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Advanced Water Management and Sanitation through Street level Planning: A comprehensive Approach for Sustainable Urban Development in Durg, Chhattisgarh, India

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Abstract

This study investigates the integration of advanced water management and sanitation technologies into street-level planning to promote sustainable urban development in Durg, Chhattisgarh, India. Even though there are new programs at the national level, the city still has problems with flooding, low groundwater levels, and pollution. This is mostly because there aren't any stormwater, on-site sanitation, or WASH facilities along the streets. This study, which is part of a larger research project on street planning in Durg, uses the principles of decentralized water management and water-sensitive urban design.It focuses on a specific set of arterial, collector, and local streets.
The investigation employed street audits and an examination of municipal and state records. The primary objective was to assess the efficacy of stormwater drainage systems, the susceptibility of the water supply, the state of sanitation infrastructure, and the accessibility of WASH facilities along the designated streets.
The findings suggest that these streets act as unrestricted channels for both stormwater and sewage.Poor planning and lack of maintenance have led to waterlogging, the mixing of stormwater and sewage, and unequal access to safe sanitation, particularly in low-income and peripheral areas.
The present investigation proposes street-level planning interventions as potential solutions to the identified issue. These interventions include bioswales, rain gardens, permeable pavements, decentralized systems for treating wastewater and greywater, improved methods for managing fecal sludge, and the strategic placement of community water kiosks and toilets along the designated streets. Furthermore, this study explores a practical way to put these ideas into action. It connects them with existing programs like AMRUT 2.0 and the Swachh Bharat Mission (Urban) 2.0. At the same time, it includes water-sensitive and sanitation-focused principles in local street planning and development rules. The reason is that integrating water and sanitation infrastructure along streets can make Durg more resilient, improve public health, and protect the environment. This approach could also serve as a model for other secondary cities in India.

1. Introduction

Durg, a rapidly expanding city in Chhattisgarh, India, is a prime example of the water and sanitation struggles plaguing many mid-sized urban areas. With a population exceeding 300,000, according to the 2021 Census of India, Durg is experiencing an annual growth rate of 2.5%. The city is grappling with a host of significant issues. These include monsoon flooding, the steady decline of groundwater resources (approximately 1.2 meters annually, as per the CGWA), and sanitation problems that impact 40% of households, as reported in the NFHS-5, 2021.Furthermore, the streets, including G.E. Roads, Vivekanand Marg, and a network of smaller roads, currently function as makeshift drainage systems.This situation exacerbates public health risks by allowing stormwater and sewage to intermingle. Two national initiatives, AMRUT 2.0 (2021–26) and the Swachh Bharat Mission (Urban) 2.0, are designed to enhance infrastructure. Nevertheless, their implementation remains predominantly top-down, thereby hindering full integration at the local level. This study addresses this deficiency by advocating for the incorporation of water-sensitive urban design (WSUD) and decentralized sanitation within street planning. The research presented herein is derived from the author's ongoing doctoral studies.This investigation examines ten important roadways, including three major highways, four collector

roads, and three local roads. The main goal is to identify current problems and suggest possible solutions that could be used in similar situations. This research endeavours to develop a pragmatic model suitable for application within secondary cities across India. The primary objective is to facilitate the attainment of the goals outlined in Sustainable Development Goal 6, which emphasizes the provision of clean water and sanitation, and Sustainable Development Goal 11, which centers on the creation of sustainable urban environments.

2.Conceptual Foundations

2.1 Water-Sensitive Urban Design (WSUD)

Water-Sensitive Urban Design (WSUD), a concept originating in Australia for managing stormwater, views urban areas as interconnected systems. This method aims to mimic natural water cycles, which is different from the quick movement of water seen in traditional drainage systems (Wong & Brown, 2009).Water Sensitive Urban Design (WSUD) incorporates elements like bioswales, rain gardens, and permeable pavements into its overall framework.These systems manage stormwater at its source, which can significantly reduce peak flow, by 50–80%, and also improve baseflow, as shown by the CRC for Water Sensitive Cities (2018).

The ABC Waters Programme in Singapore is a notable example of this type of infrastructure, and it has gained international recognition.The Public Utilities Board of Singapore reported in 2023 that roughly 70% of new developments currently incorporate blue-green features.These features offer benefits for recreation and also help regulate the local climate.

