

PLANNING TO MITIGATE URBAN FLOODING - A CASE OF GUWAHATI, INDIA

Bachelor of Planning

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PLANNING TO MITIGATE URBAN FLOODING - A CASE OF GUWAHATI, INDIA

A REPORT

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PLANNING THESIS

By

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MARCH, 2026

DECLARATION

I, Soumajit Choudhury, scholar of Bachelor of Planning (Final Year), Department of Architecture and Planning, Maulana Azad National Institute of Technology, Bhopal, hereby declare that the synopsis entitled “**PLANNING TO MITIGATE URBAN FLOODING – A CASE OF GUWAHATI, INDIA**” is an original piece of research work carried out by me under the guidance of Dr. Anugrah Anilkumar Nagaich.

I further declare that this work is original, has not been submitted elsewhere for any other degree, and all materials used have been duly acknowledged.

Date: 30/03/2026

Signature of the Student:

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CERTIFICATE

This is to certify that the declaration of **DR. ANUGRAH ANILKUMAR NAGAICH** is true to the best of my knowledge and that the student has worked under my guidance for one semester in preparing this thesis.

RECOMMENDED

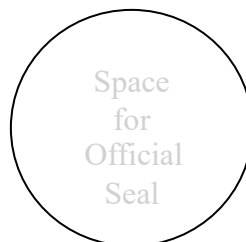
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CERTIFICATE

This thesis investigates the systemic causes and planning-based solutions for "artificial flooding" within the Guwahati Metropolitan Area (GMA). Challenging the conventional view of floods as purely natural meteorological events, the research adopts a morphological perspective, arguing that Guwahati's crisis is a human-induced failure of spatial planning and land-use management. The study identifies three primary systemic failures: the drastic loss of natural water retention bodies (beels), compromised infrastructural networks such as the Bharalu River, and a significant "implementation gap" between official master plans and the "lived" reality of informal urban growth.

Through a diagnostic-prescriptive framework, the research analyzes Land Use Land Cover (LULC) dynamics from 2000 to 2026, revealing a 220% increase in built-up area alongside a 41.5% shrinkage in essential wetlands. These changes have exacerbated the city's unique "bowl effect" topography, where rapid runoff from surrounding hills becomes trapped in the urban core during peak monsoons.

The thesis proposes a strategic shift from traditional "Grey Infrastructure"—concrete drains and pumps—toward a Blue-Green Infrastructure (BGI) and "Sponge City" strategy. Key recommendations focus on:

Catchment-based planning that aligns zoning with natural drainage basins rather than administrative boundaries.

The development of Development Control Regulations (DCRs) to enforce strict "no-build" ecological buffers around wetlands.

The integration of bio-retention systems, rain gardens, and permeable pavements to manage water at the source.

Ultimately, this work provides a practical spatial framework designed to restore Guwahati's natural hydrological balance, ensuring urban resilience even when traditional drainage outfalls are blocked by the rising Brahmaputra River.

सारांश

यह शोध प्रबंध गुवाहाटी महानगरीय क्षेत्र (GMA) में होने वाली “कृत्रिम बाढ़” (Artificial Flooding) के कारणों तथा नियोजन-आधारित समाधानों का अध्ययन करता है। अध्ययन का मुख्य उद्देश्य यह समझना है कि गुवाहाटी में बाढ़ केवल प्राकृतिक कारणों से नहीं, बल्कि अव्यवस्थित शहरी विकास, भूमि उपयोग परिवर्तन तथा स्थानिक नियोजन की विफलताओं के कारण उत्पन्न हो रही है।

इस शोध में मॉर्फोलॉजिकल एवं GIS आधारित विश्लेषण पद्धति अपनाई गई है, जिसके अंतर्गत वर्ष 2000 से 2026 तक के भूमि उपयोग एवं भूमि आवरण (LULC) परिवर्तनों का अध्ययन किया गया। विश्लेषण से यह पाया गया कि निर्मित क्षेत्र में लगभग 220% की वृद्धि हुई है, जबकि आर्द्रभूमियों (Wetlands) में 41.5% की कमी आई है। अध्ययन में प्राकृतिक जल संचयन क्षेत्रों (बीलों) के क्षरण, भारालु नदी जैसे जल निकासी तंत्र की अव्यवस्था तथा आधिकारिक मास्टर प्लान और वास्तविक शहरी विकास के बीच मौजूद “क्रियान्वयन अंतर” की पहचान की गई है। इन परिवर्तनों ने शहर की “बाउल इफेक्ट” स्थलाकृति को और अधिक संवेदनशील बना दिया है, जिसमें आसपास की पहाड़ियों से आने वाला जल मानसून के दौरान शहर के निचले भागों में एकत्र हो जाता है।

अध्ययन में पारंपरिक “ग्रे इन्फ्रास्ट्रक्चर” जैसे कंक्रीट नालों और पंपों के स्थान पर ब्लू-ग्रीन इन्फ्रास्ट्रक्चर (BGI) तथा “स्पंज सिटी” रणनीति आधारित नियोजन ढांचा प्रस्तावित किया गया है। प्रस्ताव में प्राकृतिक जल निकासी बेसिनों पर आधारित नियोजन, आर्द्रभूमियों के आसपास “नो-बिल्ड” बफर क्षेत्र, तथा रेन गार्डन, बायो-रिटेंशन सिस्टम और पारगम्य पक्की सतहों के उपयोग पर विशेष जोर दिया गया है।

यह अध्ययन स्थानिक विश्लेषण और नियोजन रणनीतियों के एकीकरण के माध्यम से गुवाहाटी के प्राकृतिक जल-वैज्ञानिक संतुलन को पुनर्स्थापित करने तथा शहरी लचीलापन (Urban Resilience) को सुदृढ़ करने हेतु एक व्यावहारिक दिशा-निर्देश प्रस्तुत करता है। प्रस्तावित रणनीतियाँ बाढ़ के जोखिम को कम करने, पारिस्थितिक संतुलन बनाए रखने तथा दीर्घकालिक सतत शहरी विकास को समर्थन देने में सहायक होंगी।

CERTIFICATE

I take this opportunity to express my heartfelt gratitude to Maulana Azad National Institute of Technology, Bhopal, for providing me with the opportunity to pursue my Bachelor's Degree in Planning and for fostering an environment of academic excellence and holistic development.

I am deeply indebted to my esteemed guide and mentor, Dr. Preeti Onkar Singh, for her invaluable guidance, constant encouragement, and insightful suggestions throughout the course of this thesis. Her unwavering support, patience, and intellectual inputs were instrumental in shaping my research, and I remain truly grateful for her mentorship at every stage of this academic journey.

I extend my sincere thanks to the Thesis Coordinators, Dr. Preeti Onkar Singh and Dr. Preemjit Das Gupta, for their constructive feedback, timely guidance, and continuous motivation, which were essential in refining the scope and structure of this thesis.

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I also acknowledge with gratitude the various institutions and agencies that facilitated the acquisition of critical secondary data and resources, which formed the analytical foundation of this study.

To my friends and peers, thank you for your encouragement and the memorable moments we have shared during our time in the hostel and classrooms. Your presence has made this journey both meaningful and enjoyable.

Most importantly, I owe immense gratitude to my family for their unconditional love, patience, and unwavering support. Their belief in me has been the backbone of my perseverance.

Finally, I offer my humble thanks to the Almighty, whose grace and guidance have enabled me to overcome challenges and complete this academic milestone with resilience and purpose.

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ABBREVIATION	FULL FORM
ESZ	Environment Sensitive Zone
GIS	Geographic Information System
GPS	Global Positioning System
Ha	Hectare
km	Kilometre
LULC	Land Use Land Cover
MDR	Major District Road
m	Meter
NDVI	Normalized Difference Vegetation Index
NGT	National Green Tribunal
NH	National Highway
RCC	Reinforced Cement Concrete
RRZ	River Regulation Zone
STP	Sewage Treatment Plant
URDPFI	Urban and Regional Development Plans Formulation and Implementation

CHAPTER 1

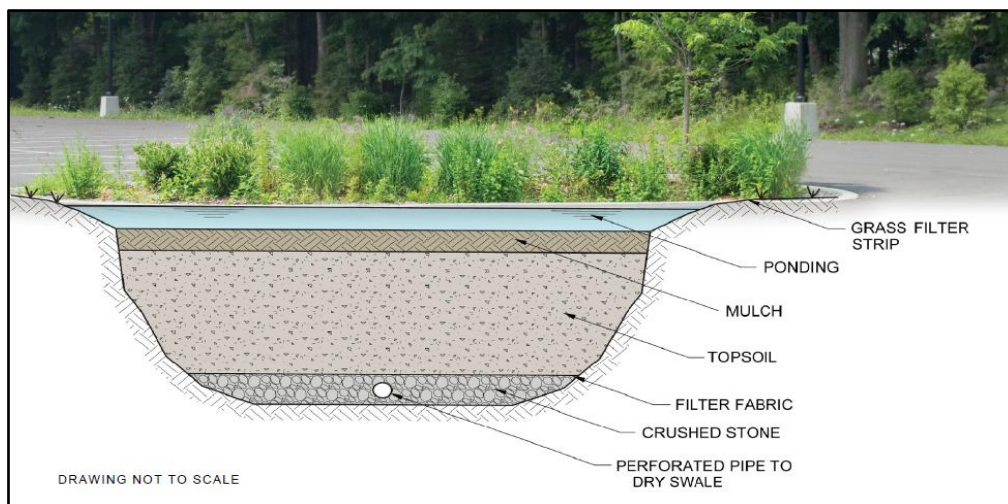
1.1. Thesis Orientation

This research investigates 'Planning to Mitigate Urban Flooding in Guwahati'. It challenges the traditional view that floods are simply natural events caused by heavy rainfall. Instead, it adopts the academic perspective that urban flooding is often 'human-induced', a result of how we build and manage our cities. The study shifts the focus from meteorology (weather patterns) to spatial planning, specifically examining how unplanned land use, the loss of natural wetlands, and the disconnect between official master plans and the actual drainage infrastructure contribute to 'artificial flooding' in the city.

1.2. Core Concepts

This thesis is grounded in three key planning concepts that challenge the current approach to flood management in Guwahati:

✚ **From "Grey" to "Blue-Green" Infrastructure:** Current approaches in Guwahati rely heavily on "Grey Infrastructure", conventional engineering solutions like concrete drains, embankments, and pumps designed solely to move water away quickly. This study argues for a shift toward "Blue-Green Infrastructure", which integrates natural systems such as parks, wetlands (*beels*), and open soil into the urban fabric. The goal is to use nature to absorb and manage water at the source, reducing the pressure on the city's overloaded concrete drains.



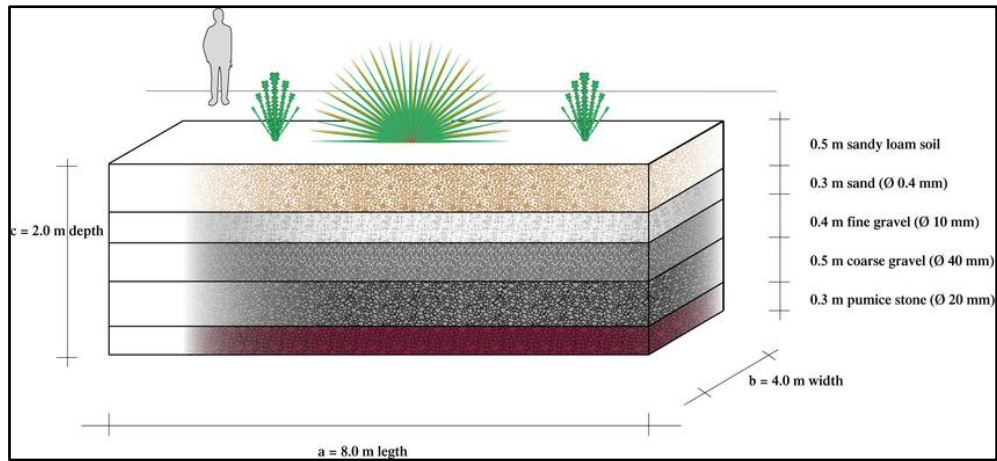


Figure 1. Bioretention systems (rain gardens) of various shapes and sizes, can be integrated into a wide range of urban settings.

