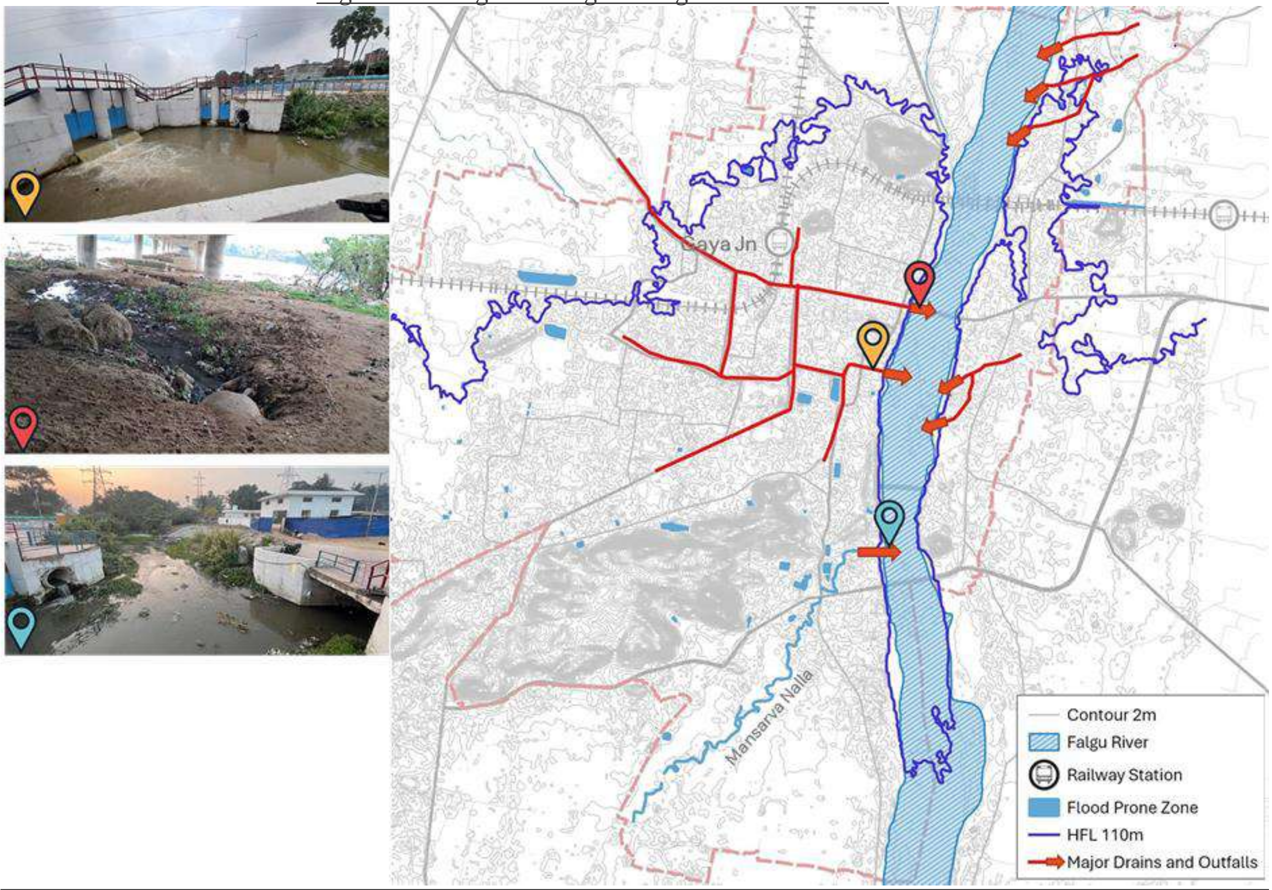
Drainage & Flood Vulnerability – Existing Condition

The existing drainage system along the riverfront is fragmented, undersized, and largely uncoordinated, resulting in inefficient stormwater management. Stormwater drains from surrounding urban areas often discharge directly into the river without adequate regulation, screening, or treatment. During intense rainfall events, this leads to sudden inflow surges, increasing flood risk and contributing to the deterioration of river water quality through the entry of silt, solid waste, and pollutants.

Extensive concretization of the riverfront and adjoining built-up areas has significantly reduced natural infiltration and soil permeability. The loss of permeable surfaces has diminished the riverfront's ability to absorb and temporarily store excess runoff, thereby reducing its natural flood-buffering capacity. As a result, storm water is rapidly conveyed to the river, causing elevated water levels and localized flooding during peak monsoon periods.

In addition, dense development patterns and encroachments along the river edge obstruct traditional drainage paths and natural overland flow routes. Informal structures, boundary walls, and unplanned construction interfere with the movement of stormwater towards designated outfalls, leading to waterlogging in low-lying areas. The absence of clearly defined riparian buffers further aggravates flood vulnerability, as there is limited space for floodplain expansion during high-flow events. Collectively, these conditions highlight the riverfront's heightened susceptibility to flooding and underscore the need for integrated drainage planning and restoration of natural hydrological pathways.

Figure 57: Image showing existing outfall in the river



Source: Consultant

Figure 58: Image showing major landmarks near the riverfront

Source: Consultant

Major Landmarks along the Existing Ghats

The riverfront is characterized by a series of historically and religiously significant ghats, which together form the spiritual core of the city and act as major attractors for pilgrims, tourists, and daily ritual users. These ghats are not only points of access to the river but also function as cultural landmarks, shaping land use patterns and activity intensity along the river edge.

Sanghat Ghat holds exceptional religious importance as the confluence point of sacred waters and is a focal location for ritual bathing and ceremonial activities. The ghat experiences high seasonal footfall, especially during religious festivals and pilgrimage periods, placing considerable pressure on the surrounding infrastructure.

The Vishnupad Temple precinct represents the most prominent religious node along the riverfront. The temple, associated with daily rituals and large-scale ceremonial events such as *Pind Daan*, significantly influences pedestrian movement, commercial activity, and ghat usage patterns in its vicinity. The adjoining riverfront is intensively used and remains highly built-up.

Sita Kund, located along the eastern bank, functions as an important ritual and cultural landmark. While relatively smaller in scale compared to Vishnupad, it attracts regular local visitors and pilgrims, serving as the primary developed riverfront node on the eastern side.

Vishnupad Devghat is closely linked to the temple complex and supports ritual immersion and ceremonial functions. The ghat remains active throughout the year, with peak pressure during religious seasons, highlighting the need for improved crowd management and resilient river-edge design.

Ahilyabai Ghat is a historic riverfront element reflecting traditional ghat architecture and religious patronage. It continues to serve ritual purposes while also possessing heritage value that warrants sensitive conservation and contextual enhancement.

Mukti Dham functions as a key cremation and last-rites facility along the riverfront. Its location and use demand careful planning to ensure dignified access, environmental safeguards, and separation from recreational riverfront activities.

Collectively, these landmarks define the existing ghat network, reinforcing the riverfront’s role as a sacred, cultural, and social spine of the city, while also underscoring the need for integrated planning that balances ritual functions with ecological sustainability.

Eco-Friendliness of Existing Riverfront Development – Existing Condition

The existing riverfront development along the river is largely characterized by hard-engineered interventions with limited ecological consideration. On the western bank, the developed stretch of approximately 1.2 km around Vishnupad, Vishnupad Devghat, Ahilyabai Ghat, and Sanghat Ghat represents the most intensively used riverfront zone, driven primarily by religious and ritual activities such as Pind Daan. Similarly, on the eastern bank, the riverfront development at Sita Kund, Manpur, covering around 0.8 km, follows a comparable design approach, dominated by rigid ghat structures and paved surfaces.

Across both banks, the river edge is overwhelmingly defined by impermeable stone and concrete surfaces, leaving little or no scope for infiltration, groundwater recharge, or natural riverbank processes. The absence of riparian vegetation and green buffers has resulted in degraded ecological conditions, with no transitional zones between the river and the urban fabric. This lack of vegetation disrupts local biodiversity, eliminates natural shading, and reduces the riverfront’s ability to filter runoff and pollutants before they enter the river.

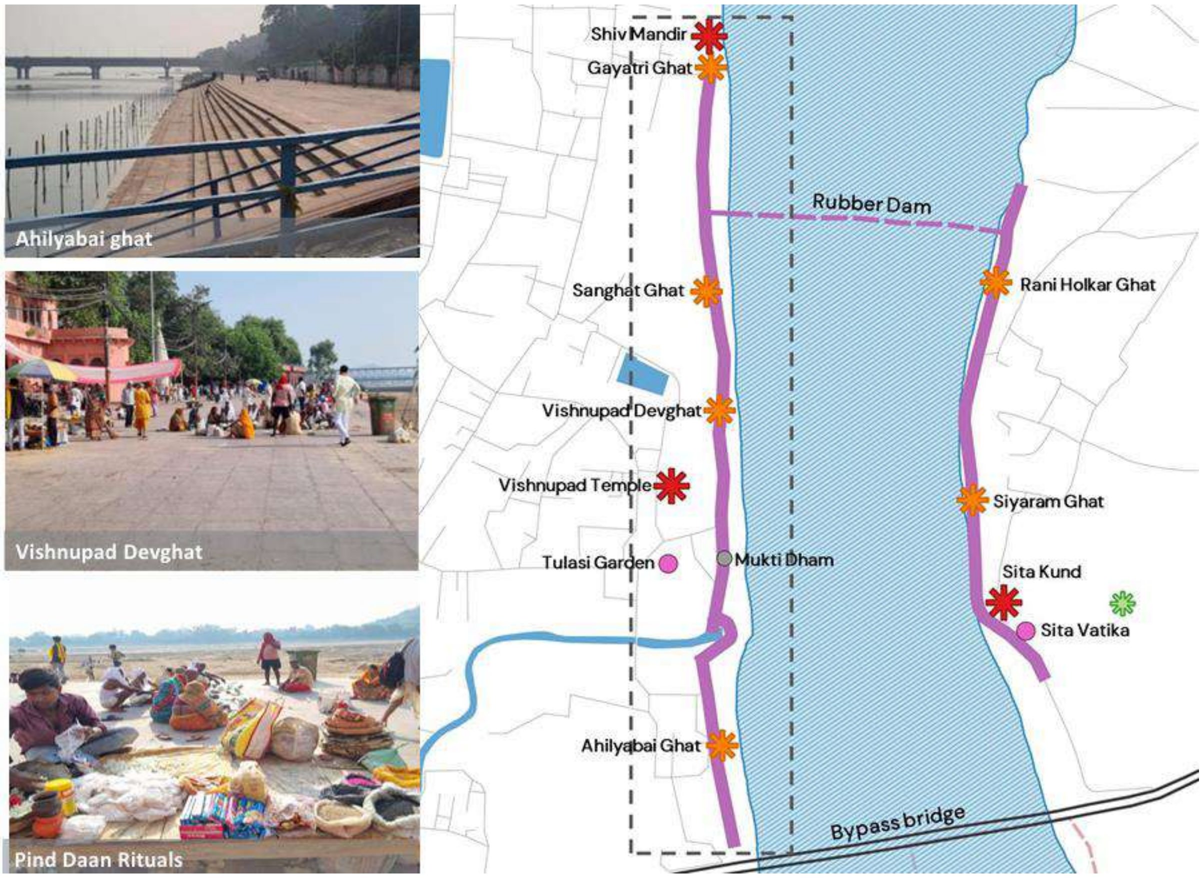
The extensive use of hard surfaces has significantly contributed to the urban heat island effect, making the riverfront uncomfortable during daytime hours, particularly in summer. At Sita Kund, despite its cultural and ritual significance, the absence of tree cover and soft landscaping further amplifies thermal discomfort for pilgrims and local users. These conditions reduce the usability of the riverfront as a public space beyond short-duration ritual activities.

From a hydrological perspective, the existing development exhibits poor flood resilience. The rigid river edge restricts natural floodplain expansion and limits the river's capacity to accommodate high flows during monsoon periods. Both the Vishnupad stretch and the Sita Kund riverfront lack flood-adaptive features such as stepped vegetated edges, buffer zones, or seasonal overflow areas, increasing vulnerability to erosion and flood-related damage.

In terms of design quality, the riverfront presents a monotonous and repetitive character, with uniform ghat steps and minimal spatial variation. The focus remains largely on ritual access rather than on creating a multifunctional, environmentally responsive public realm. While economic activities particularly those linked to Pind Daan rituals remain vital to the local economy, they are currently supported through infrastructure that prioritizes access and durability over ecological sustainability.

