

**ASSESSMENT OF PUBLIC SANITATION FACILITIES
NEAR TOURIST SPOTS IN KOLKATA**

Bachelor of Planning

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ASSESSMENT OF PUBLIC SANITATION FACILITIES NEAR TOURIST SPOTS IN KOLKATA

*A Thesis Project
submitted in partial fulfillment of the requirements for the award of the degree of*

Bachelor of Planning

By
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Under the Guidance of
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KOLKATA**

Declaration

I **ADITYA KUMAR PRASAD**, Scholar No-**2211002145** hereby declare that the thesis titled **ASSESSMENT OF PUBLIC SANITATION FACILITIES NEAR TOURIST SPOTS IN KOLKATA** submitted by me in partial fulfilment for the award of degree of Bachelor of Planning, at Maulana Azad National Institute of Technology, Bhopal, India, is a record of Bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

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**ASSESSMENT OF PUBLIC SANITATION FACILITIES NEAR TOURIST SPOTS IN
KOLKATA**

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सारांश

यह अध्ययन कोलकाता के तीन प्रमुख पर्यटन और पारगमन केंद्रों बाबूघाट रिवरफ्रंट, विक्टोरिया मेमोरियल हेरिटेज कॉम्प्लेक्स और कालीघाट काली मंदिर परिसर के आसपास के सार्वजनिक स्वच्छता बुनियादी ढांचे का एक व्यापक मूल्यांकन प्रदान करता है। पश्चिम बंगाल की राजधानी और एक प्रमुख सांस्कृतिक गंतव्य के रूप में, कोलकाता प्रतिवर्ष दैनिक यात्रियों, घरेलू तीर्थयात्रियों और लाखों अंतर्राष्ट्रीय पर्यटकों की एक विशाल "फ्लोटिंग आबादी" की मेजबानी करता है। स्वच्छ भारत मिशन (SBM) जैसे महत्वाकांक्षी राष्ट्रीय स्वच्छता ढांचों के कार्यान्वयन के बावजूद, शहर अभी भी स्थानीय स्तर पर खुले में मूत्र विसर्जन, सुविधाओं के अपर्याप्त रखरखाव और बुनियादी ढांचे के प्रावधान में गंभीर 'स्थानिक असमानता' से जूझ रहा है।

यह शोध सेवा संबंधी कमियों की सटीक प्रकृति का निदान करने के लिए एक मिश्रित-विधि दृष्टिकोण अपनाता है, जिसमें प्राथमिक भू-स्थानिक (GPS) मैपिंग, मानकीकृत बुनियादी ढांचा ऑडिट और व्यक्तिपरक उपयोगकर्ता धारणा सर्वेक्षणों का समन्वय किया गया है। मौजूदा शौचालयों की पहुंच को मापने के लिए मल्टी-रिंग बफर और नियरेस्ट-डिस्टेंस एनालिसिस जैसी उन्नत भौगोलिक सूचना प्रणाली तकनीकों का उपयोग किया गया है, जबकि व्यक्तिपरक उपयोगकर्ता संतुष्टि के विरुद्ध वस्तुनिष्ठ स्वच्छता मानकों का मूल्यांकन करने के लिए स्वच्छता स्थिति सूचकांक लागू किया गया था।

अनुभवजन्य निष्कर्ष स्वच्छता प्रावधान और जनसांख्यिकीय मांग के बीच एक गहरे स्थानिक और गुणात्मक असंतुलन को प्रकट करते हैं। जहाँ विक्टोरिया मेमोरियल जैसे प्रीमियम विरासत स्थल पर्याप्त कवरेज और उच्च उपयोगकर्ता संतुष्टि प्रदर्शित करते हैं, वहीं सामूहिक धार्मिक और पारगमन केंद्र गंभीर "कोल्ड स्पॉट्स" से ग्रस्त हैं — ये वे क्षेत्र हैं जो मानक 400-मीटर पैदल दूरी के भीतर सुलभ सुविधाओं से पूरी तरह वंचित हैं। इसके अलावा, यह अध्ययन लैंगिक समानता, उपयोगकर्ता सुरक्षा और मासिक धर्म स्वच्छता प्रबंधन (MHM) के संबंध में गंभीर प्रणालीगत विफलताओं को उजागर करता है।

इन स्थानीय कमियों की तुलना सफल घरेलू और अंतर्राष्ट्रीय केस अध्ययनों (जैसे इंदौर का पीपीपी मॉडल और टोक्यो के तकनीकी रूप से उन्नत सार्वजनिक शौचालय) से करते हुए, यह रिपोर्ट रणनीतिक, डेटा-संचालित नियोजन प्रस्ताव तैयार करती है। सिफारिशों में स्वचालित "ई-शौचालयों" (e-toilets) की रणनीतिक स्थापना, वास्तविक समय के रखरखाव के लिए इंटरनेट ऑफ थिंग्स (IoT) सेंसर का एकीकरण, नेशनल बिल्डिंग कोड (NBC 2016) मानकों को पूरा करने के लिए अनिवार्य यूनिवर्सल-डिज़ाइन रेट्रोफिटिंग, और कोलकाता की सार्वजनिक सुविधाओं को SBM-Urban 2.0 द्वारा अनिवार्य "एस्पिरेशनल" (Aspirational) मानकों तक ले जाने के लिए वित्तीय रूप से टिकाऊ प्रबंधन ढांचे को अपनाना शामिल है।

Abstract

This study provides a comprehensive evaluation of the public sanitation infrastructure surrounding three major tourist and transit hubs in Kolkata: the Babughat riverfront, the Victoria Memorial heritage complex, and the Kalighat Kali Temple precinct. As the capital of West Bengal and a premier cultural destination, Kolkata hosts an immense "floating population" of daily commuters, domestic pilgrims, and millions of international tourists annually. Despite the implementation of ambitious national sanitation frameworks like the Swachh Bharat Mission (SBM), the city continues to grapple with localized open urination, inadequate facility maintenance, and severe spatial inequity in infrastructure provision. This research employs a mixed-methods approach, synthesizing primary geospatial (GPS) mapping, standardized infrastructural audits, and subjective user perception surveys to diagnose the exact nature of these service deficits. Advanced Geographic Information Systems (GIS) techniques, including multi-ring buffer and nearest-distance analyses, were utilized to quantify the accessibility of existing toilets, while the Sanitation Condition Index (SCI) was applied to evaluate objective hygiene standards against subjective user satisfaction.

The empirical findings reveal a profound spatial and qualitative mismatch between sanitation provision and demographic demand. While premium heritage sites like the Victoria Memorial demonstrate adequate coverage and high user satisfaction, mass religious and transit hubs suffer from critical "cold spots"—areas entirely devoid of accessible facilities within a standard 400-meter walking radius. Furthermore, the study highlights severe systemic failures regarding gender equity, user safety, and menstrual hygiene management. By benchmarking these localized deficits against successful domestic and international case studies (such as Indore's Public-Private Partnership models and Tokyo's technologically advanced public toilets), this report formulates strategic, data-driven planning proposals. Recommendations include the strategic siting of automated "e-toilets," the integration of Internet of Things (IoT) sensors for real-time maintenance, mandatory universal-design retrofitting to meet National Building Code standards, and the adoption of financially sustainable management frameworks to elevate Kolkata's public conveniences to the "Aspirational" standards mandated by SBM-Urban 2.0

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Chapter 1: Introduction

1.1 Background of the Study

1.1.1 Global Context: Tourism and Public Sanitation

The provision of robust, accessible, and hygienic public sanitation infrastructure is universally recognized as a fundamental determinant of urban liveability, environmental sustainability, and economic vitality. In the context of the global tourism industry, public sanitation transcends basic civic utility to become a critical component of a destination's brand image and competitiveness. Cities worldwide intrinsically link the quality of their public conveniences to overarching visitor satisfaction. Tourism-sector assessments consistently note a high correlation between public hygiene and destination loyalty; if tourists are dissatisfied with the sanitation facilities, they are highly unlikely to revisit or recommend the destination. The economic implications of this are profound. Extensive regression analyses of global panel data reveal a statistically significant, positive causal relationship between improved local sanitation infrastructure and overall tourism economic growth. Empirical studies demonstrate that a mere one percent increase in a destination's access to improved sanitation facilities is statistically associated with a 2.6 percent increase in international tourist arrivals. Furthermore, the failure to meet basic water and sanitation targets results in massive global economic losses, while investments in sanitation yield profound returns, estimated at nine to eleven dollars for every dollar invested.

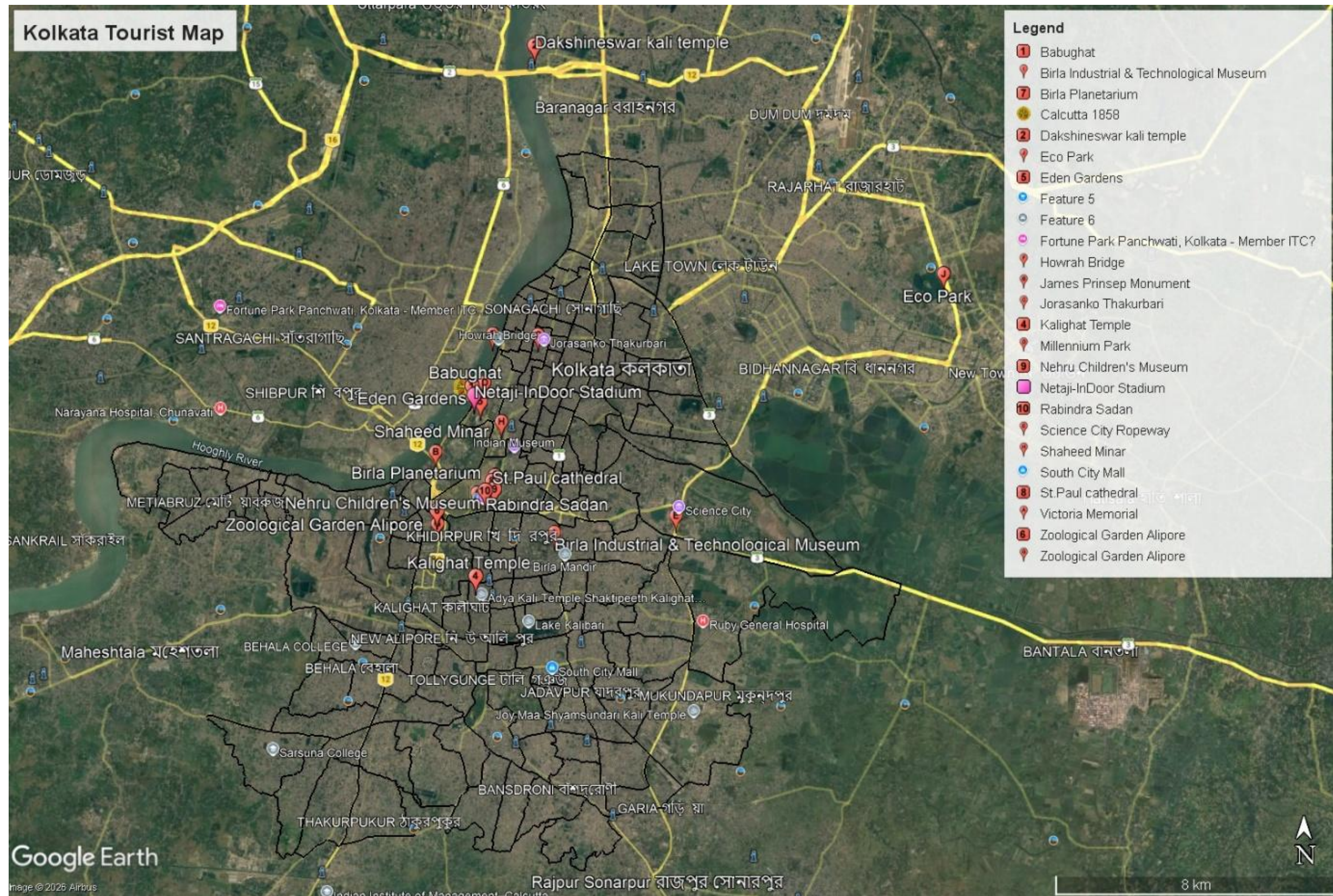
1.1.2 The Indian Sanitation Landscape and SBM

In the Indian context, the urgency of upgrading public sanitation has been brought to the forefront of national policy through the Swachh Bharat Mission (SBM). Historically, India has struggled with the pervasive issue of open defecation and urination due to a severe lack of public infrastructure. The launch of SBM-Urban revolutionized the approach to this crisis, shifting the focus toward creating Open Defecation Free (ODF) cities. However, while millions of individual household latrines and community toilets have been constructed, the operational maintenance and qualitative standard of public toilets in high-footfall areas remain a chronic challenge. Survey data indicates that approximately two-thirds of travelers in India report poor sanitation and hygiene problems as actively negatively affecting their trip experience.

Moving into its second phase, SBM-Urban 2.0 (SBM-U 2.0) has shifted the mandate from merely providing basic access to creating highly functional, universally accessible "Aspirational Toilets," particularly in iconic tourist destinations and heritage cities.

1.1.3 Kolkata: Demographic and Touristic Profile

Kolkata presents a highly complex, historically layered urban paradigm that exemplifies the challenges of modernizing sanitation in a hyper-dense environment. Serving as the primary economic, educational, and cultural engine of Eastern India, the city operates dual functions as a major commercial metropolis and a premier heritage tourism destination. Recent statistical compilations released in the India Tourism Data Compendium 2025 indicate that the state of West Bengal, with Kolkata acting as its primary gateway, has emerged as the second most visited state in India by foreign tourists, trailing only Maharashtra. In the year 2024, the state attracted an unprecedented 3.12 million foreign tourist visits, representing a robust 14.8 percent year-on-year growth. This demographic influx is structurally driven by the city's rich colonial architectural history, vibrant festival tourism, and significant mass religious pilgrimage circuits. However, this demographic and economic triumph is starkly juxtaposed against a critical, systemic infrastructural deficit within the urban core. Currently, the Kolkata Municipal Corporation (KMC) maintains roughly 500 public toilets citywide, a number grossly inadequate to service the combined needs of its 4.5 million static residents and millions of transient visitors.



Map 1: Kolkata Tourist Map

1.2 Need of the Study

The imperative for this comprehensive assessment is driven by three distinct, converging urban planning challenges specific to the Kolkata metropolitan context.

1.2.1 Managing the "Floating Population" Stress

Standard municipal planning methodologies frequently rely on static, ward-level residential census data to allocate infrastructure. However, major urban centres like Kolkata generate immense, highly localized sanitation demand driven by the "floating population." This demographic segment comprises domestic and international tourists, religious pilgrims, transit passengers, and daily commuters who heavily utilize city services during the day but return to other jurisdictions at night. The sudden, diurnal surges in solid waste generation and public convenience demand created by this highly transient demographic are rarely accounted for in traditional infrastructure provisioning. Consequently, transit hubs and pilgrimage sites become severely overwhelmed, necessitating a targeted, demand-driven assessment of sanitation carrying capacity.

1.2.2 Heritage Preservation and Aesthetic Value

The chronic inadequacy of sanitation infrastructure directly threatens the physical integrity and aesthetic value of Kolkata's invaluable cultural heritage. In the absence of highly visible, accessible, and clean public toilets, the floating population frequently resorts to open urination and the indiscriminate disposal of solid waste. This directly accelerates the visual and physical decay of historical structures, such as the ancient ghats along the Hooghly River, the labyrinthine alleys of North Kolkata, and the perimeter walls of colonial-era monumental zones. The foul odours and accumulated filth severely degrade the tourist experience. Preserving the sanctity and structural integrity of these sites demands an immediate spatial intervention to intercept and manage human waste effectively.

1.2.3 Policy Alignment with National Directives

The Government of India's Swachh Bharat Mission-Urban 2.0 (SBM-U 2.0) represents

a critical policy transition toward holistically sustainable "Garbage Free Cities." A central tenet of this national framework is the funded mandate for the development of "Aspirational Toilets" in high-footfall tourist destinations. SBM-U 2.0 strictly requires that 25% of all new public toilet seats added in an urban unit must meet these premium, highly inclusive aspirational standards. This study is urgently needed to bridge the existing gap between these ambitious national policy objectives and the localized ground realities in Kolkata. By diagnosing exact spatial and qualitative deficits, this research provides the empirical foundation required for the KMC to align its infrastructure with statutory national mandates.

1.3 Problem Statement and Research Justification

Problem Statement: The Problem Statement guiding this research is defined as: *The quality, cleanliness, and accessibility of public sanitation facilities directly impact city image and public health.*

Research Questions: The spatial analysis and qualitative assessment are guided by three central research questions:

- How accessible are public toilets from the primary entry/exit points of tourist hubs?
- Do the existing facilities meet the physical and hygiene standards required for diverse user groups (Gender/Age/Ability)?
- What is the quantitative gap between current infrastructure and estimated tourist demand?

1.3.1 The Crisis of Public Sanitation in Urban India

While the problem statement acknowledges the broad, macro-level societal impacts of poor sanitation, the justification for this research relies on delving into the specific, localized ways these infrastructural failures manifest in a densely populated metropolis like Kolkata. Public toilets are essential infrastructure necessary to guarantee the human right to sanitation in public spaces (a concept formalized under the HRWS-PS theory). Yet, empirical data from recent city-wide surveys substantiates the urgency of this study

by highlighting systemic, dangerous failures in current service provision.

1.3.2 Safety, Privacy, and Gender-Based Vulnerabilities

A significant proportion of users in Kolkata experience profound fear, discomfort, and harassment while utilizing public toilets. Surveys indicate that an alarming 54% of women, trans, and queer individuals feel unsafe in these facilities, with 52% of trans and queer people reporting actual harassment incidents. This insecurity is not merely a social issue; it stems directly from systemic functional failures in urban architectural design and safety infrastructure. Critical deficiencies include inadequate interior and exterior lighting, the absence of functional locks on cubicle doors, compromised structural privacy, and the highly inappropriate presence of male attendants stationed directly outside women's restrooms. Addressing these physical, design-based deficiencies is paramount to restoring user confidence and ensuring the basic dignity and safety of all demographics.

1.3.3 Hygiene Deficits and Public Health Implications

Beyond fundamental safety, essential hygiene and functional provisions are critically lacking across the network. The vast majority of female users (94%) report the complete absence of Menstrual Hygiene Management (MHM) infrastructure, such as sanitary pad vending machines or safe, eco-friendly incinerators for waste disposal. Furthermore, 60% of the facilities surveyed lacked the most basic necessities required to prevent disease transmission, such as soap or functional handwashing stations, and 51% suffered from an inadequate or highly intermittent supply of clean water.

The poor state of these facilities imposes disproportionate physical and health costs on vulnerable populations. The pervasive fear of filthy public toilets compels many women to actively limit their fluid intake to pre-empt the need to use a facility while traversing the city. This forced self-restriction places users at a high risk of adverse health outcomes, with 23% of surveyed respondents reporting health issues like severe urinary tract infections (UTIs) directly attributable to poor toilet conditions. The sequence of poor infrastructure leading to fluid restriction, physical health risks, and resultant self-restriction from the public sphere establishes a clear trajectory where municipal failure imposes a quantifiable health penalty on its citizens and visitors.

1.3.4 Spatial Inequity and Infrastructural Bias

A preliminary spatial analysis of existing facilities reveals a profound disparity in distribution, suggesting a clear infrastructural bias. Public toilets are frequently concentrated in more affluent areas and planned commercial districts, while lower-income neighbourhoods and hyper-dense, massive footfall transit points often lack proportionate facilities. Even at major transit hubs like the Howrah and Sealdah railway station peripheries, where daily commuter demand is immense, the provision of gender-segregated toilets is grossly inadequate relative to the population served. By focusing this research specifically on highly congested, diverse tourist and transit areas, this study critically quantifies the spatial mismatch between peak pedestrian density and actual sanitation provision.

1.4 Aim and Objectives

Aim: The primary aim of this research *is to assess the availability, accessibility, and maintenance condition of public Sanitation facilities near major tourist areas in Kolkata.*

Specific Objectives:

To operationalize this aim, the study identifies six core objectives:

1. To physically identify and map the precise spatial distribution (using GPS coordinates) of all existing public toilets, community toilets, and urinals within the defined study areas (Babughat, Victoria Memorial, and Kalighat Temple).
2. To objectively assess the physical condition, structural integrity, and service levels of these facilities utilizing a comprehensive, standardized Observation Checklist based on statutory building codes.
3. To systematically analyse user perception and subjective satisfaction regarding the ease of locating, perceived safety, and cleanliness of the facilities through on-site surveys with the floating tourist population.
4. To pinpoint acute service gaps by performing advanced GIS-based spatial analyses (Buffer and Kernel Density) to quantify the mismatch between high pedestrian footfall zones and infrastructure availability.
5. To critically benchmark the existing infrastructural reality in Kolkata against

established national statutory guidelines (such as URDPFI norms, NBC 2016 accessibility standards, and SBM-U 2.0 Aspirational guidelines) to precisely measure compliance shortfalls.

6. To develop strategic, site-specific planning proposals encompassing smart-technology integration, universal design retrofitting, spatial redistribution, and sustainable management frameworks derived from successful domestic and international case studies.

1.5 Scope and Limitations

1.5.1 Geographical and Typological Scope

To ensure a rigorous and nuanced analysis, the geographical scope of this research is tightly focused on three highly distinct major tourist precincts within the Kolkata Municipal Corporation boundaries:

1. **Babughat:** A prominent riverfront recreation zone that simultaneously functions as a massive multimodal transit hub, representing the intense sanitation demands of "Transit-linked Tourism."
2. **Victoria Memorial:** Kolkata's premier colonial heritage complex situated within the highly regulated Maidan precinct, representing the high-standard requirements of affluent "Heritage/Leisure Tourism."
3. **Kalighat Kali Temple:** An ancient, hyper-dense, and spatially constrained pilgrimage centre, representing the massive, volatile footfall and ritualistic demands of "Mass Religious Tourism."

These sites were deliberately selected because they encapsulate the fundamentally distinct urban morphologies and unique floating population pressures that characterize Kolkata's broader tourism landscape.

1.5.2 Methodological Limitations

The study acknowledges several methodological boundaries. Firstly, it does not attempt to conduct a city-wide audit; prominent tourist sites falling outside the three selected typologies (such as the Dakshineswar Temple or Millennium Park) are explicitly excluded from this specific spatial assessment. Secondly, due to the lack of digitized

municipal turnstile records, reliance was placed on observational data and randomized user sampling to estimate facility usage and footfall density, rather than exact empirical daily user counts. Finally, the primary field surveys and infrastructural audits were conducted within a limited temporal window in 2025. Consequently, the data captures a snapshot of infrastructure conditions but may not fully represent extreme, temporary demographic surges associated with major seasonal events like the Durga Puja festival. Nonetheless, the triangulation of spatial GIS data, rigorous objective audits, and subjective user experiences provides a highly robust diagnostic framework capable of informing viable urban design solutions.

1.6 Methodology Overview

To effectively address the research objectives, this study adopted a structured, mixed-methods approach, synthesizing primary quantitative geospatial data with qualitative user experience metrics.

1.6.1 Research Design and Pre-Field Data Collection

The initial phase involved gathering secondary contextual data to define the study parameters. This included analysing Kolkata's demographic statistics, tourism footfall reports, and identifying the statutory planning norms outlined in the URDPFI guidelines and the National Building Code (NBC) 2016. High-resolution satellite imagery sourced from Google Earth and OpenStreetMap (OSM) was utilized alongside municipal records to establish preliminary base maps of the study areas.

1.6.2 Primary Data Collection Framework

The core empirical data was gathered through rigorous on-site fieldwork at Babughat, Victoria Memorial, and Kalighat. This involved three concurrent data streams:

1. **Public Sanitation Infrastructure Assessment Survey:** A standardized observation checklist was deployed by the researcher to audit every identified facility. This instrument evaluated the functional status of fixtures, water availability, lighting conditions, maintenance integrity, and the critical presence of accessibility features (e.g., ramps, grab bars).

2. **Tourist Perception Survey:** To capture the human dimension of service delivery, brief, structured interviews (N≈100) were conducted on-site with the floating population (encompassing both domestic and foreign tourists). The survey measured subjective satisfaction on a Likert scale regarding ease of access, perceived hygiene, and privacy.
3. **Geospatial (GPS) Mapping:** The exact geographical coordinates (latitude and longitude) of all public toilets, community toilets, and major solid waste dustbins were physically recorded on-site to build a highly accurate spatial database.

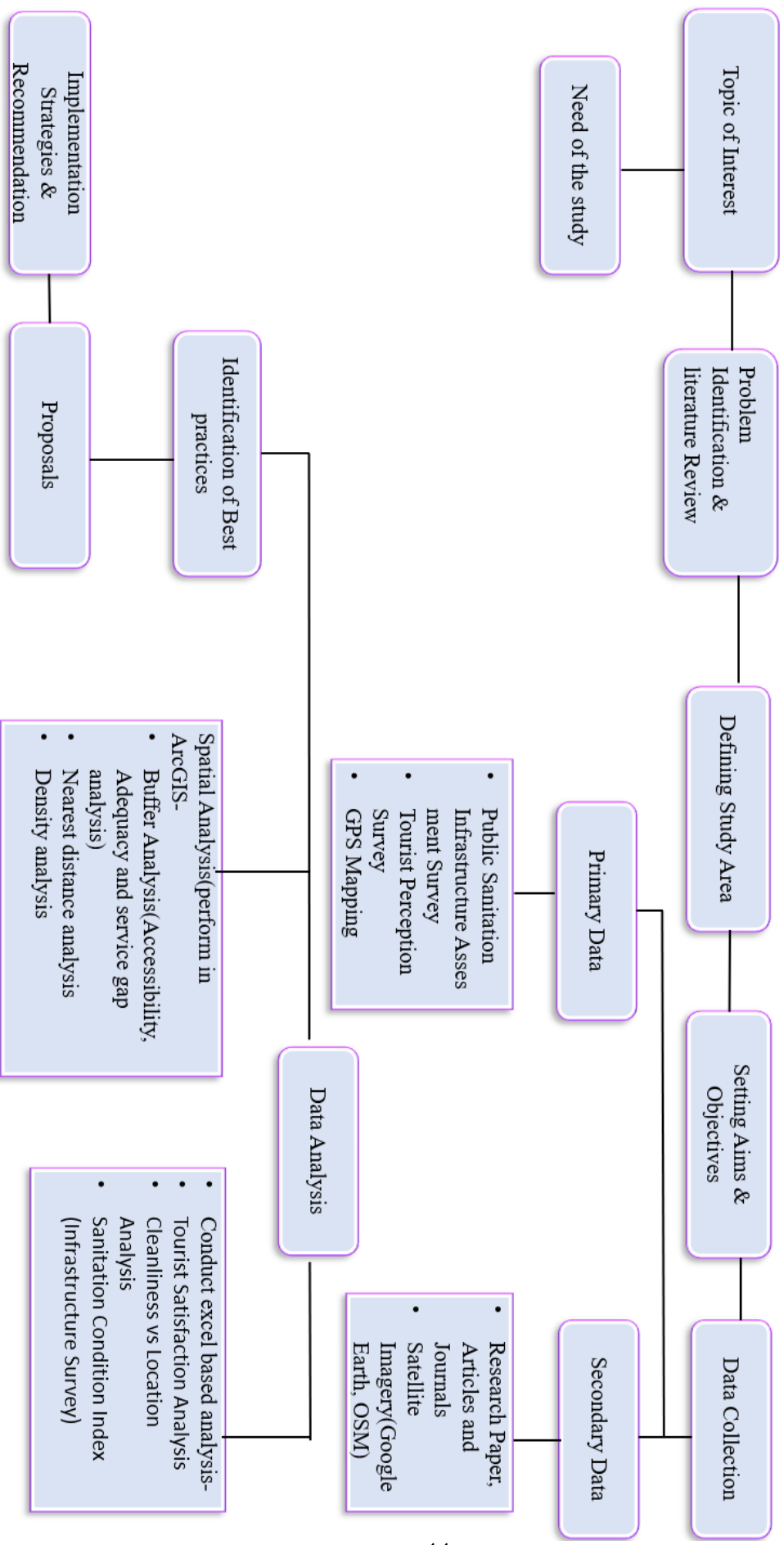
1.6.3 Analytical Framework

The analytical phase leveraged both spatial and statistical software to interpret the collected data:

- **Advanced Geospatial Analysis:** Using ArcGIS, the GPS coordinates were mapped to execute spatial diagnostics. **Multi-Ring Buffer Analysis** (generating 200m and 400m catchments) and **Nearest Distance Analysis** were performed to mathematically quantify accessibility from primary tourist nodes. **Kernel Density Estimation (KDE)** mapping was utilized to visually identify infrastructural "cold spots" (areas lacking service) and "hot spots" (areas of concentration).
- **Statistical Evaluation and Indexing:** Microsoft Excel was employed to clean the survey data and execute statistical comparisons, notably the "Gap Analysis" correlating subjective user perception against objective audit scores. Finally, the technical performance of the facilities was quantified using the **Sanitation Condition Index (SCI)**, which mathematically weighted the metrics of Cleanliness, Water Availability, Lighting, and Maintenance to produce a standardized comparative score for each tourist precinct.

