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Guwahati Clean Air Plan

গুৱাহাটী স্বচ্ছ বায়ু পৰিকল্পনা

প্রদূষণ প্রৱণ এলেকাৰ কার্যপন্থা

Hotspot Action Plan

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List of Abbreviations

AEM – Ambient Environmental Monitoring
AEDA – Assam Energy Development Agency
AGL – Above Ground Level
AMRUT – Atal Mission for Rejuvenation and Urban Transformation
ANPR – Automatic Number Plate Reading
AOD- Aerosol Optical Depth
APCB – Assam Pollution Control Board
APCD – Air Pollution Control Device
APDCL – Assam Power Distribution Company Limited
ASDMA – Assam State Disaster Management Authority
ASHA – Accredited Social Health Activist
ASOCMMS– Assam Online Consent Management & Monitoring System
AT Road – Assam Trunk Road
BC – Black Carbon
BPCL – Bharath Petroleum Corporation Limited
CAAQMS – Continuous Ambient Air Quality Monitoring Station
CAMPA – Compensatory Afforestation Fund Management & Planning Authority
CAPEX – Capital Expenditure
C&D Waste – Construction and Demolition Waste
CH_4 – Methane
CIC – Commissionerate of Industries & Commerce
CO – Carbon Monoxide
CRIF – Central Road Infrastructure Fund
CPCB – Central Pollution Control Board
CSR – Corporate Social Responsibility
CTE – Consent to Establish
CTO – Consent to Operate
DISCOM – Distribution Company
DG Set – Diesel Generator Set
DoA – Directorate of Agriculture
DOC – Degradable Organic Carbon
D2D – Door to Door
EF – Emission Factor
EI – Emission Inventory
FPD&CA – Food, Public Distribution & Consumer Affairs
FGD- Focus Group Discussion
GMC – Guwahati Municipal Corporation
GMDA – Guwahati Metropolitan Development Authority
GIS – Geographic Information System
GPS – Global Positioning System
HC – Hydrocarbons
HH – Household
HAP – Household Air Pollution
HPCL – Hindustan Petroleum Corporation Limited
IEC – Information, Education & Communication
IECT – Inspectorate of Electricity
iFOREST – International Forum for Environment, Sustainability & Technology
IITG – Indian Institute of Technology Guwahati
IOCL – Indian Oil Corporation Limited
ITMS – Integrated Traffic Management System
IPCC – Intergovernmental Panel on Climate Change
KAP – Knowledge–Attitude–Practice Survey
KM- Kilometre
LCS – Low-Cost Sensors
LDAR – Leak Detection & Repair
LFG – Landfill Gas
LPG – Liquefied Petroleum Gas
MDR – Maniram Devan Road
MRS – Mechanised Road Sweeping
MRF – Material Recovery Facility
MRV – Monitoring, Reporting & Verification
MSW – Municipal Solid Waste
MODIS - Moderate Resolution Imaging Spectroradiometer
MoEFCC – Ministry of Environment, Forest & Climate Change
MoRTH – Ministry of Road Transport and Highways
MSME – Micro, Small and Medium Enterprises
NAAQS – National Ambient Air Quality Monitoring Standards
NCAP – National Clean Air Action Program
NFHS – National Family Health Survey
NGO – Non-Governmental Organisation
NHAI – National Highways Authority of India
NH – National Highway
NIC – National Informatics Centre
NO_x – Nitrogen Oxides
NULM – National Urban Livelihoods Mission
OPEX – Operating Expenses
OMC - Oil Marketing Company
CSR - Corporate Social Responsibility
PMUY – Pradhan Mantri Ujjwala Yojana
$PM_{2.5}$ – Particulate Matter ≤ 2.5 µm
PM_{10} – Particulate Matter ≤ 10 µm
PNG – Piped Natural Gas
PPP – Public Private Partnership
PUC – Pollution Under Control
PWD – Public Works Department
RECD – Retrofit Emission Control Device
RTS – Resource Transfer Station
RWA – Residents Welfare Association
SA – Source Apportionment
SBM-U – Swachh Bharat Mission – Urban
SBF – Solid Biomass Fuel
SHG – Self-Help Group
SI – Sanitary Inspector
SLA – Service Level Agreement
SPCB – State Pollution Control Board
SO_2 – Sulphur Dioxide
SOP – Standard Operating Procedure
SWM – Solid Waste Management
TISS – Tata Institute of Social Sciences
TPD – Tonnes Per Day
ULB – Urban Local Body
VGF – Viability Gap Funding
VSK – Vertical Shaft Kiln

Executive Summary

Addressing air pollution in Guwahati offers an important opportunity to simultaneously advance public-health and climate goals. Measures that eliminate open burning and reduce reliance on polluting household fuels directly lower exposures to $PM_{2.5}$ and Black Carbon, a short-lived climate pollutant with strong warming potential and severe health impacts. Improvements in solid-waste management and the transition to engineered landfilling also lead to substantial reductions in methane emissions, one of the most impactful greenhouse gases. These actions not only improve neighbourhood-level air quality and reduce respiratory and cardiovascular health risks but also deliver meaningful climate co-benefits. By integrating clean-air strategies with climate-relevant interventions, the city ensures that each sectoral improvement contributes to a broader, more resilient pathway for sustainable urban development.

Open Burning

Municipal Solid Waste: Open burning of municipal solid waste has been found as one of the most visible and persistent sources of air pollution in Guwahati. Despite an established waste-collection system, gaps in primary collection coverage, irregular lifting schedules, inadequate segregation, and insufficient infrastructure in slum, hilly, and peri-urban settlements lead to the accumulation of waste in open spaces. The city continues to rely on a 2020's estimate of 550 TPD waste generated, despite clear growth in waste generation. Existing infrastructure is capable of processing only 35% of waste, leaving a large gap of 333 TPD of unprocessed waste that is directly linked to open dumping and burning.

Field surveys and transect assessments conducted across the city reveal frequent burning of mixed waste along roadsides, drains, vacant plots, market areas, and near containment points. This practice contributes significantly to emissions of $PM_{2.5}$, PM_{10}, Black Carbon, and toxic gases, disproportionately affecting densely populated and low-income neighbourhoods. This report identifies about 61 TPD of waste being burned across the city—approximately 7% of total waste generated. This leads to an estimated annual emission of 122 tonnes of $PM_{2.5}$ and 22 tonnes of Black Carbon, making solid waste burning one of the city's most significant contributors to poor air quality and short-lived climate pollutants. In addition, the current landfill emits 5,656 tonnes of CH_4, equivalent to 158,368 tonnes of CO_2-eq, making it one of the largest climate hotspots in the city.

Addressing these challenges requires a systemic approach that strengthens collection efficiency, expands processing capacity, and eliminates informal dumping across wards. Upgrading the city's waste-management infrastructure—through decentralised collection points, improved routing, increased manpower, mechanised equipment, and operational monitoring—is essential. Strict enforcement against burning, combined with community-level awareness, grievance response systems, and accountability mechanisms, can substantially reduce burning incidents. When implemented cohesively, these interventions will not only lower particulate emissions but also improve environmental health, strengthen public confidence in municipal services, and deliver climate co-benefits by reducing Black Carbon emissions.

Residential Cooking and Winter Heating: Residential cooking and winter heating remain significant contributors to neighbourhood-level air pollution in Guwahati. Despite high LPG penetration, fuel stacking persists across slum, mixed, and hilly settlements, where households continue to rely on firewood, charcoal, dung cakes, kerosene, and other informal fuels alongside LPG. In many areas with irregular or delayed waste collection, households also burn garden waste, leaf litter, and accumulated solid waste, adding to localised $PM_{2.5}$ and Black Carbon peaks—especially during early mornings and evenings. Addressing these emissions requires a combined strategy focused on improving energy access, ensuring LPG affordability and last-mile delivery in hilly wards, phasing out kerosene and solid biomass, promoting clean heating technologies, and strengthening community-level norms against open burning.

Quantitatively, residential cooking alone contributes approximately 3,900 tonnes of $PM_{2.5}$ per year, making it one of the largest household-driven emission sources in the city. Slum and hilly settlements account for most of this $PM_{2.5}$ and Black Carbon load due to sustained biomass and kerosene use. Together, these patterns establish slum and hilly settlements as the primary residential emission hotspots, underscoring the need for targeted interventions, robust IEC efforts, and systematic monitoring to reduce fuel stacking and transition households toward clean cooking and heating solutions.

Contd.

Commercial Cooking: Open burning associated with commercial cooking activities remains a local but important contributor to particulate emissions in Guwahati, especially in busy market corridors and areas with dense clusters of informal food vendors. Although formal restaurants predominantly use LPG, many small eateries, tandoor operators, and roadside food stalls still rely on coal or charcoal. Leftover solid fuel, packaging material, and food waste are often discarded in open spaces where inadequate waste collection leads to routine burning. These practices create concentrated pockets of $PM_{2.5}$, PM_{10}, and Black Carbon exposure, particularly during evening business hours when footfall is high and ventilation is limited. Commercial cooking activity is estimated to contribute ~21.9 tonnes/year of $PM_{2.5}$, 28.5 tonnes/year of PM_{10}, and a very high 180 tonnes/year of CO, making it a notable urban emission source—especially during evening and night-time cooking hours.

Addressing this challenge requires a combination of fuel transition, better waste management, and regulatory oversight. Restricting charcoal and coal procurement, expanding LPG or electric-cooking access for informal vendors, and establishing dedicated vendor waste-collection systems can significantly reduce burning. Complementary actions such as targeted IEC campaigns, routine inspections, and improved enforcement will help shift behaviour and maintain compliance. Collectively, these interventions can eliminate open burning in commercial food zones, reduce localised emissions, improve public health, and support the city's broader clean-air and climate objectives.

Diesel Generator (DG) Sets

City's power outages and intermittent supply in several commercial, residential-complex, and institutional zones have led to high dependence on DG sets, generating substantial $PM_{2.5}$, PM_{10}, and NO_x emissions during peak load periods. DG sets contribute an estimated 19.1 tonnes of $PM_{2.5}$, 21.1 tonnes of PM_{10}, and 10.6 tonnes of black carbon annually—making them a significant point-source emitter. The emission burden increases during the 2–3 hour daily outages reported in summer months, amplifying local pollution spikes in commercial corridors and high-rise residential zones.

Multi-storey apartments, mobile towers, hospitals, hotels, and markets account for the largest generator-hours. Guwahati currently has no consolidated DG set inventory across industrial, commercial, and residential complexes. The absence of data on capacity, fuel consumption, operating hours, and compliance with CPCB norms constrains accurate estimation of emissions and identification of high-emission clusters.

Dust Mitigation

Guwahati faces significant challenge arising from road dust resuspension, construction activities, open areas, and the large volumes of post-flood silt that settle across the city every monsoon. The current situation is marked by inadequate mechanised sweeping, scattered construction dust management practices, and limited coordination among departments.

Key issues include unpaved shoulders, poor debris handling, lack of designated material storage zones, and delayed removal of flood-deposited silt. A focused action plan that involves a hotspot-level action plan and a mitigation plan for construction sites has been recommended. The major action plans include regular mechanised sweeping, strict enforcement of construction dust norms, greening of open areas, prompt post-flood silt clearance, and interdepartmental coordination.

Contd..

Transportation

Guwahati's transportation sector is a major source of air pollution due to increasing vehicle numbers, ageing fleets, inadequate public transport share, and persistent congestion across key corridors. The city faces several critical issues, including weak PUC compliance, severe congestion at major junctions, limited adoption of EV buses with insufficient charging infrastructure, and ineffective parking management causing roadside encroachments and delays. To address these challenges, the plan proposes strengthening PUC enforcement through digital monitoring, implementing targeted congestion-reduction measures, expanding EV bus deployment with a supporting charging network, and operationalizing a location-specific parking policy with regulated zones, demand-based pricing, and strict enforcement. These actions collectively aim to reduce emissions, improve mobility efficiency, and support cleaner urban transport in Guwahati

Pollution Under Control

Present PUC system faces gaps in coverage, accuracy, and enforcement. Many centres operate with limited digital integration and inconsistent testing practices, resulting in a high number of visibly polluting vehicles still operating across the city. Key issues include weak monitoring, lack of real-time data linkage, low public compliance, and inadequate staff training. The report recommends upgrading PUC machines, mandating automated testing with CCTV supervision, and conducting random audits to ensure transparency and accountability. Public awareness drives and strict penalties for non-compliance are also essential. Strengthening the PUC ecosystem can significantly reduce vehicular emissions, support cleaner air in Guwahati, and build public confidence in the pollution control framework.

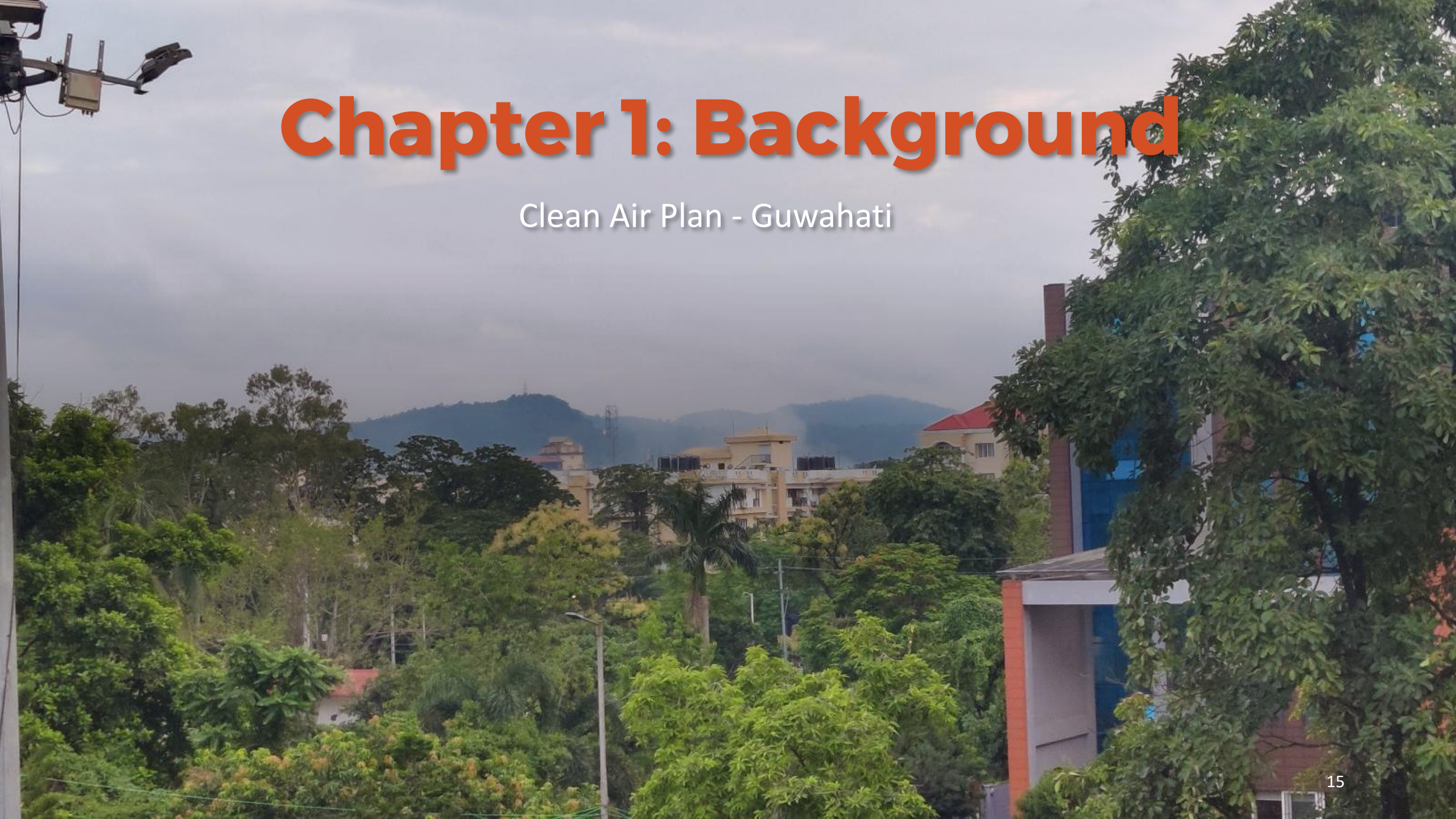
Industries

Industrial activity in the region spans a mix of sectors including chemicals, brick kilns, stone crushers, and food processing units. Most of these units still run on coal, firewood, and other polluting fuels, and many operate with older technologies that emit far more than modern alternatives. For instance, Cement plants using VSK systems alone contribute over half of the area's PM10 emissions. Several sectors including hot-mix plants, stone crushers, brick kilns does not specify the type of pollution control systems in place, making it difficult to assess compliance or ensure effective emission reduction. The total PM10 emission load of Kamrup Metro is estimated at about 1,940 tonnes per year. Adding to this, Guwahati lies adjacent to the heavily polluting Byrnihat industrial belt in Meghalaya, with a portion of industries located on the Assam side as well. Emissions drifting in from this cluster further compound the city's air quality challenge.

Industrial pollution in the region is largely driven by weak compliance, heavy dependence on polluting fuels, and the continued use of older technologies. A phased shift toward cleaner fuels and modernized systems in polluting sectors such as cement, brick kilns, and boilers, supported by infrastructure like PNG networks and stronger audit mechanism, can bring meaningful reductions. If these measures are implemented effectively, the Kamrup Metropolitan area could cut its industrial emissions by up to 26 percent.

Chapter 1: Background

Clean Air Plan - Guwahati



1.1 City Background & Demographic- Guwahati

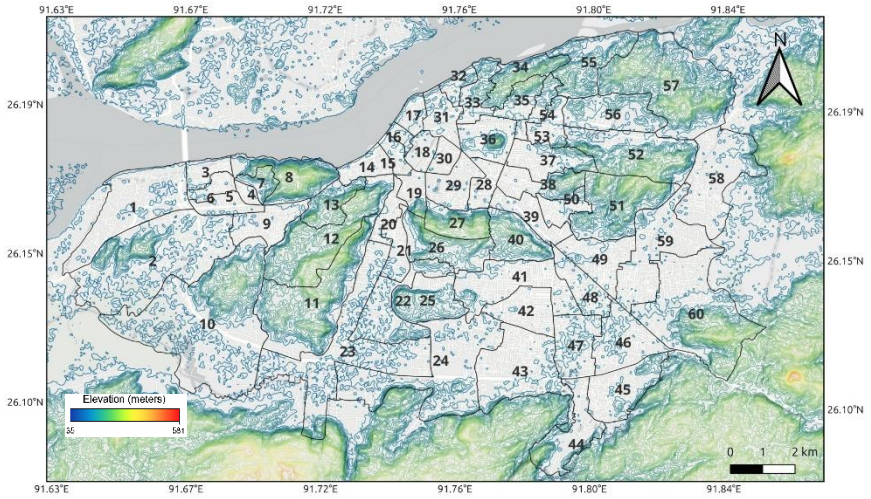
1. **Demographics of GMC**
   - **Population** – 9,57,352 (Census, 2011), 17,78,783 (2031 projected)
   - **City Area (sq. km)** – 216 (GMC, 2022)

2. **City Profile**
   - 26 slum clusters identified in GMDA's 2025 city master plan
   - 37 municipal markets of different categories as per GMC
   - Identified as one of the non-attainment cities in India as per National Clear Air Program (NCAP)

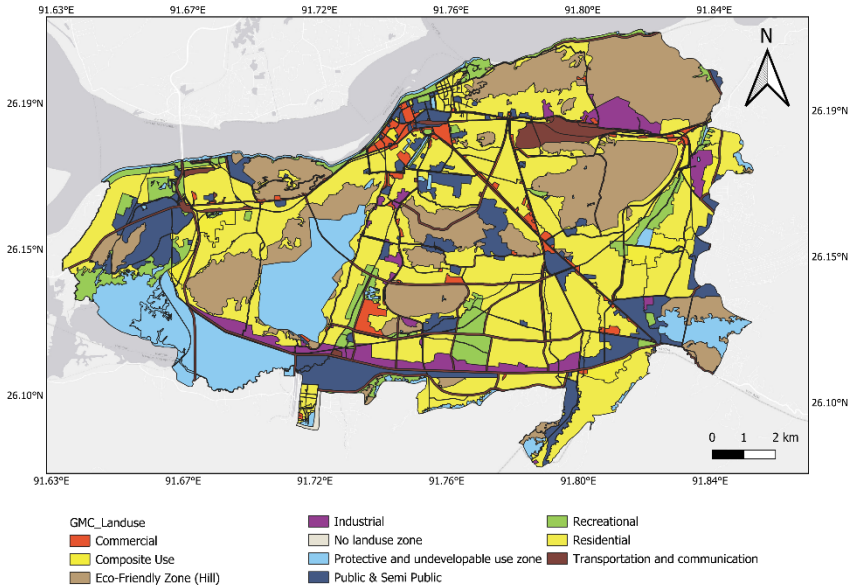
3. **Climate & Environment**
   - **Annual mean Temp** 26.0 ± 5.6 °C (13.0–37.9 °C)[1]
   - **Annual mean Humidity:** 85 ± 3.9% (68–91%)[1]
   - **Hills**– Khasi Hills
   - **Rivers** – Brahmaputra River

4. **Administrative Body and ULB:**
   - 1) Guwahati Metropolitan Development Authority (GMDA) – Urban planning & development body, 2) Guwahati Municipal Corporation (GMC) – Urban local body (ULB) managing city administration

Map 1.1: GMC ward boundaries with elevation contours



Map 1.2: GMC ward boundaries with Land Use Classification



Source: [1]Gokhale et. al. (2025); [2](GMC, 2022); [3]GMDA

1.2 Clean Air Context & NCAP Pathway

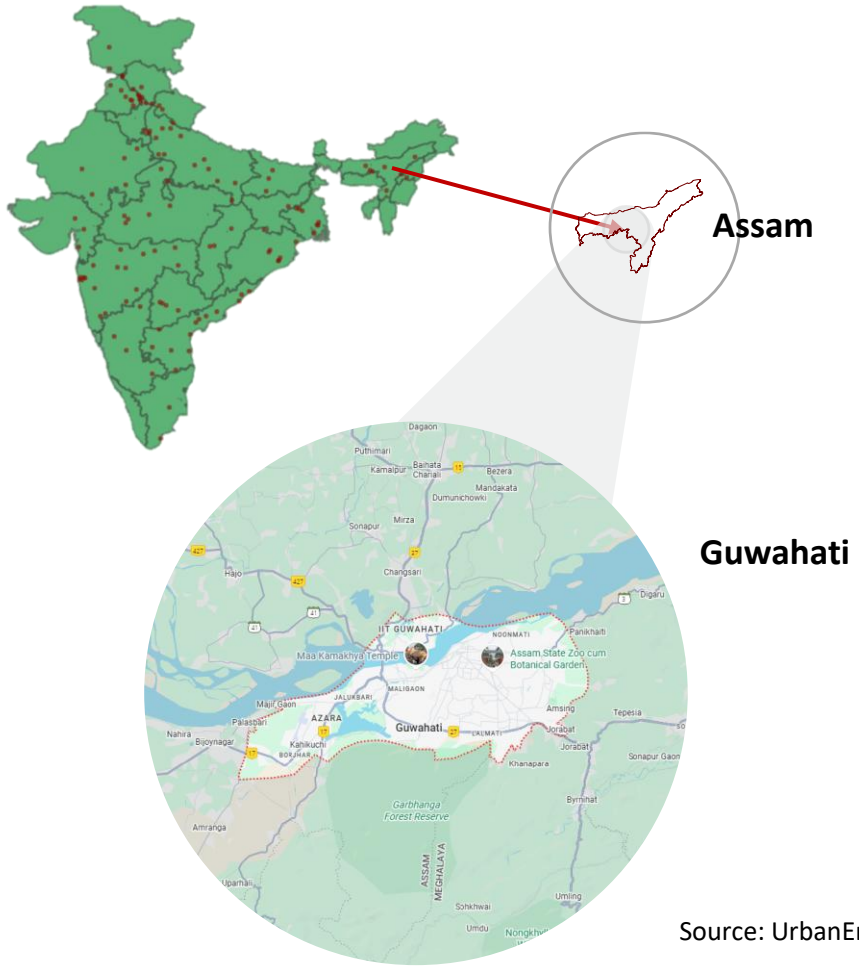
State Of Air Pollution:

- Guwahati is the fastest-growing city of Northeast India, located along the Brahmaputra with a plain and undulating topography bounded by Khasi hills—this traps pollutants and worsens winter/post-monsoon air quality (GMDA)
- Rapid urbanisation, infrastructure expansion, and commercial growth have increased vehicular load, road dust, construction dust, solid waste generation, and small-scale industrial activity.
- Air quality has shown a rising trend in PM from 2017–2022, frequently exceeding NAAQS—leading to Guwahati's designation as a non-attainment city under MoEFCC.
- Key contributors identified by NCAP: vehicular emissions, construction and road dust, DG sets, small factories, open eateries, and biomass burning—with winter and pre-monsoon seasons showing the worst levels.

Actions Taken:

- Air quality monitoring network expanded: NAMP stations 10 and CAAQMS station 5 (APCB)
- Sectoral emission inventory and source apportionment study (2025) completed by IIT Guwahati
- Measures initiated: mechanised sweeping, waste-burning restrictions, targeted enforcement

Figure 1.1: India's 131 Non-Attainment Cities, as of 2022



Source: UrbanEmissions.info

Chapter 2: Air Quality in Guwahati

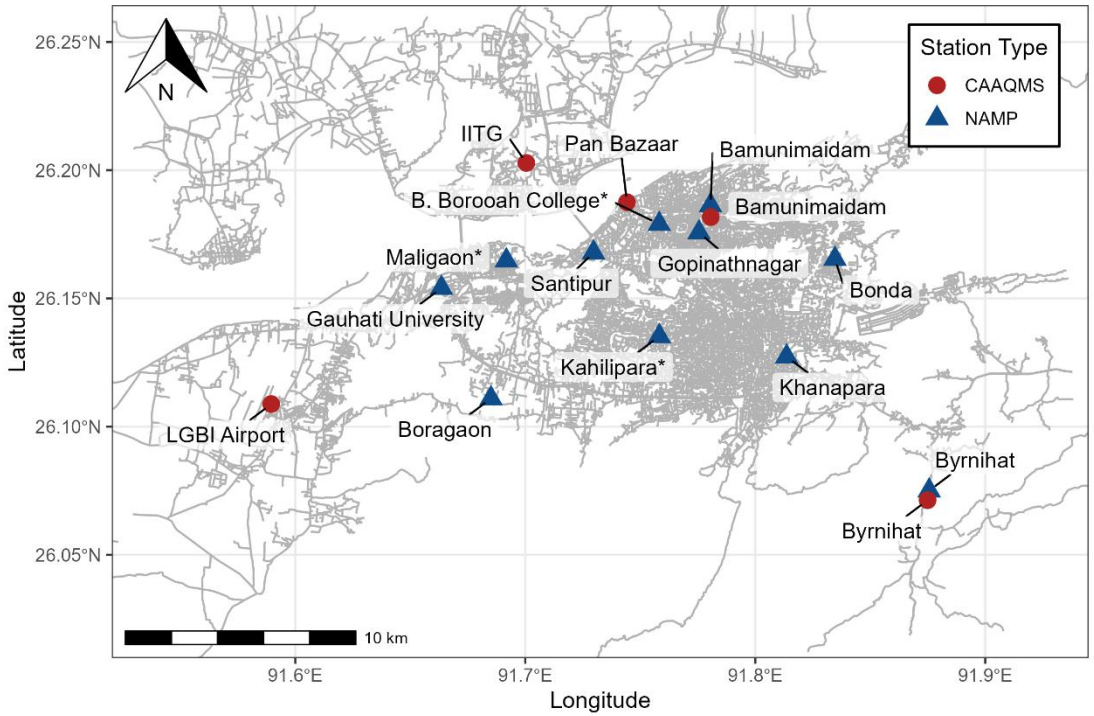
2.1 Air Quality Monitoring Stations

Air quality monitoring stations in Guwahati city

NAMP Stations: 1) Bamunimaidam, 2) Khanapara, 3) Santipur, 4) Guwahati University, 5) Boragaon, 6) Bonda, 7) Gopinath Nagar, 8) Kahilipara*, 9) B. Borooah College*, 10) Maligaon* and 11) Byrnihat

CAAQMS Stations: 1) Pan Baazar, 2) Railway Colony (Bamunimaidam), 3) IITG, 4) LGBI, and 5) Byrnihat

Map 2.1: Location of NAMP and CAAQMS stations in Guwahati city



*NAMP station codes not updated by CPCB

Table 2.1: CAAQMS - Percentage (Days) of data available for year 2023 & 2024

Location	CO	NOx	Ozone	PM10	PM2.5	SO2
Byrnihat	81% (592)	85% (619)	73% (535)	62% (454)	62% (454)	74% (542)
IITG	95% (696)	95% (696)	93% (680)	69% (507)	69% (507)	94% (685)
LGBI	89% (652)	95% (692)	84% (617)	74% (540)	74% (540)	87% (634)
PanBazaar	85% (621)	85% (621)	80% (582)	65% (472)	65% (472)	80% (582)
Railway	95% (694)	95% (694)	92% (670)	71% (522)	71% (522)	95% (691)

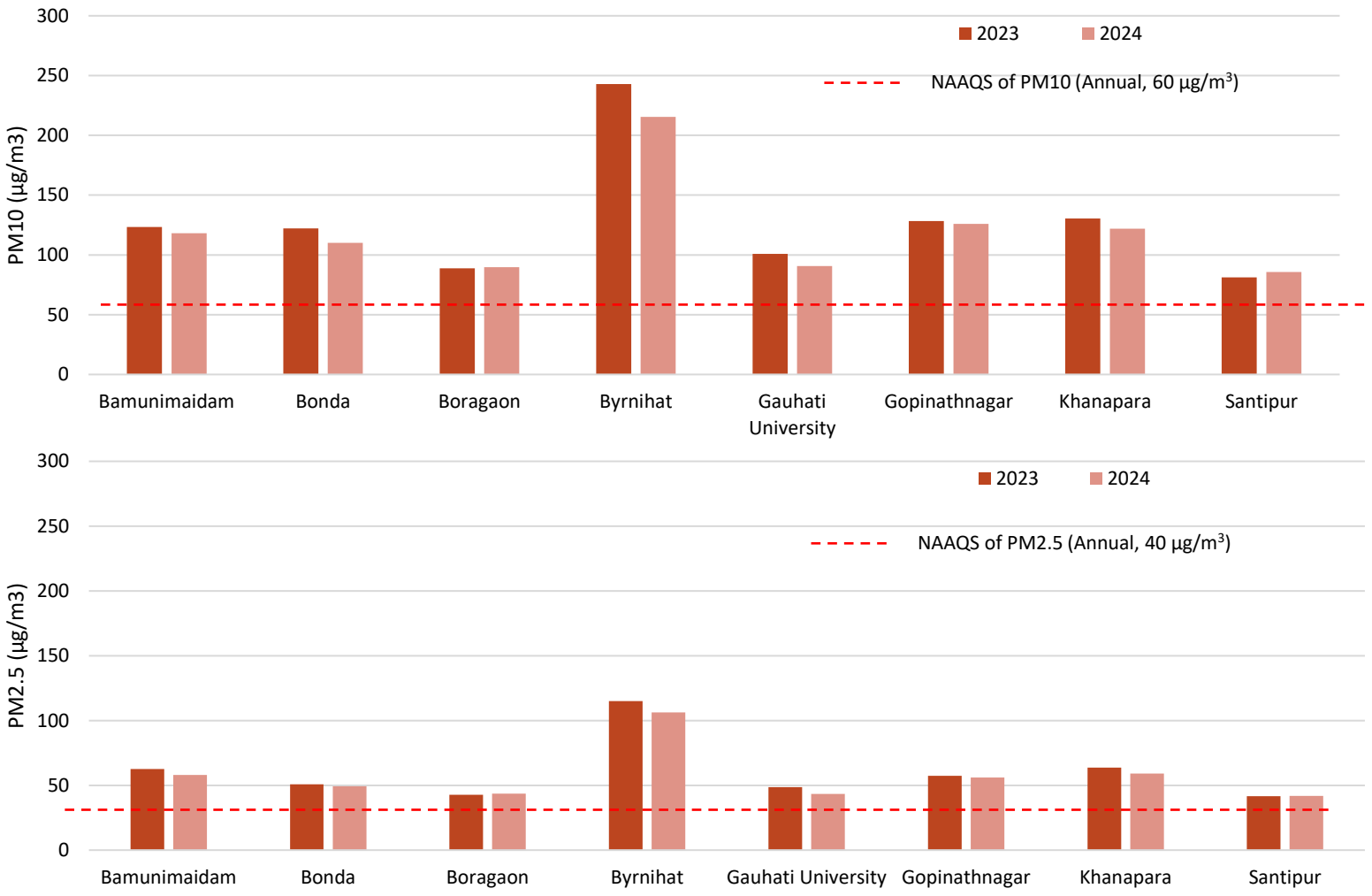
Key Findings:

1. At present, 11 NAMP stations are present including Byrnihat, however three of the NAMP stations are not coded by CPCB.
2. Lack of CAAQMS monitoring station in the southern and central part of the city
3. Monitoring stations in the central part of the city to be installed
4. Data quality specifically for PM10 and PM2.5 is a challenge – less than 75% data days for year 2023 and 2024
5. Air quality monitoring needs strengthening and proper coverage

Source: iFOREST analysis

2.2 Monitoring Data- Annual Average PM

Figure 2.1 Annual average PM10 and PM2.5 concentration 2023 and 2024 (NAMP stations)

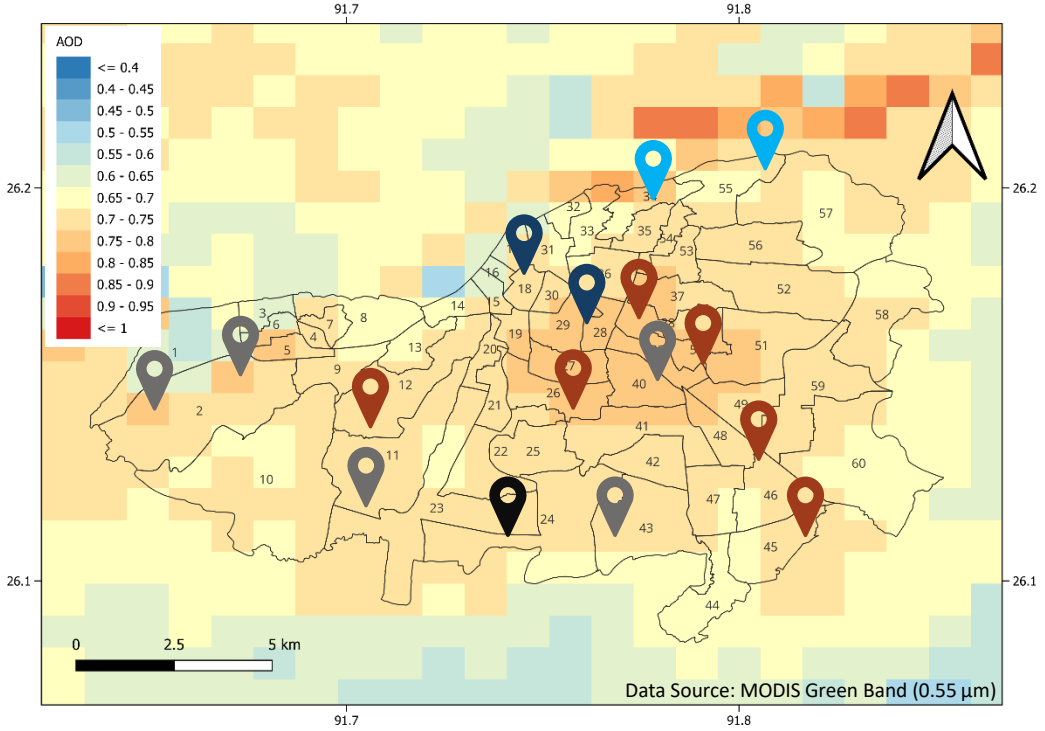


Source: iFOREST analysis

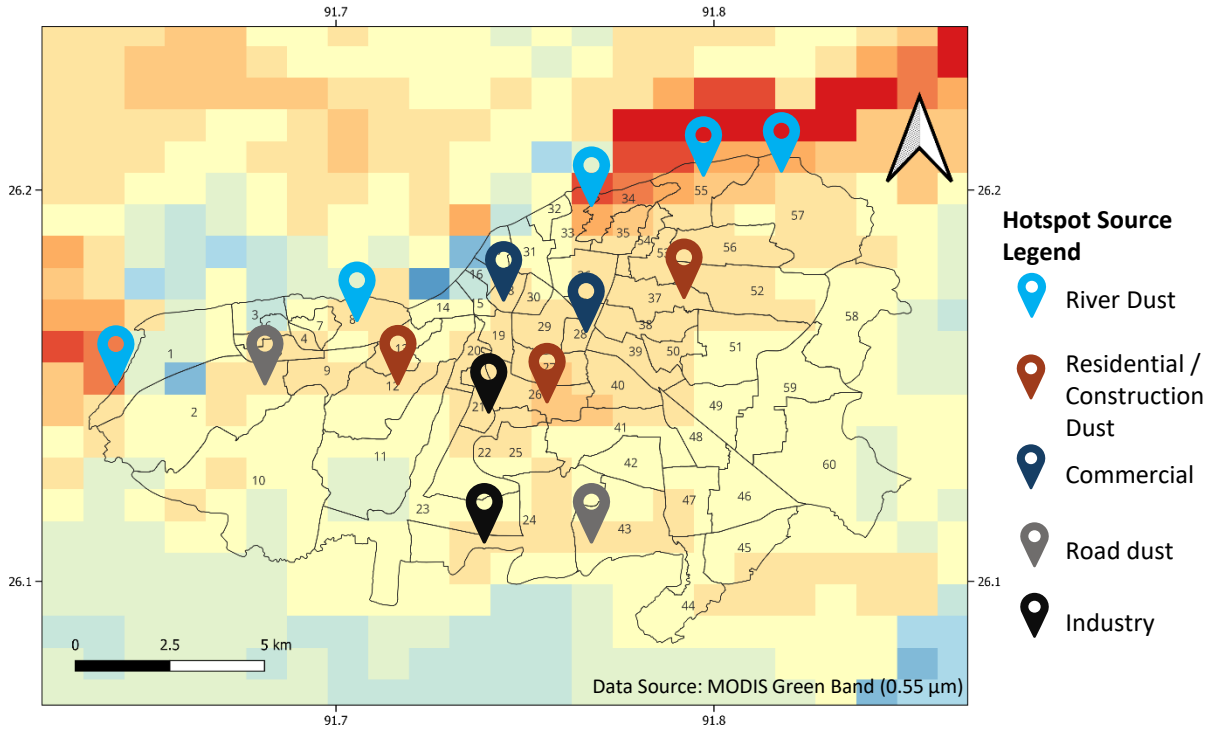
- All monitoring stations in Guwahati consistently exceed national standards for both $PM_{2.5}$ and PM_{10}, confirming chronic and citywide particulate pollution.
- A stable pollution hotspot corridor persists (Byrnihat → Khanapara → Bamunimaidam), driven by industrial activity, traffic density, construction dust, and regional transport.
- Most stations show modest year-to-year reductions (2–11%), but concentrations remain far above standards—improvements appear meteorology-driven rather than due to effective source control.
- Emerging variability across stations suggests shifting or localised sources: some sites improved, while others (e.g., Santipur, Boragaon) stagnated or increased slightly.
- Combined $PM_{2.5}$–PM_{10} patterns point to a dominant dust and combustion signature, requiring an integrated mitigation package across transport, construction, waste management, and industrial clusters.