Overall, the existing riverfront development on both the eastern and western banks reflects a ritual-centric but ecologically insensitive approach, highlighting the urgent need for nature-based interventions, riparian restoration, and climate-responsive design that can enhance environmental performance while preserving the riverfront's cultural and religious significance.

Figure 59: Image showing connectivity of existing ghat



Source: Consultant

Activities during Pitra Paksha Mela

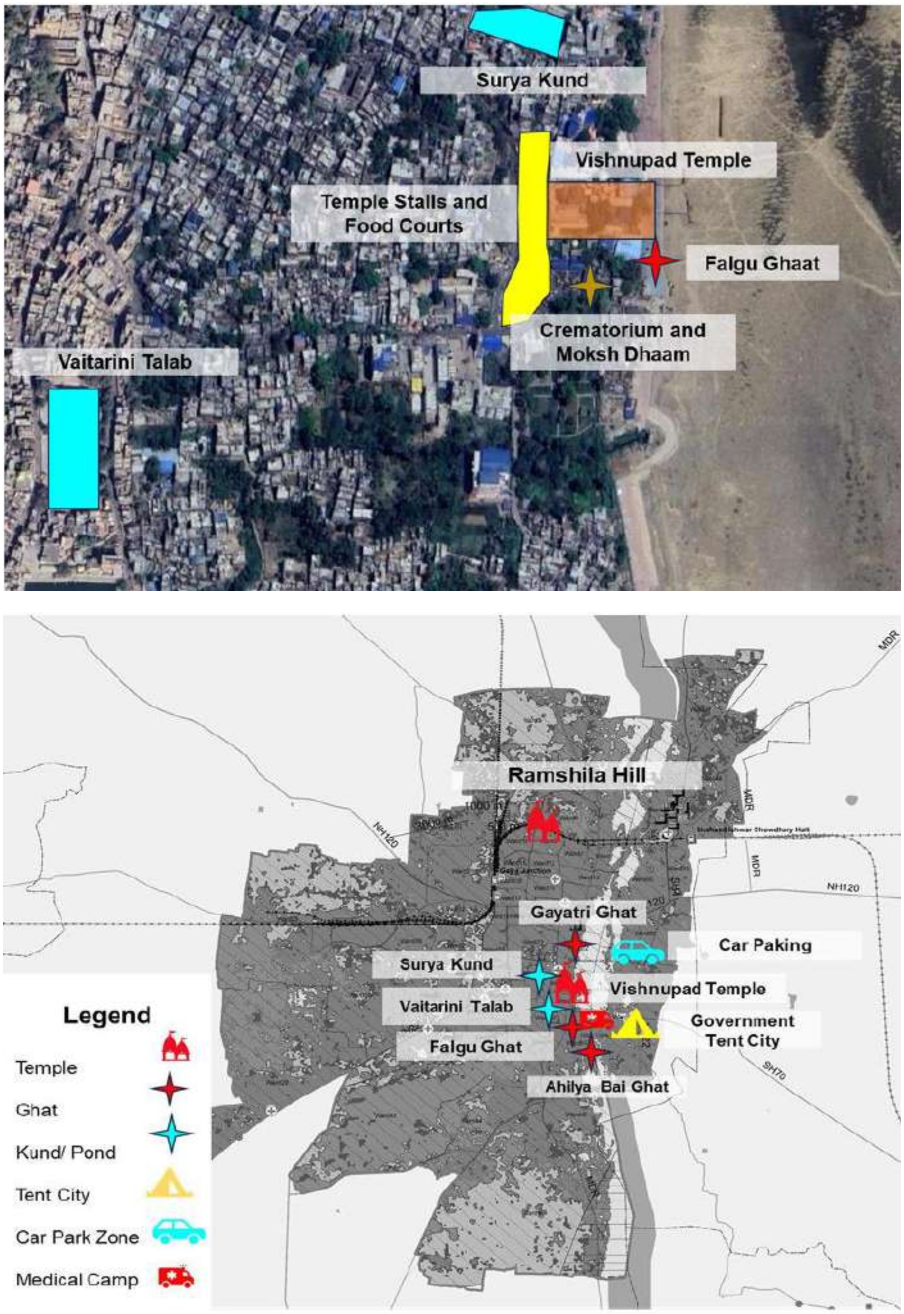
The Pitra Paksha Mela is the most significant seasonal event in the city, transforming the riverfront and temple areas into a high-density activity zone. The core zones concentrate around the Vishnupad Temple and Falgu River ghats, forming the primary ritual spine. These areas see continuous footfall for ancestral rites like Pind Daan, ritual bathing, and offerings.

Extensive seasonal infrastructure is established during the mela, including temporary tent cities and dharmashala extensions, enhanced transport arrangements, and pedestrian corridors. Medical camps, water points, mobile toilets, and waste management facilities are deployed for public health needs.

The mela creates economic clusters near the ghats and temple precincts, comprising ritual markets, priest services, food stalls, and transport services. These activities provide seasonal livelihood for local communities.

Administrative camps near high-footfall zones coordinate crowd management, safety, sanitation, and event operations. The Pitra Paksha Mela functions as an intensive urban system requiring coordinated planning and infrastructure management.

Figure 60: Major activity ritual node during pitrapaksh mela



Source: Consultant

Proposed programme 1 : Retrofitting existing ghats (limited to Vishnupad & Sita Kund stretches only):

The proposed intervention focuses on retrofitting and ecological correction of the existing riverfront, rather than undertaking large-scale reconstruction or expansion. The intent is to enhance environmental performance and user experience while respecting the sacred, cultural, and heritage significance of the ghats. This approach ensures minimal disruption to ongoing ritual practices and preserves the established urban fabric.

The primary objectives of the proposal are to restore the health of the river–land interface, improve thermal comfort, walkability, and overall ritual experience, and prevent future encroachment through clearly defined, environmentally sensitive edges. The programme also aims to support slow, heritage-based tourism circuits, encouraging longer visitor stays and improved public engagement with the riverfront in a non-intrusive manner.

Interventions are strictly limited to the existing ghat footprints, with no expansion of ghat width and no introduction of new hard structures. Existing hard concrete and impermeable surfaces will be selectively replaced or retrofitted with permeable, river-friendly materials to improve infiltration and reduce surface runoff. Riparian vegetation and green buffer zones using native plant species will be introduced wherever feasible to enhance ecological resilience and visual quality.

Shaded seating areas will be created through tree planting and lightweight pergolas, improving comfort for pilgrims and visitors, especially during peak ritual seasons and summer months. Small green pockets and soft landscape zones will function as cooling spaces without interfering with ritual circulation or river access.

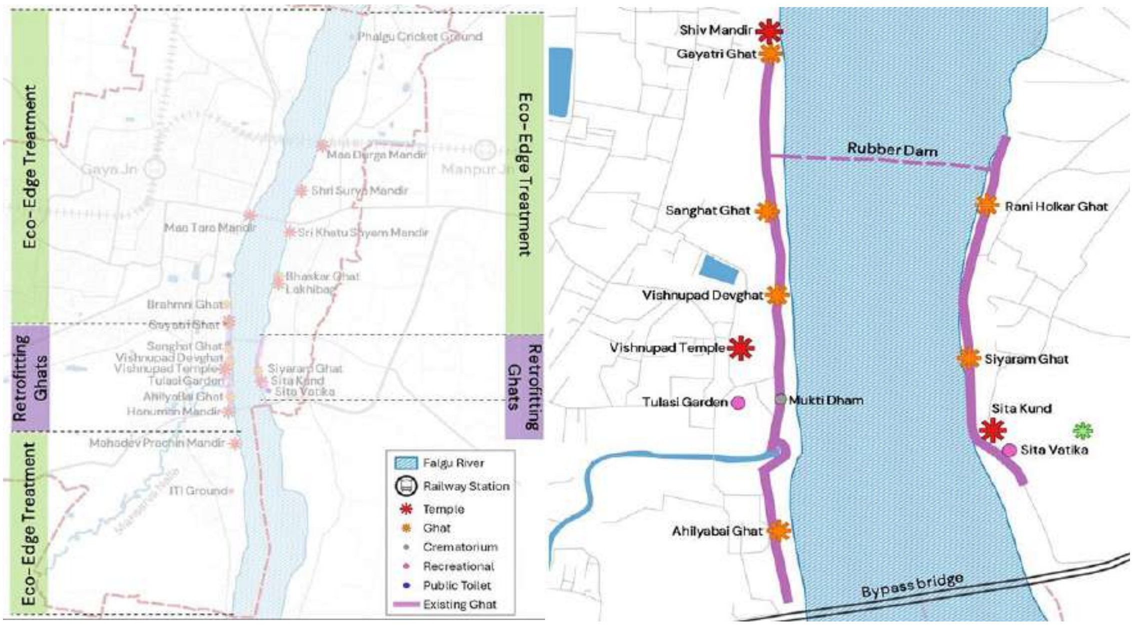
The programme covers two key stretches:

- **Vishnupad Ghat**: 1.2 km, approximately **25,000 sqm**
- **Sita Kund, Manpur**: 0.8 km, approximately **13,270 sqm**

The proposed strategy also emphasizes adaptive and climate-responsive design, ensuring that interventions remain resilient to seasonal flooding and changing river dynamics. Materials and landscape elements will be selected based on durability, low maintenance requirements, and compatibility with local construction practices. Community stakeholders, including priests, local vendors, and residents, will be engaged during implementation to ensure that design solutions align with functional needs and cultural sensitivities. Monitoring mechanisms will be integrated to assess improvements in thermal comfort, surface permeability, and vegetation health over time. By prioritizing ecological restoration alongside cultural continuity, the programme establishes a replicable model for riverfront rejuvenation in pilgrimage cities, balancing environmental sustainability with socio-economic vitality.

Overall, this is a low–medium CAPEX, high-impact ecological retrofit, designed for phased implementation, allowing flexibility in funding, execution, and monitoring while delivering measurable environmental and social benefits

Figure 61: Image showing the retrofitting area



Source: Consultant

<u>Proposed programme 2 : Eco- Edge Treatment and Linear Parks:</u>

The proposed eco-edge treatment and linear park system reimagines the riverfront as a continuous, light-touch ecological edge rather than a conventional hard promenade. The intent is to restore the natural river–land interface while accommodating controlled public access and safeguarding the river from further degradation and encroachment.

A subtly elevated eco-edge is introduced along vulnerable stretches to act as a physical and visual deterrent against future encroachments, without obstructing views or ritual access to the river. This edge is designed using soft, adaptive treatments that respond to seasonal water levels and allow natural river dynamics to function.

Edge stabilization measures will rely on nature-based solutions such as bio-engineering techniques, vegetated slopes, and soil reinforcement using native plant root systems, rather than extensive concrete retaining structures. These measures will reduce erosion while enhancing ecological resilience.

The introduction of native riparian vegetation forms the backbone of the eco-edge strategy. Carefully selected indigenous species will create a green buffer that improves microclimate, supports biodiversity, filters surface runoff, and visually softens the riverfront.

All drains and outfalls discharging into the river will be treated through decentralized solutions such as silt traps, oil-grease chambers, and vegetated bio-filters before release, significantly improving water quality at the edge.

Integrated walkways and linear parks will be aligned behind the eco-edge, using permeable materials and shaded corridors. These spaces will support walking, resting, and low-intensity recreation while reinforcing the riverfront as an ecological and public asset rather than a purely built infrastructure.

Proposed Extent

East Bank (Manpur): 5.74 km | 0.07 sq km

West Bank: 8.13 km | 0.16 sq km

Total: 13.87 km | 0.23 sq km

Figure 62: Existing and proposed linear park

Source: Consultant

Proposed programme 3 : Heritage Walk Routes:

Short Route (20–30 Minutes): Ritual and River Experience Loop

The short route, with an approximate length of 2 km, is envisioned as a high-intensity cultural and experiential loop designed to be comfortably explored within 20–30 minutes. Rather than introducing infrastructure-heavy interventions, this route is conceived as a series of experience overlays that build upon the existing ghats, temple precincts, and natural river views. The focus is on storytelling, ritual observation, and slow movement, ensuring minimal physical intervention while maximizing cultural and interpretive value.