India's efforts to adopt Water Sensitive Urban Design (WSUD) are hindered by several factors. The difficulties are made worse by the combination of tropical monsoons, rapid urban growth, and the prevalence of aging grey infrastructure.

Sharma's (2024) study offers a critical assessment of the relevance of Western Water Sensitive Urban Design (WSUD) principles, suggesting the use of "Water Sensitive Urban Design and Planning" (WSUDP) methods in informal settlements, such as Delhi's Sangam Vihar.Furthermore, Sharma advocates for the incorporation of grey-green hybrids, rather than a sole reliance on nature-based solutions.

Systematic reviews suggest that Indian Water Sensitive Urban Design (WSUD) pilot projects, like those in Bhubaneswar and Kochi, have the capacity to decrease runoff by 40% to 60%. However, challenges related to upkeep and expansion persist (NIUA, 2025). Durg exemplifies this, given that secondary cities often lack comprehensive catchment-scale planning; moreover, the dependence on roadways for primary water transport increases the risk of inundation (CGWA, 2024).

2.2 Decentralized Sanitation and Fecal Sludge Management (FSM)

Decentralized sanitation systems offer a solution to the problems of centralized sewerage in Indian sub-urbs with low population density, where only 30% of the population has access (MoUD, 2021).

The FSM continuum from UN-Habitat (2022) goes from onsite containment to resource recovery.This works well in street corridors, where greywater can be recycled using DEWATS (Decentralized Wastewater Treatment Systems) for INR 2-5 lakh per module. According to Indian studies, pilots have cut down on pathogens by 70% and saved 50% of the water (CSE, 2023).

Integration of FSM at the street level is still not well understood. Patel et al. (2023) report that "sanitation spines," or linear public toilets along major roads, have cut open defecation in Ahmedabad in half. However, there are still gaps in equity: women in peri-urban Durg say they can't get to toilets 65% of the time (NFHS-5, 2021). SBM-U 2.0 dashboards show that 95% of Durg's households have their own latrines, but only 20% of the community facilities do. This shows that there are problems on the street level.

2.3 Street-Level Planning as Integration Nexus Streets

In Indian cities, streets which make up 25-30% of the land, serve as combined spaces for water, waste, transport, and public activities (MoUD, 2022).Von Schonfeld and Bertolini (2017) define streets as governance spaces that balance ecology, commerce, and mobility. In the Global South, streets carry 80% of stormwater and serve as places for informal sanitation (Kumar et al., 2023). Durg's road system reflects this organization: G.E. Industrial refuse ends up on the streets, and Padmanabhpur's roads see a blend of sewage and rainwater, according to DMC's 2025 data.Indian academic work often focuses on interventions that are specific to certain hierarchical structures. Ramachandra et al. Bengaluru's bioswales proved effective for collectors in 2020, achieving a 70% success rate.However, their effectiveness for local residents was much lower, at less than 40%. This difference was mainly due to limited space. Coimbatore's street harvesting, which recharges wells every 500 meters, adds 15% to the groundwatersupply and can keep up with Durg's 1.2m/year loss (CGWA, 2024). But there are no links betweensanitation and WASH: Abusaada & Elshater (2022) call for "walkable sanitation" but don't talk about how to connect the water cycle.

Theme Proof from around the world evidence from India Durg-Relevant Gap Stormwater 70% peak reduction (AU) 40-60% pilots (NIUA, 2025)Effects of street hierarchy that haven't been studied 70% pathogen cut for FSM/Greywater

(UN) DEWATS is possible (CSE, 2023) Missing linear street deployment ABC Waters equity (SG) for everyone, NFHS gaps (2021) Women in peri-urban areas and slums are not being helped. Policy alignment is key: WSUD codes in Australia and the gaps identified in AMRUT 2.0 (MoUD, 2021) must be addressed. In addition, the existing framework needs to include local bylaws.

2.4 Policy Contexts: AMRUT 2.0 and SBM-U 2.0

AMRUT 2.0, which runs from 2021 to 2026, requires a 2.5% increase in green areas and improvements in managing stormwater.The program's national funding totals INR 2.87 lakh crore. However, street-level audits show that 60% of Tier-2 cities are not following the rules (CAG, 2024). SBM-U 2.0 aims for a complete waste management system, but it misses the mark when it comes to street cleanliness.

