GUARDING THE RIVER GANGES - MIRZAPUR'S COMPREHENSIVE PLAN FOR SUSTAINABLE WASTEWATER MANAGEMENT AND REUSE

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Guarding The River Ganges - Mirzapur's Comprehensive Plan for Sustainable Wastewater Management and Reuse

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Abstract

The rapid urbanization of Indian cities has led to increased freshwater demand, placing considerable stress on urban water systems. In this context, wastewater—typically viewed as waste—offers significant potential as a resource. This thesis examines the wastewater management challenges in Mirzapur, Uttar Pradesh, a city located along the Ganga River and known for its carpet industry. Mirzapur faces critical issues, including inadequate infrastructure, untreated wastewater discharges, and rising industrial and domestic water demands. A substantial volume of wastewater is released untreated into natural water bodies, severely polluting the Ganga and threatening environmental and public health.

The study identifies major gaps in existing wastewater infrastructure and regulatory mechanisms. It proposes a comprehensive wastewater management plan aligned with the principles of a circular water economy. Key strategies include reducing freshwater consumption, expanding treatment capacity, and promoting the reuse of treated wastewater for industrial, ecological, and non-potable urban applications. The approach integrates policy recommendations, stakeholder engagement, and urban planning to enable sustainable and resilient water management.

The findings aim to support evidence-based decision-making, prioritize infrastructure investments, and contribute to the national objective of Ganga River rejuvenation. Ultimately, the research positions wastewater management as a critical component of sustainable urban development in Mirzapur.

Keywords

Wastewater Management, Treated Wastewater Reuse, Circular Water Economy, Ganga River Pollution, Water Resource Recovery

1. Introduction

1.1. Background

Water is essential for life and sustainability, yet global challenges like scarcity and pollution persist. In India, 72% of urban wastewater remains untreated, polluting rivers and posing health risks. Rapid urbanization, poor infrastructure, and lack of data and coordination worsen the problem.

Mirzapur, a city on the Ganga River, faces acute wastewater management issues. With limited STP capacity and rising population, untreated sewage and industrial effluents—especially from the carpet industry—are discharged into the Ganga, degrading water quality and threatening public health and ecosystems.

This study aims to bridge the gap between wastewater generation and treatment in Mirzapur, promote water reuse, and support sustainable, circular water management to protect the Ganga.

2. Literature Review

2.1. Current Trends and Scenario

Globally, 60% of household wastewater is discharged untreated, with low-income countries treating only 4% of their wastewater. High-income nations treat 74%, while middle-income countries treat less than 50%. Reuse of treated water is more common in middle-income countries (25%) than in high- (19%) or low-income (8%) nations, highlighting the need for income-specific wastewater solutions.

India generates 72,368 MLD of urban wastewater, but only 28% is treated. Rural areas contribute an additional 39,604 MLD, widening the treatment gap. With water demand projected to exceed supply, efficient wastewater management is critical. Class-I cities face a 67% treatment shortfall, and Class-II towns up to 95%.

Challenges include lack of land, poor drainage mapping, insufficient data, and generic solutions that ignore local needs. Cost-effective technologies and public acceptance of reused water are lacking, and stakeholder coordination remains weak. The NITI Aayog (2022) stresses the urgency for localized, innovative, and integrated wastewater strategies to address India's growing water crisis.

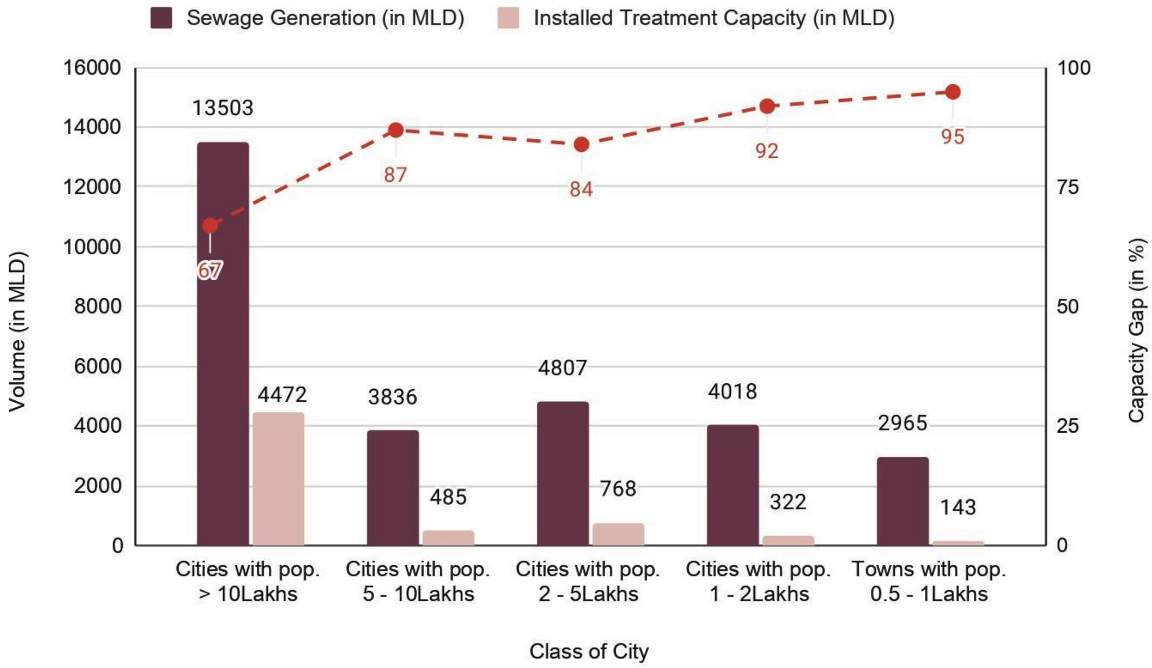

Figure 1: Wastewater generation and treatment capacity gap at city level in India (Source: CPCB, 2022)

2.2. Insights on Existing Research

2.2.1. Policy and Governance

- Many STPs in India do not meet regulatory standards, and enforcement actions are often limited, with more than half of the violations left unaddressed (CPCB, 2020).
- The shortage of staff in scientific, technical, and administrative roles ranges between 37.6% - 52.3%, making it difficult for institutions to function effectively.
- WWT can generate energy through biogas recovery and nutrient recycling, but infrastructure, policy, and cost challenges persist.
- The cost of water reuse services, social resistance, & lack of clear governance structures hinder the transition to a circular model.

2.2.2. Circular Economy

- The use of biogas from wastewater, organic manure generation, and phosphorus recovery can enhance CE but requires better policy and investment support.
- 3 Million ha of land can be fertilised annually with the sludge from treated wastewater, & reduces the need for fertilisers by 40%.

- By 2050, the freshwater abstraction by industries will be 10.1%. All these factors make a strong case for a circular economy pathway in the wastewater sector.
- A paradigm shift from “use and throw” to a “use, treat, and reuse” approach is required.

2.2.3. Wastewater Reuse

- Rainwater harvesting and recycling could supply up to 50% of domestic water demand in some regions.
- Through the utilisation of 110 major cities’ 80% untreated wastewater, the nation could meet 75% of its anticipated industrial water needs by 2030.
- Drip irrigation using treated wastewater can reduce freshwater demand by 30-40%.
- CEEW estimates suggest that by 2050, over 96,000 million litres per day of treated used water (TUW) will be available for reuse in India.

2.2.4. Wastewater Treatment

- Decentralized systems and AI-driven systems enhance efficiency and sustainability.
- Technologies like dual systems and natural treatments enhance safe reuse.
- Localized treatment can reduce costs and promote resource regeneration.
- More research is required to reduce the resource requirement associated with using advanced technologies.
- Decentralised systems are currently popular, they are detached from governance, regulatory, and political complexities.

3. Site Context and Analysis

3.1. Study Area Background

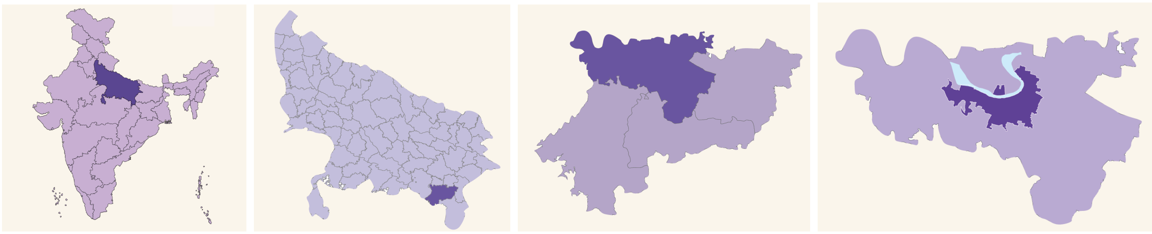

Figure 2: Site area delineation

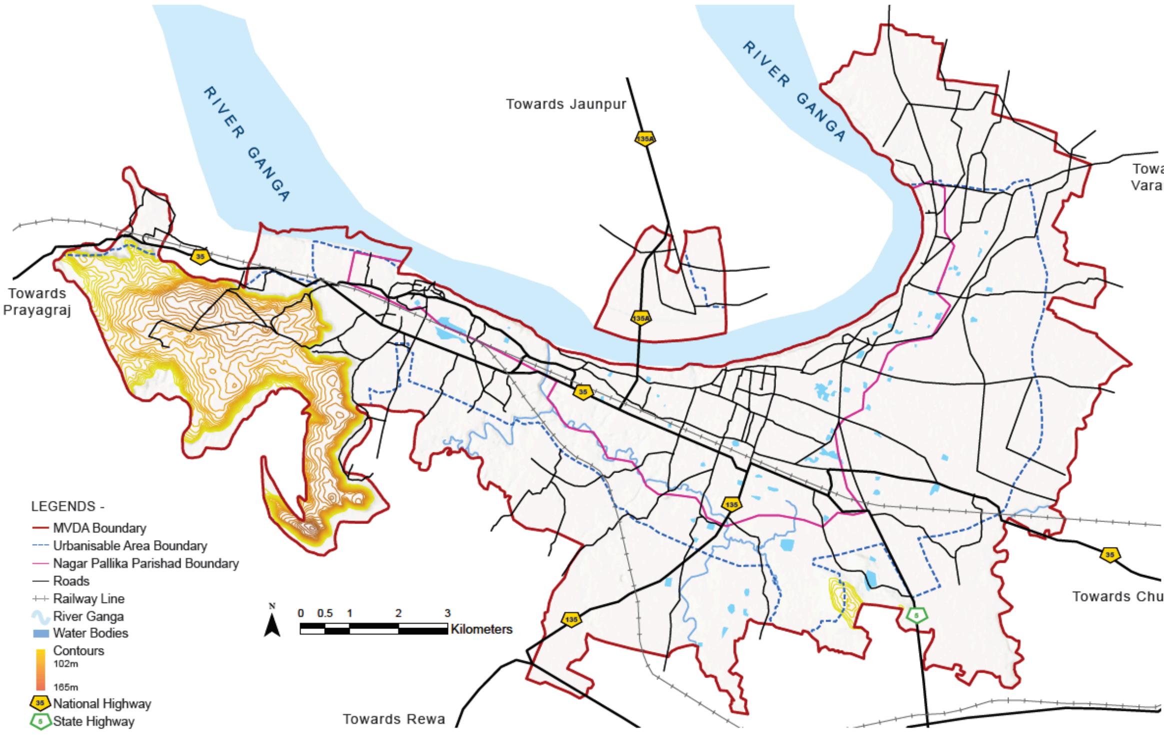

Figure 3: Basemap of Mirzapur - Vindhyachal Development Authority Area

The study area has a total area of 114.85 km² within the Mirzapur - Vindhyachal Development Authority (MVDA) Area, with the Nagar Palika Parishad Boundary Area covering 38.85 km² and Urbanisable Area Boundary of 83.2 km². It is divided into 68 revenue villages and consists of 38 municipal wards. According to the 2011 Census, the MVDA's population is 3,53,547, with a population of 2,46,920 in the Urbanisable Area (UA) and 2,34,871 in the Nagar Palika Parishad Area (NPP).

The Mirzapur city is notably recognized for its carpet industries and is geographically surrounded by the Vindhya Range, contributing to its unique environmental and cultural landscape. The climate varies between 7°C and 36.8°C, with an annual average rainfall of

978 mm. These demographic and geographic details provide essential insights into the city's growth, environmental conditions, and economic characteristics, relevant to the scope of urban wastewater management and resource reuse within the region.