2.3 Pollution Hotspot - Satellite Observations

Map 2.2: Mean AOD during Winter 2024



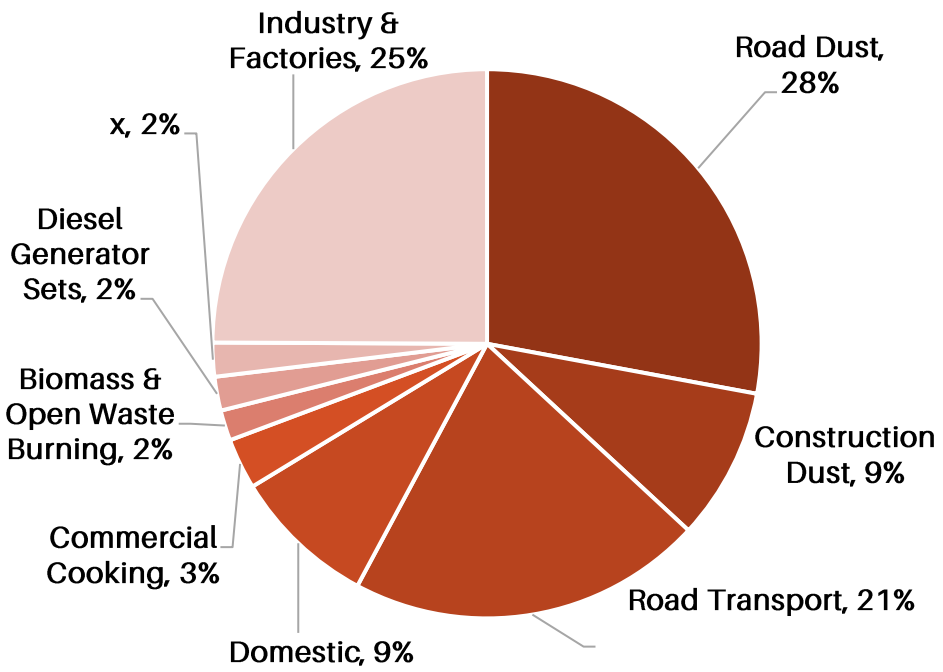
Map 2.3: Mean AOD during Summer 2024



- Satellite-derived AOD clearly highlights seasonal pollution hotspots across Guwahati (iFOREST analysis).
- Summer hotspots are concentrated in areas aligning to the silted Brahmaputra riverbank (wards 1, 8, 33, 34, 35, 54, 55, 57), dust-prone riverbed zones, and regions experiencing construction (wards 2, 4, 9, 12, 13, 26, 27, 40, 41) and road-dust resuspension (wards 4, 9, 12, 39, 40, 43, 47).
- Winter hotspots expand further to include Wards 26, 27, 40, 41, 34, 40, 50, 39, 28, 27, 26, 29, and 39, concentrated in the central part of Guwahati city. This can be attributed to activities from sectors such as construction, open burning, commercial cooking, and poor atmospheric dispersion.
- Seasonal contrast shows that summer pollution is dust-dominated, while winter hotspots are dominated by combustion sources (waste burning, heating, traffic, commercial clusters).
- The spatial pattern aligns with prevailing southwest–west winds, which tend to carry pollutants toward the northeast part of the city, intensifying hotspot formation.

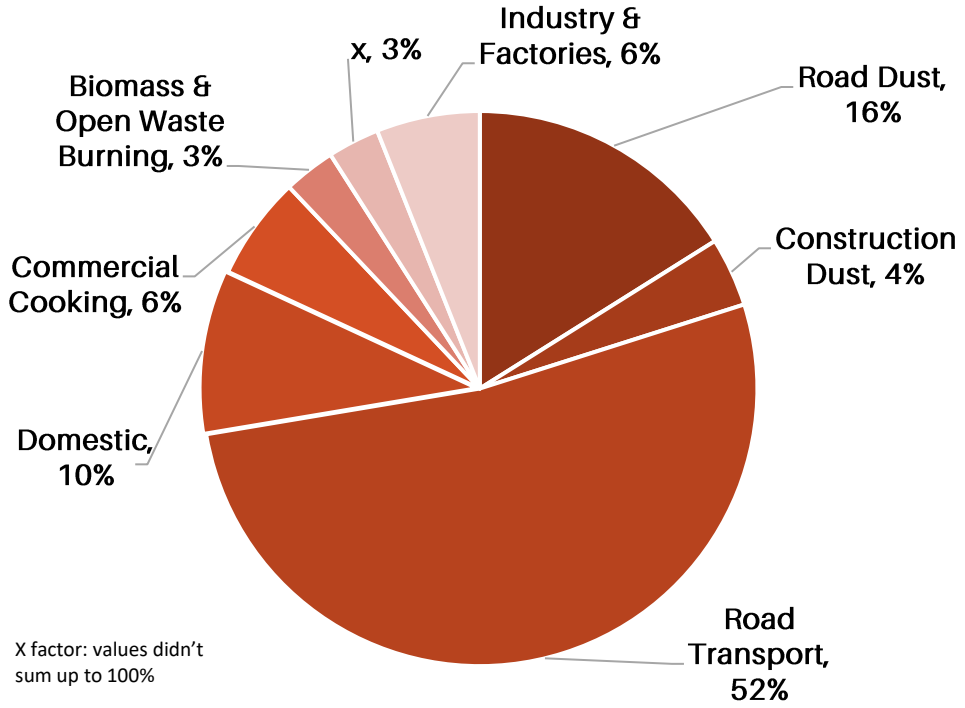
2.4 Emission Inventory Study

Figure 2.2: Sectorial emission share for PM10



- Total estimated PM10 emission 1071 T/yr
- Dust (Road dust & C&D dust) is the largest contributor (37%)
- Industries contribute about 25% and road transportation 21%
- Cooking and heating emissions from domestic and commercial sector contribute to around 12% emissions

Figure 2.3: Sectorial emission share for PM2.5



- Total estimated PM2.5 emission 435.3 T/yr
- Road transport is the largest contributor PM2.5 (52%) followed by road dust (16%)
- Emissions from Industries (6%), Construction Dust (4%), Commercial and Domestic and commercial cooking (16%)

Source: Gokhale et. al. (2025);

Contd.

Key Insights from EI and SA

- **Emission Inventory (EI):**
  - Transport (~21% PM10; ~52% PM2.5) and commercial combustion (cooking, DG sets, eateries) are the largest direct emission sources.
  - Industries + DG sets contribute ~25% PM10.
  - Construction dust and open waste burning add smaller but consistent shares.
- **Source Apportionment (SA):**
  - Ambient PM dominated by road & construction dust (30–32%), vehicles (19–22%), biomass burning (14–16%), and industry (9–12%).
  - Winter: secondary aerosols rise sharply (~30% of PM2.5).
  - Summer: industry and dust dominate.
- **Integrated Insight:**
  - EI highlights combustion; SA highlights dust + secondary aerosols.
  - Direct emissions from transport, commercial cooking, and industries drive precursor load, while poor dust management elevates ambient PM.
  - Biomass burning and waste burning remain important episodic contributors.

2.5 Ongoing Actions In Various Sectors

Waste Burning

- Regular inspections are conducted by GMC
- Fines imposed if caught burning garbage
- Door-to-door waste collection increased from 36% (2022) to 100% (2024)
- Expansion ongoing of city's waste processing plant
- GMC working towards full compliance of segregation of waste

Road Dust

- Guidelines issued by APCB regarding material handling
- End-to-end pavement achieved for major and arterial roads (1300 km)
- Regular maintenance activity conducted by PWD Roads
- Daily road sweeping activity through manual sweepers (350 km) and 4 mechanical sweepers (170 km)
- Water sprinkling has been adopted as mitigation measure and collected dust dumped in landfills

Construction Dust

- APCB directed to follow CPCB's C&D act
- PWD buildings recommended construction dust mitigation measures (green cover)
- Nodal officers appointed for implementation of dust mitigation measures (only for govt. projects)
- Fines issued by GMC upon identification of violation, or by complaint
- GMC banned stocking of construction material on roadsides/footpaths between 6AM and 10PM

Domestic Fuel

- Under PMUY, more than 71,000 LPG connections have been released
- Free LPG Connections Provided to low-Income households through Ujjwala 2.0
- Presently, 99% households are users of LPG
- Kerosene consumption dropped 91%, from 6,600 kL (2018) to 576 kL (2024).
- Orunodoi 3.0 launched for additional ₹250 subsidy on LPG cylinders

Industrial Pollution

- APCB identified Byrnihat industrial cluster as a critical polluting area
- Regular PM reduction reporting by Byrnihat (Assam) industries to APCB in place
- Industries were directed for mandatory use dust suppression and APCDs to cut particulate pollution
- Cumulative Pollution Index (CPCB) is introduced for industrial classification for improved /targeted regulation
- Out of 40 operational industries, 4 are non-compliant and action taken by APCB

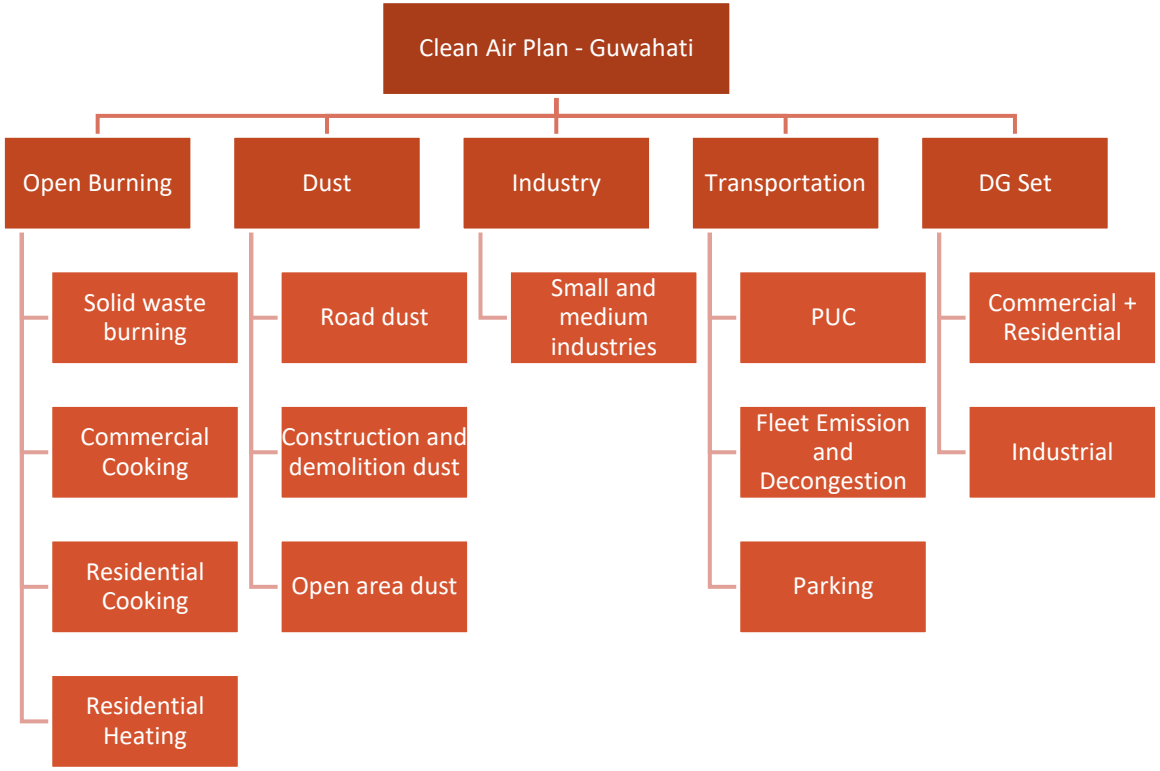
Source: GMC, PWD (roads), FPD&CA, CPCB, APCB

Chapter 3: Objective and Methodology

3.1 Objectives of the Study

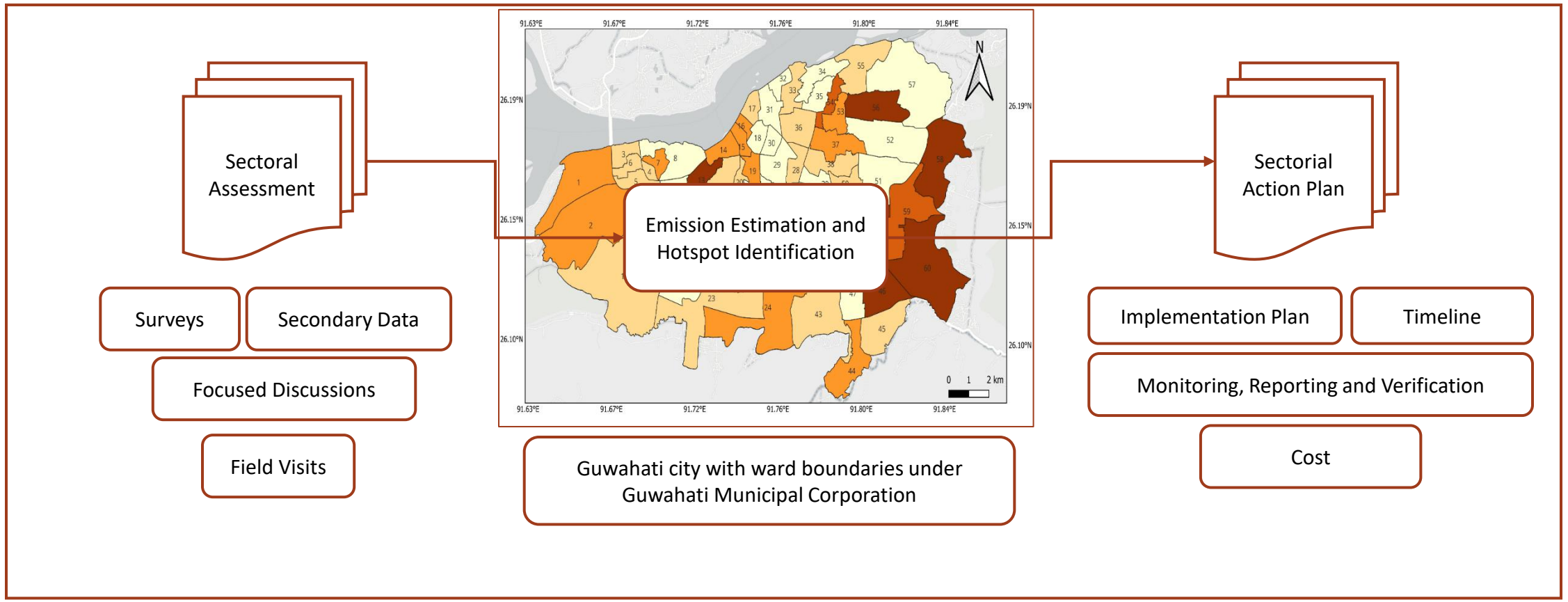
- Baseline and gap assessment on existing air quality plans and pollution monitoring systems
- Review of Sectoral air quality action plans, existing strategies and byelaws/codes related to waste management, plastic use, urban greenery, and dust mitigation
- Identification of pollution challenges and hotspot mapping
- Develop action strategies for –
  - Open Burning : Solid waste burning, residential cooking and heating, commercial cooking
  - Dust Mitigation - Construction and Demolition sites and open lands
  - Industries – MSMEs
  - Transportation – PUCs, Fleet Emission and Decongestion, Parking
  - DG Set
- Developing implementation plan
- Institutional capacity development through structured trainings
- Implementation support to implementing bodies

Figure 3.1: Sectors considered in Guwahati's clean air plan



3.2 Study Approach

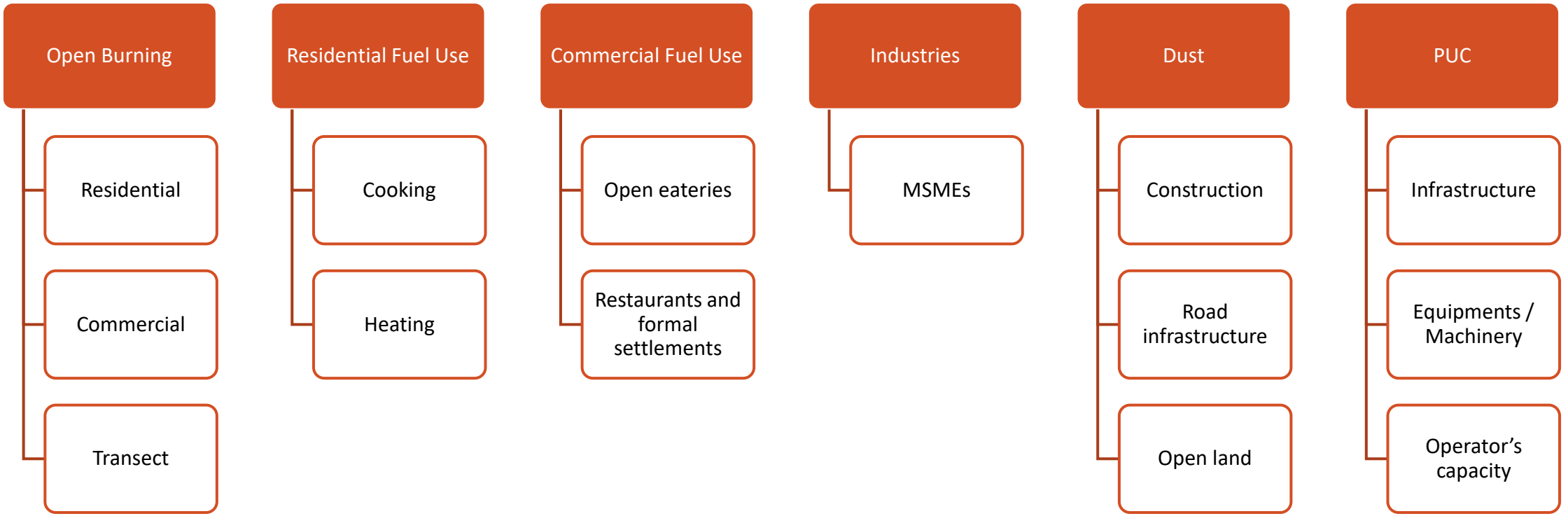
Figure 3.2: Study approach



3.3 Methodology

- **Baseline assessment**
  - Review of government reports, scientific literature, and city planning documents to understand Guwahati's air-quality challenges, sources, seasonal patterns, and regulatory context.
  - Major Documents: Emission Inventory and Source Apportionment Report by IIT Guwahati, Guwahati Master Plan by GMDA
- **Air Quality Data Assessment**
  - Analysis of hourly CAAQMS data, NAMP data, satellite derived products (MODIS AOD) to characterise particulate and gaseous pollutant trends, identification peak-pollution periods, and assessment of spatial variations across the valley and hilly settlements.
- **Data collection**
  - Primary and Secondary – Govt reports, journal articles, One-on-one interaction with government departments, FGDs
  - Site/fields visits for hotspot identification
  - Surveys – Domestic and commercial fuel use, solid waste burning locations, transact, industrial pollution hotspots, PUC stations and Construction sites
- **Hot-spot identification**
  - Emission estimates from various sectors – PM2.5, PM10, BC, CH4
  - Wards and location with high potential of emission sources
- **Identification of Sectoral Control Options and implementation timeline**

Surveys Conducted



Focused Discussion with Stakeholders

Stakeholder Consultation

- Assam Pollution Control Board (APCB)
- Guwahati Municipal Corporation (GMC)
- Guwahati Metropolitan Development Authority (GMDA)
- Public Works Department (PWD) - Roads
- Public Works Department (PWD) - Buildings
- North East Frontier Railway (NFR)
- National Highways Authority of India (NHAI)
- Directorate of Agriculture
- Department of Food, Public Distribution and Consumer Affairs
- Inspectorate of Electricity
- Commissionerate of Police
- Assam State Disaster Management Authority
- Commissionerate of Industries and Commerce

Ground Inspection

- Hilly Settlements
- Slum Settlements
- Commercial Establishments, Markets
- Road side eateries
- Waste Processing Plant
- Various Construction Sites

Chapter 4: Identification of Control Measures and Implementation Plan

4.1 Mitigating Emissions from Residential Cooking

4.1.1 Key Statistics and Background

Key Residential Activities

- Cooking using unclean fuels: kerosene, firewood, crop residue, dung cake, charcoal
- Residential heating during winter: widespread use of solid biomass fuels (SBF) and kerosene, especially in limited serviced areas

Approach for City-Level Assessment:

To identify challenges in the residential sector, the study consider three types of settlement:

- Hilly Settlements
- Slum Settlements
- Mixed Settlements

City Specific Constraints:

- Hilly areas: steep terrain limits LPG delivery, limited municipal waste collection, minimal waste infrastructure, irregular fuel supply; high reliance on wood and other SBFs
- Slum areas: poor access to clean fuels, intermittent waste services → frequent open waste burning and high kerosene/SBF use
- Mixed areas: diverse fuel-use patterns; additional emissions from commercial eateries embedded in residential zones

Resulting challenge: High residential burning driven by fuel poverty, access barriers, informal energy practices, and inadequate municipal service coverage.

Figure 4.1.1: Cooking using wood in Hilly Settlements in Guwahati

Contd.

Residential Pollution Sources

- Residential sector survey conducted (n = 440) to understand cooking fuel-use patterns and waste-management practices
- Covered diverse urban income groups, including slum areas, hilly settlements, and market/commercial hubs across 20 wards
- Aimed to generate localized insights on cooking, space heating requirements and local waste management process

Cooking Activity

- Guwahati's LPG penetration is >95%
- In Hilly settlements - One in three household and in Slums - one in five household use polluting fuels regularly (mixed fuel use)
- Slum households are the most intensive stackers — nearly 4 in 10 mixed-fuel users cook two or more meals daily with biomass or kerosene

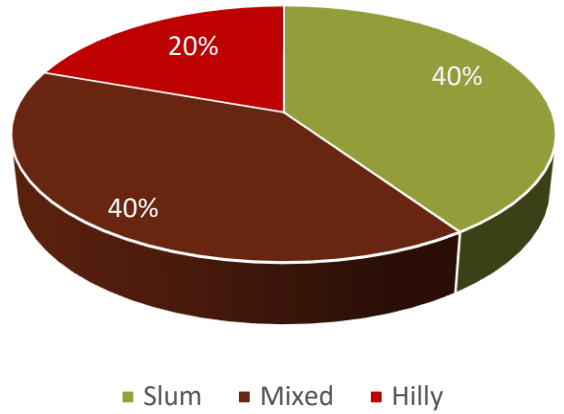
Winter Heating

- Space heating during winter is a major requirement for comfort
- Electric heater users are in found mixed settlements
- Biomass heater users are prevalent in hill and slum settlements

Open Waste Burning

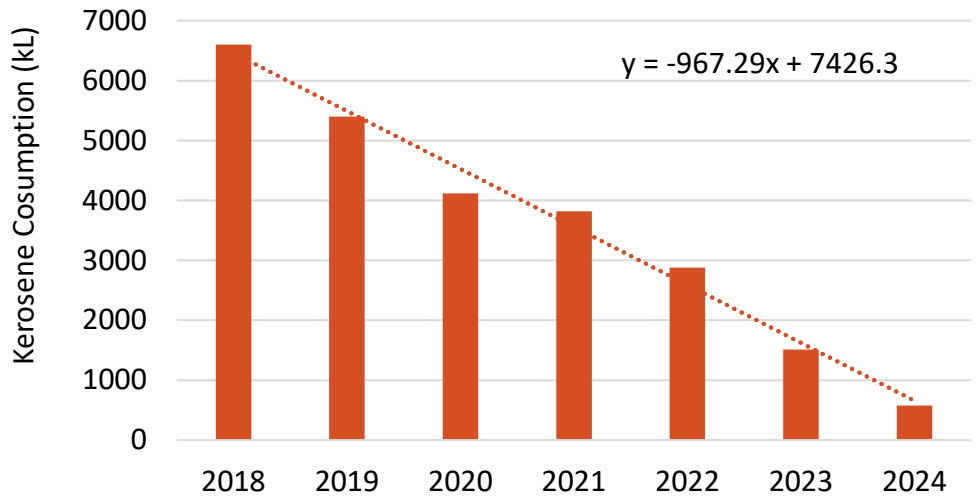
- City wide waste dumping observed and identified as a major challenge
- Mixed settlements have reported to have door-to-door collection, while slums and 'other' areas have the lowest, reflecting gaps in awareness and collection mechanism

Figure 4.1.2: Residential Survey Composition by Settlement Type



4.1.2 Residential Fuel Use in Kamrup (M) District

Figure 4.1.3: Kerosene Consumption in Kamrup Metro District.

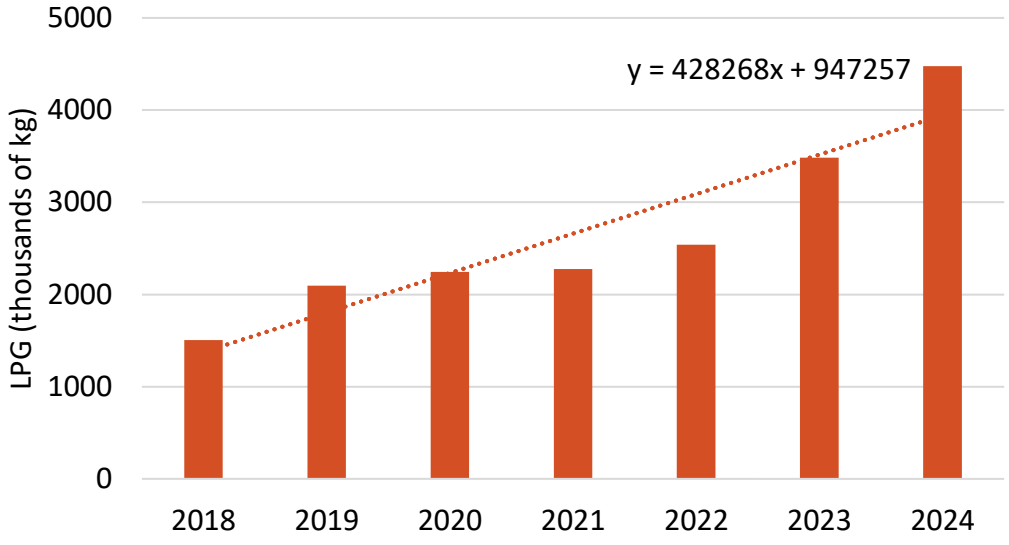


Kerosene Consumption Trends

- Kerosene usage has been steadily declining despite identified user groups
- Linear trend analysis indicates a rapid reduction in residential use
- By 2030, consumption is projected to fall below 100 kL

(Data Source: FPD&CA)

Figure 4.1.4: LPG Consumption in Kamrup Metro District.



LPG Adoption Trend Rising

- Survey findings indicate that LPG penetration is almost universal across households
- Government initiatives such as Pradhan Mantri Ujjwala Yojana (PMUY) have been key drivers of adoption
- Currently, 99% of households are equipped with LPG, highlighting a strong shift towards clean cooking fuel
- Average delivery time, as reported by IOCL, stands at 2 days
- PMUY connections have shown a consistent upward trend since 2020, reaching 27,650 new connections in 2024

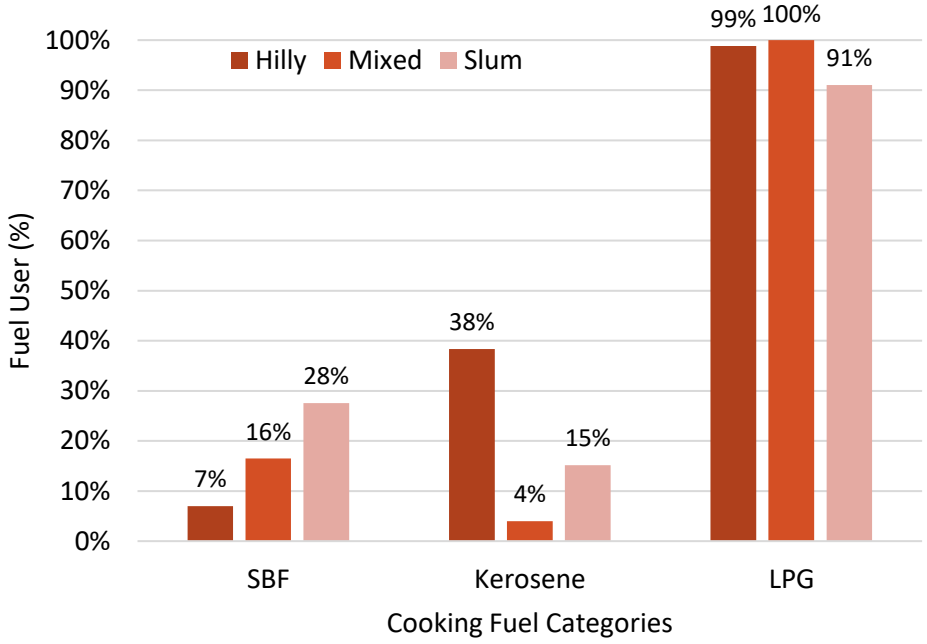
4.1.3 Assessment of City's Cooking Fuel Use

- Guwahati's uneven and multi-level urban growth has created distinct settlement types—hilly areas, mixed residential zones, and slum clusters—each showing different cooking fuel patterns
- Cooking fuels were grouped into three categories aligned with common household energy use: 1) Solid Biomass Fuel (SBF) - (firewood, dung cake, coal/charcoal), 2) Kerosene, and 3) LPG

Table 4.1.1: Key Residential Energy Use Observations and Citywide Implications

Observation Type	Survey Results (Household-Level)	Implication at City Scale
Solid Biomass Fuel (SBF) Dependence	• Users: Hilly = 6, Mixed = 29, Slum = 51 • Annual SBF use: 541–759 kg/HH/yr	• SBF consumption persists across settlements • Scaled to city HH counts, SBF becomes one of the largest contributors to $PM_{2.5}$ and BC emissions
LPG Penetration	• Users: Hilly = 85, Mixed = 170, Slum = 168 (≈95%+ coverage). • Annual LPG use: 176–205 kg/HH/yr	• High LPG connectivity city-wide, but fuel stacking reduces the clean-fuel benefits
Kerosene Use	• Users: Hilly = 33, and Slum = 27 • Annual usage ≈ 41–71 kg/HH/yr	• Even though emissions are lower in mass, kerosene use drives high indoor exposure
Fuel Stacking Patterns	• Many LPG users also use SBF or kerosene, especially in Slum and Hilly pockets	• City-wide emissions remain high despite LPG coverage • Fuel stacking behaviour is a major concern
Settlement-Specific Variation	• SBF highest in Slum (758 kg/yr) and Hilly (730 kg/yr) • Mixed users consume less SBF (541 kg/yr)	• Settlement-wise action planning becomes essential • Slum and Hilly areas are priority zones for clean cooking transitions

Figure 4.1.5: Residential Fuel Usage Across Different Settlements Types



Source: iFOREST Analysis

4.1.4 Fuel Consumption and Emission Estimation

Table 4.1.2: Residential Cooking Fuel Usage

Fuel Type	Estimated Quantity for 2025 (Tonnes)
Kerosene	1688
SBF	36,468
LPG	75,642

Figure 4.1.5: Emission from Residential Cooking Fuel Usage for 2025

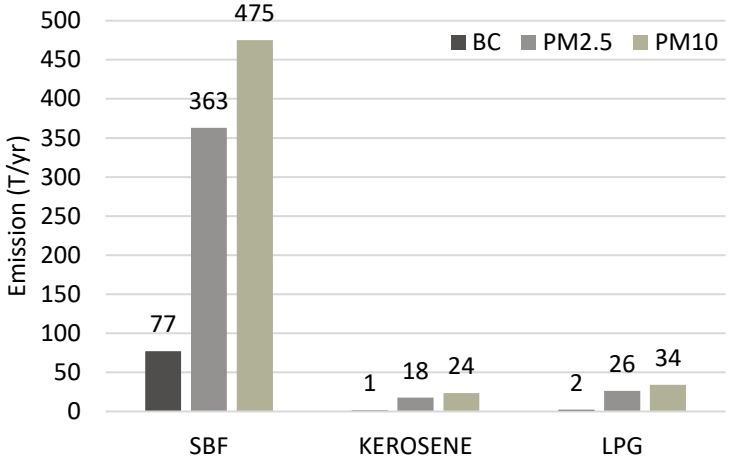
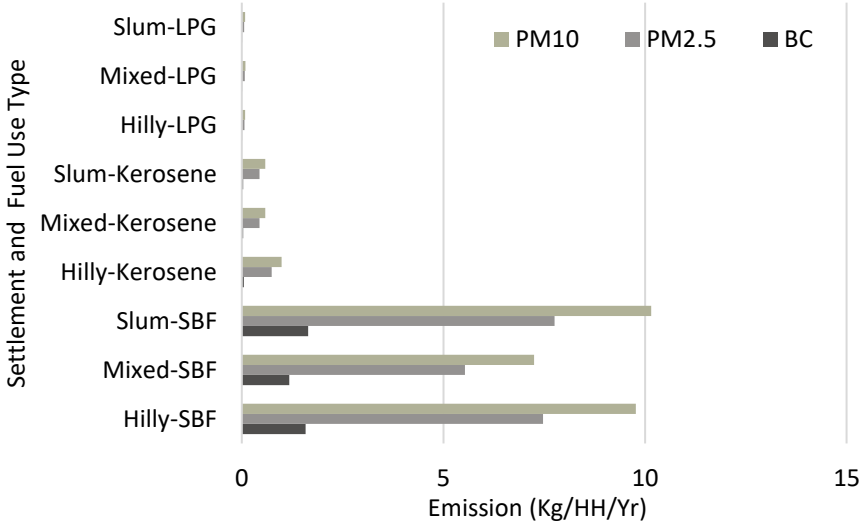


Figure 4.1.6: Emission Intensity By Fuel User Groups



- LPG penetration is around 96% in the city
- Though LPG penetration is towards saturation, fuel stacking is a major challenge. It was estimated that SBF is used around 32% and Kerosene around 2%.
- These fuel-use patterns make residential cooking one of the largest contributors to neighbourhood-level air pollution, with $PM_{2.5}$ emerging as the most critical health concern

- Residential cooking emits 81 T/yr of BC, 407 T/yr of $PM_{2.5}$, and 533 T/yr of PM_{10} under current fuel-use patterns
- SBF use alone contributes ~95% of BC, ~90% of $PM_{2.5}$, and ~90% of PM_{10} from residential cooking
- Even among LPG-using households, fuel stacking keeps SBF responsible for 89% of total $PM_{2.5}$ and kerosene adds 7%, indicating that clean fuel access has not translated into exclusive clean fuel use

- Mixed settlements generate the highest emissions due to a large user base and heavy SBF reliance,
- Slum settlements show the highest emission intensity per household, with SBF-based cooking generating ~7.8 kg $PM_{2.5}$/HH/yr and ~1.65 kg BC/HH/yr, reflecting more intensive biomass burning
- Hilly settlements have lower SBF use but high kerosene dependence, contributing ~0.75 T/yr BC and ~10.5 T/yr $PM_{2.5}$ from kerosene alone—significant despite lower household numbers

Hotspots

Slum-Dense Wards (Highest SBF & Fuel-Stacking)

- These areas show the greatest reliance on firewood, charcoal, and partial kerosene use, with high cooking frequency and shared kitchens
- Slums clusters are observed in the central and western part of the city, with few wards scattered in eastern part of the city
- Large number of slum households using SBF + LPG stacking

Identified Hotspot: Wards -3, 4, 5, 6, 7, 8, 9, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 41, 44, 48, 51, 52, 58

Hilly Settlements (Access-Constrained, High Kerosene Fallback)

- Hilly terrain limits delivery access causes LPG refill delays
- Households fallback to kerosene and biomass particularly during winter
- Ease of availability of wood, dry leaves creates major dependence

Identified Hotspot

Wards: 7, 8, 10, 11, 12, 13, 19, 25, 27, 34, 35, 38, 40, 50, 51, 52, 57, 60

Mixed/Older Residential Wards (Moderate SBF + Seasonal Coal/Charcoal)

- Not slums, but older dense areas with seasonal firewood spikes
- Significant coal and charcoal consumption was seen

Identified Hotspot: Wards- 2, 10, 14, 15, 20, 21, 23, 24, 28, 29, 37, 41, 42, 43, 46, 47, 48, 49, 56, 58, 59

Figure 4.1.7: Slum households using SBF for cooking

4.1.5 Suggested Control Options

Category	Sub-Category	Example Control Measures
Technology & Infrastructure	LPG Access Expansion	▪ LPG micro-distribution kiosks in slum hotspots ▪ Mini-depots + buffer storage in hilly wards ▪ Expansion of LPG delivery fleet for difficult terrain
	Clean Fuel access (Transition from Polluting Fuels)	▪ Household kerosene stove buy-back programme ▪ Restriction of informal biomass vendors ▪ Support for replacing traditional biomass stoves
Compliance, Monitoring & Enforcement	Fuel Bans & Regulatory Controls	▪ Citywide ban enforcement on SBF + kerosene for cooking ▪ Crackdown on illegal charcoal/biomass vendors ▪ Enforcement at market/vendor clusters in hotspot wards
	Seasonal & Hotspot Monitoring	▪ Winter-season hotspot monitoring (slum + hilly areas) ▪ Monitoring biomass fallback during high-PM seasons
	Compliance Audits & Reporting	▪ Annual LPG-only compliance audits ▪ Household LPG safety & readiness checks ▪ Community reporting mechanism for fuel-use violations
Community Engagement, Behaviour Change & IEC	Ward-Level Outreach	▪ Ward-level IEC campaigns (winter + monsoon) ▪ LPG safety demonstrations & clean-cooking messaging
	Community Leadership Activation	▪ SHGs and ASHAs as “Clean Cooking Champions” ▪ Ward committees mobilised for behaviour reinforcement
	Youth & Public Mobilisation	▪ School/youth climate–health campaigns ▪ Community events, clean cooking festivals ▪ Street plays, posters, audio campaigns

4.1.6 Emission Reduction Strategies

Prime strategy for emission reduction is to completely transition to clean fuel alternative i.e. LPG along with their persistent usage without any fall back towards SBF or kerosene

Scenario: Baseline (Status Quo in 2025)

- Existing mix of SBF, kerosene, and LPG continues.
- No interventions; used as the reference case.