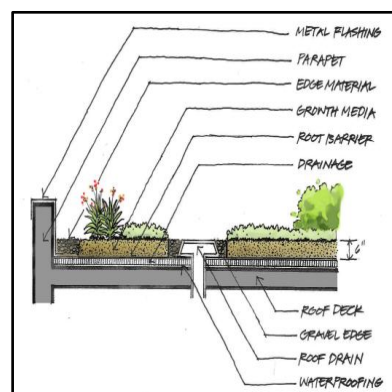
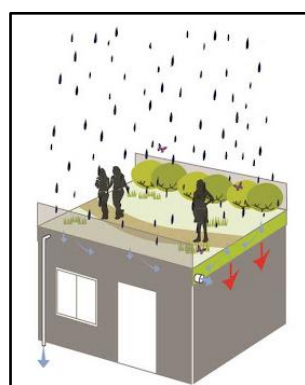
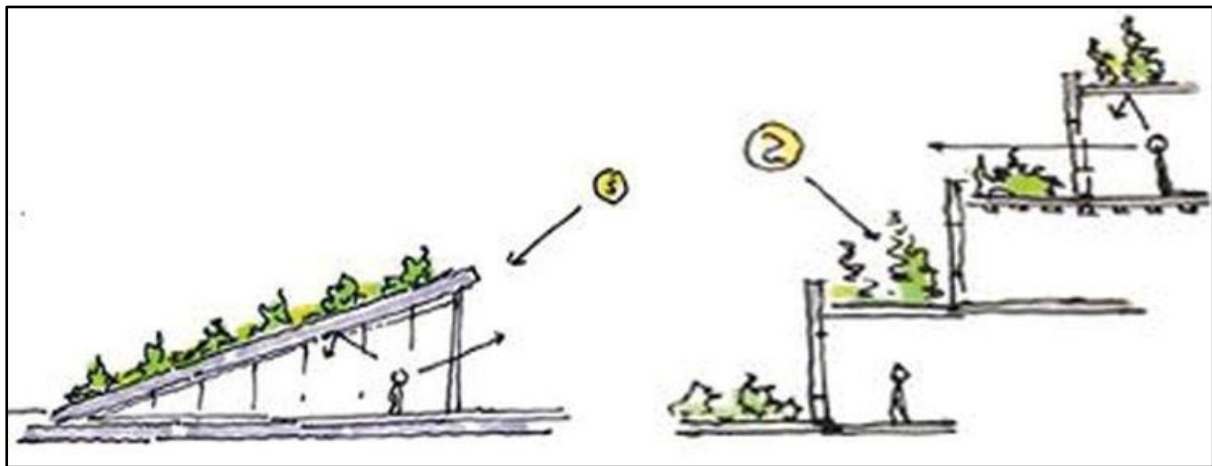


Figure 2. Green roof and green wall systems come in a variety of styles, matching plant species, substrate, and irrigation.

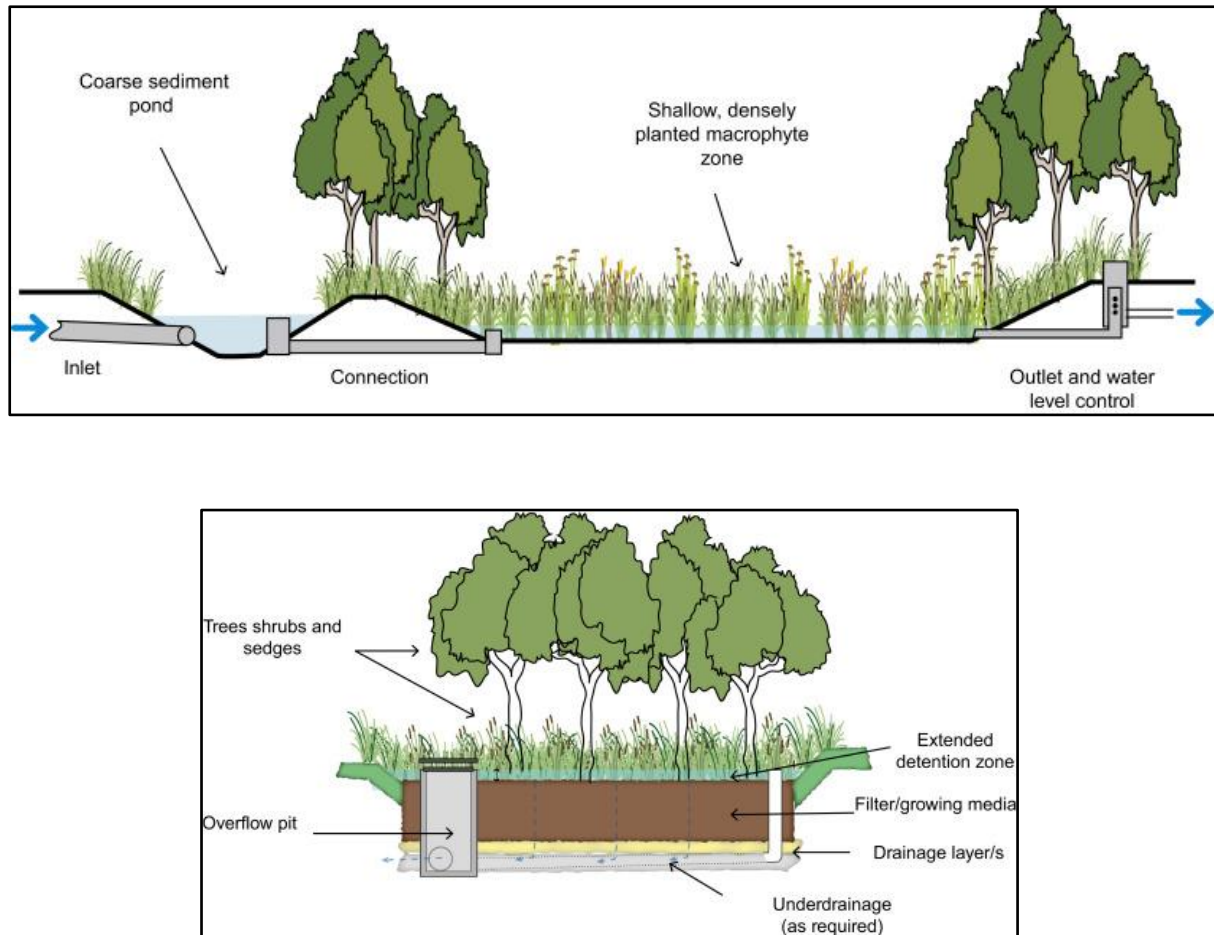
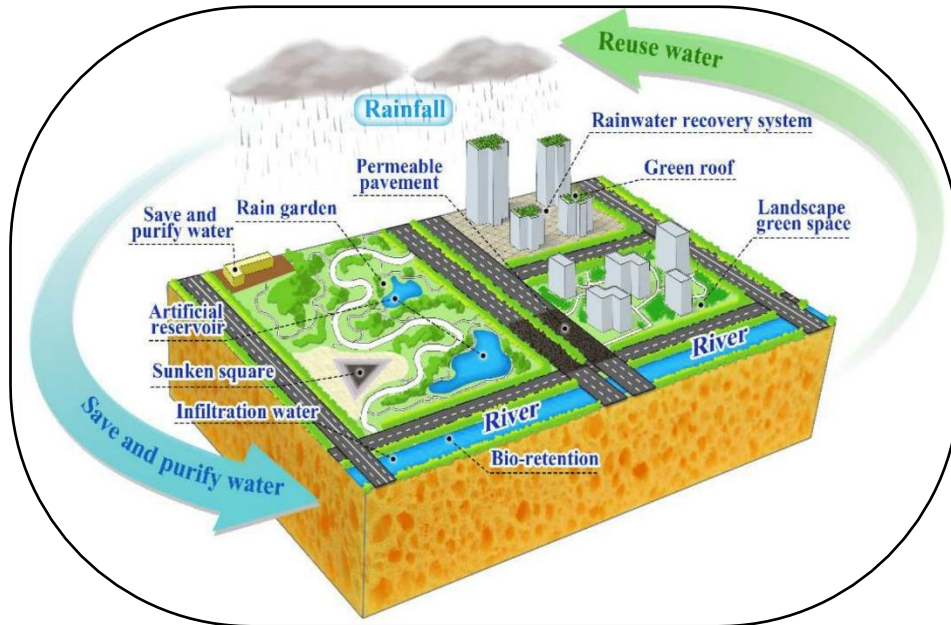


Figure 3. Constructed stormwater wetlands can come in many forms and provide key opportunities for engagement and interaction; however, they are susceptible to major plant dieback.

✚ **The "Sponge City" Potential:** The study examines Guwahati's potential to function as a "Sponge City". Instead of treating rainwater as a waste product to be flushed out, this approach views the city as a sponge that should soak up excess water. This is critical because Guwahati has lost significant natural water-holding capacity due to the encroachment of essential wetlands like Deepor Beel. Restoring these "natural sponges" is essential to managing the increased surface runoff caused by rapid urbanisation..3.



The "Lived" vs. The "Planned" City: A critical gap exists between the "Official City" (the idealised version shown on master plan maps) and the "Lived City" (the messy reality on the ground). Official plans often ignore informal settlements, unauthorised drains, and the "patchwork" infrastructure built by residents themselves. This thesis acknowledges that effective planning cannot rely solely on government maps but must account for these invisible, informal networks and blockages that define how the city actually functions during a flood.

1.3. Identification of Planning Problem

Planning Problem: "Artificial Flooding" The core issue is not merely meteorological (heavy rain) but morphological (how the city's form has changed). The study identifies three systemic planning failures that have created a crisis of "artificial flooding":

- ✚ **Diminished Natural Retention:** The city has undergone drastic land-use changes due to rapid, unplanned urban growth. The natural depressions and wetlands (*beels*) that historically acted as "retention bowls" for excess water have been encroached upon, leaving the water with nowhere to sit.
- ✚ **Infrastructural Degradation:** The natural drainage network has been compromised. The Bharalu River, which serves as the main natural drainage channel for the city, has effectively become a "sewage canal". Its capacity to carry stormwater is severely limited by heavy siltation and the unchecked dumping of solid waste, creating a bottleneck that backs water up into neighbourhoods.
- ✚ **The Implementation Gap:** There is a critical disconnect between policy and practice. Recent studies highlight the gap between the "imagined" infrastructure (what is in the Master Plan) and the "lived" infrastructure (the actual patchwork of drains on the ground). While regulations exist, the reality involves informal networks and maintenance failures that the official plans often overlook.

1.4. Study Area

✚ **Macro Context:** Guwahati Metropolitan Area (GMA).