3.2. Land Use

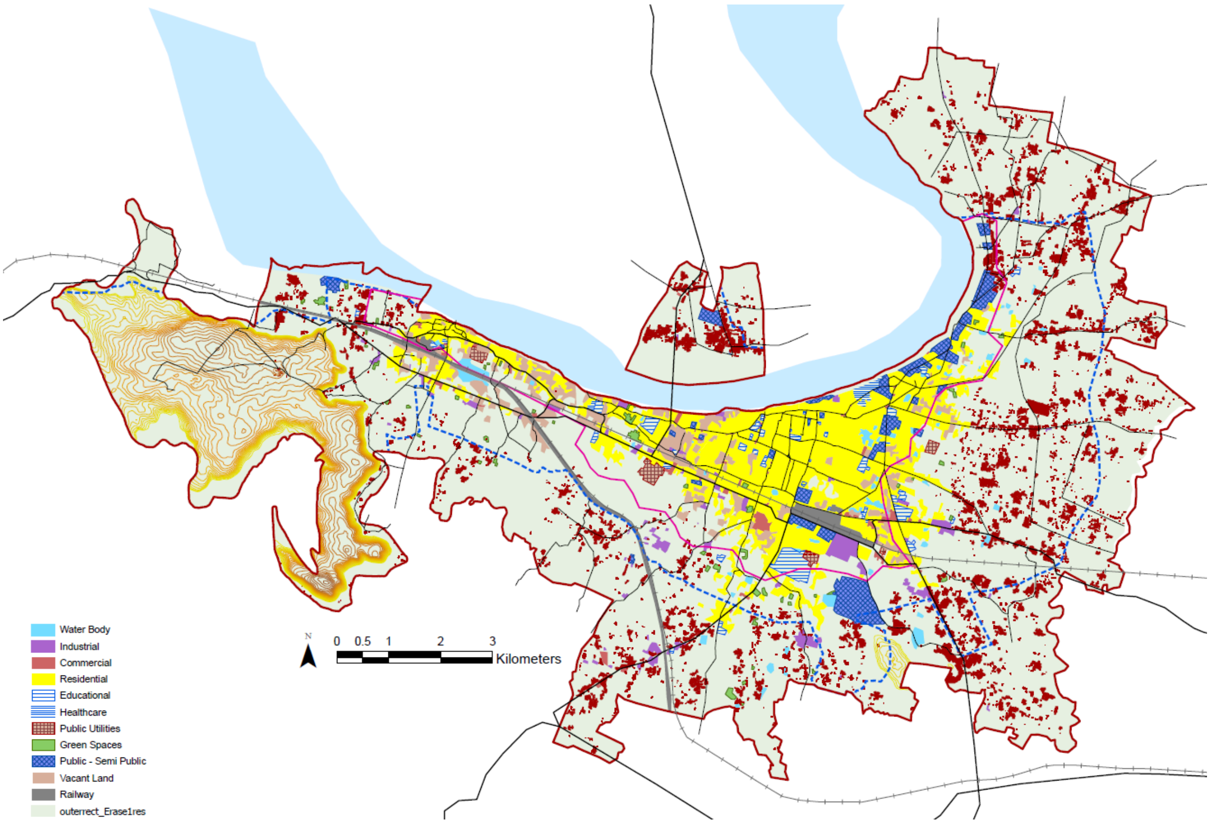

Figure 4: Land Use Map of Mirzapur - Vindhyachal Development Authority Area

Percentage Distribution of various land use -

- Residential - 12.48 %
- Commercial - 0.5 %
- Industrial - 1.06 %
- Public - Semi Public - 1.85 %
- Educational - 0.85 %
- Healthcare - 0.16 %
- Public Utilities - 0.29 %
- Vacant Land - 2.69 %
- Green Spaces - 0.34 %
- Waterbody - 0.84 %

- Railways - 1.24 %
- Rural Area - 49.83 %
- Agriculture - 27.82 %

3.3. Water Scenario

Population of MVDA
MVDA = Urbanisable Area + Revenue Villages

- Census 2001 - 2,97,838
    - Urbanisable Area - 2,15,450
    - Revenue Villages - 82,388
- Census 2011 - 3,53,547
    - Urbanisable Area - 2,46,920
    - Revenue Villages - 1,06,627

Projected Population for 2025

- Arithmetic Increase Method - 4,31,540
    - Urbanisable Area - 2,90,978
    - Revenue Villages - 1,40,562
- Geometric Increase Method - 4,51,308
    - Urbanisable Area - 2,98,754
    - Revenue Villages - 1,52,554
- Incremental Increase Method - 4,40,540
    - Urbanisable Area - 2,94,578
    - Revenue Villages - 1,45,962
- Exponential Growth Method - 4,41,500
    - Urbanisable Area - 2,94,818
    - Revenue Villages - 1,46,682

Population of 2025 MVDA (avg of all method) - 4,41,222

- Population of 2025 UA (avg of all method) - 2,94,782

- Population of 2025 RV (avg of all method) - 1,46,440

Total Water Consumption

- UA Population of 2025 x 135 LPCD - 39.7 MLD
- RV Population of 2025 x 55 LPCD - 8.05 MLD

3.3.1. Water Supply Zones

There are a total of 8 Water Supply Zones in the area, mostly covering Municipal Area Boundary.

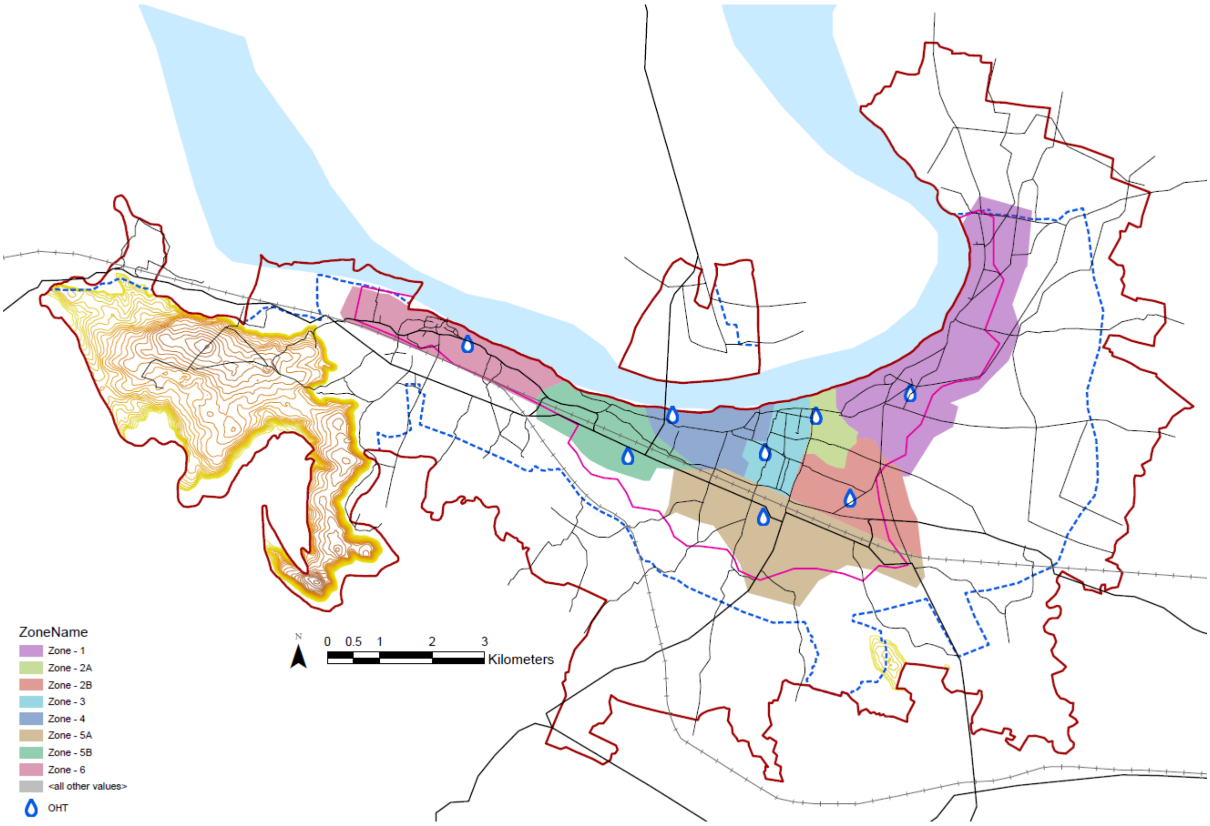

Figure 5: Water Supply Zone Map

3.4. Wastewater Scenario

Population of 2025 MVDA (avg of all method) - 4,41,222

- Population of 2025 UA (avg of all method) - 2,94,782
- Population of 2025 RV (avg of all method) - 1,46,440

Total Water Consumption

- UA Population of 2025 x 135 LPCD - 39.7 MLD

- RV Population of 2025 x 55 LPCD - 8.05 MLD

Total Wastewater Generated in UA

- 80% of Total Water Consumption - 31.76 MLD

Installed Capacity of STP - 38 MLD (14 + 8.5 + 8.5 + 7)

Operation Capacity of STP - 28 MLD (14 + 4 + 6 + 4)

Wastewater Treated - 88 %

Wastewater Reused - 0 %

As per the projected population for 2025, the MVDA is expected to house 4,41,222 people, with 2,94,782 in the Urban Area (UA) and 1,46,440 in the Revenue Villages (RV). Based on standard per capita water demand, the total water consumption in the UA is estimated at 39.7 MLD, while the RVs consume approximately 8.05 MLD. This results in a total urban wastewater generation of around 31.76 MLD, assuming 80% of the consumed water returns as wastewater.

Although the city has an installed sewage treatment capacity of 38 MLD, only 28 MLD is currently operational, leading to a treatment efficiency of 88%. Despite this relatively high treatment rate, there is currently no reuse of treated wastewater, indicating a significant gap in circular water resource management. This highlights the urgent need for integrating reuse strategies and optimizing the functioning of STPs to promote sustainability and reduce pressure on freshwater sources.

3.4.1. Wastewater Collection Zones

The study area is divided into six wastewater collection zones, primarily encompassing the municipal boundary. These zones are integrated into the city’s wastewater infrastructure and are connected to four Sewage Treatment Plants (STPs) and six pumping stations, facilitating the collection, conveyance, and partial treatment of the generated wastewater.