Scenario: Kerosene to LPG Transition

- Full elimination of kerosene use across all settlements
- All kerosene users move to LPG
- Help reduce exposure to indoor pollution significantly

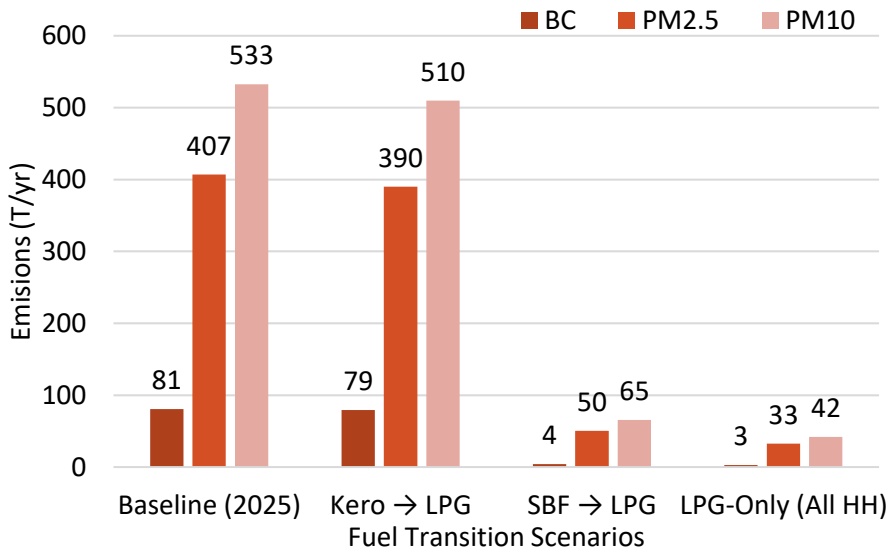
Scenario: SBF to LPG Transition

- Complete phase-out of firewood, dung cake, and coal/charcoal
- All households shift to LPG, with adjusted LPG demand
- Delivers the largest $PM_{2.5}$ and BC reductions

Scenario: LPG-only (No Fuel Stacking)

- All households use only LPG
- SBF and kerosene use discontinued/ banned (specifically during winter season)
- Represents a complete clean-cooking transition

Figure 4.1.8 : Emissions reduction with Fuel Transition



Source: iFOREST Analysis

4.1.7 Implementation Cost

Technology Interventions

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Public/ Private Cost (Cr.)	Total 5-yr Cost (Cr.)
LPG micro-distribution kiosks in slum hotspots (30 kiosks × ₹12 lakh)	OMCs, GMC	24	11	29	6	35
Mini-depots + buffer storage in hilly wards (8 depots × ₹1 Cr.)	OMCs, GMC					
LPG delivery fleet expansion (10 vehicles)	OMCs					
Kerosene stove buy-back (20,000 HH × ₹1,000 incentive)	GMC, OMC CSR					
Replacement of biomass stoves (target: 30,000 HH × ₹1,200 subsidy)	GMC, FPD&CA					

Policy and Enforcement

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Public/ Private Cost (Cr.)	Total 5-yr Cost (Cr.)
Citywide SBF + kerosene ban enforcement	GMC, District Admin, Police	2	16	18	-	18
Crackdown on biomass/charcoal vendors (enforcement squads)	GMC					
Market-level enforcement in slum/hilly hotspots	Ward Committees, GMC					
Winter-season hotspot monitoring (3 months/yr)	APCB, GMC					
Illegal vendor raids (joint ops: GMC + Police)	GMC, Police					

Contd.

Audit / MRV

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Public/ Private Cost (Cr.)	Total 5-yr Cost (Cr.)
Annual LPG-only compliance audits	GMC, OMCs	1	11	10	2	12
HH-level readiness checks (slum + hilly wards)	GMC, ASHAs					
Winter hotspot MRV (fuel-use sampling)	APCB					
Community reporting system / app dashboard	Smart City Mission					
Vendor transition monitoring (biomass → LPG)	NULM, GMC					

Capacity Building and Awareness

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr)	Cost incurred by Govt. (Cr.)	Public/ Private Cost (Cr.)	Total 5-yr Cost (Cr.)
Ward-level IEC campaigns (winter + monsoon)	GMC, SBM-U	--	8	7	1	8
SHGs/ASHAs as Clean Cooking Champions	Health Dept., NULM					
School & youth campaigns	Education Dept., GMC, APCB					
Community festivals, street plays, posters, audio	GMC, NGOs					

Total Cost of Implementation for 5-yr (in Cr)	**73**
Total Cost of Implementation for 5-yr (in Cr) – Incurred by Govt.	**64**

4.1.8 Implementation Pathway

2026

- LPG micro-distribution kiosks in slum hotspots (ward: 3, 4, 5, 6, 7, 8, 9, 13, 14, 15, 18) and hilly wards (wards: 7, 8, 10, 11, 12, 13, 19, 25, 27)
- Ban informal firewood/ charcoal/ kerosene vendors
- Complete ban during Winter – SBF + Kerosene

2027

- LPG micro-distribution kiosks in slum hotspots (ward: 19, 20, 21, 23, 23, 41, 44, 48, 51, 52, 58) and hilly wards (wards: 34, 35, 38, 40, 50, 51, 52, 57, 60)
- Expand LPG delivery fleet
- Eliminating illegal firewood / charcoal vendors

2028

- Issue Notification and Enforcement: citywide ban on SBF + kerosene for cooking
- Winter-season monitoring for SBF fallback

2029

- Annual LPG-only compliance audits across all wards
- Permanent enforcement of SBF/ kerosene prohibition

2030

- "SBF & Kerosene-Free Zones'' in hotspot wards
- Seasonal reinforcement campaigns (winter + monsoon)
- Sustain LPG-only adoption through SHGs /ASHAs/ Ward Committees

Emission Reduction Potential

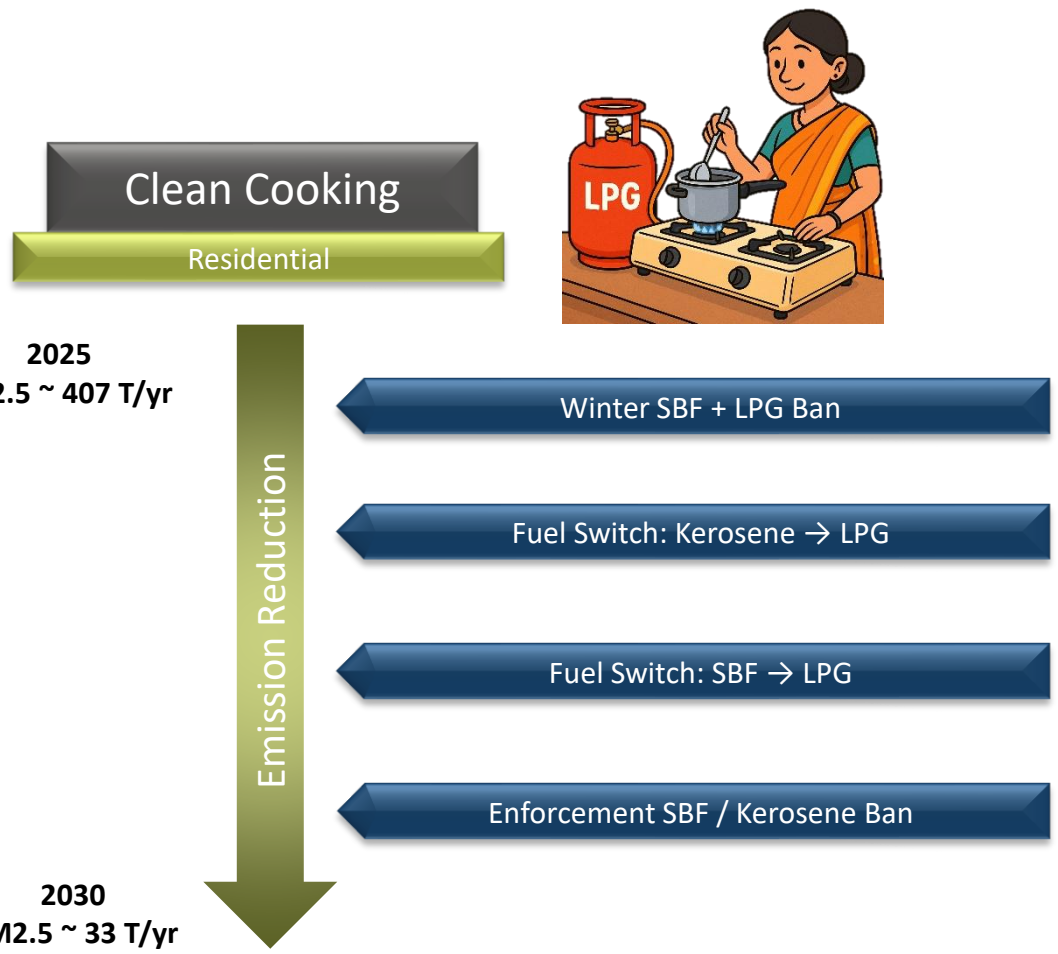
PM2.5 ~ 90%

4.1.9 MRV

Category	Monitoring (M)	Reporting (R)	Verification (V)	Action Plan Linkages
Reduction in SBF Use	▪ Monitor SBF availability in local markets as a proxy	▪ GMC prepares a 6-monthly ward-wise update of SBF availability	▪ APCB conducts random checks (10 households/ ward) to validate SBF usage/ availability claims	▪ Measures progress of biomass phase-out, kerosene elimination, clean cooking targets
Increase in LPG Use	▪ Monitor LPG refill frequency and new connections using quarterly OMC data ▪ Track % of households using LPG as primary fuel via rapid survey	▪ Quarterly LPG adoption dashboard (new connections, refills /HH/ month)	▪ Verification through cross-checking OMC refill data with household survey responses	▪ Supports actions on LPG reliability, delivery improvements, refill affordability
Hotspot Surveys	▪ Winter hotspot survey in wards with high fuel stacking or persistent SBF use	▪ "Cooking Fuel Hotspot List" updated annually by GMC	▪ APCB verifies hotspot wards by field observation and vendor fuel checks	▪ Directly guides targeting of IEC campaigns, subsidy schemes, last-mile delivery improvements
Annual Citywide Fuel-Use Survey	▪ Conduct a structured annual survey across all settlement types (slum, mixed, hilly, formal) ▪ Collect data on fuel type, stacking patterns, refill frequency, affordability barriers	▪ Annual "Household Fuel Use Report" prepared by GMC and FPD&CA	▪ External verification by an academic partner (e.g., IITG, TISS-G) to validate sampling and results	▪ Calibrates the emission inventory, identifies behaviour trends, and updates action prioritization

4.1.10 Key Highlights

- Residential cooking is a major $PM_{2.5}$ source in Guwahati, generating an estimated ~407 tonnes of $PM_{2.5}$ annually from biomass and kerosene use.
- Although LPG penetration exceeds 95%, mixed-fuel use (LPG + firewood/charcoal/kerosene) remains common in several settlement pockets.
- Hotspots are concentrated across slum, hilly, and older dense residential wards, where fuel stacking and seasonal fallback behaviour are highest.
- Slum-dense hotspot wards—2, 3, 4, 6, 7, 8, 11, 12, 13, 15, 18, 21, 22, 23, 24, 28, 29, 30, 31, 32—show extensive use of firewood/charcoal due to shared kitchens, high cooking frequency, and easy access to informal biomass vendors.
- Hilly settlement hotspot wards—40, 41, 42, 43, 44, 50, 51, 52, 53, 55, 56—face persistent LPG delivery challenges, causing refill delays and winter fallback to kerosene or firewood, sharply increasing seasonal emissions.
- Older mixed residential hotspot wards—16, 17, 19, 25, 26, 27, 33, 34, 36, 37, 38, 39—exhibit seasonal coal/charcoal spikes, including use of coal tandoors, shared kitchens, and festival-driven firewood burning.
- A complete transition to LPG-only cooking, especially across these hotspot clusters, can reduce residential $PM_{2.5}$ emissions by up to 90%, offering one of the strongest air-quality gains for the city.

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4.2 Mitigating Residential Heating Emissions

4.2.1 Key Statistics and Background

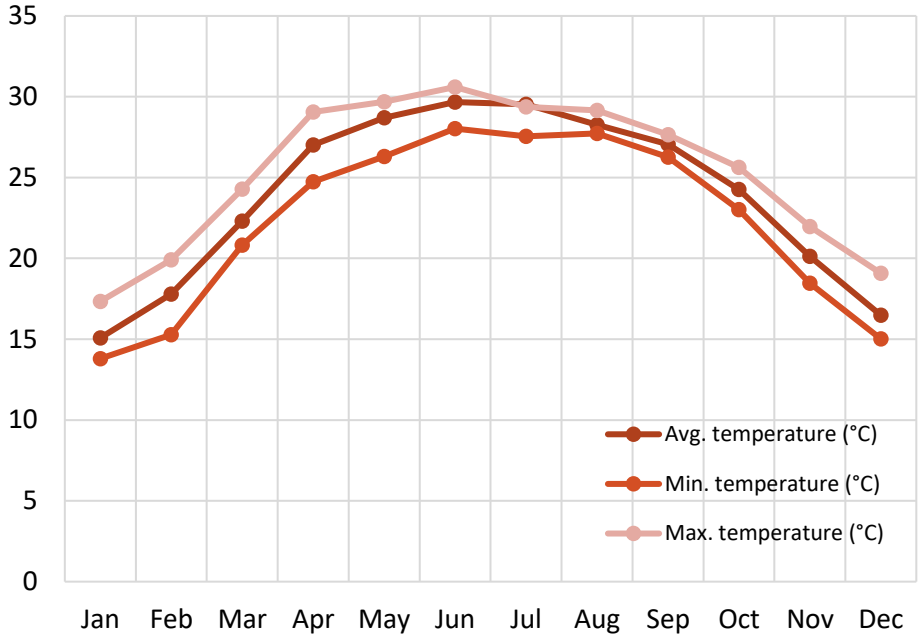
Residential Heating – A seasonal activity

- **Temperature drop in winter season:** Residential heating emerges as a major requirement for household's comfort
- **Emerging winter pollution source:** Even limited household heating in hill and peri-urban areas adds to seasonal $PM_{2.5}$ and black carbon peaks.
- **Often overlooked in clean-air strategies:** TERI (2021) notes that residential heating remains an unrecognized contributor in low-altitude Indian cities.
- **High co-benefit potential:** Promoting cleaner heating options can simultaneously reduce winter emissions and improve indoor air quality.

Lack of Information

- **Low winter temperatures but limited evidence on heating needs :** The city experiences relatively low temperatures during December–February, often dropping below 20 °C; however, there is limited empirical information on actual residential heating demand and practices.
- **SBF-using households often extend biomass use for heating**, but this practice is undocumented in official energy-use datasets and absent from policy guidance.
- **Residential heating is not explicitly covered under NCAP or existing CAAPs**, and limited data on household heating behaviour, fuel types, and intensity creates a significant gap in understanding and estimating winter emission sources.

Figure: 4.2.1 Monthly temperature profile in Guwahati city



Source: Ahmed et. al (2021)

4.2.2 Emissions

City's Heating Need

- Households reported using three primary heating options: electric heaters, biomass heaters, and charcoal-based heaters (Figure 4.2.1)
- Electric heaters were considered as the cleaner alternative for this study; emissions were estimated only for biomass and charcoal
- Electric heating use is highest in mixed residential areas, reflecting stronger purchasing power and better access to electricity
- Biomass and charcoal remain common heating fuels in hill settlements and slum areas, where affordability and fuel availability drive choices
- Heating activity was modelled using an 8-week heating period, following the survey responses and discussions with an average of 4 hours of heating per day

Figure 4.2.2: Share of residential heating

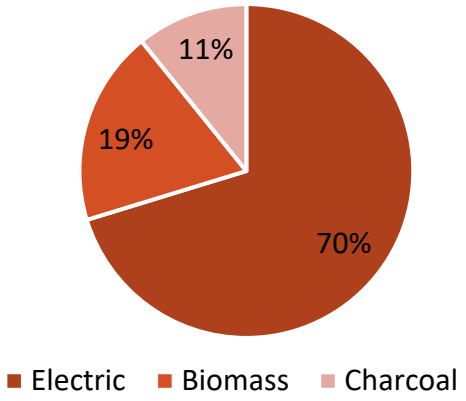


Table 4.2.1: Estimated Fuel Demand - 2025

Fuel Type	Quantity (T/yr)
Biomass	3395
Charcoal	452

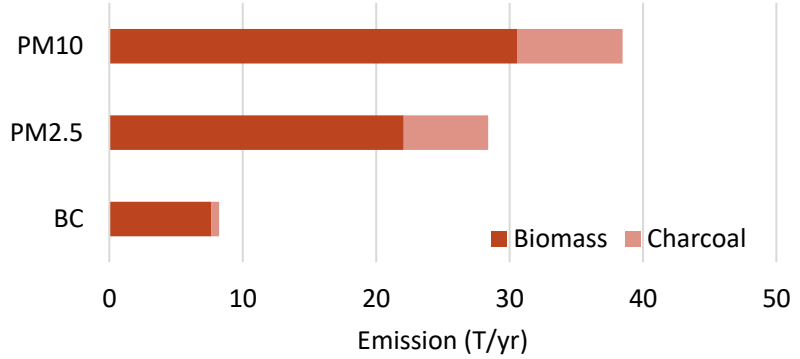


Figure 4.2.3 : City's Emission from Residential Heating

- City is estimated to use 3395 Tonnes of biomass (wood, dung cake, leaves) and 452 Tonnes of charcoal for residential heating purposes (Table 4.2.1)
- Estimated emission from residential heating contributed to 8 Tonnes of BC, 28 Tonnes of PM2.5, and 38 Tonnes of PM10 in year 2025
- Biomass contributes most emissions, accounting for ~79% of total $PM_{2.5}$ (22 T/yr) from residential heating (Figure 4.2.2)
- Residential heating hotspots overlap with the settlements identified in residential cooking emissions (Section 4.1.4)

4.2.3 Suggested Control Options

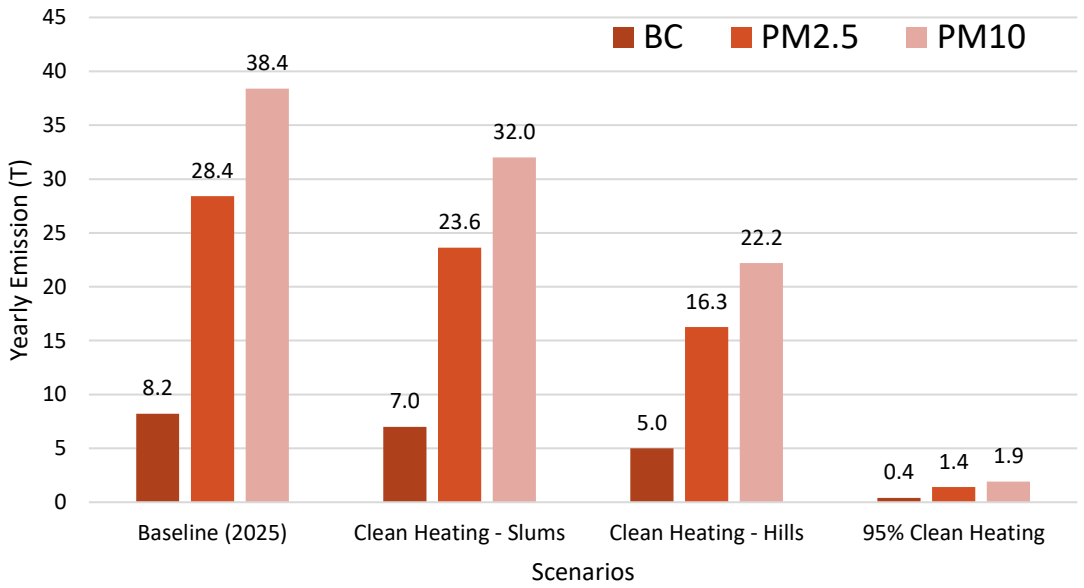
Measures	Type	Typical Features	Expected Result / Benefit
Subsidised Electric Room Heaters for Low-Income Households	Technology + Financial Support	Provide radiant/convection heaters at 50% subsidy for slum & hilly wards	• Eliminates biomass/kerosene heating. • ~90–95% reduction in $PM_{2.5}$ & BC at household level.
Winter Low-Tariff Electricity Slab	Policy / Tariff Reform	Seasonal tariff reduction (Nov–Feb) so households can afford electric heating	• Prevents fallback to firewood/charcoal. • Ensures sustained clean-heating adoption.
Ban & Strict Enforcement on Sale of Firewood/Charcoal for Heating	Regulatory	Winter specific bans and restrictions	• Rapid drop in biomass heating practices. • Strong behavioural push to electric options.
Improved Housing Insulation for Slum & Hilly Households	Infrastructure / Civil Works	Low-cost insulation boards, sealing gaps, roof insulation	• 20–30% reduction in heating hours. • Lower electricity demand + lower bills.

4.2.4 Emission Reduction Scenario

Scenario Definitions – Residential Heating Transition

- **Clean Heating – Slums:** Distribution of subsidised electric room heaters to 24,000 slum households (HH), replacing biomass/charcoal. Represents a targeted intervention in high-density, high-exposure communities.
- **Clean Heating – Hills:** Distribution of subsidised electric heaters to 36,000 hilly-settlement HH, where heating dependence is highest due to terrain-access constraints and frequent LPG refill delays. Captures a larger share of heating-related emissions.
- **95% Clean Heating Transition:** A citywide transformation scenario where 95% of all HH using biomass or charcoal for heating switch to clean electric alternatives. Represents the maximum and realistic feasible mitigation potential under an aggressive clean-heating programme.

Figure 4.2.4: Scenarios of Emission from Residential Heating



Scenario Result Summary - Residential Heating Transition

- Targeted clean-heating interventions in slum HH (24,000) achieve 15–17% reduction in $PM_{2.5}$, PM_{10}, and BC emissions, indicating strong benefits even with partial sectoral coverage.
- Clean-heating adoption in 36,000 hilly HH reduce emissions by 39–43%, which is driven by high baseline dependence on biomass and kerosene.
- 95% Clean Heating (transition away from biomass/charcoal) - 95% reduction across all pollutants, representing the maximum mitigation potential.
- High emission reductions with more HH coverage, highlights that hilly clusters are the most emission-intensive and offer the largest mitigation payoff.
- Transitioning HH from biomass/charcoal to electric heating provides large co-benefits: lower neighbourhood-level PM spikes in winter, reduced black carbon, and improved indoor air quality for vulnerable HH.

4.2.5 Implementation Cost

Technology Interventions

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Cost incurred by Public/ Private (Cr.)	Total 5-yr Cost (Cr.)
Electric heater distribution (50% subsidy or ₹700/HH, total 60,000 HH)	GMC, APDCL, AEDA	10	5	12	3	15
Pilot - Improved housing insulation for slum & hilly HHs (10,000 units; basic roof/wall insulation)	GMC, AERA, DoHUA, CSR					

Policy and Enforcement

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Cost incurred by Public/Private (Cr.)	Total 5-yr Cost (Cr.)
Winter low-tariff electricity slab for clean heating (Nov–Feb)	APDCL	91	5	96	-	96
Ban & strict enforcement on sale/use of firewood/charcoal for heating (with focused winter drives in slum & hilly wards)	GMC, Ward Committees, APCB, Police					

Audit / MRV

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Cost incurred by Public/Private (Cr.)	Total 5-yr Cost (Cr.)
Identification & monitoring of heating fuel use in hotspot wards	GMC, ASHAs, Academic Partner	0.5	5	5.5	-	5.5
Annual winter KAP survey on heating behaviour	GMC, Academic Partner					
Winter hotspot MRV (fuel-use + ambient sampling)	APCB, GMC					

Capacity Building and Awareness

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Cost incurred by Public/Private (Cr.)	**Total 5-yr Cost (Cr.)**
Multilingual IEC + mass & social-media campaigns on clean heating (Nov–Feb)	GMC, APCB, NGO	0.5	6.5	5	2	7
Ward-level outreach in slum & hilly hotspots; demos of electric heaters & insulation	GMC, Ward Committee, AEDA					
Winter community events (street plays, local radio, etc.)	APCB, NGO					

Total Cost of Implementation for 5-yr (in Cr)	**123**
Total Cost of Implementation for 5-yr (in Cr) – Incurred by Govt.	**118**

4.2.6 Implementation Pathway

2026

- Clean-heating subsidy scheme (50% or ₹700/HH) for low-income HHs.
- Priority heating hotspot wards (3-7, 9, 14-20, 49, 50, 54)
- Grid electricity winter low-tariff slab for clean heating
- Winter Ban & strict enforcement on sale/use of firewood/charcoal for heating

2027

- Distribution of subsidised electric heaters across slum & hilly heating hotspots
- Improved housing insulation for slum & hilly HH
- Partnerships with vendors/MSMEs for steady heater supply and servicing.

2028

- Clean-heating coverage to all households in slum + hilly heating clusters.
- Provide household-level guidelines on safe electric-heater use and support for replacement of old biomass bukharis / biomass heaters.

2029

- Extend subsidy access to remaining uncovered household pockets in the hotspot wards.
- Expand APDCL winter tariff benefits to all low-income households in hotspot wards.
- Integrate heater support with housing/welfare schemes in slum + hilly rehabilitation zones.

2030

- Achieve near-complete elimination of biomass/charcoal heating in slum and hilly wards
- Continue programme as a recurring annual winter initiative (Nov–Feb).
- Provide replacement/maintenance support to ensure sustained use of clean-heating devices.

Emission Reduction Potential

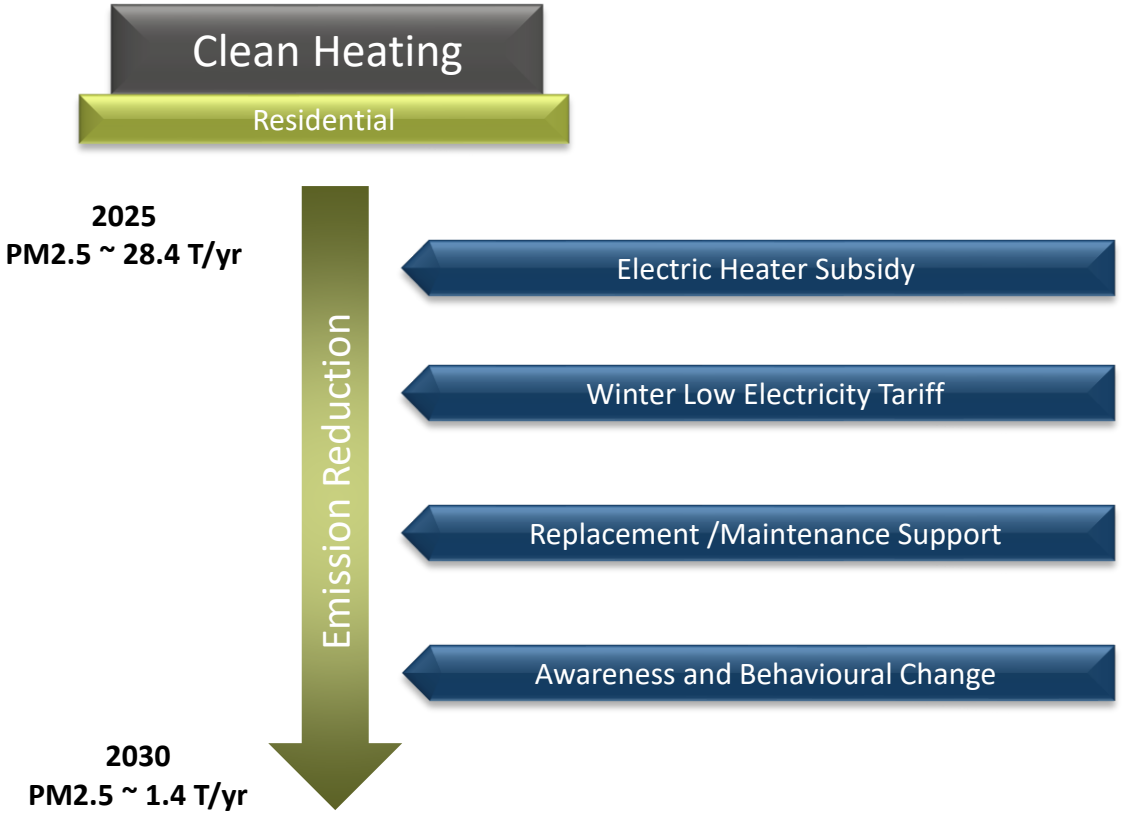
PM2.5 ~95%

4.2.7 MRV Structure

Action	Monitoring	Reporting	Verification
1. Deployment of Clean Heating Solutions (Electric, Solar, Improved Biomass)	**Winter only (Dec–Jan):** ▪ Number of households receiving clean heaters ▪ Vendor/supply logs	▪ Bi-weekly clean-heater uptake report (Dec–Jan)	▪ Report verification of installations ▪ Confirmation of device distribution
2. Phase-Out of Biomass/Charcoal Heating in Slum & Hilly Areas	**Winter only (Dec–Jan):** ▪ Ward-level list of biomass/charcoal users ▪ Winter checks on charcoal & firewood sales	▪ Bi-weekly winter compliance report	▪ Surprise winter-night inspections ▪ Market-level cross-check of charcoal/fuel availability ▪ Independent winter compliance audit
2. Awareness & Behaviour Change Campaign (Clean & Safe Winter Heating)	**Pre-Winter (Nov):** ▪ Participation in outreach events ▪ Media & radio campaign log **Winter (Dec–Jan):** ▪ Attendance at demos ▪ Geo-tagged photos of sessions **Post-Winter (Feb):** ▪ Short feedback survey on heating practices	▪ Pre-winter IEC rollout report ▪ Bi-weekly outreach summary during winter ▪ Post-winter KAP summary	▪ Verification of IEC distribution ▪ Random checks on winter events ▪ Third-party validation of KAP findings

4.2.8 Key Highlights

- Residential heating is used mainly during December–February, with households reporting 6–10 weeks of heating activity.
- Biomass and charcoal are the dominant heating fuels in slum and hilly settlements, leading to substantial winter fuel consumption.
- Heating-related combustion contributes significantly to seasonal $PM_{2.5}$ (28 T/yr) and black carbon (8 T/yr) emissions, intensifying neighbourhood-level winter pollution.
- Poor insulation and inadequate thermal performance of houses increase heating fuel demand and associated emissions.
- Heating is not explicitly covered in NCAP or existing CAAPs, resulting in major data gaps and underestimation of winter emissions.

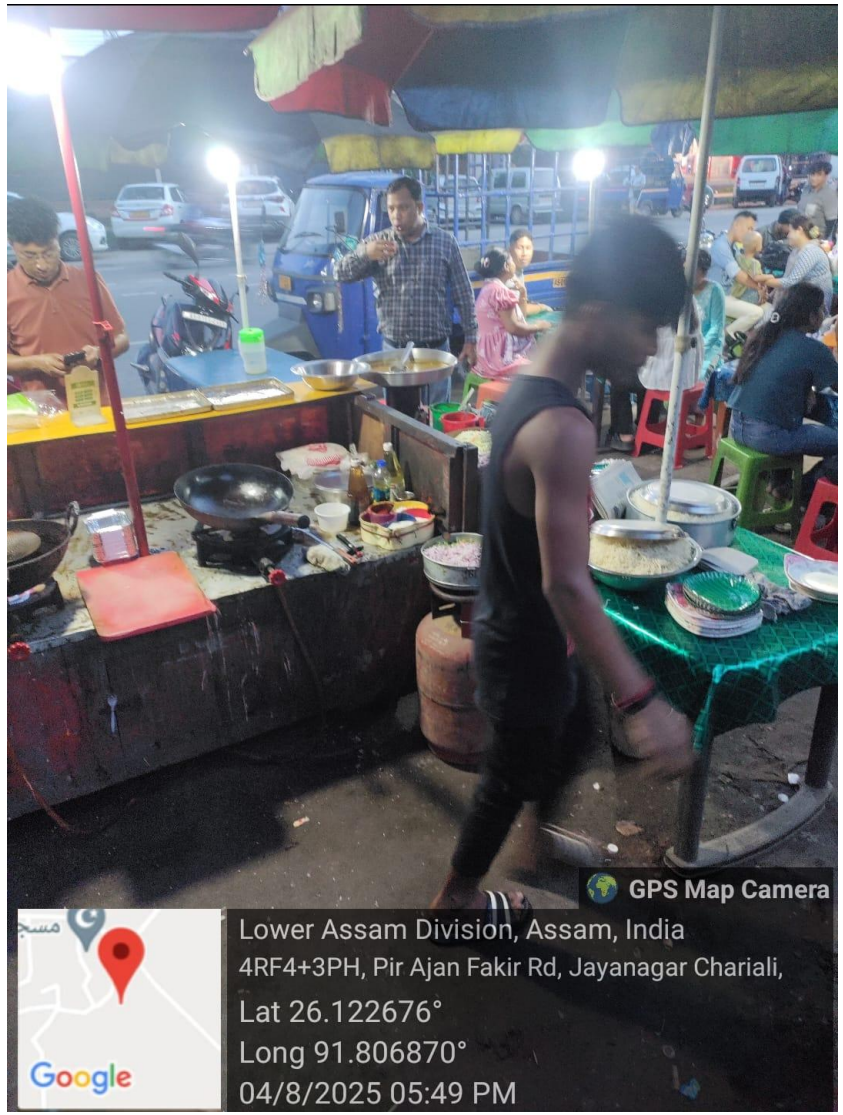








4.3 Mitigating Commercial Cooking Emissions


GPS Map Camera
Lower Assam Division, Assam, India
4RF4+3PH, Pir Ajan Fakir Rd, Jayanagar Chariali,
Lat 26.122676°
Long 91.806870°
04/8/2025 05:49 PM
Google

4.3.1 Key Statistics and Background

- Major activity in commercial sector is fuel used for **commercial cooking** purposes
- As per GMC:
  - Total number of Hotels + Restaurants = 1851
  - Total number of Street vendors (SVNidhi Scheme) = 23483
- Food related street vendor share (Aye & Sharma, 2022) = 16%

Survey Coverage

- 124 establishments surveyed across five categories: Banquet halls, Hotels, Restaurants, Formal tea stalls, Informal street eateries
- Captured data on fuel type, user share, and average monthly consumption.