By triangulating this spatial, technical, and perceptual data, the methodology directly facilitates the formulation of the evidence-based planning proposals detailed in the concluding chapters of this report

METHODOLOGY



Chapter 2: Literature Review

2.1 Introduction to the Literature Review

A rigorous evaluation of public sanitation infrastructure necessitates a profound understanding of established urban planning norms, statutory engineering guidelines, and the broader socio-economic frameworks governing urban service delivery. The literature surrounding this domain bridges highly technical engineering standards with macro-economic impact assessments, human rights frameworks, and advanced technological integrations. As metropolitan areas grapple with rapid urbanization, the discourse on sanitation has shifted from a mere focus on disease prevention to a holistic view encompassing spatial justice, gender equity, economic vitality, and sustainable tourism. This review systematically unpacks the multifaceted dimensions of public sanitation, transitioning from foundational statutory frameworks in India to global economic multipliers, theoretical models of spatial equity, and cutting-edge operational paradigms. By synthesizing these diverse streams of research, the review establishes a robust theoretical and methodological context required to evaluate the adequacy, inclusivity, and sustainability of public sanitation facilities in high-density urban tourist hubs, providing the critical foundation for subsequent empirical investigations.

2.2 Statutory Frameworks and Urban Planning Norms in India

The spatial, demographic, and technical provisioning of public conveniences in India is directed by a strict hierarchy of national guidelines. These frameworks establish the baseline for evaluating whether existing infrastructure meets the minimum acceptable standards for public health and urban planning, ensuring that cities can sustainably manage both their resident and floating populations.

2.2.1 The URDPFI Guidelines and Spatial Hierarchies

The Urban and Regional Development Plans Formulation and Implementation

(URDPFI) Guidelines, published by the Ministry of Urban Development, provide the foundational framework for spatial planning across Indian municipalities. The URDPFI guidelines explicitly recognize the differentiated needs of commercial zones, transit corridors, and tourist areas, which experience massive daily influxes of visitors. By categorizing these distinct urban morphologies under specific land-use zones—such as U-Zones and T-Zones—the framework mandates a substantially higher density of public convenience units to accommodate high-volume floating populations, moving away from the lower density norms applied to static residential neighbourhoods. The guidelines recommend the provision of public toilet facilities every 500 to 1000 meters in open areas, public parks, plazas, and major transport arteries. Furthermore, the URDPFI strictly stipulates that all such infrastructure must be universally accessible, ensuring that urban centres remain navigable and hygienic for all demographic segments.

2.2.2 National Building Code (NBC) 2016 Standards

Complementing the spatial distribution framework established by the URDPFI, the National Building Code (NBC) of India (2016) dictates the technical, spatial, and structural design standards for the built environment. The NBC establishes rigid engineering parameters for fixture ratios based on user volume, minimum floor areas per cubicle, and necessary natural and mechanical ventilation systems to ensure both structural longevity and sanitary efficiency. The NBC 2016 specifies exact fixture ratios tailored to the nature of the building and its expected footfall, which is highly relevant for assessing diverse tourist typologies such as heritage museums, transit hubs, and religious sites. The assumption underlying these metrics is often based on demographic breakdowns; for instance, in public assembly buildings like cinemas and museums, the population is assumed to be two-thirds male and one-third female for the purpose of calculating minimum fixture requirements.

The following table outlines the statutory fixture requirements across various public and institutional categories based on the NBC 2016 provisions.

Table 1 Statutory Fixture Requirements for Public Facilities Based on NBC 2016 Standards:

Building Category	User Group	Water Closets	Urinals (Males Only)	Wash Basins

		(WCs)		
Art Galleries, Libraries, and Museums	Public Males	1 per 200 (up to 400). Over 400: Add 1 per 250	1 per 50	1 per 200 (up to 400). Over 400: Add 1 per 250
Art Galleries, Libraries, and Museums	Public Females	1 per 100 (up to 200). Over 200: Add 1 per 150	Not Applicable	1 per 200 (up to 200). Over 200: Add 1 per 150
Cinemas, Concert Halls, and Stadia	Public Males	1 per 100 (up to 400). Over 400: Add 1 per 250	1 per 50	1 per 200 or part thereof
Cinemas, Concert Halls, and Stadia	Public Females	3 per 100 (up to 200). Over 200: Add 2 per 100	Not Applicable	1 per 200 or part thereof
Office Buildings (General)	Staff/Public Males	1 per 25	Nil up to 6; 1 for 7-20; 2 for 21-45; 3 for 46-70	1 per 25
Office Buildings (General)	Staff/Public Females	1 per 15	Not Applicable	1 per 25
Hospitals (Indoor Patient Wards)	Patients/Visitors	1 per 5 beds or part thereof	1 per 15 beds	2 for every 30 beds. Add 1 per additional 30 beds

Beyond numerical fixture ratios, the NBC 2016 mandates critical operational and accessibility standards that govern the holistic usability of the facility. Every water closet must be provided with an ablution tap and a flushing apparatus to maintain internal hygiene. In high-traffic public venues such as cinemas, art galleries, and museums, the code requires the provision of one water tap with comprehensive draining arrangements for every fifty persons in the immediate vicinity of the water closets and urinals. Furthermore, Section 13 of the NBC enforces mandatory accessibility standards across all public buildings, requiring that public toilets integrate appropriately sloped ramps, structurally sound grab bars, tactile flooring, and specific spatial dimensions to allow independent wheelchair maneuverability. The code also addresses broader public health concerns by strictly prohibiting the installation of drinking water fountains inside toilet facilities, thereby preventing cross-contamination and mitigating the spread of waterborne pathogens. In specialized environments such as hospitals, the code recommends against placing drinking fountains in patient ward toilets entirely to enhance infection control protocols.

2.2.3 CPHEEO Advisory and Functional Design

Further operational and engineering guidance is provided by the Central Public Health and Environmental Engineering Organisation (CPHEEO) Advisory on Public and Community Toilets. The CPHEEO fundamentally emphasizes the principle of "Functional Design," asserting that the integrity of continuous water supply, sufficient overhead storage, and robust subsurface drainage mechanisms must be the primary considerations. According to the advisory, these foundational engineering requirements must take absolute precedence over superficial aesthetic architectural design to prevent the rapid degradation of public assets. The advisory comprehensively outlines the critical components of continuous Operation and Maintenance (O&M), detailing standardized cleaning schedules, revenue generation options through nominal user fee collections, and stringent occupational health and safety protocols required to protect the sanitation workforce.

2.2.4 Swachh Bharat Mission-Urban 2.0 and Aspirational Toilets

The most contemporary policy influence dictating the development of urban sanitation is the Swachh Bharat Mission-Urban 2.0 (SBM-U 2.0), launched in October 2021 with

an enhanced financial outlay of ₹1,41,600 crores. SBM-U 2.0 was designed to transition urban India from achieving mere Open Defecation Free (ODF) status to realizing the ambitious vision of "Garbage Free Cities" by 2026. The mission framework mandates comprehensive solid waste management, including the processing of 16 crore tonnes of legacy waste to reclaim approximately 15,000 acres of urban land, alongside robust strategies for used water management in cities with populations under one lakh. SBM-U 2.0 introduces standardized evaluation protocols—including ODF+, ODF++, Water+, and Star Rating for Garbage Free Cities—which are verified by independent third parties to guarantee that no untreated fecal sludge or used water is discharged into open environments.

A cornerstone of the SBM-U 2.0 infrastructure mandate is the conceptualization and construction of "Aspirational Toilets," specifically designated for tourist destinations, iconic heritage cities, and zones characterized by massive pedestrian footfalls. The mission dictates that at least 25% of all new public toilet seats added in any urban unit must meet these aspirational criteria. These facilities are designed to move far beyond basic utilitarian functionality, transforming into premium, highly inclusive civic spaces that elevate the standard of gender equity and public hygiene.

The technical and aesthetic specifications for Aspirational Toilets include stringent requirements designed to maximize comfort, safety, and operational sustainability.

Table 2 Technical and Functional Specifications for SBM-U 2.0 Aspirational Toilets:

Aspirational Toilet Feature	Description and Functional Requirement
Cleanliness & Aesthetics	Walls and floors must be impeccably clean, stain-free, and graffiti-free. Landscaping, including plants and shrubs in the facility's vicinity, must be well-maintained to enhance visual appeal.
Child-Friendly Infrastructure	Mandatory inclusion of low-height toilets, smaller Indian-style water closets, and lower washbasins specifically designed to accommodate the ergonomic needs of children.
Menstrual Hygiene Management (MHM)	Washrooms designated for women must feature functional sanitary napkin vending machines. Facilities with more than ten seats must also include safe, eco-friendly incinerators for

	the hygienic disposal of used sanitary products.
Drying & Hygiene Amenities	Provision of mechanical hand dryers or paper napkin dispensers in washing areas to maintain dry floors, reduce slip hazards, and enhance overall hand hygiene.
Digital Feedback Systems	Implementation of SMS-based or digital feedback systems with prominently displayed contact numbers to track user satisfaction and trigger immediate maintenance responses.
Financial & Operational Sustainability	Spaces specifically earmarked for commercial advertisement to generate independent revenue for Operation & Maintenance (O&M), ensuring the facility remains financially self-sustaining.

This paradigm shift demonstrates a national policy alignment toward viewing public toilets not as municipal burdens, but as critical, value-generating civic infrastructure that directly impacts the daily lived experience of millions of urban residents and tourists.

2.3 The Economic, Health, and Tourism Nexus

The academic literature robustly establishes that public sanitation is not merely a baseline public health prerequisite but a potent economic multiplier, particularly within the highly competitive international tourism sector. Tourism destination development requires a combination of closely aligned public planning and private interventions; however, the efficacy of these interventions is frequently undermined by a failure to invest in foundational sanitary infrastructure.

2.3.1 The Tourism Multiplier Effect

Extensive regression analyses of global panel data reveal a statistically significant, positive causal relationship between improved local sanitation infrastructure and overall tourism economic growth. Empirical studies consistently indicate that a mere 1% increase in a destination's access to improved sanitation facilities is statistically associated with a 2.6% increase in international tourist arrivals. The broader economic implications of the tourism sector further magnify this impact; tourism generates

trillions in global sales and is a primary driver of employment and foreign exchange, making any infrastructural deterrent a critical macroeconomic threat.

Conversely, poor urban sanitation serves as a severe structural deterrent to tourism development. Destination brand image is highly susceptible to the visible presence of inadequate sanitation, with international and high-end domestic tourists explicitly citing poor hygiene, open defecation, and the lack of functional public toilets as primary deterrents to revisitation. This dynamic is particularly damaging to heritage and religious tourism sites. High-footfall World Heritage sites face unique infrastructural challenges, where the sudden surge in floating populations creates extreme stress on local sanitation networks, leading to the visual and physical decay of architectural monuments due to open urination and unregulated waste accumulation. Preserving the outstanding universal value of heritage sites therefore requires sanitation strategies that are decentralized, technologically advanced, and capable of handling volatile pilgrim and tourist densities without visually disrupting the archaeological aesthetic.

2.3.2 Economic Penalties of Inadequate Sanitation

The economic cost of administrative inaction in the sanitation sector is staggering and imposes a massive burden on developing economies. Research conducted for the United Nations Human Development Report estimated that the total cost of the current deficit in investment in water and sanitation stands at approximately \$170 billion, representing 2.6% of the aggregate Gross Domestic Product (GDP) of all developing countries. The lack of access to basic sanitation causes profound economic losses related to both the direct costs of treating sanitation-related gastrointestinal diseases and the indirect cost of lost income through reduced labor productivity.

Furthermore, time poverty exacerbates these macroeconomic losses. In developing regions, the time spent seeking a safe place to defecate or walking long distances to collect water accounts for billions of dollars in lost economic opportunities. Improved sanitation provides households with thousands of additional hours annually—time that can be redirected toward education, childcare, or income-generating activities. This regained time has an estimated global economic value of over \$100 billion each year. Achieving universal access to basic water and sanitation would result in an estimated \$18.5 billion in economic benefits each year from avoided deaths alone. Consequently, investments in sanitation yield profound and immediate economic returns. Scientific

evidence demonstrates that for every \$1 invested in achieving universal sanitation access, the global return on investment is estimated to be between \$9.1 and \$11.2, optimizing local public health resilience while simultaneously maximizing foreign exchange and tourism revenue streams.

2.3.3 Public Health Ramifications

Inadequate sanitation is the primary driver of infectious gastrointestinal diseases, most notably diarrhea, which disproportionately degrades the health of vulnerable local populations and directly discourages tourism. Beyond communicable diseases, the lack of dependable public restrooms creates acute physical hardships for transit populations and informal workers. Individuals with underlying health issues or incontinence may need to use a restroom numerous times throughout the day; the absence of clean facilities perpetuates social isolation, as such individuals are forced to avoid public areas lacking dependable infrastructure. In rapidly urbanizing contexts, the deficit in public toilets forces tourists, street vendors, and commuters into prolonged urine retention, which can lead to severe abdominal pain and a dramatically increased risk of urinary tract infections (UTIs) and chronic kidney diseases.

2.4 Theoretical and Methodological Frameworks for Sanitation Assessment

To evaluate the highly qualitative aspects of sanitation infrastructure—moving beyond mere spatial presence to assess actual user experience—contemporary urban planning research increasingly utilizes sophisticated theoretical frameworks and indexing methodologies. Traditional assessments often oversimplify sanitation by merely counting the number of toilet blocks in a given area, failing to account for the actual usability, dignity, and safety those facilities provide to diverse user groups.

2.4.1 Human Rights to Water and Sanitation in Public Spaces (HRWS-PS)

In 2010, the United Nations General Assembly officially recognized the right to safe drinking water and sanitation as essential human rights essential for the full enjoyment of life. However, traditional national sanitation policies historically limited their scope

to household provisions, severely neglecting populations who depend heavily on public spaces—such as tourists, transit workers, the homeless, and informal sector employees. This systemic oversight results in frequent and disproportionate human rights violations for vulnerable populations living or working outside the household sphere. To rectify this, the UN expanded the normative content of these rights to encompass spheres of life beyond the household, establishing the Human Rights to Water and Sanitation in Public Spaces (HRWS-PS) standards.

The HRWS-PS theory categorizes the evaluation of public sanitation facilities into five interdependent dimensions, moving beyond physical indicators to prioritize humanistic care and spatial dignity.

Table 3 Theoretical Dimensions of the HRWS-PS (Human Rights to Water and Sanitation in Public Spaces) Framework:

HRWS-PS Dimension	Theoretical Definition and Urban Planning Implications
Accessibility	The extent to which public sanitation facilities meet the quantitative demand of the population and the spatial time required for individuals to reach them without physical exertion, danger, or excessive deviation from their route.
Usability	The functional utility of the facility, focusing on the absence of physical barriers (e.g., stairs, narrow corridors) and the presence of universal design features (e.g., ramps, grab bars, tactile indicators) ensuring safe use by the elderly, children, and disabled individuals.
Affordability	The economic prerequisite that any user fees levied for sanitation services must not act as a deterrent to use, ensuring that economically marginalized populations are not excluded from basic public hygiene.
Acceptability	The cultural and social appropriateness of the facility, which encompasses aesthetic design, additional amenities, and the preservation of absolute privacy, modesty, and dignity for all user groups.
Safety and	The paramount foundational concern determining usability;

Quality	includes physical safety from harassment, adequate internal and external lighting, reliable door locks, surveillance at entrances, and stringent environmental hygiene to control disease vectors.
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Empirical applications of the HRWS-PS framework consistently reveal a hierarchical dependency among these dimensions. Physical safety and fundamental hygiene quality act as the absolute, non-negotiable prerequisites for the utilization of public facilities; if a toilet is perceived as dangerous or visibly filthy, it will not be used regardless of its proximity. Once baseline safety needs are met, usability and accessibility dictate the frequency of use, while acceptability determines long-term user satisfaction and institutional trust. Researchers increasingly utilize Multi-Criteria Decision Analysis tools, such as the Analytic Hierarchy Process (AHP) and entropy weight methods, to quantify these dimensions. By applying index models based on HRWS-PS, urban planners can identify specific deficiencies in architectural design and environmental sanitation, translating subjective humanistic needs into actionable, data-driven urban renewal strategies.

2.4.2 The Sanitation Condition Index (SCI)

Complementing the theoretical depth of the HRWS-PS framework, the Sanitation Condition Index (SCI) serves as an applied methodological tool utilized in comprehensive infrastructural audits. Methodologies employing the SCI utilize structured, multi-point observation checklists combined with subjective user satisfaction surveys. This dual approach bridges the gap between objective infrastructural audits—such as measuring water flow, assessing lighting lux levels, and evaluating structural integrity—and subjective user perception, which captures feelings of safety, visual disgust, and perceived convenience. By identifying the dissonance between mere physical provision and perceived utility, the SCI ensures that assessed infrastructure is not only spatially mapped but is functionally viable and psychologically acceptable to the floating population. Through zoning the city into homogeneous sub-sectors and superimposing the SCI over socioeconomic data, municipalities can effectively prioritize interventions, addressing specific technological, institutional, and financial bottlenecks in the waste and sanitation stream.

2.5 Socio-Spatial Equity: Urban Feminism and Gender-Inclusive Sanitation

Traditional urban planning has historically operated under a gender-neutral facade, which, in practice, defaults to a cis-male-centric paradigm. This structural bias manifests acutely in the design, distribution, and governance of public sanitation facilities, creating profound inequities that restrict marginalized groups' fundamental "right to the city" and severely undermine urban health equity.

2.5.1 Urban Feminism and Spatial Justice

Urban feminism provides a critical theoretical lens to examine gender inequality in the built environment, emphasizing core concepts such as intersectionality, spatial justice, safety, and participatory planning. According to feminist urban theorists, spatial justice refers to the fair and equitable distribution of resources and opportunities in physical space. In the context of sanitation, the widespread architectural adoption of a 1:1 spatial footprint ratio for male and female restroom facilities represents a profound failure of spatial justice. This ostensibly "equal" distribution results in highly unequal outcomes due to fundamental biological, social, and cultural differences.

Research demonstrates that women typically require up to six times longer in a restroom than men. This massive time disparity is driven by physiological realities, such as menstruation and pregnancy, the logistical complexities of gendered clothing, and the socio-cultural reality that women disproportionately bear caregiving responsibilities, frequently accompanying young children or the elderly into toilet cubicles. Furthermore, male facilities process users much faster due to the spatial efficiency of urinals, a compact fixture absent in standard female facilities. Consequently, the 1:1 footprint allocation directly causes the chronic, global phenomenon of extended queuing outside women's restrooms. Urban feminism argues that achieving genuine equity requires an asymmetrical allocation of physical space—often a 2:1 or 3:1 ratio in Favor of female facilities—to equalize the actual waiting time and usability outcomes.

The lack of adequate, safe female toilets acts as a severe, hidden barrier to female workforce participation, social inclusion, and overall urban mobility. To pre-empt the trauma of navigating filthy, overcrowded, or unsafe public toilets, many women

practice "defensive dehydration"—actively restricting their fluid intake before leaving the home or traveling to tourist destinations. This forced behavioural adaptation leads to chronic health issues, including recurring urinary tract infections (UTIs) and renal complications, thereby imposing a quantifiable physical, health, and economic penalty directly linked to infrastructural failure.

2.5.2 Transgender and LGBTQ+ Inclusive WASH Infrastructure

The structural violence embedded in urban sanitation is magnified exponentially for transgender and gender non-conforming (TGNC) individuals. Despite significant legal recognition in India—such as the landmark Supreme Court judgment in *National Legal Services Authority (NALSA) v. Union of India (2014)* and the *Transgender Persons (Protection of Rights) Act (2019)*, which affirmed the right to self-perceived gender identity—public infrastructure remains rigidly entrenched in a binary (male/female) design logic.

This binary structure prioritizes administrative standardization over social diversity, forcing TGNC individuals into spaces where their presence disrupts deeply ingrained cis-heteronormative expectations. In male-designated toilets, TGNC individuals, particularly trans women, are often perceived as threats to conventional constructions of masculinity and male sexuality, exposing them to severe risks of verbal abuse, sexual harassment, and physical assault. Conversely, in female-designated toilets, trans men and masculine-presenting individuals are frequently viewed with suspicion and violently evicted under the false premise that they are predators intruding into women's privacy. The hypervisibility of TGNC individuals in binary restrooms transforms a basic biological function into a site of intense psychological distress, surveillance, and social regulation.

The psychological toll of this infrastructural exclusion is severe. Research indicates that TGNC youth who feel unsafe in public bathrooms exhibit significantly lower levels of resilience and overall quality of life, alongside heightened problematic anxiety and internalized stigma. As a coping mechanism, many transgender individuals entirely shun public spaces, avoiding overcrowded or dimly lit areas, which severely restricts their employment opportunities, educational access, and civic participation. Furthermore, TGNC individuals who have undergone gender-affirming medical procedures often require more frequent restroom access or specific hygienic

conditions—needs that are entirely overlooked in binary sanitation planning.

To achieve transformative spatial justice, sanitation discourse must shift from mere distributive infrastructure provision to recognizing dignified access as a fundamental human right. Inclusive Citywide Sanitation (CWIS) frameworks mandate the integration of standalone, gender-neutral, or all-gender cubicles equipped with floor-to-ceiling doors, internal washbasins, and sanitary disposal bins. These architectural interventions counteract cis-heteronormativity, mediating identity, visibility, and belonging to ensure that no social group is systematically excluded from the urban public realm.

2.6 Technological Innovations and Smart Sanitation Governance

As metropolitan areas and tourist hubs grapple with escalating footfalls, changing climate parameters, and constrained municipal budgets, conventional schedule-based maintenance of public toilets is increasingly failing. A facility cleaned at 8:00 AM may be rendered entirely unusable by 9:00 AM due to a sudden influx of tourist buses or transit commuters. To sustain the exacting standards mandated by frameworks like SBM 2.0 and HRWS-PS, global cities are pioneering data-driven, IoT-enabled (Internet of Things) sanitation governance, transitioning from reactive maintenance to proactive management.

2.6.1 The DFEC Model: Singapore's Happy Toilet Programme

The absolute pinnacle of smart sanitation governance is exemplified by the Restroom Association (Singapore)'s Happy Toilet Programme (HTP). Established initially in 1998 and formalized as a grading initiative in 2003, the HTP utilizes a rigorous star-grading system (ranging from 3 to 6 stars) based on a comprehensive 108-point evaluation covering design, cleanliness, maintenance effectiveness, and user satisfaction.

To achieve premium certifications (4 stars and above), facilities are strictly mandated to integrate the

DFEC (Detect, Feedback, Eliminate, Clean) model. The DFEC model represents a holistic technological paradigm shift designed to optimize resource allocation and guarantee pristine public hygiene.

Table 4 The DFEC (Detect, Feedback, Eliminate, Clean) Technological Integration Model:

DFEC Component	Technological Integration and Operational Mechanism
Detect	Utilizing Low Power Wide Area Networks (LoRaWAN), inexpensive IoT sensors are retrofitted into the washroom ecosystem without the need for complex rewiring. These include footfall counters, inventory sensors (monitoring soap and paper levels), and smart bin capacity monitors. Crucially, the system deploys ammonia detectors that continuously monitor ambient air quality. When specific malodor thresholds are breached, the system automatically triggers a targeted maintenance alert.
Feedback	Facilities are equipped with interactive feedback tablets positioned at the exit. This allows users to rate their experience or instantly report specific defects—such as wet floors, broken locks, or empty soap dispensers—in real-time, bridging the gap between user perception and facility management.
Eliminate	The architectural integration of preventative materials, such as anti-stain surfaces, self-cleaning protective coatings, and specialized "looscaping" (internal landscaping utilizing specific flora to neutralize odours and improve psychological perception), actively eliminates the build-up of grime, bacteria, and negative user impressions.
Clean	The deployment of automated, touchless hardware, including self-powered sensor taps, automated flush valves, and high-speed fast-drying hand dryers. This reduces physical touchpoints, mitigating the spread of pathogens, and minimizes the dispersion of contaminated water onto the floor, thereby preventing slip hazards and bacterial growth.

The continuous data stream generated by the DFEC model is fed into a centralized digital dashboard, allowing facility managers to transition to "Outcome-Based Contracting". Instead of relying on arbitrary, rigid cleaning schedules, cleaning crews

receive real-time push notifications directing them to a specific cubicle the exact moment ammonia levels rise or a user reports an issue. This targeted deployment maximizes labour efficiency, drastically reduces water and chemical wastage, and guarantees a consistently pristine environment, thereby directly addressing the critical "Safety and Quality" dimension of the HRWS-PS framework. The incorporation of these smart systems ensures that public toilets remain resilient, hygienic, and highly functional, regardless of volatile tourist footfalls.

2.7 Synthesis of Literature and Identification of Research Gaps

The synthesized literature reveals that effective public sanitation in high-footfall tourist zones operates at the complex intersection of rigid statutory engineering, macro-economic tourism strategies, socio-spatial equity, and smart governance. While Indian planning norms (NBC 2016, URDPFI) provide the structural calculus for facility provision, and the SBM-U 2.0 guidelines elevate the qualitative benchmark via the Aspirational Toilets mandate, there remains a critical gap in on-ground, localized implementation.

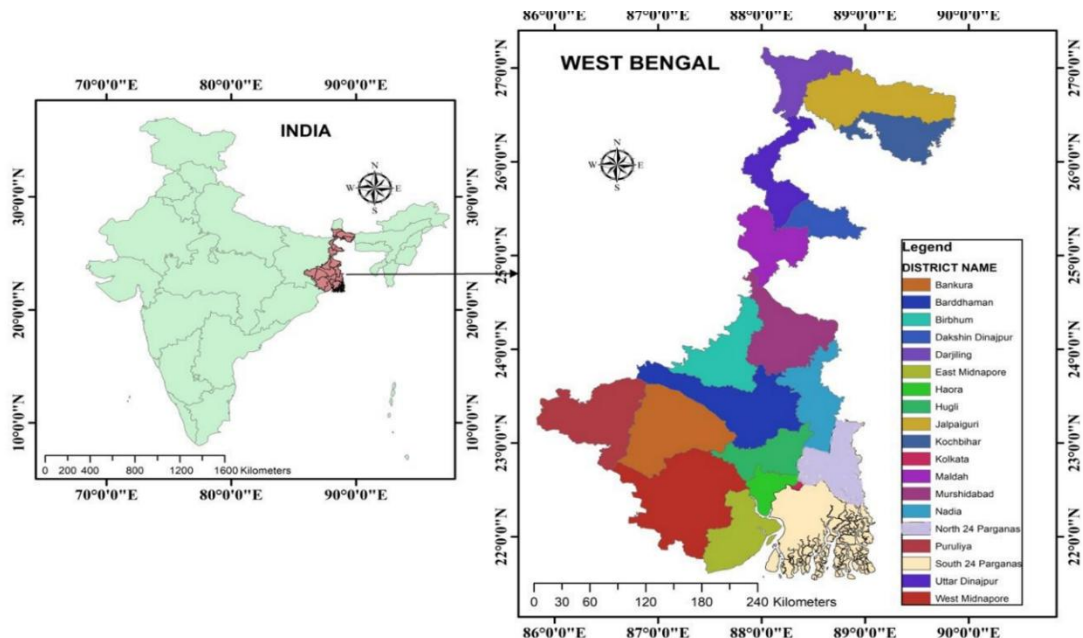
The HRWS-PS theory and urban feminist discourse critically expose that mere physical availability does not equate to equitable accessibility. The persistent reliance on binary spatial ratios and aesthetic-first design actively disenfranchises women, transgender individuals, the elderly, and the disabled, manifesting in severe public health and economic penalties that ultimately degrade a city's tourism potential. Furthermore, while smart technologies like Singapore's DFEC model offer a proven, data-driven roadmap for sustained operational excellence, their adoption in heritage-sensitive and resource-constrained Indian contexts remains highly nascent.