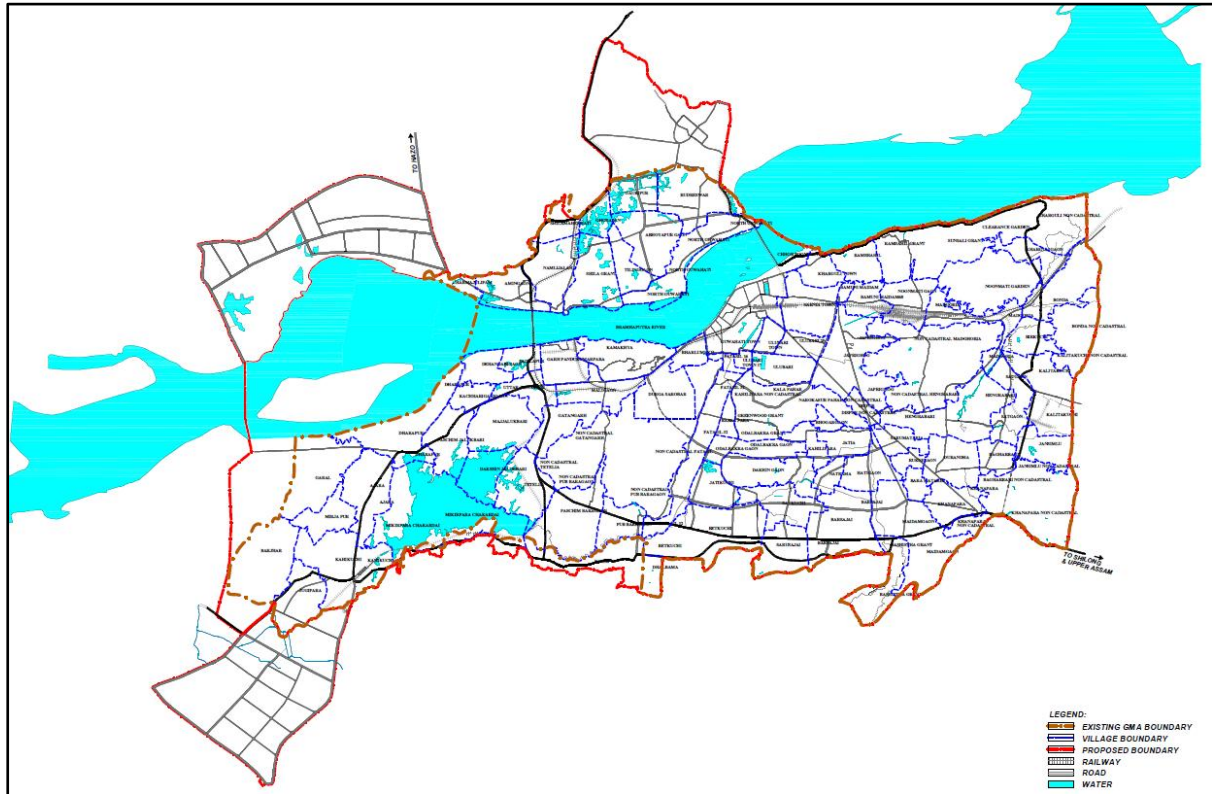


Figure 4. Administrative Map of Guwahati Metropolitan Area

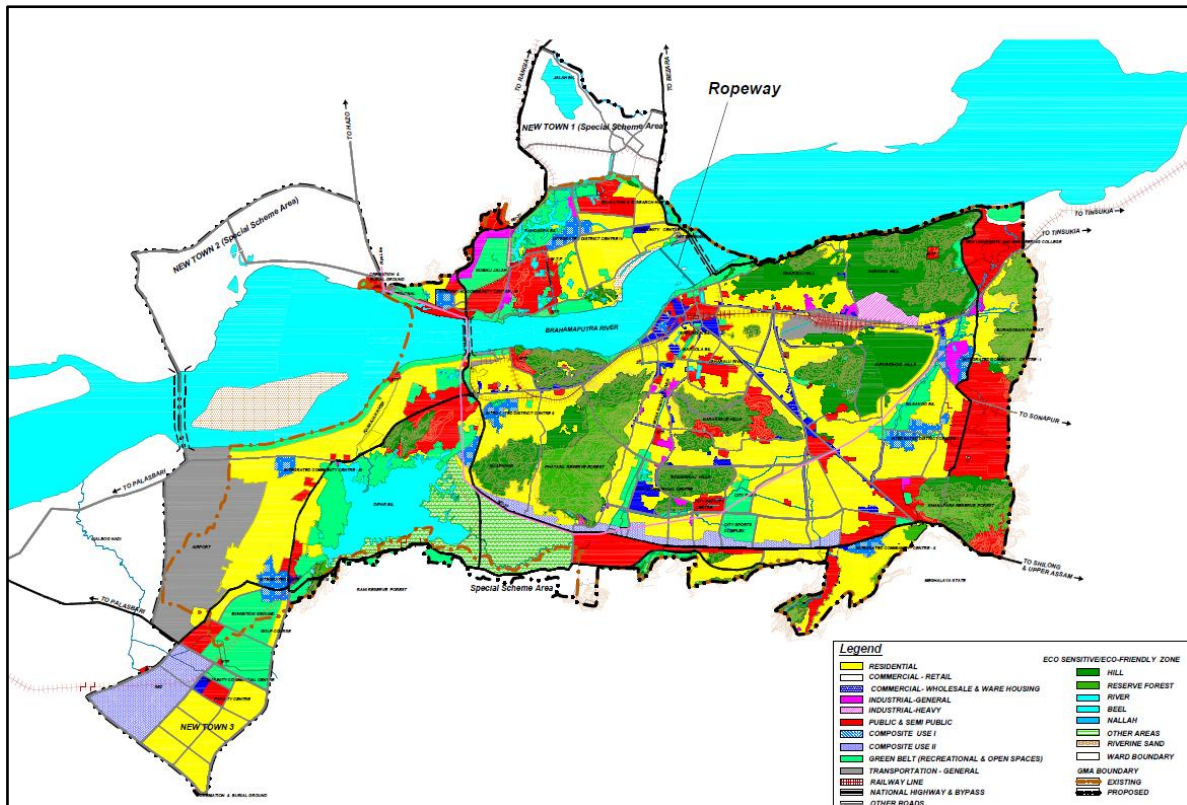


Figure 5. Comprehensive Master Plan for Guwahati Metropolitan Area

✚ **Micro Focus:** The Bharalu River Basin (specifically high-vulnerability wards such as Anil Nagar and Nabin Nagar).

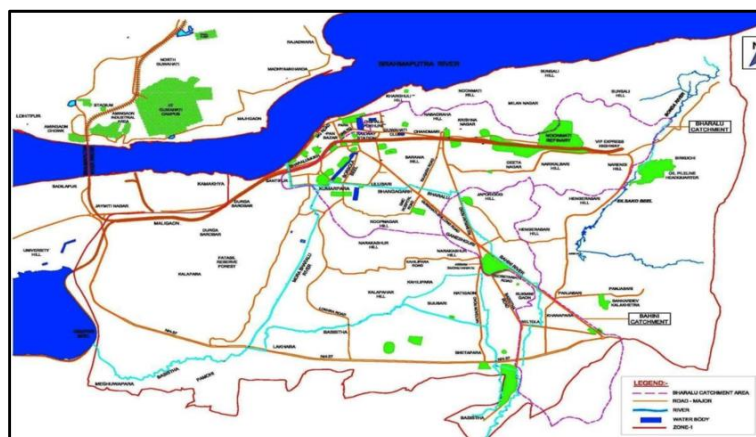


Figure 6. Bharalu River Basin Map

✚ **Rationale for Selection:** The Bharalu Basin is selected because it functions as the hydrological "spine" of the city. It is the catchment area where the conflict between high-density urbanisation and natural drainage is most acute, making it the ideal laboratory for studying urban flood mitigation strategies.

1.4. Aim

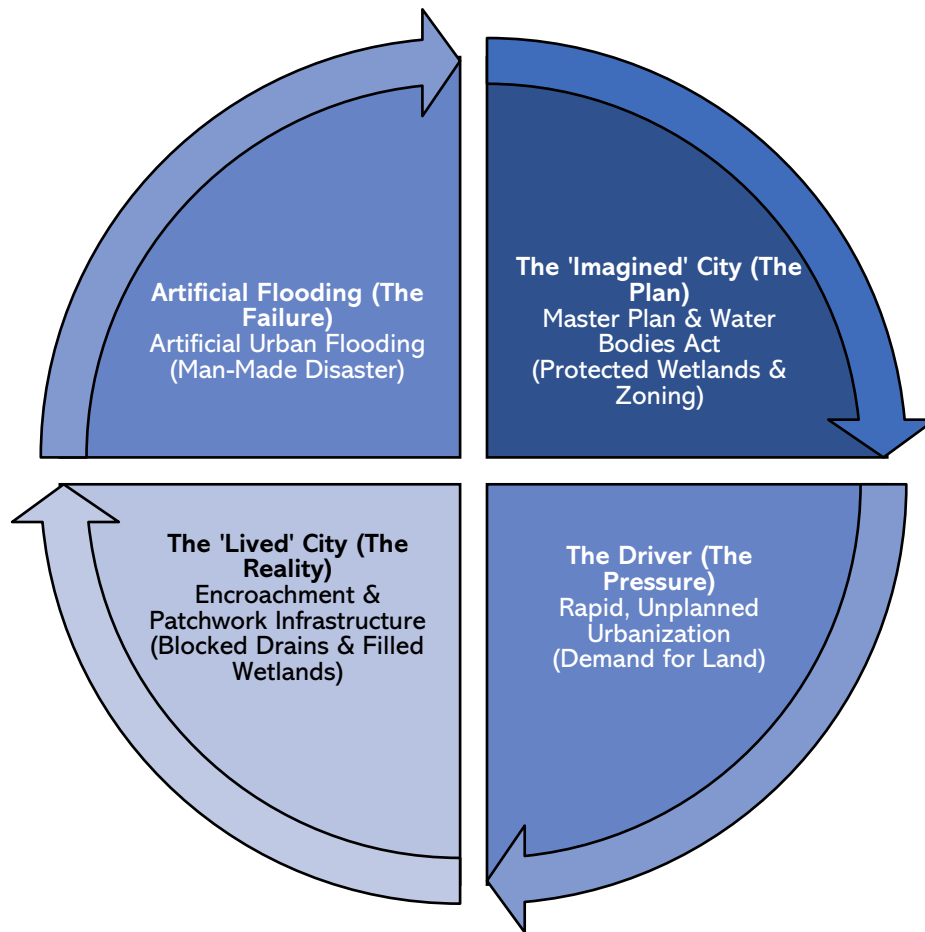
"To develop a practical planning strategy for the Guwahati Metropolitan Area (GMA) that reduces urban flooding by combining drainage improvements with better land-use regulations."

1.5. Objectives

✚ **To Examine Policy Failures:** To investigate why existing rules, such as the *Guwahati Master Plan* and the *Water Bodies Act*, have failed to stop construction in flood-prone areas and wetlands.

Goal: To investigate why existing rules, such as the Guwahati Master Plan and the Water Bodies Act, have failed to stop construction in flood-prone areas and wetlands.

- **Methods for Achieving Objective:** Institutional analysis and policy gap assessment. This involves comparing the "Imagined City" (what is protected on paper) with the "Lived City" (actual encroachments on the ground).
- **Types of Data & Acquisition (Primary Data):** Key Informant Interviews (KIIs) with officials from the Guwahati Metropolitan Development Authority (GMDA) and Guwahati Municipal Corporation (GMC) to understand the enforcement challenges.
- **Types of Data & Acquisition (Secondary Data):** The Guwahati Water Bodies (Preservation and Conservation) Act, 2008, and the Master Plan for Guwahati Metropolitan Area 2025.
- **Analytical Tools and Methods:** Qualitative policy analysis and matrix evaluation to identify the implementation gap between policy regulations and informal ground realities.
- **Justification based on Literature:** The literature explicitly highlights a gap between official maps and what is actually built, including unauthorized buildings and informal settlements ignored by official plans. Qualitative institutional analysis is required to understand *why* these policies fail on the ground.



✚ **To Analyze Land Use Changes:** To study how the rapid growth of the city and the filling up of wetlands (like *beels*) have increased the amount of rainwater runoff over the last 20 years.

Goal: To study how rapid growth and the filling up of wetlands have increased rainwater runoff over the last 20 years (2000–2026).

- **Methods for Achieving Objective:** Spatio-temporal mapping and land use transition analysis. This will calculate the exact loss of natural "sponges" (wetlands) and the increase in impermeable built-up areas.
- **Types of Data & Acquisition (Secondary Data):** Historical satellite imagery (from the year 2000 to present), past land use maps, and baseline wetland area data (e.g., showing the drop from 124.15 ha in 2000 to 32.31 ha in 2020).
- **Analytical Tools and Methods:** Geographic Information Systems (GIS) and remote sensing for Land Use Land Cover (LULC) classification and spatial overlay analysis.
- **Justification based on Literature:** Studies by Nath et al. (2021) and Tamuli & Bora (2021) extensively rely on GIS to track spatial urbanization, the shrinkage of water bodies, and the resulting morphological impacts on Guwahati.