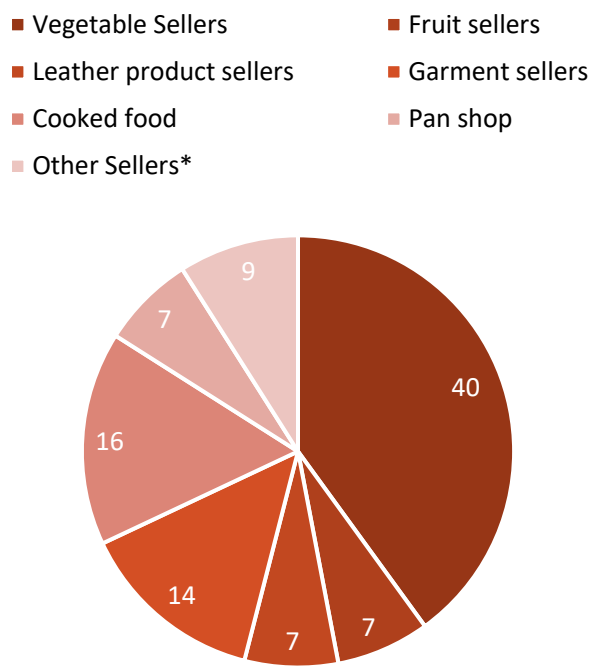
Fuel Use Highlights:

- LPG is the dominant cooking fuel — used by ≈96 % of all establishments.
- Coal/charcoal used by ~10 %, mainly in restaurants and tea stalls for tandoors/grills.
- Kerosene use limited (~6 % overall) but concentrated among small informal vendors.
- Diesel (DG sets) present in ~22 % of establishments, primarily hotels and banquet halls.

Table 4.3.1 : Key fuel use observations in different commercial cooking establishments

Category (count)	Key Observations
Banquet halls (2)	100 % LPG; all have DG sets (~180 L month^{-1}).
Hotels (22)	100 % LPG; ~90 % use DG sets (~177 L month^{-1}).
Restaurants (47)	LPG dominant; 17 % use coal/charcoal; one still uses kerosene.
Formal tea stalls (31)	LPG primary; small share use coal/charcoal.
Informal street stalls (22)	Mixed fuels — LPG + kerosene + charcoal; lowest clean-fuel access.

Figure 4.3.1: Percentage share of street vendors in Beltola, Guwahati.
(Aye & Sharma, 2022)



4.3.2 Emission Estimation and Hotspots

Figure 4.3.2: City's fuel use in 2025 from commercial cooking sector

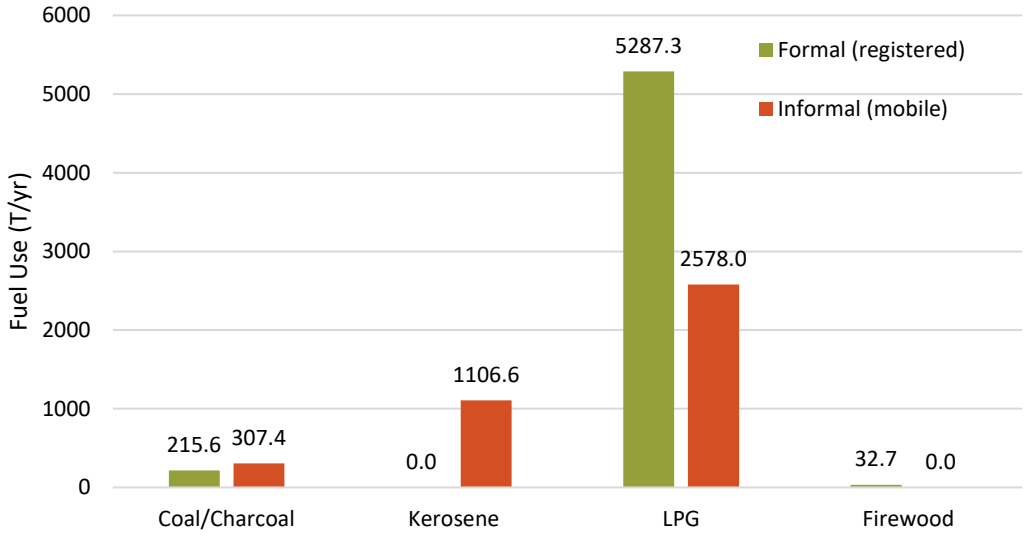


Table 4.3.2: Emission load from city's commercial cooking activity in 2025

Pollutant	City Level Emission (T/yr)
BC	2.1
PM2.5	22.4
PM10	29.3

Fuel Use and Emission Insights

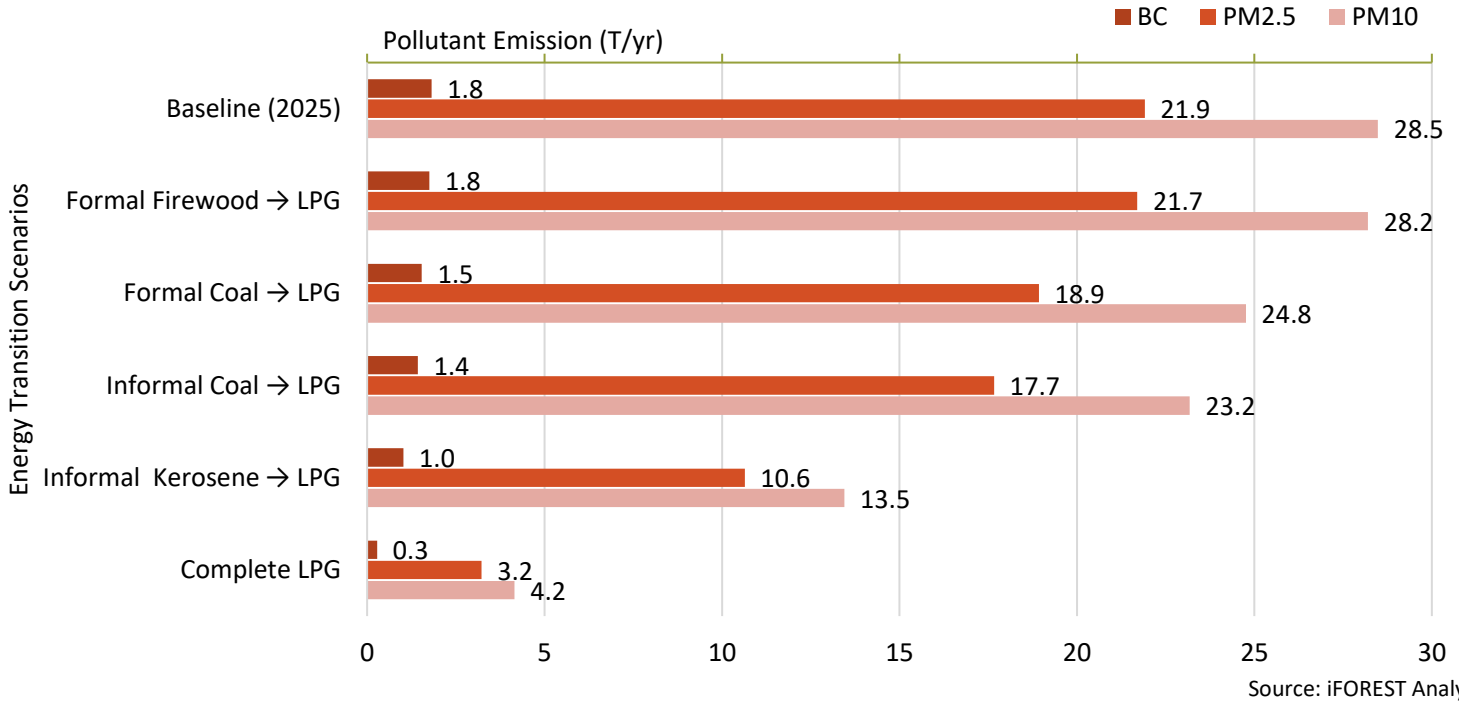
- Commercial cooking uses a mixed fuel basket, LPG for routine cooking but charcoal/coal widely for tandoors and barbeque in both formal and informal establishments.
- Formal restaurants were also found to use firewood for cooking purposes for wooden fired food preparation (Tandoor, Pizzerias, BBQs)
- Informal vendors additionally rely on kerosene and biomass, creating higher-emission clusters around markets and food streets.
- Tandoors and coal-fired stoves are major sources of $PM_{2.5}$, PM_{10}, and BC.
- Commercial cooking activity emits ~2.1 tonnes of BC and ~29.3 tonnes of PM_{10} annually (Table 4.3.2), driven largely by charcoal/coal and kerosene use.

Hotspots of Commercial Cooking Emissions

- High-density commercial corridors such as Fancy Bazar, Beltola, Ganeshguri, Zoo Road Tiniali, Maligaon and Lokhra are characterised by clusters of restaurants, tandoor kitchens, tea stalls, and evening food streets with concentrated coal, kerosene and LPG use.
- Major GMC Markets and food hubs including Uzan Bazar, Pandu, Silpukhuri, Six Mile, Paltan Bazar, Bhangagarh, Azara and Jalukbari where continuous cooking, grilling and frying activities lead to elevated PM2.5, PM10, CO and BC emissions.
- Ward-level hotspots around Wards 10, 17, 18, 23, 31, 37, 41 and 43 where dense informal eateries, night-time food vending and coal/charcoal tandoors create persistent localised pollution plumes due to poor dispersion in narrow streets and mixed-use zones.

4.3.3 Emission Reduction Pathway

Figure 4.3.3: Commercial Cooking Emissions for Different Fuel Transition Scenarios



Source: iFOREST Analysis

- Target informal kerosene and coal users first—this delivers the largest immediate gains, cutting BC and PM emissions by 30–50% in the most polluting clusters.
- Shift formal coal/firewood kitchens to LPG next, producing consistent citywide reductions (13–20%) and cleaning commercial corridors.
- Combine informal + formal transitions to achieve a strong cumulative impact, moving the city toward 40–60% overall emission reduction.
- Complete LPG saturation across all sectors delivers the maximum mitigation (~85%), establishing a long-term clean-cooking, low-emission ecosystem for the city.

4.3.4 Suggested Control Measure

Intervention Category	Control Measures
Clean Fuel Access for Informal Vendors	Clean-fuel access points in vendor zones
	Ban kerosene in commercial informal use
	Pilot 50% subsidy for first 500 LPG/electric units
Scale-Up of LPG Adoption & Vendor Support	LPG connection + refill support (informal vendors)
	Vendor safety & awareness campaigns
	Subsidy for LPG/electric conversion (equipment + small pipeline fixes)
Formal-Sector Clean Fuel Transition	Mandate LPG/electric appliances for new restaurants
	Phase-out charcoal procurement in urban limits
	Tandoor buy-back programme + subsidy for clean models
Enforcement & Licensing Compliance	LPG-only compliance checks in restaurants
	Linking trade licenses to clean-fuel norms
	Winter enforcement on coal/wood use
Citywide LPG Stabilisation by 2030	Ensure kerosene-free, coal-free commercial cooking
	Market coordination with OMCs for LPG supply reliability

4.3.5 Implementation Cost

Technology Interventions

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Cost incurred by Public/ Private (Cr.)	Total 5-yr Cost (Cr.)
Clean fuel access (LPG micro-cylinder kit) for informal vendors	GMC, FPDCA, OMCs, CSR	15	0.5	8	7.5	15.5
Rolling out Electric/infrared tandoor and LPG tandoor conversion						
Tandoor buy-back incentive scheme						
Market-level LPG distribution and kiosk support						

Policy and Enforcement

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Cost incurred by Public/ Private (Cr.)	Total 5-yr Cost (Cr.)
Vendor registration and fuel declaration system	GMC, FPD&CA, APCB	3	6	7.5	1.5	9
Winter ban and enforcement drive on coal/kerosene/firewood						
LPG/Electric compliance checks in restaurants/hotels						
Clean-cooking zone implementation						

Audit and MRV

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Cost incurred by Public/ Private (Cr.)	Total 5-yr Cost (Cr.)
Annual fuel use survey and sampling	GMC, FPD&CA	-	3.5	3.5	-	3.5

Capacity Building and Awareness

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Cost incurred by Public/ Private (Cr.)	Total 5-yr Cost (Cr.)
Annual LPG safety, handling and clean tandoor training	GMC, FPD&CA, APCB	2.5	5.5	6	2	8
Clean-fuel awareness campaign in markets and commercial hubs						
Vendor conversion subsidy and scheme – knowledge dissemination						
TOTAL COST (5 year program)				25	11	36

4.3.6 Implementation Pathway

2026

- Roll out LPG micro-kits for vendors
- Pilot 500 clean tandoors with subsidy
- Establish vendor registration and fuel records
- Conduct clean appliance demonstrations

2027

- Expand LPG connections with refill support
- Run vendor safety and awareness campaigns
- Provide LPG/electric conversion subsidy package
- Introduce charcoal restrictions in priority zones

2028

- Mandate clean appliances for new restaurants
- Launch tandoor buy-back and clean models
- Phase out charcoal use in urban areas
- Operationalise clean-cooking commercial zones

2029

- Enforce LPG-only usage in restaurants
- Link trade licenses to clean-fuel norms
- Strengthen winter coal/wood enforcement drives
- Conduct annual MRV: surveys + sampling

2030

- Achieve kerosene-free, charcoal-free commercial cooking
- Maintain coordinated LPG supply with OMCs
- Institutionalise annual vendor training programmes

Emission Reduction Potential

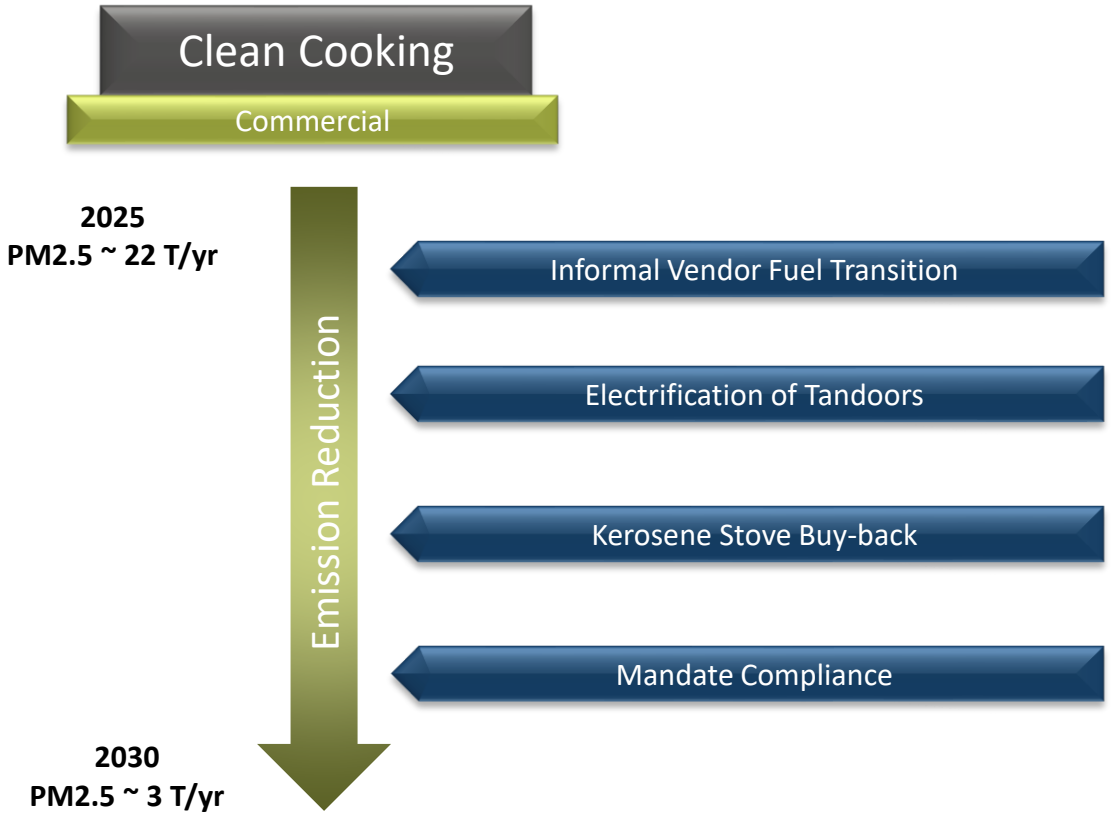
PM2.5 ~85%

4.3.7 MRV Structure

Action Area	Monitoring	Reporting (Quarterly)	Verification (Annual)
Informal Vendor Transition (Kerosene/Coal → LPG)	▪ Update LPG vendor registry ▪ Spot checks for kerosene/coal use during operational hours	▪ Quarterly transition progress report ▪ Non-compliance list and corrective action notes	▪ Third-party audit of vendor registry + OMC logs ▪ Annual field-validation survey
Formal Sector Shift (Coal/Firewood → LPG/Electric)	▪ Update inventory of coal/wood tandoors ▪ Record LPG/electric replacements ▪ Track city-level charcoal/coal procurement ▪ Check winter ban compliance for tandoors	▪ Status of conversions vs pending units ▪ Winter-season compliance summary	▪ Annual enforcement audit of restaurants/ eateries ▪ Market-level coal/charcoal sales cross-check
LPG Safety, Training & IEC	▪ Safety training registration ▪ Safety compliance checklist during inspections	▪ Quarterly IEC & safety status report ▪ Ward-level readiness summary	▪ Annual IEC effectiveness review ▪ Vendor/user feedback survey
Seasonal Pollution Controls (Winter)	▪ Monitor winter ban on coal/wood tandoors ▪ Random operational-hour field surveys ▪ Spot checks during high-PM days	▪ Winter compliance summary (Dec–Feb) ▪ Violations & actions taken report	▪ Annual winter enforcement evaluation ▪ Hotspot comparison of compliance vs. pollution levels

4.3.8 Key Highlights

- Commercial cooking is a significant pollution source, emitting an estimated 22 T/yr of $PM_{2.5}$ and 2 T/yr of BC.
- Guwahati currently hosts ~1,900 registered hotels and restaurants and ~3,800 informal vendors, including open eateries and street food stalls.
- Informal commercial cooking operates year-round, with rising demand for cafés, open eateries, and small food joints—a dispersed and difficult-to-regulate sector largely dependent on kerosene and coal/charcoal.
- Formal establishments frequently operate tandoors and grills powered by wood or charcoal, adding substantial emissions due to the absence of pollution-control systems in most units.



4.4 Mitigating Emissions from Open Burning of Solid Waste

4.4.1	Key Statistics and Background (Existing Infrastructure & treatment)
4.4.2	Complaint and Grievance Redressal/Byelaws/Gap assessment
4.4.3	Treatment Capacity and Future Requirement Gap analysis
4.4.4	Waste Burning Emissions and Hotpots
4.4.5	Landfill Methane Emission
4.4.6	Suggested control measure and timeline
4.4.7	Landfill methane emission and suggested control measure

4.4.1 Key Statistics and Background

Outdated waste data: MSW generation and collection reported as 550 TPD for the last 6 years with no updated assessment

Low segregation at source: Only 30% segregation observed during field interactions with NGOs involved in waste collection

Inadequate collection system: 64% alternate-day and 32% daily collection, insufficient for high-waste commercial zones leading to dumping and burning

Limited NGO role & awareness: NGOs focus mainly on collection; awareness and segregation enforcement are minimal

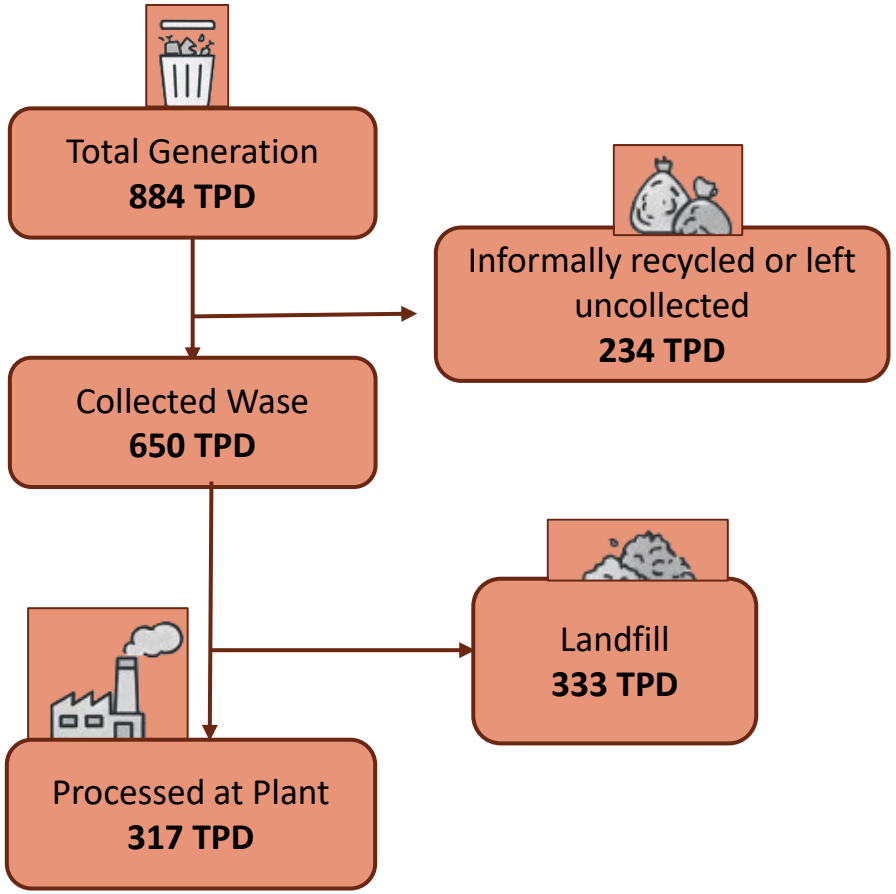
Informal and mobile stalls: Waste not picked up on time; mobile vendors lack fixed spots or bins leading to burning at closing time

Disposal bottlenecks: Slow unloading at RTS sites, time taken 3–4 hours

Unserved areas: Hilly settlements and slum areas have low frequency of waste collection (typically once a month) leading to dumping and open burning

Solid Waste Infrastructure

Figure 4.4.1: City's Current SWM Infrastructure



Data Source: GMC, iFOREST Analysis

Figure 4.4.2: Future Sufficiency of Existing Infrastructure (2025–2030) & Identified Gaps

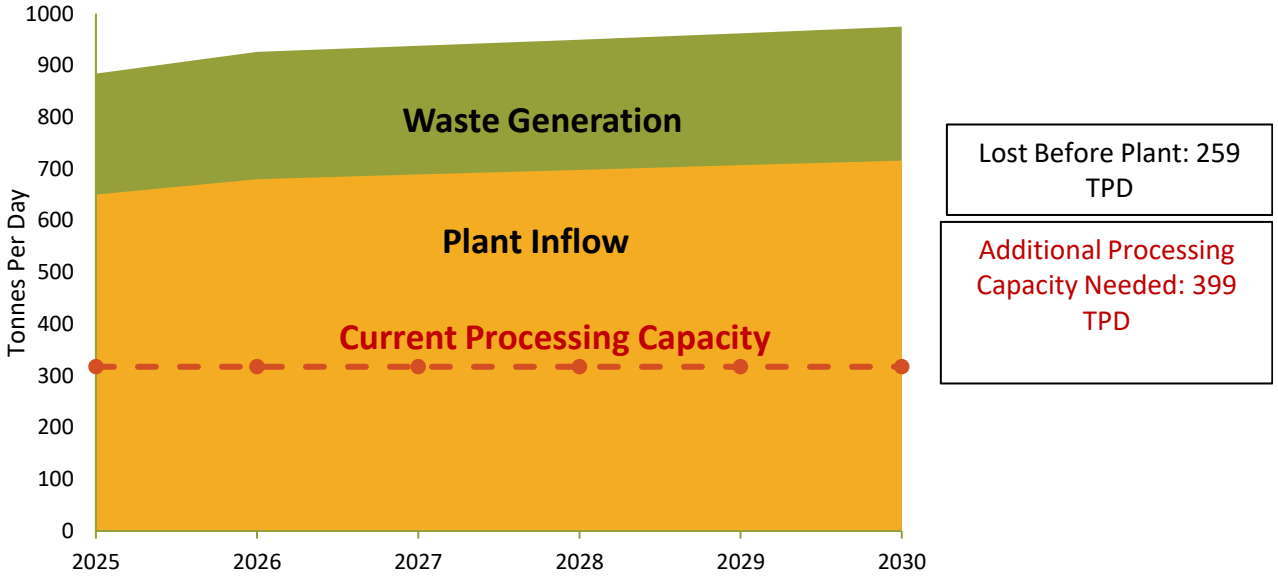


Table 4.4.1: Current Waste Treatment Technologies Adapted by GMC

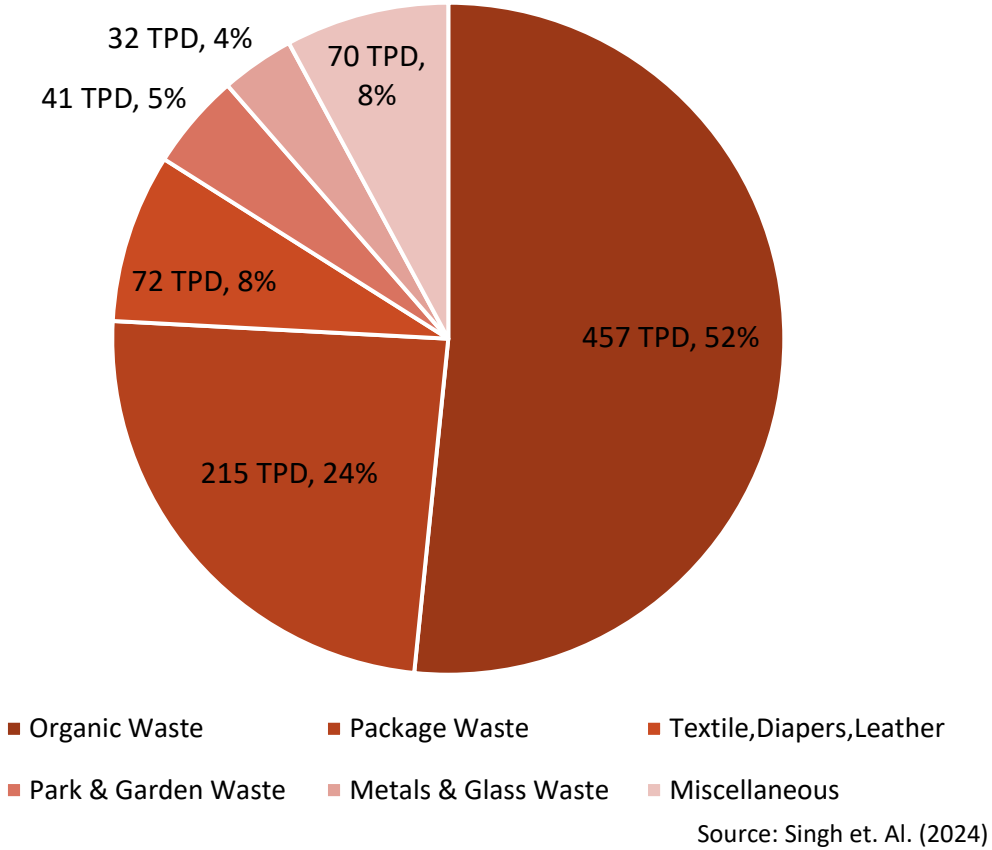
Current Treatment Technologies	Capacity (TPD)
Compost	302.5
Biogas	5
Refuse Derived Fuel (RDF)	75
Material Recovery Facility (MRF)	10
Waste to Energy (WtE)	5

Source: GMC, iFOREST Analysis

Treatment Capacity and Future Requirement - 2030

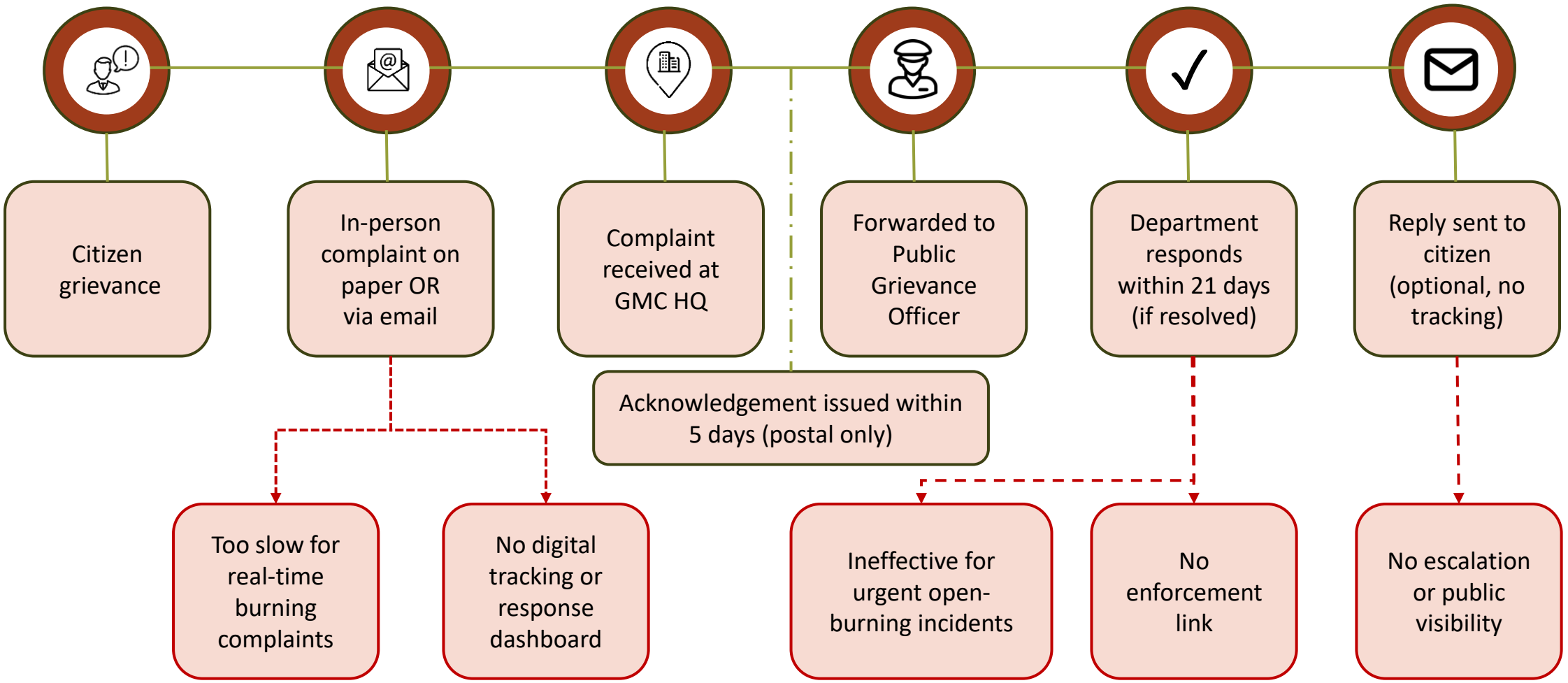
Treatment Technology	Current Capacity	Required
Windrow Compost Plant	300 TPD + 2.5 TPD OWC	**150 TPD** 15 units x 10 TPD each
Automated MRF	10 TPD	**229 TPD** 1 unit x 100TPD + 3 units x 50TPD
RDF Fluff Plant	75 TPD	**24 TPD** 1 unit x 25 TPD
Sanitary Landfill	-	**175 TPD** 1 engineered SLF x 175 TPD

Figure 4.4.3: Characterization of GMC Municipal Solid Waste (MSW)



Source: Singh et. Al. (2024)

4.4.2 Complaint & Grievance Redressal



- Helpline (08811007000) exists but is non-responsive
- Swachhata App is available but not integrated with GMC enforcement, so burning issues reported there still don't result in fines or field action

Bye-laws with SWM Rules 2016

Table 4.4.2: Analysis of Existing Bye-laws with SWM Rules 2016

Category	GMC Bye-laws 2000 (Clauses)	GMC Notices 2024 (Fines)	SWM Rules 2016	How It Leads to Open Burning
Legal Gaps	• **No clause on open burning** (Bye-laws 1–26) • Penalties only for dumping/segregation (Rs. **100**, **200**, **500**)	• Rs. **1000** – Open burning– Burning /littering causing hazard • Rs. **2000** – Burning of waste)	• Burning **explicitly banned** (Rule 3, 15) • Requires environmental compensation	• Burning **not illegal** in bye-laws → weak authority • Notices cannot replace law → enforcement gaps
Monitoring Gaps	• **No monitoring, patrolling, or air-quality checks** (no clause) • Clause 25 only allows penalty for visible violations	• Notices give fines but **no monitoring mechanism**	• Requires daily **monitoring, logs, surveillance**	• Burning goes **undetected**, no hotspot tracking
Penalty & Enforcement Gaps	• **No burning-related penalty** (no clause) • Existing fines: Rs **100**, **200**, **500**; Rs **20/day** for continued breach	• Rs **1000**, **2000+** for burning • No repeat-offender escalation	• Requires graded penalties + follow-up verification	• Low deterrence → **repeat burning** • No complaint or verification system → cases unreported

Gap Assessment

Infrastructure & Plants

- Lack of sufficient collection points (commercial + slum + hilly settlements)
- Irregular pickup in commercial belts
- Frequency of collection in slums & hilly settlements is low
- Insufficient waste processing capacity
- Processing backlog → waste piles → burning

Policy, Bye-laws & Digital Redressal System

- Weak penalties and poor enforcement follow-up
- No graded fines → repeated violations
- No quick response mechanism (requires structured redressal workflow)
- Monitoring and enforcement needs to be stricter at hotspots

Awareness & Outreach

- Very low segregation at household level (16%)
- Lack of awareness about harmful effects of burning
- Low ownership & behavior responsibility
- Insufficient community participation

Audits & Community Checks

- No quick response for burning events
- Weak field monitoring in hotspots
- Local dumping/burning in hilly settlements, slums & commercial belts due to delayed action

Capacity Building

- Training for plant operators and maintenance staff for efficient performance
- With limited manpower for field checks and enforcement, technology integration and handholding is important
- A trained workforce to handle hotspots and burning incidents

4.4.3 Emission Estimation and Hotspots

Table 4.4.3: Transect Survey – Details and Findings

Transect No	Length (km)	Active + Burnt Incidents	Dump Incidents	Transect type	Wards/Areas covered
1	6.56	3	18	Slum Area	Partially covering 53, 54, 56, 57
2	8.54	19	67	Commercial Area	39,46,47,48
3	9.14	9	54	Commercial Area	16,17,31,32
4	8.68	11	35	Mixed Residential	24,41,42
5	18.67	21	39	Mixed Residential	49,51
6	3.59	3	4	Hilly settlement	35
7	15.6	3	18	Hilly settlement	11,12,23
Total	**71**	**69**	**235**		

- The total surveyed length covers **71 km** across seven transects
- The highest incidents were recorded in **Transect 2 (19 burnt, 67 dump)** and **Transect 5 (21 burnt, 39 dump)**, indicating major waste hotspots

Some Burning Incidents During Transect Survey

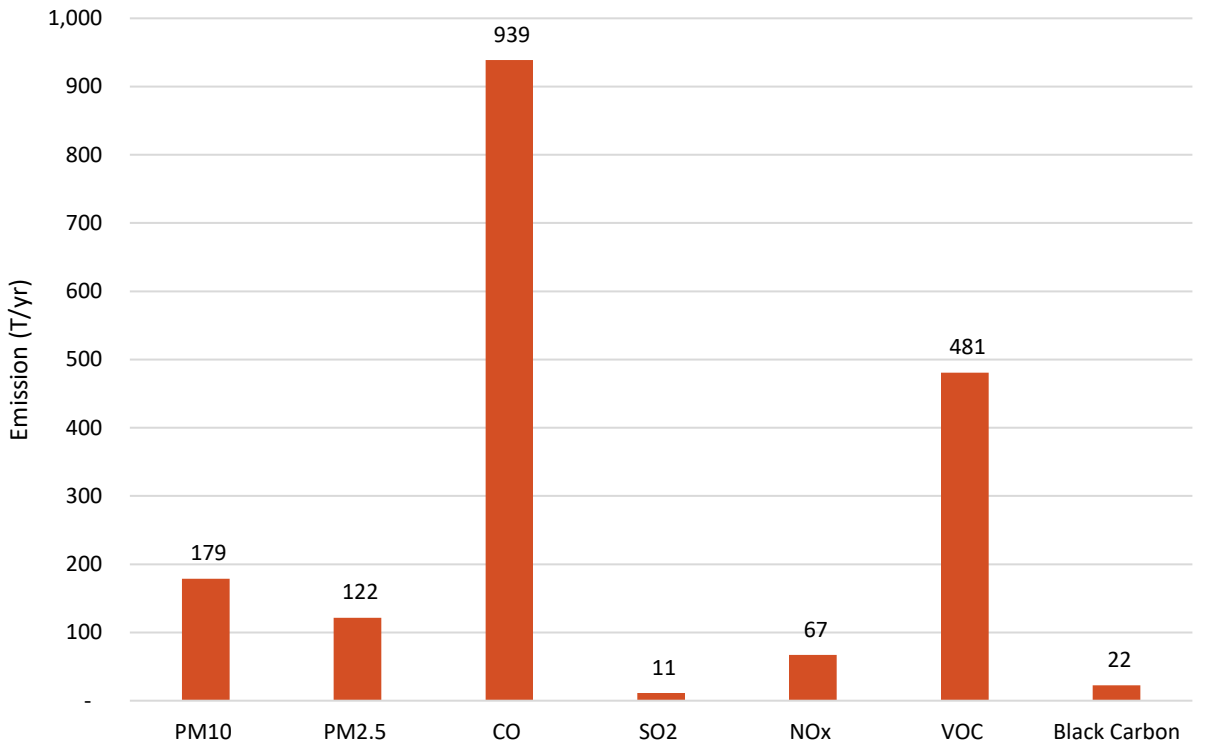
1) Open Waste Burning

Table 4.4.4: City wide Incidents and Emissions Estimates

Land-use Type	Incidents/day	Estimated Waste Burnt (kg/day)
Slum	18	360
Commercial	199	3,980
Mixed Residential	2590	51,800
Hilly Settlement	254	5,080
Total	**3062**	**61,240**