This research bridges these identified gaps by utilizing the Sanitation Condition Index (SCI) and spatial analysis to empirically audit existing facilities in Kolkata against these advanced global paradigms. By mapping physical infrastructure deficits and subjective user perceptions against the theoretical mandates of spatial justice and the technological potential of IoT integration, this study aims to formulate targeted, context-specific planning interventions. The ultimate goal is to align Kolkata's tourist infrastructure with the highest echelons of global sanitation standards, ensuring dignity, public health, and sustainable tourism growth.

Chapter 3: Study Area

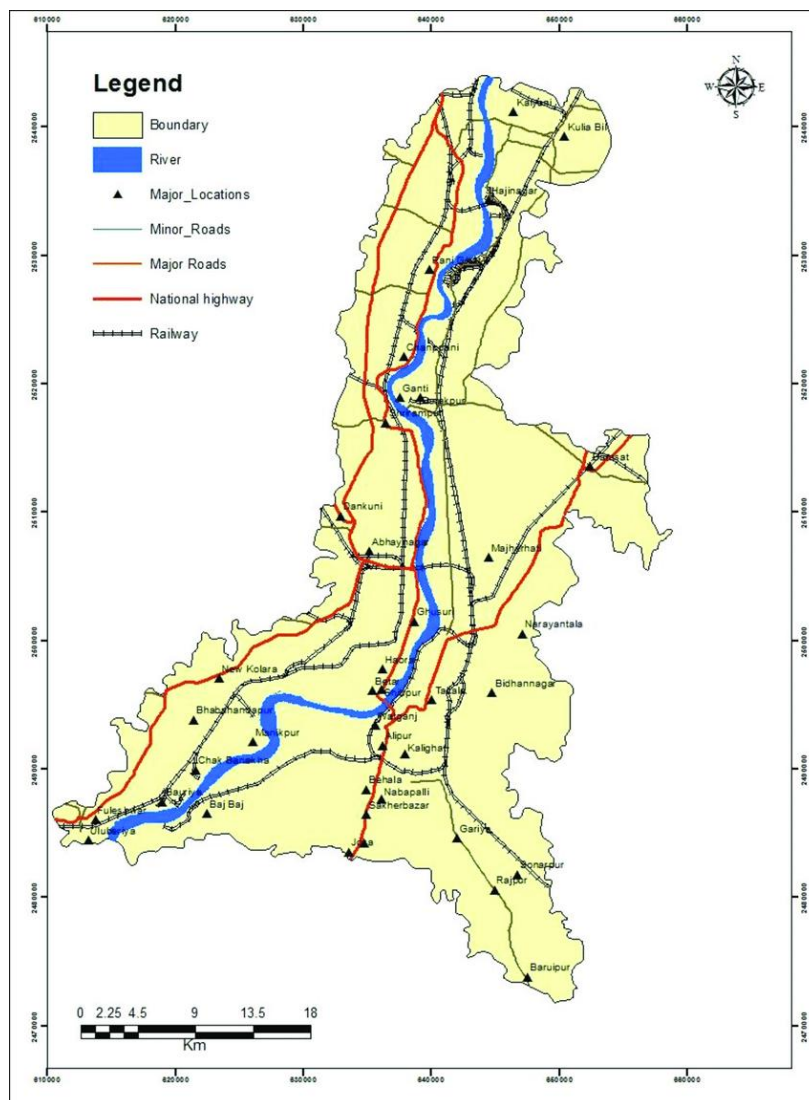
3.1 Regional Setting and Geographical Profile of the Kolkata Metropolitan Area

The spatial, environmental, and demographic context of this research is deeply embedded within the Kolkata Metropolitan Area (KMA), the capital of the state of West Bengal and the primary economic engine of Eastern India. Analysing the specific geographical constraints, historical development, and localized tourism dynamics of the city is an absolute prerequisite for contextualizing the subsequent infrastructural assessment and proposing viable engineering solutions. Kolkata is geographically situated at a longitude of $80^{\circ} 30' E$ and a latitude of $22^{\circ} 33' N$, sprawling along the eastern banks of the Hooghly River, a major distributary of the Ganges. The city's topography is remarkably flat, lying at an average altitude of merely 9 meters (30 feet) above sea level, with certain central and eastern zones dipping as low as 6.4 meters (20 feet).

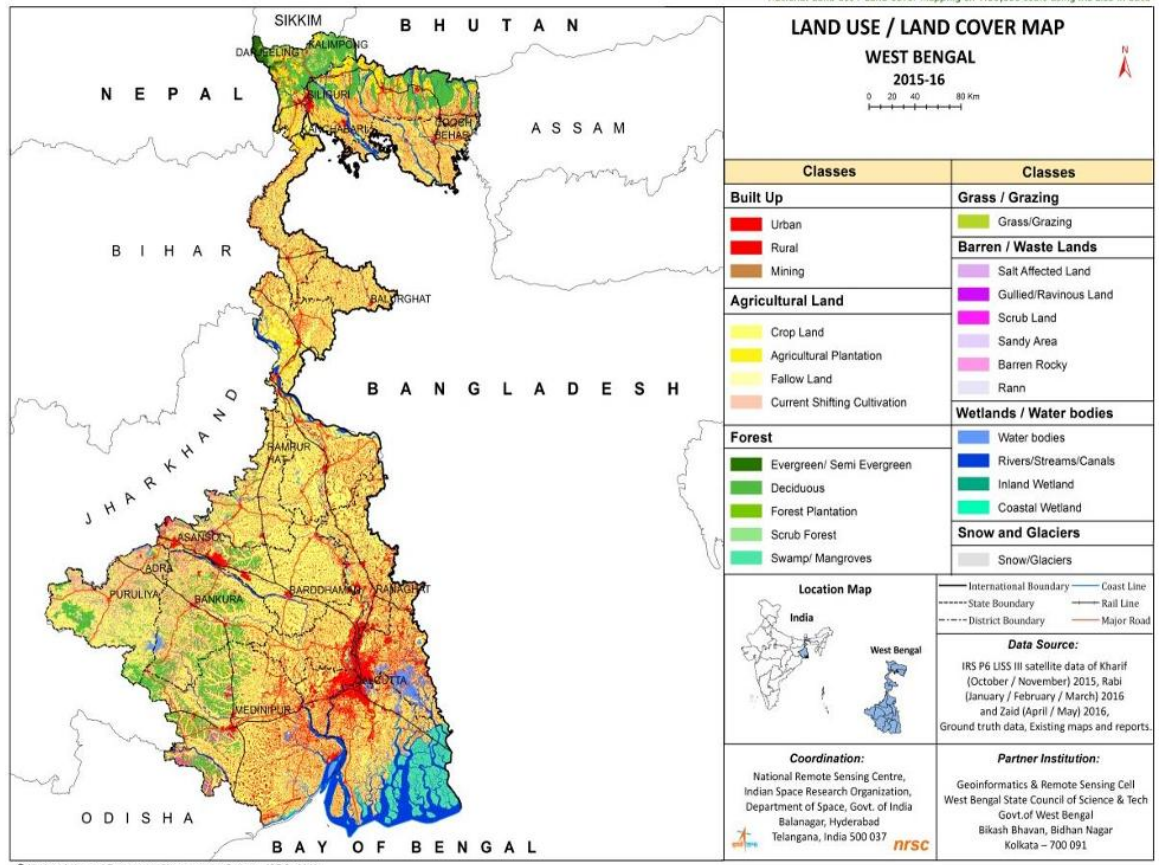


Map 2: Location map of study area

Administratively, the Kolkata Municipal Corporation (KMC) jurisdictional area spans approximately 205 square kilometres, while the broader, highly integrated Greater Kolkata metropolitan region, stretching from Baruipur in the south to Kalyani in the north and Bansberia to Budge Budge, covers a massive 1,480 square kilometers. The city is historically divided into three distinct zones that reflect its evolution: Old Kolkata (comprising Sutanuti, Chitpur, Baghbazar, Sobhabazar, and Hatkhola), Central Kolkata (the administrative heart including Dharmatala, Bowbazar, and Janbazar), and New Kolkata (modern expansions in the north like Sinthi and Cossipore, and in the south like Tollygunge and Behala).



Map 3: Kolkata Administrative boundary Map



Map 4: Land use/Landcover of West Bengal

The land use and land cover (LULC) profile of the region indicates an extremely dense built-up core that has expanded linearly along the river banks. Historically, the city grew haphazardly, leading to a "premature metropolis" characterized by high population absorption but lagging infrastructure. This unplanned peripheral growth has exerted a huge strain on the existing land, economy, and basic infrastructure of the city. Consequently, the rise in urban spatial poverty has become more evident in terms of the quality of water, sanitation, and sewerage. The urban fabric is further defined by its proximity to the East Kolkata Wetlands, a Ramsar site that traditionally served as a natural wastewater treatment system but has faced degradation due to encroachment and neglect.

Table 5 Basic Geographical and Demographic Statistics of Kolkata:

Basic Statistics of Kolkata	Value / Detail
Latitude / Longitude	22 ⁰ 33'N / 80 ⁰ 30' E

Average Altitude	9m (Central) to 6.4m (Eastern)
KMC Area	205 sq. km
Total KMA Area	1,480 sq. km
Global Rank (Area/Pop)	7th biggest city in India
Administrative Units	16 Boroughs, 144 Wards
Road Space Ratio	6% of total city area

3.2 Climatological Trends and Environmental Vulnerabilities

Kolkata's regional climate is officially characterized as a tropical wet-and-dry environment, featuring a highly humid and oppressive summer contrasted by a mild and pleasant winter. The city is subject to intense monsoonal precipitation, with an average annual rainfall of 158 cm to 183 cm, heavily concentrated between the months of June and September. This flat topography combined with intense seasonal rainfall creates severe, perennial challenges for subsurface drainage, wastewater management, and the structural integrity of underground sanitation engineering, necessitating highly resilient infrastructure designs.

3.2.1 Temperature and Humidity Profiles

The thermal profile of the city exhibits high ambient temperatures and oppressive humidity, especially during the pre-monsoon months of April and May. Maximum temperatures regularly fluctuate between 24⁰C and 42⁰C, while winter minimums range from 8⁰C to 26⁰C on average. Recent longitudinal studies indicate a rising trend in minimum temperatures, signifying a decrease in nocturnal cooling and an intensification of the Urban Heat Island (UHI) effect. Kolkata has the highest recorded urban warming among global megacities over the past seven decades, with a rise of about 2.6⁰ C (4.7⁰F) between 1950 and 2018.

Humidity levels vary from 65% to 85% during the summer months, exceeding pleasant levels in the winter. The combination of high heat and moisture creates a significant bioclimatic stress on both residents and tourists. The UHI effect, driven by rapid urbanization and the replacement of green cover with concrete and asphalt, results in localized temperature increases of up to 3⁰ C in dense environments. This phenomenon is particularly acute in the central and northern parts of the city, including hotspots like

Kidderpore, Chitpur, and Cossipore.

3.2.2 Precipitation and Flooding Dynamics

The city's aging Victorian-era drainage system, which is over 140 years old, is increasingly unable to handle contemporary climate extremes. The system was originally designed for a much smaller population and a lower intensity of rainfall. On September 23, 2025, Kolkata received more than 12% of its average annual rainfall—some 247.5 mm—in just 24 hours, leading to widespread flooding, fatalities from electrocution, and property damage. The interaction between a high-water table, tidal backflow from the Hooghly River, and clogged canals creates a perennial flooding crisis.

Flooding in Kolkata is not merely an environmental issue but a failure of urban governance. The city's green cover has declined below 30%, while historic canals like Tolly's Nalla have deteriorated into toxic conduits unable to manage storm surges. The lack of proper maintenance and the deposition of solid waste in sewer lines exacerbate waterlogging, which can linger for up to two days in low-lying informal settlements. This environmental factor directly impacts public sanitation, as heavy rains often cause sewer overflows and render ground-level toilets inaccessible, increasing the risk of waterborne diseases like typhoid and hepatitis.

Table 6 Seasonal Climate and Precipitation Guide for Kolkata:

Seasonal Climate Guide	Months	Temperature (°C)	Rainfall/Humidity
Summer	March - June	24 – 42	High humidity (65-85%); Nor'westers
Monsoon	June - Sept	25 - 35	Heavy rainfall (avg 158-183 cm)
Post-Monsoon	Oct - Nov	20 – 35	Cyclonic activity; retreating monsoon
Winter	Dec - Feb	8 - 26	Low humidity; pleasant weather

3.3 Demographic Evolution and the Floating Population

Challenge

Kolkata represents one of the most intensely congested urban environments on the planet. The city's demographic structure is defined by a stagnant core population and a rapidly expanding peripheral metropolitan region, complicated by a massive daily influx of non-residents.

3.3.1 Population Distribution and Density

Based on historical census data and 2026 projections, the population within the KMC limits is estimated at approximately 6.77 million, while the broader metropolitan area exceeds 21.15 million. The population density within the corporation limits is staggering, reaching approximately 24,760 to 25,000 persons per square kilo meter. In specific administrative units, such as Ward 45 (Central Business District) and Ward 63, the density is even higher during daylight hours due to commercial activities.

The literacy rate of the city is progressively high at 81.31% to 86.31%, with a sex ratio of approximately 908 to 956 females per 1,000 males. Hinduism represents the majority religion at 76.51% to 78%, followed by a significant Muslim minority at approximately 20%.

3.3.2 The Floating Population Phenomenon

A critical factor for urban planning in Kolkata is the "floating population," which is estimated at a staggering 6 million individuals per day. This demographic includes daily commuters from neighbouring districts like Howrah, Hooghly, and North/South 24 Parganas, interstate bus passengers, and domestic and international tourists. Unlike the residential population, this group relies exclusively on public infrastructure for their sanitation and waste disposal needs.

Standard ward-level planning often ignores this sudden surge in demand, leading to massive shortfalls in facility coverage at transit nodes and tourist hubs. The spatial inequity in sanitation provision is most evident when comparing affluent residential neighbourhoods (where water and sewerage coverage is often 100%) to high-footfall areas like Kalighat or Babughat, where immediate access to clean toilets is sparse. Even

at major high-footfall transit points like Howrah and Sealdah Stations, the provision of toilets—especially for women—is grossly inadequate relative to the population served.

3.3.3 Urban Poverty and Informal Settlements

Approximately 31.35% of Kolkata's residents—roughly 1.41 million people—live in one of the city's 5,600 registered or unregistered slums (*bastis*). These areas are characterized by derelict housing, critically disproportionate access to drinking water and sanitation, and high overcrowding. Residents in these settlements face severe health risks, particularly during the monsoon when waterlogging persists for days. The residents of these settlements often serve as the backbone of the city's informal economy, providing services to the middle class as drivers, maids, and casual labourers, yet they are the most marginalized in terms of civic infrastructure.

Table 7 Population Distribution of Selected KMC Wards (2011):

KMC Ward Population (2011)	Ward Number	Population
Ward 45 (CBD)	45	8,394
Ward 63 (Park St/Maidan)	63	24,387
Ward 71 (Kalighat)	71	29,922
Ward 83 (Kalighat)	83	22,163
Ward 58 (Eastern)	58	88,465

3.4 Socio-Economic Framework and Sectoral Distribution

Kolkata is the undisputed primary business, commercial, and financial hub of Eastern India, contributing approximately 25% of West Bengal's total GDP. The regional economy is characterized by a high degree of "flexible production" and a dominant tertiary sector that has eclipsed the city's historic manufacturing base.

3.4.1 Sectoral Dominance and Employment

The city's workforce is heavily concentrated in the tertiary sector, which accounts for 83.69% of all employment. Key industries include financial services, banking (headquarters of UCO Bank and Bandhan Bank), steel, heavy engineering, and a rapidly growing IT/ITeS sector. The city also hosts the oldest stock exchange in India, the

Calcutta Stock Exchange.

The manufacturing sector, once the city's mainstay, has been in a general decline since independence due to factors like militant trade-unionism and infrastructure bottlenecks. The historic jute-processing industry, established in the 1870s, still maintains a presence along the Hooghly banks, but engineering and light manufacturing now constitute the primary industrial output.

3.4.2 The Informal Economy and Street Vendors

The informal sector is a foundational element of Kolkata's economy, employing more than 40% of the total workforce. This includes a vast network of street vendors, hawkers, and casual laborers. In commercial hubs and near tourist spots, street vendors are social and economic institutions that connect rural producers directly with urban consumers.

An estimated 2.7 to 3 lakh street vendors operate in Kolkata, with a high concentration in areas like B.B.D. Bagh, New Market, Gariahat, and the temple precincts. While these vendors stimulate economic activities by creating backward linkages and offering low-price options, they are often excluded from formal planning. Only about 5,422 vendors have benefited from government loan schemes like PM SVANidhi due to documentation hurdles. The lack of formal recognition forces many vendors to pay "usuli" (informal commissions) to local enforcement to avoid eviction, further marginalizing this vital segment of the labor force.

3.4.3 Socio-Economic Impact of Inadequate Sanitation

The poor state of public toilets imposes disproportionate physical and economic costs on marginalized populations. Surveys indicate that 51% of women report that the inadequacy of inclusive and well-maintained public toilets restricts their mobility to work outside the home, impacting their income and working hours. Furthermore, many women actively limit fluid intake to avoid using public facilities, placing them at risk of adverse health outcomes like urinary tract infections (UTIs). This sequence of poor infrastructure leading to health risks and resultant self-restriction from the public sphere creates a quantifiable economic and health penalty on the most vulnerable workers in the tourism and informal sectors.

Table 8 Key Economic and Employment Indicators for Kolkata:

Economic Indicator	Value / Detail
GDP (PPP) 2024	\$220 Billion
Tertiary Sector Share	83.69% of workforce
Informal Sector Share	40%+ of labour force
Estimated Street Vendors	2.7 to 3.0 Lakh
State GDP Growth	7% annual average

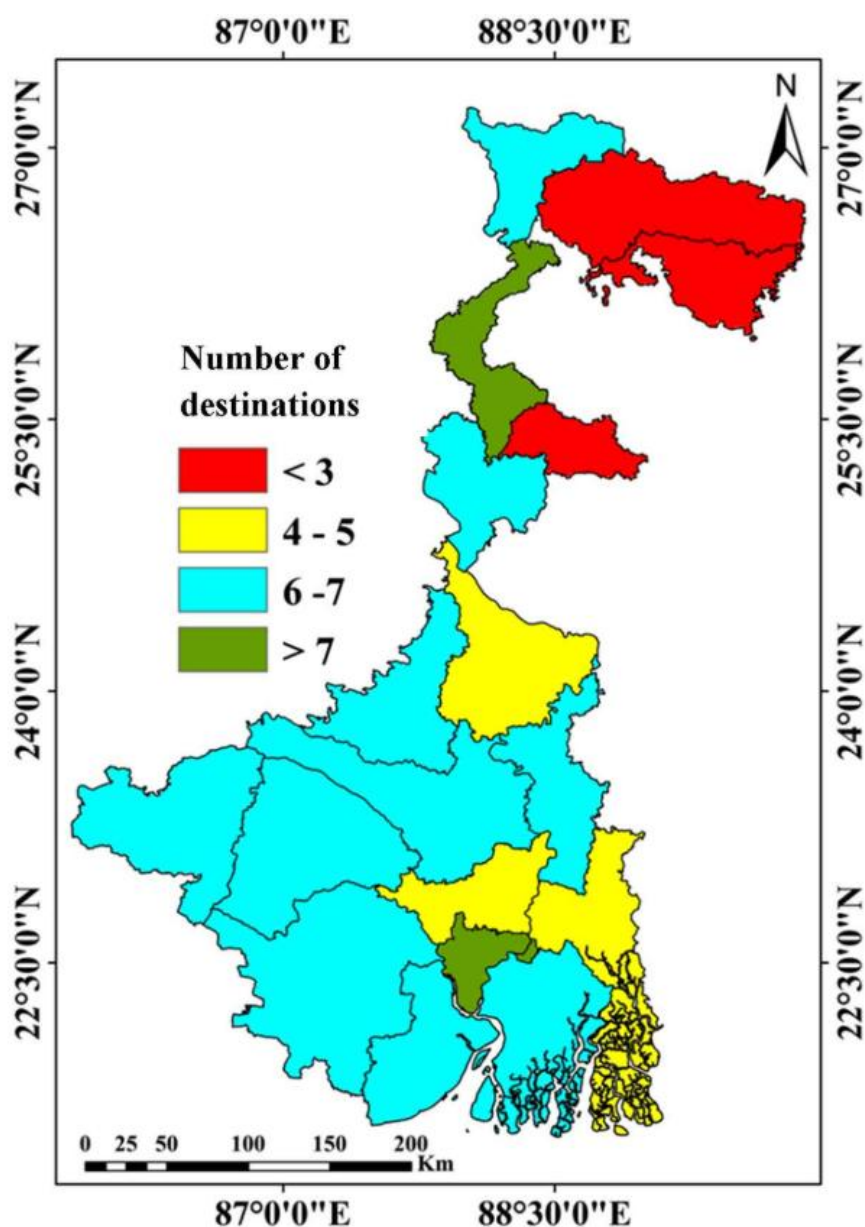
3.4.4 Tourism Economy and Visitor Footfall

West Bengal has emerged as a powerhouse in the Indian tourism sector, with Kolkata acting as the primary gateway and cultural anchor. The state is currently ranked as the second most visited destination for international tourists in India, following only Maharashtra.

State-Level and Metropolitan Trends

In 2024, West Bengal attracted a record 3.12 million foreign visits, a 15% increase from 2023, accounting for roughly 14.9% of all foreign arrivals in India. This growth is driven by the state's diverse cultural heritage, festivals, and colonial history. Overall, the state received approximately 18.5 crore tourists in 2024.

The tourism sector contributes approximately 5% to India's GDP and accounts for 12.57% of total jobs. In Kolkata, tourism is an economic multiplier that sustains a wide range of industries, including hospitality, transportation, and handicrafts. The city district possesses the highest concentration of categorized tourist destinations in the state, with more than seven major destinations located within the KMC limits.



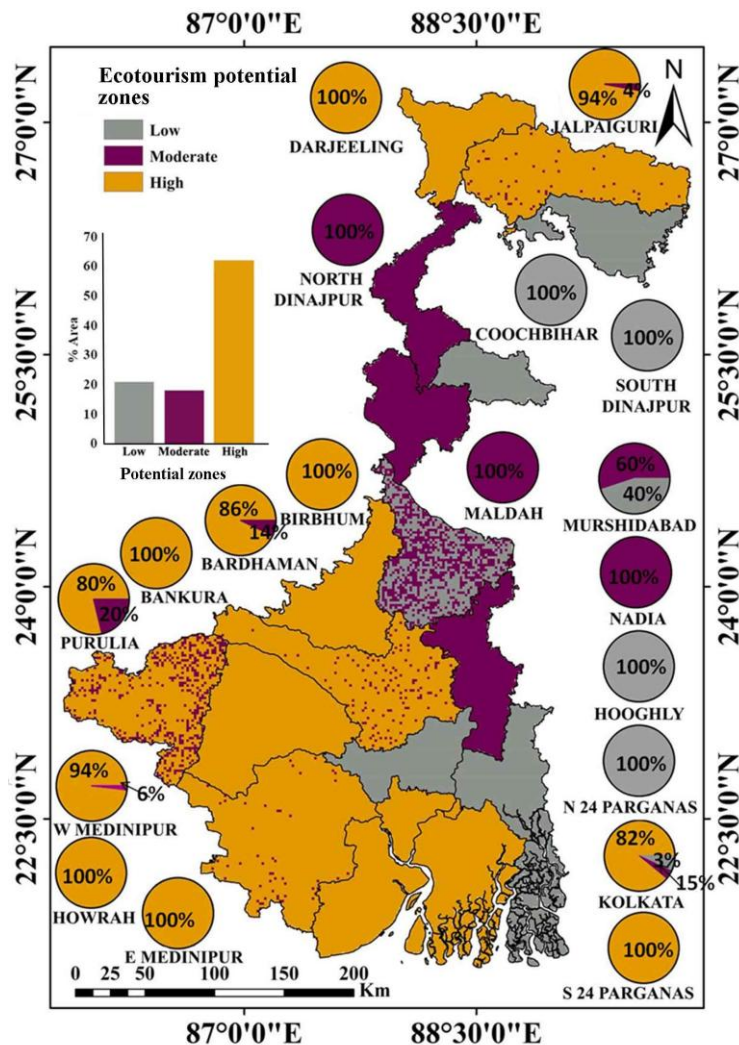
Map 5 Tourist Destinations

3.4.5 Festival Tourism and Spikes in Demand

Tourism in Kolkata is highly seasonal, peaking during the winter months (December recording the highest arrivals) and during major religious festivals. The recognition of Durga Puja as a UNESCO Intangible Cultural Heritage has led to a significant surge in both domestic and international visitors who come to see the city transform into a massive installation art platform.

During the six days of Durga Puja in 2024, Kolkata airport saw its highest footfall ever, with nearly 4 lakh flyers. Similarly, the Kolkata Metro network handled over 46.56 lakh passengers during the festival, with Kalighat station recording the single highest footfall

on the entire network. These sudden spikes in pedestrian and transit volumes place immense localized stress on sanitation infrastructure, often exceeding the capacity of existing facilities.



Map 6: Ecotourism Potentiality Zones

3.4.6 Religious and Heritage Tourism Multipliers

The economic impact of religious tourism is particularly profound at sites like the Kalighat Temple. The "Temple Economy" supports thousands of livelihoods, from priests and shopkeepers selling *puja* offerings to street vendors and budget hotel operators. Studies indicate that pilgrimage tourism can contribute up to 7% to a regional economy, with significant multiplier effects. Similarly, the Victoria Memorial, with its 5 million annual visitors, acts as a primary anchor for the formal heritage tourism sector,

supporting high-end hotels and commercial centres in the central city.

Table 9 Tourism Metrics and Major Visitor Footfall Statistics:

Tourism Metric	Value / Detail
Foreign Tourist Arrivals (WB 2024)	3.12 million
National Rank (Foreign Arrivals)	2nd in India
Victoria Memorial Annual Visitors	5 million
Durga Puja Airport Footfall (2024)	approx. 4Lakh
Metro Ridership (Puja Peak)	9.82 Lakh in a single day

3.5 Multimodal Connectivity and Transport Hierarchy

The study area is serviced by one of the most complex and diverse transit systems in India, comprising an expanding underground metro network, a vast suburban rail system, historic trams, and a robust riverine ferry service.

The Kolkata Metro Expansion

Kolkata is home to India's first underground railway system, which has been operational since 1984. As of 2025, the network is undergoing a significant expansion to bridge the city's disparate nodes.