- ✚ **To Assess Drainage Capacity:** To identify the major blockages in the Bharalu River network caused by silt, garbage dumping, and unscientific construction that prevent water from flowing out of the city.

Goal: To identify major blockages in the Bharalu River network caused by silt, garbage dumping, and unscientific construction.

- **Methods for Achieving Objective:** Ground-truthing and physical infrastructure surveys. Because the study explicitly avoids complex civil engineering calculations, the focus will be on mapping the visual and functional failures of the drainage network.
- **Types of Data & Acquisition (Primary Data):** Transect walks and observation checklists in high-vulnerability micro-focus areas like Anil Nagar and Nabin Nagar. This will capture the "patchwork" infrastructure and unauthorized drains built by residents.
- **Types of Data & Acquisition (Secondary Data):** Existing Bharalu River Basin drainage maps.
- **Analytical Tools and Methods:** Participatory GIS (PGIS) or manual spatial mapping of physical bottlenecks, siltation points, and solid waste dumping hotspots that turn the river into a "sewage canal".
- **Justification based on Literature:** The thesis review identifies a major data limitation: government data is not fully up-to-date, and detailed maps of every small drain's exact depth and width are unavailable. Therefore, primary spatial mapping is strictly necessary to document the "messy reality on the ground".

- ✚ **To Propose Mitigation Solutions:** To recommend specific planning actions such as creating "flood-safe" zones and improving drain networks that can help the city manage heavy rainfall better.

Goal: To recommend specific planning actions (e.g., "flood-safe" zones, improving drain networks) to manage heavy rainfall better.

- **Methods for Achieving Objective:** Formulating spatial planning guidelines and Development Control Regulations (DCRs) to transition the city from "Grey" to "Blue-Green Infrastructure".
- **Types of Data & Acquisition:** Synthesis of the primary and secondary spatial data collected in Objectives 1, 2, and 3, combined with global best practices for "Sponge Cities".
- **Analytical Tools and Methods:** Scenario building, spatial zoning plans, and schematic planning for integrating bio-retention systems, rain gardens, and permeable pavements into the existing urban fabric.
- **Justification based on Literature:** As argued in the proposal, conventional engineering solutions (concrete drains and pumps) are failing. Sarmah and Das (2018) advocate for planning-based mitigation in the Bharalu basin. The literature justifies spatial integration of natural systems to absorb water at the source, reducing pressure on overloaded grey infrastructure.

1.6. Research Questions

- ✚ How much natural water retention capacity has Guwahati lost due to urbanization since 2000?
- ✚ Why are zoning regulations and the Water Bodies Act not effectively enforced on the ground?
- ✚ What are the specific physical and behavioural barriers (e.g., waste dumping) clogging the Bharalu basin?
- ✚ What specific planning interventions can be applied at the ward level to reduce surface runoff?

CHAPTER 2

2.1. Literature Review

Introduction: Shifting from Engineering to Spatial Planning

Historically, urban flooding in Indian cities has been treated primarily as an engineering problem—a matter of calculating rainfall and building wider concrete drains. However, recent urban planning literature argues that flooding in rapidly growing cities like Guwahati is fundamentally a failure of spatial planning and land-use management. This review examines the existing research on Guwahati's flood crisis, categorizing the problem into four distinct areas: natural topographical constraints, unregulated land-use changes, the destruction of ecological buffers, and fragmented institutional responses.

The Topographical Reality: Guwahati as a Catchment "Bowl"

To understand Guwahati's flooding, the literature emphasizes that one must first understand its geography. Guwahati is topographically unique; it functions as a natural saucer or "bowl."

- **The Hill-to-Valley Flow:** The city is bordered by the Brahmaputra River to the north and surrounded by the foothills of the Shillong Plateau (Meghalaya) to the south and east. Research indicates that during the monsoon, massive volumes of rainwater naturally flow down from these surrounding hills directly into the central, low-lying urban areas.
- **The "Backflow" Phenomenon:** A critical issue highlighted in hydrological studies of Guwahati is the "backflow" effect. The city relies on primary channels (like the Bharalu and Bahini rivers) to carry internal stormwater out to the Brahmaputra. However, during peak monsoons, the Brahmaputra's water level frequently rises higher than the city's drainage outfalls. To stop the river from flooding the city, authorities must close the sluice gates.
- **The Result:** When the gates are closed, the city's internal rainwater has nowhere to drain. It becomes trapped inside the urban core. The literature shows that standard drainage networks cannot solve this; the city must find ways to *store* this trapped water internally.

Unplanned Urbanization and the Crisis of Hill-Cutting

A major theme in recent planning literature is the impact of rapid, uncontrolled demographic growth. As the flat valley areas of Guwahati filled up, informal settlements and new developments expanded upward into the fragile, eco-sensitive hillsides.

- **Deforestation and Earth-Cutting:** Research documents widespread illegal hill-cutting to clear land for housing. This strips the hills of their natural vegetation, which previously held the soil together and slowed down rainwater.

- **The Siltation Problem:** Without vegetation, the loose topsoil washes down the slopes during heavy rains. This creates massive sediment runoff (mudflows). The literature repeatedly points out that Guwahati's municipal drains are not just failing because they are too small, but because they are instantly choked by this hill sand and silt, reducing their water-carrying capacity to near zero.

Land Use Conversion and the Loss of Urban "Sponges"

Perhaps the most heavily researched aspect of Guwahati's flooding is the systematic destruction of its natural wetlands, known locally as *Beels*.

- **The Shrinking Beels:** Historically, water bodies like Deepor Beel, Borsola, and Silsako acted as the city's natural retention basins (or "sponges"). They safely absorbed and held millions of liters of excess monsoon runoff.
- **Encroachment:** Spatial mapping studies using satellite imagery reveal a drastic reduction in the surface area of these wetlands over the last two decades. Aggressive real estate development, the construction of physical infrastructure (like roads and railway lines through wetland buffer zones), and unchecked solid waste dumping have filled in these areas.
- **Loss of Permeability:** At the same time, the city has paved over natural, permeable soil with concrete and asphalt. This transition from "green" to "grey" surfaces means rainwater can no longer soak into the ground. It immediately becomes surface runoff, moving faster and in greater volumes straight onto the streets.

Governance Gaps and the Need for Blue-Green Infrastructure

The final section of the literature review focuses on institutional frameworks. Planning scholars note that flood mitigation in Guwahati suffers from an over-reliance on reactive measures (like post-flood relief or pre-monsoon drain cleaning) and a lack of proactive, integrated planning.

- **Institutional Silos:** The literature identifies a gap between the authorities that plan the city (GMDA), the authorities that maintain the infrastructure (GMC), and the agencies managing the river systems (Water Resources Department). This fragmentation leads to overlapping jurisdictions and a lack of accountability.
- **The Shift to BGI:** Recent policy frameworks advocates for a transition toward Blue-Green Infrastructure (BGI). This involves moving away from just building concrete drains ("grey" infrastructure) and moving towards integrating nature into the urban design. Recommendations in the literature include enforcing strict "no-build" zones around wetlands, mandating permeable pavements in new developments, and creating localized holding ponds to temporarily store rainwater until the Brahmaputra's water levels drop.

2.2. Scope of Existing Literature

A systematic review of the literature on urban flood mitigation reveals a distinct pattern in how the problem is framed and studied across different spatial and thematic scales.

Spatial Focus

- **Global Level:** International literature predominantly focuses on overarching theoretical frameworks. The scope at this level is heavily oriented toward climate change adaptation, resilience theory, and macro-concepts like "Sponge Cities" (originating in China) or Sustainable Urban Drainage Systems (SUDS) heavily researched in Europe.
- **National Level (India):** Indian national-level studies and policy documents (such as those from the NDMA or the World Bank's assessments of Indian cities) focus on the consequences of rapid urbanization, shifting monsoon patterns, and the broad failures of municipal governance. The scope here usually compares extreme events across mega-cities like Mumbai, Chennai, and Bengaluru.

Sectoral & Thematic Focus

- **Engineering and Hydrology:** A massive portion of the literature is sectorally confined to civil and hydrological engineering. The themes revolve around calculating peak runoff, simulating drainage capacity, and proposing structural interventions (e.g., larger pumps, concrete embankments).
- **Geospatial Analysis:** Another dominant theme is the use of Remote Sensing and GIS to track Land Use Land Cover (LULC) changes. These studies focus on the physical transition of the city from permeable green cover to impermeable built-up areas.

2.3. Limitations Identified in the Research

Despite the volume of research, a critical review exposes significant constraints and gaps that justify the need for your specific spatial planning intervention.

Data Constraints

- **Lack of High-Resolution Topographical Data:** A recurring limitation in South Asian flood modeling is the absence of ultra-high-resolution Digital Elevation Models (DEM) and highly granular LiDAR data. Most researchers are forced to rely on open-source, lower-resolution satellite imagery, which fails to capture micro-topographical barriers (like a raised road or a blocked culvert) that actually dictate street-level waterlogging.
- **Absence of Short-Duration Rainfall Data:** Granular, hourly rainfall data is critical for understanding flash floods, but municipal stations often only provide daily averages.
- **Missing Wetland Inventories:** There is a severe data constraint regarding legal, digitized inventories of wetland boundaries and their catchments, making it difficult to enforce precise "no-build" buffer zones.

Methodological Gaps

- **Lack of Hybrid Methodologies:** The literature exhibits a heavy over-reliance on purely quantitative, remote-sensing methods (GIS and hydrological models). There is a stark methodological gap in utilizing mixed-method or hybrid approaches that combine physical satellite data with primary, qualitative ground-truthing.
- **Omission of Socio-Economic Vulnerability:** Current methodologies map where the water flows, but rarely overlay this with *who* it affects. The socio-economic dimension—how marginalized communities adapt, or the structural modifications households are forced to make—is largely missing from spatial planning literature.
- **Administrative vs. Watershed Boundaries:** Methodologically, most municipal planning studies analyze data based on political ward boundaries rather than natural drainage basins, which leads to fragmented and ineffective policy recommendations.

Contextual Limitations

- **Unrealistic Assumptions for the Indian Context:** Many theoretical mitigation frameworks (like implementing complex Blue-Green Infrastructure or SUDS) suffer from a "Global North bias." They assume the existence of highly regulated land markets, strictly enforced building byelaws, and ample public space.
- **Ignoring the Informal City:** These global models often fail contextually in Indian cities like Guwahati, where they do not account for informal settlements, complex land tenure, overlapping institutional jurisdictions (e.g., GMC vs. GMDA), and the

reality of politically driven illegal hill-cutting. The literature lacks frameworks adapted for highly dense, organically developed neighborhoods.

2.4. Research Gaps & Personal Insights

Identified Research Gaps from Literature and Policy Review

While the physical and climatic causes of Guwahati's flooding are well-documented, a critical review reveals distinct gaps in how the problem is being addressed spatially:

Gaps in Literature

- **Engineering vs. Planning Bias:** The majority of existing studies approach the Guwahati flood crisis purely as an engineering failure (inadequate drain capacity) or a geographical phenomenon (macro-level Land Use Land Cover changes). There is a distinct lack of research focusing on **micro-level spatial planning interventions**, such as ward-level zoning regulations, permeable surface mandates, or revised building byelaws.
- **Missing Socio-Spatial Correlation:** Current literature rarely overlays hydrological risk maps with household-level socio-economic vulnerability. The human adaptability aspect—how residents structurally modify their homes or suffer economic losses—is largely disconnected from physical infrastructure planning.

Gaps in Policy & Governance

- **Administrative vs. Watershed Boundaries:** Urban planning policies in Guwahati currently operate on administrative ward boundaries. However, water flows according to natural topography. There is a policy gap in adopting a catchment-based planning framework where zoning is dictated by the natural drainage basin.
- **Reactive Disaster Management over Proactive Zoning:** Existing state policies (like those from ASDMA) focus heavily on early warning systems, post-flood relief, and pre-monsoon desilting. There is a critical lack of proactive Development Control Regulations (DCRs) to strictly enforce "no-build" ecological buffers around the shrinking wetlands (Deepor Beel, Borsola).