About **7%** of the **total generated waste** is **burnt.** Emissions from burned waste is estimated around **61 tonnes per day (22349 tonnes per year),** with share of ***179 T of PM_{10}*** and ***122T of $PM_{2.5}$ per year***

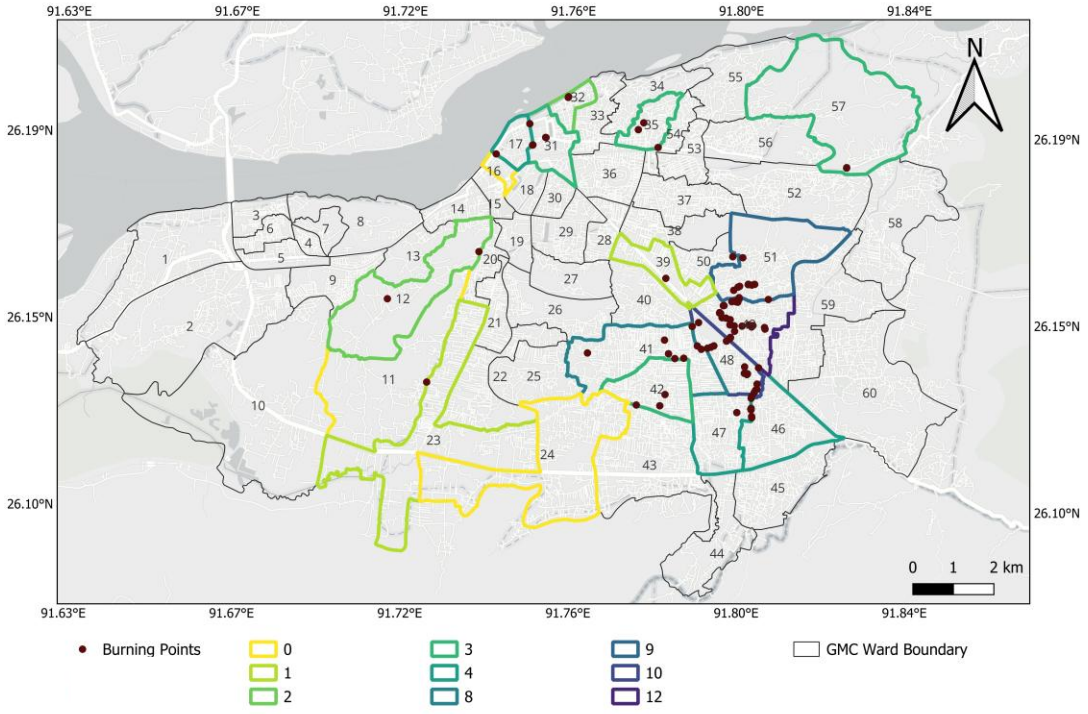
Figure 4.4.4: Pollutant emitted (T/yr) from Open Burning



Source: iFOREST Analysis

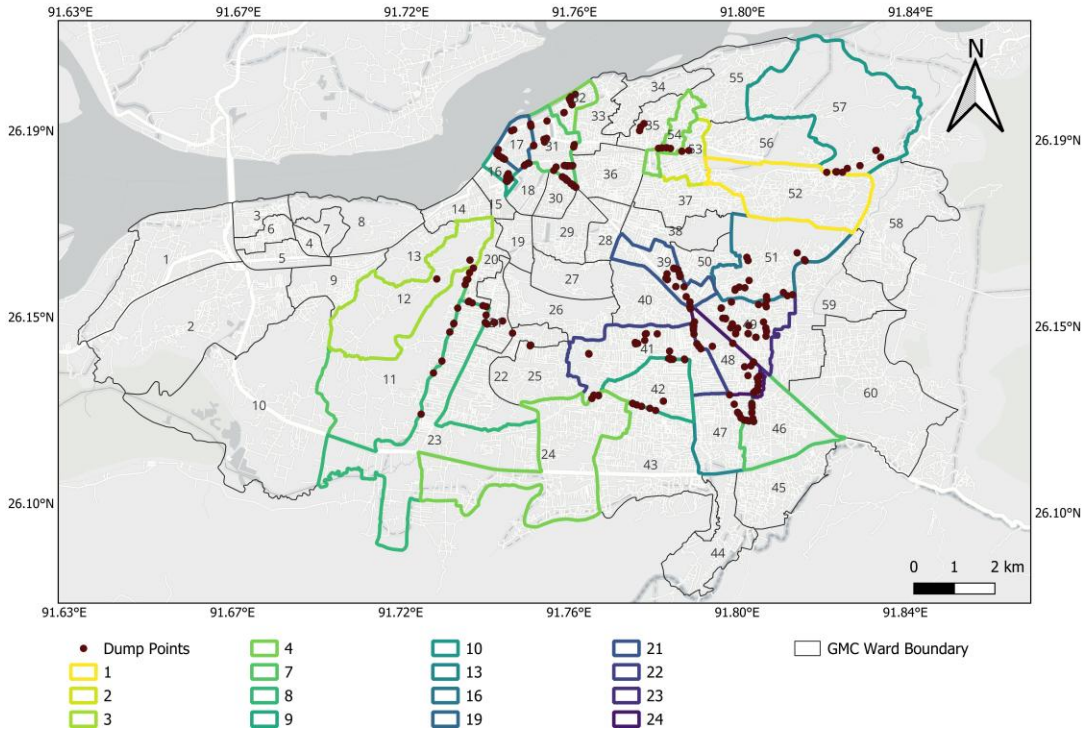
Hotspot Mapping of Waste Burning & Dumping Sites

Map 4.4.1: Map Showing Waste Burning and Burnt Spots from Transect Survey



Open waste burning is concentrated in mixed-residential, commercial, and difficult-to-access hilly areas, driven by inadequate waste-collection infrastructure

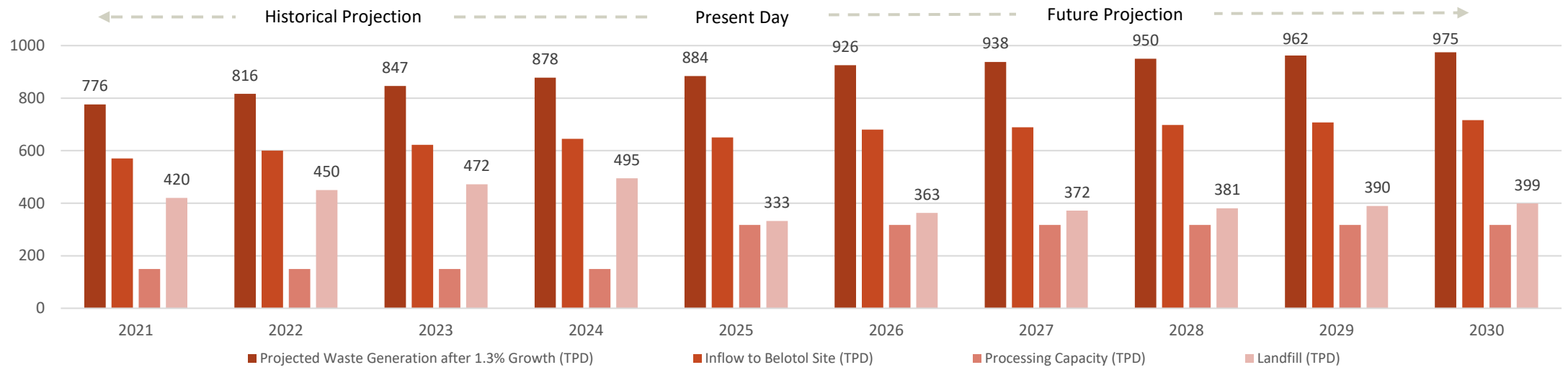
Map 4.4.2: Map Showing Waste Dump Spots from Transect Survey



Waste-dumping is heavily concentrated in mixed-residential neighborhoods and hilly settlement areas, driven by accessibility challenges and inadequate waste-management infrastructure

2) Landfill CH4 Emission

Figure 4.4.5 : Guwahati's waste profile historical and future projections



Source: iFOREST Analysis

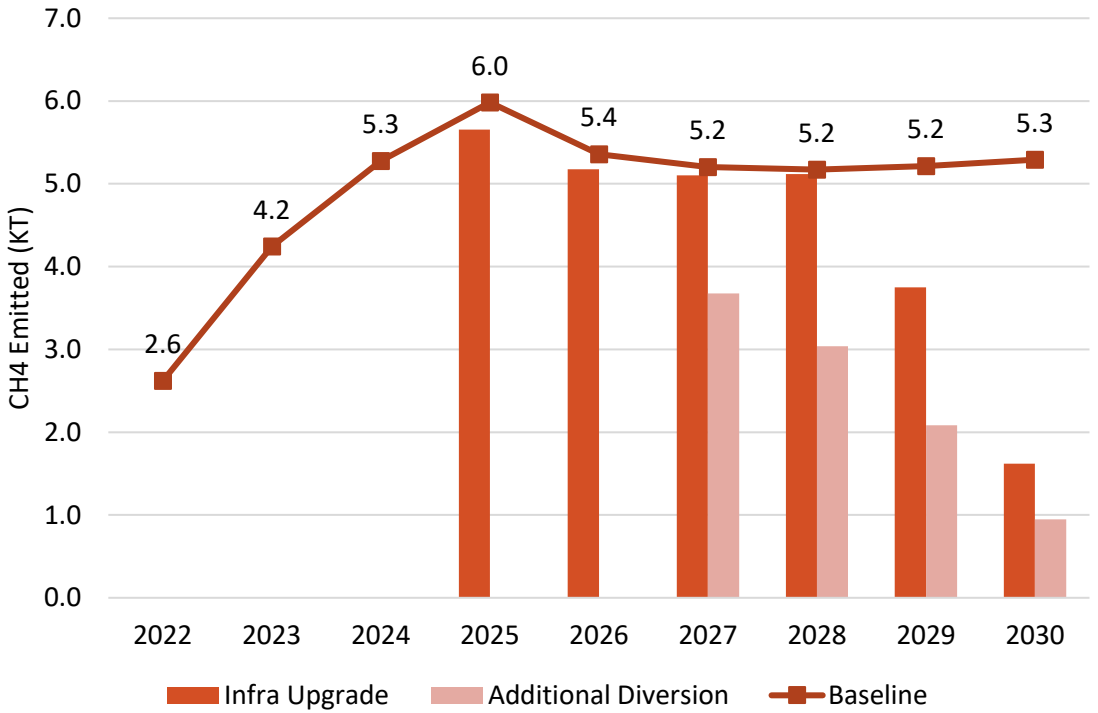
- Landfill waste quantities are estimated based on the city's current waste-management system and the proposed processing and diversion infrastructure
- In 2025, the landfill inflow is assessed at 333 TPD, which is projected to decline and reach net-zero (negative inflow) by 2029 as proposed treatment plan facilities become operational
- After 2029, methane emissions continue due to the decomposition of legacy organic waste already present in the landfill, even though fresh waste deposition is eliminated.
- Total emission of CH_4 in 2025 is 5.7 kilo tonnes (KT), which is equivalent to 158.4 KT of Carbon Dioxide (CO_2) equivalent (Figure 4.4.7)

Table 4.4.5: Waste Composition and Dissolved Organic Carbon (DOC)

Category	Share (%)	DOC (IPCC)	Contribution
Organic waste	51.62	0.15	0.08
Package (paper + plastic)	24.22	0.16	0.04
Burnable (textile mix)	8.13	0.1	0.01
Park & garden	4.62	0.3	0.014
Metals & glass	3.54	0	0
Miscellaneous	7.87	0.05	0.002
Total DOC (Guwahati)	100		0.14

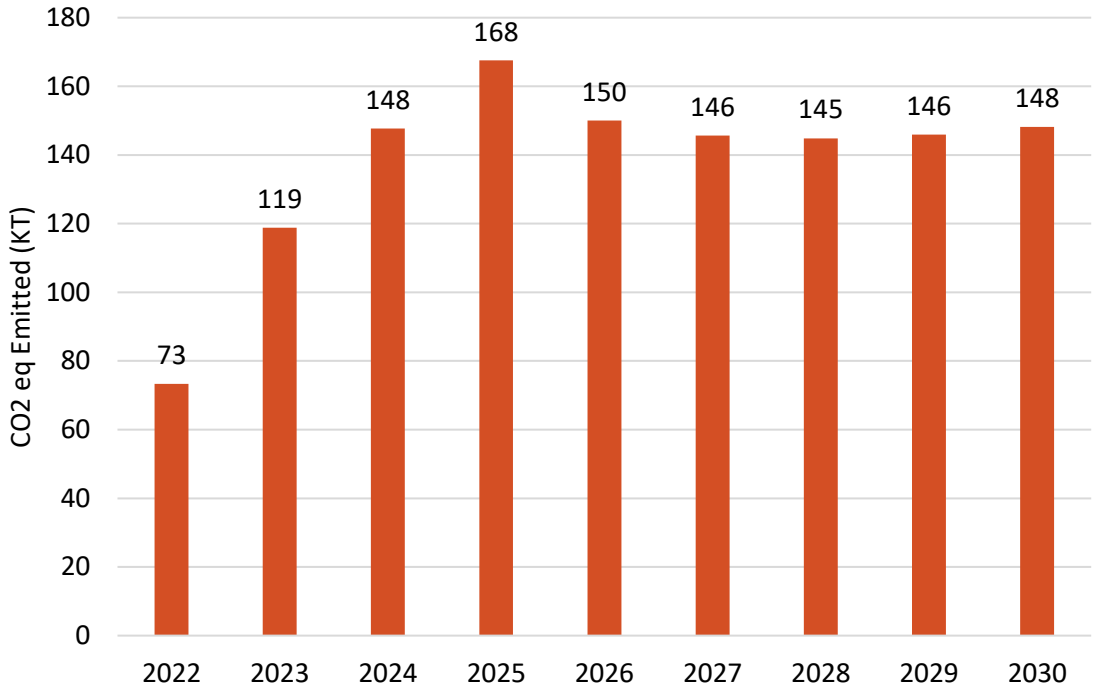
Cont.

Figure 4.4.6: CH4 emission from landfill site over the years



Source: iFOREST Analysis

Figure 4.4.7: Equivalent CO2 emitted from landfill site (baseline)



Source: iFOREST Analysis

Baseline estimates indicate that, with the current infrastructure and no upgrades, CH_4 emissions would peak at 6 KT (equivalent to 168 KT CO_2eq) in 2026, followed by a stable emission level of about 5.3 KT through 2030.

With the proposed SWM infrastructural upgrades, CH_4 emissions steadily decrease to 1.6 KT (equivalent to 45.3 KT CO_2eq) by 2030, representing a reduction of nearly 72% compared to 2025.

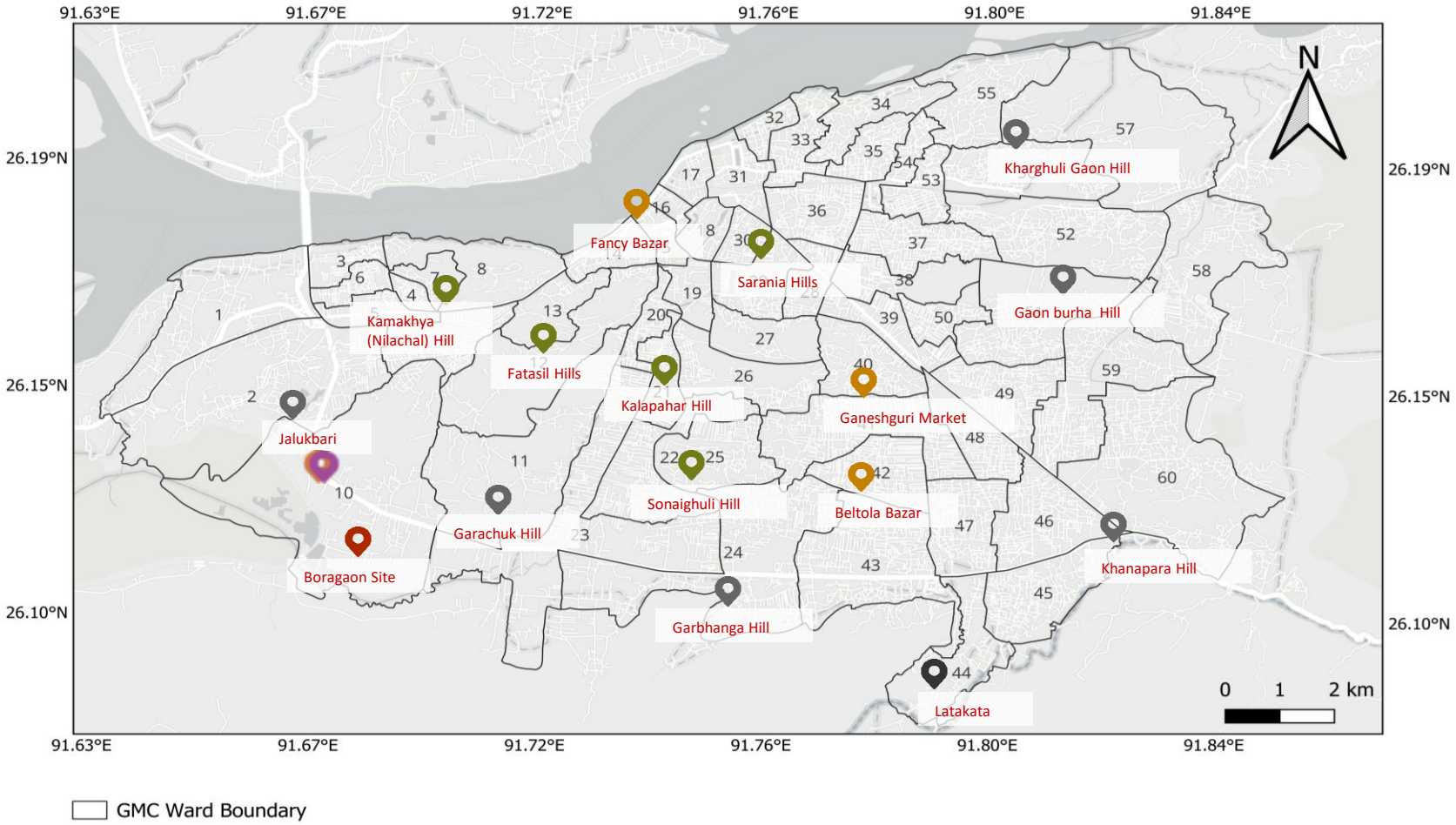
Furthermore, an additional 30% diversion of waste has been found to be effective, resulting in an 83.3% reduction relative to 2026, with Oil India Ltd.'s proposed CBG plant, which has a capacity to process 125 TPD of waste and generate 2 TPD of biogas.

4.4.4 Suggested Control Measures

Category	Control Measures
Technology and Infrastructure	Windrow Compost Public Depot (Dry + Hazardous)
	Automated MRF
	RDF Fluff Plant
	Sanitary Landfill
Policy	Unified Digital Platform – Grievance redressal, 48-hr SLA
	Revised Municipal Bye-law – Segregation mandate, burning ban, penalties
Awareness and Outreach	Segregation & No-burning drives – Door-to-door awareness, reporting, hotspot identification
	Targeted IEC in commercial & slum areas – Weekly awareness on open waste burning
	City-wide awareness campaigns – Radio, newspapers, social media
Audit and Community engagement	Quarterly ward audits – Form ward committees; 45-day intensive drives to remove visible incidents; strengthen monitoring (esp. winter)
Capacity Building	Training for plant operators & maintenance staff – Safe operation, maintenance protocols, improving performance of compost, MRF, RDF & landfill sites
	Technology integration & handholding support – Training on digital tools, mobile reporting, real-time monitoring; support for field enforcement

Proposed Infrastructure Development

Map 4.4.3: Proposed Plant Locations



Windrow Compost Plant (Jan 2026 – Dec 2026)
- Kamakhya (Nilachal) Hill
- Fatasil Hills
- Kalapahar Hill
- Sonaighuli Hill
- Sarania Hills

Automated MRF & Windrow Compost Plant (Jan 2026 – Dec 2026)
- Beltola Bazar
- Fancy Bazar
- Ganeshguri Market

Windrow Compost Plant (Jan 2027 – Dec 2027)
- Gaon Burha Hill
- Garbhanga Hill
- Garchuk Hill
- Khanapara Hill
- Kharghuli Gaon Hill
- Latakata
- Jalukbari

Automated MRF (Jan 2027 – Dec 2027)
- Boragaon waste processing facility

RDF Plant (Jan 2028 – Dec 2028)
- Boragaon waste processing facility

Sanitary Landfill (Jan 2028 – Dec 2029)
- Boragaon waste processing facility

4.4.5 Implementation Cost

Technology + Infrastructure upgradation

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Public/ Private Cost (Cr.)	Total 5-yr Cost (Cr.)
Windrow Compost Public Depot (Dry + Hazardous)	•**GMC SWM Cell** – overall execution & supervision •**SHGs/Plant Operators** – run compost plants & 2-bin dry waste collection depots •**PPP Operator** – MRFs and RDF •**SPCB** – environmental compliance	55	16	33	38	71
Automated MRF		48	29	29	48	77
RDF Fluff Plant		2	2	1.2	2.8	4
Sanitary Landfill		25	5	30	-	30
Total		130	52	93.2	88.8	182

Policy, Bye-laws & Digital Redressal System

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Public/ Private Cost (Cr.)	Total 5-yr Cost (Cr.)
Unified Digital Platform – Grievance redressal,	GMC IT Cell, NIC, Selected Vendor, SWM Dept, Enforcement Wing, Ward Supervisors	0.32	0.3	0.62	-	0.62
Revised Municipal Bye-law – Segregation mandate, burning ban, penalties	GMC Enforcement Wing, Legal/By-law Cell, SWM Dept, Ward Offices	-	-	-	-	-

Contd.

Awareness & Outreach

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	**Cost incurred by Govt. (Cr.)**	**Public/ Private Cost (Cr.)**	**Total 5-yr Cost (Cr.)**
Segregation & No-burning drives	GMC IEC Cell, NGOs, CSR Partners, SPCBs	0.15	0.33	0.48	-	0.48
Targeted IEC in commercial & slum areas						
City-wide awareness campaigns						

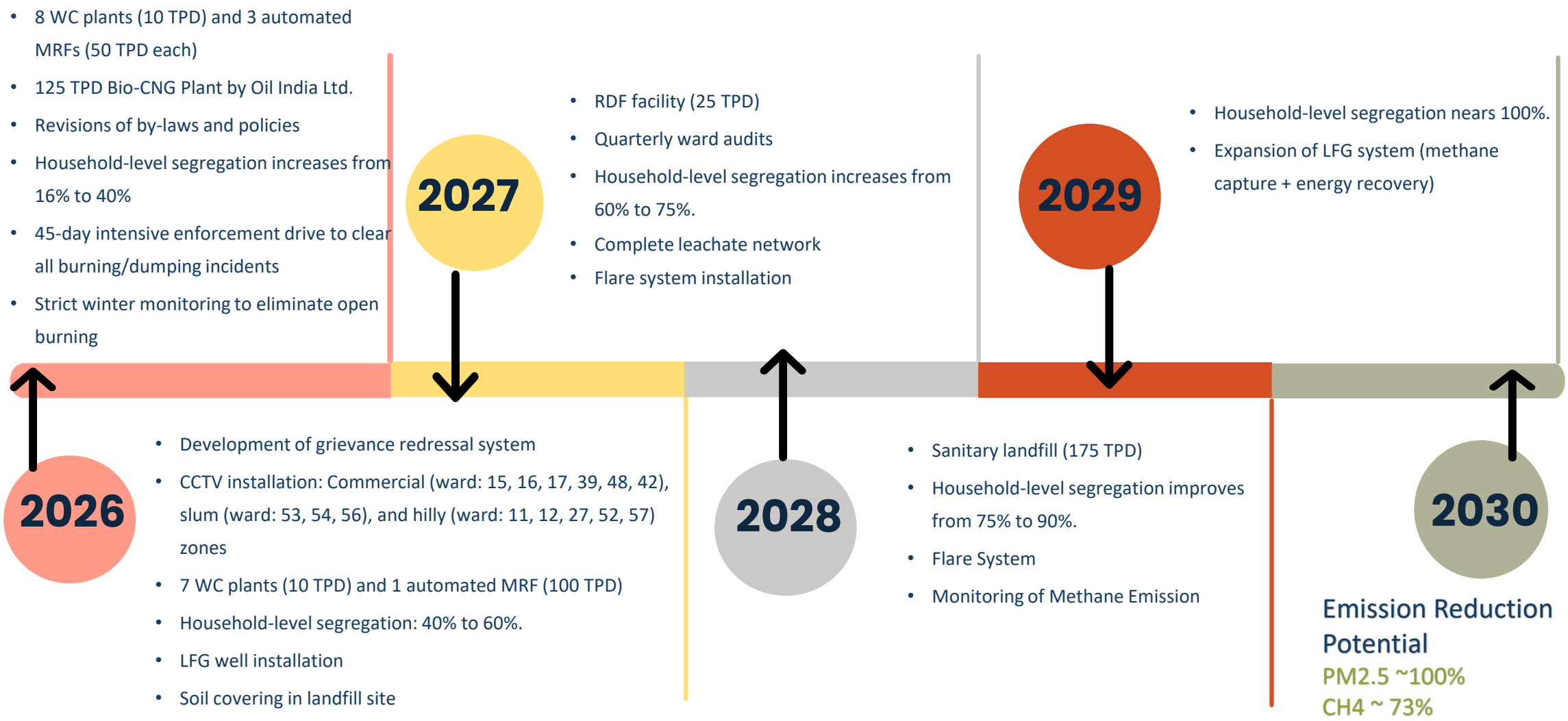
Audits & Community Checks

Control Measures	**Implementing Agencies**	**Cost Incurred (Cr.)**	**Operational Cost (Cr.)**	**Cost incurred by Govt. (Cr.)**	**Public/ Private Cost (Cr.)**	**Total 5-yr Cost (Cr.)**
Quarterly ward audits	GMC Enforcement Dept., Ward Representatives, RWA Members	0.30	0.15	0.45	-	0.45

Capacity Building

Control Measures	Implementing Agencies	Cost Incurred (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Public/ Private Cost (Cr.)	Total 5-yr Cost (Cr.)
Training for plant operators	GMC, Agencies for plant operations, trainers	0.15	0.4	0.55	-	0.55
Technology integration & handholding support	GMC, Agencies for plant operations, trainers, iFOREST					
TOTAL COST (in Cr. for 5 years programme)		**184 Cr. (cost incurred by Govt.- 95.3 Cr. and cost incurred by Public/Private - 88.8 Cr.)**				

4.4.6 Implementation Pathway



4.4.7 MRV Structure

Control Measure	Monitoring	Reporting	Verification
Windrow Compost	Daily checks by ULB supervisor on segregation, equipment & worker safety	Digital operations log , Monthly summary	Monthly review + quarterly third-party audit
Public Depot (Dry + Hazardous)	Daily checks by SHGs/plant operators	Digital segregation log, Monthly depot report	Third-party audit of depot performance
Automated MRF	Daily operational monitoring by PPP operator	Digital throughput report , Monthly MRF summary	Monthly review + quarterly third-party audit
RDF Fluff Plant	Routine plant operations monitoring	Digital logbook entries of input, output, rejects, attendance	Third-party audits
Sanitary Landfill	Operational monitoring and safety checks	Digital logbook & weighbridge entries	Third-party landfill performance audits
Unified Digital Platform	GPS hotspot tracking, real-time alerts, SLA monitoring	Photo-based reports, SLA closure logs, monthly performance reports	Field verification by SI/Supervisors using GPS & photo checks
Revised Municipal By-law (Segregation, Penalties)	Routine field inspections, enforcement checks, compliance tracking	Daily enforcement reports, penalty summaries, monthly compliance reports	On-ground verification of violations, fire logs, segregation compliance
Segregation + No-burning Drives	Ward-level tracking of segregation; burning incidents recorded via APP	Monthly ward-wise IEC & outreach reports	Random spot-checks; geo-tagged photo validation

Cont.

Control Measure	Monitoring	Reporting	Verification
Targeted IEC in Commercial Areas & Slums	Geo-tagged reporting; incident tracking	Digital Documentation of IEC materials, photos	Surprise inspections in commercial, slum & hilly areas
City-wide IEC Campaigns (radio, print, digital)	Media and outreach coverage monitoring	Media coverage documentation	Review of IEC deployment effectiveness
Quarterly Ward-level Audits	CCTV monitoring, APP alerts, patrolling	Daily digital incident logs, action-taken reports, monthly summaries	Field checks by SI/Supervisors; GPS + CCTV log match; inputs from ward committees
Training for Plant Operators & Maintenance Staff	Monitoring of number of trainings, attendance & quality of modules	Digital Training/event completion reports	Assessment of trained staff; verification of operational efficiency
Technology Integration & Handholding Support	Monitoring of digital tool usage & system performance	—	Verification of staff's digital readiness; training validation

4.4.8 Key Highlights

- Existing infrastructure can process only about 35% of this waste, leaving a gap of 333 TPD that remains unprocessed and is directly linked to open dumping and burning.
- Transect-based assessments indicate that 61 TPD of waste is burned across the city—approximately 7% of total waste generated.
- Citywide waste burning emits an estimated 122 tonnes of $PM_{2.5}$ and 22 tonnes of BC in 2025.
- Methane emissions from landfill mismanagement amount to 5,983 tonnes in 2025, equivalent to 168 kilo tonnes of CO_2 emission.
- Improper waste management contributes to both $PM_{2.5}$ and BC emissions through open burning, while inadequate landfill practices lead to significant methane generation—both of which are critical health- and climate-relevant pollutants.

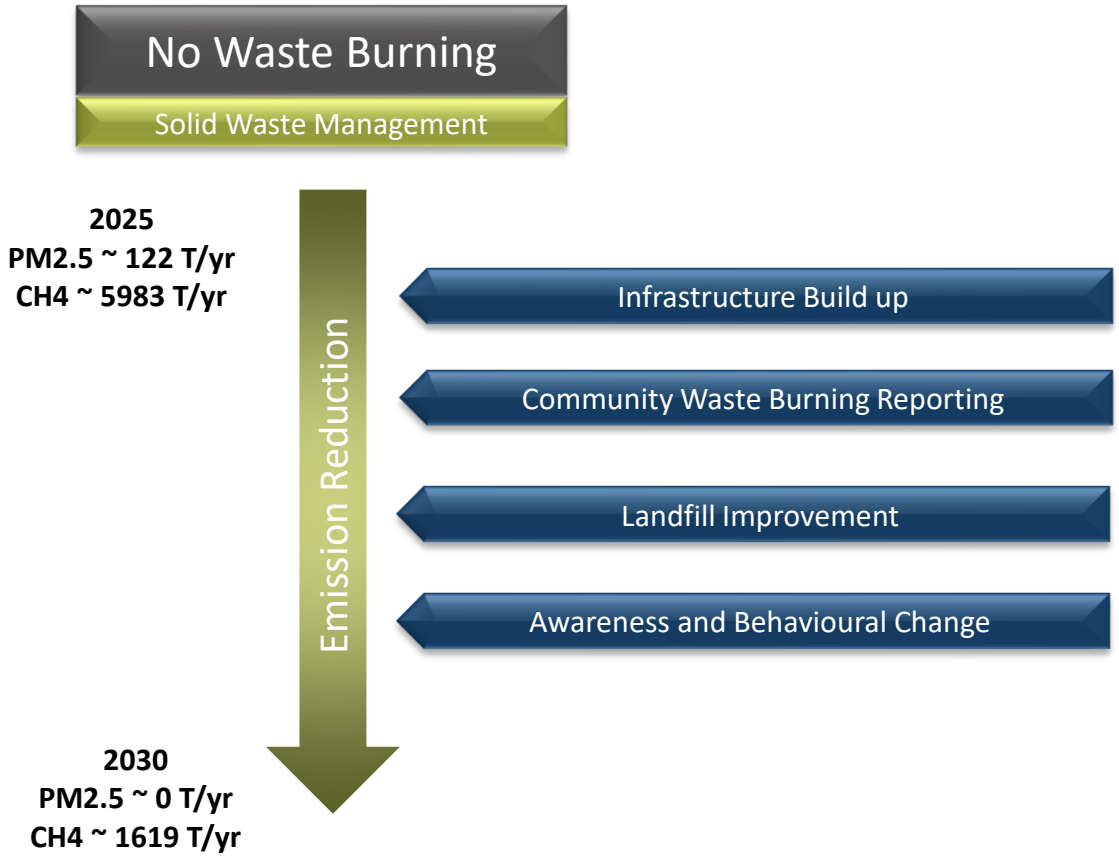


Image: GMC landfill site at Belortol and solid waste processing plant

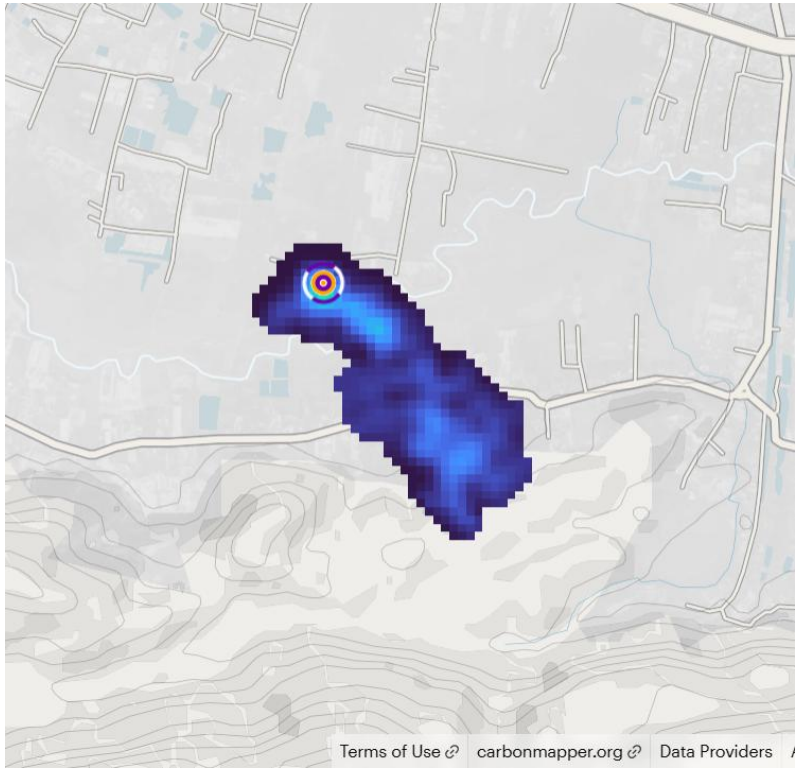


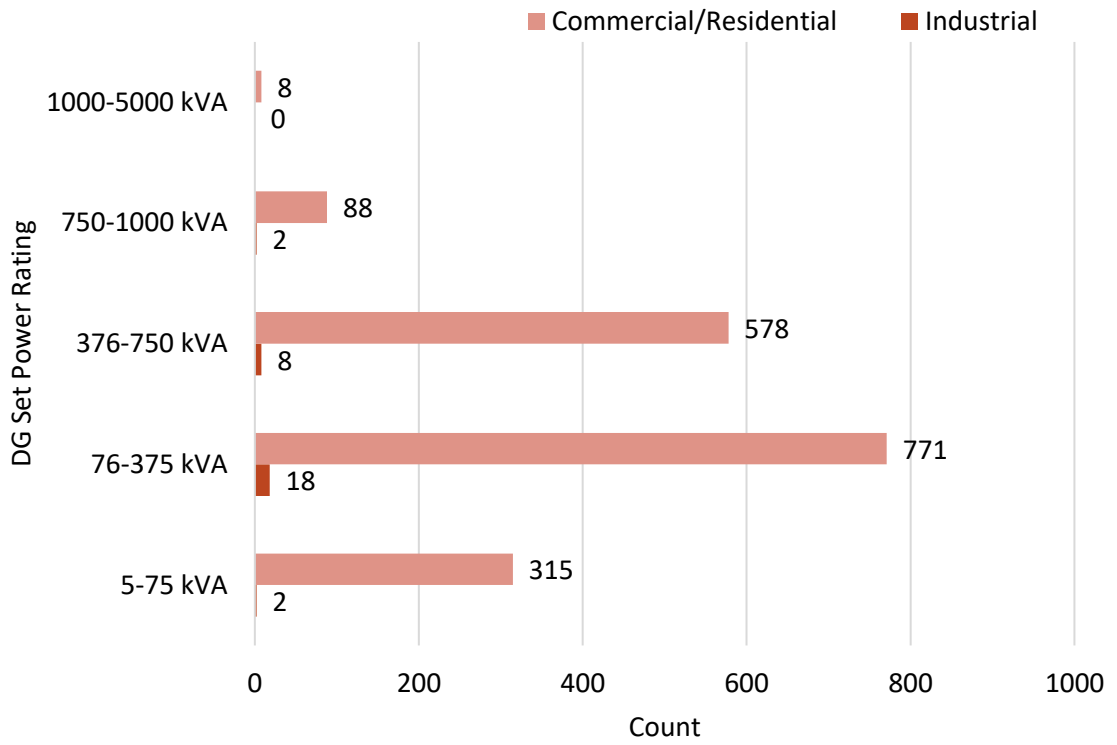
Image: Methane emission plume at GMC's landfill site.
Source: Carbonmapper.org

4.5 Diesel Generators Action Plan

4.5.1 Key Statistics and Background

- DG sets act as a critical backup power source across commercial, industrial, and institutional establishments
- High DG-set adoption observed across hotels, restaurants, community halls, industries, commercial hubs, and telecom towers, with clustering in major residential, commercial, and industrial zones
- Capacity distribution varies by user type: 5–75 kVA and 76–375 kVA units dominate residential, commercial, and small institutional buildings; >1000 kVA units are concentrated in industrial facilities
- Smaller establishments mainly use DG sets to meet essential backup needs such as lighting, lifts, pumps, and critical loads
- Power outages average 1.2 hours per day, rising to 2–3 hours in summer due to peak demand
- Guwahati's strong tourism and service sector drives frequent DG-set usage in hotels and guest houses during grid interruptions

Figure 4.5.1: Count of DG Sets by Capacity in Guwahati city



Source: iFOREST analysis, Data: APCB, GMC

4.5.2 Emissions from DG Sets

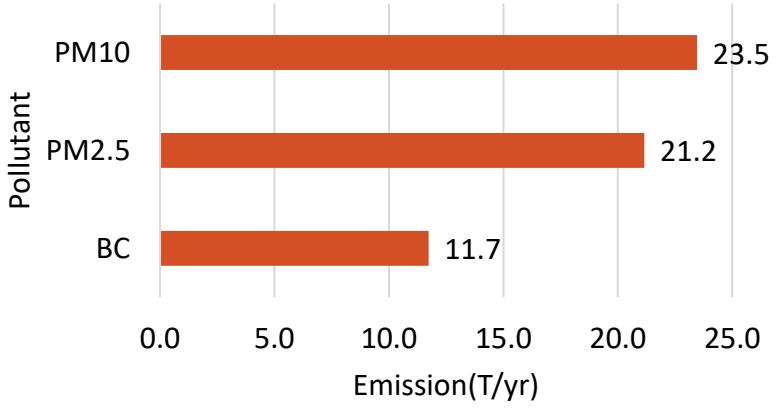
Insights from Pollutant Emission

- DG-set operations generate an estimated 21 tonnes of $PM_{2.5}$ emissions annually, underscoring their role as a major point-source contributor in the city's pollution.
- In addition to $PM_{2.5}$, DG sets release significant amounts of black carbon (BC) approximately 12 tonnes per year with particularly high soot emissions occurring during engine start-up
- $PM_{2.5}$ emissions are predominantly driven by 376–750 kVA DG sets, which account for 53% of total emissions, while 76–375 kVA units contribute another 29%, indicating that mid- to high-capacity systems are the primary emitters.