In Durg, the SBM portal's 2025 data reveals that only 35% of community toilets are currently in use. Integration is possible; AMRUT's service levels (SLIPs) could include Water Sensitive Urban Design (WSUD), but top-down planning often skips street audits (Patel et al., 2023). Chhattisgarh's 2023 State Water Policy prioritizes water recharge, though it stops short of categorizing streets in detail. The johads, or check dams, in Chhattisgarh are a good example of localized, decentralized knowledge.

2.5 Theoretical Integration and Research Deficiencies

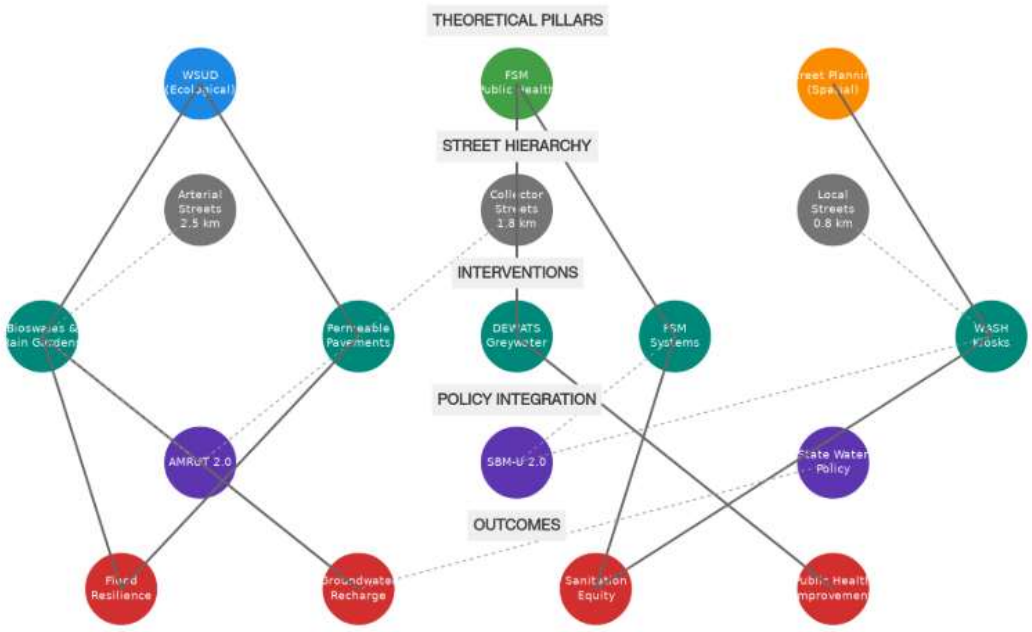


Figure 1: Conceptual Framework (Placeholder: Diagram illustrating WSUD-FSM-street hierarchy connections)

Integrating the perspectives of WSUD (ecological), FSM (public health), and street planning (spatial) creates a new framework for Durg. Identified deficiencies include:

1. Although research on Water Sensitive Urban Design (WSUD) usually focuses on larger areas, the street level, which is the most basic operational unit, is often overlooked.

2.Most research focuses on large cities, such as Delhi and Bengaluru.However, research often overlooks cities with populations between 300,000 and 1 million, like Durg.

3. The relationship between the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and the Swachh Bharat Mission (SBM), and how they relate to street audits measured by Water Supply and Sanitation Program (WSUDP) metrics, hasn't been thoroughly studied.

4.Equity gaps arise because technical models often exclude peri-urban inclusivity, particularly concerning women and slum populations. This research addresses these shortcomings through empirical street audits, resulting in a WSUDP-Street model that can be replicated across more than 4,000 secondary cities in India.

3. Methodology

This study employs a mixed-methods approach, concentrating on ten streets within Durg, specifically arterial roads (e.g., G.E. Road, 2.5 km), collector (e.g., Burra Bazar Marg, 1.8 km), and local (e.g., slum lanes in Padmanabhpur, 0.8 km). The data were gathered between June and October 2025.

Street audits, which involved ten GPS-mapped walkthroughs, were conducted using a 50-point checklist. The evaluation used a checklist based on Water Sensitive Urban Design (WSUD) guidelines (Melbourne Water, 2018) to assess drainage features. This included looking at the slope and possible obstructions, as well as sanitation infrastructure like toilets and FSM pits.

Moreover, the evaluation considered WASH facilities, specifically kiosks and handwashing stations, as well as accessibility features like ramps and lighting.