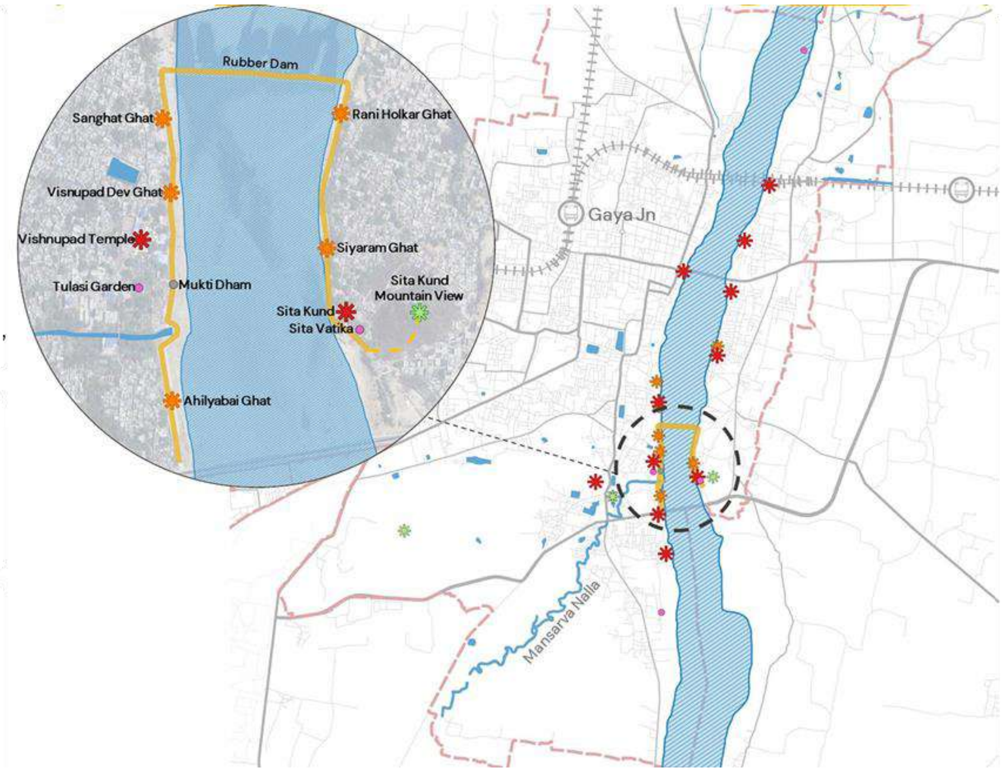
The route begins at Sita Kund, extending through Sita Vatika and the Mountain View stretch, before connecting to Siyaram Ghat and Rani Holkar Ghat. It then passes the rubber dam, continues to Sanghat Ghat, Vishnupad Devghat, the Vishnupad Temple, and culminates at Mukti Dham and Ahilyabai Ghat. Together, these nodes form a continuous narrative linking mythology, ritual practices, river engineering, and living heritage.

Key design elements along the route include interpretive signage narrating mythological stories and historical significance, seating nodes placed at pause points for reflection, and select viewing decks at ghats that offer unobstructed views of rituals and river activities without disturbing ceremonial processes.

Major interpretive stops anchor the experience. Sita Kund introduces visitors to the legend of the curse of the Phalgu River, establishing the mythological context of the landscape. The rubber dam highlights contemporary river management and seasonal water regulation. At Vishnupad Devghat, visitors experience the intensity of Pind Daan rituals and, during the monsoon, the visual and auditory richness of the Phalgu Aarti. The route's spiritual climax occurs at the Vishnupad Temple, centered around the sacred footprint (*pad*) of Lord Vishnu.

Overall, the short route offers a condensed yet immersive riverfront experience, blending mythology, ritual, ecology, and urban life into a walkable, respectful, and culturally sensitive journey.

Figure 63: Image showing short walk route



Source: Consultant

Long Short Route of about 3.5kms

The Heritage Route is envisioned as a comprehensive cultural and spiritual journey that connects the riverfront, temple precincts, and surrounding sacred landscapes into a single, immersive experience. With an approximate length of 3.5 km, extending further into the Brahmyoni Hills through improved hill trails, the route is designed for visitors seeking a deeper engagement with the city's layered heritage, mythology, and natural setting.

Unlike conventional tourism circuits, the Heritage Route prioritizes experience-led interventions over infrastructure-heavy development. Enhancements are limited to interpretive elements, improved walkability, and selective visual installations, ensuring that the route remains respectful of its sacred character and environmentally sensitive terrain. The riverfront stretch closely follows the sequence of existing ghats, creating a seamless transition from ritual spaces to historic temples and finally to the elevated sacred landscape of the hills.

The route begins at Sita Kund, where interpretive storytelling introduces visitors to the mythological curse of the Phalgu River, establishing the spiritual narrative that underpins the entire landscape. It proceeds through Sita Vatika, the Mountain View stretch, and a series of historically significant ghats including Siyaram Ghat and Rani Holkar Ghat, before reaching the rubber dam, which represents contemporary interventions in river management and seasonal flow regulation.

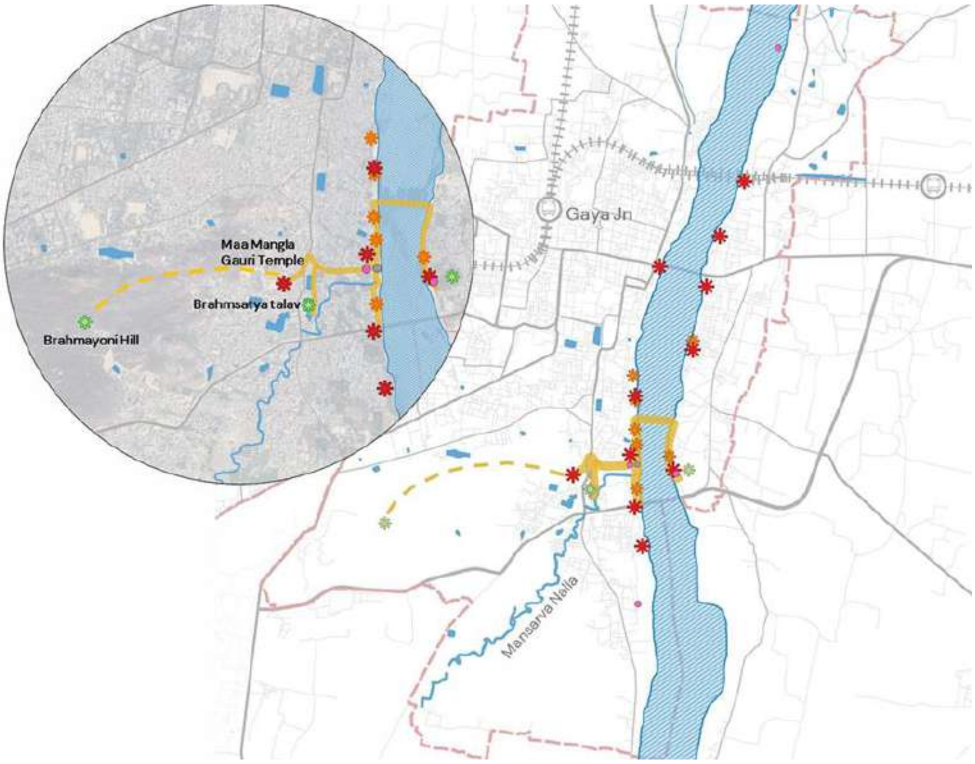
At Sanghat Ghat and Vishnupad Devghat, the route intersects with the city's most intense ritual spaces. Here, visitors witness Pind Daan ceremonies and, during the monsoon season, the visually rich Phalgu Aarti, offering insight into living religious practices. The spiritual core of the route lies at the Vishnupad Temple, centered on the sacred footprint (*pad*) of Lord Vishnu, which anchors the pilgrimage significance of the city.

Beyond the riverfront, the Heritage Route extends to Maa Mangla Gauri Temple, one of the region's prominent Shakti Peethas. This transition marks a shift from river-based rituals to hill-based worship, reinforcing the city's diverse sacred geography. The route then culminates at Brahmsatya Talav, envisioned as a focal cultural node featuring a light and laser show. This installation is carefully restricted to this location alone, using controlled timings and non-invasive technology to narrate the mythological and historical evolution of the city without disturbing ritual areas.

The final ascent to the Brahmyoni Hills is supported through light-touch trail improvements, ensuring safety, accessibility, and minimal ecological disturbance. From the hilltop, visitors gain panoramic views of the river, city, and temple landscape, offering a reflective conclusion to the journey.

Overall, the Heritage Route functions as a slow, layered pilgrimage and heritage trail, integrating mythology, ritual, ecology, and topography into a unified experience. It strengthens cultural tourism, disperses visitor pressure across multiple nodes, and reinforces the city's identity as a living sacred landscape rather than a destination of isolated monuments.

Figure 64: Image showing long walk route



Source: Consultant

Costing of the three programmes

The proposed riverfront project adopts a cost-efficient, eco-sensitive development model with a total outlay of ₹115 crore, focused on retrofitting rather than reconstruction. Investments prioritize river health and ecological restoration**,** with over 52% of the budget allocated to eco-edge treatment and stabilization across 13.87 km of riverbank using nature-based solutions. Retrofitting of existing ghats at Vishnupad and Sita Kund enhances ritual comfort, permeability, and thermal performance without expanding footprints**.** Linear parks and heritage routes improve walkability, tourism experience, and public access with minimal built infrastructure. The phased, low-RCC approach ensures high environmental impact, fiscal prudence, and long-term urban and economic resilience.

Table 16: Costing model of all three interventions

Component	**Scope / Cost-Control Strategy Applied**	**Revised Cost (₹ Cr)**
Retrofitting Existing Ghats(Vishnupad 1.2 km + Sita Kund 0.8 km)Total Area ≈ 38,270 sqm	Surface retrofitting, riparian buffers, shaded seating, drain correction(Limited to existing ghat footprint – 2.0 km)	15.0
Eco-Edge Treatment(East + West Banks)Total Length = 13.87 km	Elevated eco-edge, bio-stabilization, pedestrian pathways, drain interception using nature-based solutions	55.0
Linear Parks(Selective locations only)Total Area = 0.23 sq km	Landscape development, seating, lighting, shaded walkways	20.0
Heritage Walk & Interpretation(No heavy construction)	Wayfinding signage, viewing decks, Brahmsatya Talav light–laser show, Brahmyoni Hill trail improvements	8.0
Project Support Costs	DPR preparation, environmental monitoring, construction management	7.0
Base CAPEX		105.0
Contingency (10%)	Provision for cost escalation and unforeseen works	10.5
TOTAL PROJECT COST	(Rounded)	₹115 Cr

Source: Consultant

5.7. Objective 9 & 10: River-Sensitive Behaviour among Citizens and Engagement in River Management

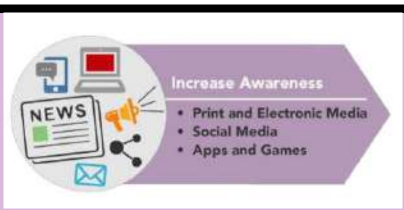
Objective 9 *aims to foster river-sensitive values through education, media campaigns, school programs, and innovative outreach such as festivals and digital tools. The focus is on building a shared culture of stewardship where citizens recognize the benefits of healthy rivers and their role in protecting them.*

Objective 10 *calls for citizens to become active participants in river management. Community groups, NGOs, and volunteers can be mobilized for monitoring, clean-up, and stewardship activities. By embedding citizen participation in governance frameworks, cities can build long-term ownership and collective responsibility for river systems.*

Element : SOCIAL

Significance:

A city's river cannot be sustained by laws and infrastructure alone citizen attitudes matter. **Irresponsible waste disposal, overuse of water, and lack of awareness about river ecology** all undermine formal efforts. Cultivating river-sensitive behaviour ensures long-term ownership and collective responsibility. Once people understand the river's value and their role in



protecting it, behavioural change follows, **turning passive residents into active stewards of their river.**	**Scope as per URMP:** • Public awareness • Community-based monitoring programs • Citizen groups for river conservation Public participation in governance

5.7.1.Existing Situation

Currently, within Gayaji Municipal Corporation limits, the city has taken only minimal steps to deepen public understanding of the Falgu River's cultural, ecological, and economic importance and the urgent need to protect it. The sole visible initiative to date is the adoption of river-themed wall paintings that depicting indigenous fish, riparian trees, pilgrims in ritual immersion and wildlife at key ghats such as Vishnupad, Mangala Gauri, and Sita Kund. These vibrant murals span over half a kilometre of ghat-facing walls, enlivening the riverfront and hinting at the waterway's value, yet they remain unaccompanied by interpretive signage, guided educational walks, school outreach, or citizen-science programmes that could translate aesthetic appeal into lasting stewardship.

Figure 65: Religious Activities at Ghat along the Falgu River

Current Efforts

There are currently no dedicated programmes or activities in Gayaji city to engage individuals in the management of the Falgu River.