DG Set User Hotspots:

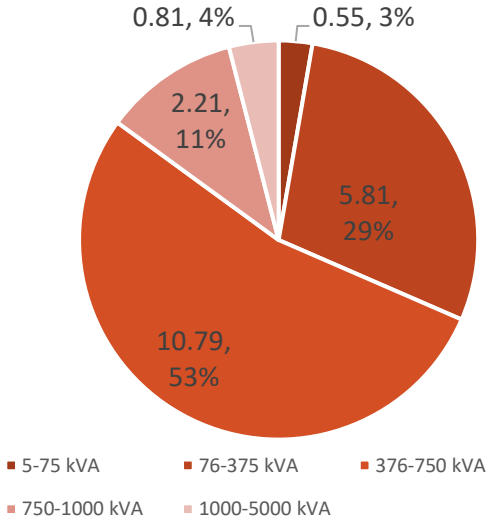
- High dependency on DG sets: ~92% of hotels, restaurants, and community halls use DG sets for backup power.
- Hospitality clusters: Major DG-set concentrations in Wards 30, 31, 36, 37, 38, 39, 41, 46, 50.
- Industrial usage: 30 industries reported DG-set use, clustered in Wards 23, 24, 43, 53, 54, 56.Commercial hubs: DG-set presence notable in Wards 16, 17, 31.
- Telecom infrastructure: Mobile phone towers citywide operate with DG-set installations.

Figure 4.5.2: Yearly Emission from DG Sets



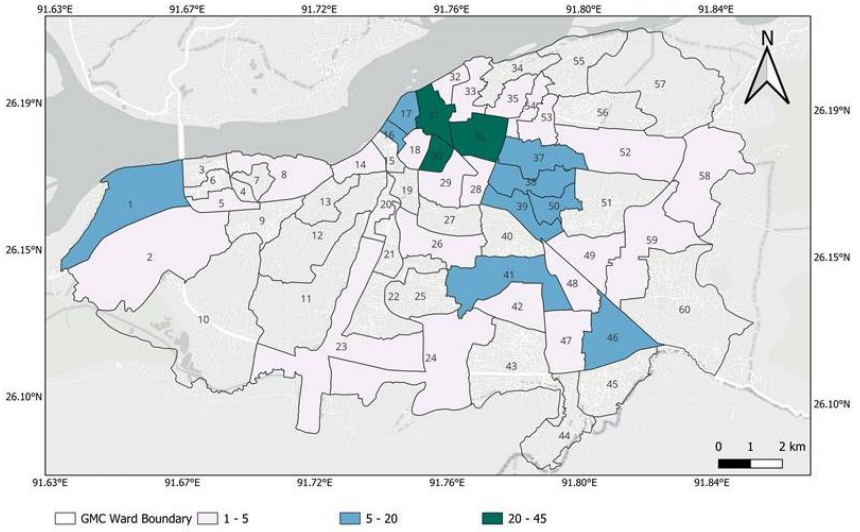
Source: iFOREST analysis

Figure 4.5.3: Share of PM2.5 emission by DG set power rating



Source: iFOREST analysis

Map 4.5.1: Hospitality clusters in Guwahati



Source: GMC

4.5.3 Suggested Control Measures

Intervention Theme	Control Options	Implementation Focus
Retrofit & Technology upgrade	▪ RECD installation on in-use DG sets	▪ Mandate Retrofit Emission Control Devices (RECD) for all DG sets ≥ 15 kVA and link to consent/renewal ▪ Adopt CPCB/NGT norms (≥ 70% PM reduction, certified devices)
	▪ Shift to CPCB IV+ / low-emission DGs	▪ Require all new installations to meet latest CPCB genset norms ▪ Phase-out pre-CPCB II sets via age cap (e.g. >10–15 years) and scrappage incentives
	▪ Dual-fuel / gas-based DGs where feasible	▪ Promote conversion to gas or dual-fuel DG sets through tariff incentives and soft loans
Reduce DG runtime (demand-side)	▪ Grid reliability improvement (DG-free feeders)	▪ Identification of high-DG corridors (malls, hospitals, IT parks, high-rise clusters) and prioritise: (i) 24×7 “DG-free” feeders, (ii) faster fault redressal, (iii) scheduled outage windows
Clean backup alternatives	▪ Rooftop solar + battery storage for backup	▪ Support rooftop PV plus battery/inverter systems in residential complexes, commercial establishments via local subsidies, fast-track approvals and convergence with PM Surya Ghar or state solar schemes.
Governance, inventory & enforcement	▪ Citywide DG set inventory & registry	▪ Create and maintain a geo-referenced registry of all DG sets by capacity, fuel, sector and age ▪ Integration of registry with consent to operate and property approvals.
	▪ Periodic emission testing & compliance audits	▪ Mandate periodic stack/opacity checks for large DGs and Random checks for medium DGs ▪ Non-compliance linked to penalties and loss of consent/occupancy certificate
	▪ Scrappage programme for old DG sets	▪ Introduce age/efficiency-based scrappage for old, high-emitting DGs (e.g. >15 years) with rebates for shifting to RECD-equipped / gas / solar-battery alternatives
Planning, siting & awareness	▪ Siting norms & stack / enclosure standards	▪ Update building byelaws: (i) avoid DGs in courtyards/basements without proper stack height, (ii) require acoustic enclosures and adequate dispersion, especially near schools/hospitals and dense residential areas
	▪ Sector-specific guidelines & IEC	▪ Develop simple sector notes (malls, hospitals, IT parks, RWAs, MSMEs) summarising: RECD, maintenance, solar options, legal obligations; run targeted awareness campaigns.

4.3.4 Implementation Cost

Technology Intervention

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred - Govt. (Cr.)	Public/ Private cost (Cr.)	Total (Cr.)
Citywide RECD installation (industrial + commercial)	APCB, RECD Vendors, IECT	56	3	3	56	59
Battery backup / rooftop solar–battery transition support (RWAs, hotels, offices)	AEDA, APDCL					
Runtime monitoring meters for DG sets (to support MRV)	APCB, GMC, IECT					

Policy and Enforcement

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred - Govt. (Cr.)	Public/ Private cost (Cr.)	Total (Cr.)
DG Registry (database + reporting portal)	APCB, RECD Vendors, IECT	2	1	3	0	3
Enforcement actions (penalties, legal processing)	AEDA, APDCL					

Audit / MRV

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred - Govt. (Cr.)	Public/ Private cost (Cr.)	Total (Cr.)
Quarterly runtime inspections & compliance checks	APCB, RECD Vendors, IECT	2	1	3	0	3
Annual DG emission / noise audits (PM/BC sampling)	AEDA, APDCL					

Capacity Building and Awareness

Control Measures	Implementation Agency	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost incurred by Govt. (Cr.)	Public/ Private cost (Cr.)	Total (Cr.)
Awareness on RECD, DG misuse, penalties	GMC, APCB APDCL	0.5	0.5	1	0	1
Training for DG operators, RWAs, hotels, industries						
Guidance on solar/battery transition						
TOTAL COST (5-year programme)				**10**	**56**	**66**

4.3.5 Implementation Pathway

2026

- Citywide DG set mapping
- Issue RECD mandate and notification
- Develop DG compliance and audit framework
- Begin RECD enforcement and vendor approval

2027

- Targeted feeder upgrades to cut power outages
- Incentive scheme for DG-to-clean-backup transition
- Launch of DG inspection and certification drive
- Scale up enforcement actions
- Awareness and operator training programme

2028

- Full RECD compliance across industrial and commercial DGs
- Enforce runtime monitoring and emission checks
- Roll out battery-backup subsidy programme
- Notification on ban DG sets older than 15 years

2029

- Move toward 24x7 reliable supply
- Integration of rooftop solar-battery system
- Implement performance-linked incentives
- Strengthen compliance monitoring

2030

- Phase-out remaining non-compliant DG sets
- Institutionalization of annual DG audit cycle
- Maintain continuous enforcement regime

Emission Reduction Potential

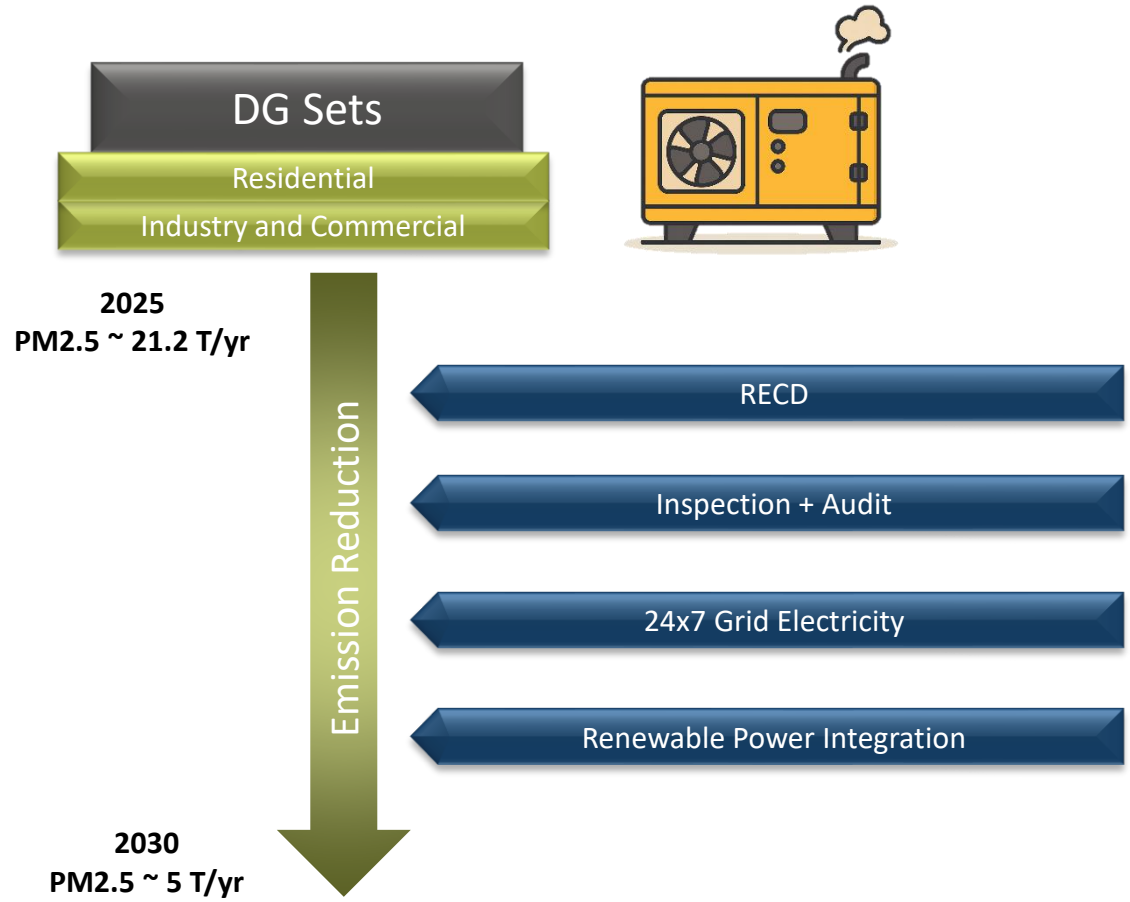
PM2.5~70%

4.3.6 MRV Structure

Action Area	Monitoring (M)	Reporting (R)	Verification (V)
DG Set Registry & Compliance	▪ Update DG set registry (industrial, commercial, RWAs) ▪ Spot checks for unregistered DGs.	▪ Quarterly registry update. ▪ Non-compliance list and corrective actions.	▪ Third-party audit of registry completeness. ▪ Cross-check with APDCL/building approvals.
RECD Installation Compliance	▪ Record RECD installation certificates. ▪ Field checks for RECD presence and functioning.	▪ Installed vs pending units summary. ▪ Defaulters and enforcement actions.	▪ Annual RECD audit (installation + functioning). ▪ Sample PM/BC emission testing.
DG Runtime & Operational Control	▪ Review runtime logbooks (industries, hotels, malls) ▪ Random operational-hour spot checks.	▪ Runtime summary by sector.	▪ Annual DG operation audit. ▪ Runtime vs power-cut data verification.
Clean Backup Transition (Solar/Battery)	▪ Track adoption of battery /solar backup systems. ▪ Spot checks of installed systems.	▪ Quarterly transition progress update. ▪ DG replacement/ adoption summary.	▪ Annual verification of installed systems. ▪ Assessment of DG-use reduction.
Enforcement & Penalties	▪ Record violations (no RECD, excessive runtime, unregistered DGs). ▪ Maintain penalty log.	▪ Enforcement actions summary. ▪ Compliance improvement report.	▪ Annual enforcement audit. ▪ Penalty recovery and compliance review.

4.5.7 Key Highlights: DG Sets

- Presently, city's power outage-driven DG operation (1.2–3 hours/day) results in temporal $PM_{2.5}$ surges in commercial corridors, markets, and hotel clusters.
- DG sets contribute 21.2 T/year of PM2.5 and 11.7 tonnes/year of Black Carbon, making them a significant distributed emission source across commercial and institutional zones.
- Medium and high-capacity DGs (76–750 kVA), accounting for ~1,350 units, are responsible for more than 80% of total DG-related PM2.5 emissions due to higher load factors and longer runtime.
- Major hotspots of DG sets involve industrial area (Bamunimaidam, Lokhra, Maligaon, Adabari, NH-27 corridor), commercial zones (Pan Bazaar, Paltanbaaar, Ulubari, Lachit nagar, Ganeshguri), residential townships and telecom towers.
- Very large DGs (>750 kVA), although only ~100 units, contribute 15% of the pollution load, driven by high fuel consumption and industrial usage patterns.



4.6 Mitigation Measures for Dust Management


GPS Map Camera
Lower Assam Division, Assam, India
4RV8+HV9, Radha Nagar Path, Barbari Village,
Lat 26.143961°
Long 91.817255°
04/8/2025 11:24 AM
Google


Dulux


ON THE ROCKS
CAMPUS
Street Hart

4.6.1 Key statistics and Background

- Dust has been identified as a major environmental concern in Guwahati city.
- Similar to other urban regions, construction dust, road dust and dust from open areas are common sources of dust in the city.
- Additionally, Guwahati city has a specific issue related to dust due to
  - Silt dust generated after intermittent floods,
  - Wagon movement in the railway warehouses located within the city.

- Construction dust and open-area dust hotspots are identified at the ward level
- Road dust hotspots are mapped along specific road corridors and networks rather than by ward boundaries.

Contd.

Road Specifications

Table 4.6.1 Road network details

Type of road	Length (km)
National Highway (NH)	72
State Highway (SH)	5
Arterial Roads	146.8
Sub-arterial Roads	1397.2
Collector Roads	1025.7
Local Roads	66.3
Total road length	**2713**

Major Road Corridors: GS Road, AT Road, RGB Road, VIP Road, Dr. B. Baruah Road, GMCH Road, Dr. B.K.K. Road, M.D. Road, A.K. Dev Road, M.G. Road, and ASEB Road

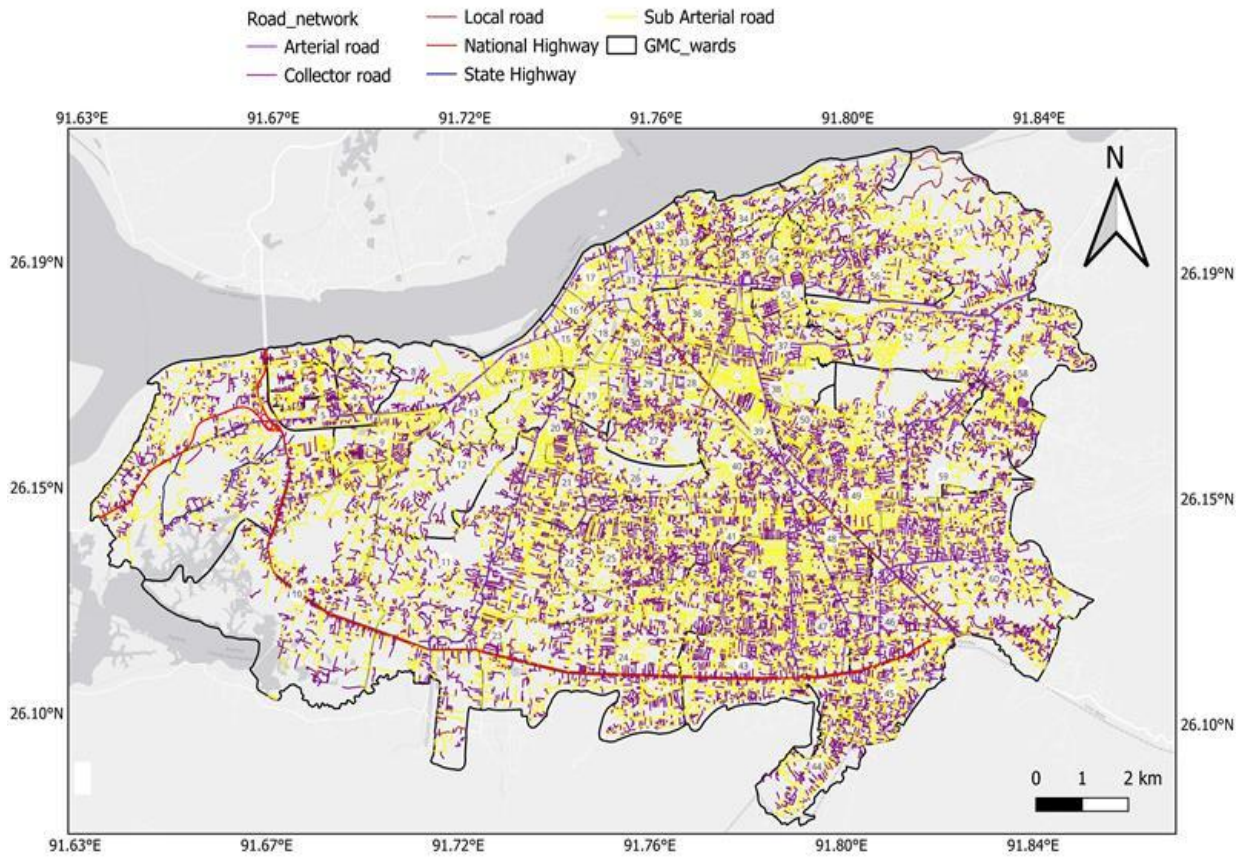
Status of Road Sweeping

1. Number of mechanical sweepers deployed in the city: **4 units**
2. Road length covered per day by mechanical sweepers: **170 km**
3. Potential road network suitable for MRS: **271.8 km**
4. Road length covered per day by manual sweepers: **350 km**

Status of Barren Land

1. Total barren land within GMC area: **5.2 sq. km** out of **216 sq. km** total area.
2. Riverbed area: approximately **20 km** in length

Map 4.6.1: Road network and classification



4.6.2 Dust sources and Gaps

Table 4.6.2: ward wise Exposed riverbed area

S.No	Length (km)	Ward numbers
1	< 1	15, 16 & 31
2	1 to 2	3, 14, 17, 32, 33, 34 & 57
3	> 2	1, 8 & 55

Table 4.6.3: Ward-wise Barren Land area

S.No	Area (Sq. km)	Ward numbers
1	< 0.5	3, 8, 9, 14, 15, 16, 17, 18, 21, 22, 32, 34, 36, 38, 41, 42, 43, 44, 46, 49, 50, 55, 57, 58 & 60
2	0.5 to 1.0	23 & 59
3	> 1	1, 2 & 24

Sources of Dust

- Resuspension of dust, Heavy vehicle movement near railway junction(poor road condition)
- Dust from unpaved parking lots
- Dust from debris dumping along roads
- Dust from exposed riverbank soil
- Construction & demolition activities – buildings and infrastructure (Roads & flyovers), C&D material on road shoulders
- C&D dust from warehouses, industrial construction
- Dry soil resuspension from barren lands
- Post-flood silt deposits
- Drain Overflow & De-siltation Spoils
- Hill-Wash Silt From Slope Erosion

Gaps identified in Construction sites

- CPCB guidelines for Dust management were not followed.
- No green net cover in construction sites
- No barricading around flyover works.
- Construction materials left uncovered.
- Multiple agencies digging roads without coordination.
- Excavated sites left open without barricades
- Dumping of C&D materials and waste on road-sides, unauthorized regions

4.6.3 Dust Byelaws

The Guwahati Municipal Corporation (GMC) has issued two Public Notifications: One on Construction and Demolition (C&D) Waste Management and another on Dust Abatement.

Existing policy and gaps

Table 4.6.4: Summary of C&D policy and Gaps

Aspect	C&D Waste Management Notification	Gap
Focus	Waste collection, transport, disposal and recovery	Fine mechanism is not clear for repetitive offenders
Primary Objective	Prevent illegal dumping and improve waste logistics	No mandatory C&D waste disposal followed
Key Measures	Deposit points, service fees, segregation and recycling	Only 4 collection points are provided for the entire city
Target Group	Waste generators, contractors, and developers	Interlinking of waste generators and treatment facility missing
Enforcement	Financial penalties and reporting requirements	Very less fine amount compared to other cities

Table 4.6.5: Summary of Dust mitigation policy and Gaps

Aspect	Dust Abatement Notification	Gap
Focus	Air quality and dust mitigation	Ambiguity on thresholds & classification of sites
Primary Objective	Reduce fugitive emissions from construction	Lack of prescriptive technical standards (barricade height, net porosity, watering frequency)
Key Measures	Vehicle washing, water sprinkling, green barriers	No requirement for continuous/real-time PM monitoring
Target Group	Project proponents, site managers, and workers	Responsibility matrix not provided
Enforcement	Environmental compensation and work stoppage	Enforcement workflows are manual & reactive

Infrastructure facility

GMC has designated transfer stations at Adabari, Fancy Bazaar, GMCH Morgue area and Purabi Dairy for the collection and temporary storage of C&D waste. These serve different city wards, and the list is periodically updated on the GMC website.

Contd.

Table 4.6.6: Fee Structure

Waste Quantity (cubic metre)	Fee (INR)
Up to 5 Cu.m	500
5 to 10 Cu.m	1,000
10 to 15 Cu.m	1,500
15 to 20 Cu.m	2,000

Table 4.6.7 Enforcement

Type of Violation	Penalty
Disposal at unauthorised site	5 times the applicable service fee
Mixing municipal solid with C&D waste	5 times the applicable service fee
Littering or failure to notify GMC	Equivalent to applicable service fee
Non-compliance by bulk generators	Action under Section 15 of C&D Rules, 2016
Violation of dust control norms	Imposition of environmental compensation and/or stoppage of construction activity

Grievance Redressal Mechanism

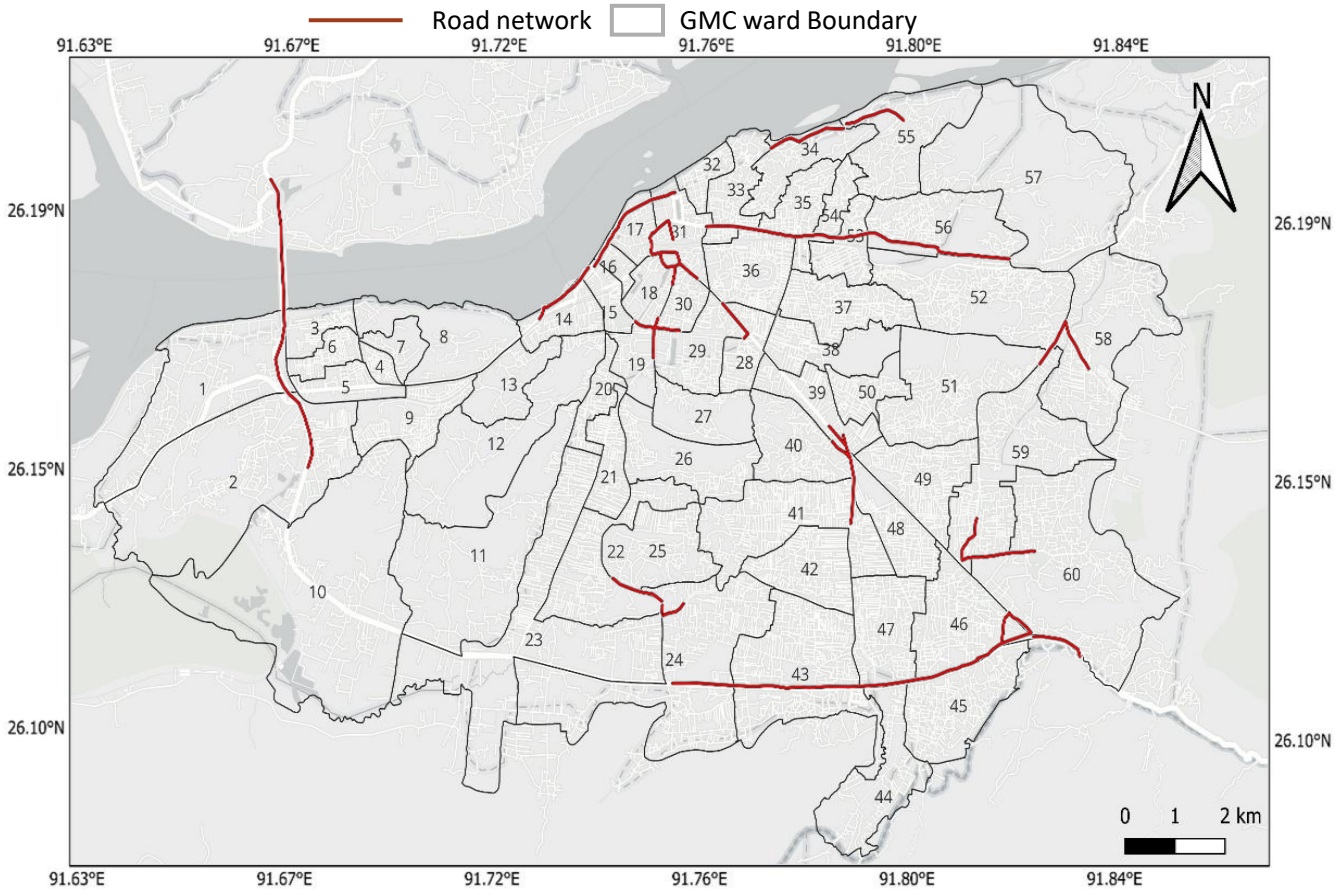
Helpline: 8811007000

GMC City Mobile Application, or Swachhta App (under "Debris Removal / Construction Material" category) complaints are routed through GMC's grievance redressal system, ensuring accountability and timely action.

4.6.4 Hotspots and Control Measures

1) Road Dust

Map 4.6.2: Major road stretches with heavy dust loading



Suggested Mitigation Measures

- Mechanised sweeping of 106km
- including NH-27 entry stretch
- GS road, AT road, Beltola road and Naregi tiinali road
- Green median and shoulder paving on NH 27 near Industrial zones in Amingaon and Adabari regions.
- Priority pothole filling near the railway junctions (ward 31, 30 and 18)
- Manual sweeping on daily basis - Fancy Bazar, Pan Bazar
- End-to-end Block pavments to reduce dust emissions
- Use to geo-synthetics on road dividers

Suggested Policy Measures

- Enforce a penalty of Rs. 5,000 for first-time violators and increase the penalty to Rs. 10,000 for repeat violations (Dumping on road)
- Mandatory Mechanised Road Sweeping on Priority Corridors
- Strict Control on the Handling and Transport of C&D Waste.

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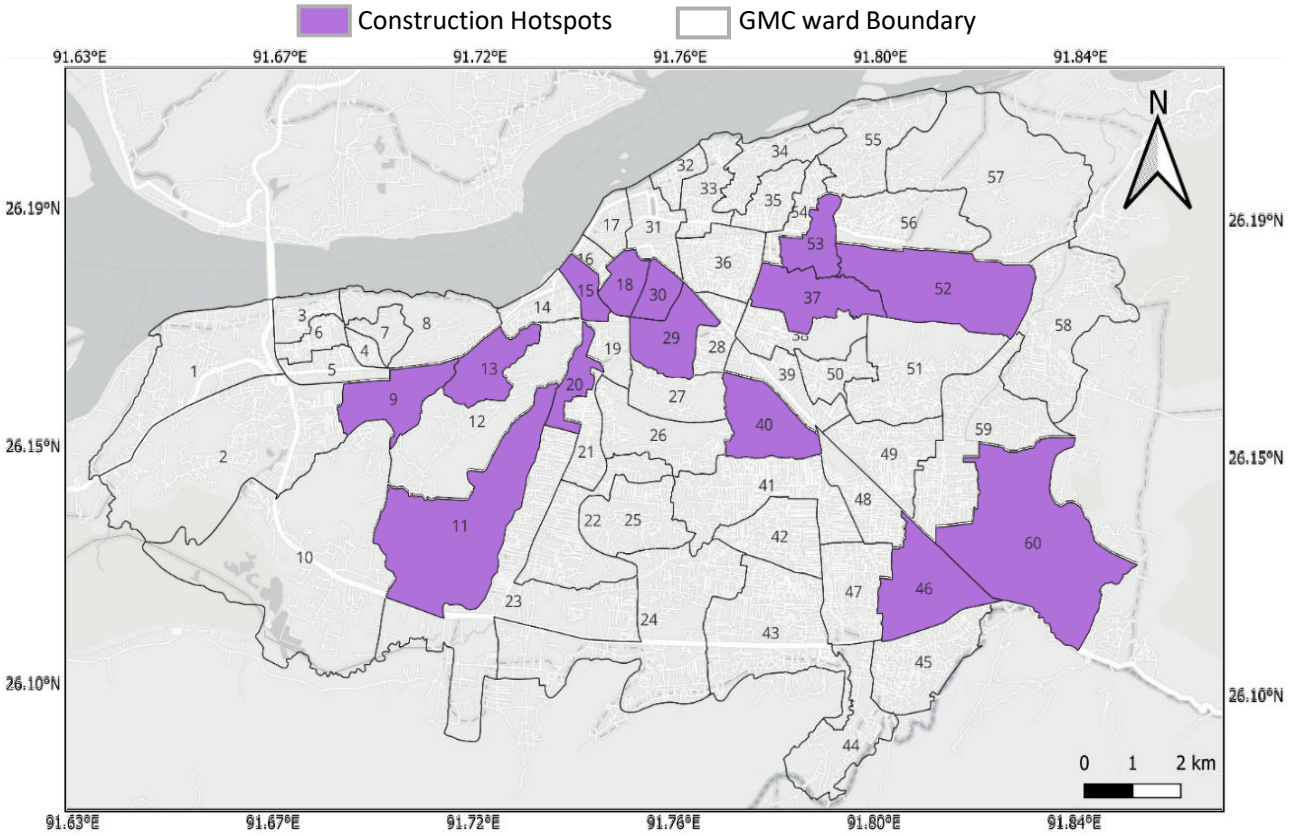
2) Construction Dust

Map 4.6.3: Major wards with heavy construction dust loading



Suggested Mitigation Measures

- Water sprinkling at flyover construction sites in the wards 53 and 52 (Ambari-chandmari-bamunimaidam stretch)
- Strict monitoring of construction dust for large real-estate projects in wards 9, 13, 11, 52
- Commercial construction sites at wards 40, 20, 13 should use Green nets for entire building.
- Roadside stockpiling in wards 15, 18, 30, 29, 46 and 60 should be cleared.
- Set up C&D waste collection points with a capacity of 50 TPD in Six Mile, Khanapara, to collect C&D waste generated.

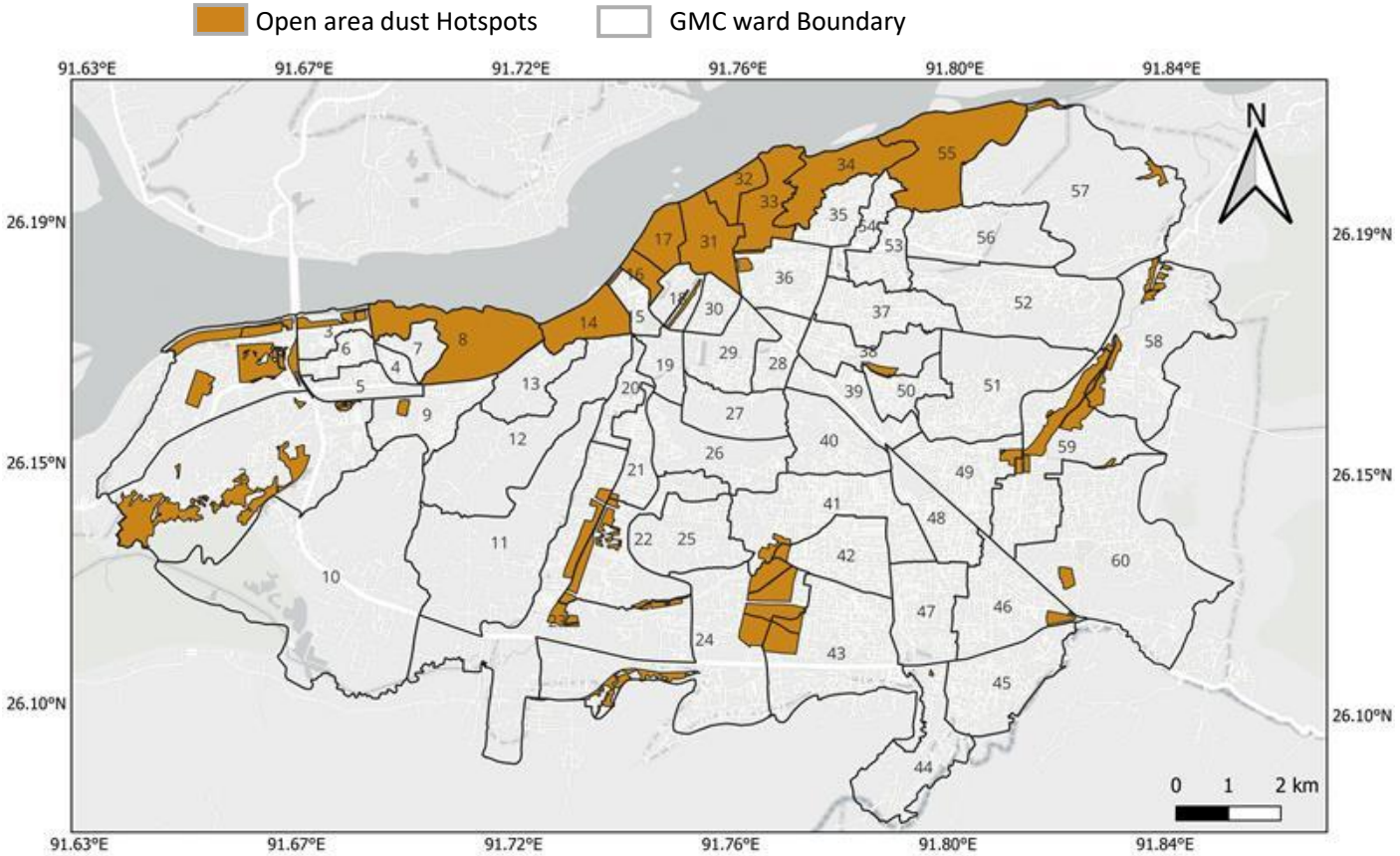
Suggested Policy Measures

- Mandate CPCB Guidelines for dust mitigation in construction Sites.
- Impose a fine for storage of construction materials on road and not covering storage piles in sites.
- Issue a show-cause notice for the first violation, halt construction on the second, and impose a ban on the third

Contd.