1. **Blue Line (Line 1):** The north-south spine connecting Dakshineswar to Kavi Subhash. It remains the most utilized corridor, carrying 18.93 crore passengers in 2024-25.
2. **Green Line (Line 2):** The East-West corridor, which includes India's first underwater metro section under the Hooghly River. The section between Sealdah and Esplanade opened in August 2025, increasing ridership from 78,000 to over 2.04 lakh per day. This line is critical for connecting the IT hub of Sector V with the transit hub of Howrah Station.
3. **Purple Line (Line 3):** Currently operational between Joka and Majerhat. The section from Majerhat to Esplanade is under construction and will include a dedicated station for the Victoria Memorial.
4. **Orange Line (Line 6):** Connecting New Garia to the airport. Completion has been delayed by a 366-meter "missing link" at the Chingrighata intersection,

which prevents seamless connectivity with the IT hub.

5. **Yellow Line (Line 4):** A 18-km corridor from Noapara to Barasat via the airport, with the first phase becoming operational in 2025.

3.5.1 Road and Bus Network Dynamics

Kolkata is characterized by a uniquely low road space ratio of only 6%, compared to 23% in Delhi. This limited capacity leads to chronic congestion, particularly at intersections where motorized and non-motorized modes coexist. Between 2016 and 2024, vehicle registrations surged—four-wheelers increased five-fold while two-wheelers surged 12-fold.

Babughat serves as one of the city's three main bus termini, alongside Esplanade and Howrah Station. It is a critical hub for interstate buses traveling to Bihar, Jharkhand, and Odisha, and it handles thousands of passengers daily. These bus termini are the primary arrival points for the floating population, but they often lack basic urinal and eating facilities, leading to a degraded user experience.

3.5.2 Riverine and Suburban Rail Connectivity

The Hooghly River acts as a vital transport spine. Ferry services managed by the Inland Waterways Corporation and WBSTC connect Babughat to Howrah, Telkal Ghat, and Bally. These services are essential for commuters seeking to avoid the peak-hour traffic rush on the Howrah Bridge. Furthermore, the Kolkata Circular Railway features the Eden Gardens station adjacent to Babughat, allowing commuters to board and disembark directly within the riverfront precinct.

Table 10 Multimodal Transit Connectivity and Passenger Frequencies:

Transit Mode	Line / Route	Footfall / Frequency
Metro Blue Line	Dakshineswar-Kavi Subhash	5-15 min frequency
Metro Green Line	Howrah-Salt Lake Sector V	2.04 Lakh daily riders
Ferry	Babughat-Howrah	30 min frequency; ₹7-10 fare
Interstate Bus	Babughat Terminus	81 routes to Bihar, Odisha, etc.
Suburban Rail	Sealdah/Howrah	Over 1 million daily footfall each

3.6 Victoria Memorial Precinct: The Heritage and Leisure

Landmark

The Victoria Memorial is Kolkata's premier monumental structure and museum, standing as a globally recognized icon of the city. Built between 1906 and 1921, it was envisioned by Lord Curzon as a "stately, spacious, and grand" tribute to the memory of Queen Victoria.

3.6.1 Architectural Morphology and Design

Designed by architect William Emerson, the memorial is an "exquisite blending of the Oriental and Occidental," characterized by the Indo-Saracenic Revival style. The building is constructed of white Makrana marble—the same source as the Taj Mahal—and measures 338 by 228 feet, rising to a height of 184 feet. The design deliberately echoes the Taj Mahal, featuring a central dome 64 feet in diameter, four subsidiary domes, and corner towers.

The structure is crowned by a 16-foot bronze "Angel of Victory" that rotates with the wind. The facade is adorned with allegorical sculptures representing Art, Architecture, Justice, and Charity. Inside, the memorial houses 25 distinct galleries containing over 50,000 artifacts, including the Kolkata Gallery which chronicles the city's visual history.

3.6.2 Urban Context and Tourism Profile

The memorial is situated in the middle of 64 acres (26 hectares) of sprawling gardens at the southern end of the Maidan. These gardens, designed by Lord Redesdale and David Prain, bridge the gap between traditional English "parks" and geometric Mughal gardens, creating pristine environmental surroundings in the heart of the city.

With 5 million annual visitors, the Victoria Memorial is one of the most popular cultural destinations in India. The site handles a diverse range of visitors, from affluent international tourists and students to local families and morning walkers. This high-profile status requires maintenance that meets international standards for cleanliness and barrier-free access. Currently, accessibility is robust, with the Rabindra Sadan and Maidan metro stations nearby, and the future Purple Line adding a dedicated "Victoria" station.

Table 11 Site Profile of the Victoria Memorial Precinct:

Victoria Memorial Site Profile	Detail
Construction Period	1906 - 1921
Architectural Style	Indo-Saracenic Revival
Material	White Makrana Marble
Garden Area	64 Acres (26 Hectares)
Annual Visitors	5 Million
Owner	Ministry of Culture, Govt. of India

3.7 Kalighat Temple Enclave: The Sacred and Mass Tourism Center

The Kalighat Temple, situated tightly beside the Adi Ganga River, is one of the most potent pilgrimage centers in India. Universally recognized as one of the four *Adi Shakti Peethas*, it is the site where Sati's right toe is believed to have dropped during the cosmic dance of destruction.

3.7.1 Morphology and Historical Evolution

The temple in its current form is approximately 200 years old, completed in 1809 under the patronage of the Sabarna Roy Chowdhury family. Architecturally, it follows the *ath-chala* style of Bengal temple design, featuring gabled roofs that emulate the thatched huts of rural Bengal. The structure is a four-sided building with a truncated dome and two roofs bearing a total of eight faces. The outer walls are designed with diamond-shaped chessboard patterns in green and white.

The urban morphology surrounding the temple is a hyper-dense, labyrinthine fabric characterized by narrow alleys and historic bazaars. This organic, unplanned growth has resulted in severe physical space constraints, making the deployment of large-scale

modern sanitation infrastructure exceptionally difficult. The temple precinct is an active site of worship where structural integrity must be balanced with the uninterrupted continuation of sacred rituals.

3.7.2 Pilgrimage Dynamics and Sanitation Issues

Kalighat represents "Mass Religious Tourism," with extremely high and volatile daily footfall. The site handles hundreds of thousands of devotees annually, with massive surges during festivals like Kali Puja, Durga Puja, and the Snan Yatra. On special occasions, daily footfall can reach 2 to 3 lakh people.

The sanitation dynamics at Kalighat are uniquely complex. The demand is driven by specific ritual-based needs, such as holy dipping in the temple's Kundupukur tank and traditional bathing in the adjacent river. The site generates massive amounts of organic, floral, and religious waste daily. Furthermore, the practice of daily animal sacrifice (*pathabali*) adds to the environmental stress. Chronic poor maintenance and the lack of trash bins have historically led to littering in the temple alleys, with devotees, priests, and shopkeepers often treating the surroundings as a contiguous waste bin. A recent 2024 renovation has improved ventilation and waste removal, but the "proximity gap" for basic toilets remains a significant structural planning failure.

Table 12 Site Profile of the Kalighat Temple Enclave

Kalighat Temple Site Profile	Detail
Present Structure Built	1809
Architectural Style	Ath-chala (Bengal Temple Style)
Religious Importance	Adi Shakti Peeth (1 of 4)
Ritual Waste Sources	Flowers, belpatas, animal sacrifice
Peak Demand Season	Sept-Nov (Durga & Kali Puja)
Accessibility Status	Poor (410m walk to nearest facility)

3.8 Babughat Transit Node: The Gateway and Waterfront Precinct

Babughat, located prominently on the eastern bank of the Hooghly River, is a historically significant ghat that has evolved into one of Kolkata's most critical multimodal transit junctions.

3.8.1 Historical and Architectural Significance

Originally known as the Babu Raj Chandra Das Ghat, it was built in 1830 by Rani Rashmoni, the zamindar of Janbazar, in memory of her late husband. Architecturally, the landing berth features a tall and grand pavilion built in the Doric-Gothic style with massive decrepit pillars. A marble tablet at the site indicates that Lord William Bentinck encouraged the construction as part of an effort to improve public facilities, highlighting its 19th-century role as a social reform initiative.

3.8.2 Multi-Functional Urban Role

Babughat serves a dual function that creates a unique set of planning challenges. It acts simultaneously as a prominent riverfront leisure and ritual space, and as a massive multimodal transit hub.

The hub functions include:

- **Interstate Bus Terminus:** One of the three main termini in Kolkata, hosting buses traveling to Bihar, Jharkhand, and Odisha.
- **Ferry Terminal:** Managing cheap and timely ferry services across the Hooghly River to reach Howrah Station and Bally.
- **Railway Connectivity:** Adjacent to the Eden Gardens station of the Kolkata Circular Railway.
- **Ritual and Leisure Space:** Busy from morning to late evening with people performing bathing, puja, religious ceremonies (like Chhat Puja), and leisure activities.

3.8.3 Transit-Linked Tourism and Sanitation Pressure

The floating population utilizing Babughat is highly transient, moving rapidly between transport modes. This generates a continuous, high-volume demand for immediately

accessible public conveniences. However, the old colonial structure and stairs leading to the river are in various stages of decay and derelict. The pavilion is currently encroached upon by vendors and priests, and a section of the ghat originally meant for women's bathing has turned into a garbage dumping point. Commuters frequently report the lack of clean urinals and eating options, which degrades the image of this vital gateway to the city.

Table 13: Precinct Profile of the Babughat Transit Node

Babughat Precinct Profile	Detail
Year Established	1830
Architecture Style	Doric-Gothic Pavilion
Transit Modes	Bus, Ferry, Circular Rail
Interstate Destinations	Bihar, Jharkhand, Odisha
Cultural Events	Chhath Puja, Ganga Aarti, Idol Immersion
Accessibility Rating	Poor (331m to nearest facility)

3.9 Synthesis of Study Area Characteristics and Planning

Inferences

The three selected sites—Victoria Memorial, Kalighat Temple, and Babughat—represent three distinct "Tourism Typologies" in Kolkata, each presenting unique morphology and spatial planning challenges for public sanitation.

3.9.1 Comparative Spatial patterns

The spatial dimension of sanitation delivery in these areas reveals extreme, systemic inequity. The Victoria Memorial precinct is robustly and adequately serviced, featuring five separate facilities within an immediate 200-meter primary catchment area. This pattern reflects a well-planned infrastructure appropriate for a major international heritage site.

Conversely, both Babughat and Kalighat exhibit exactly zero immediate provision within the critical 200-meter radius. At Kalighat, the 410-meter walk to the nearest

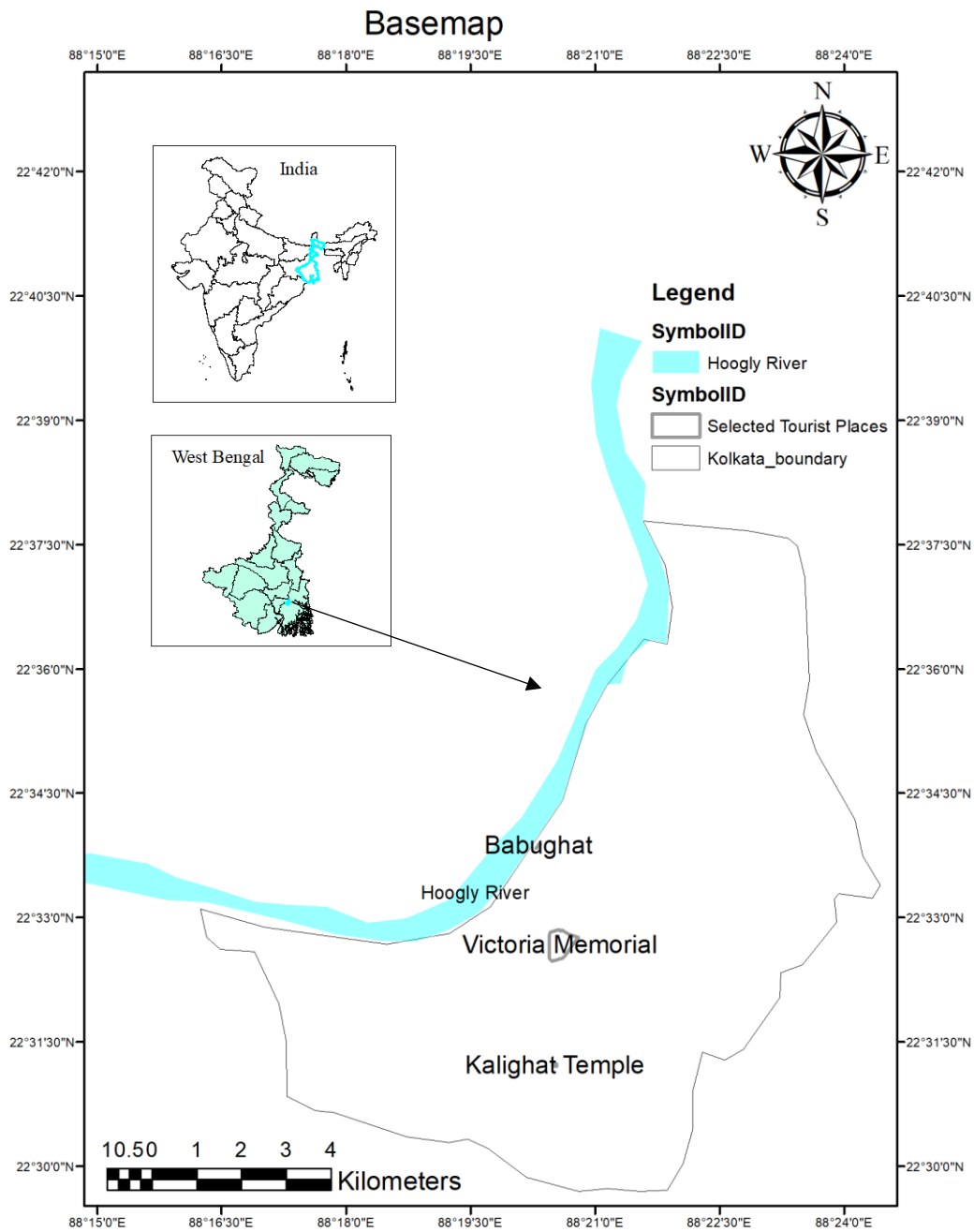
facility through a congested urban fabric directly violates planning norms, such as the 500-meter maximum normative standard observed in cities like Melbourne. This spatial mismatch forces weary pilgrims and transit users to walk significant distances, leading directly to the high incidence of open urination observed in these precincts.

3.9.2 Synthesis of Planning Challenges

Table 14: Comparative Synthesis of Urban Planning Challenges Across Study Sites

Challenge Category	Victoria Memorial	Kalighat Temple	Babughat
Environmental	High heat stress (UHI)	Waterlogging; River pollution	Riverine waste discharge
Morphological	Heritage-sensitivity	Hyper-density; Lack of land	Multi-functional sprawl
Demographic	Sightseeing tourists	Mass pilgrim surging	Rapid-turnover commuters
Accessibility	Excellent	Poor	Moderate
Waste Type	Litter; Plastics	Ritual; Floral; Animal	Transit-related; Garbage

The undeniable planning inference drawn from this data is that sanitation facilities in Kolkata are not proportionately distributed with respect to user demand. There is a profound discrepancy between the abstract formal city (as seen at Victoria Memorial) and the messy reality of the "lived spaces" in high-footfall transit and religious zones. The city must transition away from ad-hoc, historically biased facility placement toward a balanced, data-driven redistribution strategy that prioritizes equity and actual demographic surge demand.



Map 7: Basemap of Study Area



Babughat



Victoria Memorial



Kalighat Temple

Chapter 4: Case Studies (Indian and International)

The formulation of a robust sanitation strategy for Kolkata's high-profile tourist precincts necessitates an exhaustive examination of successful paradigms across diverse geographical and administrative contexts. A rigorous analysis of both Indian and international models reveals that the transition from a failing public utility to a high-performance civic asset is predicated on the convergence of three critical pillars: innovative financial modeling, the deployment of cutting-edge technology, and a data-driven spatial planning framework. The following case studies delineate the operational mechanics of leaders in the field, providing a technical and qualitative benchmark for the specific challenges identified at Babughat, Victoria Memorial, and the Kalighat Temple precinct.

4.1 Indian Case Studies: The Indian Context of High Footfall and Cultural Heritage

Urban sanitation in India is currently undergoing a transformative phase under the aegis of the Swachh Bharat Mission (SBM) 2.0, shifting focus from mere "Open Defecation Free" (ODF) status to the creation of "Garbage Free Cities" and "Aspirational Toilets". The following cases highlight how Indian municipalities have navigated the complexities of high-density "floating populations," sensitive heritage regulations, and the perennial challenge of sustainable operations and maintenance.

4.1.1 Indore, Madhya Pradesh: The "Lootel" Model and IoT-Enabled Self-Sustainability

Indore has maintained its status as the cleanest city in India for eight consecutive years, a feat achieved through a meticulous blend of solid waste segregation, decentralized composting, and innovative Public-Private Partnerships (PPP). A cornerstone of this success is the "Lootel" (Loo of Hotel) model, which addresses the systemic failure of traditional municipal maintenance by transforming public restrooms into commercially

viable "Smart Toilet Cafes".

The Lootel model operates on a "Pay, Use, and Redeem" mechanism, which fundamentally alters the user's economic relationship with public infrastructure. Users pay a nominal fee to access a premium, hospital-grade restroom facility. Upon exit, they receive a digital or physical voucher of equivalent value, redeemable for food, beverages, or other services at an attached commercially operated kiosk or cafe. This cross-subsidization is highly effective; empirical data indicates that approximately 70% of the facility's overall revenue is derived from commercial sales, while direct restroom fees account for only 30%. This ensures that the facility covers its capital expenditure (CAPEX) and operating expenditure (OPEX) within a short timeframe, typically achieving self-sufficiency within 12 months.

From a technical perspective, the Lootel facilities are integrated with a sophisticated Internet of Things (IoT) backbone managed by the Indore Smart City Development Limited (ISCDL). These "Smart Toilets" utilize an array of sensors to ensure consistent hygiene standards without the need for constant human supervision.

Table 15:IoT Technical Components of the Indore "Lootel" Smart Toilet Model

Technical Component	Specification and Functionality
Odor Monitoring	Real-time ammonia (NH ₃) sensors that trigger automated ventilation and ozonization when thresholds are breached.
Occupancy/Footfall	Bi-directional infrared sensors (PX 25A) to track utilization rates and predict cleaning cycles.
Water & Waste Management	Smart fill-level sensors in overhead tanks and waste chambers to prevent overflows and service interruptions.
Environmental Hygiene	Automated UV/Ozonisation cleaning systems and self-cleaning protective coatings (infused anti-stain materials) on tiles and basins.

The governance of these facilities is equally innovative. Under the PPP agreement, the Indore Municipal Corporation (IMC) facilitates rapid approvals for business licenses and provides the necessary land, water, and sewage connections. In return, the private operator handles all construction and maintenance risks. Furthermore, Indore has

pioneered the use of IoT-based systems to generate revenue through carbon credits. By digitizing civic assets—including solar-powered restrooms and bio methanation units—the city captures data on methane reduction and renewable energy generation. This data allowed Indore to earn ₹8.34 crore in climate finance between 2021 and 2022, which is reinvested into urban sustainability projects. For a city like Kolkata, the Lootel model presents a viable strategy for high-value land parcels like those surrounding the Victoria Memorial, where premium user expectations can be leveraged for commercial cross-subsidization.



LOOTEL SERVICES
SMART TOILET CAFÉ: THE PAY, USE AND REDEEM MECHANISM



4.1.2 Gangtok, Sikkim: Legislative Rigor and the Pedestrianization of M.G. Marg

Gangtok represents a premier model for sanitation in hilly terrains and pedestrian-centric commercial zones. The city consistently ranks high in the Ministry of Tourism's Cleanliness Index, largely due to its uncompromising enforcement of public behaviour and the strategic pedestrianization of M.G. Marg. The transformation of M.G. Marg into a vehicle-free promenade resulted in a significant rise in public satisfaction, from 76% to 86%, and an 82% positive response from local merchants regarding increased business and footfall.

The administrative backbone of Gangtok's cleanliness is the "Solid Waste Management Cleanliness and Sanitation Byelaws-2019". These byelaws provide a rigorous legal framework for maintaining the public realm, supported by a specialized force of "Nuisance Detectors" equipped with uniforms and official monitoring vehicles.

Table 16: Penalty Structure under Gangtok's Solid Waste and Sanitation Byelaws

Offense Category	Byelaw Number	Penalty (INR)
General Littering	Byelaw 5.1	₹500/-
Public Spitting	Byelaw 5.2	₹500/-
Public Urination/Defecation	Byelaw 5.3	₹500/-
Pet Animal Littering	Byelaw 7.5	₹500/-

Burning of Waste	Byelaw 5.11	₹500/-
Obstruction of Sweeping (Parking)	Byelaw 7.9	₹1000/-

The Gangtok model emphasizes that infrastructure alone is insufficient; it must be coupled with behavioural change and strict enforcement. The "WOW – War on Waste" initiative, launched in early 2026, utilizes 21 dedicated teams led by municipal engineers to conduct outreach and monitoring. This program focuses on mandatory source segregation into four streams: biodegradable (wet), non-biodegradable (dry), domestic hazardous, and sanitary waste. For the Kolkata study, Gangtok's success suggests that creating "pedestrian-only" nodes around heritage or transit zones (such as Babughat) can significantly reduce environmental degradation if supported by a localized fine-based enforcement system.

4.1.3 Hampi, Karnataka: Decentralized Engineering in Sensitive Heritage Precincts

The Hampi World Heritage Site, a UNESCO-listed sprawling landscape of medieval ruins, presents the ultimate challenge in heritage-sensitive sanitation. The objective is to provide modern amenities for a massive international and domestic "floating population" without physically or visually disrupting the archaeological integrity of the Vijayanagara ruins.

Following warnings from UNESCO regarding the construction of unauthorized modern bridges and structures, the Hampi World Heritage Area Management Authority (HWHAMA) adopted an "integrated management" approach. This involves the use of decentralized, "invisible" infrastructure. Instead of excavating the fragile core zone to install centralized sewer lines—which could destroy buried artifacts—HWHAMA utilizes advanced bio-digester technology developed by the Defence Research and Development Organization (DRDO).

The bio-digester is a self-contained anaerobic treatment system that breaks down human excreta into usable water and odourless gas through a continuous biological process. The biochemical mechanism within the digester tank follows a specific four-stage metabolic pathway:

1. Hydrolysis: Complex organic polymers → Simple monomers (sugars, amino acids)

2. Acidogenesis: Monomers→ Volatile fatty Acids (VFA)
3. Acetogenesis: VFA- Acetic acids, H_2 , and CO_2
4. Methanogenesis: Acetic acid/Hydrogen- CH_4 (Methane)
And H_2O

The resulting liquid effluent is pathogen-free (reduction of >99%) and can be reused for landscape irrigation, which is critical in Hampi's arid environment. This technology allows for the placement of "plug-and-play" toilet units in sensitive locations, such as near the Queen's Bath or the Virupaksha Temple, without risking the environmental degradation of the Tungabhadra River or the contamination of groundwater. Furthermore, the architectural shell of these facilities is strictly regulated under the Hampi Master Plan 2021 to ensure they blend with the natural bouldered landscape using local stone and timber. This model is directly applicable to Kolkata's Maidan and Victoria Memorial area, where the High Court and heritage committees restrict large-scale construction.



Karnataka's Hampi to be developed as iconic tourism site, announces Centre

4.2 International Case Studies: Architectural Innovation, Spatial Spacing, and Quality Grading

Global sanitation leaders demonstrate how public toilets can be transformed from marginalized "back-alley" utilities into celebrated civic landmarks through the application of advanced data analytics and high-end design.

4.2.1 Tokyo, Japan: The "Tokyo Toilet" Project and Behavioral Nudging

In preparation for the Tokyo Olympics, the Nippon Foundation launched the "Tokyo Toilet" project in the Shibuya district. The project's central thesis was to eliminate the social stigma of public toilets—which are often perceived as dark, dirty, and dangerous—by hiring 16 world-renowned architects, including Pritzker Prize winners Shigeru Ban, Tadao Ando, and Fumihiko Maki, to design 17 public restrooms.

Each facility was designed to solve specific behavioural or psychological barriers to use:

Table 17 Architectural Innovations and Designs of The Tokyo Toilet Project:

Facility Name	Designer	Key Innovation and Technical Specification
Haru-no-Ogawa Park	Shigeru Ban	Smart Glass Technology: Walls remain transparent when vacant (allowing users to check for cleanliness and intruders) but turn opaque instantly when the door is locked.
Nanago Dori Park	Kazuo Sato	Hi Toilet: Fully voice-activated, contactless system where all commands (flush, door, taps) are triggered by AI-trained voice recognition to maximize hygiene.
Jingu-Dori Park	Tadao Ando	Amayadori: Circular structure with vertical metal louvers and an <i>engawa</i> (veranda) to promote natural cross-ventilation and a sense of safety through sightlines.
Nishisando	Sou Fujimoto	Urban Watering Place: Features an elongated communal hand-washing fountain with five faucets at varying heights to encourage gathering and multi-age accessibility.
Nabeshima Shoto Park	Kengo Kuma	A Walk in the Woods: Five decentralized huts clad in 240 random-angled Yoshino cedar boards, creating an open, breezy "toilet village" suitable for post-pandemic safety.

The Tokyo model demonstrates that design can be a powerful tool for "behavioural nudging." By making the facilities aesthetically striking and technologically advanced,

the perception of "publicness" shifts from a liability to an asset. Furthermore, the project mandates extreme inclusivity: every toilet is wheelchair accessible, equipped with high-tech "Washlets," and many include ostomate facilities for people with medical needs. The use of "Andon" (lantern) lighting concepts in the Nishihara Itchome Park toilet ensures that the structure also serves as a safety light for the entire park after dark.



THE TOKYO TOILET



4.2.2 Melbourne, Australia: The 500-Meter Spacing Standard and CPTED Planning

The City of Melbourne's Public Toilet Strategy (2014-2023) and its 2023-2033 successor provide a masterclass in data-driven spatial planning. The city's core objective is to ensure that public toilets are "accessible, inclusive, and safe" by using rigorous spatial distance norms and Geographic Information Systems (GIS).

A primary planning parameter used in Melbourne is the "500-meter spacing rule." The city mandates that a public toilet must be available within a maximum walking distance of 500 meters in all high-pedestrian, commercial, and transit zones. This norm ensures that service gaps are eliminated, and the "loo leash"—the psychological constraint where people restrict their movement based on toilet proximity—is broken.

Table 18: Strategic Pillars and Implementation Standards of Melbourne's Public Toilet Strategy

Strategic Pillar	Implementation Detail and Standards
Spatial Spacing	Maximum 500m between units in activity centres; 400m walkable catchment for neighbourhood parks.
CPTED Principles	Crime Prevention Through Environmental Design: Highly visible locations, open layouts, and entrances oriented toward active pedestrian streets to deter anti-social behaviour.

Universal Design	"Changing Places" facilities that go beyond standard ADA/DDA compliance, including tracking hoists, showers, and adult-sized change tables.
Digital Wayfinding	Integration with the "National Public Toilet Map," providing real-time data on accessibility, opening hours, and specific features via a GIS interface.
Modular Deployment	Increasing use of prefabricated modular units (e.g., Exeloo Galaxy) to reduce construction time and cost while maintaining high durability.

Melbourne also utilizes a sophisticated tiered maintenance schedule. Toilets in high-load areas are cleaned up to six times daily during the peak summer season and twice daily during cooler months, with at least one cleaning session occurring after-hours. The city has begun trialing non-invasive data counters and environmental sensors to detect odor thresholds, allowing cleaning crews to move from fixed schedules to demand-responsive maintenance.

4.2.3 Singapore: The "Happy Toilet" Certification and the DFEC Operational Model

Singapore addresses the qualitative dimension of sanitation through the Restroom Association (Singapore)'s "Happy Toilet Programme" (HTP). This initiative uses a star-grading system (ranging from 3 to 6 stars) based on a comprehensive 108-point checklist covering design, cleanliness, maintenance, effectiveness, and user satisfaction.