Keys Gaps

- **Establish a Dedicated River Awareness and Engagement Cell:** Create a multi-stakeholder unit to design and implement sustained, river-specific IEC programs beyond campaign cycles, integrating schools, communities, and media partners.

- **Expand Digital and Multimedia Outreach:** Develop interactive mobile apps, social media campaigns, and gamified educational content targeting youth and urban populations to deepen awareness and participation.
- **Integrate River Ecology into School Curricula:** Collaborate with education authorities to embed river ecology and conservation topics into core curricula, establish "River Ambassador" programs, and sustain eco-club activities year-round.
- **Formalize Citizen Participation in Governance:** Institutionalize citizen roles in river management committees and policy-making bodies, enabling community co-management and enhancing accountability.
- **Launch "Adopt-a-Ghat" and Stewardship Programs:** Mobilize resident groups, local businesses, and NGOs to adopt riverfront sites for regular clean-ups, biodiversity monitoring, and maintenance.
- **Engage Religious and Cultural Leaders:** Train priests, temple authorities, and festival organizers to champion eco-friendly rituals and promote pollution prevention messages.
- **Organize Annual River Festivals and Events:** Establish a dedicated river day or festival in the city calendar to celebrate the river, build civic pride, and highlight conservation successes.
- **Allocate Dedicated Budgets for Sustainable Outreach:** Ensure sustained funding for river-specific IEC and citizen engagement initiatives supported by ULB, CSR partnerships, and state/national missions.
- **Develop Citizen-led Water Quality and Biodiversity Monitoring:** Provide training and tools for local volunteers and schools to participate in regular monitoring, generating data to inform decisions and foster ownership.
- **Coordinate with Ongoing National and Local Programs:** Align outreach efforts with Jal Jeevan Hariyali Abhiyaan, Swachh Bharat Mission, Namami Gange, and local environmental initiatives for synergy and resource optimization.

These pathways will scale and deepen river-sensitive behaviours, embed citizens in stewardship roles, and reinforce long-term collective responsibility for river health, making Gayaji a model for participatory urban river management.

5.7.2.URMP Score

Objective 9: Based on baseline assessment, site visits, and stakeholder consultations, Gayaji achieves a very low level of citizen sensitization, with a points of 20 out of 100., translating to a score of 2 . Citizen sensitization in Gayaji remains limited, with minimal awareness and participation in activities such as clean-up drives, plantation programs, and river conservation events.

Objective 10: Gayaji receives a high citizen engagement score of 5. Citizen engagement in Gayaji is currently low but holds significant potential for improvement. Formal integration of citizens into decision-making processes and committees is absent, limiting long-term ownership and accountability. Structured platforms such as digital reporting tools, participatory forums, and institutional partnerships can help bridge this gap. Exploring Public-Private Partnership (PPP) models with corporate funding can bring financial and technical resources while creating opportunities for local communities, youth groups, and NGOs to co implement projects alongside corporate partner

5.7.3.Interventions

5.7.3.1 Intervention 9.1: Heritage kiosks + QR signage for Falgu awareness and eco-friendly behaviour Eco-religious walking trails with solar shelters and CSR-backed amenities

The Falgu River holds immense religious, cultural, and ecological significance for Gayaji, serving as the spiritual landscape for rituals such as Pind Daan while also functioning as a critical urban ecological corridor. However, increasing anthropogenic pressure, lack of awareness, and unsustainable visitor practices have led to environmental degradation of the riverfront. To address this, the proposal introduces heritage kiosks integrated with QR-based signage and eco-religious walking trails with solar shelters, aimed at promoting river awareness, responsible behaviour, and sustainable pilgrimage tourism.

Heritage kiosks are proposed at strategic locations along the ghats, entry points, and congregation zones of the Falgu riverfront. These kiosks will act as interpretation and orientation nodes, narrating the river's mythological importance, historical evolution, traditional water practices, and current ecological challenges. Designed using local materials and vernacular architectural elements, the kiosks will blend seamlessly with the sacred landscape while maintaining low visual and environmental impact. Interactive panels, maps, and illustrations will explain the river's seasonal nature, floodplain dynamics, and the need for riparian protection.

To enhance accessibility and engagement, QR-coded signage will be embedded within kiosks and along the river edge. Scanning these codes will direct visitors to multilingual digital content, including short videos, audio stories, ritual guidelines, do's and don'ts, and information on eco-friendly offerings. This digital approach reduces physical clutter, allows real-time content updates, and caters to diverse user groups such as pilgrims, tourists, students, and local residents. The QR system can also be linked with city-level platforms for feedback, reporting pollution hotspots, and citizen participation in river stewardship.

Complementing the kiosks, eco-religious walking trails are proposed along designated stretches of the riverfront, connecting ghats, heritage structures, and ecological nodes. These trails will be universally accessible, shaded with native trees, and designed to maintain safe distance from sensitive riparian zones. Interpretive trail markers will highlight spiritual narratives alongside ecological messages, reinforcing the concept of the river as a living sacred entity rather than a consumable resource.

Solar-powered shelters will be installed at intervals along the trail, providing resting spaces for elderly pilgrims and visitors while serving as demonstration units for renewable energy. These shelters will support solar lighting, mobile charging points, drinking water kiosks, and CCTV for safety. Waste segregation bins, drinking water refill stations, and eco-toilets will be integrated as part of CSR-backed amenities, encouraging corporate participation in long-term maintenance and awareness programs.

Overall, this initiative transforms the Falgu riverfront into a learning landscape, where faith, heritage, and ecology converge. By combining low-impact physical infrastructure with digital outreach and CSR partnerships, the project promotes behavioural change, strengthens river stewardship, and enhances the spiritual experience ensuring that devotion to the Falgu River is expressed through care, respect, and sustainability.

Figure 66: Installation of signage for falgu awareness

Intervention	Responsible Agency	Intervention Type	Estimated Budget (Revised)	Potential Funding Sources	Timeline
Heritage Kiosks & QR Signage for Falgu Awareness and Eco-friendly Behaviour – Installation of heritage-themed kiosks and QR-enabled signages at key ghats, temples, pilgrimage routes, and riverfront locations in Gayaji to spread awareness on Falgu River's cultural importance, river-friendly rituals, waste reduction, and responsible public behaviour.	District Ganga Committee (Gayaji) & Gayaji Municipal Corporation	Program / Project (IEC & Behavioural Change)	₹4–6 Lakhs	NMCG (IEC component), SBM (Urban), CSR	Short Term (0–2 year)
Eco-Religious Walking Trails with Solar Shelters and CSR-Backed Amenities – Development of a pilot eco-religious walking trail along selected stretches of the Falgu River connecting ghats and heritage nodes, supported by solar-powered resting shelters, benches, drinking water points, dustbins, wayfinding signage, and interpretive panels promoting low-impact pilgrimage and walkability.	District Ganga Committee (Gayaji) & Gayaji Municipal Corporation	Program / Project (Heritage-led Sustainable Public Realm)	₹15–22 Lakhs (pilot stretch)	NMCG, CSR (temple trusts, local industries), SBM (Urban)	Short Term (0–2 year)

5.7.3.2 Intervention 9.2: Sustainable tourism & cultural circuits across major ghats/temples "Adopt-a-Ghat" model for funded, community-led upkeep Dry season riverbed activation for recreational activities

The Falgu River forms the cultural and spiritual spine of Gayaji, connecting a network of ghats, temples, ritual spaces, and seasonal landscapes that collectively define the city's identity as a major pilgrimage destination. Yet, unstructured tourism, fragmented management, and seasonal neglect especially during the dry months have weakened both the experiential quality of pilgrimage and the ecological health of the riverfront. A sustainable and people-centric approach is therefore required to transform the Falgu into a well-managed cultural landscape that balances faith, ecology, and everyday urban life. This strategy proposes the development of sustainable tourism and cultural circuits across major ghats and temples, supported by an "Adopt-a-Ghat" model for community-led upkeep and regulated dry-season riverbed activation for recreational use.

The establishment of sustainable tourism and cultural circuits aims to reorganize pilgrim movement while enhancing the interpretive depth of the riverfront. Rather than treating ghats and temples as isolated destinations, the circuits will connect them into a continuous, walkable sacred landscape that narrates the spiritual, historical, and ecological significance of the Falgu. These routes will be designed as low-impact, pedestrian-friendly corridors with shaded pathways, universal accessibility features, and clear wayfinding systems. Interpretation elements both physical and digital will communicate the religious importance of each ghat, traditional ritual practices, seasonal river behaviour, and guidelines for eco-sensitive conduct. By distributing footfall across multiple nodes, the circuits will reduce overcrowding at select ghats, lower localized pollution loads, and improve overall visitor experience. At the same time, integration of local vendors, crafts, and services along these routes will ensure that economic benefits from pilgrimage tourism directly support river-dependent communities.

To ensure the long-term sustainability of these interventions, the proposal introduces an "Adopt-a-Ghat" model that promotes shared responsibility and local stewardship. Under this model, individual ghats can be adopted by temple trusts, resident welfare associations, local institutions, non-governmental organizations, or corporate entities through CSR initiatives. Adopting agencies will take responsibility for defined aspects of ghat management, including cleanliness, minor maintenance, landscaping, signage upkeep, and facilitation of eco-friendly ritual practices. Municipal authorities will provide standardized design and maintenance guidelines to ensure heritage sensitivity and visual consistency, while allowing flexibility for local identity and participation. This approach shifts ghat management from a purely municipal function to a collaborative governance framework, fostering accountability, pride, and continuous care. Adopted ghats can also function as demonstration sites for sustainable practices such as waste segregation, composting of floral offerings, plastic-free rituals, solar lighting, and water-efficient facilities, reinforcing behaviour change among pilgrims and residents alike.

A critical component of this strategy is the activation of the Falgu riverbed during the dry season, when large stretches remain exposed and underutilized. Instead of allowing these areas to become neglected or misused, the proposal encourages regulated and reversible activation through recreational and cultural activities. Temporary uses such as sports matches, yoga sessions, heritage walks, cultural performances, and seasonal events can be introduced within designated zones, ensuring that ecological sensitivity and flood preparedness are maintained. All installations will be lightweight, removable, and strictly time-bound to avoid interference with monsoon flows and sediment dynamics. Dry-season activation transforms the riverbed into a vibrant public space, fostering everyday engagement beyond ritual use and strengthening the relationship between citizens and the river.

Together, sustainable tourism circuits, the Adopt-a-Ghat stewardship model, and dry-season riverbed activation create an integrated framework for riverfront management. Tourism becomes more meaningful and less extractive, communities evolve from passive users to active custodians, and the riverfront remains animated, respected, and well-maintained throughout the year. This holistic approach repositions the Falgu River not merely as a seasonal ritual site, but as a living cultural and ecological corridor one that supports spiritual practice, environmental resilience, local livelihoods, and a shared sense of urban identity for Gayaji.

Figure 67: Image of Dry season riverbed activation

Source: Consultant

Citizen Sensitization Strategy: A Three-Level Engagement Framework

The long-term ecological rejuvenation of the Falgu River cannot be achieved through infrastructure interventions alone. Given its deep religious, social, and seasonal importance, the riverfront requires a people-centric sensitization strategy that reshapes everyday practices of households, pilgrims, communities, and institutions. This strategy adopts a three-level engagement framework to progressively move citizens from basic awareness to sustained behaviour change, collective stewardship, and finally, institutionalized eco-sensitive practices embedded within city systems.

Household & Pilgrim-Level Engagement: Building Awareness and Individual Responsibility

The first level of engagement focuses on direct interfaces with households and pilgrims, who exert the most immediate and visible pressure on the river system. Pilgrim-facing Information, Education, and Communication (IEC) interventions will be deployed at ghats, approach roads, and ritual zones to promote eco-friendly religious practices. These include guidance on biodegradable offerings, avoidance of single-use plastics, designated ritual waste handling points, and the ecological consequences of indiscriminate disposal into the riverbed.

Special emphasis will be placed on context-specific sensitization, addressing issues such as dry-season hydrology of the Falgu, impacts of sand mining on river morphology, and the importance of native riparian flora and fauna. Visual aids, QR-enabled content, multilingual signage, and audio messages will ensure inclusivity for diverse user groups, including elderly pilgrims and first-time visitors.

At the household level, neighbourhood IEC campaigns will highlight responsible water use, sanitation linkages, and protection of river-adjacent land. The objective at this stage is to shift citizens from passive users of the riverfront to informed individuals, aware of how daily actions influence river health. This level establishes the foundation for behavioural nudges, encouraging voluntary compliance rather than enforcement-driven regulation.