3) Open area Dust

Map 4.6.4 : Major wards with open area dust loading



Suggested Mitigation Measures

- Greening buffer, Soil stabilisation and vegetative cover along Brahmaputra embankments in wards 8, 14, 16, 17, 31, 32, 33, 34 and 53
- Grass plantation & soil stabilisation in barren lands with loose topsoil in wards 42 & 43
- Develop a thick green belt around open vacant lands in wards 1 and 59

Suggested Policy Measures

- Mandate vegetation cover on all identified barren land parcels.
- Require mulching or geotextile protection on exposed riverbank stretches.
- Enforce strict controls on soil and sand extraction along river banks.
- Require periodic watering or compaction of open land near roads and settlements.

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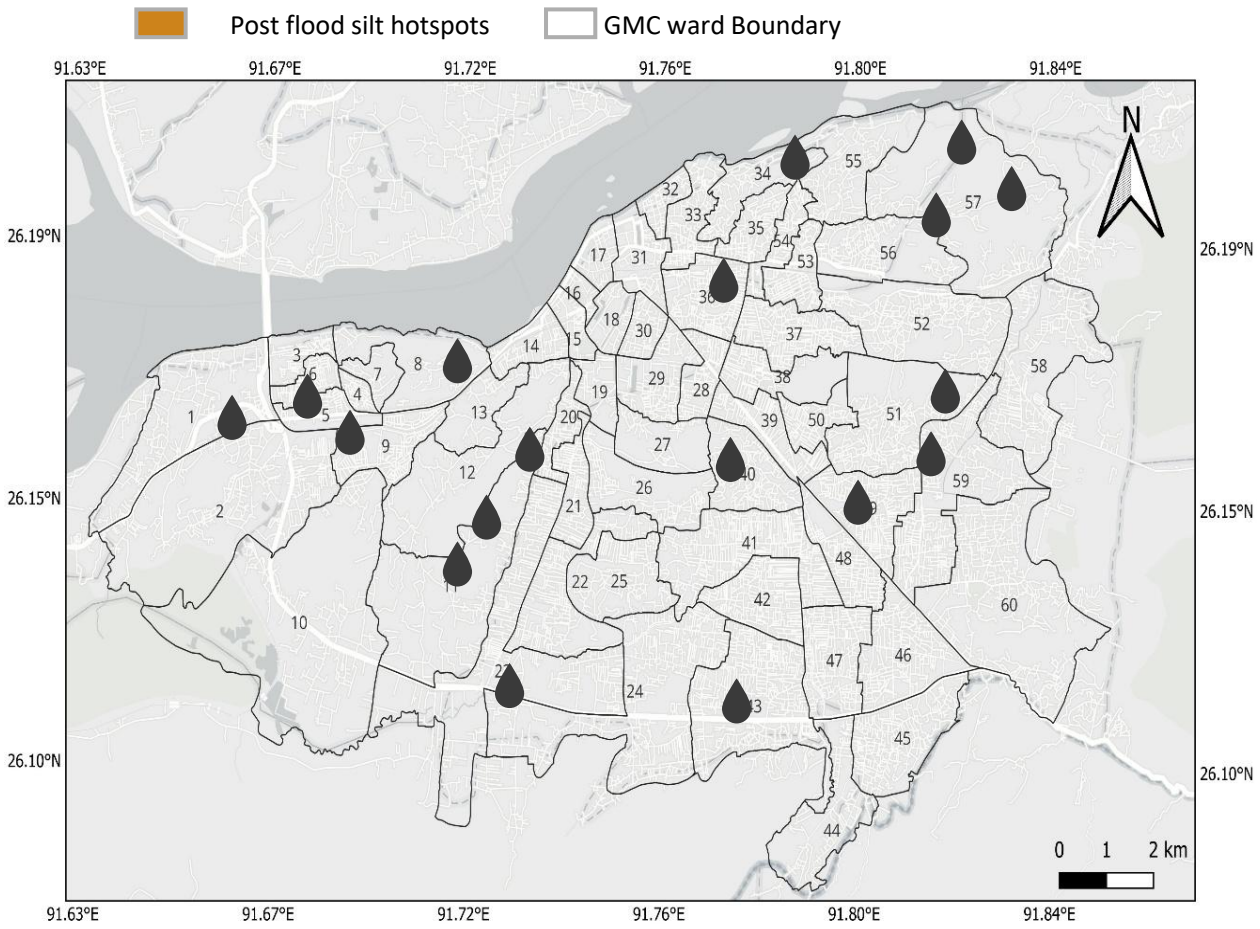
4) Post flood silt Dust

Map 4.6.5: Major hotspots of flood inundation in Guwahati city



Source: North Eastern Regional Node for Disaster Risk Reduction (NER-DRR)

Suggested Mitigation Measures

- Immediate cleaning of roads in GS Road, Paltan Bazar, Zoo Road, Fancy Bazar, NH-37
- Remove overflowed silt from Bharalu–Basistha drains and river ghats
- Wetting, Compaction of silt on road shoulders and Unpaved margins in for NH-37, Maligaon, Adabari, Jalukbari, and foothill zones
- Stabilization of open low-lying Plots in Narengi, Hengrabari area

Suggested Policy Measures

- Mandate removal of post-flood silt from roads and public areas within a fixed 48-hour timeframe.
- Require immediate covering or wetting of silt heaps during clearance operations.
- Prohibit temporary stockpiling of desilted material on road shoulders and open spaces.
- Enforce authorised transport and disposal of all collected silt at designated sites

4.6.5 Implementation Cost

Technology & Infrastructure Development

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost Incurred (Cr.)
2 Mechanical Road Sweepers (MRS) 150 TPD C&D Processing Plant, Paving of Road Shoulders	GMC, PWD (Roads), PWD buildings,	267.05- 277.95	3.25 - 6	270.03- 283.95
Fencing & CCTV for Illegal Dumping, Dust Monitoring + Dashboard Pothole Detection (IoT) + Repair	GMC, GMDA & APCB	1.07- 1.22	0.40- 0.85	1.47- 1.97

Policy Reforms

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost Incurred (Cr.)
Policy Reforms & Regulatory Framework Audit, Vigilance & Enforcement Teams IoT System for Pothole & Dumping Reporting	APCB, Traffic police	1.22 – 1.27	1.60 – 2.30	2.82 – 3.57

Capacity Building

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost Incurred (Cr.)
Capacity Building & Training Awareness & IEC Campaigns	PWD, APCB	0.29 – 0.30	1.75	2.04 – 2.05
Total cost 277.15 – 291.07 crore				

4.6.6 Implementation Pathway

2026

- Purchase of 2 new MRS
- Vegetative buffer on river-bed zones with > 2 kms length (ward –55,34 and 8)
- Green zone on barren lands with an area of > 1 sq m. (Wards-1,2 & 24)
- C&D processing facility within GMC limits (50 TPD)
- End-to-end block pavement to reduce dust
- Strict enforcement of CPCB guidelines for construction sites

2027

- Increasing mechanised sweeping to another 100 KM
- Dust bye-laws revision
- Vegetative buffer development in exposed river zones with 1-2 km area in wards 8, 14, 16, 17, 31, 32, 33, 34 and 53
- Greening in identified barren lands with an area of 0.5 to 1 sq m (Wards 23 & 59)
- Reuse collected road dust as paver blocks and filler material in construction

2028

- Increasing C&D plant capacity in GMC to 100 TPD.
- Mandating green cover and barricading for all construction sites.
- Integrating Dust mitigation as a part of building approval
- Greening and vegetative buffer development in wards 15, 16, 31, 3, 14, 17, 32, 33, 34, & 57.
- Introducing IOT enabled system for pothole reporting and C&D waste dumping

2029

- Pay and use demolition material collection facility.
- Fencing &CCTV monitoring at major illegal dumping points
- Real-time monitoring of PM2.5 at construction sites and data dashboard monitoring.

2030

- Ensure 100% proper disposal of C&D waste in designated sites
- Ensure dust generated from construction sites does not exceed 100 $\mu g/m^3$.
- Ensure all major roads are swept using MRS

Emission Reduction Potential 40- 45%

4.6.7 MRV Structure

Section	Monitoring	Reporting	Verification
1. Road dust mitigation (Mechanised sweeping & water sprinkling)	• GPS logs and daily corridor checks track sweeper movement and tanker trips.	• Weekly coverage summary is generated from GPS and field inspections.	• Third-party GPS audit and photo validation confirm actual sweeping done.
2. Road dust mitigation (Paving of shoulders)	• GIS mapping and basic quality/compaction checks monitor paving progress.	• Monthly progress report updates completed stretches.	• Joint PWD–GMDA inspection validates quality and dust-level improvement.
3. Construction Dust (on-site dust suppression)	• Contractor e-logbooks and geo-tagged photos capture compliance.	• Weekly compliance score summarises suppression performance.	• APCB audits and penalty record checks verify actual adherence.
4. Construction Dust (Covered transport of sand, soil, and aggregates)	• Gate registers and CCTV at major exit points monitor tarpaulin cover compliance.	• Weekly violation list is compiled from field and CCTV observations.	• Surprise inspections and CCTV cross-verification confirm violations.
5. Open barren land dust	• High-resolution satellite imagery and periodic field surveys	• Document and publish quarterly changes in vegetative cover of barren lands	• Independent technical agency to validate reported vegetation cover metrics through on-site sampling

4.6.8 Key Highlights

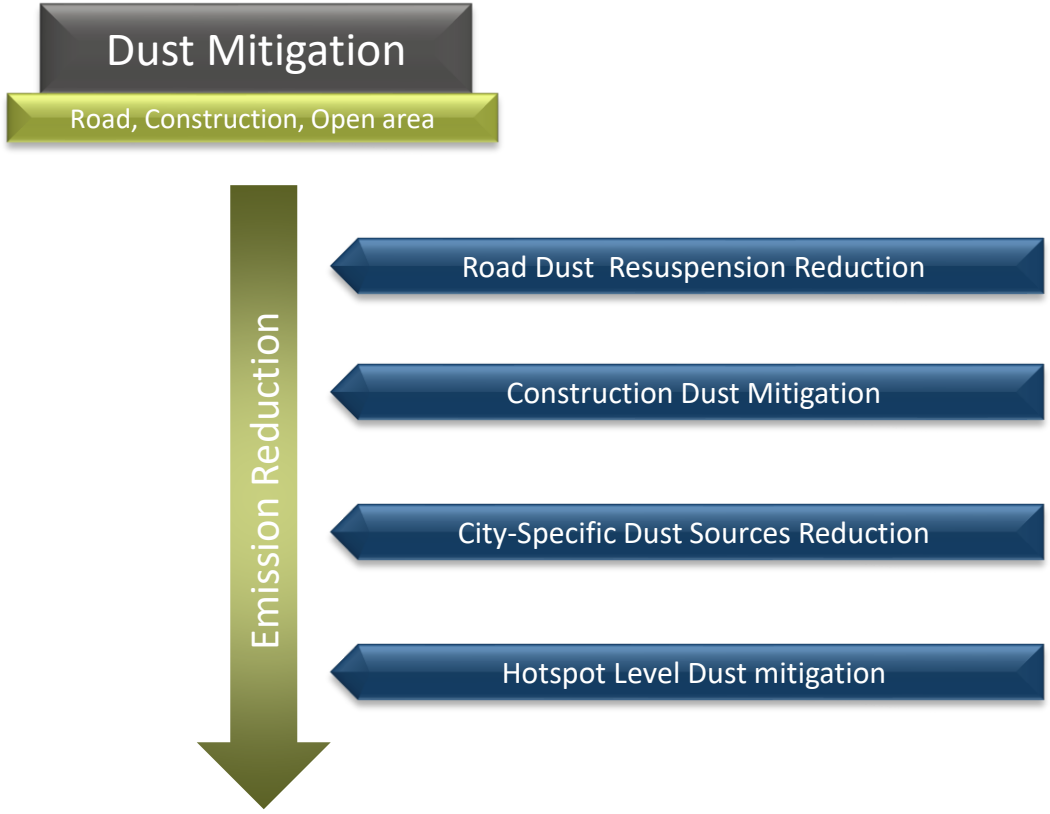
- Road Dust Hotspots: NH-27, NH-37, GS Road, AT Road, Beltola Road, Narengi Tiniali; high dust zones near railway junctions (Wards 31, 30, 18) and busy markets (Fancy Bazar, Pan Bazar).

- Construction Dust Sources: Major emissions from Ambari - Chandmari - Bamunimaidam and real-estate clusters in Wards 9, 11, 13, 40, 20, 52 due to inadequate covers and barricading.

- Opea area & Seasonal Dust: Exposed Brahmaputra embankments (Wards 8, 14, 16, 17, 31–34, 53), barren lands (Wards 42–43), and flood-affected zones in Maligaon, Adabari, Jalukbari, foothill belts.

- Enforcement Gaps: Unauthorised C&D dumping in Wards 15, 18, 29, 30, 46, 60, poor site compliance, and uncoordinated road excavations across multiple agencies.
- Priority Actions: Mechanised sweeping across 106 km, pothole repair in Wards 31, 30, 18, and strict construction-site dust control in Wards 9, 13, 11, 52.

- Long-Term Dust Reduction: Greening and soil stabilisation at Brahmaputra embankments, Narengi, Hengrabari, vacant lands in Wards 1, 59, and proper silt management along NH-37, Maligaon, Adabari, Jalukbari, and Bharalu–Basistha drains.



Emission Reduction Potential $PM_{2.5}$ 40- 45%

4.7 Mitigating Emissions from Transportation Sector

4.7.1 Key Statistics and Background

- Guwahati's transport sector is dominated by private vehicles, contributing over 85% of the fleet.
- Public transport remains limited, with only 725 buses (0.52 buses per 1,000 people), while goods vehicles (1.5 lakh) add a significant traffic load.
- Integrated Public Transport (IPT) supply is modest with 2,769 autos and 1,160 share taxis, increasing reliance on two-wheelers.
- Electric buses uptake in private modes is still low

Figure 4.7.1: Vehicle growth from 2020 to 2025

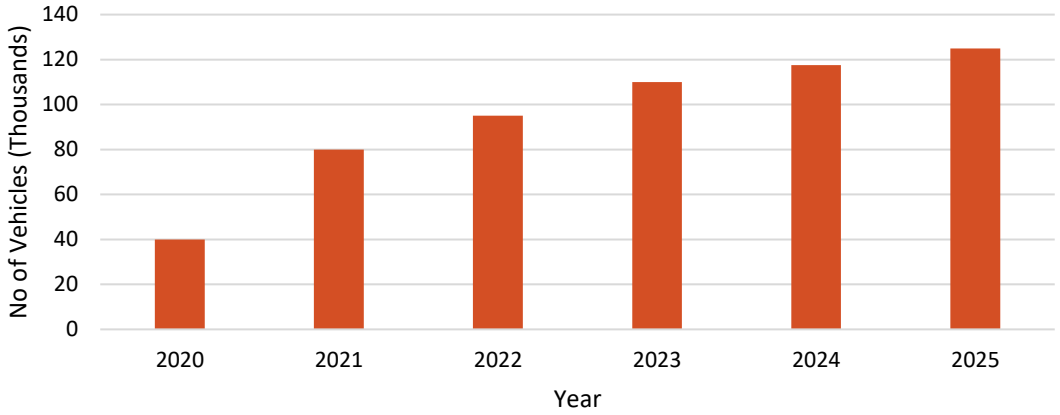


Table 4.7.1: City Population & Motorisation

Indicator	Value
City Population (2024–25 baseline)	14,05,000
Annual New Vehicle Registrations (2023–24)	1,13,293
Monthly New Vehicle Registrations	9,441 vehicles/month

Table 4.7.2: Public Transport Availability (Bus Fleet)

Parameter	Value
Buses per 1,000 Population	0.52
Total Seated Capacity (40 seats/bus)	29,000 passengers
Total Seated + Standing Capacity (60 pax/bus)	43,500 passengers
% of Population Served at Once (40 seats)	2.06%
% of Population Served at Once (60 pax)	3.10%

Table 4.7.3: Category-wise Vehicle numbers

Vehicle Category	Estimated Total
Two-Wheelers	8,00,000
Private Cars (LMV)	3,80,000
Goods Vehicles	1,50,000
E-Rickshaws	4,000
Auto-Rickshaws	2,769
Share Taxis (IPT)	1,160
Buses (Diesel)	269
Buses (CNG)	100
Buses (Electric)	356
Total	**13,38,654**

4.7.2 Major Gaps: Transportation and Parking

Table 4.7.4: Infrastructure and Policy Gaps

Focus Area	Insights	Gaps Identified
1. Transport Infrastructure & Traffic Flow	• High load on major corridors (NH-27, GS Road, AT Road) • Multiple bottlenecks due to narrow sections and junction delays	• Missing network links & bottlenecks • Poor intersection geometry • Encroachments on ROW
2. Public Bus System (ASTC & City Buses)	• 225 ASTC buses operational • Daily ridership ~36,600 • Demand for public transport increasing	• Narrow roads limit operation of large buses • Low frequency & aging fleet • Insufficient bus priority lanes • Unorganised IPT/feeder stands
3. Urban Mobility & Local Access	• High dependence on private vehicles • Majority of trips <5 km • Under-utilised formal parking spaces	• No structured parking system • Heavy on-street parking causing congestion

Table 4.7.5: Gaps in Parking System

Sector	Specific Gaps
1. On-Street Parking Management & Enforcement	• High congestion on MG Road, HB Road, Dr. JC Das Road, market corridors.
2. Off-Street Parking & Land Use Optimisation	• Low alignment of GMC parking lots with public transport nodes.
4. Freight & Commercial Vehicle Parking	• Trucks halting near commercial zones causing road blockage • Peak-hour loading/unloading worsening congestion. • Lack of designated loading bays in market areas.
5. Smart Parking Systems & EV-Ready Infrastructure	• Mostly manual operations; no real-time occupancy visibility. • Lack of digital permits or integrated parking database. • No structured EV-charging integration in parking sites

4.7.3 Control Measures: Transportation and Parking

Table 4.7.6: Control measures for transportation

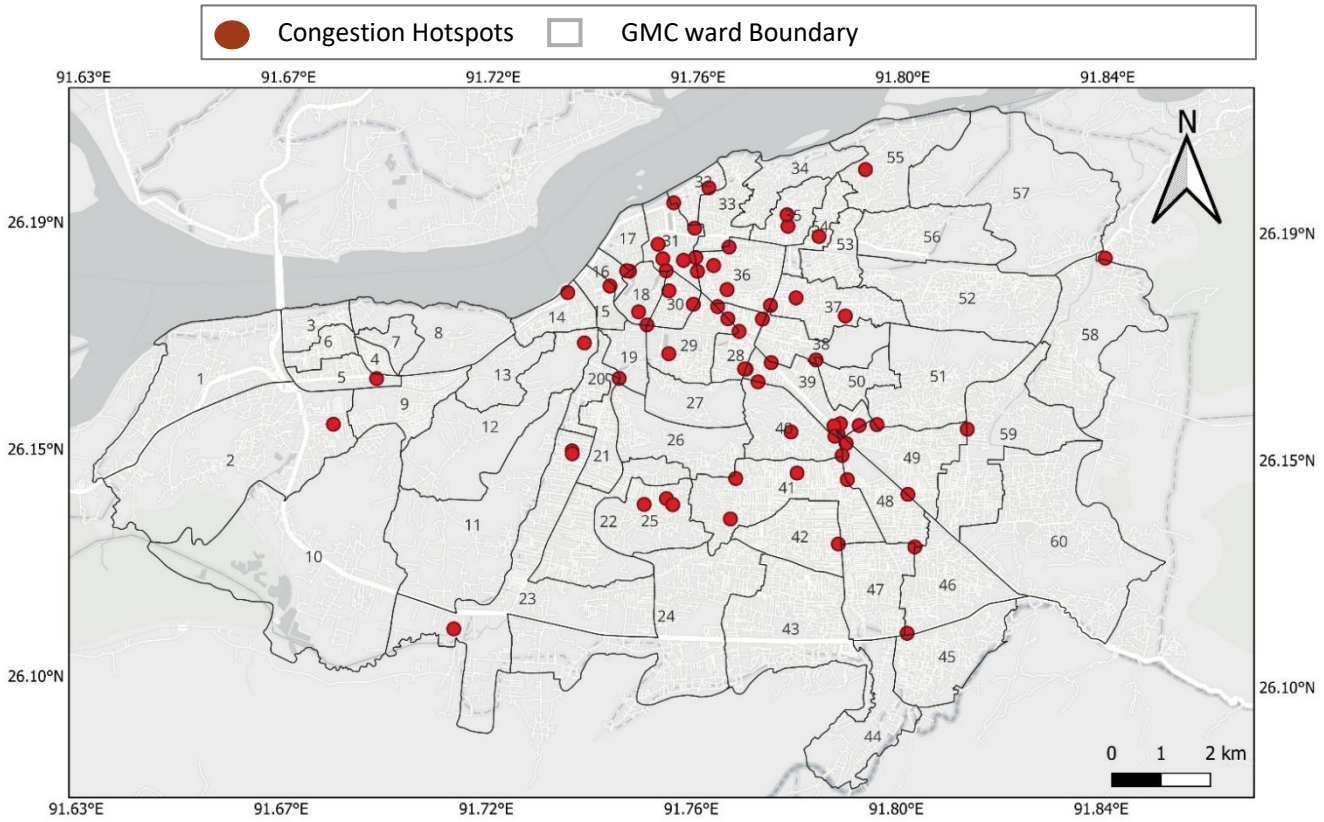
Focus Area	Control Measures
1. Transport Infrastructure & Traffic Flow	• Junction redesign and signal optimisation • Removal of ROW encroachments • Completion of missing links and corridor widening
2. Public Bus System (ASTC & City Buses)	• Expand and modernise bus fleet (small size bus) • Create dedicated bus lanes on GS Road, AT Road • Develop organised IPT/feeder hubs • Increase service frequency on trunk corridors
3. Urban Mobility & Local Access	• Develop multilevel parking facilities in key zones (Beltola area, GS Road Commercial area, Adabari / ISB, Khanapara/Six Mile Junction) • Implement priced on-street parking • Enforce no-parking zones on GS Road, AT Road, MG Road, Zoo Road, Panbazar Road, Fancy Bazar road,

Table 4.7.7: Control measures for parking

Sector	Control Measures
1. On-Street Parking Management & Enforcement	• Introduce dynamic/area-based pricing in high-demand corridors. • Enforce digital payments + authorised operators only. • Mark short-stay bays and strictly enforce no-parking in corridors with high traffic flow.
2. Off-Street Parking & Land Use Optimisation	• Implement maximum parking limits and stop capacity expansion in CBD areas. • Strengthen operator KPIs through digital occupancy tracking and audits. • Convert low-utilisation surface lots to TOD/public spaces.
4. Freight & Commercial Vehicle Parking	• Develop peripheral truck terminals to reduce central truck movement. • Enforce time-window (off-peak) delivery rules in commercial zones. • Create dedicated loading/unloading bays and enforce use.
5. Smart Parking Systems & EV-Ready Infrastructure	• Deploy citywide parking platform with real-time occupancy and digital payments. • Digitise all permits and standardise e-receipts across public/private lots • Mandate EV-ready wiring and introduce charging hubs in major off-street sites.

4.7.4 Traffic Decongestion Plan

Map 4.7.1: Major traffic congestion zones



- Introduce Bus Priority Lane from Khanapara to Bhangagarh
- Ban roadside vending on approach roads (Zoo Road, GS Road arms
- Introduce right-turn pockets on GS Road to reduce signal cycle length near ganeshguri junction
- Restrict parking and loading activity near Six Mile Market
- Remove encroachments at Zoo Road Tiniali for better turning radius
- Establish truck restriction zone at Jalukbari Junction during peak hours
- Restrict goods vehicle entry in Fancy Bazaar from 10 AM to 8 PM
- Mark dedicated loading/unloading windows near Machkhowa to reduce random halts
- Improve turning lanes at Bamunimaidan approach and Noonmati junction

4.7.5 PUC – Observations

- Assam currently has approximately 175 government - authorised PUC centres statewide, with an estimated 30 centres operating within Guwahati, based on public listings.
- Guwahati accounts for roughly 15 to 25% of Assam's total authorised testing capacity.
- Audit of 10 PUC centres was conducted to assess the overall performance of the PUC sector in the city.
- Only 40% of the survey vehicles renew their PUC before expiry
- Faulty renewal system : Produce previous certificate, pay money and get new certificate

Table 4.7.8 : Performance assessment of PUC centres

Parameter	No of PUC Centers
Gas analyser/(CO-HC) for petrol vehicles and smoke density meter for diesel vehicles	9
Valid calibration certificate, regular calibration and its renewal process	7
Vehicle PUC failure rate	<0.5
Testing Mechanism: Attachment of sampling probe, Following testing SOPs	3
Skilled and trained manpower (with certificate)	0
Skilled and trained manpower (experience)	6

Table 4.7.9 Parameters considered in PUC audit

Section	Major Pointers considered
1) Instrument Setup	• Sampling not leak-proof • Probe length adequate • Filters clogged or not cleaned • Smoke meter sensors missing or non-functional
2) Calibration	• Outdated or invalid calibration certificate • Missing calibration certificates • Calibration frequency not followed • Instruments used despite overdue calibration
3) Vehicle PUC Failure Rate	• Percentage of vehicle getting failed during PUC testing
4) Renewal of PUC (Before Expiry)	• Renewal of PUC (before/after expiry of previous certificate)
5) Proper Testing Practices	• Incorrect sampling technique / probe placement • SOP not followed
6) Skilled manpower	• Operators not trained or uncertified

Contd.

Figure 4.7.2: Key challenges in existing PUCs system

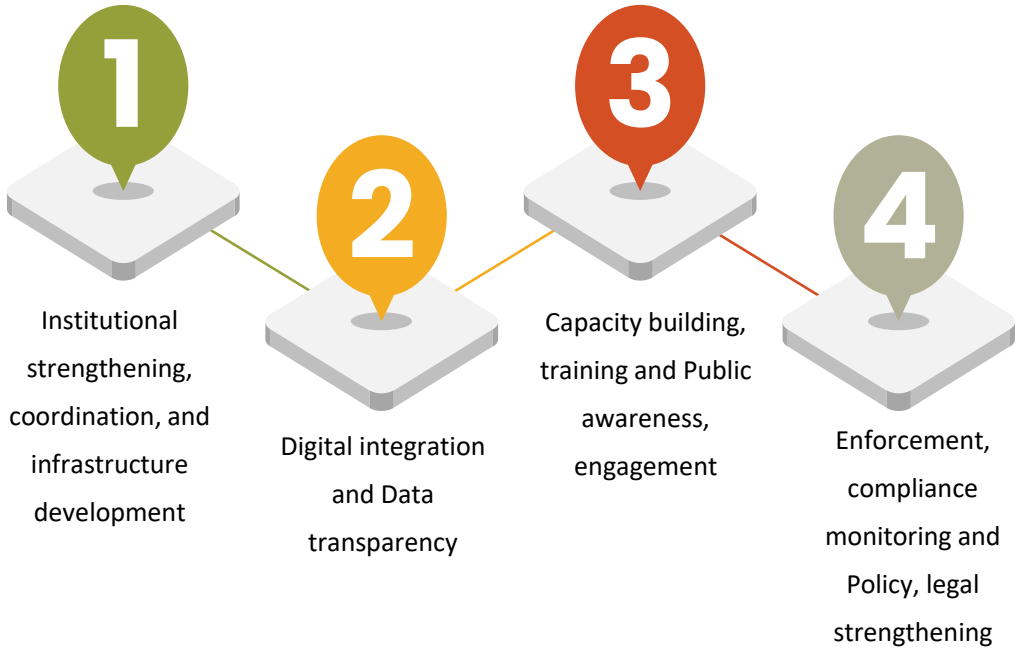
Weak Institutional Coordination
Coordination between the Transport Department, Pollution Control Board, and enforcement agencies is often inadequate

Non-uniform Testing Practices
There are variations in testing procedures, calibration of instruments, and operator capability across centers

Low Public Awareness
Vehicle owners often lack awareness about the importance of regular PUC testing or the penalties for non-compliance

Insufficient Enforcement
Enforcement agencies have limited manpower and digital tools to check PUC validity on the spot

Figure 4.7.3: Suggested Framework for Strengthening PUCs



4.7.6 Implementation Cost

Technology and Infrastructure Development

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost Incurred (Cr.)
150 Small E-Buses (9 m), Charging Infrastructure, Bus Stops / Shelters, Bus Depots, Last-Mile EV Feeder Fleet,	ASTC, Transport Department.	406.7 – 423.3	181 – 127	505.7 – 550.3
Road Widening, Intelligent Transport Systems (ITS),&Footpath + Cycle Track Upgrades,	GMC, GMDA, PWD	641.9 – 668.1	17-28	658.9 – 696.1
Multilevel Parking & Parking Management Systems	GMC, GMDA	83.3 - 87	7- 12	90.3 – 98.

Policy Reforms

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost Incurred (Cr.)
Transport Policy Reforms, Demand Management (No-Idling, Congestion Enforcement) and Vigilance & Enforcement Teams	GMC, Traffic Police	16.66 – 17.34	8 – 12	24.66 – 29.34

Capacity Building

Control Measures	Implementing Agencies	Capital Cost (Cr.)	Operational Cost (Cr.)	Cost Incurred (Cr.)
Awareness & Behaviour Change Campaigns Capacity Building & Training.	ASTC, GMC, Transport Dept.	0.88 – 0.92	3	3.88 – 3.92
Total Cost: 1,284.44 – 1,374.36 crore				

4.7.7 Implementation Pathway

2026

- Purchase of 50 new E buses for ASTC
- Assessment of public transport performance deficit – bus frequency, route gaps, depot limitations
- Infrastructure changes in Road width, new bus stops
- Integrated vehicle-fleet profiling using VAHAN (ageing fleet, fuel-type split, heavy-duty vehicle clusters).
- Increasing vigilance in PUC system
- Construction of new Multilevel parking

2027

- Upgrade of PUC centres in high-demand zones (Khanapara, Jalukbari, Beltola, Lokhra ISBT)
- 100% digital PUC process rollout (camera-recorded tests, geo-tagged calibration, encrypted certificates).
- Deployment of 100 – 150 additional buses (electric) under ASTC's ongoing electrification plan.
- Charging infrastructure for E buses and other E vehicles.
- Ban on roadside parking in commercial zones (Fancy bazar Panbazaar)

2028

- Complete ANPR–VAHAN–e-challan integration enabling automatic fitness, PUC, and tax compliance checks.
- Operationalisation of two large e-bus charging depots (North Guwahati + Khanapara) with feeder electrification.
- Real-time transport monitoring dashboard for Guwahati (fleet movement, congestion, compliance analytics).
- Ban on roadside parking in all major roads (GS road, AT road, MD road).

2029

- Addition of 150–200 electric buses + corridor optimisation for Airport Road, Jalukbari–ISBT, Six Mile, Chandmari.
- Mobile PUC/emission-testing vans deployed for peri-urban and industrial areas (Panagbari, Kahilipara, Sonaguli, Noonmati, Amingaon).

2030

- Mandatory PUC checks at all fuel stations within GMC limits with automatic API verification.
- Automatic blacklisting & penalty routing for non-compliant vehicles via ANPR + VAHAN (fitness, tax, PUC).
- Public transport modal shift achieved through expanded EV bus network, last-mile EV services, and strengthened parking policy.

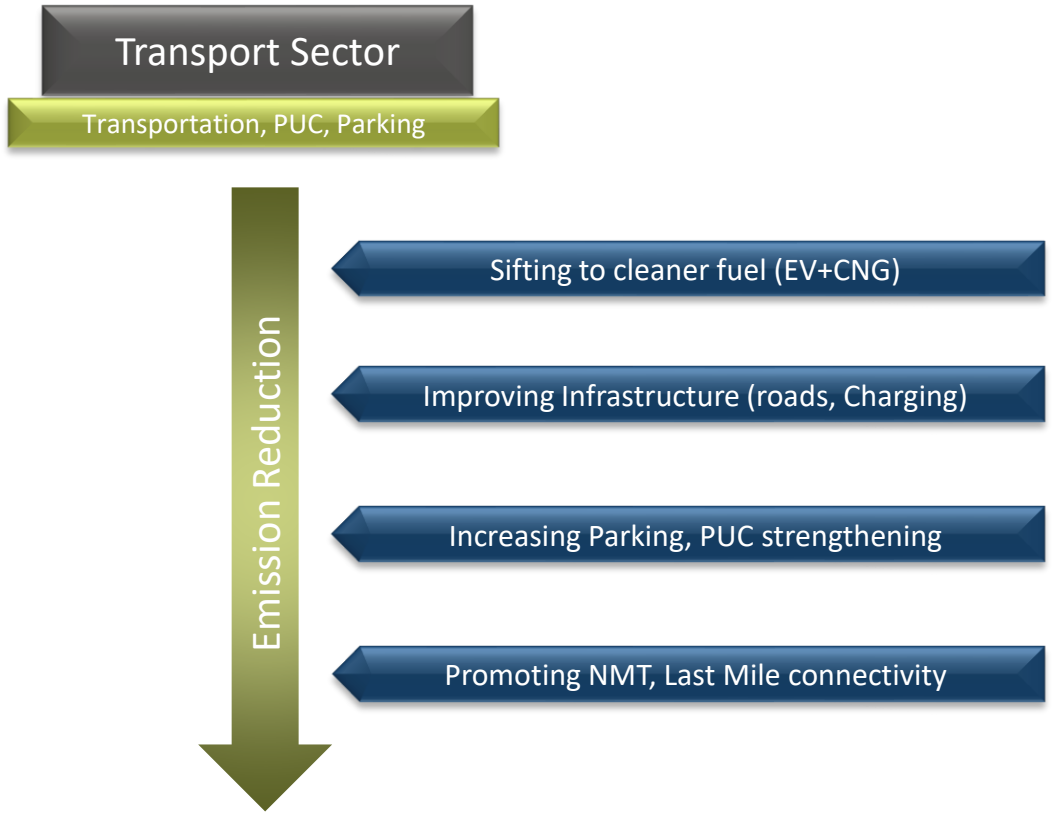
Emission Reduction Potential 20- 25%

4.7.8 MRV Structure

Section	Monitoring (M)	Reporting (R)	Verification (V)
1. Transportation - Public Transport Integration & Fleet Efficiency	• GPS-based bus-km, route adherence & headway data	• Monthly clean-fleet & service-level performance summary	• Third-party audit of GPS logs & depot records
2. Parking Management - Digital Enforcement & Occupancy Control	• ANPR scans, digital parking occupancy feed	• Monthly parking compliance & violation summary	• Audit of ANPR datasets & field spot verification
3. Traffic Congestion & Corridor Management	• ANPR congestion index, travel speed data, idling duration logs	• Monthly congestion & idling compliance report	• Independent audit of ANPR datasets & on-ground checks
4. PUC System Strengthening - Digital PUC, Roadside PUC Enforcement	• Digital PUC uploads, ANPR detection of non-PUC vehicles, instrument calibration logs	• Monthly PUC compliance dashboard (centre-wise failure, calibration, testing quality)	• APCB verification of emission files & random field audits of PUC centres

4.7.8 Key Highlights

- Private vehicles dominate (85%), while public transport capacity remains low; congestion is highest on GS Road, AT Road, MG Road, HB Road, Dr. JC Das Road, Panbazar, Fancy Bazar.
- Network gaps and encroachments (Zoo Road Tiniali, GS Road arms) restrict bus operations; missing links, poor junction geometry, and unorganised IPT stands worsen delays.
- Parking dysfunction heavy on-street parking, low integration of GMC lots, no digital system drives bottlenecks in GS Road, Panbazar, Fancy Bazar, and market corridors.
- Freight and truck movement cause peak-hour disruption near Machkhowa, Jalukbari, Fancy Bazar, due to lack of loading bays and uncontrolled halts.
- Priority actions include bus-lane implementation (Khanapara–Bhangagarh, GS Road), 150 to 200 new e-buses, multilevel parking at Beltola, GS Road, Adabari/ISBT, Khanapara, strict no-parking enforcement, truck time-windows, and citywide digital parking + PUC + ANPR integration.