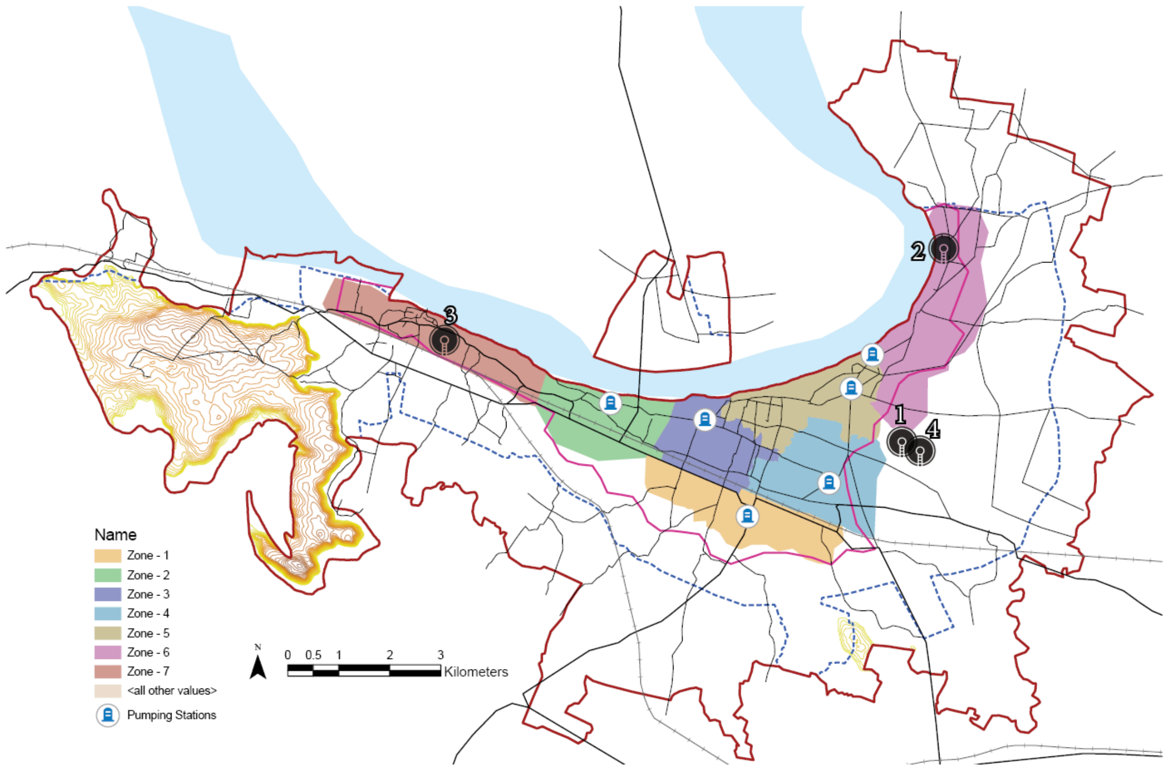

Figure 6: Wastewater Collection Zones

3.4.2. Wastewater Flow

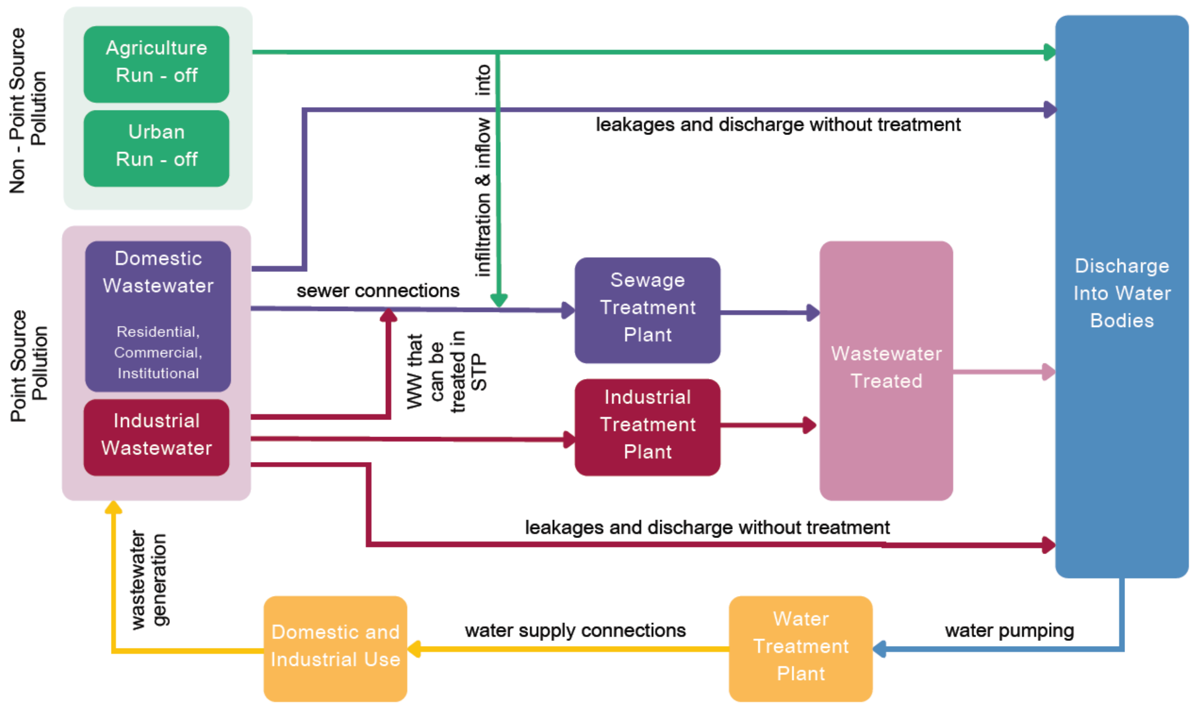

Figure 7: Wastewater Flow

The wastewater management cycle involves both point and nonpoint source pollution. Point sources include domestic (residential, commercial, institutional) and industrial wastewater, which, through sewer connections, are directed towards respective treatment facilities—Sewage Treatment Plants (STPs) and Industrial Treatment Plants (ITPs). A portion of this wastewater, especially from domestic sources, infiltrates the STP system. However, due to infrastructural deficiencies, leakages and untreated discharges from both sources often end up directly contaminating nearby water bodies.

On the other hand, non-point source pollution, such as urban and agricultural runoff, also contributes significantly to water contamination, often bypassing treatment altogether. The treated wastewater, although a potential resource, is typically discharged without reuse. This highlights a linear system where water, after being pumped, treated, and used for domestic and industrial purposes, is mostly wasted post-treatment without reintegration. The cycle indicates urgent needs for leak-proof infrastructure, effective runoff management, and integration of treated wastewater reuse to move towards a sustainable and circular urban water management model.

3.4.3. Stakeholder Involved and Their Roles

Wastewater management in Mirzapur involves multiple stakeholders performing distinct yet interconnected functions. Notably, although wastewater is treated, the treated effluent is discharged into the **Ganga River** via city drains, without any current reuse mechanism in place.

Process Stage	Stakeholders Involved	Roles & Responsibilities
Wastewater Generation	Private & Public	Generate wastewater from residential, commercial, institutional, and industrial activities.
Wastewater Collection	Nagar Palika Parishad Mirzapur Uttar Pradesh Jal Nigam (UPJN)	Lay sewer pipelines, establish sewage connections, and ensure operation and maintenance.
Wastewater Treatment	Mirzapur Ghazipur STP Pvt. Ltd. UPJN	MG STP Pvt. Ltd. handles construction and O&M of STPs; UPJN oversees the process.

Sludge Disposal	Uttar Pradesh Jal Nigam (UPJN)	Collects sludge from STPs and disposes of it by transporting via trucks to empty land.
Treated Water Discharge	-	Treated effluent is discharged into the Ganga through city drains.

Figure 8: Stakeholders and Their Roles in Wastewater Management.

3.5. Drains

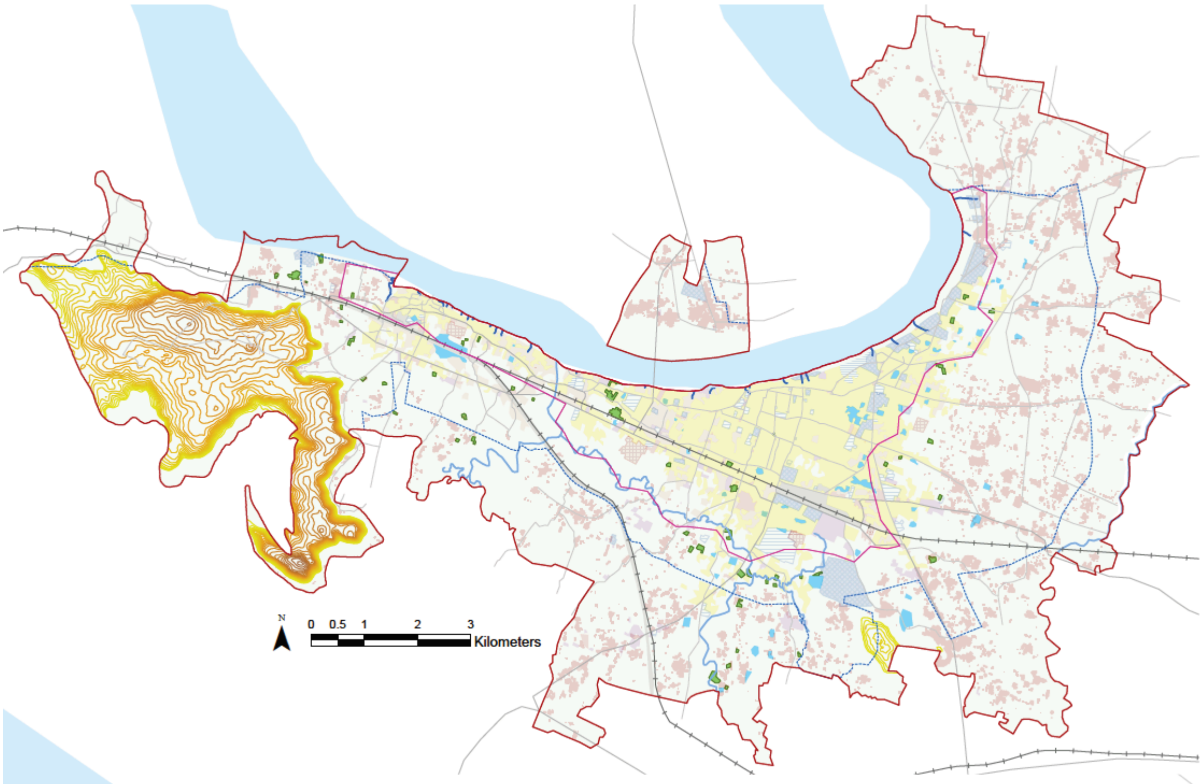

Figure 9: Location of drains

In Mirzapur, out of 27 identified drains, 12 (44.4%) remain untapped and discharge untreated wastewater into natural water bodies, including the Ganga. Many of these, like the Chorawa Drain (BOD 155 mg/l) and Ghoreshahid Drain (5 MLD, BOD 24.8 mg/l), exhibit high BOD levels, indicating severe organic pollution and public health risks. Even some tapped drains, such as Khandwa and Lift Canal, show BOD levels over 100 mg/l, highlighting issues with treatment efficiency or poor O&M.

Currently, 15 drains (55.6%) are connected to STPs, with Pakka Pokhra STPs handling 44.5% of the load, Bisunderpur STP 33.4%, and Vindhyachal STP 22.1%, reflecting dependence on a few centralized facilities.

Urgent action is needed to tap high-discharge untapped drains like Ghoreshahid and Balaji and integrate them into a city-wide sewage network with sufficient treatment capacity. Existing STPs should be assessed and upgraded as necessary, and real-time monitoring must be introduced to detect illegal discharges or malfunctions. In areas unsuitable for centralized treatment, decentralized systems should be promoted. This integrated approach is vital to reduce pollution, restore river health, and achieve urban sustainability in Mirzapur

S.No	Area	Drain Name	Drain Type	BOD (mg/l)	Discharge (MLD)
1	Vindhyachal	Shivpur Drain	Untapped	-	0.03
2	Vindhyachal	Malhaya Drain	Untapped	34	0.27
3	Vindhyachal	Balughat Pakka Drain	Tapped	-	0.17
4	Vindhyachal	Balughat Drain	Untapped	-	0.09
5	Vindhyachal	Balughat Kaccha Drain	Untapped	41.4	0.01
6	Vindhyachal	Gudara Drain	Tapped	-	0.2
7	Vindhyachal	Parasuram Drain	Tapped	55.7	1.39
8	Vindhyachal	Diwan Ghat New Drain	Untapped	-	0.02
9	Vindhyachal	Diwan Ghat Old Drain	Tapped	-	0.1
10	Vindhyachal	Patengra Drain	Untapped	19	0.74
11	Vindhyachal	Dargah Sharif Drain	Untapped	-	0.32
12	Mirzapur	Chorawa Drain	Untapped	155	0.25
13	Mirzapur	Basvariya Drain	Untapped	6	1.13
14	Mirzapur	Lift Canal Drain	Tapped	110	0.5
15	Mirzapur	Public Club Drain	Tapped	35.4	0.6
16	Mirzapur	District Judge Drain	Tapped	-	0.4
17	Mirzapur	Khandawa Drain	Tapped	100	4.5
18	Mirzapur	Balaji Drain	Untapped	38	2.2
19	Mirzapur	Narghat Drain	Tapped	-	0.78
20	Mirzapur	Badali Drain	Tapped	-	0.39
21	Mirzapur	Sundar Ghat Drain	Tapped	-	0.24
22	Mirzapur	Oliyar Drain	Tapped	-	0.31
23	Mirzapur	Kachahari Drain	Tapped	35.4	1.2
24	Mirzapur	Ghoreshahid Drain	Untapped	24.8	5
25	Mirzapur	Morchghar Drain	Tapped	24.6	1.64
26	Mirzapur	Hanuman Ghat Drain	Untapped	30.4	0.68
27	Mirzapur	Bisundarpur Drain	Tapped	20.4	1.58
Total Discharge in MLD					24.74

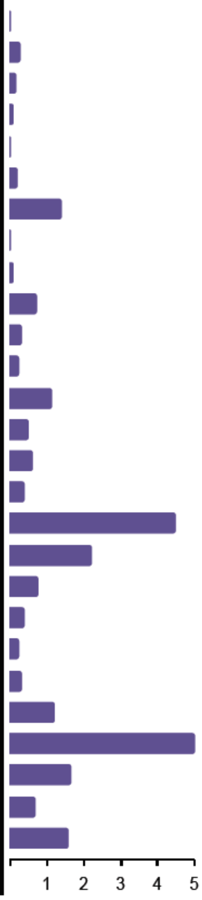

Figure 10: Drains discharging wastewater directly into Ganga

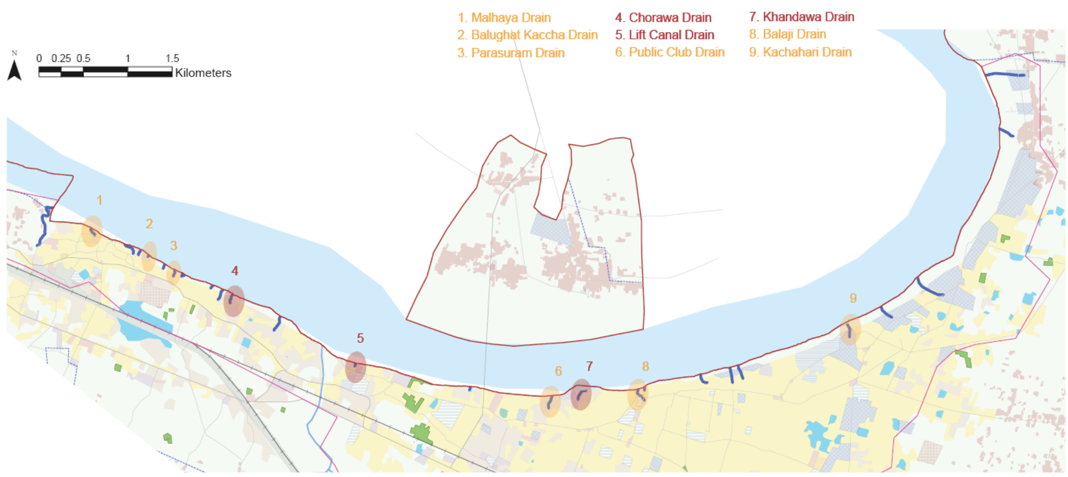

Figure 11: Hotspot Analysis of most polluted drains

In Vindhyachal and Mirzapur, several open drains directly carry untreated wastewater into the Ganga, significantly contributing to river pollution. Many of these drains have high BOD levels and remain untapped, while nearby households often dispose of waste illegally into them, worsening contamination. These open drains pose serious health and environmental risks, especially during monsoons when they overflow into residential areas. There is an urgent need to tap all open drains, expand sewer networks, install localized treatment units, and create awareness to prevent illegal dumping and protect the river.