Best Practices Emerging Across Studies

Reviewing both national and international literature brings forward several successful frameworks that move beyond traditional concrete drainage:

- **The "Sponge City" Framework (Blue-Green Infrastructure):** Studies highlight the success of integrating natural water retention systems into the urban fabric. Instead of immediately channelling water out, best practices involve creating localized retention ponds, restoring wetland buffers, and utilizing permeable pavements to let water infiltrate the soil.

- **Integrated Catchment Management:** Rather than piecemeal drain construction, emerging best practices treat the entire hill-to-valley system as one unit. This involves intercepting runoff at the foothills through strategically placed check-dams or bioswales before it can overwhelm the urban core.
- **Decentralized Stormwater Management:** Successful case studies emphasize moving away from relying on a single, massive outfall system (which fails in Guwahati due to the Brahmaputra backflow) toward smaller, decentralized water-holding areas within residential neighborhoods.

How These Directly Shape the Thesis Direction (Personal Insights)

Based on these identified gaps and emerging best practices, the trajectory of this thesis is clearly defined:

- **Shifting the Paradigm:** This thesis will not propose "bigger drains or more pumps." Instead, the direction is shifted entirely toward **spatial planning and land-use management**. The core focus will be on how to accommodate and manage water spatially when the outfall gates are closed.
- **Methodological Pivot:** Because the literature lacks socio-spatial correlation, the primary survey is designed explicitly to capture household-level structural adaptations and economic impacts. This ground-truthed data will be overlaid with GIS drainage maps to identify the exact friction points between planning policies and ground reality.
- **Output Orientation:** The final objective of the thesis is strictly guided by the policy gaps. The expected outcome will be a set of specific, actionable **Development Control Regulations (DCRs) and zoning guidelines**. This includes proposing strict eco-sensitive buffers, defining mandatory permeable area ratios for new constructions, and developing spatial guidelines for integrating Blue-Green Infrastructure into Guwahati's existing highly dense residential zones.



CHAPTER 3

3.1. Methodology

3.1.1. Research Design

The project follows a **Diagnostic-Prescriptive Framework**. The "Diagnostic" phase utilizes geospatial data to identify the physical and regulatory causes of flooding, while the "Prescriptive" phase develops a **Blue-Green Infrastructure (BGI) Strategy** for the Bharalu Basin.

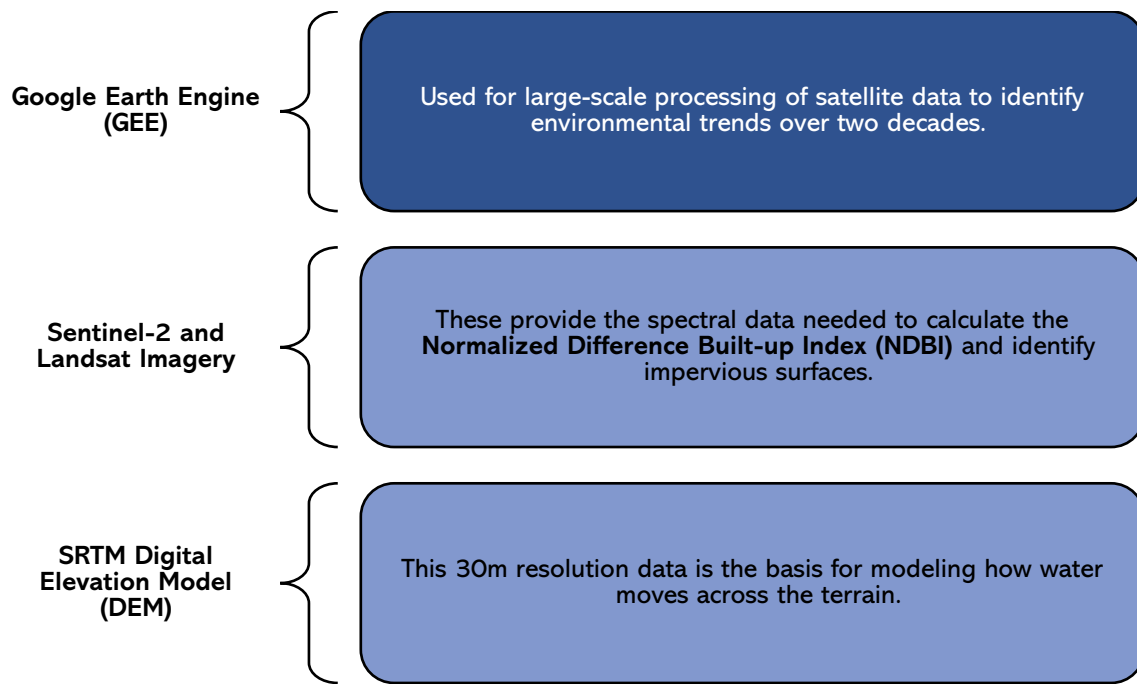
3.1.2. Unit of Analysis and Temporal Scope

Study Area: The research is centered on the **Bharalu River Basin**, identifying it as the most critically affected hydrological unit within the Guwahati Metropolitan Area (GMA).

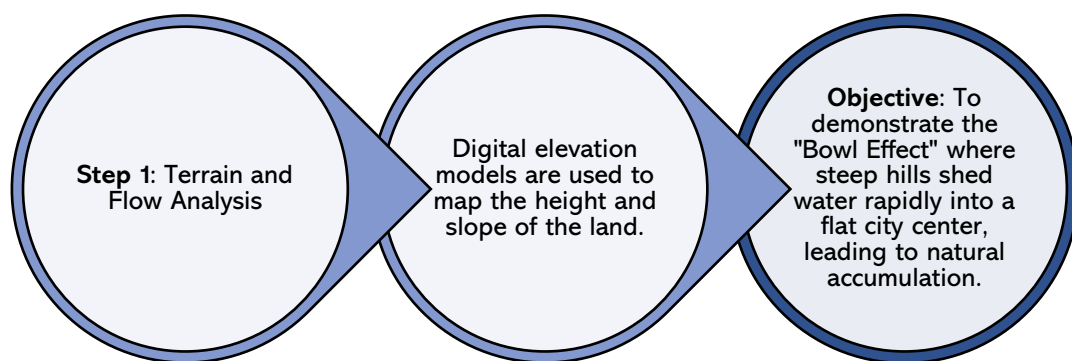
Timeframe: A 26-year analysis period from **2000 to 2026** is established to track the correlation between rapid urban expansion and the decline of natural drainage capacity.

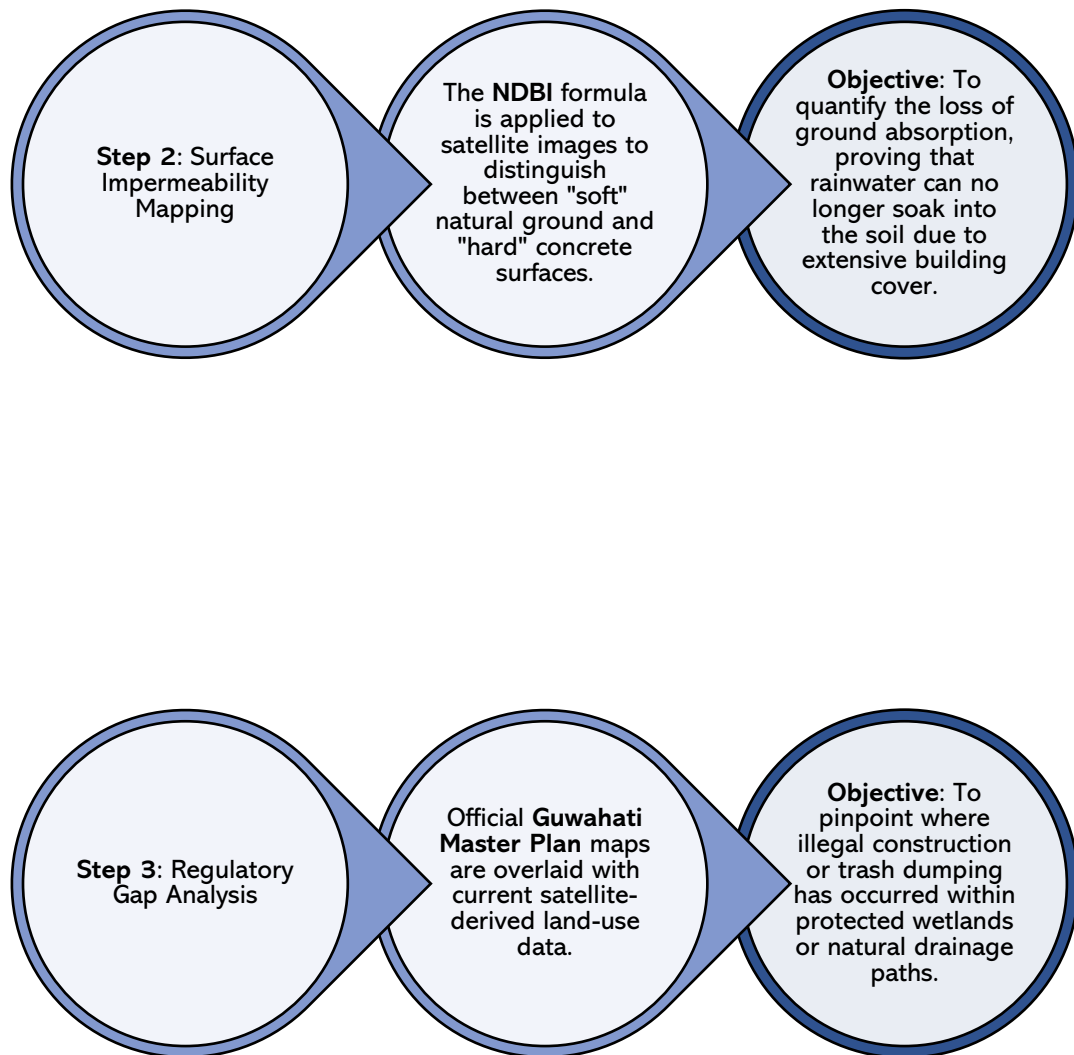
3.2. Materials and Technical Tools

The methodology integrates several advanced planning tools to ensure data accuracy:



3.3. Methodological Process





3.4. Proposed Framework: The Sponge City Strategy

The final output is a spatial framework based on the **Sponge City** concept to manage water naturally:

Wetland Restoration: Establish legal "No-Build Zones" around the Silsako and Deepor Beels to restore their role as natural flood basins.

Upstream Silt Management: Propose "Silt Traps" at the base of the hills to prevent mud and debris from entering and clogging the urban drain network.

Source Control Regulations: Introduce new building bylaws requiring a **Permeable Area Ratio (PAR)** for all new developments to encourage on-site rainwater soaking.

CHAPTER 4

4.1. Results and Discussion

4.1.1. Statistical and Spatial Analysis

The analysis of the Guwahati Metropolitan Area (GMA) reveals a critical correlation between urban expansion and environmental degradation over the 2000–2026 study period.