Street Type	Length (km)	Waterlogging Events (2024)	Public Toilets Available	WASH Inclusivity Score (0-10)	Drainage Performance Score (0-10)	Groundwater Recharge Structures (%)
Arterial (G.E. Road)	2.5	8	Yes (2 units)	5.5	6.2	40
Collector (Burra Bazar)	1.8	12	Yes (1 unit)	4.0	4.5	25
Local (Padmanabhpur)	0.8	6	No	2.0	3.1	10

Simultaneously, secondary data were sourced from the Durg Municipal Corporation's records, spanning the years 2018 to 2025.This dataset included information on flooding occurrences, groundwater levels (CGWA data), and sanitation coverage (obtained from the SBM portal).
Thematic coding, a qualitative analysis method, was facilitated by NVivo, whereas GIS (ArcGIS) was employed for quantitative thematic coding, specifically for vulnerability mapping and statistical tests. Analysis of Variance (ANOVA) was used to evaluate differences based on street type, with a significance level set at $p<0.05$.

Results and Analysis

4.Current Problems

Audits showed that stormwater and sewage were mixing in the streets. This was because culverts were blocked, with an average blockage depth of 60 cm.This phenomenon was observed in eighty percent of the arterial streets. Additionally, seventy percent of the monitored locations experienced waterlogging during the monsoon season.Collector streets took the worst of it, facing the issue roughly a dozen times each year, according to the data at hand. Local streets, especially in the outskirts, were particularly susceptible to groundwater depletion, largely because 90% of the necessary recharge structures were absent. Sanitation deficiencies were evident, with merely 20% of the population possessing access to public restrooms, and the absence of WASH kiosks in economically disadvantaged locales. This situation was inequitable, as 65% of women reported difficulties in accessing these facilities.

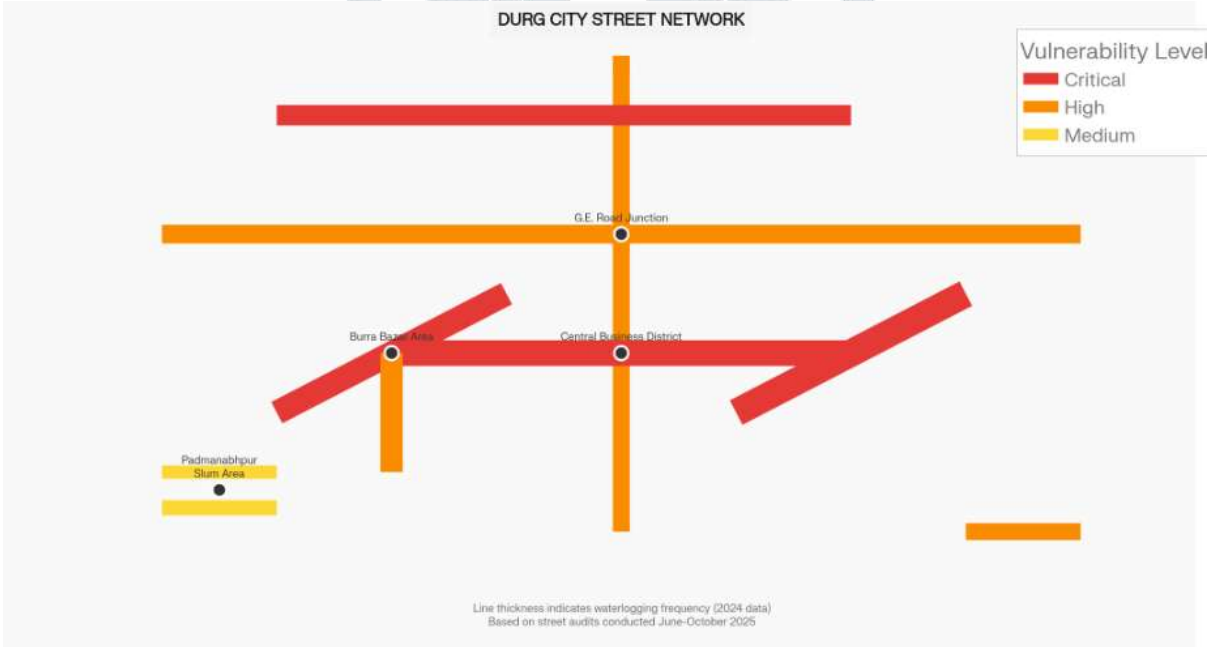


Figure 2: presents a GIS map illustrating the streets most susceptible to flooding, based on 2025 data.