Figure 12: Drains condition

3.6. Sewage Treatment Plant (STP)

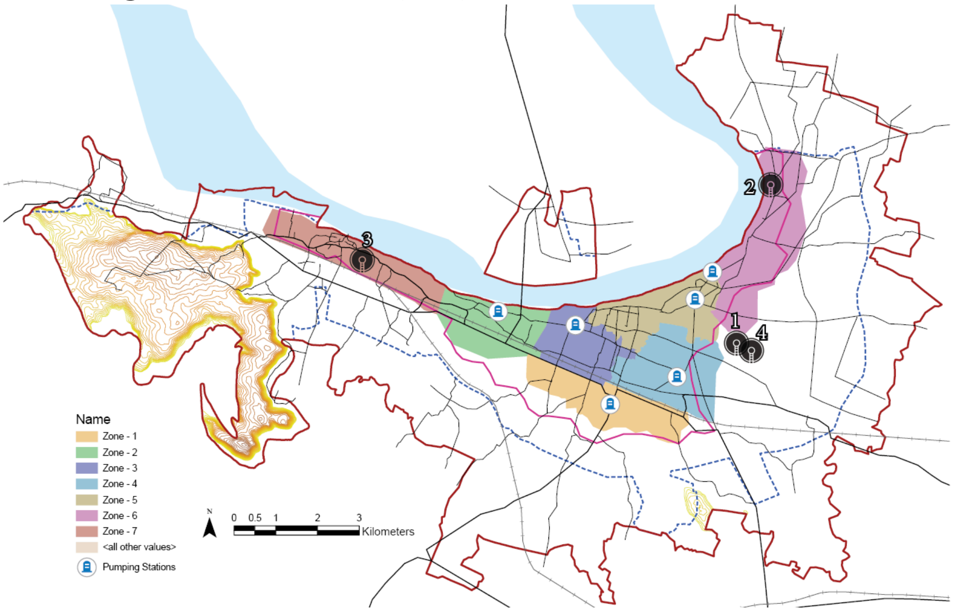

Figure 13: Location of STPs

3.6.1. STP - 1 : Pakka Pokhra

- **Location:** Pakka Pokhra
- **Year of Establishment:** 1992
- **Zones Covered:** Zone 1, 2, 3, 4 and 5
- **Installed Capacity:** 14 MLD
- **Operational Capacity:** 14 MLD
- **Treatment Technology:** UASB (Upflow Anaerobic Sludge Blanket)
- **Treated Water Reused:** 0 MLD
- **Sludge Generated:** 35 kg/MLD
- **Disposal of Sludge:** sent to Kanpur
- **Drainage Network Tapped:**
  - Badali Drain
  - Kachahari Drain
  - Khandawa Drain
  - Narghat Drain
  - Oliyar Drain
  - Sundar Ghat Drain

Treated Water Quality (Outlet Parameters)

Parameter	Value	CPCB 2017 Norm	Compliance
pH	7.89	6.5–8.5	✅ Yes
BOD	16.4 mg/l	≤10 mg/l	❌ No
COD	111.4 mg/l	≤50 mg/l	❌ No
TSS	30.7 mg/l	≤20 mg/l	❌ No

Figure 14: Water Quality Parameters

Issues

- Environmental Standards Compliance:
    - CPCB 1986 Guidelines: Compliant with all 4 parameters
    - CPCB 2017 Guidelines: Compliant with only 1 out of 4 parameters (only pH is within limits)
- Treated water is discharged into an open drain that merges with the Goreshahid Drain, ultimately flowing into the Ganga River.
- Household waste is frequently disposed of into this open channel after the treatment stage, leading to recontamination of the treated water.
- This nullifies the entire treatment effort, as the water re-enters the Ganga in a polluted state, defeating the purpose of investment in sewage treatment.


Figure 15: Outlet Water Chamber after Treatment and Open Outlet Drain from STP

3.6.2. STP - 2: Bisunderpur

- **Location:** Bisunderpur
- **Zones Covered:** Zone 6
- **Installed Capacity:** 8.5 MLD
- **Operational Capacity:** 4 MLD
- **Treatment Technology:** SBR (Sequencing Batch Reactor)
- **Treated Water Reused:** 0 MLD
- **Sludge Generated:** 55–60 kg/MLD
- **Disposal of Sludge:** sent to Kanpur
- **Drainage Network Tapped:**
    - Bisunderpur Drain
    - District Judge Drain
    - Irrigation Colony Drain
    - Lift Canal Drain
    - Morcha Ghar Drain
    - Public Club Drain

Treated Water Quality (Outlet Parameters)

Parameter	Value	CPCB 2017 Norm	Compliance
pH	7.57	6.5–8.5	✅ Yes
BOD	7.0 mg/l	≤10 mg/l	✅ Yes
COD	32.4 mg/l	≤50 mg/l	✅ Yes
TSS	8.1 mg/l	≤20 mg/l	✅ Yes

Figure 16: Water Quality Parameters

Issues

- Environmental Standards Compliance:
    - CPCB 2017 Guidelines: Fully compliant – all 4 discharge parameters are within acceptable limits.

- The STP is operating at less than 50% of its installed capacity (4 MLD vs. 8.5 MLD), indicating inefficiencies in either sewage collection or plant operations.
- Despite achieving excellent effluent quality, none of the treated water is reused.
- Treated water is released into open drains, where domestic and industrial wastewater is further added. This leads to recontamination before the water ultimately reaches the Ganga River, undermining the treatment efforts.

Figure 17: Inlet WW Chamber from Households and Transportation of Sludge

3.6.3. STP - 3: Vindhayachal

- **Location:** Vindhyachal
- **Zones Covered:** Zone 7
- **Installed Capacity:** 7 MLD
- **Operational Capacity:** 4 MLD
- **Treatment Technology:** SBR (Previously WSP – Waste Stabilization Pond)
- **Treated Water Reused:** 0 MLD
- **Sludge Generated:** 75–80 kg/MLD
- **Disposal of Sludge:** to Waste Stabilisation Pond
- **Drainage Network Tapped:**
    - Balughat Pakka Drain
    - Diwan Ghat Old Drain
    - Gudara Drain
    - Parasuram Drain

Treated Water Quality (Outlet Parameters)

Parameter	Value	CPCB 2017 Norm	Compliance
pH	7.39	6.5–8.5	✅ Yes
BOD	7.2 mg/l	≤10 mg/l	✅ Yes
COD	36.0 mg/l	≤50 mg/l	✅ Yes
TSS	8.9 mg/l	≤20 mg/l	✅ Yes

Figure 18: Water Quality Parameters

Issues

- Environmental Standards Compliance:
    - CPCB 2017 Guidelines: Fully compliant – all 4 discharge parameters are within acceptable limits.
- The plant operates at 4 MLD, despite being designed for 7 MLD, pointing towards inefficient sewage inflow, pipeline limitations, or maintenance gaps.
- Treated water is discharged into Diwan Ghat and Parasuram Drains, both of which receive untreated domestic (HH) wastewater, resulting in recontamination.
- The STP previously used WSP (Waste Stabilization Ponds)—a nature-based treatment technology appreciated globally for being cost-effective, low-energy, and sustainable.
- However, it has now been replaced with an energy-intensive SBR system, going against the global trend of promoting nature-based solutions (NBS) for urban wastewater management.
- Countries like Singapore, Germany, and many Indian smart cities are incorporating constructed wetlands, bioremediation, and pond-based systems to integrate water reuse with green infrastructure.

Figure 19: Waste Stabilisation Pond for WW Treatment and Transportation of Sludge

3.6.4. STP - 4: Pakka Pokhra

- **Location:** Pakka Pokhra
- **Zones Covered:** Zone 1, 2, 3, 4 and 5
- **Installed Capacity:** 8.5 MLD
- **Operational Capacity:** 6 MLD
- **Treatment Technology:** Sequential Batch Reactor (SBR)
- **Treated Water Reused:** 0 MLD
- **Sludge Generated:** 41.6 kg/MLD
- **Disposal of Sludge:** sent to Kanpur
- **Drainage Network Tapped:**
    - Barahmilliah Drain
    - Konia Drain

Treated Water Quality (Outlet Parameters)

Parameter	Value	CPCB 2017 Norm	Compliance
pH	8.13	6.5–8.5	✅ Yes
BOD	6.0 mg/l	≤10 mg/l	✅ Yes
COD	29.7 mg/l	≤50 mg/l	✅ Yes
TSS	11 mg/l	≤20 mg/l	✅ Yes

Figure 20: Water Quality Parameters

Issues

- Environmental Standards Compliance:
  - CPCB 2017 Guidelines: Fully compliant – all 4 discharge parameters are within acceptable limits.
- Despite being designed for 8.5 MLD, the plant operates at only 6 MLD, reflecting a 30% underutilization. This could stem from inadequate sewage conveyance, blockages, or poor demand estimation.
- The generated sludge is openly dumped, exposing nearby residents and environments to health hazards, odour, and potential soil and water contamination.

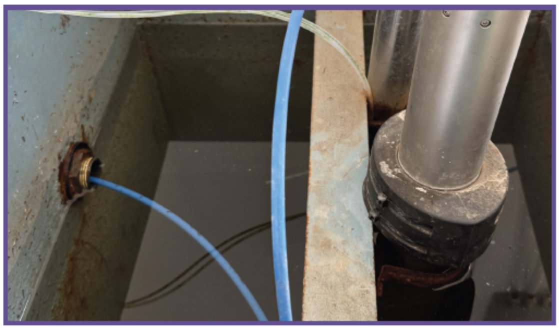

Figure 21: Outlet Water Chamber after Treatment and Treated WW Flowing Back to Ganga

3.7. Industrial Profile

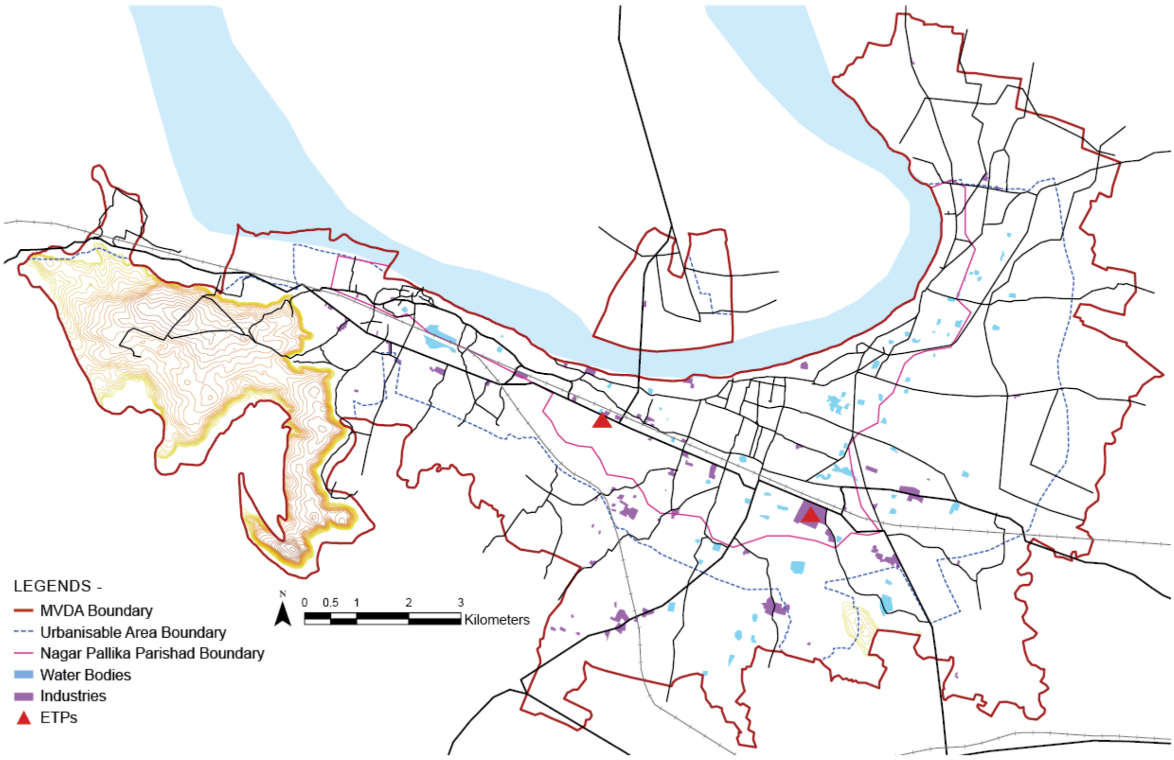

Figure 22: Location of Industries

3.7.1. Types Of Industries

The industrial composition of the site is predominantly led by the carpet industry, which accounts for 60% of the total industrial base. This is followed by the brassware industry, contributing 30%, while the remaining 10% is composed of other industries such as steel, cement, agro-based, and food processing industries.