Land Use and Land Cover (LULC) Dynamics

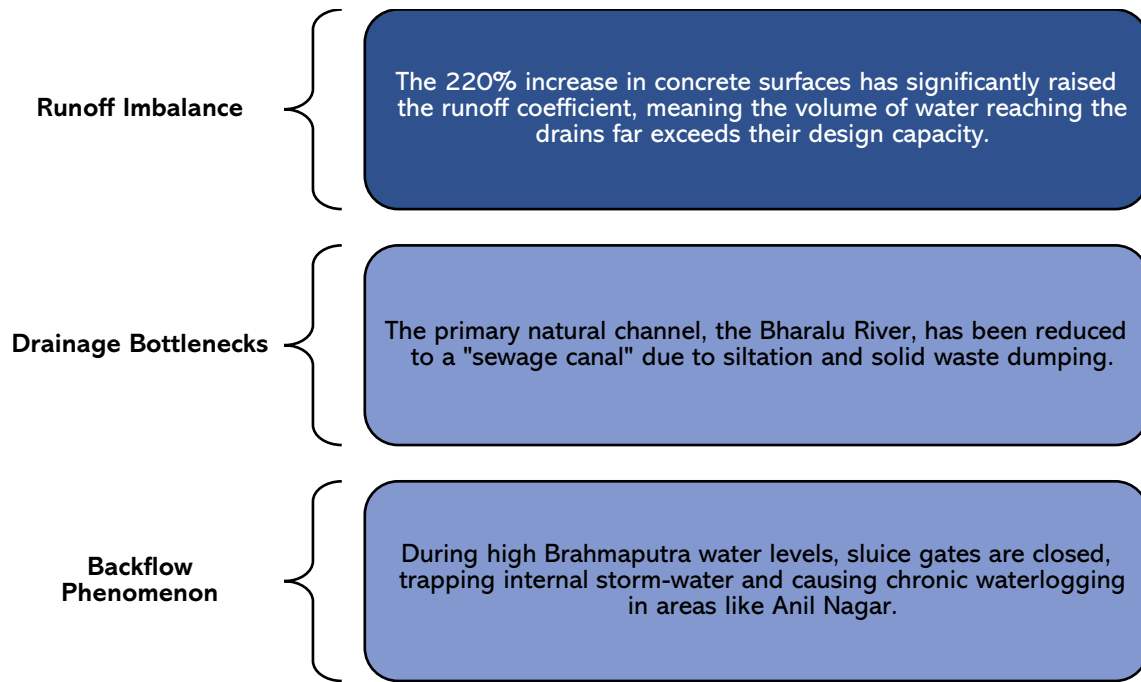
- **Built-up Expansion:** The built-up area increased from 310.4 sq. km in 2001 to 992.5 sq. km in 2021, marking a 220% growth.
- **Vegetation Loss:** Cropland and vegetation cover decreased by 52.3%, reducing the city's natural "green lungs" and absorption capacity.
- **Wetland Shrinkage:** Water bodies shrunk by 41.5% due to aggressive infrastructure and real estate encroachment.
- **Case Study (Silsako Beel):** Originally covering 1,758 hectares in 1912, the wetland was reduced to 124 hectares by 2000 and just 32 hectares by 2020.

Topographic and Hydrological Modeling

- **The "Bowl Effect":** Hypsometric analysis confirms that the urban core lies in a low-elevation "sink" (approx. 40m–50m), surrounded by high-gradient hills that trigger rapid peak discharge.
- **Impermeability (NDBI):** High-intensity urban clusters show a high Normalized Difference Built-up Index (NDBI), indicating nearly total surface sealing which prevents groundwater recharge.

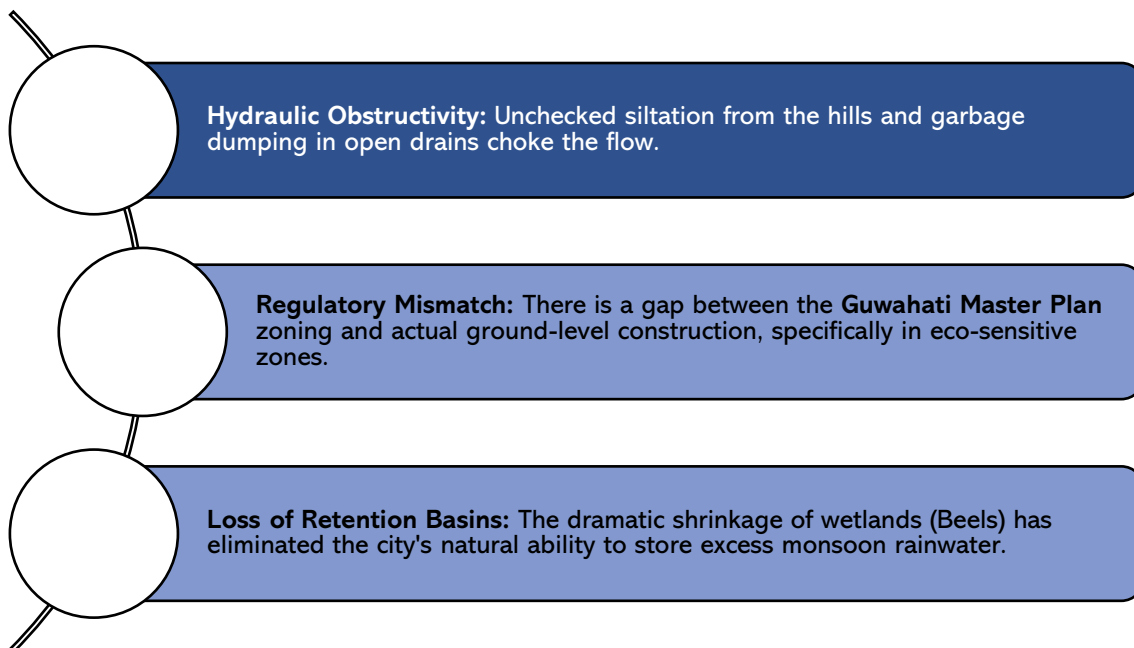
4.1.2. Interpretation and Synthesis of Findings

The findings indicate that flooding in the Bharalu Basin is a result of Morphological Failure.



4.1.3. Identification of Key Planning Issues

Based on the spatial and qualitative appraisal, three primary issues must be addressed:



4.3. Proposal Outline: Strategic Spatial Framework

The upcoming proposals move away from "Grey Infrastructure" toward an **Integrated Urban Water Management (IUWM)** approach.

Macro-Level: Wetland and Basin Protection

Ecological Buffers: Establish "No-Build Zones" around remaining wetlands like Deepor and Silsako Beels to restore natural storage.

Catchment Protection: Restrict construction on steep hill slopes to prevent high-velocity runoff and erosion.

Meso-Level: Drainage and Infrastructure Upgrades

Silt Management: Implement "Silt Traps" at hill-city interfaces to stop sedimentation before it enters the urban drain network.

Integrated Authority: Shift toward a single, catchment-based planning authority to coordinate between GMDA and GMC.

Micro-Level: The Sponge City Toolkit

Source Control: Introduce building bylaws requiring **Permeable Area Ratios (PAR)** and the use of permeable pavements.

Nature-Based Interventions: Deploy bioswales, rain gardens, and sunken plazas to catch and filter water locally.

4.4. Maps

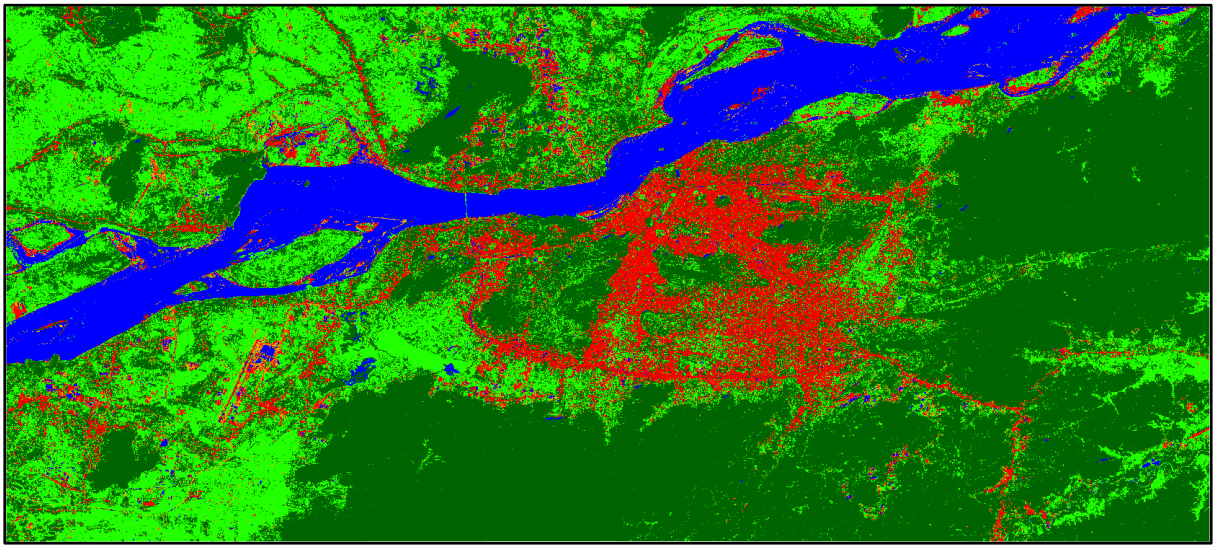


Figure 7. LULC Map of GMA (2025)

Source Reference: ESA WorldCover / Copernicus Global Land Cover, GEE.

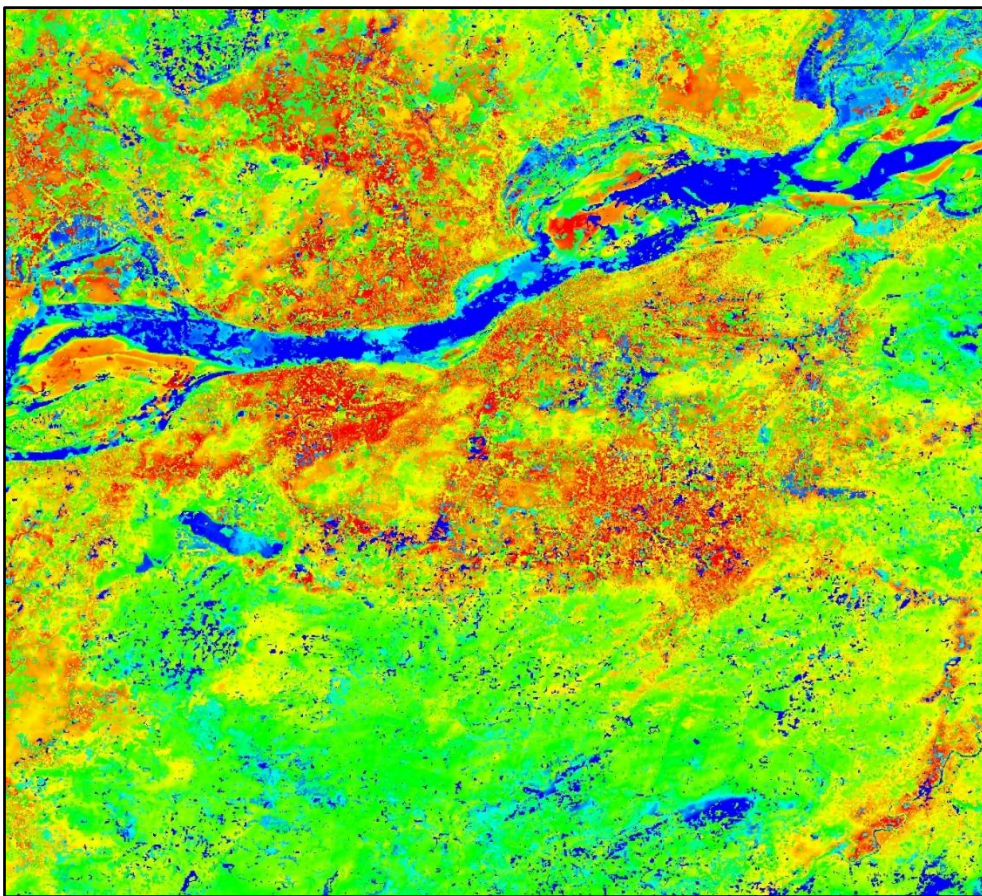


Figure 8. LST Map of GMA (2026)

Source Reference: Landsat 8/9 TIRS, United States Geological Survey (USGS), GEE.