To achieve the "Magnificent" 6-star rating, a facility must not only achieve a near-perfect score (at least 104 out of 108 points) but must also adopt all four components of the DFEC smart model:

1. **Detect:** The use of IoT sensors to autonomously monitor ammonia levels, user traffic, water usage, and the availability of consumables like hand soap and paper towels.
2. **Feedback:** The installation of interactive digital feedback panels where users can instantly record dissatisfaction.



HAPPY TOILET PROGRAMME

These systems complement sensors by validating automated data with human perception.

3. **Eliminate:** The application of long-term self-cleaning protective coatings on high-touch surfaces to prevent grime and moisture, and the use of green sanitizers like ozonated water.
4. **Clean:** The adoption of advanced cleaning machinery and self-cleaning user facilities, such as bidets and integrated hand-drying taps that eliminate the need for paper waste.

The HTP system also professionalizes the workforce. All attendants cleaning 6-star toilets must have completed Singapore Workforce Skills Qualifications (WSQ) modules in washroom cleaning and inspection. This ensures that the high-tech infrastructure is supported by trained, dignified labour. The HTP's effectiveness is validated through frequent "mystery audits" by Volunteer Eco-Assessors (VEA) during the certificate's one-year validity period. For a high-load site like the Kalighat Temple in Kolkata, adopting a localized version of the HTP—where contractor payments are directly tied to an objective star-rating—could provide the accountability currently missing in municipal management.

4.3 Integration Strategy: Implementation of Case Insights into the Kolkata Thesis

The insights derived from these global and domestic case studies are not merely academic; they form the logical basis for the strategic planning interventions proposed for Kolkata. The following table delineates exactly how each case study element should be integrated into the existing mid-thesis report structure to replace and expand the current "Literature & Case Studies" sheet (Sheet 3).

Table 19: Strategy for Integrating Global Case Study Insights into the Kolkata Assessment

Case Study Element	Application in Kolkata Report
Indore LooTel	Propose a PPP framework for Victoria Memorial and North-West

Model	Maidan to ensure O&M sustainability through commercial cross-subsidization.
Gangtok Fine System	Propose a "Tourist Sanitation Bylaw" with localized spot fines for littering and spitting at transit nodes like Babughat.
Hampi Bio-digesters	Recommend DRDO-developed bio-digester units for the environmentally sensitive riverfront of Babughat and heritage precincts.
Tokyo Design Logic	Propose "Aspirational" high-visibility designs (e.g., "Hi Toilet" voice-AI) to combat the negative "Stinking Loos" perception in Kolkata.
Melbourne 500m Rule	Use as the primary benchmark for the "Gap Analysis" to justify new facility siting in identified "Cold Spots".
Singapore HTP/DFEC	Recommend a "Happy Toilet" star-rating system for KMC to monitor contractor performance and install interactive user feedback panels.

4.4 Synthesis and Conclusion

The comparative analysis of these six sanitation models reveals a clear trajectory for modern urban planning. The most successful cities have moved beyond viewing public toilets as "isolated cabins" to seeing them as "connected nodes" within a broader smart city and heritage management network. Indore demonstrates that financial viability can be achieved through PPPs and climate finance; Gangtok proves that legislative enforcement is the bedrock of clean public spaces; and Hampi provides a technical solution for infrastructure in sensitive historic landscapes.

Internationally, Tokyo shows how design can solve psychological barriers; Melbourne offers a data-driven spatial rule for equitable distribution; and Singapore provides an operational blueprint for maintenance excellence. For Kolkata, the immediate strategy must involve bridging the "accessibility gap" identified at Kalighat and Babughat—where current distances to facilities exceed 400 meters—using the modular, decentralized, and smart-monitored technologies highlighted in these case studies. By weaving these international standards into the local planning framework, the Kolkata Municipal Corporation can ensure that its sanitation infrastructure not only meets basic

human rights standards but actively enhances the city's image as a global cultural destination.

Chapter 5: Data Collection and Analysis

The provision of public sanitation infrastructure represents one of the most significant challenges for urban planning in hyper-dense metropolitan environments like Kolkata. This chapter details the data collection protocols, the methodological framework for primary research, and the subsequent analytical processes employed to evaluate the state of public facilities near Babughat, the Victoria Memorial, and the Kalighat Temple. The study utilizes a bifurcated approach, combining objective technical audits of the built environment with subjective surveys of the floating population to determine the efficacy of service delivery in high-footfall tourist zones.

5.1 Primary Data Collection Protocols and Instrument Design

The research methodology relies on primary data generated through two distinct survey instruments deployed via digital platforms. These instruments were designed to capture the duality of the sanitation crisis: the physical condition of the assets and the social acceptability of the services provided. By utilizing mobile-based data collection, the researcher ensured the inclusion of real-time geospatial tagging and high-resolution documentation of existing facilities.

5.1.1 Protocol for Form 1: Public Sanitation Infrastructure Assessment Survey

The first instrument, titled the "Public Sanitation Infrastructure Assessment Survey," was administered exclusively by the researcher through on-site observation. The goal of this technical audit was to provide a standardized, unbiased evaluation of the existing infrastructure without the influence of user subjectivity. This survey targets three specific locations—Babughat (transit/waterfront), Victoria Memorial (heritage/leisure), and Kalighat Temple (religious/pilgrimage)—because they represent distinct "Tourism Typologies" with unique sanitation demands.

The design of Form 1 focuses on the structural integrity, functional availability, and

maintenance standards of the facilities. The data generated through this audit serves as the baseline for the Sanitation Condition Index (SCI) and the objective component of the "Perception vs. Reality" gap analysis.

Table 20: Form 1: Public Sanitation Infrastructure Assessment Survey Parameters

Category	Parameter / Question	Response Options / Scale
Site Identification	Name of Location	Babughat / Victoria Memorial / Kalighat Temple
Availability	Is a public toilet available near the tourist spot?	Yes / No
Capacity	Number of toilet units available	0 / 1 / 2-3 / More than 3
Typology	Type of facility	Public toilet (free) / Pay-and-use toilet / Temporary-mobile toilet
Accessibility	Distance from main tourist entry point to nearest toilet	Less than 100m / 100-250m / 250-500m / More than 500m
Gender Inclusion	Availability of separate toilets	Yes (Male/Female) / No
Wayfinding	Is the toilet easily visible/signposted?	Yes / No
Physical Audit	Cleanliness level	Star Rating (1 = Very Poor to 5 = Very Good)
	Water availability	Star Rating (1 = Very Poor to 5 = Very Good)
	Lighting condition	Star Rating (1 = Very Poor to 5 = Very Good)
	Ventilation standard	Star Rating (1 = Very Poor to 5 = Very Good)
	Maintenance level	Star Rating (1 = Very Poor to 5 = Very Good)
	Safety (especially for women)	Star Rating (1 = Very Poor to 5 = Very Good)
Qualitative	Remarks (Optional)	Open-ended text for major

Notes		observed issues
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The technical rationale for including specific parameters like "signage visibility" and "separate blocks for women" is rooted in the Swachh Bharat Mission (SBM) Urban 2.0 guidelines for "Aspirational Toilets". These guidelines mandate that in high-footfall areas, facilities must not only be present but must also be inclusive and easily locatable to prevent the formation of "Yellow Spots" (open urination areas). The observation of water availability and ventilation standards is critical because, as per the CPHEEO Advisory, functional design (supply and drainage) must precede aesthetic considerations.

Public Sanitation Infrastructure Assessment Survey

For Planning Thesis topic- ASSESSMENT OF PUBLIC SANITATION FACILITIES NEAR TOURIST SPOTS IN KOLKATA

aditya2022manit@gmail.com [Switch account](#)

Not shared

* Indicates required question

Name of Location *

- ☐ Babughat
- ☐ Victoria Memorial
- ☐ Kalighat temple

Is a public toilet available near the tourist spot? *

- ☐ Yes
- ☐ NO

Number of toilet units available

- ☐ 0
- ☐ 1
- ☐ 2-3
- ☐ More than 3

Type of facility

- ☐ Public toilet (free)
- ☐ Pay-and-use toilet
- ☐ Temporary/mobile toilet

Distance from main tourist entry point to nearest toilet

- ☐ Less than 100 m
- ☐ 100-250 m
- ☐ 250-500 m
- ☐ More than 500 m

Availability of separate toilets

- ☐ Yes (Male/Female)
- ☐ No

Is the toilet easily visible/signposted?

- ☐ Yes
- ☐ No

Condition Assessment (Rate 1-5)
(1 = Very Poor, 5 = Very Good)

Your answer

Cleanliness

- 1 2 3 4 5
- ☆ ☆ ☆ ☆ ☆

Water availability

- 1 2 3 4 5
- ☆ ☆ ☆ ☆ ☆

Lighting condition

- 1 2 3 4 5
- ☆ ☆ ☆ ☆ ☆

Ventilation

- 1 2 3 4 5
- ☆ ☆ ☆ ☆ ☆

Maintenance level

- 1 2 3 4 5
- ☆ ☆ ☆ ☆ ☆

Safety(especially for women)

- 1 2 3 4 5
- ☆ ☆ ☆ ☆ ☆

Remarks (Optional)

Major issues observed

Your answer

Submit

Clear form



5.1.2 Protocol for Form 2: Tourist Perception on Public Sanitation Facilities

The second instrument, "Tourist Perception on Public Sanitation," was designed to capture the lived experience of the users. This survey was conducted via face-to-face intercepts with the floating population, including domestic visitors, local residents, and international tourists. The importance of user perception cannot be overstated; urban planning literature indicates that if a facility is perceived as dirty or unsafe, tourists will avoid it regardless of its technical functionality, leading to a breakdown in the city's public health system.

Tourist Perception on Public Sanitation Facilities

For Planning Thesis topic- ASSESSMENT OF PUBLIC SANITATION FACILITIES NEAR TOURIST SPOTS IN KOLKATA

aditya2022manit@gmail.com [Switch account](#)

Not shared

* Indicates required question

Location *

☐ Babughat

☐ Victoria Memorial

☐ Kalighat Temple

Age *

☐ Below 18

☐ 18-30

☐ 30-50

☐ Above 50

Gender *

☐ Male

☐ Female

☐ Prefer not to say

Did you use a public toilet here?

☐ Yes

☐ No

If NOT Used

Why did you not use the toilet?

☐ Could not find it

☐ Too dirty

☐ Too crowded

☐ Prefer other options

How easy was it to locate the toilet?

(1 = Very Poor, 5 = Very Good)

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Cleanliness of the toilet.

(1 = Very Poor, 5 = Very Good)

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Waiting time

☐ No wait

☐ less than 1 min

☐ 5-10 min

☐ More than 10 min

Are public toilets sufficient in this area?

☐ Yes

☐ No

☐ Not sure



1
2
3
4
5

☆
☆
☆
☆
☆

Waiting time

☐ No wait

☐ less than 1 min

☐ 5-10 min

☐ More than 10 min

Are public toilets sufficient in this area?

☐ Yes

☐ No

☐ Not sure

Overall satisfaction

(1 = Very Poor, 5 = Very Good)

1
2
3
4
5

☆
☆
☆
☆
☆

Suggestions for improvement

Your answer

Submit
Clear form

Table 21: Form 2: Tourist Perception on Public Sanitation Facilities Survey Parameters

Category	Question	Response Options / Scale
Demographics	Location of intercept	Babughat / Victoria Memorial / Kalighat Temple
	Age group	Below 18 / 18-30 / 30-50 / Above 50
	Gender	Male / Female / Prefer not to say
Usage Patterns	Did you use a public toilet here?	Yes / No
Barrier Analysis	If NOT used, why did you not use the toilet?	Could not find it / Too dirty / Too crowded / Prefer other options
Experience	How easy was it to locate the toilet?	Star Rating (1 = Very Poor to 5 = Very Good)
	Cleanliness of the toilet	Star Rating (1 = Very Poor to 5 = Very Good)
	Waiting time	No wait / < 1 min / 5-10 min / > 10 min
Planning	Are public toilets sufficient	Yes / No / Not sure

Adequacy	in this area?	
Global Satisfaction	Overall satisfaction score	Star Rating (1 = Very Poor to 5 = Very Good)
Improvement	Suggestions for improvement	Open-ended text box

The inclusion of the "Waiting Time" metric is a proxy for adequacy analysis. In urban centers like Kalighat, high waiting times often signal a mismatch between the current unit density and the actual demand generated by mass religious tourism. Similarly, the question regarding why a toilet was *not* used provides deep insight into the "Psychological Barriers" to sanitation, which are often overlooked in purely engineering-based assessments.

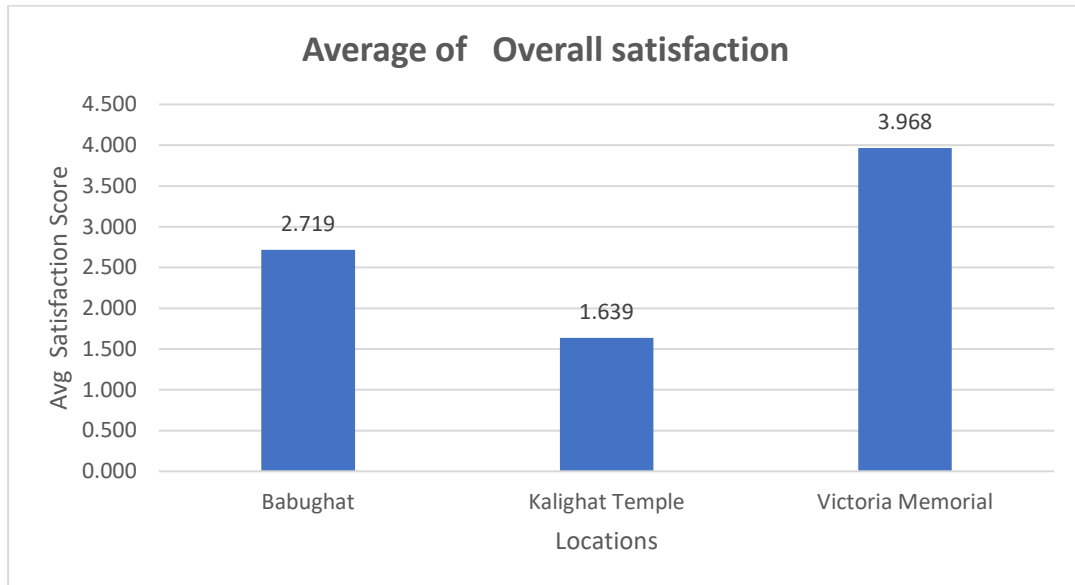
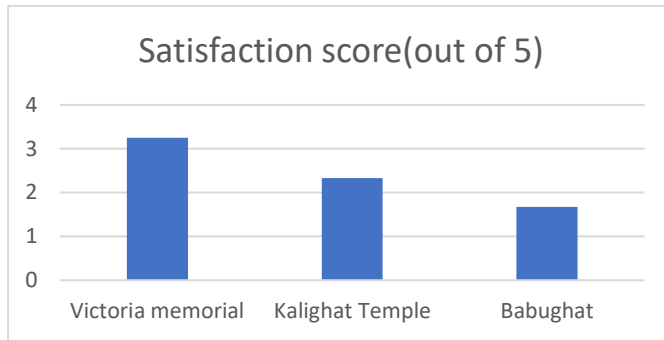
5.2 Statistical Evaluation and Quality Metrics

Following the collection of primary data, several statistical analyses were performed to convert raw responses into actionable planning metrics. These analyses focus on quantifying the disparity between municipal provision and public satisfaction, using the Sanitation Condition Index (SCI) as the primary technical benchmark.

5.2.1 Aggregate Tourist Satisfaction Analysis

of performance emerges:

- **Victoria Memorial:** Achieves the highest satisfaction level with a mean score of **4.13/5.0**. This indicates that the facility meets the "Aspirational" category standards, likely due to its placement within a regulated heritage zone with controlled access.
- **Babughat:** Exhibits moderate satisfaction scores, averaging **2.50/5.0**. This reflects the systemic strain on transit gateways where high turnover and a massive floating population outpace current maintenance cycles.
- **Kalighat Temple:** Represents a critical infrastructure failure with a satisfaction score of only **1.62/5.0**. The data suggests a severe "Service Level Gap," where the religious precinct's footfall is not met with commensurate sanitation services, leading to poor user perception.



5.2.2 Cleanliness vs. Location Analysis: The Perception-Reality Gap

This analytical step involves a comparative evaluation of the researcher's technical audit (Form 1) and the tourists' subjective experience (Form 2). The "Gap Analysis" chart produced from this data reveals a systemic variance across the three locations.

Table 22: Cleanliness vs. Location Gap Analysis (Objective Audit vs. Subjective Perception)

Site	Researcher Audit Score (Objective)	Tourist Perception Score (Subjective)	Service Gap (Variance)
Victoria Memorial	4.43	4.50	0.07
Babughat	2.38	2.20	-0.18
Kalighat Temple	1.75	1.40	-0.35

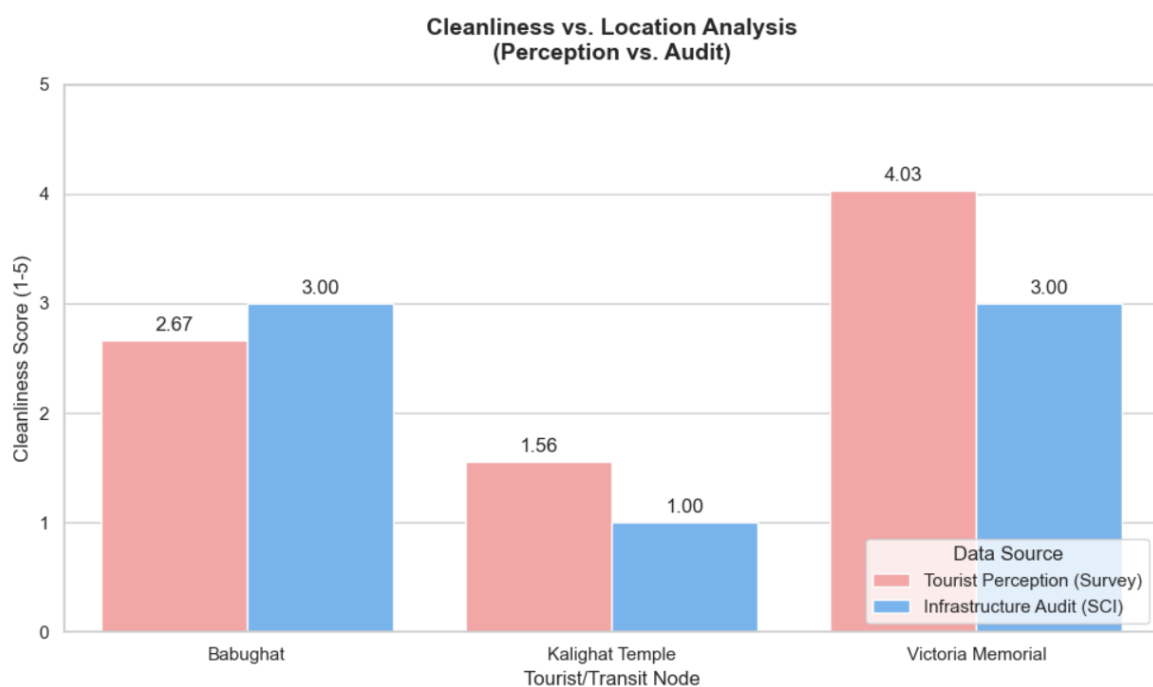
The "Heritage Premium" Effect (Victoria Memorial): With a score of **4.5**, this site represents the "Reality" of high-standard maintenance. From a planning perspective,

this is a **Managed Buffer Zone** where the entry-fee model or dedicated municipal attention ensures that cleanliness aligns with international tourist expectations. It meets the **NBC 2016** criteria for high-end public amenities.

The "Transit Stress" Gap (Babughat): The score of **2.2** reveals a significant **Perception-Reality Gap**. Despite being a major node for the "floating population" (ferry and bus commuters), the infrastructure is struggling under high usage density. In planning terms, the **cleaning frequency (Cycle Time)** is likely insufficient to match the footfall peak hours, leading to a "Sub-standard" classification.

The "Religious-Organic" Neglect (Kalighat): The lowest score of **1.4** identifies a critical infrastructure-behavioural gap. In dense, organic areas like Kalighat, the high footfall-to-seat ratio leads to rapid deterioration. The perception of "Unclean" here acts as a deterrent to usage, further exacerbating the issue of open urination in the immediate vicinity.

The data indicates a **3.1-point disparity** between the best-performing (Victoria Memorial) and worst-performing (Kalighat) locations. This suggests that sanitation quality in Kolkata's tourist spots is currently **site-specific** rather than **systemic**, highlighting a lack of uniform service level benchmarks (SLBs) across different land-use zones.



5.2.3 Sanitation Condition Index (SCI) Technical Breakdown

To provide a granular technical profile, the research utilized the Sanitation Condition Index (SCI), a composite metric that weights four core indicators of facility performance: Cleanliness, Water Availability, Lighting, and Maintenance.

The formula for the SCI is derived from a weighted average:

$$SCI = \frac{(C*W_C)+(W*W_W)+(L*W_L)+(M*W_M)}{\sum W}$$

Where C, W, L, and M represent the scores (1-5) for Cleanliness, Water, Lighting, and Maintenance, and the W values represent their respective weights (assigned based on user priority in Form 2).

Table 23: Component Breakdown of the Sanitation Condition Index (SCI) by Site

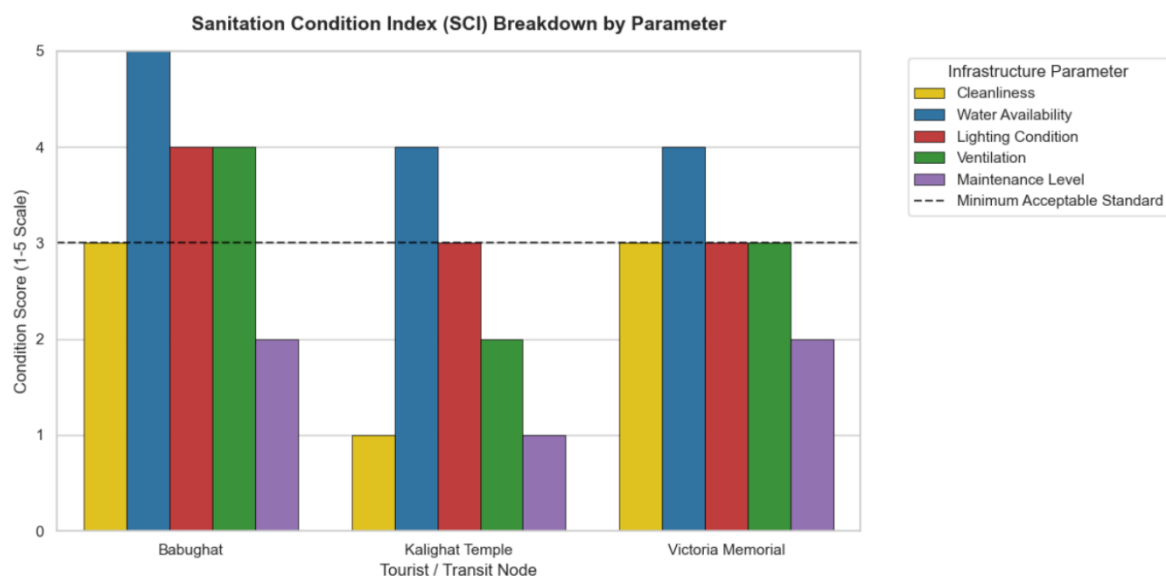
Metric	Babughat Score	Victoria Memorial Score	Kalighat Score
Cleanliness	2.2	4.5	1.4
Water Availability	2.8	4.8	2.4
Lighting	2.5	4.1	1.9
Maintenance	2.0	4.3	1.3
Total SCI	2.38	4.43	1.75

Victoria Memorial (SCI 4.43): The facility demonstrates a near-perfect score in Water Availability (4.8) and high scores in Cleanliness (4.5). This indicates a high Service Level Benchmark (SLB) compliance. It qualifies as a "Five-Star" facility under the SBM-U 2.0 Aspirational Toilet guidelines.

Babughat (SCI 2.38): While Water Availability (2.8) is functional, the site suffers from a Maintenance deficit (2.0). The gap between Water (2.8) and Cleanliness (2.2) suggests that while resources are present, the Operations & Maintenance (O&M) workflow is insufficient for the high-density transit footfall.

Kalighat Temple (SCI 1.75): This site falls below the "Minimum Functional Threshold" (SCI < 2.0). The critical failure in Maintenance (1.3) and Cleanliness (1.4) points toward a "Sunk Cost" infrastructure where existing facilities are practically

unusable for tourists. This represents a high Spatial Inequity in the city's tourism-sanitation nexus.



5.3 Advanced Geospatial Analysis

The spatial dimension of the sanitation crisis was evaluated using Geographic Information Systems (ArcGIS) to determine the accessibility and density of facilities relative to tourist movement. This phase of the analysis identifies the physical "service gaps" that cannot be captured through statistical surveys alone.

5.3.1 Multi-Ring Buffer Analysis: Accessibility and Adequacy

To evaluate accessibility, multi-ring buffers were created at 200-meter and 400-meter radii around the primary entry points of each tourist node. In urban planning standards, a distance of 200m is considered "Immediate Access" (approx. 2.5-minute walk), while 400m is the "Maximum Standard Service Area" (approx. 5-minute walk). Any facility located beyond 400m is deemed inaccessible for high-density pedestrian zones.