Community & Neighbourhood Platforms: Enabling Behaviour Change and Shared Stewardship

The second level moves beyond individual awareness to foster collective ownership and community-led stewardship. During the dry season, the Falgu's exposed riverbed offers a unique opportunity for regulated activation through recreational and cultural activities, such as sports matches, yoga sessions, heritage walks, and *Nukkad Natak*. These activities reframe the riverbed as a shared public space, reinforcing the idea that the river is a living system rather than a dumping ground.

Community events will integrate environmental messaging through storytelling, street theatre, and participatory art, translating technical concepts like sediment balance and floodplain protection into relatable narratives. Local resident welfare groups, shopkeepers, and informal vendors will be engaged as partners in maintaining cleanliness and monitoring misuse.

Parallelly, school and college networks will be mobilized to build youth-led stewardship. Environmental clubs, NSS units, and planning or science departments can participate in citizen-science initiatives such as water quality testing, biodiversity mapping, and seasonal river documentation. Students become ambassadors of change within their households and communities, creating intergenerational learning loops.

At this level, the transition from awareness to habitual behaviour change is reinforced through social norms, peer influence, and visible community leadership. The river gradually becomes a matter of collective pride and responsibility.

Citywide Campaigns & Public Narratives: Institutionalizing Eco-Sensitive Practices

The third level scales localized efforts into citywide public narratives that normalize sustainable behaviour and embed it within institutional frameworks. Partnerships will be forged with local media, temple committees, educational institutions, and cultural organizations to mainstream river-sensitive messaging across platforms.

A unified pilgrim-tourism communication and branding strategy will position Gayaji as a city of sacred ecology, where spiritual practices coexist with environmental responsibility. Messaging will be synchronized with major religious and cultural events through festival-specific IEC campaigns. For instance, during *Chhath*, the focus will be on waste-free ghats and safe ritual practices, while during *Pitru Paksh Mela* and Shraddh rituals, emphasis will be placed on eco-friendly offerings and regulated ritual zones.

6. ANNEXURES

Annexure 1: Policies Governing Floodplains in Gayaji

National Policies and Judicial Orders

1. Model Bill for Flood Plain Zoning, Central Water Commission, 1975[15]: Proposed: proposed delineating the areas that are subject to flooding including classification of land with reference to relative risk of flood.
2. The National Green Tribunal (NGT) orders: Issued orders for demarcation and protection of floodplains, referencing standards such as the 1:100-year flood elevation plus contour buffers for accurate mapping and regulation. NGT has instructed Ganga basin states (including Bihar) to remove encroachments, regulate development, and ensure river rejuvenation. Some of important relevant orders are: o
    - Order dated 13.07.2017 in the matter of O.A. No. 200 of 2014 – M C Mehta Vs Union of India : Established no-development zones (NDZs) within 100 meters of the river edge and prohibited waste dumping within 500 m of the Ganga and imposed environmental compensation. (note - NDZ provisions have not been notified for Bihar.)
    - Indian Council for Enviro-Legal Action vs NGRBA & Ors (2015): Mandated segment-wise rejuvenation of the Ganga (Bihar under Phase III/IV), with time-bound actions for drains, STPs, CETPs, and demarcation of floodplains.
3. Draft Notification for River Regulation Zones, Ministry of Environment, Forests and Climate Change (MOEF & CC), February 2016: intended to regulate developmental and industrial activities upto 5 kms from the banks of the river stretches having floodplains and an equivalent area for mountain/ hill stretches under three River Conservation Zones (RCZ) demarcated with reference to the Highest Flood Level (HFL) with a 100 year return period. Draft Notification for River Regulation Zones, Ministry of Environment, Forests and Climate Change (MOEF & CC), February 2016: Intended to regulate developmental and industrial activities up to 5 kms from the banks of the river stretches having floodplains and an equivalent area for mountain/ hill stretches under three River Conservation Zones (RCZ) demarcated with reference to the Highest Flood Level (HFL) with a 100 year return period. Further the river stretches and their tributaries are classified into three categories namely floodplain rivers, seasonal rivers and mountain rivers/hill streams.

Table 17: Defined flood plain zones , Draft Notification for River Regulation Zones, MOEF&CC, 2016

Sl. No.	Zone Code	Zone Name	Description	Spatial Demarcation / Extent
1	RCA–PA	Prohibited Activity Zone	Areas subjected to frequent flooding and most vulnerable to adverse impacts of human activities.	• Flood-prone area up to 500 m from the highest flood level recorded in the past 50 years.• Where embankments exist, the zone extends from the riverbank up to the outermost embankment, plus an additional 100 m buffer outside the embankment.
2	RCA–RA I	Restricted Activity Zone	Floodplain areas less frequently affected by floods and located farther from the river.	Extends from the outer limit of the Prohibited Activity Zone up to 1 km.
3	RCA–RA II	Regulated Activity Zone	Zone where certain regulated activities may be permitted, subject to guidelines.	Extends up to 3 km from the outer limit of the Restricted Activity Zone (RCA–RA I).

4. Technically guidelines on Flood plain zoning, Central Water Commission, Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, July 2025[16]

- Immediate Restrictions: Until floodplain identification and demarcation are completed, no activity is permitted within 100 meters of the river edge, designated as a No Development/Construction Zone. States and UTs may be given phased compliance, with exceptions permitted for essential infrastructure such as railway lines, bridges, and public utilities.
- Defining River's Edge: For enforcement purposes, the "river edge" may be determined by adopting either the maximum dry-season waterline or the maximum flood line recorded during the past five years

Table 18: Flood zones and prohibited activities, Technical Guidelines on flood plain zoning, Central water Commission, 2025

Sl. No.	Zone Name	Applicability	Flood Frequency	Zone Characteristics	Prohibited / Regulated Activities
1	Protected Zone	Rural & Urban Areas	Up to 1 in 5 years	Active flood zone subjected to the most frequent flooding and highest flood risk.	i. All kinds of permanent construction including addition of floor area or elevation of existing structures, except civil and railway infrastructure (embankments/bridges for railway infrastructure with adequate safety measures, flood/bank protection works; construction of new embankments remains prohibited).ii. Any construction disturbing the natural course of the river channel, except essential services and infrastructure (gas/petroleum lines, power transmission pylons, water supply pipelines, bridges, barrages, ghats, green riverfronts, navigation jetties) and temporary structures for defence establishments, disaster management during natural calamities, religious and socio-cultural activities, and recreational activities not involving permanent structures.iii. Dumping of solid waste or creation of landfills.iv. Storage of highly volatile, inflammable, explosive, or toxic materials.v. Establishment of large-scale commercial or industrial facilities, except sustainable activities such as non-commercial groundwater withdrawal by handpumps, traditional organic farming, traditional fisheries, animal grazing, eco-friendly tourism, and permanent utilities like parks, playgrounds, gardens, and discharge of treated domestic wastewater.
2	Regulatory Zone	Rural & Urban Areas	Between 1 in 5 years and 1 in 25 years	Flood severity is lower than the Protected Zone; activities are regulated based on risk.	i. Residential settlements except public institutions, government offices, universities and educational institutions without residential facilities, public libraries, sewage treatment plants, and community halls, subject to conditions: minimum plinth level above 1 in 100-year flood level, earthquake safety compliance, ground floors used for non-residential purposes, and controlled afforestation/conservation projects without

Sl. No.	Zone Name	Applicability	Flood Frequency	Zone Characteristics	Prohibited / Regulated Activities
					obstructing natural flood flows.ii. Critical defence installations.iii. Construction of basements.
3	Warning Zone	Urban Areas Only	Between 1 in 25 years and 1 in 100 years	Outermost zone where most activities may be permitted after vulnerability assessment to minimize flood risk.	i. Hazardous waste–producing chemical industries; however, other industries and public utilities such as hospitals, power installations, water supply systems, telephone exchanges, railway stations, airports, and commercial centres may be permitted, subject to minimum plinth levels corresponding to the 1 in 100-year flood.ii. Nuclear plants.

Note - Demarcation of floodplain corresponding to 100-year return period flood shall necessarily be done for both urban and rural areas

Governing policy-Governing policies / guidelines at State Level:

1. Notification on Flood plain zoning, Water Resource Department, Bihar (March 2025): Given that the State is currently in the process of determining the High-flood line (red and blue lines) and flood plain zones, it has directed temporary provisions to demarcate flood plain zones with uses as "prohibited zone". The current notification is Phase -1 and is applicable for cities with rivers having exiting embankment. Refer Annex 1 for the notification. Defining "flood plain zones":
    - For rivers with existing embankment on both edges, the embankment will be considered as the flood line, and the area in between will be considered as flood plain zone
    - For rivers having embankment only on one side of the river, the area from the embankment including the width of the river and 500 meters from the river edge of the other side, will be considered as flood plain zone
    - Flood plain zones area earmarked as "Prohibited zone"

Table 19: Permissible activities in the Flood plain zone, WRD Bihar Notification, 2025

Category	Activities
Permissible Activities	1. Traditional organic and natural farming without use of agricultural chemicals or heavy machinery. 2. Parks, playgrounds, gardens, and recreational activities without permanent structures. 3. Traditional fish farming without chemicals, toxic substances, explosives, or electricity connections. 4. Pasture land for grazing of animals. 5. Groundwater extraction through hand pumps for domestic and other non-commercial uses. 6. Temporary/mobile defence-related structures with permission from the competent authority. 7. Flood protection and bank protection works. 8. Essential services infrastructure such as gas/petroleum pipelines, power transmission towers, water supply pipelines, bridges, and barrages. 9. Temporary/mobile housing and structures for disaster management and natural calamities. 10. Discharge of domestic wastewater after treatment as per prescribed standards. 11. Religious and socio-cultural activities (e.g., Kumbh Mela, puja rituals) with purely temporary/movable structures during the non-monsoon season only. 12. Temporary or movable jetties and riverfront facilities.

Category	Activities
	13. Eco-friendly tourism activities without permanent construction, including use of non-diesel motorboats. 14. Construction of new railway infrastructure (embankments/bridges) with adequate flood protection measures 15. Plantation of local tree and shrub species for commercial purposes. 16. Regulated sand/stone/sediment/river-borne material mining as per MoEFCC and State Government guidelines 17. Essential repairs to existing buildings without any expansion or new construction. 18. Works related to STPs, river conservation, and NMCG programmes. 19. Completely temporary/mobile buildings or structures that can be folded or moved in original form, excluding areas within 250 m from the riverbank.
Not Permissible Activities	1. Any increase in floor area or height of existing structures of any kind. 2. Dumping of solid waste or creation of landfills 3. Storage of highly volatile, flammable, explosive, or toxic substances 4. Establishment of large-scale commercial or industrial facilities. 5. Construction activities obstructing or altering the natural course of the river channel, except permitted essential services and flood protection works.

1. Bihar State Pollution Control Board (BSPCB) Directives: regulate effluent discharge, sand mining, and solid waste in floodplain-adjacent wards, but enforcement capacity is thin in smaller cities like Gayaji
2. State Disaster Management Plan (2015, updated 2021): Identifies flood-prone districts and stresses non-structural measures, but implementation remains limited.
3. Draft Floodplain Zoning Considerations: Bihar has initiated consultations for adopting a state specific floodplain zoning act, but as of 2025, no legislation has been notified
4. Jal Jeevan Hariyali Mission: Bihar's flagship program for water conservation and climate resilience, focusing on the rejuvenation of water bodies, check dams, rainwater harvesting, afforestation, and sustainable farming.