3.7.2. Classification Based on Pollution Level

CATEGORY	DESCRIPTION	POLLUTION LEVEL
Red	Highly Polluting	Pollution Index ≥ 80
Orange	Moderately Polluting	55 ≤ Pollution Index < 80
Green	Low Polluting	25 ≤ Pollution Index < 55
White	Non Polluting	Pollution Index < 25

Figure 23: Industries Classification

Industries are classified into four categories—Red, Orange, Green, and White—based on their Pollution Index (PI), which is a measure of the environmental load an industry places on air, water, and land. The White category includes non-polluting industries with a PI of less than 25, Green industries are low polluting with a PI between 25 and 55, Orange industries are moderately polluting with a PI between 55 and 80, and Red industries are highly polluting with a PI of 80 or above. This classification system helps in regulating industrial activities by prioritizing environmental clearance and monitoring according to the pollution potential of each sector.

In the context of local industries, handloom and carpet weaving (without dyeing and bleaching) is classified under the White category, indicating it is non-polluting and environmentally sustainable. On the other hand, the manufacture of brassware utensils falls under the Green category, considered low polluting. Meanwhile, jute processing involving dyeing operations is categorized as an Orange industry, reflecting its moderate pollution potential due to chemical usage in dyeing processes. This classification highlights the need for targeted environmental management, promoting eco-friendly practices in traditional sectors while implementing stricter controls where moderate pollution is involved.

3.7.3. Effluent Treatment Plants

Neeman Carpets, Pathriya, Mirzapur

The Effluent Treatment Plant (ETP) at Neeman Carpets has an installed capacity of 15 KLD, out of which only 11 KLD is currently operational, reflecting underutilization of the system. Despite achieving basic treatment goals, only 1 KLD of treated water is reused, primarily for flushing, gardening, and car washing, which indicates a limited focus on resource recovery. The major share of treated water is still being disposed of into drains that ultimately connect to the Ganga, posing a potential threat of recontamination during transit. The sludge generated is around 200 grams per liter, which is responsibly transported to Kanpur for disposal, highlighting a relatively structured sludge management mechanism.

As per the outlet water quality parameters, the pH is 8.23, BOD is 11.8 mg/l, COD is 60.5 mg/l, and TSS is 8.5 mg/l. These figures suggest a moderate level of treatment, with BOD and COD values falling within permissible limits for non-potable reuse but potentially requiring further polishing if discharged near ecologically sensitive zones like the Ganga. While the ETP demonstrates partial success in wastewater treatment and reuse, it still lacks a robust reuse strategy and secure discharge mechanism. Scaling up reuse and preventing recontamination through closed-loop systems or dedicated reuse infrastructure could significantly enhance its environmental impact.

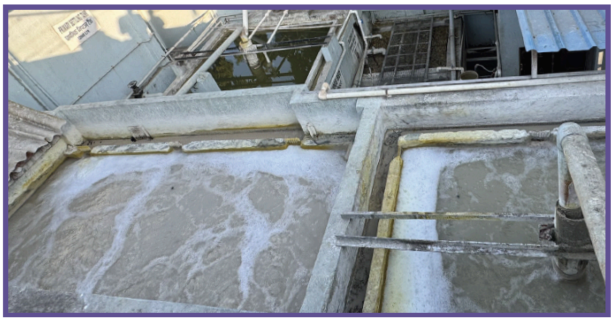

Figure 24: ETP at Neeman Carpets, Mirzapur

Jaipur Rugs, Rajapur, Mirzapur

The Effluent Treatment Plant at Jaipur Rugs in Rajapur has an installed capacity of 400 KLD, with an operational capacity of 350 KLD, indicating efficient utilization of the system. The plant follows a three-step treatment process designed to ensure effective wastewater management and enable water reuse, particularly for irrigation purposes.

1. Primary Treatment involves the use of lime and alum, which help in removing suspended solids and neutralizing the acidity of the wastewater.
2. In the Secondary Treatment, biological processes come into play, where bacteria decompose organic matter, and the water is further purified through sand and carbon filters to eliminate residual impurities.
3. The Tertiary Treatment stage refines the water quality to a level suitable for agricultural irrigation, after which the treated water is discharged into nearby fields for reuse, promoting sustainable water management practices in the region.

3.7.4. Issues

The carpet and dyeing industries in Mirzapur, including major players like Obeetee Carpets, Neeman Carpets, and Jaipur Rugs, are heavily dependent on groundwater drawn through borewells, leading to unregulated extraction and stress on local water resources. On average, 30 buckets (approximately 450–500 liters) of water are used per square yard during the rug washing process, which significantly contributes to water consumption. Despite being mandated to operate their own Effluent Treatment Plants (ETPs)—a rule these companies comply with—there remains a growing concern over the inefficient reuse of treated water and continued dependence on fresh groundwater, especially in a region already experiencing water scarcity.

While dyeing industries are officially classified under the "Orange" pollution category, indicating moderate pollution levels, their actual water discharge quality often reflects characteristics of the "Red" category, due to the presence of high chemical loads and untreated effluents in some instances. Notably, Obeetee Carpets pioneered industry-led wastewater management by establishing the first ETP in 1984, setting an important precedent. However, broader challenges persist, such as inadequate enforcement of reuse practices, lack of advanced treatment upgrades, and insufficient groundwater regulation. This points to a critical need for integrated water management policies, promotion of closed-loop recycling systems, and stricter monitoring to ensure environmental sustainability and long-term water security in the region.

3.8. Upstream - Downstream Water Quality

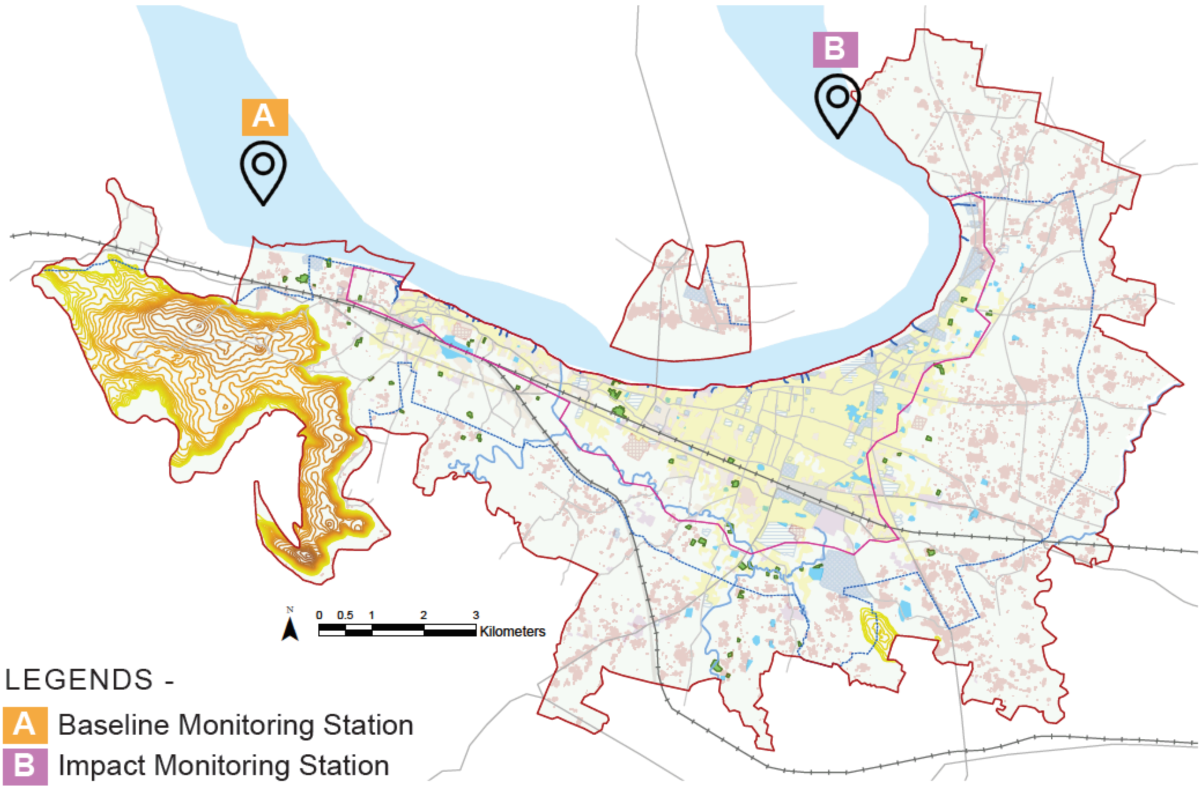

Figure 25: Location of Monitoring Stations

3.8.1. Dissolved Oxygen (D.O.) Level

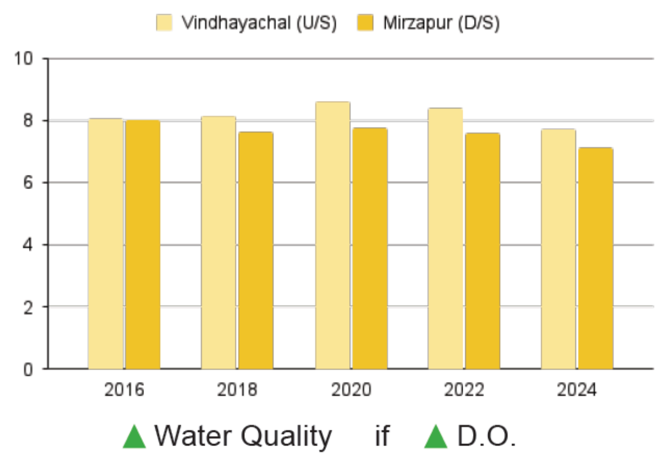

Figure 26: Dissolved Oxygen Level

The Dissolved Oxygen (DO) levels in the Ganga River at both upstream (U/S) and downstream (D/S) locations in Mirzapur have shown a gradual decline from 2016 to 2024, signaling a worsening water quality trend. DO is a critical parameter for assessing the health of a water body, as it directly influences the survival of aquatic organisms. A decline in DO levels typically points to an increase in organic pollution and reduced self-purification capacity of the river.

In particular, the sharp decrease in DO values at the downstream site of Mirzapur reflects the growing organic load and discharge of untreated or partially treated wastewater into the river. This is likely due to inputs from domestic sources, industrial effluents, and recontaminated treated water from open drains. Lower DO concentrations negatively impact aquatic biodiversity, leading to fish kills, reduced ecosystem resilience, and impaired riverine health. The data emphasizes the urgent need for better wastewater treatment, strict discharge regulations, and restoration efforts to improve the river's ecological balance and ensure long-term sustainability.

3.8.2. Biochemical Oxygen Demand (B.O.D.) Level

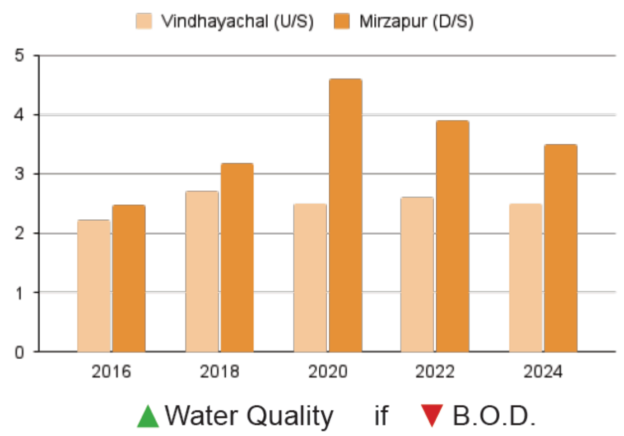

Figure 27: Biochemical Oxygen Demand Level

The Biochemical Oxygen Demand (BOD) levels at the downstream (D/S) location in Mirzapur peaked in 2020, indicating a period of high organic pollution and poor water quality in the Ganga River. However, with the commissioning of a new Sewage Treatment Plant (STP) shortly after, there has been a gradual decline in BOD levels from 2020 to 2024. This decline reflects a positive impact of improved wastewater treatment infrastructure, suggesting that the STP has played a role in reducing the organic load entering the river.

Despite this improvement, the BOD values still remain relatively high, especially downstream, which points to persistent pollution challenges such as incomplete treatment, illegal discharges, and recontamination from open drains. High BOD levels consume more dissolved oxygen (DO) from the water, which further degrades the aquatic ecosystem and river health. The trend indicates that while the new STP has made a difference, there is a need for stricter enforcement, better maintenance of sewer systems, and efforts to prevent untreated waste from mixing with treated effluents to achieve sustainable water quality improvements.