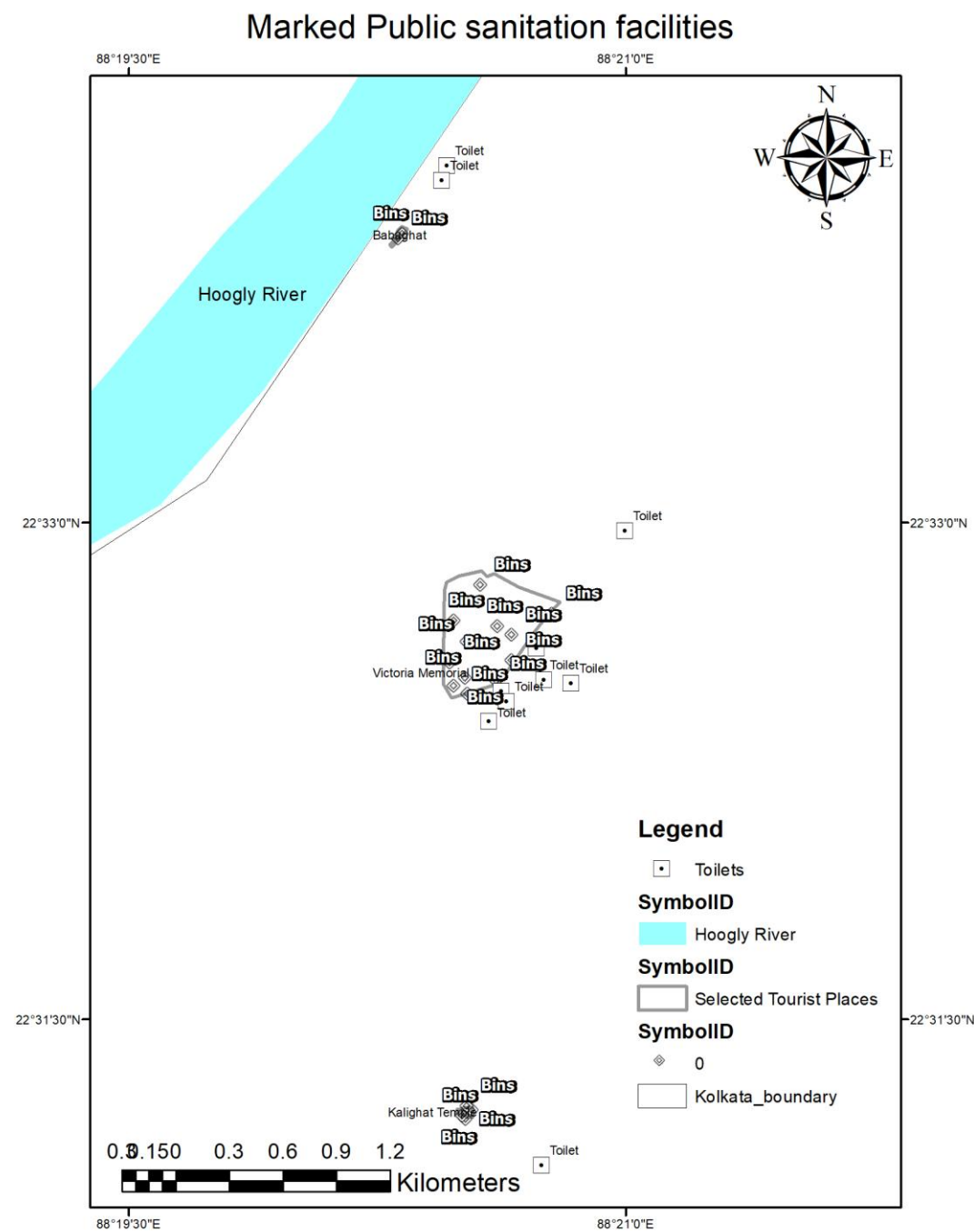
Table 24: Multi-Ring Buffer Analysis for Spatial Accessibility and Facility Adequacy

Tourist Spot	Toilets in 0-200m Buffer	Toilets in 200-400m Buffer	Accessibility & Adequacy Rating
Victoria Memorial	5	1	Good (Adequate)
Babughat	0	2	Poor (Deficient)

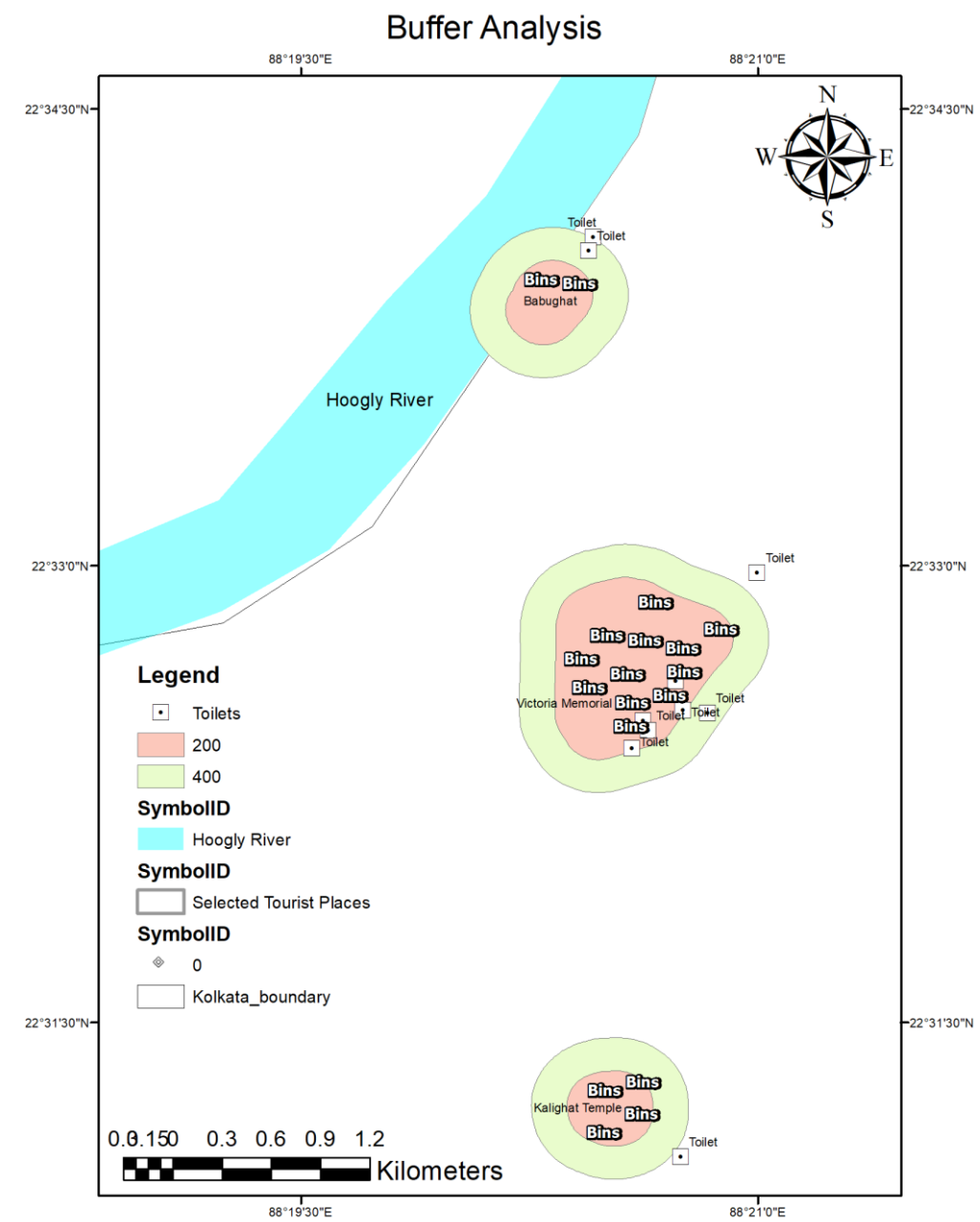
Kalighat Temple	0	1	Poor (Severe Deficit)
------------------------	---	---	------------------------------

The spatial data reveals extreme inequity. Victoria Memorial is robustly serviced with six facilities within a comfortable walking distance. Conversely, both Babughat and Kalighat exhibit a total absence of sanitation infrastructure within the critical 200-meter primary catchment zone. This "Proximity Gap" is a primary planning failure; tourists arriving at the Babughat ferry terminal or the Kalighat main gate must physically navigate hundreds of meters through chaotic urban traffic to find a toilet, which directly contributes to the observed prevalence of open urination in the immediate vicinity of these heritage sites.

Refer to-Map:8 & 9



Map 8: Marked Public sanitation facilities near study areas



Map 9: Buffer Analysis

5.3.2 Nearest Distance Analysis and Mathematical Calculation

To provide a precise geometric validation of the buffer results, the absolute nearest neighbour distance was calculated from each activity centroid to the nearest public toilet. This calculation utilized coordinate geometry based on the recorded GPS points, where 1 degree of latitude/longitude in Kolkata is approximately equal to 111,000 meters.

The formula for the Euclidean distance D is:

$$D = \sqrt{\{(Lat_2 - Lat_1)^2 + (Long_2 - Long_1)^2\}} * 111000$$

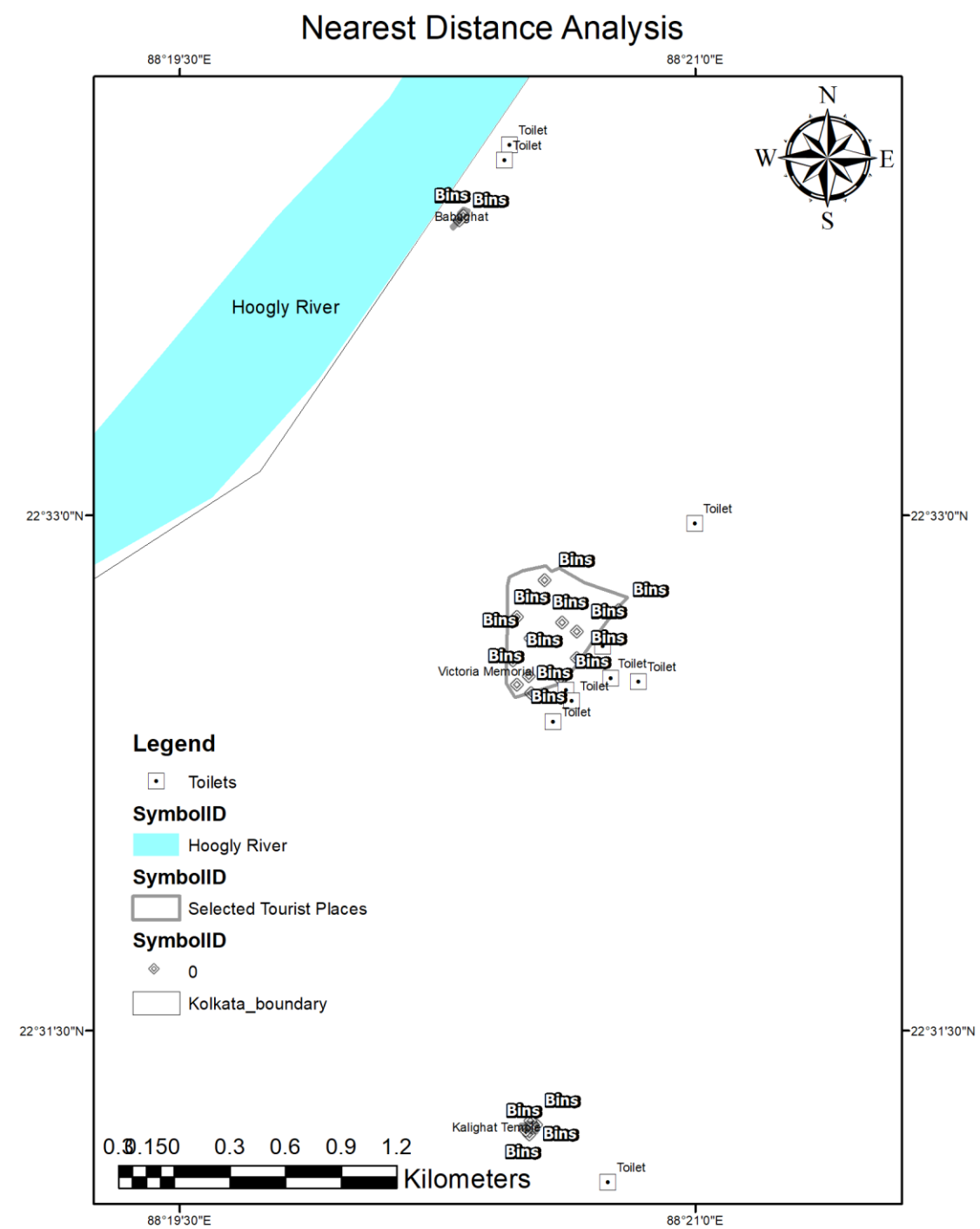
Table 25: Nearest Distance Analysis and Accessibility Assessment for Tourist Hubs

Site	Calculated Distance (m)	Category Assessment
Victoria Memorial	46	Excellent (Immediate access)
Babughat	331	Moderate (Suboptimal for transit)
Kalighat Temple	410	Poor (Critical service gap)

The nearest distance at Kalighat (410m) represents a violation of the 500m maximum normative standard adopted by cities like Melbourne and the aspirational 250m standard suggested for high-density religious hubs. For an elderly pilgrim or a person with limited mobility, a 410-meter walk through a hyper-congested, labyrinthine urban fabric effectively renders the facility non-existent, highlighting the need for a more decentralized infrastructure model.

Refer to-Map:10

Map



10: Nearest Distance Analysis

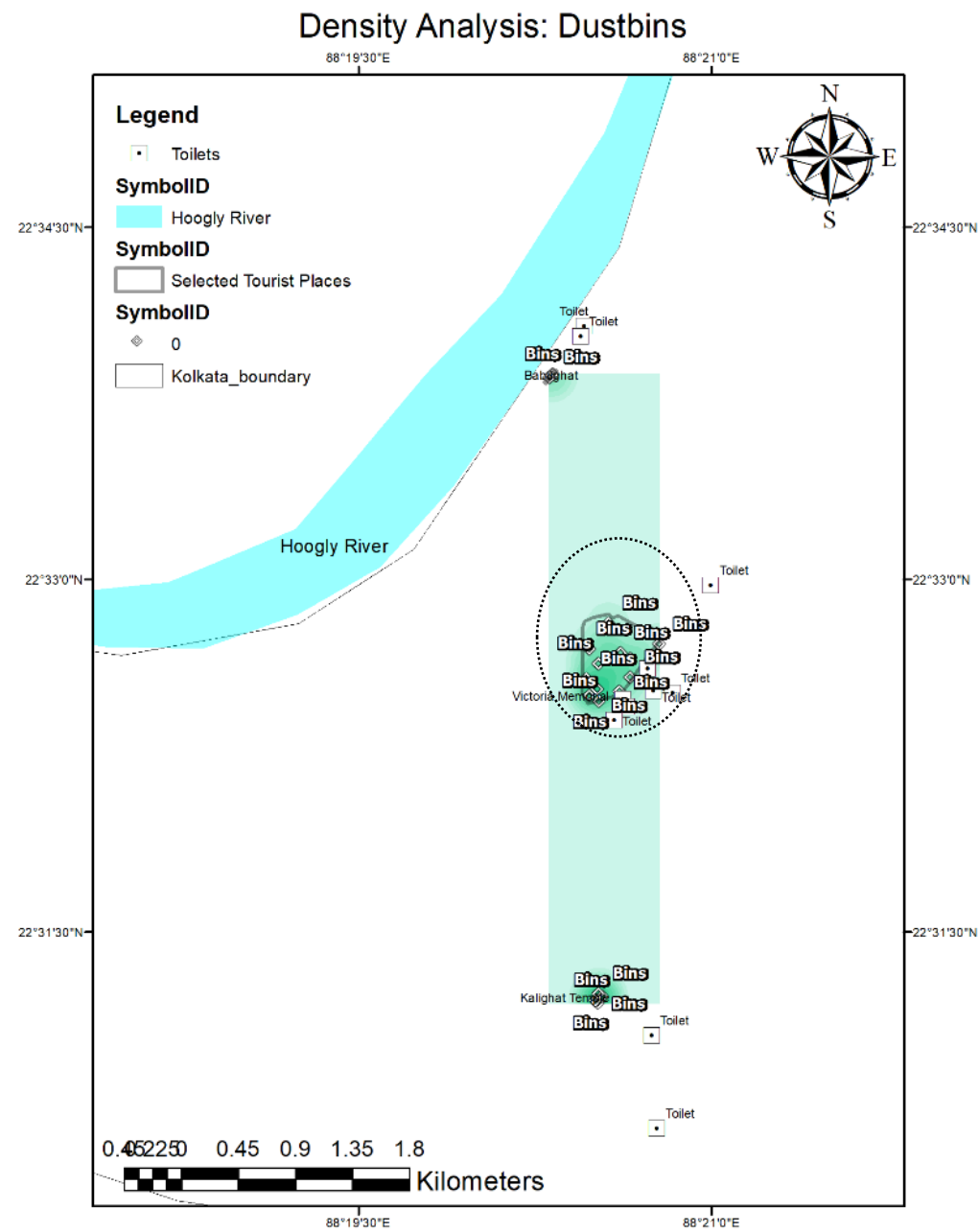
5.3.3. Kernel Density Estimation (KDE) for Dustbins and Toilets

Kernel Density maps were generated to visualize the intensity of service availability across the spatial plane. Darker gradients in the KDE maps represent high-concentration "Hot Spots," while lighter or unshaded areas represent "Cold Spots" or service voids.

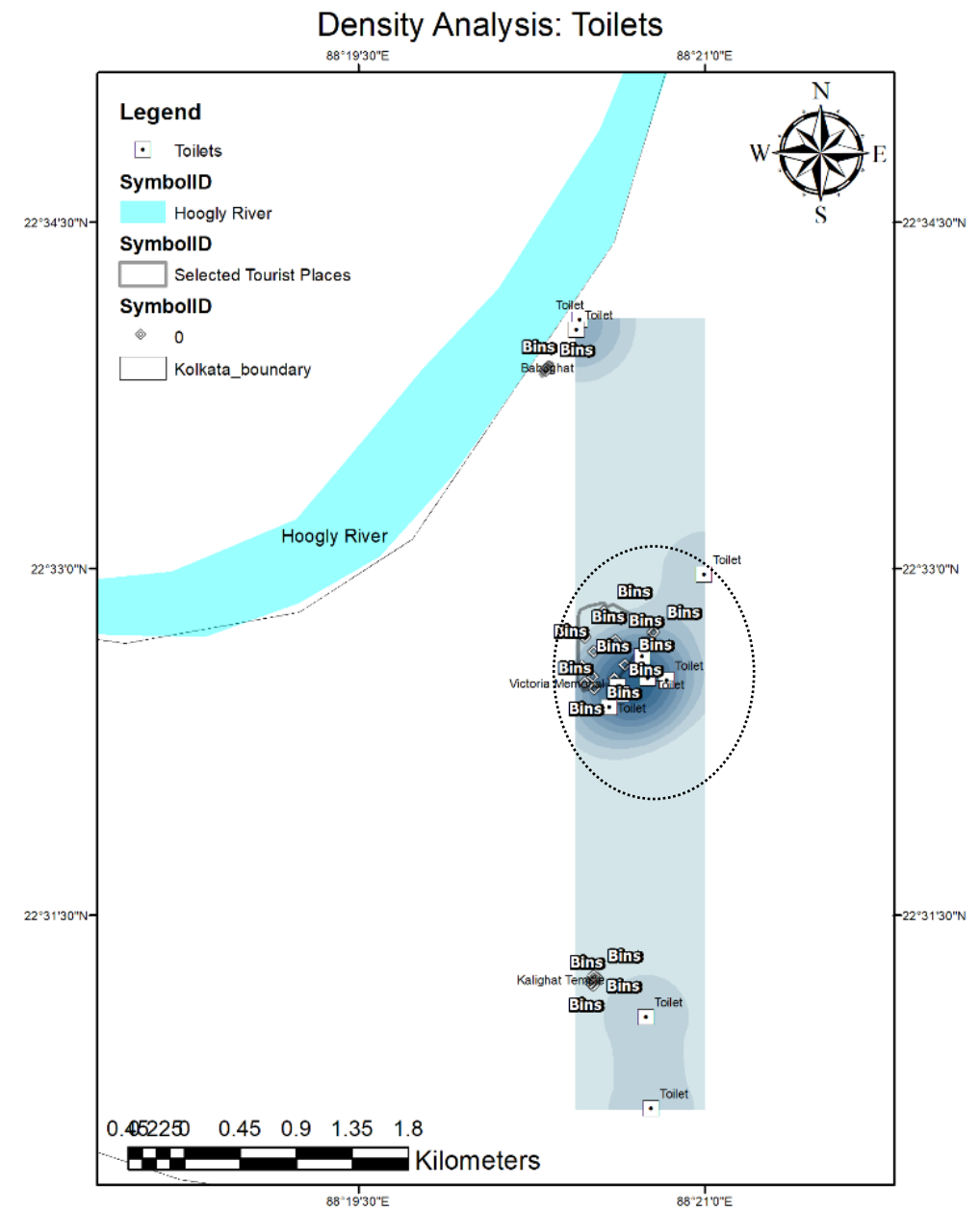
1. **Spatial Concentration Pattern (Victoria Memorial):** The KDE map shows a dark, saturated cluster of both toilets and dustbins. This indicates a well-planned infrastructure where sanitation is integrated into the landscaping of the heritage precinct.
2. **Moderate Service Zone (Babughat):** The map exhibits moderate density, but the distribution is non-uniform. Facilities are present but clustered away from the ferry landing, creating a localized gap at the primary transit node.
3. **Service Gap / Imbalance Zone (Kalighat):** The map reveals a critically low density of toilets relative to the massive pedestrian footfall. Furthermore, the distribution of dustbins is erratic, explaining the accumulation of solid waste near the sacred water bodies.

The planning inference drawn from the KDE analysis is that sanitation facilities in Kolkata are not proportionately distributed relative to user demand. There is a clear "Infrastructural Bias" where regulated leisure areas like the Maidan receive superior provisioning compared to the organic, high-load pilgrimage and transit zones.

Refer to -Map:11 & 12



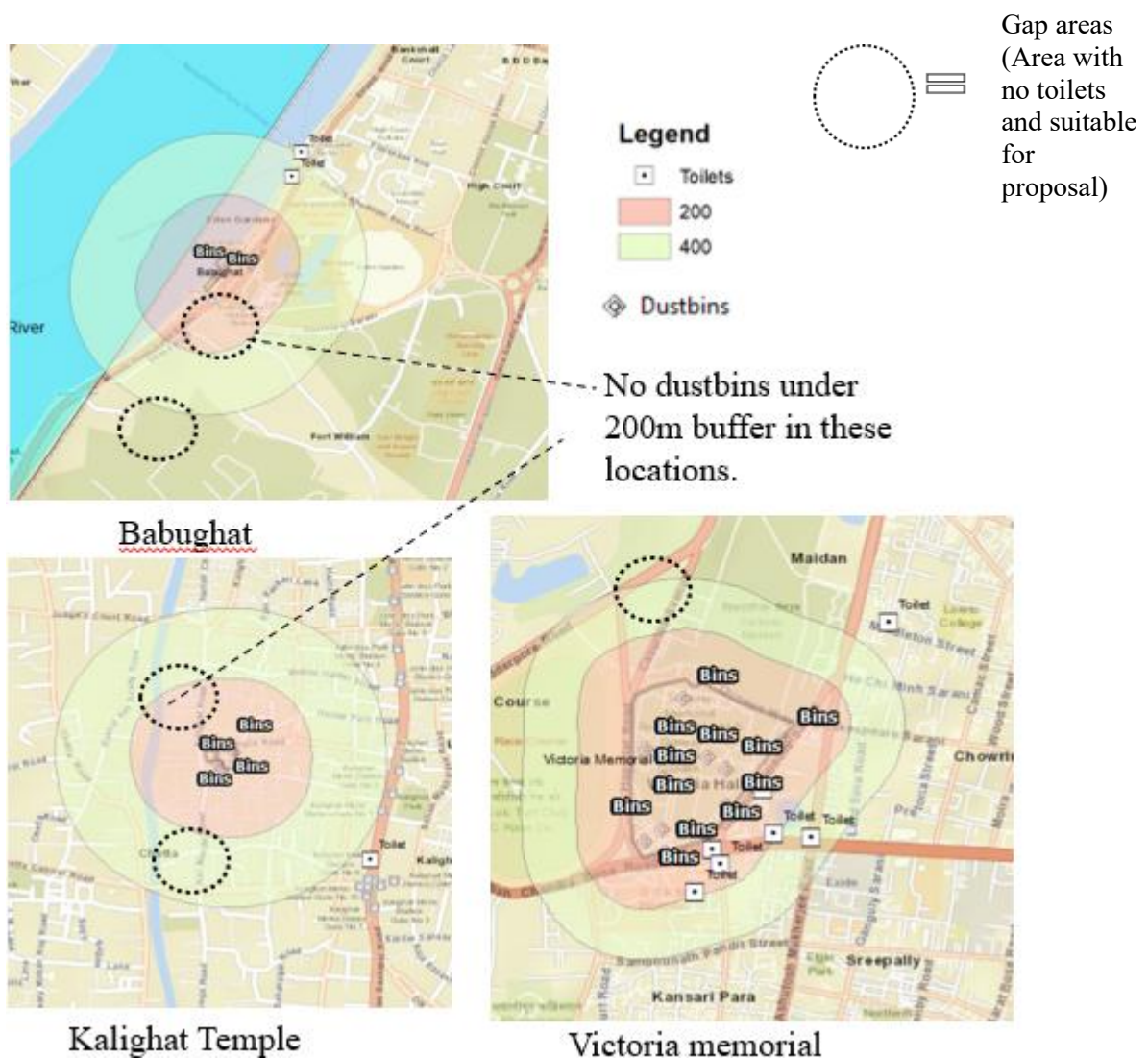
Map 11: Density Analysis-Dustbins



Map 12: Density Analysis-Toilets

5.3.4 Service Gap Identification and Suitability Analysis

The final step in the spatial analysis involves identifying the "Empty Zones"—buffer areas with high pedestrian activity but zero infrastructure. These identified cold spots serve as the primary locations for proposed interventions. Specifically, the analysis identifies the Babughat riverfront and the North-Western perimeter of Victoria Memorial as "Gap Areas" suitable for the deployment of automated, small-footprint "E-toilets". These locations are chosen because they minimize the need for land acquisition in dense areas while maximizing accessibility for the floating population.



5.4 Contextual Relevance and Policy Alignment

The empirical findings from Kolkata's tourist spots must be viewed through the lens of national and global sanitation norms. The systemic failures identified at Kalighat and Babughat reflect a broader urban crisis in the global south, where "floating population stress" is often ignored in traditional ward-level planning.

5.4.1 Alignment with SBM-U 2.0 Aspirational Standards

The research highlights a critical disconnect between Kolkata's current infrastructure and the national mandate for "Aspirational Toilets." Under SBM 2.0, public toilets in tourist zones are required to include premium features such as touchless flushing, menstrual hygiene facilities (incinerators and vending machines), and universal design elements (ramps and grab bars). The SCI breakdown reveals that these features are currently absent in most municipal facilities, particularly the Menstrual Hygiene Management (MHM) infrastructure, which was reported as missing by 94% of users in recent surveys.

5.4.2 Technological Integration: The Singapore Model

The "Perception Gap" identified in the Cleanliness vs. Location Analysis suggests that odours and minor technical failures are the primary deterrents to usage. This provides a compelling case for the adoption of Singapore's DFEC (Detect, Feedback, Eliminate, Clean) model. By integrating IoT sensors (such as ammonia and fill-level detectors), the Kolkata Municipal Corporation (KMC) could transition from ineffective fixed cleaning schedules to a dynamic, real-time maintenance system. This technology is specifically recommended for high-load sites like Kalighat, where sudden surges in pilgrim numbers often lead to rapid hygiene failure.

5.4.3 Economic Sustainability: The Lootel Model

The financial burden of maintaining "Magnificent" (6-star) sanitation standards remains a hurdle for many Indian municipalities. The "Lootel" model from Indore, which utilizes a Public-Private Partnership (PPP) to cross-subsidize toilet maintenance through integrated cafes and retail kiosks, offers a viable solution for Kolkata. The high footfall and willingness to pay among tourists at Victoria Memorial make it an ideal candidate for such a "Pay-Use-Redeem" model, ensuring that the facility achieves self-

sustaining operations without recurring municipal deficits.

5.5 Conclusion

The comprehensive evaluation of public sanitation in Kolkata's tourist hubs reveals a landscape of profound spatial inequity and technical deficiency. While the Victoria Memorial serves as a regional benchmark for well-integrated infrastructure, the precincts of Babughat and Kalighat represent critical failures in urban service delivery. The statistical data highlights a significant "Perception-Reality Gap," where the absence of professional maintenance and basic hygiene triggers a total rejection of facilities by the floating population.

The spatial analysis, validated through GIS buffer and nearest neighbour calculations, identifies the primary activity nodes of Kalighat and Babughat as "sanitary cold spots" that exceed international walking distance norms. To rectify these deficits, the city must move beyond ad-hoc facility placement and adopt a data-driven redistribution strategy. The integration of automated E-toilets, the adoption of IoT-based maintenance models (DFEC), and the implementation of PPP financial frameworks will be essential to transform Kolkata's public sanitation into an "Aspirational" system that supports both public health and the global tourism economy. This research provides the necessary evidentiary foundation to transition Kolkata from an ODF city to a world-class, hygienic urban destination.

Chapter 6. Planning Proposals

The following planning proposals represent a strategic shift from traditional, reactive municipal management toward a proactive, data-driven, and citizen-centric sanitation framework for the Kolkata Municipal Corporation (KMC). Grounded in the empirical findings of the preceding chapters, which identified critical spatial gaps and maintenance failures in high-footfall areas like Kalighat and Babughat, these proposals leverage the Internet of Things (IoT), Geospatial Information Systems (GIS), and sustainable financial modeling. These interventions are not merely infrastructure projects but are conceptualized as "Smart Sanitation Grids" that align with the national mandates of the Swachh Bharat Mission-Urban (SBM-U) 2.0 and the Urban and Regional Development Plans Formulation and Implementation (URDPFI) guidelines. The proposal is divided into three integrated components: the deployment of autonomous e-toilets to bridge immediate service gaps, the implementation of a reward-based intelligent garbage system (REBIGS) to incentivize behavioral change, and the establishment of the "Swachh Parikrama" portal for real-time governance and user navigation.