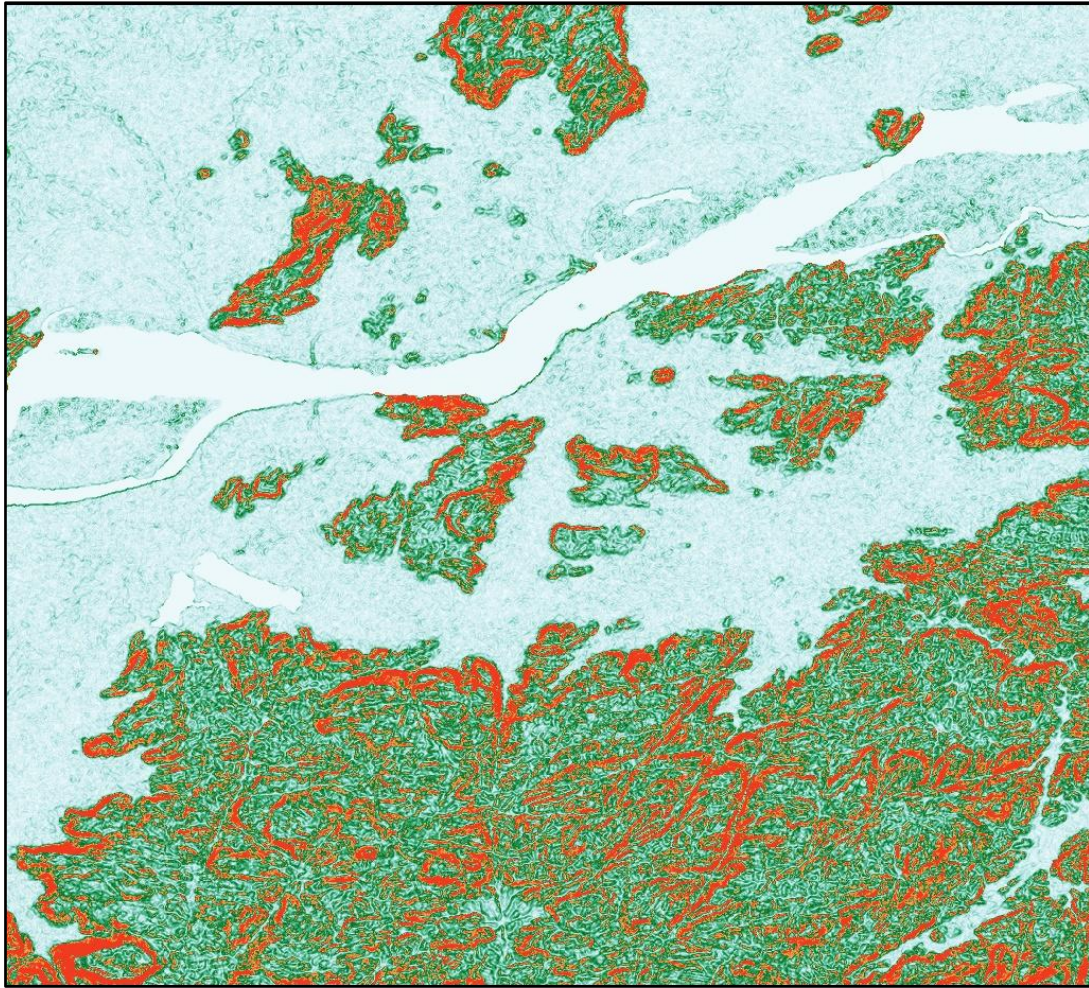


Figure 9. Slope and Flow Accumulation Map of GMA (2026)

Source Reference: Shuttle Radar Topography Mission (SRTM), NASA/USGS, GEE.

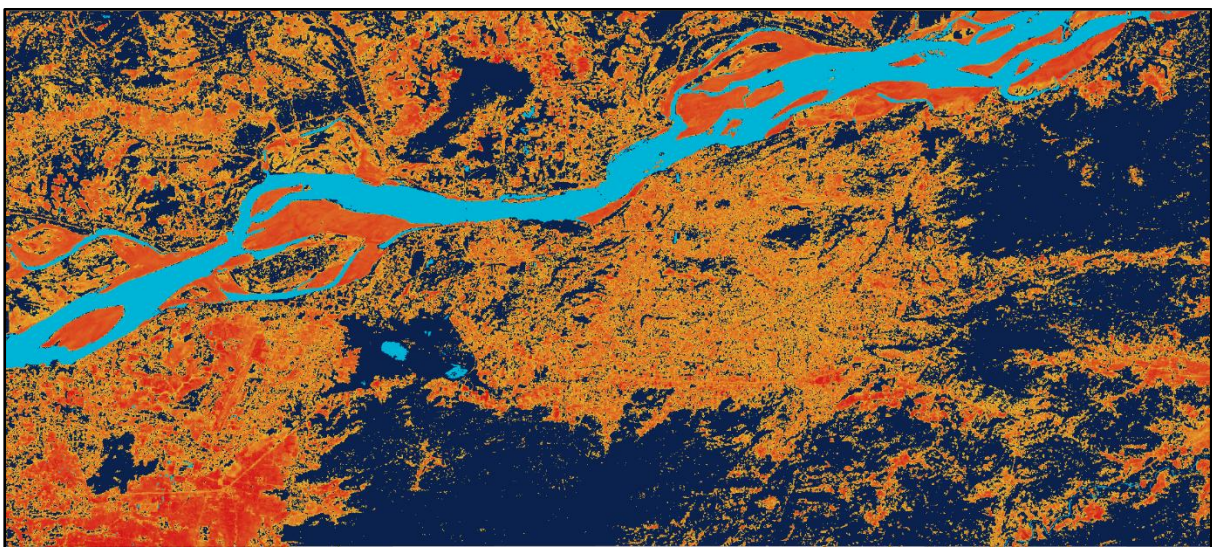


Figure 10. ISF Map of GMA (2026)

Source Reference: Sentinel-2 MSI, European Space Agency (ESA), GEE.

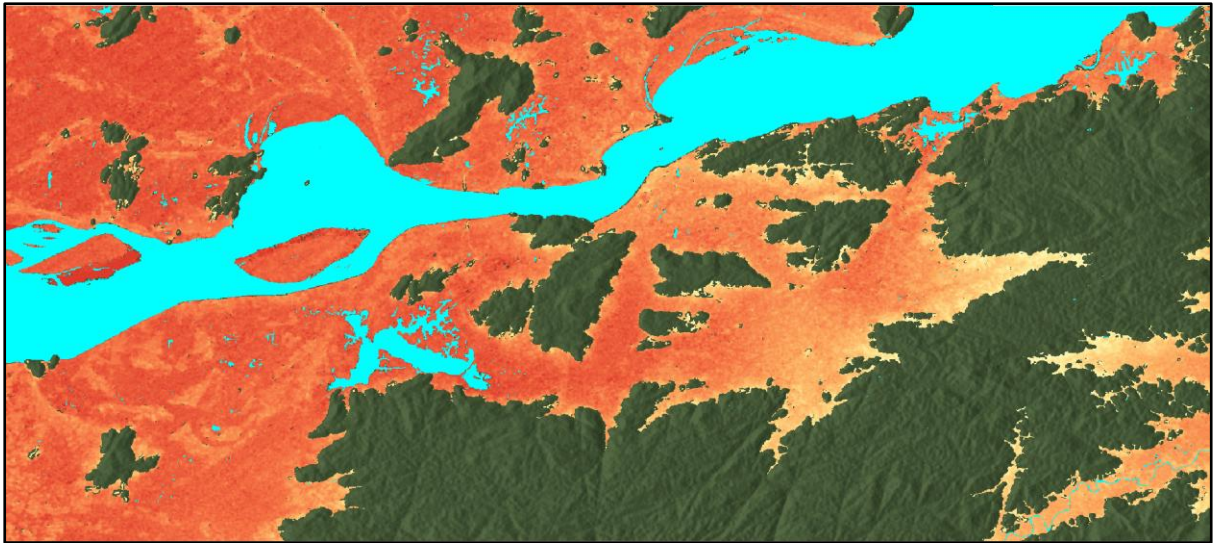


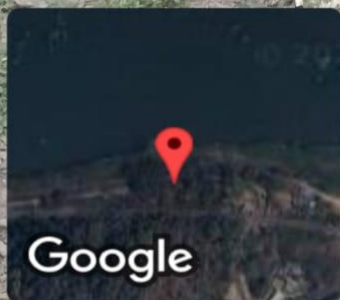
Figure 11. FVI Map of GMA (2026)

Source Reference: Dept. of Water Resource, Govt. of Assam, GEE.

4.5. Geo-tagged Images







Guwahati, Assam, India 
Anushka Tumung, A01, Dipor Bol Rd,
Chakardeo Village, Guwahati, Assam 781035,
India
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Friday, 06/03/2026 05:10 PM GMT +05:30