3.8.3. Faecal Coliform (F.C.) Level

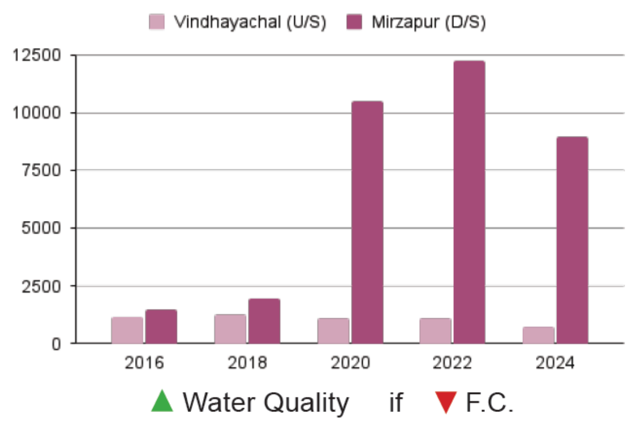

Figure 28: Faecal Coliform Level

The Fecal Coliform (FC) levels, a key indicator of sewage contamination, have been observed to be alarmingly high in the downstream (D/S) sections of the Ganga River in Mirzapur. This rise in FC levels signifies a serious deterioration in water quality, driven largely by the discharge of untreated or partially treated wastewater. While the upstream (U/S) areas have remained relatively stable, the surge in pollution load downstream points to localized contamination, especially from urban drains and household discharges that bypass treatment systems.

Although the commissioning of new Sewage Treatment Plants (STPs) has helped reduce overall pollution, the lack of complete drain coverage and open discharge points continues to compromise the gains made in wastewater management. Elevated FC levels not only signal poor sanitation practices but also pose direct health risks, contributing to the spread of waterborne diseases such as diarrhea, cholera, and dysentery. A sustainable improvement in river health demands not only infrastructural upgrades but also behavioral changes, strict enforcement of discharge norms, and full utilization and maintenance of existing STPs to ensure a long-term decrease in FC levels and a significant boost in overall water quality.

3.8.4. Total Coliform (T.C.) Level

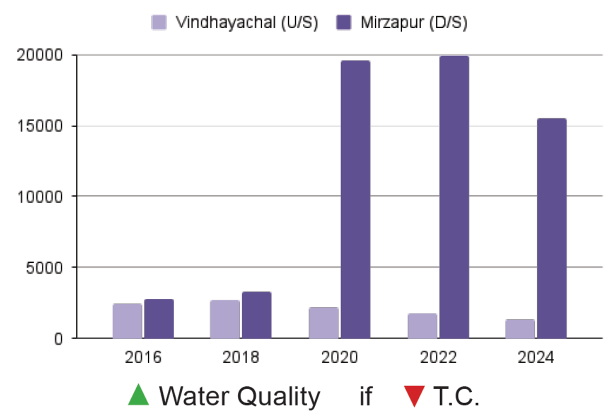

Figure 29: Total Coliform Level

The Total Coliform (TC) levels in the Ganga River around Mirzapur have shown a sharp rise between 2016 and 2022, reflecting a significant deterioration in water quality due to untreated sewage discharge and inadequate sanitation infrastructure. Although there was a slight decline in TC levels in 2024, the values still remain critically high, far exceeding the safe limits for domestic or recreational water use. This indicates that despite recent efforts such as the construction of new STPs, the impact on microbiological contamination has been limited.

However, a positive trend was observed in Vindhyachal, where TC levels declined, suggesting better upstream wastewater management or reduced contamination sources in that region. Nevertheless, persistently high TC levels downstream signal the continued presence of untreated sewage inflows, posing serious public health risks and threatening aquatic ecosystems. These findings highlight the urgent need for a holistic wastewater management strategy, including the tapping of all drains, behavioral change campaigns, regular water quality monitoring, and most importantly, reuse of treated water to prevent recontamination of cleaned water bodies.

3.8.5. Water Quality Assessment at Monitoring Stations (2024)

	PH	DO (mg/l)	BOD (mg/l)	FC (MPN/100ml)
Vindhayachal (U/S)	8.07	7.7	2.5	735
Mirzapur (D/S)	7.75	7.1	3.5	8945
Permissible Limit	6.5 - 8.5	> 5	<3	500-2500

Figure 30: Water Quality Parameters 2024

- Upstream (Vindhyachal) water quality is within permissible limits for all measured parameters.

- Downstream (Mirzapur) shows significant degradation in water quality, especially due to high BOD and FC levels, pointing to:
  - Untreated or partially treated sewage discharge
  - Lack of sanitation infrastructure in nearby settlements
  - Impact of human activities and insufficient wastewater treatment

3.8.6. Issues

- **Discharge of Untreated Wastewater from Drains into the Ganga River -**
  Numerous open drains directly discharge untreated domestic and industrial wastewater into the Ganga River. This occurs **despite the presence of multiple Sewage Treatment Plants (STPs)** in the region, indicating either **underutilization or inefficiency** of existing infrastructure. These untreated discharges significantly elevate the **organic and microbial pollution loads** in the river, especially downstream, leading to **environmental degradation and threats to aquatic ecosystems**.
- **Lack of Sewerage Connections Among Riverbank Households-**
  A substantial number of **households located along the riverbanks** lack proper sewerage infrastructure and connections to the municipal sewer system. Consequently, **wastewater from these households is disposed of directly into the river** without undergoing any form of treatment. This not only contributes to increased **faecal contamination** and **pathogen load**, but also poses **serious public health risks** for communities that rely on the river for domestic or agricultural purposes.
- **Downstream WQ Falls Below Class B Standards – Relegated to Class C -**
  Water quality analysis at **Mirzapur (D/S)** reveals **Biochemical Oxygen Demand (BOD) and Faecal Coliform (FC)** levels that exceed the permissible limits defined for **CPCB Class B water quality standards (outdoor bathing)**. As a result, the downstream water **does not qualify for Class B** and is more accurately categorized under **Class C**, which is intended for **drinking water sources with conventional treatment**. This shift in classification indicates that the **river water has become unsuitable for direct contact or recreational use**, reflecting **serious pollution levels** and degradation of water quality.

4. Proposal, Strategies and Recommendations

4.1. Treated Wastewater Reuse Action Plan

4.1.1. Procedure To Identify Potential Bulk Users

- Identify potential avenues for wastewater reuse.
- Calculate the water demand of each identified avenue.
- Determine the accessibility and location of potential bulk users.
- Assess the frequency of water requirements for each user.
- Define the required water quality standards based on usage.
- Identify suitable modes of wastewater conveyance.
- Establish safety protocols and appropriate methods for using treated wastewater.