6.1 Strategic Infilling via Autonomous Smart E-Toilet Networks

The primary spatial challenge in Kolkata's dense urban fabric, particularly within the historic and pilgrimage precincts of Kalighat, is the severe lack of available land for traditional sanitation blocks. Traditional public toilet units typically require over 100 square meters of space, making them physically unviable in congested areas where the "Service Gap" is most acute. To address this, the proposal suggests the strategic infilling of identified spatial gaps—410 meters at Kalighat and 331 meters at Babughat—using modular, self-contained electronic toilets (e-toilets) that require a footprint of only 25–30 square meters.

6.1.1 Spatial Logic and URDPFI Compliance

The identification of Kalighat and Babughat as target areas stems from a rigorous gap analysis compared against URDPFI standards, which mandate an immediate

accessibility buffer of 200 meters at high-footfall transit and tourist nodes. Currently, the imbalance in these zones forces pedestrians and pilgrims to traverse distances nearly double the permissible limit, leading to instances of open urination and a degraded public realm. The e-toilet units are designed to be "surgically" placed at high-density points such as the Kalighat Temple entrance and the Babughat ferry ghat, ensuring that no user is more than a three-minute walk from a hygienic facility.

The following table contextualizes the proposed infill locations and their respective spatial justifications:

Table 26: Proposed Infill Locations and Spatial Justification

Target Area	Zone Classification	Identified Spatial Gap	URDPFI Mandate	Proposed Infill Strategy
Kalighat Temple	Service Gap/Imbalance	410 meters	200 meters	2-unit e-toilet cluster at temple entry.
Babughat	Moderate Service Zone	331 meters	200 meters	3-unit e-toilet cluster at transit nodes.
Victoria Memorial	High-Density Tourist Node	Variable	200 meters	Aspirational "Pink Toilet" e-units.
Kansari Para	Residential/Transit	450 meters	200 meters	Standard e-toilet infill.

6.1.2 Technical Architecture: Connected e-Toilet Infrastructure (CeTI)

The core innovation of the proposed e-toilets is the transition from manual, human-dependent maintenance to automated, unmanned operations governed by the Connected e-Toilet Infrastructure (CeTI). To avoid the "Stinking Loo" syndrome characterized by the maintenance failures identified in the observation checklist, the CeTI platform

utilizes GPRS-enabled remote monitoring to ensure 24/7 functionality.

The technical specifications of the units are designed for durability and resource efficiency:

- **Automated Maintenance Cycles:** The units feature an auto-flushing mechanism that operates before and after every use. To maintain peak hygiene during tourist surges, a comprehensive floor-washing cycle is automatically triggered every 10 uses.
- **Water Conservation:** Traditional flush systems consume approximately 6 liters per use, contributing to the depletion of the urban water table. The proposed e-toilets utilize sensor-controlled valves that calibrate water usage to 1.5 liters for short usage periods (under three minutes) and 4.5 liters for longer periods, achieving a significant reduction in overall consumption.
- **Structural Integrity:** Given the high risk of vandalism and the corrosive humid climate of Kolkata, the units are constructed with a stainless-steel superstructure. This modular, pre-fabricated approach allows for installation within 5 to 10 hours without extensive civil work, making it ideal for the "infill" approach.

6.1.3 The 3-Stream Revenue Model for Operational Sustainability

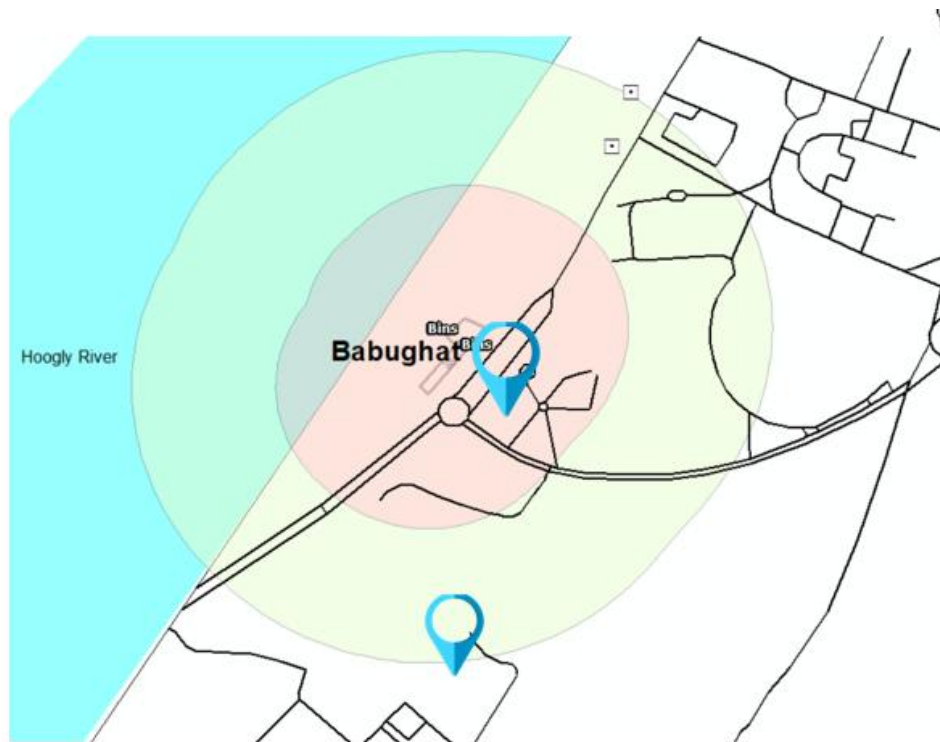
A common failure in public sanitation infrastructure is the lack of funding for long-term Operations and Maintenance (OPEX). To ensure these units remain functional without burdening the KMC budget, a "3-Stream" revenue model is proposed, designed to make the units economically self-sustaining through a Public-Private Partnership (PPP).

1. **Direct User-Pay Mechanism:** Entry is controlled via a coin or QR-based system (nominal fee of ₹5–10). This serves two purposes: providing immediate revenue for daily consumables (soap, electricity) and acting as a behavioral filter to prevent misuse of the facility.

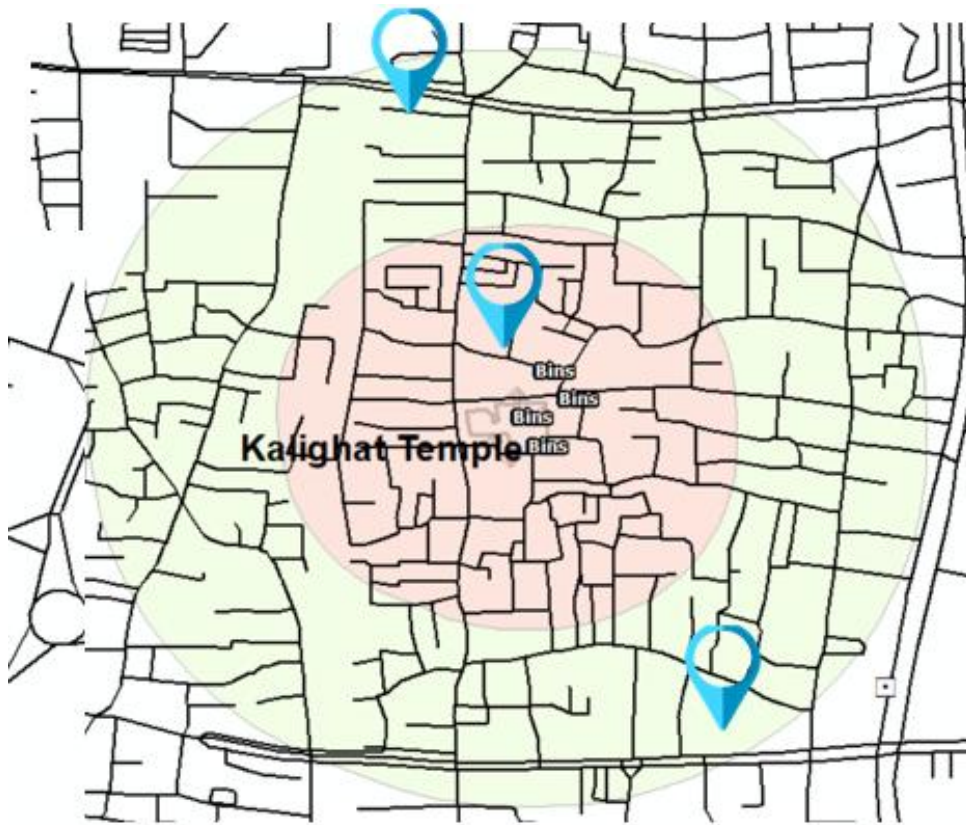


Toilet unit at Surajkund Fair, Faridabad

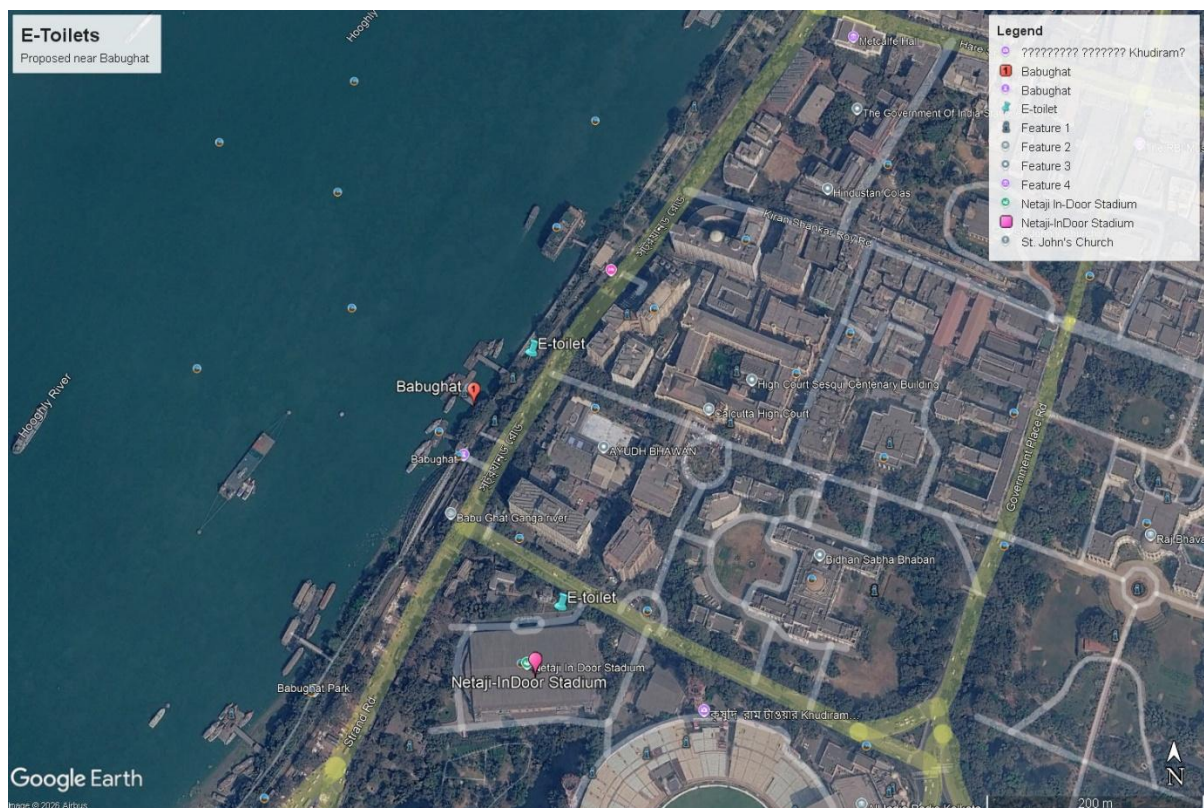
2. **Out-of-Home (OOH) Branding and Advertisement:** The exterior "skin" of the e-toilet serves as a high-visibility OOH branding space. In locations like Victoria Memorial and Park Street, the premium ad rates generated can cross-subsidize the maintenance of units in less commercially viable areas.
3. **Environmental Credit Harvesting:** By utilizing low-water technology (0.5L–1.5L per flush) and solar-powered sensors, the private partner can claim carbon and water credits. This financial incentive aligns with the SBM-U 2.0 vision of tech-driven, inclusive urban sanitation.



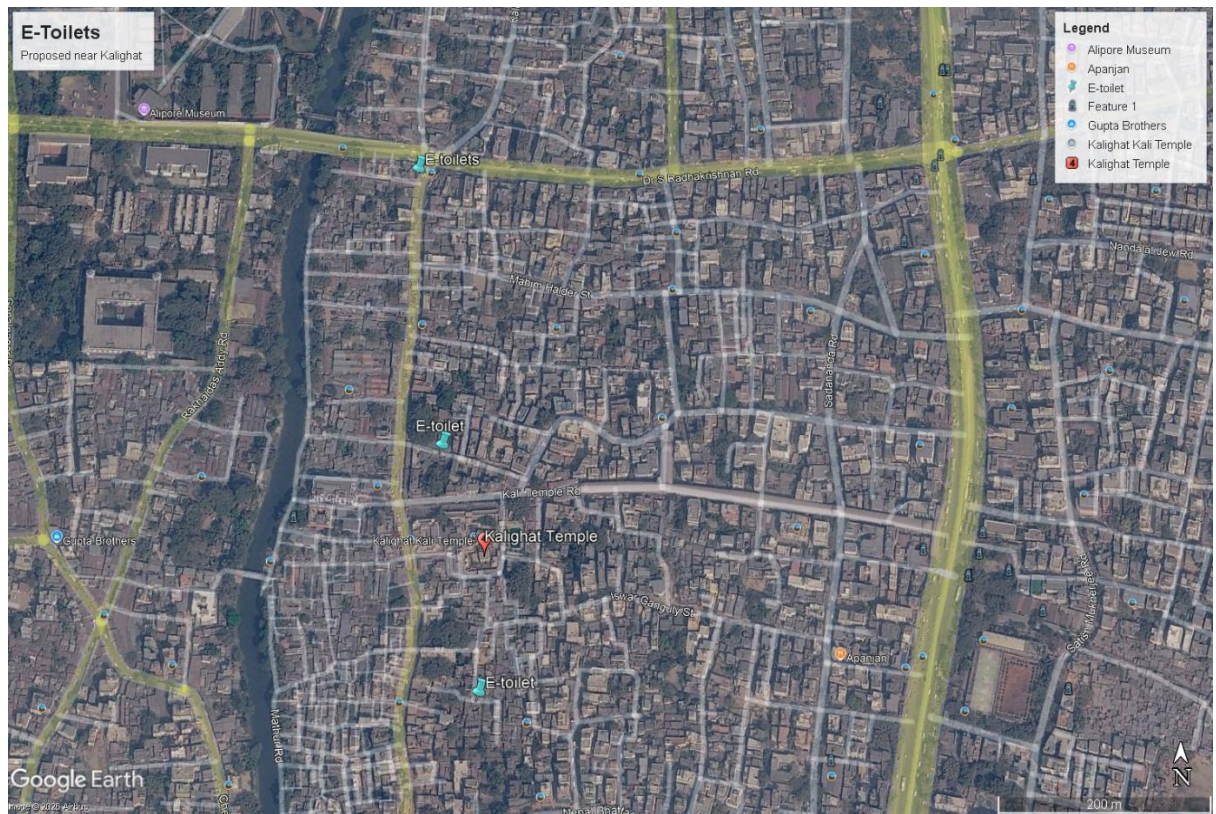
Map 13: Proposed e-Toilet Location near Babughat



Map 14: Proposed e-Toilet Location near Kalighat



Map 15: Proposed e-Toilet Location near Babughat(Google Earth)



Map 16: Proposed e-Toilet Location near Kalighat(Google Earth)

6.2 IoT-Based Smart Waste Infrastructure (REBIGS)

The second proposal addresses the "breeding homes for germs" identified in Babughat and Kalighat, where traditional dustbins frequently overflow due to surge loads from tourists. The proposal introduces the IoT-based Smart Bin system with an integrated Reward-Based 'REBIGS' (Reward-based Intelligent Garbage System). This system moves beyond simple waste collection, transforming the bin into a node within a "Smart Grid" that incentivizes responsible disposal among tourists and residents.

6.2.1 Operational Logic and Reward Algorithm

The REBIGS system addresses the psychological disconnect between waste generation and disposal. By utilizing RFID smart cards or mobile app-based QR codes, tourists earn "Swachh Points" for every deposit, redeemable at local kiosks or attractions. This creates a behavioral "nudge," significantly improving the overall Sanitation Condition Index (SCI) of the precinct.

The technical core of the REBIGS bin is the load-sensing algorithm that tracks dumping events in real-time. This is essential for both municipal logistics and user rewarding. The calculation for rewards and fill levels is governed by the following logic:

Let W_t be the total weight measured by the sensor and W_i be the weight from the previous measurement. The system calculates the specific dumping weight of each user to assign reward points:

This process continues sequentially for every user until the authorities clear the bin, at which point W_t and W_i are reset to zero.

Table 27: REBIGS Operational Logic and Weight Measurement Steps

Step	Status	Weight Measurement	System Action
Step 1	Empty	$W_t = 0, W_i = 0$	Ready for first user.
Step 2	Dumping (User A)	$W_t = 5\text{kg}, W_i = 0$	Send 5kg data to server; set $W_i = 5$.
Step 3	Dumping (User B)	$W_t = 12\text{kg}, W_i = 5$	Send 7kg data to server; set $W_i = 12$.
Step 4	Threshold	$W_t \geq 85\%$	Trigger automated collection ticket to KMC.
Step 5	Clearance	$W_t \rightarrow 0$	Reset system parameters.

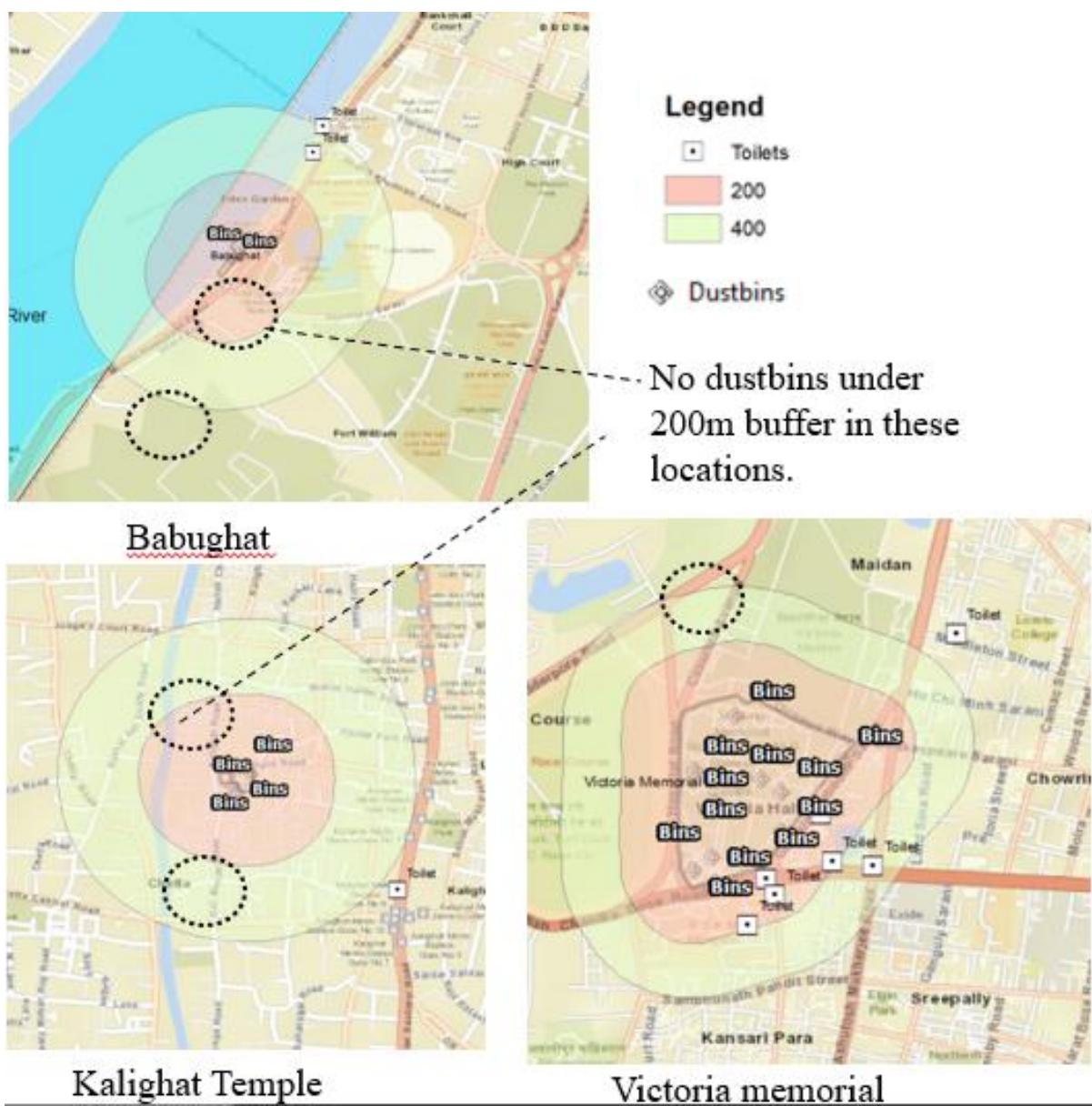
6.2.2 Integration with Municipal Logistics

Current waste collection in Kolkata relies on periodic, fixed-route collection, which is inefficient and fuel-intensive. The proposed IoT units feature ultrasonic level sensors that alert KMC authorities when a bin reaches 85% capacity. Integrated GPS modules then provide the shortest possible collection route for KMC vehicles, saving fuel and time by ensuring that only "full" bins are visited. This optimized logistics framework directly supports the SBM-U 2.0 mandate of scientific processing and 100% source segregation.



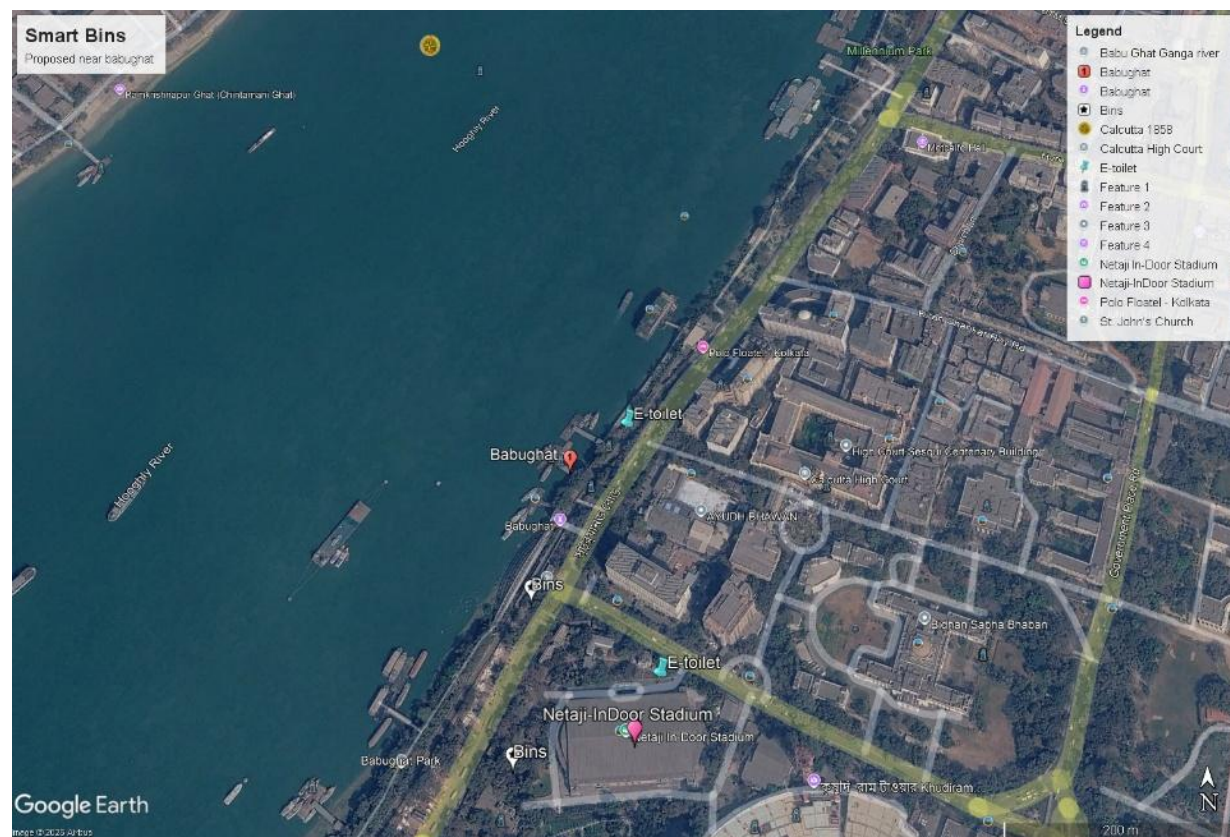
6.2.3 Hardware Specifications and Hardware-Software Fusion

The REBIGS bins are envisioned as hardware-software hybrids, utilizing low-cost but powerful IoT components to ensure scalability across 144 wards. Each bin is equipped with a Raspberry Pi or Arduino-based controller, an HC-SR04 ultrasonic sensor for volume measurement, and a load cell for weight-based reward tracking. To support the goal of "Garbage Free" certification, the bins utilize machine learning models (such as SSD MobileNetV2) to classify waste into biodegradable, recyclable, and hazardous categories, ensuring cleaner waste streams for the Dhapa landfill.