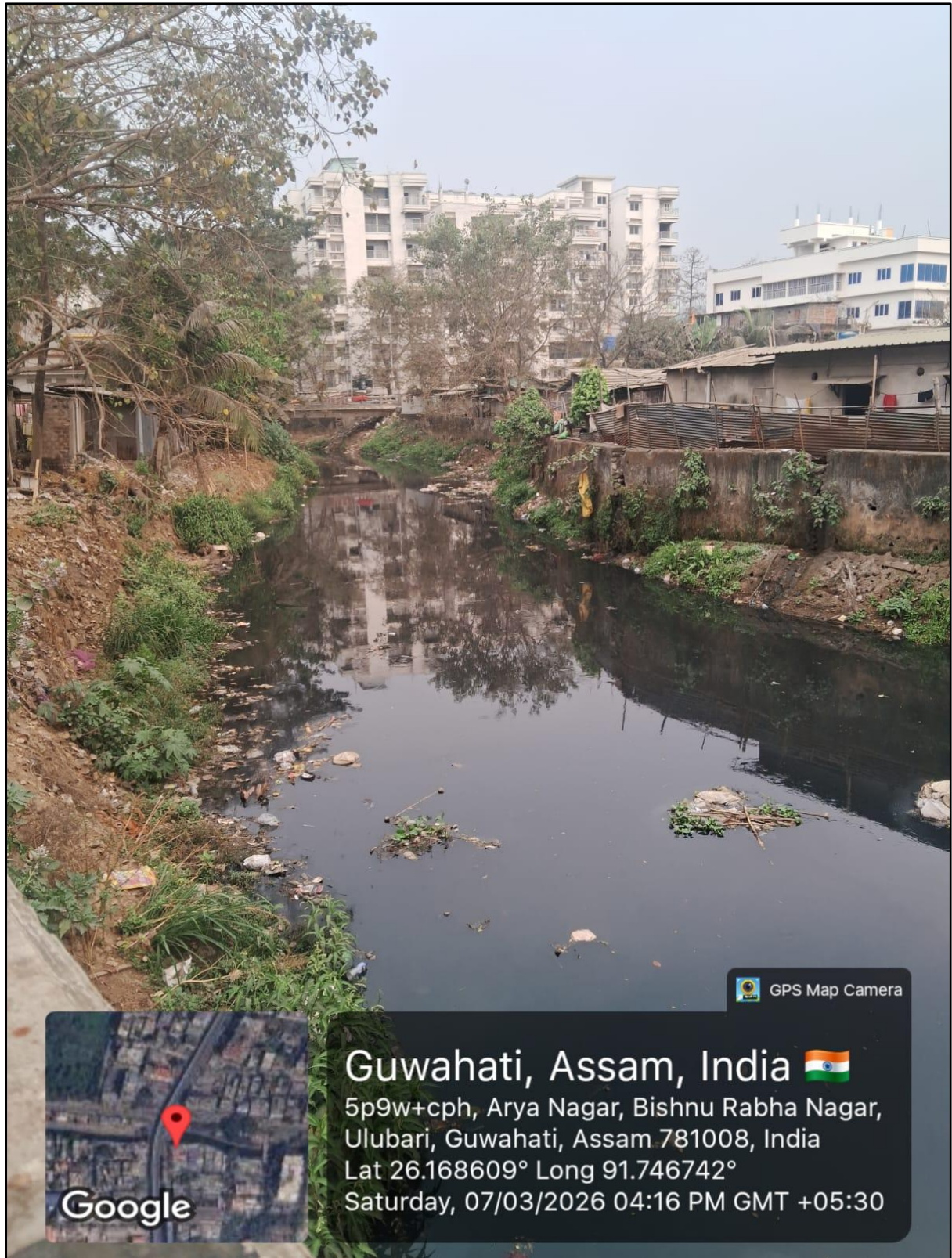




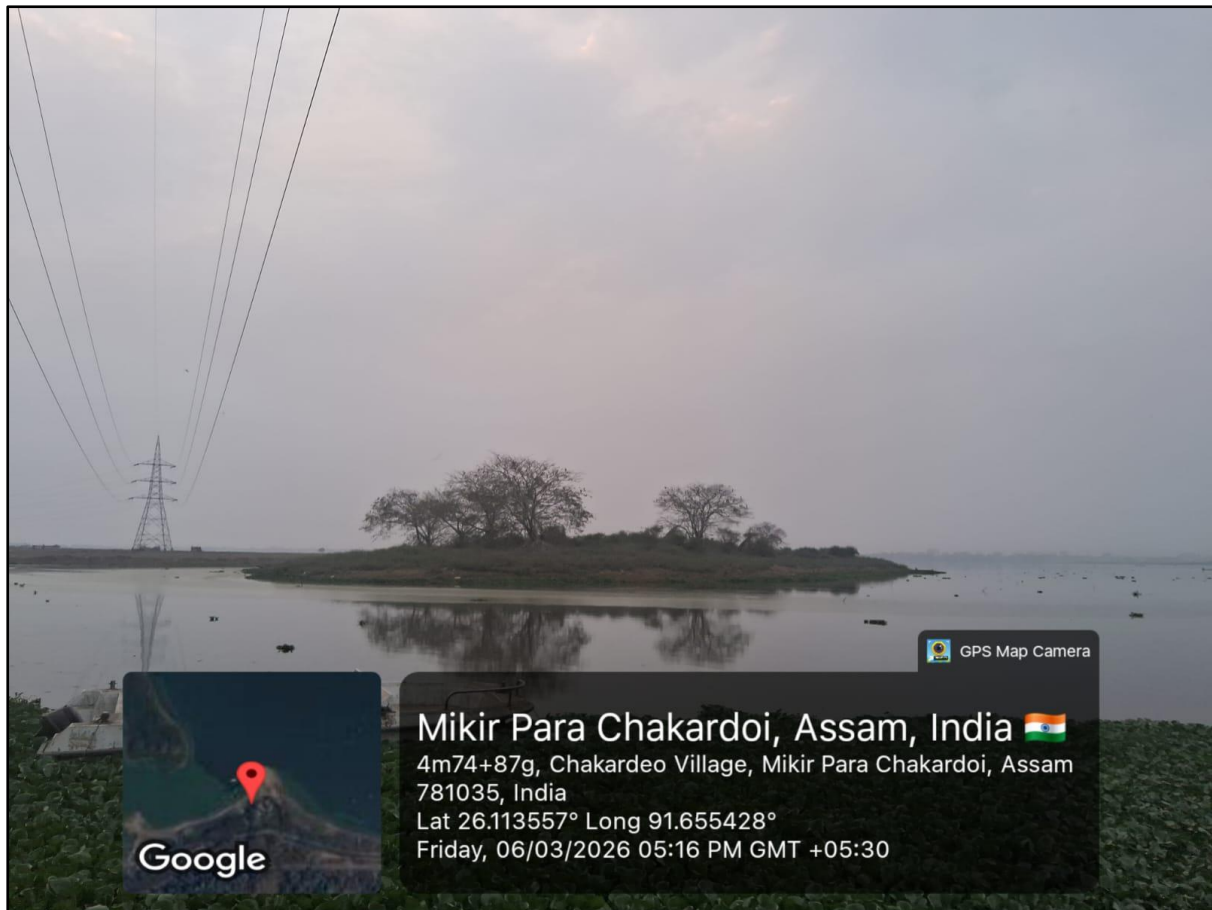


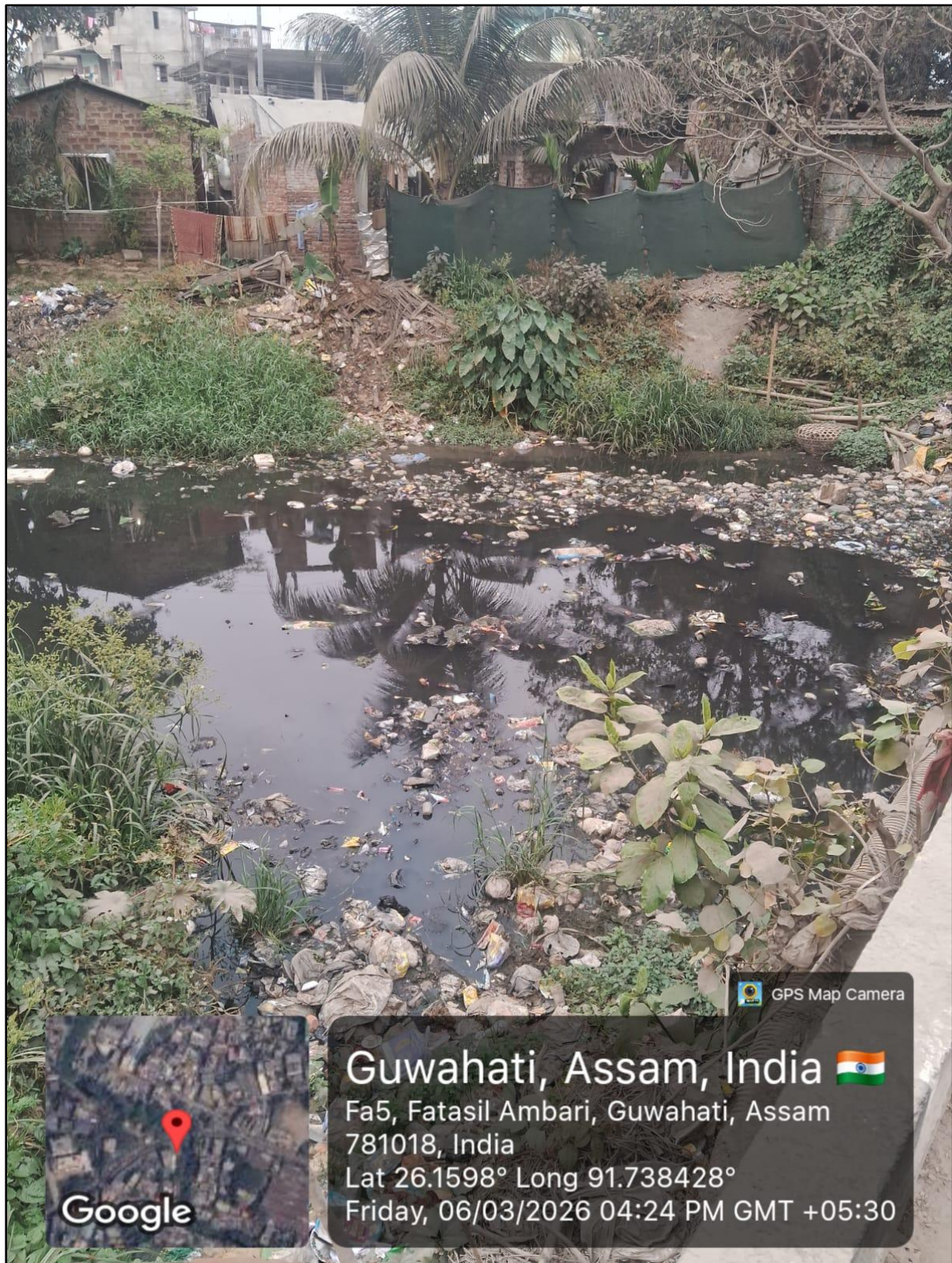


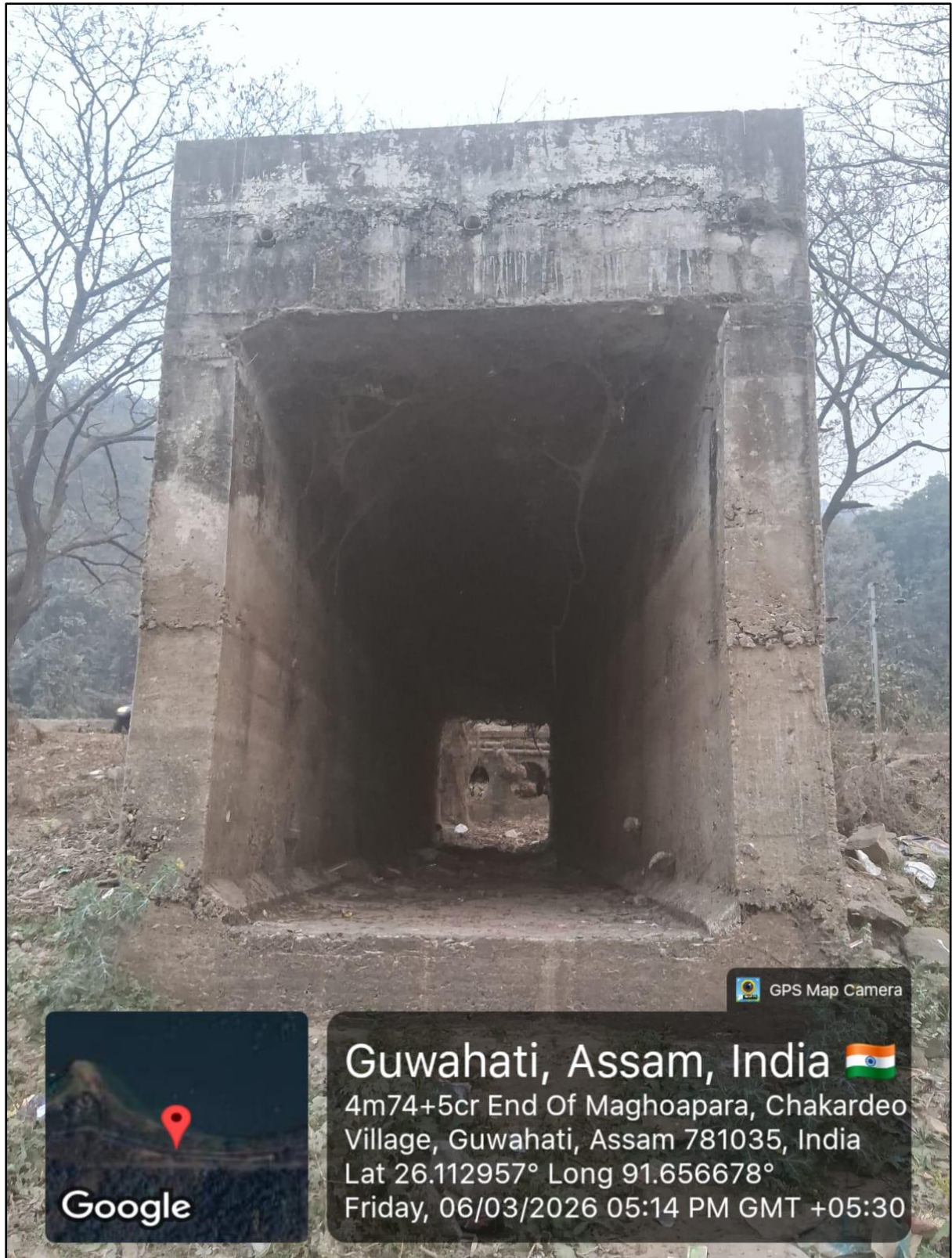










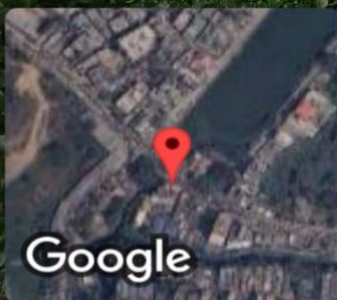












Guwahati, Assam, India 🇮🇳
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India
Lat 26.16962° Long 91.742996°
Saturday, 07/03/2026 04:23 PM GMT +05:30



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