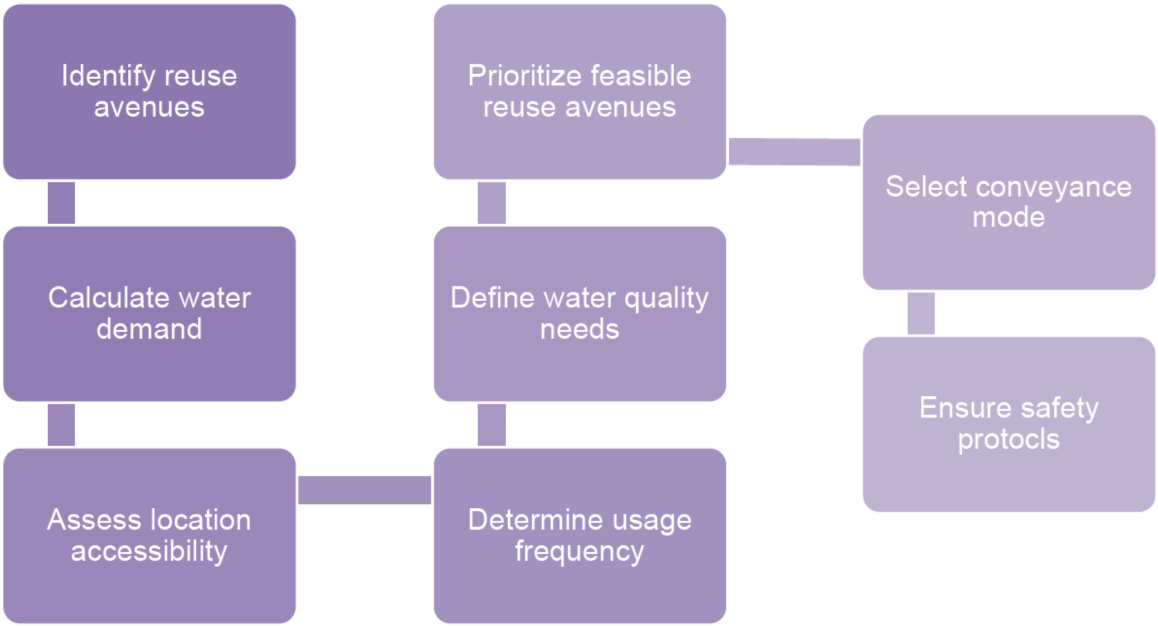

Figure 31: Procedure To Identify Potential Bulk Users

4.1.2. Potential Reuse Avenues For Treated Wastewater

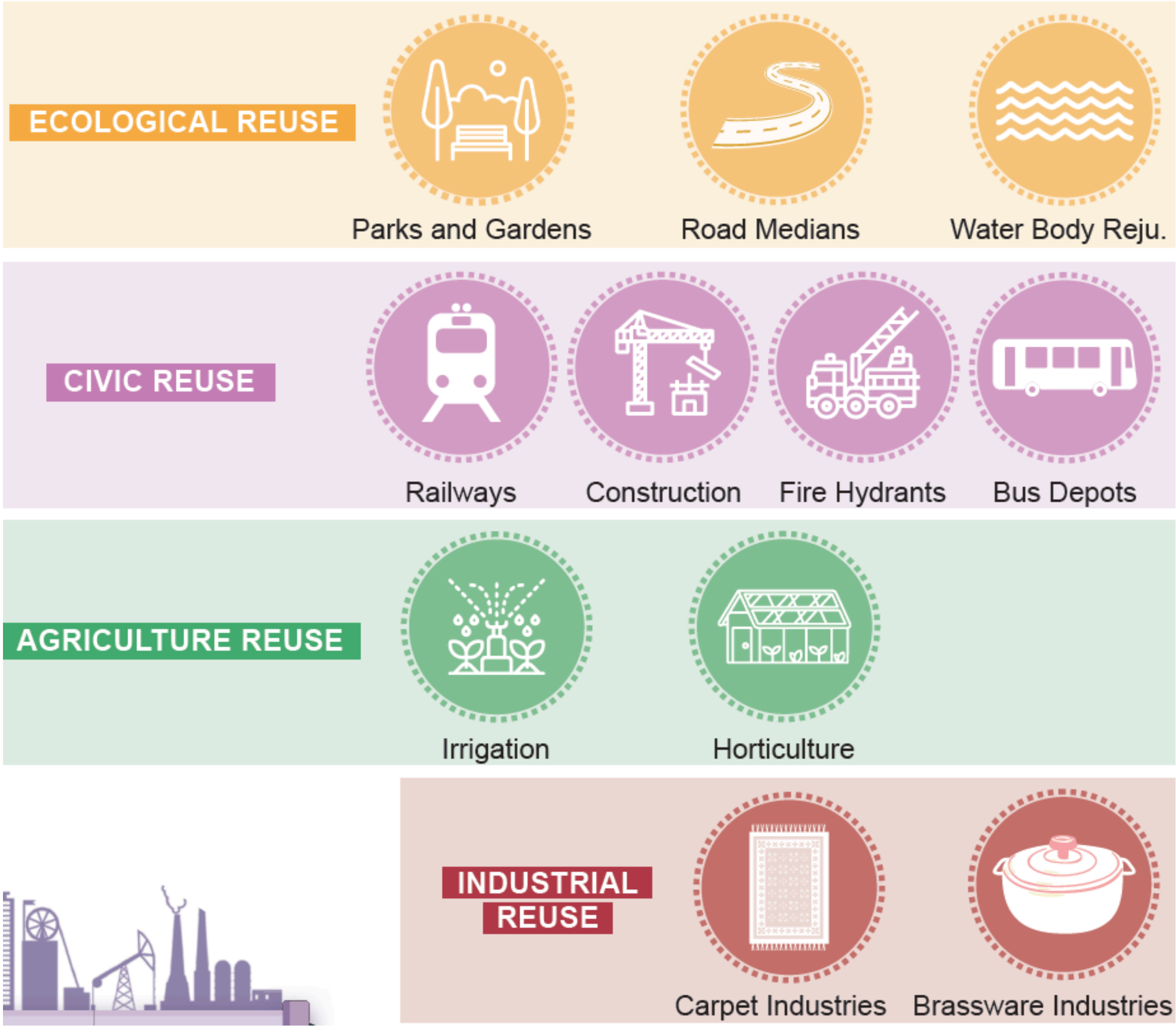

Figure 32: Possible reuse avenues

4.1.3. Identified Bulk Users in Accessible Radius of STP 1 And 4 - Pakka Pokhra

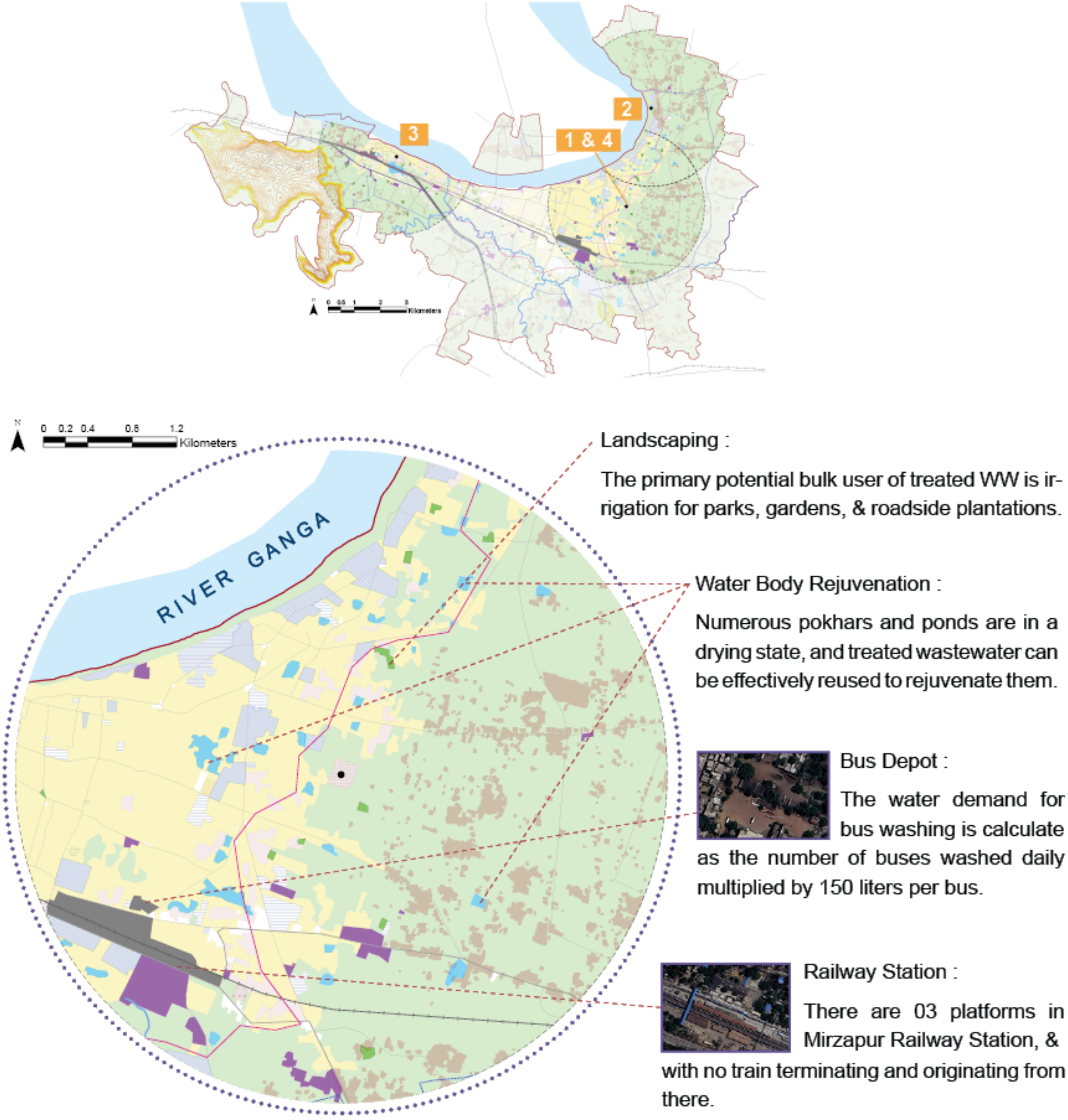

Figure 33: Identified Bulk Users in Accessible Radius of STP 1 And 4 - Pakka Pokhra

Landscaping

WD = total area (in sq m) * water required / sq m (2.5 L / sq m)

- Total Area = 61,265 sq m
- Water Demand = 153162.5 L or 0.15 ML

Railways

WD = water required to wash platform (5 liters / sqm)

- Total Area = 22,378.79 sq m
- Water Demand = 111894 L or 0.11 ML

4.1.4. Identified Bulk Users in Accessible Radius of STP 2 - Bisunderpur

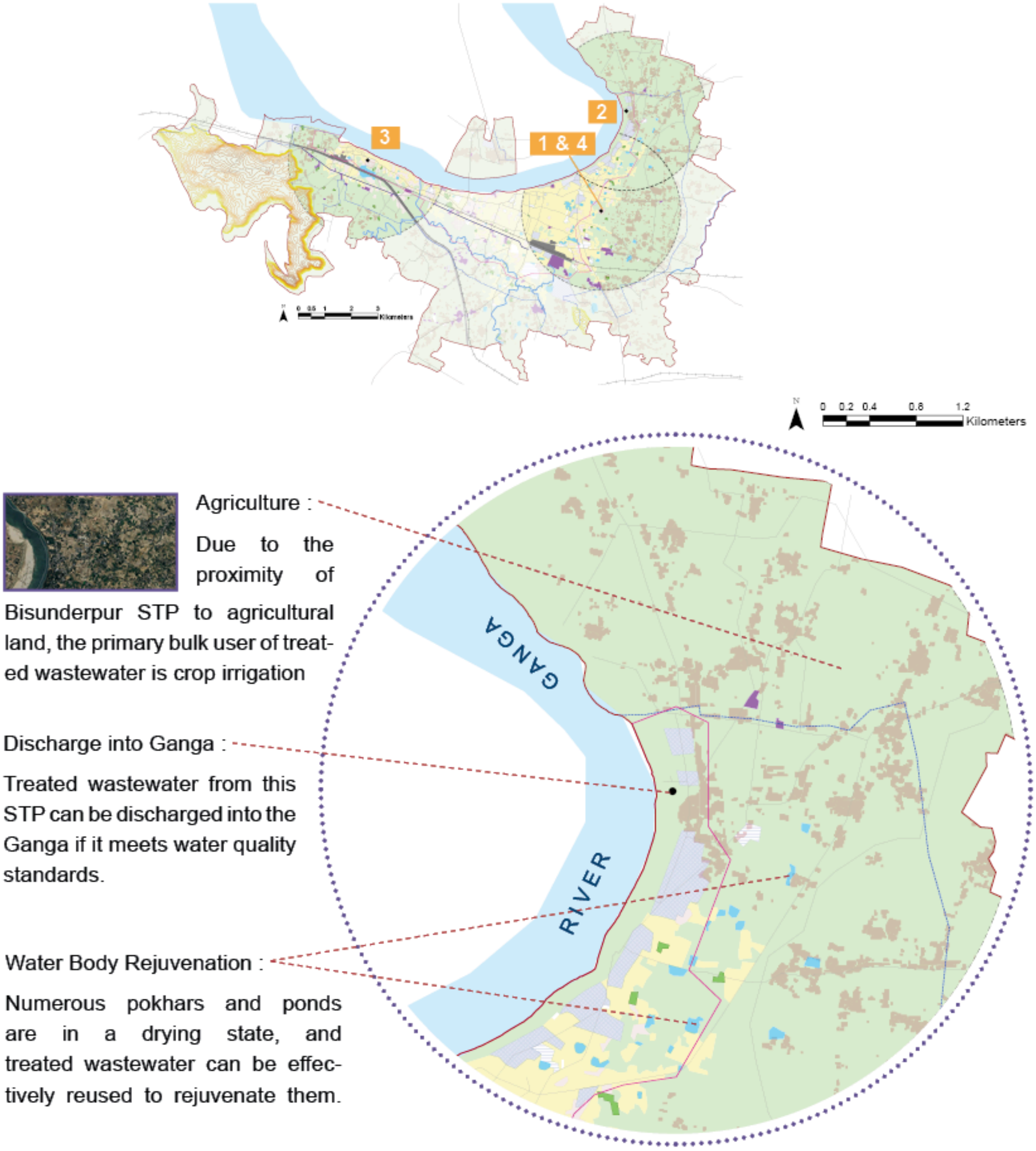

Figure 34: Identified Bulk Users in Accessible Radius of STP 2 - Bisunderpur

Water Body

WD = calculate the volume of water body

4.1.5. Identified Bulk Users in Accessible Radius of STP 3 - Vindhyachal

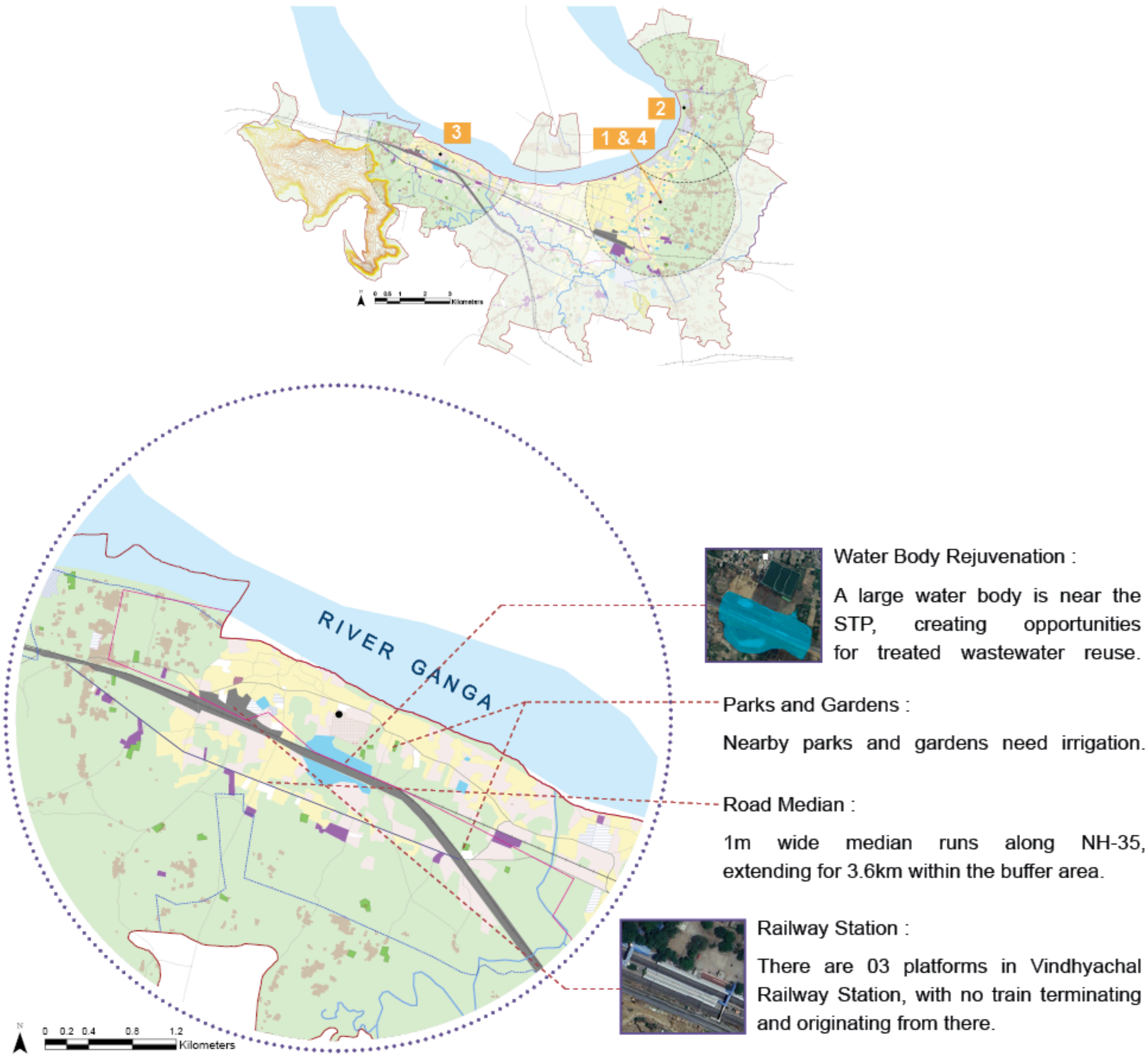

Figure 35: Identified Bulk Users in Accessible Radius of STP 3 - Vindhyachal

Landscaping

WD = total area (in sq m) * water required / sq m (2.5 L / sq m)

- Total Area = 87,960 sq m
  - Parks and Gardens = 84,294 sq m
  - Road Median (1 m thick) = 3,666 sq m
- Water Demand = 153162.5 L or 0.15 ML

Railways

WD = water required to wash platform (5 liters / sqm)

- Total Area = 12,663.84 sq m
- Water Demand = 63319 L or 0.06 ML

4.1.6. Recommendations & Strategies For Potential Reuse Avenues For Treated Wastewater

Construction

Strategies

- ULBs should make it mandatory for large construction projects to use treated wastewater, reducing dependence on freshwater sources.
- During project approvals, water demand should be assessed and a specific quantity of treated wastewater should be enforced for reuse.
- Treated wastewater should be supplied to construction sites via tankers at a minimal or subsidized cost to make it economically viable.
- Treated wastewater can be safely used for concrete mixing, curing, dust suppression, soil compaction, and road construction, as long as it meets BIS standards.
- To promote adoption, ULBs can offer incentives like reduced fees, tax rebates, or fast-track approvals for projects that use treated wastewater.