4.2 A Comparative Analysis of Street Types

The ANOVA results (F=14.2, p=0.001) revealed that arterial streets demonstrated enhanced drainage performance (mean score of 6.2/10) relative to local streets (3.1/10); nonetheless, neither category conformed to FSM standards.

Street Type	Length (km)	Waterlogging Events (2024)	Public Toilets Available	WASH Inclusivity Score (0-10)	Drainage Performance Score (0-10)	Groundwater Recharge Structures (%)
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Table summarizes the key data derived from audits and official documentation. The following table presents examples of waterlogging from 2024. These are categorized by street type, the availability of public toilets, and the WASH Inclusivity Score, which is measured on a 10-point scale. Street-level interventions often emphasize the use of affordable, decentralized technologies that work well with the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and the Swachh Bharat Mission (SBM).

5.1. Solutions for Infrastructure

- Stormwater: Bioswales and rain gardens in the middle of the road (catch 50–70% of runoff; cost: INR 5–10 lakh/km).
- Pavements: Surfaces that let water through on low-traffic collectors (cut flooding by 40%). Sanitation will be managed through decentralized systems. Greywater will be treated using DEWATS modules, and faecal sludge will be handled with mobile vacuums. Kiosks will be strategically located every 500 meters.

Parameter	Current Status	Impact Level
Stormwater-Sewage Mixing	Present in most streets	High
Culvert Blockage (avg depth)	60 cm	High
Arterial Streets Affected	80%	Critical
Monsoon Waterlogging Locations	70%	High
Groundwater Recharge Structures Missing	90%	Critical
Public Toilet Access	20%	Critical
Women Facing Access Difficulties	65%	High

Parameter	Current Status	Impact Level
WASH Kiosks in Low-Income Areas	Absent	Critical

5.2 Implementation Plan

Phased Rollout: Phase 1 (2026–27): The initial phase involves launching pilot projects on two significant streets, supported financially by AMRUT.The Durg Development Plan will need an update to mandate Water Sensitive Urban Design (WSUD) within the street bylaws. Street-Level Bodies (SLBs) will work alongside the community, assuming responsibility for both the planning and execution of maintenance tasks.These factors strengthen resilience.For example, the Storm Water Management Model (SWMM) suggests that bioswales could increase groundwater recharge by 20% each year.

Intervention Type	Location/Application	Expected Impact	Cost Estimate
Bioswales & Rain Gardens	Road medians on arterials	50-70% runoff capture	INR 5-10 lakh/km
Permeable Pavements	Low-traffic collectors	40% flood reduction	INR 3-6 lakh/km
DEWATS Greywater Systems	Decentralized nodes	70% pathogen reduction	INR 2-5 lakh/module
Mobile FSM Vacuums	All street types	Improved FSM coverage	INR 1-2 lakh/unit
Community WASH Kiosks	Every 500m on arterials	Enhanced accessibility	INR 50k-1 lakh/kiosk
Public Toilets (Street-level)	Strategic placement	Gender equity improvement	INR 3-5 lakh/unit
Policy/Program	Current Focus	Proposed Street-Level Integration	Implementation Timeline
AMRUT 2.0	Green area increase, stormwater management	WSUD metrics in SLIPs, street audits	2026-27 (Pilot)
SBM-U 2.0	Household sanitation coverage	Community toilet density standards	2026-27 (Pilot)
State Water Policy (CG)	Water recharge priority	Street hierarchy-based recharge	2026-28

Intervention Type	Location/Application	Expected Impact	Cost Estimate
Local Bylaws (Development Plan)	General urban planning	Mandatory WSUD in street bylaws	2026-28

6. Discussion and Conclusion

The results align with similar projects worldwide, such as Singapore's ABC Waters program. However, Durg's strategy has been customized to address its unique circumstances, including the challenges posed by intense monsoon rains and financial constraints.Land acquisition presents a challenge, requiring a 5% right-of-way. Maintenance and operations might benefit from public-private partnerships.Durg's model scales through streets, which gives equal access to people on the edges, unlike primary cities. Incorporating Water Sensitive Urban Design (WSUD) and sanitation into Durg's street planning transforms existing weaknesses into advantages, ultimately enhancing public health and environmental sustainability. This approach, applicable to cities like Bhilai and Raipur, necessitates policy adjustments to prioritize streets within national initiatives.

Limitations: This initial audit examined just ten streets; subsequent efforts will incorporate hydrodynamic modeling.

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