Local Level Provisions

- Gayaji lacks a fully notified Development Plan or floodplain zoning overlay. A masterplan is currently being drafted.
- The Nagar Parishad has supported embankment construction in certain stretches but has not developed bye-laws on permissible activities

Annexure 2: Common Native Species List

A. **Grasses and Sedges** *(Suitable for frequently inundated zones; erosion control)*

Agrotis Capillaris

Cyperus rotundus

B. **Shrubs and Herbs** *(Suitable for moderately flooded zones; runoff filtration and biodiversity support)*

Justicia procumbens

Phyllanthus amarus

Abutilon indicum

Boerhavia diffusa

Mimosa pudica

C. **Trees** *(Suitable for higher floodplain edges; bank stabilisation and habitat)*

Dalbergia sissoo

Azadirachta indica

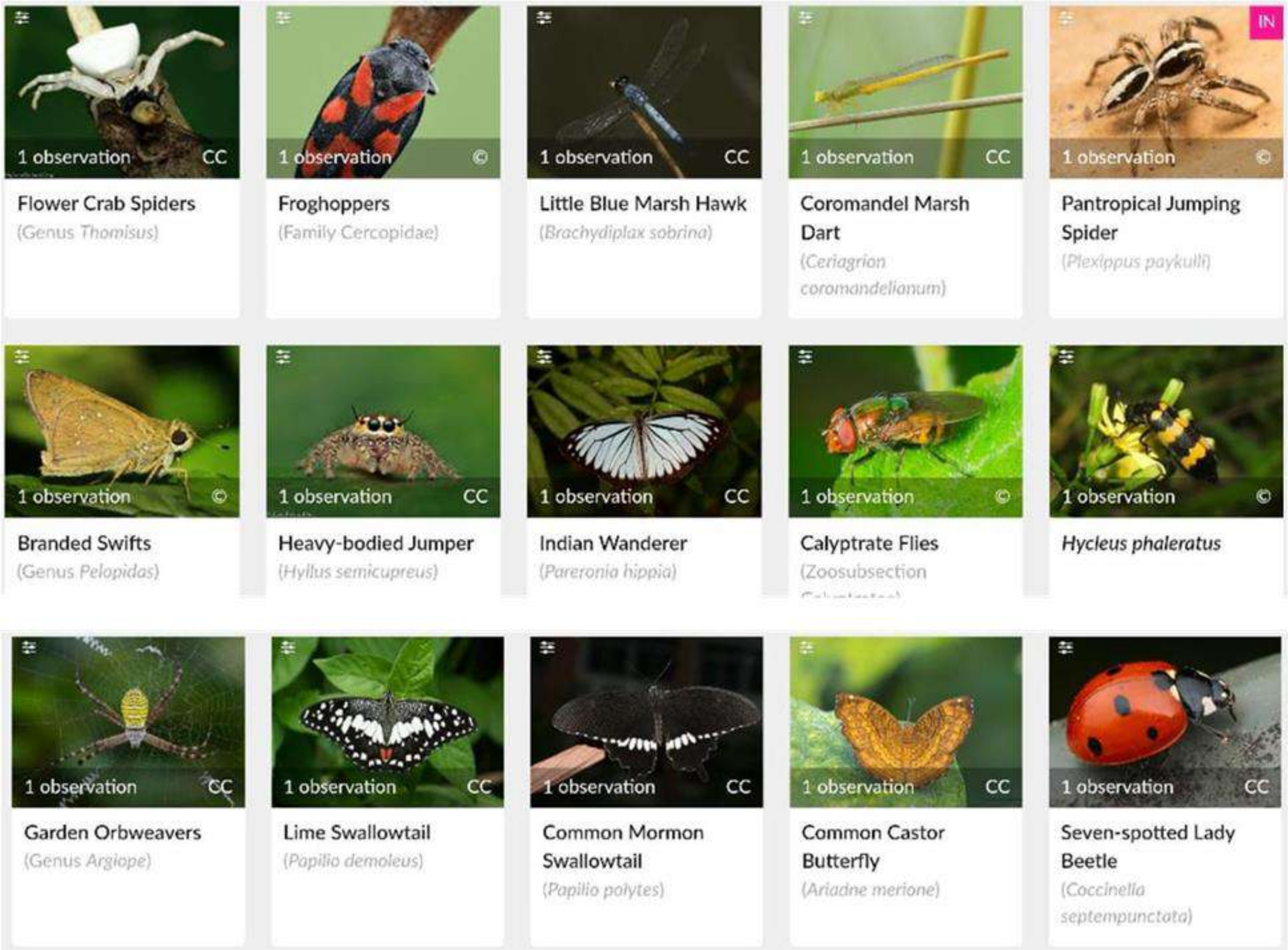
Syzygium cumini

Ziziphus mauritiana

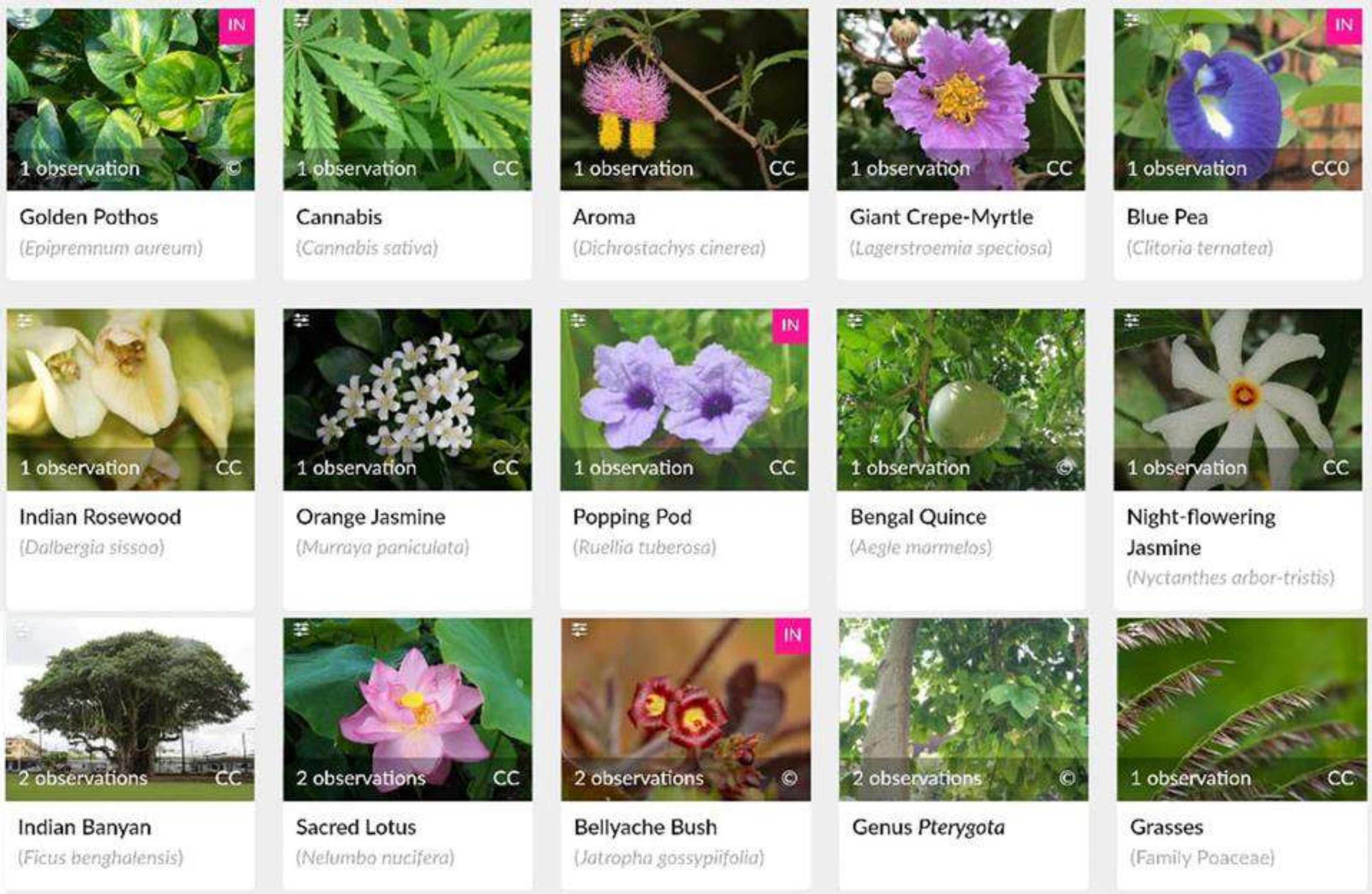
Mangifera indica

Using the iNaturalist (https://www.inaturalist.org/) website which is a global citizen science platform that allows users to record, identify, and share observations of plants, animals, fungi, and other organisms using photographs, sound recordings, and location data. In the context of an Urban River Management Plan, iNaturalist can serve as a practical tool for building and updating ecological evidence at the river-corridor scale. Observations along the river and its floodplain can help document riparian vegetation, aquatic and semi-aquatic species, birds, insects, and invasive species, forming a baseline of urban river biodiversity that is often missing in conventional surveys. Spatial patterns from iNaturalist data can highlight ecologically sensitive stretches, degraded reaches, or biodiversity refuges that warrant protection or restoration. Over time, repeated observations can support monitoring of river health, assess outcomes of interventions such as riparian buffers or wetland restoration, and enable community participation in stewardship, strengthening both ecological management and public ownership of the river system.

Common Fauna



Common Flora



Annexure 3: Methodology of groundwater protection zoning

The Phalgu River defines Gayaji's identity as "Moksh Dham," yet it is largely a seasonal, subsurface river flowing through sandy alluvium, surfacing mainly during the monsoon. Its flow depends on rainfall (800–1100 mm annually) and the region's geology, including fractures and lineaments that shape the aquifer system.

Gayaji developed on the elevated Dobhi–Gayaji alluvial terrace of older alluvium, underlain by Precambrian crystalline rocks. Clay layers act as aquitards above sandy aquifers, which connect to the river's base flow, while fractured bedrock supports semi-confined aquifers. Surrounding hills and traditional water systems (ahars, pynes, tanks) historically aided runoff collection and groundwater recharge. Groundwater is vital for the city, but fluoride levels (up to 3.23 mg/l) exceed BIS limits in places. CGWB (2022) notes Gayaji Sadar block is semi-critical (<70% exploitation), while Manpur block is overexploited, highlighting the need for sustainable groundwater management.

MCDA METHODOLOGY FOR GROUNDWATER PRROTECTION ZONING, INTEGRATING ANALYTIC HIERARCHY PROCESS (AHP)

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1. Introduction and Rationale
Groundwater Protection Zoning involves delineating areas where natural and induced recharge potential is high or low. A robust approach must incorporate both hydrogeological controls (recharge factors) and vulnerability factors that might constrain recharge or influence groundwater quality. Multi-Criteria Decision Analysis (MCDA) provides a systematic framework to integrate multiple thematic layers, and Analytic Hierarchy Process (AHP) is used to derive relative weights based on expert judgment and consistency checks.
In this exercise we take:

Recharge Factors:

1. Geology
2. Geomorphology
3. Proximity to River
4. LULC
5. Soil Type
6. Drainage Density
7. Slope
8. Lineament Density

Vulnerability Factors: (affect quality or susceptibility to pollution)

9.Aquifer/Vadose Zone
10. Depth to Groundwater
11. Pollution Source Kernel Density

We have the final AHP weights assigned:

Factor	Weight
Geology	0.12
Geomorphology	0.11
Proximity to River	0.1
Soil Type	0.078
Drainage Density	0.071
Slope	0.075
Lineament Density	0.072
Aquifer-Vadose Zone	0.063
Depth to Groundwater	0.064
Pollution Source Kernel Density	0.155

Conceptual Framework

Recharge and Vulnerability Dimensions

Recharge potential and groundwater vulnerability are interlinked but distinct. High infiltration does not always mean effective recharge if the aquifer is highly vulnerable to contamination.

- Recharge factors determine the capacity of water to infiltrate and percolate.
- Vulnerability factors determine the degree of aquifer protection and contamination risk.

Therefore, the Groundwater Protection Zoning Map must integrate both, identifying areas with high recharge but also high vulnerability for regulated protection and treatment measures.

AHP Justification

The Analytical Hierarchy Process (AHP) includes:

1. Hierarchy structuring (goal → criteria → sub-criteria → alternatives)
2. Pairwise comparison of criteria
3. Weight normalization
4. Consistency verification (CR < 0.10)

Although weights are pre-assigned, they must be validated through a pairwise comparison matrix and checked for consistency.

Pairwise comparison matrix

Pairwise comparison is based on the principle that the relative importance of any two criteria (i, j) should reflect the ratio of their weights:

A[i,j] = w_i / w_j

Where:

- A[i,j] is the pairwise score of criterion i compared to j
- w_i and w_j are their normalized weights

Since we already have final weights, this matrix can be constructed directly and will inherently reflect the AHP weight structure if consistent.

Below is the 11×11 matrix (upper triangular) of normalized criteria comparisons (rounded to 3 decimals for clarity.