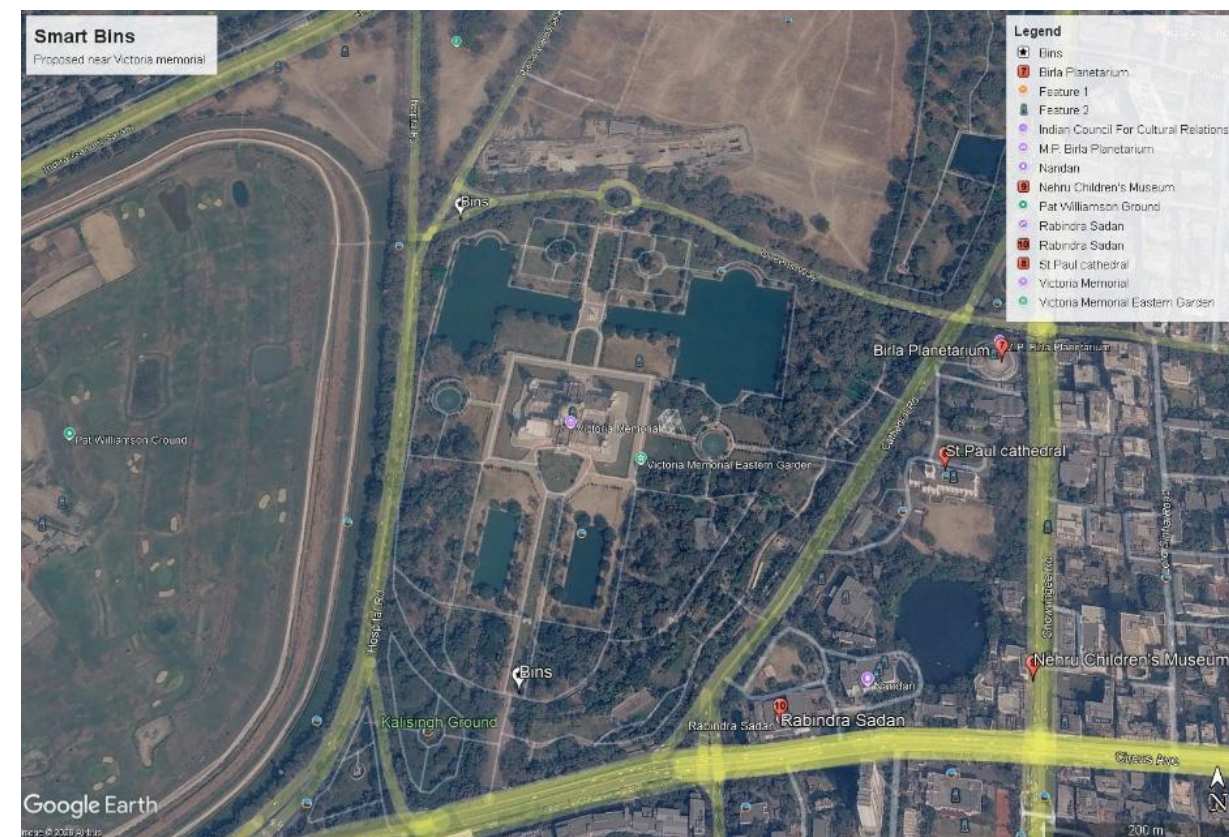


Map 17: Gap areas (Area with no toilets and suitable for proposal)

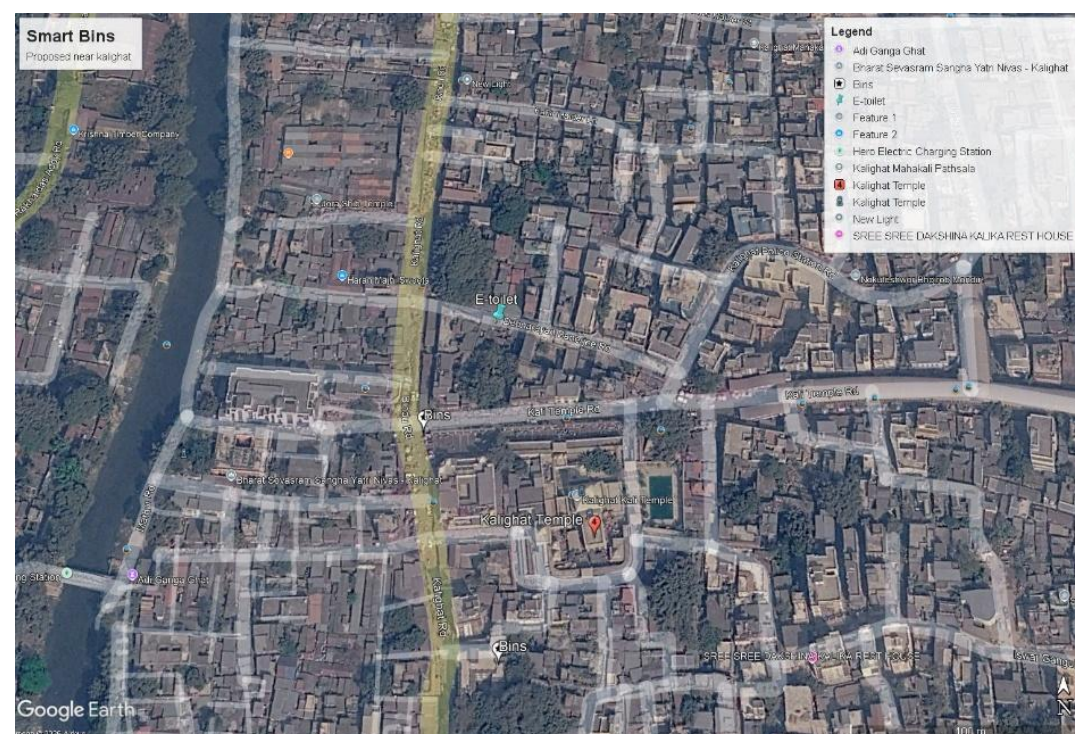
Refer to- Map 18, 19, 20



Map 18: Proposed Smart Bins near Babughat



Map 19: Proposed Smart Bins near Victoria Memorial



Map 20: Proposed Smart Bins near Kalighat

6.3 "Swachh Parikrama": The Interactive Tourist Sanitation Portal

To bridge the information gap between available facilities and the mobile tourist population, the third proposal is the creation of "Swachh Parikrama," a Python-based interactive GIS portal. This portal functions as both a "Planning Decision Support Tool" for the KMC and a "Facility Finder Tool" for tourists.

6.3.1 Portal Features and User Experience

The portal addresses the "Sanitation Blindness" that often leads to open defecation in tourist areas. By integrating real-time data from the e-toilets (CeTI) and smart bins (REBIGS), the portal provides a live street-level map of Kolkata's sanitation health.

Key features include:

- **Interactive Web Map:** Renders a 200m pedestrian accessibility buffer around every facility, allowing users to find the nearest toilet without exceeding the URDPFI-recommended walking distance.
- **Real-Time Operational Status:** Using GPRS data, the portal indicates if a toilet is "Active" or under maintenance. For bins, it shows current fill levels, assisting users in finding a bin that is not overflowing.
- **Algorithmic Wayfinding:** The portal calculates the shortest pedestrian route to the nearest facility, eliminating the "Loo Leash" effect where tourists are forced to cut short their visits due to lack of sanitation options.

6.3.2 Strategic Data Inputs for Smart Governance

The portal is designed to be a living data repository. By aggregating user ratings (currently expected at 4.5/5 for new e-toilets) and maintenance alerts, it provides KMC with a "cleanliness dashboard". This data is crucial for the performance-linked PPP model, where payments to private partners are tied to the real-time health status of the

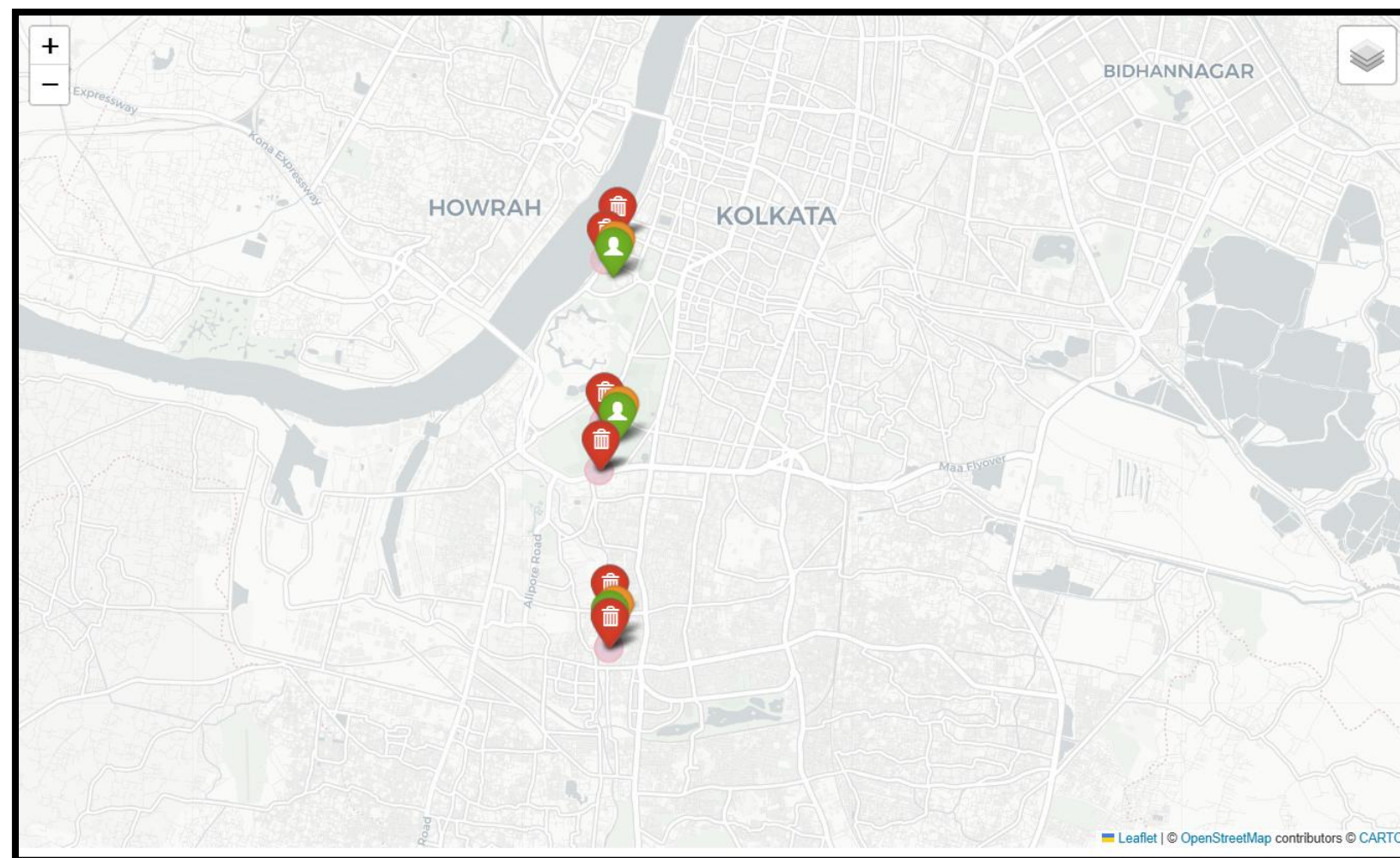
units.

The following table details the data architecture of the "Swachh Parikrama" portal:

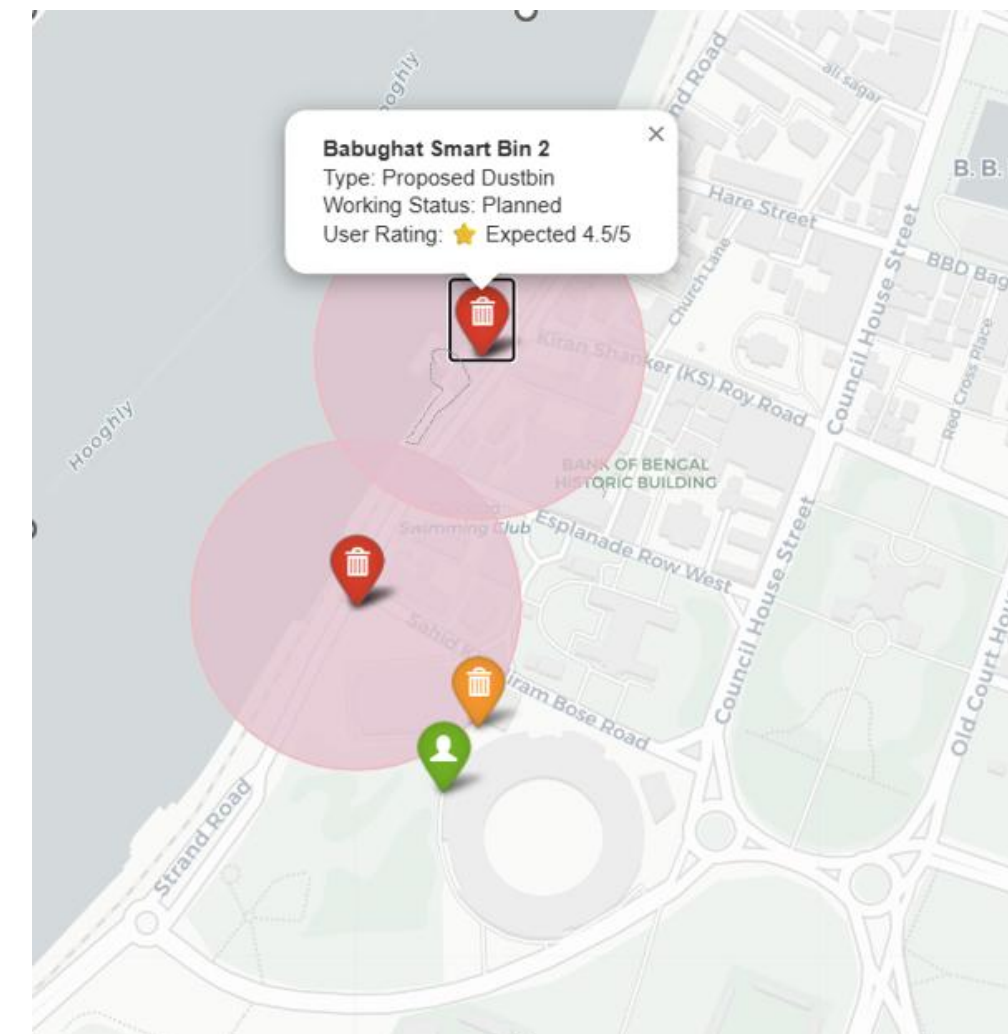
Table 28: Data Architecture and Utility of the Swachh Parikrama Portal

Data Layer	Source	Planning Utility	User Utility
Spatial Layer	Field Surveys/GPS	Identification of "Sanitation Deserts".	Visualizing 200m buffer zones.
Operational Layer	IoT Sensors (CeTI)	Monitoring PPP compliance and faults.	Checking "Active/Inactive" status.
Perception Layer	User Feedback	SCI (Sanitation Condition Index) mapping.	Real-time facility ratings.
Logistics Layer	Fill-Level Sensors	Route optimization for KMC vehicles.	Locating empty bins.

Refer to -Map:21 & 22

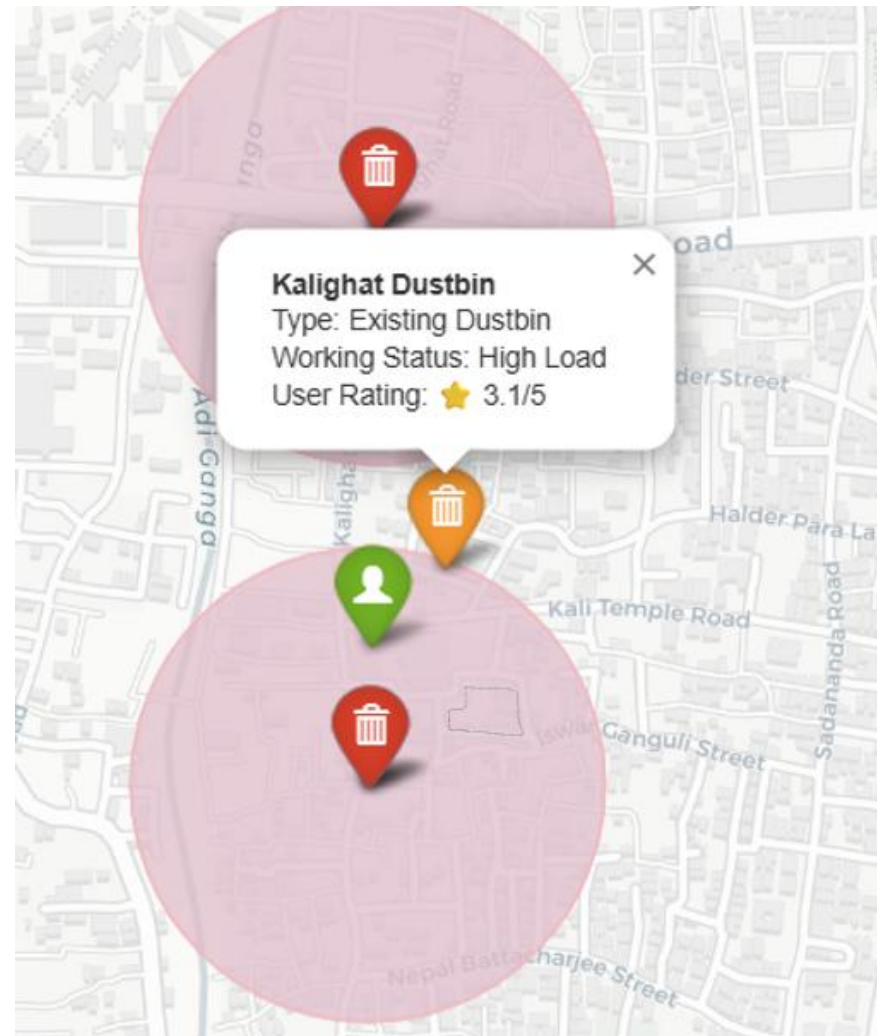


Map 21: Interactive Tourist Sanitation Portal: Swachh Parikrama

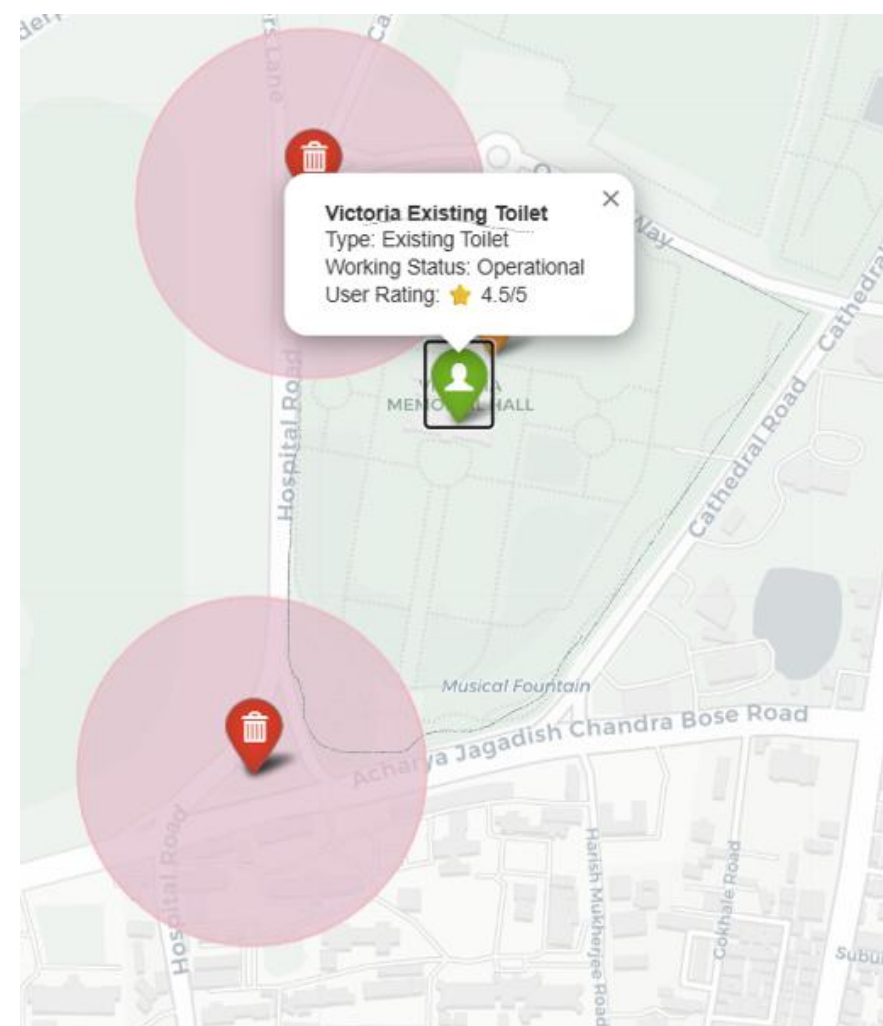


Map 22: Swachh Parikrama: Babughat Cluster

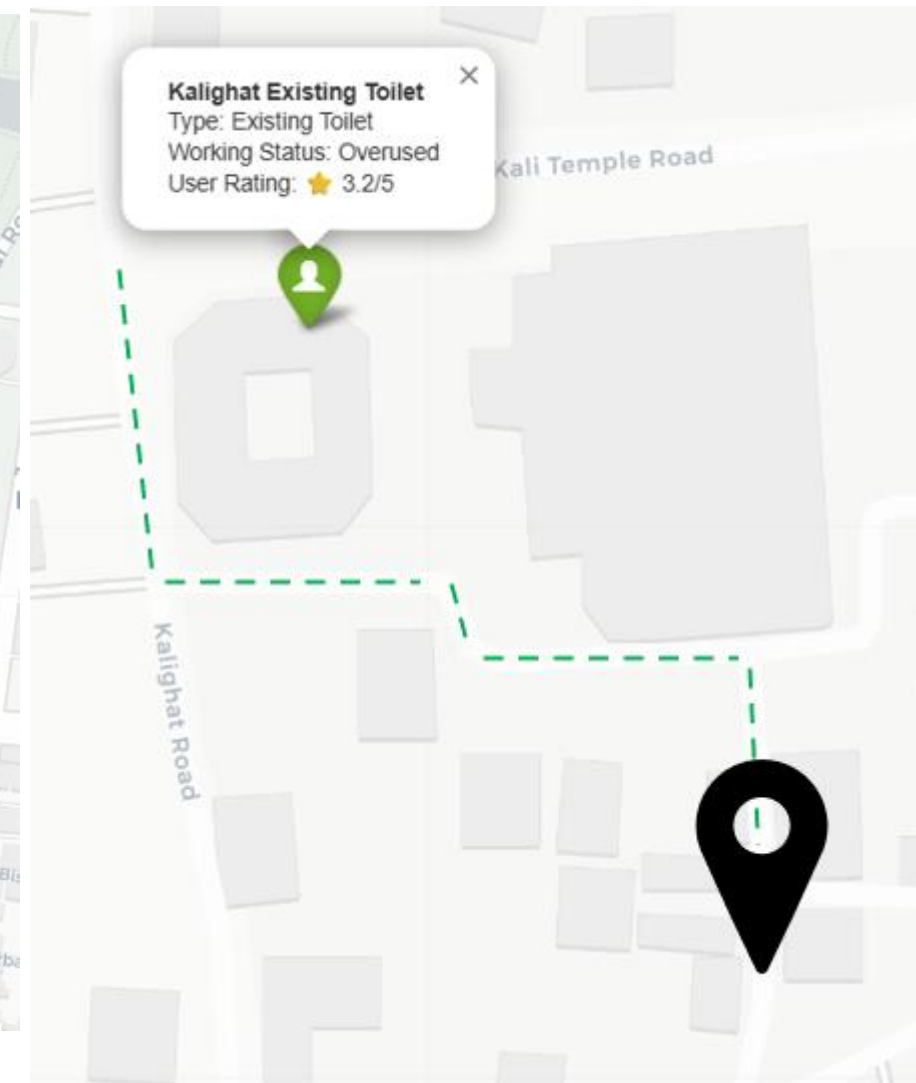
Map 23:Swachh Parikrama: Kalighat Cluster



Map 24:Swachh Parikrama: Victoria Memorial Cluster



Map 25:Swachh Parikrama: Existing Facility from user location



6.4 Implementation Framework and Financial Structuring

The successful rollout of these proposals requires a departure from traditional "Build-Operate-Transfer" models toward a more integrated "Performance-Linked" framework. This ensures that the private sector is incentivized not just to build, but to maintain the quality of service over the infrastructure's 10-year life expectancy.

6.4.1 PPP Model: Risks and Responsibilities

The implementation model follows a structured Public-Private Partnership where the KMC provides the site and policy framework, while a private vendor manages the technology and revenue streams.

- **Operator (Private Vendor):** Responsible for the capital investment of the e-toilet units (estimated at \$13,500/unit), management of the IoT network, and securing advertisement partnerships.
- **Authority (KMC):** Monitors the "Swachh Parikrama" dashboard to ensure KPI-based compliance. If a unit's water level is low or the flush fails, the KMC system automatically generates a penalty ticket, removing the need for physical inspections which are difficult in congested areas like Kalighat.
- **Revenue Management:** The 3-stream model (User-fee, Ads, Credits) provides the operator with a sustainable ROI, while a portion of the revenue can be shared with the KMC to fund further sanitation infills.

6.4.2 Compliance with SBM-U 2.0 Aspirational Standards

The proposed e-toilets are designed to meet the "Aspirational Toilet" criteria set by the Ministry of Housing and Urban Affairs (MoHUA). These criteria include features beyond basic functionality:

- **Gender-Specific Facilities:** Inclusion of "Pink Toilets" equipped with sanitary napkin vending machines and incinerators.
- **Universal Design:** Ramps, handrails, and Braille signage to ensure accessibility

for the elderly and Persons with Disabilities (PwDs), as mandated by the Rights of Persons with Disabilities Act and URDPFI.

- **Hygienic Ambience:** Stainless steel interiors that are easy to sterilize, integrated exhaust fans, and LED lighting to ensure safety and comfort for women and children.

6.5 Long-Term Impacts on Urban Sanitation and Public Health

The integration of these three proposals—E-Toilets, Smart Bins, and the GIS Portal—creates a comprehensive "Sanitation Ecosystem." This framework addresses the four primary dimensions of urban hygiene: Accessibility (via surgical infilling), Reliability (via CeTI automation), Sustainability (via the 3-stream revenue model), and Visibility (via the Swachh Parikrama portal).

By reducing the spatial gap at Kalighat and Babughat, the KMC can directly reduce the incidence of water-borne diseases and improve the dignity of pilgrims and commuters. The transition to a data-driven waste management system via REBIGS ensures that Kolkata remains on track for the SBM-U 2.0 vision of "Garbage Free" urban India, while the GIS portal empowers citizens to become active participants in the city's cleanliness. This holistic planning approach provides a scalable template for other Indian metropolises facing similar challenges of density, surge footfalls, and maintenance decay.

6.5.1 Scalability and Future Scope

The pilot phase targets the most critical service gaps in the Kalighat and Babughat clusters. However, the modular and digital nature of these interventions allows for a phased expansion across all 144 wards. Future phases of the "Swachh Parikrama" portal could integrate with Google Maps API and the KMC's existing solid waste management apps, creating a unified digital interface for all civic services. As the network of connected e-toilets grows, it will form a resilient infrastructure backbone that can adapt to the changing demographic and spatial needs of Kolkata's urban future.

6.5.2 Environmental and Economic Benefits

The proposed shift to low-water e-toilets is projected to save millions of liters of municipal water annually, significantly reducing the energy required for sewage pumping and treatment. From an economic perspective, the PPP-led e-toilet model can generate local employment for technology maintenance and advertisement sales, while the REBIGS system provides a tangible economic return to citizens for their recycling efforts. This synergy between environmental responsibility and economic incentive is the cornerstone of a truly sustainable and "smart" city.

In conclusion, the proposed Chapter 6 interventions provide a robust planning pathway to transform Kolkata's sanitation landscape. By leveraging technology to solve spatial constraints and behavioral challenges, these proposals ensure that the city's growth is matched by a corresponding evolution in its public health infrastructure, fulfilling the vision of a clean, hygienic, and inclusive urban environment for all.

Chapter 7: Conclusion

The comprehensive assessment of public sanitation infrastructure surrounding Kolkata's primary tourist and transit hubs—**Babughat**, **Victoria Memorial**, and **Kalighat**—reveals a landscape of profound spatial inequity and technical deficiency. While the **Victoria Memorial** precinct serves as a benchmark for well-integrated infrastructure with high user satisfaction and robust service level compliance, the areas of **Babughat** and **Kalighat** represent critical failures in urban service delivery.

The empirical data highlights several key challenges that must be addressed to elevate the city's image and protect public health:

- **Spatial Inaccessibility:** Analysis shows that both Babughat and Kalighat lack sanitation facilities within the critical 200-meter primary catchment zone, with Kalighat requiring a 410-meter walk that directly violates international planning norms.
- **Maintenance and Hygiene Deficits:** Significant "Perception-Reality Gaps" exist at transit and religious sites, where the absence of professional maintenance and basic hygiene facilities—such as handwashing stations and menstrual hygiene management (MHM) infrastructure—triggers a total rejection of facilities by the floating population.
- **Demographic Pressure:** The city's massive daily "floating population" of 6 million individuals places extreme localized stress on infrastructure that is currently not accounted for in traditional, static ward-level planning.

To rectify these deficits, this report proposes a transition toward a **Smart Sanitation Grid**. By deploying autonomous, small-footprint **e-toilets** to fill spatial gaps, integrating **IoT-based real-time monitoring (DFEC model)** for maintenance excellence, and utilizing the **Swachh Parikrama** GIS portal for user wayfinding, Kolkata can bridge the gap between current ground realities and national **SBM-U 2.0 Aspirational standards**.

Ultimately, moving beyond ad-hoc facility placement toward a data-driven, inclusive redistribution strategy is essential. Implementing these strategic interventions will not only fulfill the human right to sanitation but will also secure Kolkata's status as a world-class, hygienic, and sustainable global cultural destination.

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