Indian Case Example

- **Delhi Metro Rail Corporation (DMRC):** Used treated wastewater for concrete mixing and curing, significantly reducing potable water consumption in metro construction.
- **Pune Municipal Corporation:** Enforced mandatory use of treated wastewater for construction activities, supplying water through tankers at a subsidized rate.

Safety Protocols

- **Water Quality Compliance:** Ensure wastewater meets BIS/CPHEEO standards for non-potable use.

- **Storage & Handling:** Store wastewater in designated tanks to prevent contamination and odors.
- **Prevent Cross-Contamination:** Use separate pipelines and equipment for freshwater and treated wastewater.
- **Regular Monitoring:** Conduct periodic quality checks to maintain safe usage standards.

Agriculture

Strategies

- Promote treated wastewater reuse under Pradhan Mantri Krishi Sinchayi Yojana.
- Farmers can be charged ₹5 per 1,000L of treated WW to ensure affordability while covering OC.
- Early adopters of wastewater reuse can receive financial incentives or reduced water tariffs.
- The Ojhala Nadi can be used as a natural irrigation canal for transporting treated wastewater to agricultural fields.
- Encourage WW irrigation for non-edible crops, fodder, and floriculture to minimize health risks.
- Collaborate with private entities to develop WW irrigation projects.

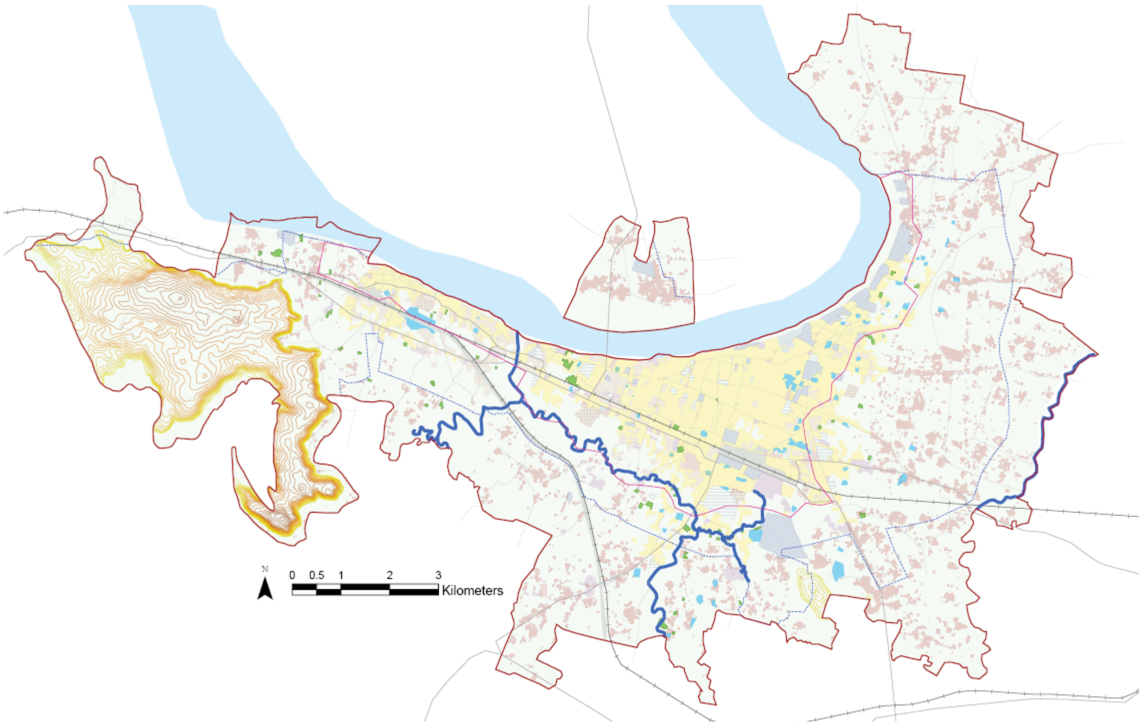

Figure 36: Location of Ojhala Nadi

Safety Protocols

Subsurface drip irrigation is ideal for using treated wastewater because it applies water directly to the root zone beneath the soil, avoiding contact with leaves, fruits, or humans. This minimizes health risks, prevents odor and pathogen exposure, reduces evaporation losses, and ensures efficient, safe irrigation—especially for parks, gardens, and non-edible crops.

Industries

Strategies

- Industries should be restricted from extracting groundwater.
- On-Site reuse of ETP-treated wastewater for dyeing, cooling, and cleaning instead of discharge.
- Additional water needs should be met from nearby STPs.
- Strict monitoring & enforcement for compliance.
- Industries adopting wastewater reuse should receive benefits like tax rebates or lower industrial water tariffs.

Indian Case Example

- **Tiruppur, Tamil Nadu:**
    - The textile industry **reuses treated wastewater** for dyeing and finishing, reducing dependence on fresh water.
    - **Common Effluent Treatment Plants (CETPs)** are installed for collective wastewater treatment.
- **Nagpur, Maharashtra:**
    - Industries purchase **treated wastewater from Bhandewadi STP**, reducing groundwater extraction.
    - **PPP models** ensure financial sustainability and efficient wastewater reuse.

Safety Protocols

- **Water Quality Compliance:** Ensure treated wastewater meets required BIS and CPCB standards for industrial applications.
- **Regular Monitoring:** Conduct routine testing of treated wastewater for heavy metals, toxins, and pathogens.

- **Proper Disposal of Sludge:** Sludge generated during treatment should be safely managed to prevent environmental hazards.
- **Efficient Storage & Distribution:** Treated wastewater should be stored in leak-proof tanks and transported through a regulated supply system.

Fire Hydrant

Water Demand

Q = 100 √P, where Q is water required in cubic meters & P is population in thousands

- Population = 2,94,782
- Water Demand = 29,47,820 L or 2.95 ML

Strategies

- Treated WW can be safely reused for non-potable firefighting purposes, for refilling fire tenders.
- Since the fire station is near the Pakka Pokhra STP, treated wastewater can be easily supplied via tanker trucks or piped network.

Landscaping (parks, gardens and road medians)

Water Demand (for areas outside buffer area of any STP)

WD = total area (in sq m) * water required / sq m (2.5 L / sq m)

- Total Area = 2,30,205 m
  - Parks and Gardens = 2,26,550 sq m
  - Road Median (1 m thick) = 3,655 sq m
- Water Demand = 5,75,512 L or 0.57 ML

Frequency

Landscaping should be watered daily using treated WW.

Mode of Conveyance

Water tanker trucks should be used for watering it.

Strategies

- **Sprinkler Systems**: Encourage mechanized watering (sprinklers, drip irrigation) to reduce human contact and water wastage.
- **Early Morning Watering**: Schedule irrigation during early hours to minimize public exposure and maximize efficiency.
- **Community Participation**: Involve RWAs and park committees in monitoring and managing wastewater reuse.

Safety Protocols

- Avoid direct human contact during reuse.
- Use mechanized irrigation methods like sprinklers, or drip irrigation.
- Schedule reuse during early morning or late evening to minimize public exposure.

Railways

Frequency and Mode of Conveyance

Treated WW should be supplied daily via water tankers.

Safety Protocols

- Implement a color-coded or labeled pipeline system to prevent cross - contamination with potable water supplies.
- Conduct it during non-peak hours to reduce public exposure.

Water Body Rejuvenation

Mode of Conveyance

- Transported primarily through pipelines or dedicated canals.

Safety Protocols

- Ensure treated WW meets environmental standards before discharge.
- Allow treated wastewater to percolate into aquifers through recharge groundwater.

Strategies

- Allow treated WW to flow into degraded water bodies to support ecological rejuvenation, & maintain base flow.

Indian Case Example

- **Nagpur, Maharashtra:**
  - ULB uses treated wastewater to recharge lakes and for industrial reuse, reducing stress on freshwater sources while improving urban water bodies.

4.2. Desired Wastewater Flows

This diagram illustrates a circular approach to wastewater management, connecting wastewater generation, treatment, reuse, and resource recovery. Domestic and industrial wastewater from point sources is sent through sewer connections to Sewage Treatment Plants (STPs) or Industrial Treatment Plants (ETPs). Non-point source pollution like urban and agricultural runoff also enters the system. After treatment, the water is either reused or safely discharged.

Treated wastewater is reused in various sectors such as landscaping, construction, bus depots, and railways. Excess treated water helps rejuvenate water bodies, which can later be pumped, treated again, and supplied for domestic use—closing the water loop.

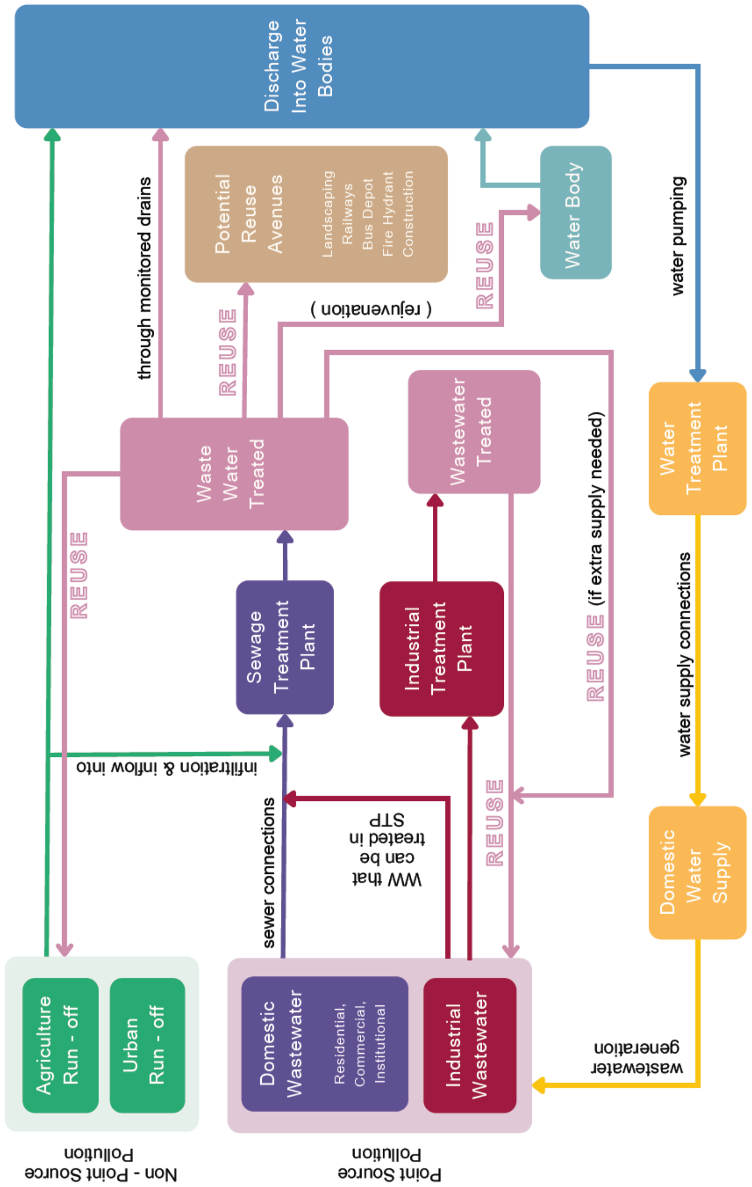

Figure 37: Desired Wastewater Flows

4.3. Sewage Treatment Plant

4.3.1. Infrastructure Upgradation

- **Mandate Full-Capacity Operation:** Introduce a local/state-level regulation that requires all operational STPs to function at ≥ 85% capacity utilization based on actual wastewater inflow data.

- **Penalty for Underperformance**: Impose penalties or notices for consistent underutilization (e.g., <60% usage for more than 6 months) without technical justification.

4.3.2. Aligning Pakka Pokhra With Cpcb 2017

- **Mandatory Upgrade to CPCB 2017 Norms:** Enforce statutory compliance requiring the STP to align with CPCB 2017 discharge standards, replacing the outdated 1986 norms.

4.3.3. Stopping Re - Pollution

- The open outlet drain should be converted into a covered or piped system to avoid illegal discharges by households.
- Enforcement measures and penalties should be introduced for unauthorized waste disposal.

4.4. Circular Economy

4.4.1. Sludge to Biofertilizer (Agricultural Use)

- Treat and convert sewage sludge into nutrient-rich compost or organic manure.
- Distribute the processed sludge to farmers at minimal or no cost through municipal partnerships.

4.4.2. Energy Recovery from Sludge (Biogas)

- Generate biogas from sludge using anaerobic digestion.
- Use biogas to power STP operations.

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