Criteria	Geology	Geomorphology	Prox to River	LULC	Soil Type	Drainage Density	Slope	Lineament Density	Vadose Zone	Depth to GW	Pollution Kernel Density
Geology	1	1.091	1.2	1.304	1.538	1.69	1.6	1.667	1.905	1.875	0.774
Geomorphology	0.916	1	1.1	1.195	1.384	1.523	1.419	1.472	1.744	1.719	0.71
Prox to River	0.833	0.909	1	1.087	1.258	1.383	1.288	1.336	1.583	1.559	0.644
LULC	0.767	0.836	0.92	1	1.157	1.272	1.184	1.228	1.455	1.433	0.592
Soil Type	0.65	0.723	0.795	0.864	1	1.099	1.022	1.061	1.257	1.238	0.511
Drainage Density	0.591	0.656	0.723	0.786	0.91	1	0.93	0.965	1.143	1.126	0.465
Slope	0.625	0.705	0.776	0.845	0.978	1.075	1	1.036	1.227	1.209	0.5
Lineament Density	0.6	0.679	0.749	0.814	0.942	1.036	0.965	1	1.184	1.167	0.483
Vadose	0.525	0.573	0.632	0.687	0.796	0.875	0.815	0.845	1	0.986	0.409
Depth to GW	0.533	0.582	0.642	0.697	0.808	0.887	0.827	0.857	1.015	1	0.413
Pollution Kernel Density	1.292	1.408	1.553	1.689	1.956	2.147	2	2.07	2.442	2.42	1

Note:

- Diagonal = 1
- A[i,j] = 1 / A[j,i]
- Values reflect how many times more important one layer is than another from hydrogeological perspective.

Normalization and Weight Vector

Each column of the pairwise comparison matrix is normalized by dividing by the column sum. Row-wise averaging yields the final weight vector. Since the weights are predefined, the normalized results should reproduce the original weights within numerical tolerance.

Consistency Check

Model consistency is verified using the Consistency Index (CI) and Consistency Ratio (CR). The maximum eigenvalue (λ_{max}) is obtained by multiplying the pairwise matrix with the weight vector. CI is computed as $(\lambda_{max} - n)/(n - 1)$, and CR as CI/RI. For $n = 11$, RI ≈ 1.51. The matrix is acceptable if $CR < 0.10$; otherwise, weight judgments must be revised.

<u>GIS-Based Methodology</u>

Base Layer

The analysis uses geology, geomorphology, river network, LULC, soil, drainage density, slope (from DEM), lineaments, aquifer units, groundwater depth, and pollution source data. All layers are projected to a common coordinate system and resolution.

Standardization and Reclassification

All thematic layers are converted to raster format (10–30 m resolution). Each factor is reclassified into 5–7 classes using hydrogeological thresholds and assigned a 1–9 scale, where higher values indicate higher recharge potential or vulnerability.

Pollution Kernel Density

Major pollution sources are mapped and processed using the Kernel Density tool to generate a continuous vulnerability surface, which is subsequently classified.

Weighted Overlay Analysis

Recharge Score = (Geology*0.12) + (Geomorphology*0.11) + (ProxRiver*0.10) + (LULC*0.092) + (Soil*0.078) + (DrainageDen*0.071) + (Slope*0.075) + (LineamentDen*0.072)

Vulnerability Raster

Weighted sum of vulnerability layers: Vulnerability Score = (AquiferVadose*0.063) + (DepthGW*0.064) + (PollutionDensity*0.155)

Zonation and Classification

Classify results into 4 classes using natural breaks or equiprobable

<u>Class</u>	**<u>Interpretation</u>**
Very High Protection Need	No activity to be proposed as these are Ground water runoff collection areas from the structural hills where applicable and recharge zones
High Protection Need	Regulated activity to be proposed based on recharge potential and vulnerability

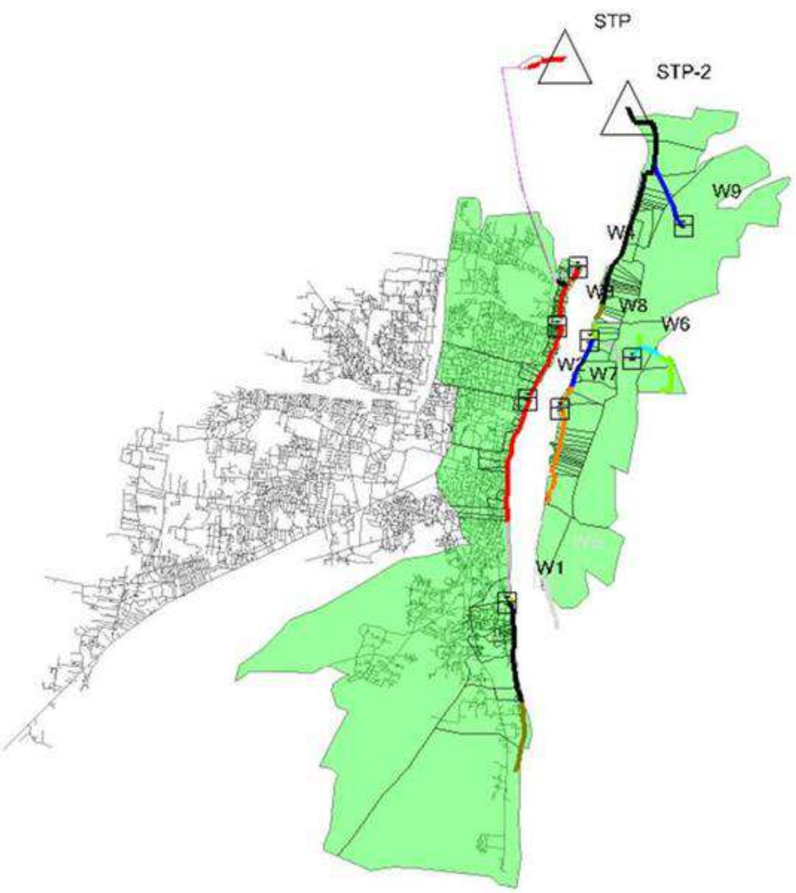
Moderate Protection Need	Moderate recharge & vulnerability
Low Protection Need	Excellent recharge & low vulnerability

Recharge Suitability \ Vulnerability	Very High	High	Moderate	Low
Low	Very High	High	Moderate	Low
Moderate	Very High	High	Moderate	Moderate
High	Very High	High	High	High
Very High	Very High	Very High	Very High	Very High

Based on the above, a matrix has been developed (as adapted from the Zoning Atlas for Siting of Industries Project, EMCBTA, CPCB 1995-2005). The matrix has been kept on the conservative to protect groundwater especially within the city and adjacent to the structural hills that enables collection of runoff. This shall not only protect the recharge zones and enable maintaining the aquifer connect and the connect to the river Phalgu but also enable drafting of a groundwater management plan for the city. The environmental regulations within the city's Master Plan in the form of development control regulations allowing only low density development with low FAR should be allowed in the very high and high protection zone need. This is not only an imperative for a river sensitive master plan but also a plan that is environmentally sensitive.

Annexure 4: Proposed STP and CETP (Approved Stage)

Figure 68: Loading based on interception points



Source: BUIDCO

Category	Particulars	Details
General	Town	Gayaji
	Sector	Sewerage – Interception & Diversion (I&D) Scheme
	Area of Town	40.29 sq. km
Population	Census 2011	4,68,614
	Base Year (2027)	6,03,988
	Intermediate Year (2042)	7,67,565
	Design Year (2057)	9,75,443
Existing Situation	Sewerage System	Non-existent
	Drainage Coverage	~80%
	Water Supply	~600 km network / 10 OHTs (ongoing)
	Solid Waste Management	Partial coverage

Category	Particulars	Details
Proposed STP Infrastructure	Total STP Capacity	87 MLD (73 + 14 MLD)
	No. of STPs	2
	Treatment Technology	SBR
Pumping Infrastructure	Main Pumping Stations	2
	Intermediate Pumping Stations	6 + 2 (away from river)
Network Components	Sewerage Network Length	16.14 km
	Rising Main Length	6.4 km
CETP (Manpur–Patwa Toli)	CETP Capacity	2 MLD
	No. of I&D Structures	8 Nos.
	CETP Network Length	1.8 km

Source: BUIDCO

Annexure 5: Detailed BOQs

5.1 Cost estimate- River pollution Waste management strategy for Gayaji city

Sl. No.	Item	Description / Scope	Cost (INR)
1	Hiring of 3rd Party Agency	Preparation of integrated River Pollution & Solid Waste Management Strategy including river drains, legacy waste, pilgrimage waste, institutional framework, phasing and DPR support	18,00,000
2	Baseline Survey & On-ground Assessment	Primary survey of solid waste generation, drain outfalls into Falgu River, ghats, cremation areas, temples, hotels, and seasonal pilgrim load	2,00,000
3	GIS & GPS-based Tracking System	GIS mapping of waste sources, drains, dumping sites; GPS tracking for collection vehicles and riverfront cleaning	12,00,000
4	Water Quality Monitoring System	Installation of real-time/periodic water quality sensors at critical locations on Falgu River and drains	10,00,000
5	IEC & Pilgrim Awareness Drives	Awareness campaigns for residents, pilgrims, temple committees, hotels; signage, pamphlets, workshops	3,00,000
6	Additional Manpower / Staff Cost	Project management unit support, data handling, monitoring staff (short-term contractual)	12,00,000
7	Legacy Waste Management & Bioremediation	Bioremediation of existing dump sites, waste transfer to authorised facilities as per CPCB & NGT guidelines	60,00,00,000
8	Monitoring, Reporting & Third-party Review	Periodic progress reports, compliance monitoring, third-party technical review	3,00,000
Total Estimated Cost			60,60,00,000

5.2 Cost estimate- GIS based inventory for water body and assessment based on UWD tool

Sl. No.	Item / Activity	Scope (23 Water Bodies)	Amount (INR)
CAPEX			
1	Water body mapping & GIS database creation	City base map, satellite imagery, secondary data (WRD, Census), GIS layers with attributes	2,50,000
2	Primary water quality assessment (UWD parameters)	Field sampling & testing (DO, pH, turbidity, basic physico-chemical parameters), GPS tagging	2,30,000
3	Integration with UWD Tool / Central Dashboard	Data structuring, scoring, dashboard setup as per UWD methodology	2,50,000
4	Mobile / SMS alert system	Alerts to Municipal Commissioner / District officials on threshold breach	25,000
5	Integration with water quality dashboard	Linking with state/central dashboards and system testing	4,00,000
6	Signage & information boards	Name boards, UWD score, dos & don'ts at 23 water bodies	6,90,000
	Subtotal – CAPEX		18,45,000
OPEX			
7	Agency fee for monitoring & updating	Quarterly monitoring, sampling, UWD score update & reporting (4 cycles/year)	10,00,000
8	System maintenance & data hosting	GIS server, dashboard upkeep, troubleshooting	6,00,000
9	Contingency / reserved fund	Emergency sampling, data gaps, minor replacements	2,50,000
	Subtotal – OPEX		18,50,000
	Grand Total (CAPEX + OPEX)		36,95,000

5.3 Cost estimate for Ritual Waste Management – Vishnupad Temple & Ghat Area (Self-Sustainable Model)

Waste Stream / Item	Technology / Description	Capacity / Quantity	Land / Space	Cost / Value (₹ lakh)	Frequency	Remarks
Floral waste	Portable aerobic composters (FRP/HDPE, containerised)	3 × 3 TPD	200 sqm	18.00	One-time	Movable units
Pinda & food residue	Prefab bio-digester (plug-flow)	6 TPD	120 sqm	22.00	One-time	Sealed, odourless
Ash & inert waste	Covered ash bins + handling system	2.1 TPD	40 sqm	2.00	One-time	Inert reuse
Cloth waste	Sorting shed + NGO linkage	2.1 TPD	60 sqm	3.00	One-time	Reuse-based
Dry waste	Manual MRF corner	2.1 TPD	80 sqm	5.00	One-time	Low-tech
Total CAPEX	—	—	~500 sqm	50.00	—	Approximate
Compost / manure	From floral waste	250–300 kg/day	—	0.45	Monthly	Temple gardens, farmers

Waste Stream / Item	Technology / Description	Capacity / Quantity	Land / Space	Cost / Value (₹ lakh)	Frequency	Remarks
Biogas	From bio-digester	250–350 m³/day	—	0.60	Monthly	Lighting, crematorium
Digestate slurry	Soil conditioner	3 TPD	—	0.18	Monthly	Agricultural reuse
Reused cloth	NGO resale	—	—	0.10	Monthly	Livelihood support
Recyclables	Plastic, paper	~2 TPD	—	0.12	Monthly	MRF output
Total Revenue	—	—	—	1.45	Monthly	—
Labour	10 workers	—	—	0.80	Monthly	Local employment
Consumables & repairs	Enzymes, tools	—	—	0.20	Monthly	Routine
Electricity	Mostly solar/biogas	—	—	0.10	Monthly	Minimal
Transport & logistics	Ash & rejects	—	—	0.15	Monthly	Safe disposal
Total O&M Cost	—	—	—	1.25	Monthly	—
Net balance	Revenue – O&M	—	—	+0.20	Monthly	Self-sustaining

5.4 Cost estimate for rejuvenation of Digghi talab

Sl. No.	Item / Activity	Detailed Description & Specifications	Unit	Qty	Unit Rate (₹)	Amount (₹)	Remarks
1	Desilting – mechanical excavation	Excavation of accumulated silt using excavator including cutting, loading and stacking	Cum	8,000	110	8,80,000	Avg. depth 0.8–1.0 m
2	Deweeding of waterbody	Removal of aquatic weeds, algae and organic matter (manual + mechanical)	Cum	2,000	160	3,20,000	Pre-monsoon
3	Transport & disposal of silt	Transportation up to 5 km including spreading and leveling at disposal site	Cum	10,000	40	4,00,000	Approved site
4	Embankment slope dressing	Manual trimming, shaping and slope formation (1:2 / 1:3)	Sqm	2,000	120	2,40,000	Before pitching
5	Stone pitching on slopes	230 mm thick hand-packed stone pitching with filter media	Sqm	1,500	420	6,30,000	Erosion control
6	Toe wall / gabion support	Gabion boxes filled with stones at vulnerable edges	Rm	100	800	80,000	Critical points
7	Granular sub-base for pathways	100 mm thick compacted granular sub-base	Sqm	1,200	180	2,16,000	Mechanical compaction
8	Paver block / stone pathway	60 mm paver blocks / Kota stone including sand bedding	Sqm	1,200	520	6,24,000	1.5–2.0 m wide
9	Precast edge kerbing	Precast concrete kerbs along pathway edges	Rm	400	300	1,20,000	Path retention
10	Solar LED street lights	6–7 m solar poles with panel, battery and luminaire	No.	30	15,500	4,65,000	MNRE compliant

Sl. No.	Item / Activity	Detailed Description & Specifications	Unit	Qty	Unit Rate (₹)	Amount (₹)	Remarks
11	Light pole foundation & erection	PCC foundation, grouting and alignment	No.	30	2,500	75,000	Inclusive
12	Seating benches	RCC / MS benches including foundation	No.	20	18,000	3,60,000	Anti-vandal
13	Twin waste bins	FRP / HDPE dry–wet bins with stand	No.	8	7,000	56,000	SBM compliant
14	Entry signage	Main entry signage with MS frame and printed board	No.	1	35,000	35,000	Identity
15	Awareness & rule boards	Do's & Don'ts, ecological information boards	No.	5	13,000	65,000	IEC
16	Soil preparation for plantation	Pit digging, manure, soil conditioning	Sqm	5,000	90	4,50,000	Riparian buffer
17	Plantation (native species)	Trees, shrubs and grasses	Sqm	5,000	210	10,50,000	Biodiversity
18	Initial maintenance of plantation	Watering & replacement for 3 months	Sqm	5,000	50	2,50,000	Survival rate
19	Floating Treatment Wetlands (FTW)	Modular FTW units with macrophytes	No.	4	90,000	3,60,000	In-situ treatment
20	Floating aerators	Solar/electric aerators for DO improvement	No.	2	90,000	1,80,000	Stagnant zones
	TOTAL					₹62,96,000	

5.5 Cost estimate for rejuvenation of Haveli talab

S. No.	Item / Activity	Upgraded Specifications & Scope	Unit	Qty	Revised Rate (₹)	Revised Cost (₹)	Remarks
PATH & SURROUNDING AREAS							
1	Low-height fencing / green hedge with entry gates	MS powder-coated fencing + native hedge plantation, drip watering provision, 4 decorative entry gates	Meter	665	650	4,32,250	Durable + aesthetic
2	Stone / natural pathway	Kota stone / granite pavers, PCC base, edge kerbing, anti-skid finish	Meter	665	1,200	7,98,000	Urban promenade standard
3	Solar LED street lights @ 20 m	7–8 m poles, Li-ion battery, smart controller, higher lumen output	No.	33	28,000	9,24,000	Long-life system

S. No.	Item / Activity	Upgraded Specifications & Scope	Unit	Qty	Revised Rate (₹)	Revised Cost (₹)	Remarks
4	Benches @ 25 m	Designer RCC–MS benches with armrests, vandal-proof anchoring	No.	25	30,000	7,50,000	Public comfort
5	Waste bins	Triple-bin system (wet–dry–sanitary), MS stand with signage	No.	12	12,000	1,44,000	SBM 2.0 compliant
6	Signage, IEC & pond rules	Entry gateway signage, QR-based awareness boards, heritage panels	Lumpsum	1	75,000	75,000	Smart IEC
WATER SPREAD AREA							
7	Removal of invasive aquatic vegetation	Mechanical harvester + manual finishing, transport & disposal	Sqm	15,804	110	17,38,440	Intensive cleaning
8	Reed bed development	Engineered reed beds with gravel filter, native macrophytes	Meter	665	1,100	7,31,500	Bio-filtration
9	Floating Treatment Wetlands (FTWs)	HDPE modular FTWs with multi-species planting & anchoring	No.	3	75,000	2,25,000	Improved efficiency
10	Floating aerators (solar/hybrid)	High-capacity aerators with hybrid power & control panel	No.	2	1,50,000	3,00,000	DO stabilization
WATER EDGE							
11	Stone / gravel edge treatment	Stone pitching with geotextile, toe protection	Meter	665	650	4,32,250	Bank protection
12	Viewing decks	RCC + MS composite decks, railings, seating, lighting	No.	4	2,25,000	9,00,000	Landmark elements
		SUBTOTAL (A)				74,50,440	
13	Contingency & execution overheads (6%)	Unforeseen site conditions, rate variation, minor design changes	Lumpsum	—	—	4,47,000	Standard DPR norm
		TOTAL ANNUAL CAPEX				₹78,97,440	

5.6 Cost estimate Vishnupad Ghat – Heritage Walk & Ghat Connector

S. No.	Item Description	Unit	Quantity	Rate (₹)	Amount (₹)
A. Site Preparation & Demolition					
1	Clearing, dismantling & debris disposal along heritage walk	Sqm	2,200	250	5,50,000
2	Earthwork, grading & subgrade preparation	Cum	1,400	400	5,60,000
B. Heritage Walkway Development					
3	Stone-paved heritage walkway (Kota/Sandstone), 75mm thick	Sqm	2,200	2,200	48,40,000
4	Decorative stone kerb edging	Rm	950	900	8,55,000
5	Tactile paving for elderly & divyang	Sqm	180	2,800	5,04,000
C. Ghat & Edge Treatment					
6	Ghat step repair, stone pitching & anti-slip finish	Sqm	750	3,500	26,25,000
7	River edge protection with stone pitching & filter layer	Rm	400	3,000	12,00,000
D. Street Furniture & Heritage Elements					
8	Heritage-style benches (stone + cast iron)	No.	32	35,000	11,20,000
9	Waste bins (segregated, heritage finish)	No.	24	15,000	3,60,000
10	Drinking water points with stone enclosure	No.	6	85,000	5,10,000
E. Lighting & Electrical Works					
11	Heritage LED lamp posts (5–6 m height)	No.	45	55,000	24,75,000
12	Underground electrical cabling & control panels	Lumpsum	1	8,50,000	8,50,000
F. Interpretation, Signage & Cultural Assets					
13	Heritage signage, wayfinding & interpretation boards	No.	18	45,000	8,10,000
14	Wall murals, relief art & cultural storytelling panels	Lumpsum	1	9,00,000	9,00,000
G. Landscape & Public Realm Improvement					
15	Soft landscaping, native plantation & planters	Sqm	1,200	750	9,00,000
16	Tree guards (heritage design)	No.	40	12,000	4,80,000
H. Universal Access & Safety					
17	Ramps, handrails & safety balustrades	Rm	220	3,500	7,70,000

S. No.	Item Description	Unit	Quantity	Rate (₹)	Amount (₹)
18	CCTV, emergency call points & safety signage	Lumpsum	1	6,50,000	6,50,000
I. Miscellaneous & Project Support					
19	Public conveniences (prefab toilets – male/female/divyang)	No.	2	7,50,000	15,00,000
20	Contingency (5%)	Lumpsum	1	—	8,20,000
	TOTAL				**₹1,69,79,000**

5.7 Cost estimate for Upgradation of Falgu River

S. No.	Item	Unit	Quantity	Rate (NPR)	Cost (NPR)	Notes
ZONE 1 – RECREATIONAL ZONE (Urban Edge + Public Realm)						
1	Nature Walk Trails (1.5 m wide paver track)	meters	1,600	1,200	1,920,000	Extended length along urban ghats
2	Children's Play Area / Sports Park	Sqm	5,000	2,600	13,000,000	High footfall pilgrimage zone
3	Shaded Seating Pockets (every 50 m)	No.	32	5,000	160,000	Bench + tree + shade structure
4	Outdoor Gym	Sqm	1,200	1,900	2,280,000	Flood-resilient equipment
5	Green Areas (Turf + Shrubs)	Sqm	28,000	360	10,080,000	Sandy soil improvement included
6	Trash Booms	No.	2	20,000	40,000	For monsoon floating waste
7	Riparian Buffer with Native Vegetation	Sqm	22,000	520	11,440,000	Primary flood buffer
ZONE 2 – ECOLOGICAL RESTORATION (River Bed + Floodplain)						
8	Trash Booms (Upstream control)	No.	3	20,000	60,000	Prevents city waste inflow
9	Floating Treatment Wetlands (seasonal pools)	No.	12	35,000	420,000	Installed only in retained water pockets
10	Biodiversity Zones	Sqm	65,000	620	40,300,000	Grassland + native riparian species
11	Walking Trails with Viewing Decks	meters	1,200	2,700	3,240,000	Raised decks for flood safety

S. No.	Item	Unit	Quantity	Rate (NPR)	Cost (NPR)	Notes
12	Non-Concrete Bund / Bank Protection	meters	600	2,000	1,200,000	Gabion + vegetated slopes
13	Secondary Riparian Buffer	Sqm	10,000	520	5,200,000	Seasonal erosion control
ZONE 3 – ECONOMIC & PILGRIM SUPPORT ZONE						
14	Riparian Buffer Restoration (Commercial Edge)	Sqm	35,000	520	18,200,000	Protects kiosks & walkways
15	Edge Treatment (Stone + Gravel)	meters	1,800	400	720,000	Dry-season usability
16	Boat Landing / Ritual Access Ghat	No.	2	350,000	700,000	Concrete + stone steps
OVERALL RIVER SYSTEM INTERVENTIONS						
17	Soft River Boundary (Bamboo Crib Wall)	meters	4,000	900	3,600,000	Adapted for wide river
18	Total Annual CAPEX	—	—	—	112,540,000	
ADDITIONAL COSTS						
19	15% Contingency & Flood Damage Allowance	Lumpsum	—	—	16,881,000	Seasonal river risk
	TOTAL PROJECT COST				129,421,000	

5.8 Cost estimate for River based sensitisation program

No.	Item	Scope / Description	Budget (Yearly) – ₹	Remarks
1	Citizen Awareness Campaigns	Designing & printing posters, hoardings, IEC material, venue arrangements, awards & certificates (1 campaign per quarter)	3,00,000	Focus on Falgu river, ghats & ritual waste
2	Youth Mobilization Programs	Clean-up drives, workshops & awareness programs in colleges, institutions & communities (4 programs/year)	1,00,000	Higher student participation than Gayaji
3	Youth Mobilization – Internship Program	3-month internship for 15 students (₹5,000/month/student) for field monitoring, surveys & reporting	2,25,000	Priority to local & underprivileged students
4	Community & Committee-based Clean-up Drives	Ward committees, temple committees, festival clean-up groups, school eco-clubs, NGOs/SHGs (6 committees × 4 drives = 24 events/year)	1,50,000	Vishnupad, ghats & waterbodies
5	Social Media & Outreach Campaign	Yearly contract with agency: local influencers, citizen feedback, quizzes, reels, minimum 20 posts/month	3,00,000	City-wide digital engagement

No.	Item	Scope / Description	Budget (Yearly) – ₹	Remarks
6	Administrative & Operational Costs	Office furniture, printing, transport, monitoring & reporting, ad-hoc labour	4,00,000	For field-level execution
7	Yearly IEC Booklets	Household-level & school-level booklets on river protection & waste management	2,50,000	Distributed via schools & wards
8	Special Festival & Pilgrimage Fund	Extra clean-up drives, manpower, logistics during Pitrapaksha, fairs & processions	15,00,000	Critical for Gayaji
9	Reserved / Emergency Fund	Floods, sudden pollution events, emergency awareness actions	10,00,000	Flexibility buffer
	TOTAL ANNUAL BUDGET		42,25,000	₹42.25 lakh / year

END OF REPORT