Emission Reduction Potential $PM_{2.5}$ 20- 25%

4.8 Mitigating Emissions from Industrial Sector

4.8.1	Key Statistics and background
4.8.2	Emission Estimation by industries
4.8.3 Control	Suggested control options: Switch, Improve,
4.8.4	Timeline and emission reduction potential


Jai Maa


4.8.1 Key Statistics and Background

Geographic Context

- Guwahati borders Byrnihat, Meghalaya — one of India's most polluted industrial clusters
- Industrial units on the Byrnihat belt significantly influence cross-border emissions
- Regional air quality affected by transboundary pollution transport

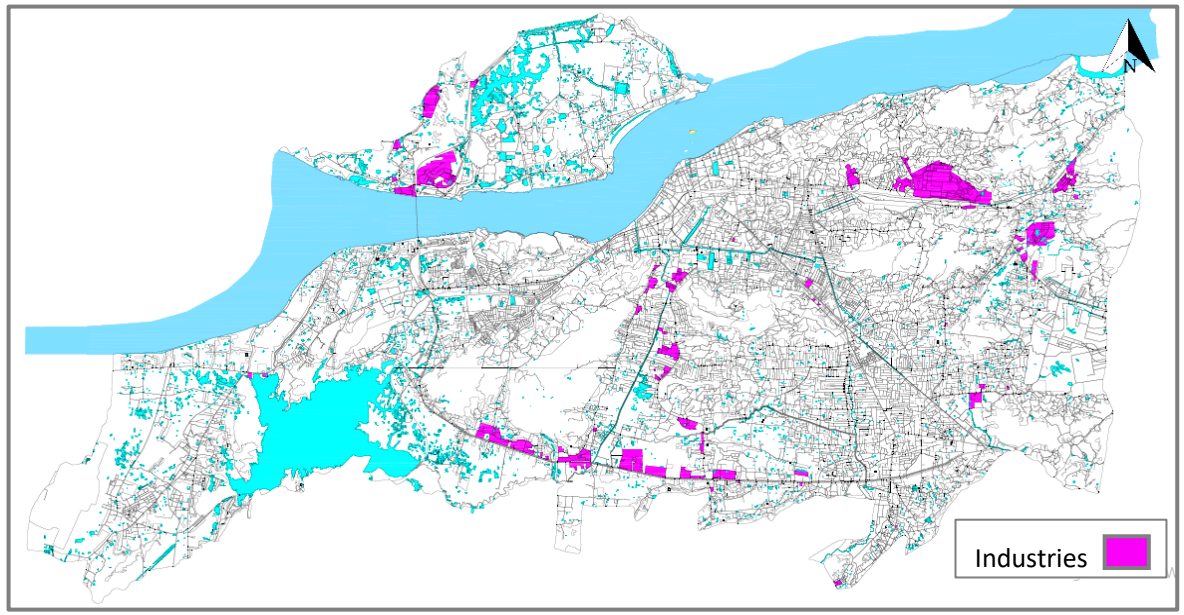
Major Industrial Areas

- Two major industrial clusters: Bamunimaidam Industrial Estate and Amingaon Industrial Area
- 47 industries registered under Assam Pollution Control Board out of which 17 are red category industries and 30 are orange category industries
- Major type of industries are Iron and Steel, Coke making, oil refineries, Ferrous and non-ferrous metal extraction
- Wards: 13, 17, 46, 15, 16 and 54 have numerous industries

Fuel Supply Chain

- Proximity to Meghalaya provide easy access to Salang coal
- City gets additional coal supplies from Tinsukia Belt

Map 4.8.1: Industrial Areas in Guwahati



Source: GMDA

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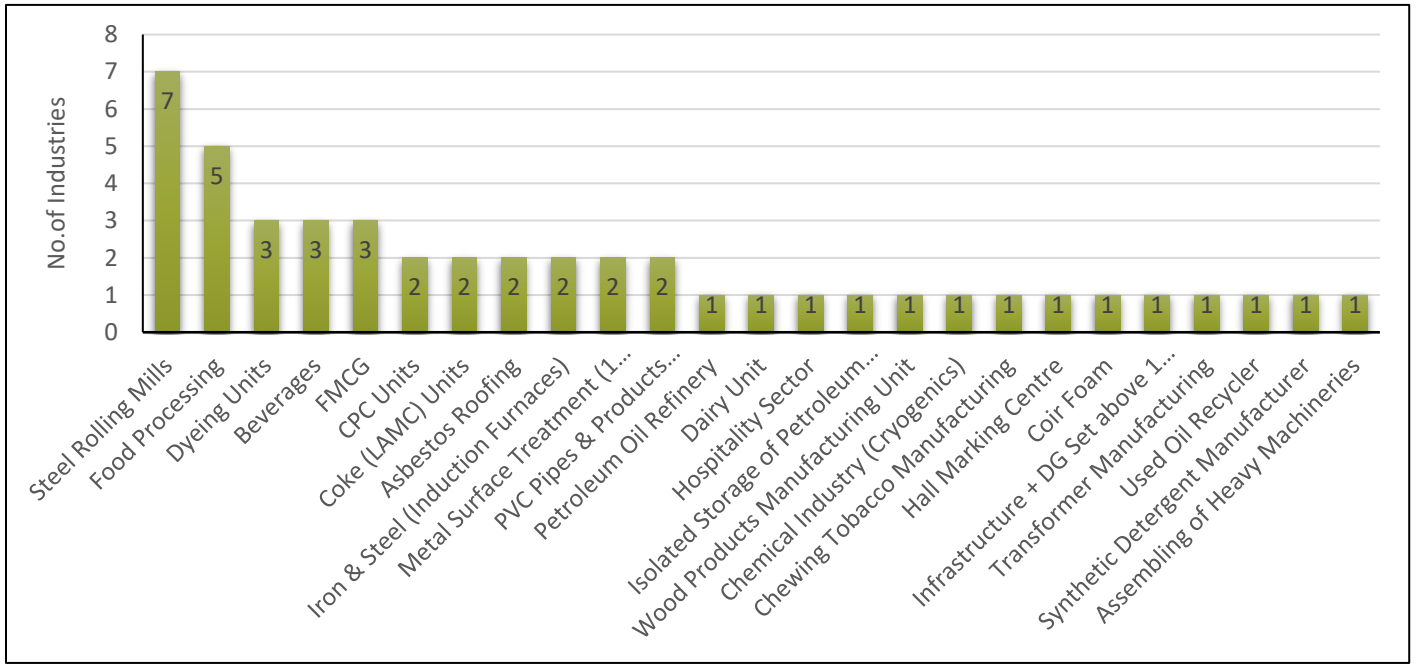
Figure 4.8.1: Count of various Industries Operating in Guwahati City



47

Industry (Red + Orange) Present within the City Boundary

Key Insights

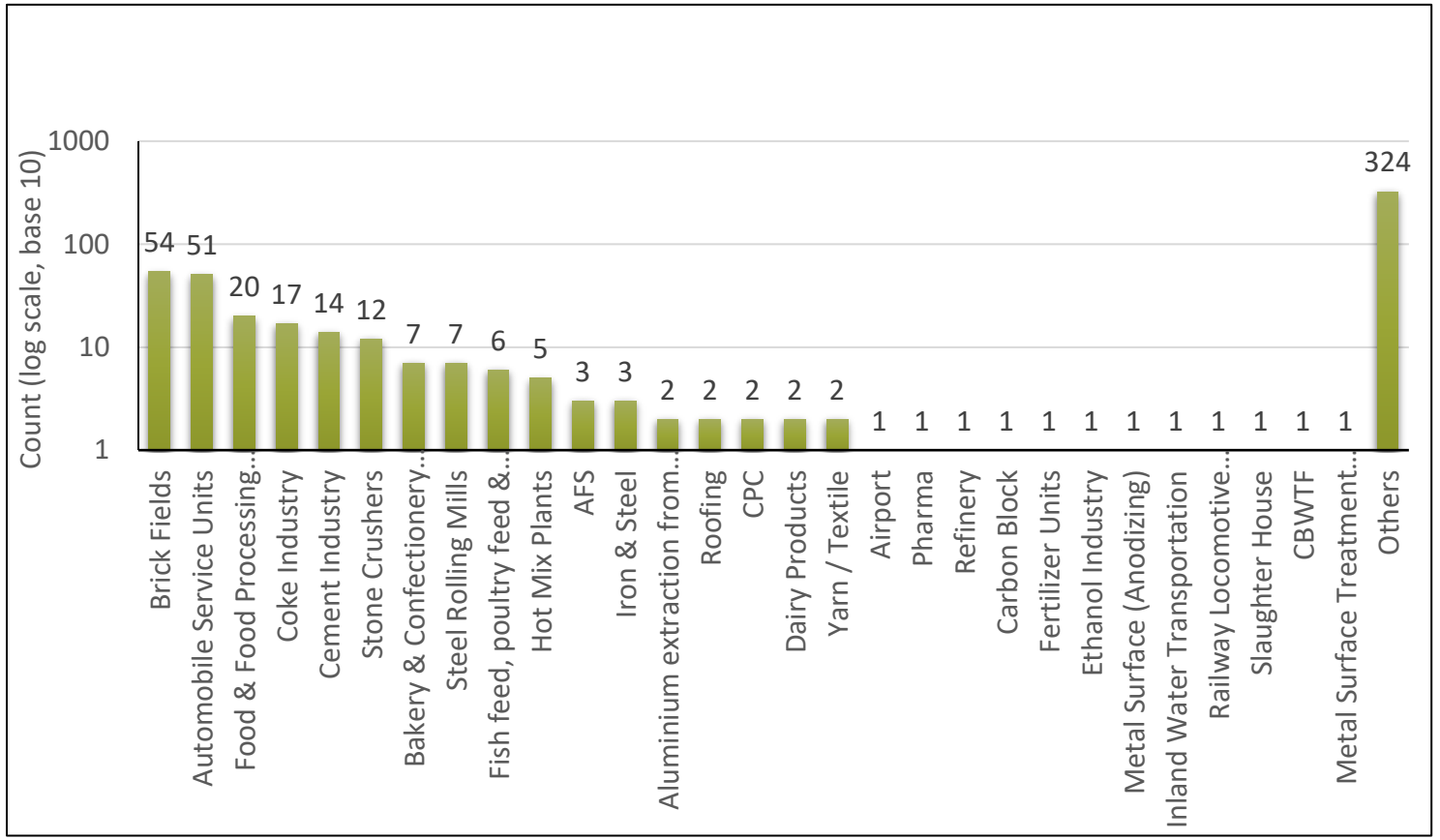
Sectors with the **highest number of units** include:

- Iron and Steel making
- Dyeing units
- Food Processing and Textile
- Other miscellaneous small industries

The “Others” category groups smaller sectors such as hallmarking industries, plastic industries, bottle packaging units etc.,

Industrial Units in Kamrup Metropolitan District

Figure 4.8.2: Count of various kinds of industries present



545

Industrial Units (Red and Orange) in Kamrup Metropolitan

Key Insights

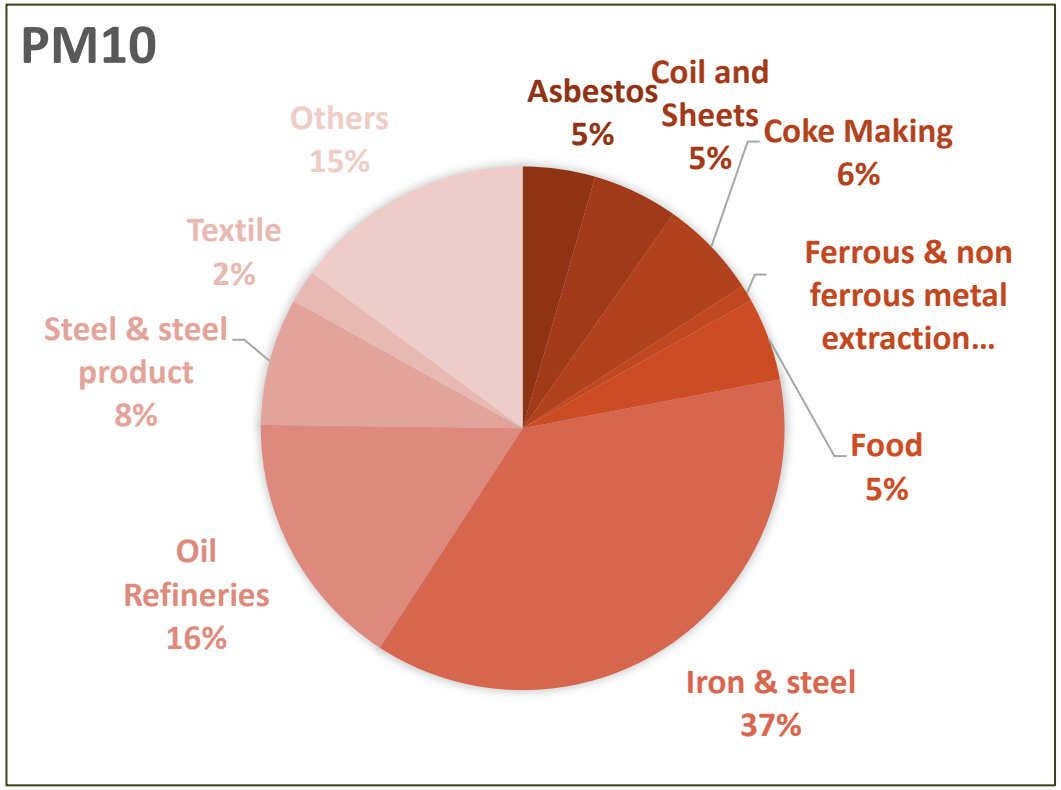
Sectors with the **highest number of units** include:

- Brickfields
- Food processing
- Stone crushers
- Cement
- Coke-making units
- Other miscellaneous small industries

The “Others” category groups smaller sectors such as fuel stations, tea-processing units, lead-acid battery manufacturers, and various micro-industries that individually have low counts but together add to the overall industrial activity

4.8.2 Emissions – Key polluting Industries

Figure 4.8.3: PM10 emissions from industries in Guwahati City



368 Tonnes per Year
Total PM10 Emission Load in Guwahati city

Key Findings

- **Iron and steel sector dominates** with approximately **37%** of total PM10 emissions
- **Oil Refineries** contribute to around **16% of the** total PM10 emission load
- **Ferrous metal extraction and Coke Making industries** add around **10% and 6%** to the total PM10 load
- **Iron and steel along with Ferrous and Non-Ferrous extract industries** together contribute to around **46%** of the total PM10 load
- Other categories include emissions from coil industry, FMCG industry, hot mix plants, etc

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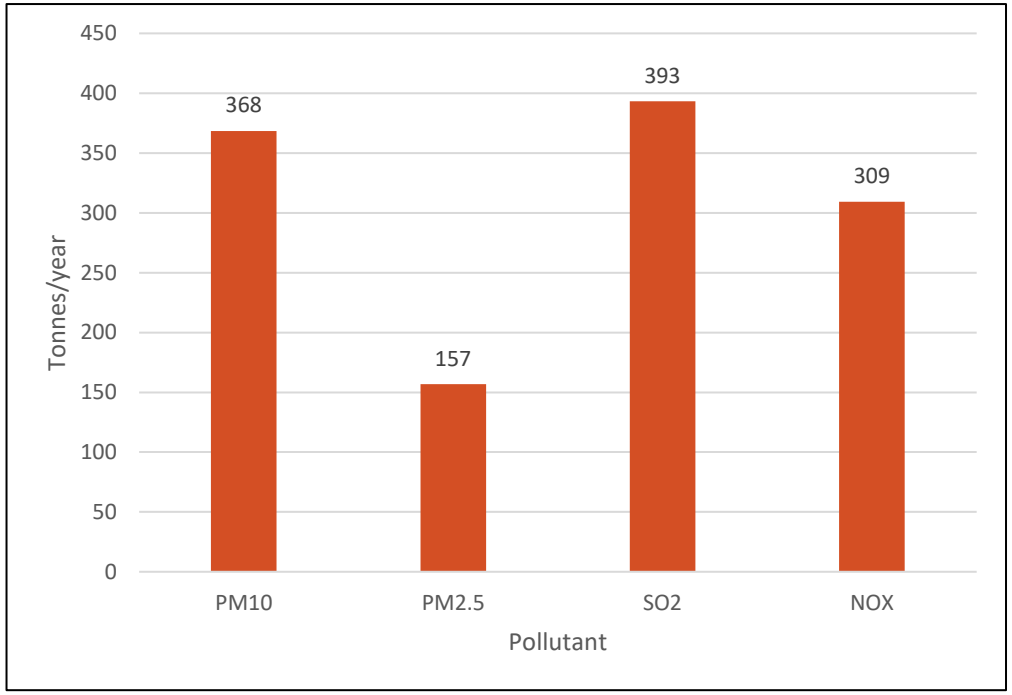
Figure 4.8.4: Pollutant emission share



Insights

- Most emissions from the steel sector come from coal-fired furnaces, though these units have APCDs in place
- Refineries show high emissions simply because their operational scale is very large.
- Food-processing units rely on boilers that mostly run on briquettes or firewood.
- Out of the 47 industries, 19 use DG sets for their operations
- Out of 47 identified industries in Guwahati city, 17 fall under the Red category and 30 fall under the Orange category
- Among the four coke-making units, two operate rotary kilns and two are a LAMC crusher.
- There are two LAMC coke units—one is operating only the crusher section, while the other is functioning intermittently
- Textile units depend on boilers for their thermal needs.
- Several bottle-packaging units were identified, and they fall under the orange industry category
- There are three dyeing units, of which two share a common boiler. Additionally, the two iron and steel units in the cluster operate using induction furnaces

Key Findings

- **PM10 and SO2 are the highest,** each close to 400 tonnes per year, showing strong emissions from combustion and **use of coal with high Sulphur content**
- The emissions pattern is **broad**; no single pollutant dominates, which means control measures must target both particulates and gases.
- NOx emissions stand at a little over 300 tonnes per year, indicating an **intense combustion process**

4.8.3 Suggested Control Measures

Switch – Technology and Fuel

Industry Type	Control Measures
Steel	▪ Upgrade 2 units using coal-based furnaces to electric systems
Coke	▪ Coke-making use rotary kilns, others run as crushing units, and the rest have APCDs such as Venturi scrubbers, cyclones, or wet scrubbers. Effective maintenance & operational checks by APCB
Food and Textile	▪ Transition boilers (3 food and 3 Textile) from firewood and HSD to biomass briquettes or PNG
Asbestos	▪ Ensure both asbestos units operate only with electrically powered furnaces ▪ Require the adoption of wet sheet-forming processes in both units to minimise the resuspension of dust.

Improve and Control

Focus Area	Control Measure
Continuous Monitoring and Compliance	• Mandate CEMS for all red-category industries, regardless of size • Install LCS sensors near high-emission units/Wards with automated alerts that trigger shutdown or power cuts through APDCL and district authorities • Periodic third-party verification of CEMS/LCS data
Inspections	• Conduct routine field visits to ensure APCDs operate efficiently, and CTO norms are followed • Maintain digital inspection logs with non-compliance tracking and mandatory follow-up actions
Siting	• Restrict new polluting industries within Guwahati city limits. • Relocate non-compliant polluting units to designated industrial areas
APCD and Fuel Management	• Mandate installation of APCD in all polluting industries • Phase out coal use and develop the infrastructure needed for a transition to PNG

4.8.4 Implementation Cost

Technology Upgradation

Control Measures	Implementing Agencies	Cost Incurred (Cr.) (Ind)
Industries shifting to Cleaner technologies (Cement – Rotary Kilns, Coke – stamp charged ovens, Coke – Recovery Ovens)	Industries	20 - 30

Awareness & Outreach

Control Measures	Implementing Agencies	Cost Incurred (Cr.) (Gov)
Conduct targeted compliance-awareness sessions for all major polluting industrial sector	PCBA, Industry Department	0.25–0.3
Publish Annual compliance scorecards to improve industrial performance		

Audits & Community Checks

Control Measures	Implementing Agencies	Cost Incurred (Cr.) (Gov)
Conduct biannual inspections for each industry (e.g., cement, brick, poultry) to ensure compliance and emission control	PCBA, Industry Department	2.35

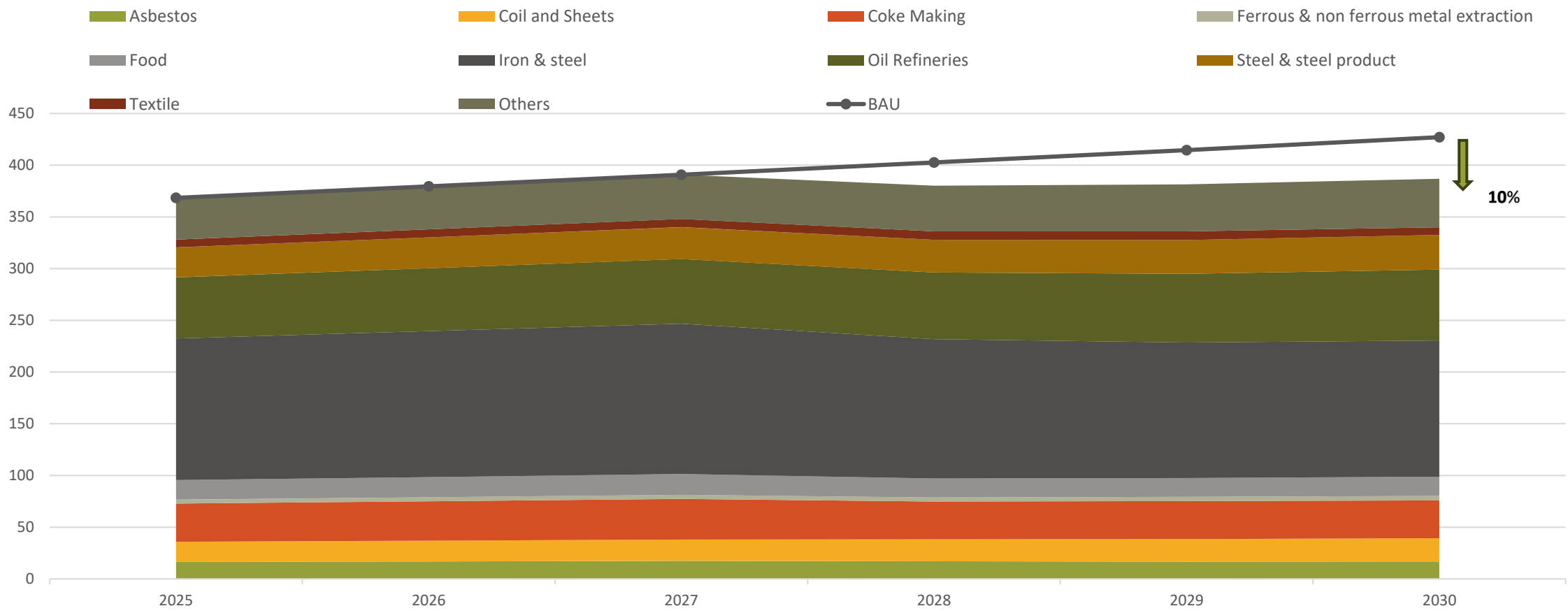
Capacity Building

Control Measures	Implementing Agencies	Cost Incurred (Cr.) (Gov)
Dashboard for real time monitoring of fuel usage, LCS data and others	PCBA	0.78
Portable stack monitoring kits for PCBA field teams LCS to install in highly polluted regions	PCBA	1.10 to 1.20
Total Cost of Implementation for 5-yr (in Cr)	**25 – 35 Cr. (Cost to industry: 20 -20 Cr., Cost to government: ≈5 Cr.)**	

* Cost reflects establishing new industries with updated technology, while PNG infrastructure is already available in Guwahati and continuing to expand.

Emission Reduction Potential – Industries

Figure 4.8.5: Emission Reduction Scenario - Industries



4.8.5 Implementation Pathway

2026

- Mandate CEMS and deploy LCS around high-emission clusters
- Begin strict inspections and APCD enforcement
- Start coal phase-down in small industries
- Launch real-time dashboard to track industry emissions

2027

- Shift boilers in food units to briquettes/PNG
- Enforce dust suppression and enclosures in all polluting industries

2028

- Steel units convert to induction furnace
- Relocate non-compliant units to industrial zones
- Expand PNG network and reduce coal availability

2029

- Integrate CEMS–LCS systems with automated shutdown triggers.
- Conduct annual third-party audits for all major sectors
- All Plants to have suggested APCDs Installed & audit mechanism

2030

- Complete coal phase-out in all major industries
- Maintain continuous ambient monitoring in clusters
- Use real-time dashboard for compliance alerts and rapid response

Emission Reduction Potential – 10 -15%

4.8.6 MRV Structure

Activity / Strategy	Monitoring (M)	Reporting (R)	Verification (V)
Baseline Technology Inventory	Build a verified register of all units with existing kiln/furnace/oven type, fuel, APCDs, and capacity	Annual compliance dashboard with list of units lacking APCD details, gaps in disclosures or fuel reporting	PCBA field verification; cross-checking environmental statement with on-site inspection findings
Fuel Use Monitoring (Coal, Biomass, PNG, HSD)	Collection of Quarterly fuel-consumption logs from industries	Quarterly fuel-use summary by sector showing shifts (coal→ briquette /PNG, HSD→PNG)	Random fuel-storage audits; verification of invoices, and furnace/boiler operations
Technology Transition Tracking (Kilns, Furnaces, Ovens)	Track transition to zig-zag kilns (brick), rotary kilns (cement), improved coke ovens, induction furnaces (steel) Monitor CEMS/LCS trends for emission drops	Annual technology-transition report with before-and-after pollution levels and percentage change	On-site verification by PCBA
Continuous Monitoring & Alerts	Real-time CEMS and LCS dashboards, exceedance alerts	Quarterly CEMS-LCS performance summary and exceedance logs	Third-party calibration and certification of CEMS; PCBA review of alert-response actions

4.8.7 Key Highlights

- Total PM10 emissions from the industrial sector are estimated at **386 tonnes per year**.
- **Iron and steel units** alone account for about **34 percent** of this load, largely due to coal-fired furnaces.
- **Coke-making units** and the **refinery** contribute roughly **6** percent and **16** percent, respectively.
- **Significant reporting gaps** remain across several sectors; many units do not disclose their fuel use or APCD configuration, pointing to weak compliance and limited monitoring .
- **Coal dependence** is still high, especially among steel units and small-scale boilers.
- A shift to cleaner technologies and cleaner fuels could realistically **reduce industrial PM10 emissions by at least 10** %.
- Most transition costs will fall on industry operators, while PCBA and industry associations will need to invest in low-cost sensors, monitoring dashboards, and stronger compliance systems.

Cost Incurred by the government

Table 5.1.1 :Cost Breakup Incurred by government in Various Sectors

Sl. No	Sector	Government Total (Cr.)	Private Total (Cr.)
1	Residential Cooking	64	9
2	Residential Heating	118	5
3	Commercial Cooking	25	36
4	Open Burning of Solid Waste	95.3	88.8
5	DG Sets	10	56
6	Dust Mitigation	277 – 290	-
7	Transportation	1,284 – 1,374	
8	Industries	5	25-35
Total		**1875 - 1982**	

Under National Clean Air Program, INR 52.82 Cr released, and 33.42 Cr utilized until 2025

The total estimated cost of implementation for Guwahati is around INR 2000 cr.

Conclusion

The study identifies open waste burning, residential cooking and heating, commercial eateries, road dust, transport emissions, and industrial activities as the dominant contributors to air pollution in Guwahati. Ward-level surveys, emission estimation, and hotspot mapping indicate that targeted, phased interventions when implemented through coordinated inter-departmental efforts can significantly reduce $PM_{2.5}$, PM_{10}, and black carbon emissions. Key measures for long-term emission reduction include clean-fuel transitions in households and commercial cooking, strengthened enforcement in industries, mechanised road sweeping, improving public transportation and improved traffic management.

Open Burning:

- Residential cooking and heating are among the major sources of air pollution in the city. Despite an LPG penetration rate of 96%, fuel stacking remains a significant practice. The combined $PM_{2.5}$ emissions from residential cooking and heating are the highest among all sectors, estimated at approximately **435 tonnes per year**.
- Commercial cooking activities predominantly use LPG; however, the use of solid biofuels (SBF) contributes substantially to $PM_{2.5}$ emissions. Emissions from commercial cooking are nearly comparable to those from diesel generator (DG) sets, at around **22 tonnes per year**.
- The city's solid waste treatment capacity requires significant enhancement, as currently only about **50% of the generated waste is being treated**. To achieve full treatment coverage, Guwahati requires an additional **399 tonnes per day (TPD)** of waste processing capacity.
- Citywide waste burning is estimated to emit approximately **122 tonnes of $PM_{2.5}$** and **22 tonnes of black carbon (BC)** in 2025.
- Additionally, methane emissions resulting from improper landfill management are estimated at **5,983 tonnes in 2025**, equivalent to approximately **168 kilotonnes of CO_2 emissions**.
- Expanding the number of LPG kiosks in slum areas and hilly regions will play a critical role in reducing fuel stacking and significantly lowering $PM_{2.5}$ emissions.

Industries:

- As the National Clean Air Programme focuses on pollution sources within city boundaries, the study considered only industries located within the Guwahati city limits. Approximately **47 industrial units** are operational within the city boundary, with **iron and steel, oil refineries, and ferrous and non-ferrous metal processing units** identified as the major polluting industries.
- In addition, around **545 industrial units** are operational in the Kamrup Metropolitan Region. Considering prevailing meteorological parameters, emissions from these units also contribute to air pollution levels within Guwahati city.
- Industries located within the city boundary contribute approximately **396 tonnes per year (T/yr) of SO_2 emissions**, followed by **370 T/yr of PM_{10} emissions**. This emission profile indicates a **high sulphur content in the coal used for industrial fuel combustion**.
- To strengthen monitoring and compliance, it is recommended that the **Continuous Emission Monitoring System (CEMS)** be mandated for **small RED-category industries** as well.

Cont.

Transportation and PUC system:

- High number of privately owned vehicles in the city contributes to congestion. Inadequate public transport systems and supporting infrastructure are key contributors to urban air pollution.
- City needs to increase the deployment of small-sized electric buses, improve road infrastructure, strengthen the rail network for local travel, and promote the use of electric buses for shared commuting by government offices. The PUC system needs to be strengthen by – regular audits, training manpower, and following CPCB protocols for testing
- Introducing small trains or enhanced suburban rail services for local commuting can further reduce travel time, ease traffic congestion, and lower transport-related emissions.

Dust from Road, Construction and open lands:

- Extensive construction of flyovers and bridges in the city has contributed significantly to dust emissions - construction activities, use of heavy tools and machinery, open storage of construction materials along roadsides, and the absence of proper barricading or green covers to contain dust.
- The Brahmaputra riverbed on the northern side of the city also contributes to natural dust resuspension. Improved soil stabilisation measures and increased green cover along the riverbanks are required to mitigate this source.
- Green cover on open and barren patches across the city to reduce dust generation. Use of geo-synthetics, recycling of dust collected in the city to make blocks for end-to-end paving, pay and use facility for C&D waste, and COORDINATION of various agencies with PWD is crucial.

Diesel Generators:

- Large diesel generator (DG) sets are predominantly used in industrial zones, commercial hubs, and a few high-rise residential buildings.
- On average, the city experiences around **1.5 hours of power outages per day**, which increases to approximately **2–3 hours during the summer season**.
- Black carbon emissions from DG sets contribute an estimated **21 tonnes per year (T/yr)**.
- To reduce reliance on DG sets in both commercial and domestic sectors, the city should promote **phased adoption of solar photovoltaic (PV) systems** and other reliable clean energy solutions to ensure sustained power supply.

Awareness and outreach activities:

- Community involvement is key to improving air quality. Empowering ward officials, self-help groups, and local communities can help ensure better compliance, support monitoring on the ground, enable quick reporting of violations, and build shared responsibility for clean air.
- Improving institutional capacity, using digital tools such as geo-tagged reporting and dashboards (public redressal system), and strengthening coordination between departments for effective monitoring, blind audits, and capacity building of ground-levels karamcharis for improving the health of the city and citizens

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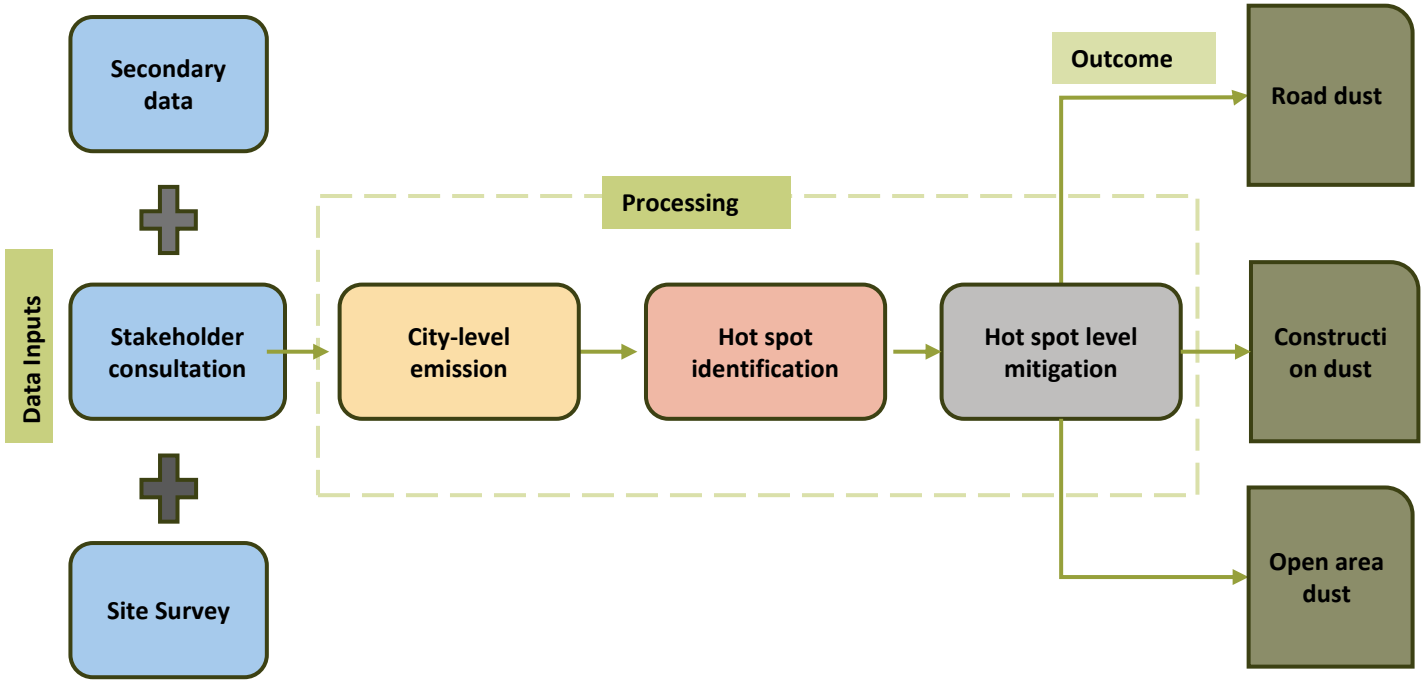
Annexure

A) Methodology

Methodology: Dust Mitigation Plan

- ❑ Emission estimates from the Emission Inventory (EI) and Source Apportionment (SA) of the IITG report were taken as input
- ❑ Field surveys, interviews, and stakeholder discussions for identification of locations with intense dust emission.
- ❑ Hotspots were identified using survey inputs, EI/SA data, and stakeholder information and action plans are suggested at hotspot level for each major dust source.

Figure: Development of Dust Mitigation Plan



Methodology: Emission Estimation

Sector	Formula	Variables	City Level Emissions
Residential and Commercial Cooking	$E_i = \sum_k N_j \times F_k \times EF_{i,k}$	▪ N_j = Number of households / establishments in stratified category j ▪ F_k = Fuel usage by type k ▪ $Ef_{i,k}$ = Emission Factor for pollutant i and fuel type k	▪ Unit fuel consumption for residential and commercial categories and prevalence of fuel use were derived from primary surveys. ▪ City-level emissions were estimated using secondary data on population, vendor numbers, and category-wise distributions. ▪ Residential stratification: slum, mixed, and hilly settlements. ▪ Commercial stratification: formal establishments (restaurants, hotels) and informal vendors (open eateries, small stalls).
Residential Heating	$E_i = \sum_i^n (N_i \times F_i \times EF_i)$	▪ Ni Number of households or devices using fuel type or heating appliance i ▪ Fi Average daily fuel consumption per household/device per week ▪ EFi PM2.5 emission factor for process i (eg. g/kg of fuel)	▪ Number of heating requirement hours and prevalence of heating need were estimated from the surveys. ▪ City emissions were estimated from the secondary data collected (household and population) from various stakeholders.
Open Waste Burning	$E_i = \sum_j Q_j \times EF_i$	▪ Q_i = Quantity of waste burnt in stratified category j (kg) ▪ EF_i = Emission Factor for pollutant i for waste burnt (g/kg)	▪ Stratification considered : Slum, commercial, hilly settlements, mixed-residential ▪ Ward classification and land use for stratification was considered from GMDA master plan ▪ Quantity of waste burnt per incident was estimated through Transect survey
Industrial Emission	For industries with fuel usage data $E_i = \sum F_j \times EF_i$	▪ Ei = Total emission of pollutant i (T/yr) ▪ F_j = Fuel (type j) ▪ EF_i = Emission Factor for fuel type i (kg/T)	▪ Industrial fuel use, operating hours, and process details were collected through primary industrial surveys. ▪ Additional insights on enforcement challenges, regulatory gaps, and compliance levels were gathered from interviews with policymakers and officials. ▪ Secondary data from PCB records provided fuel estimates (CTO/CTE forms), geotagged industry inventory, and category-wise classification of registered units. ▪ Combined datasets enabled stratification of industries by type, scale, and pollution potential for emission estimation.
	For industries with no available fuel usage data $E_c = E_s \times \frac{I_c}{I_s}$	▪ E_c = Emission load of the considered industry ▪ E_s = Emission load of a similar industry ▪ I_c = Investment of the considered industry ▪ I_s = Investment of the reference/ similar industry	

Methodology: Emission Estimation (Cont.)

Sector	Formula	Variables
Landfill CH4 Emission	$CH_4\ generated\ in\ year\ T = DDOC_{m,decomp\ T} \times F \times \frac{16}{12}$	• **Lo = CH4 generation potential, Gg CH4** • F = Fraction of CH4 generated landfill gas (volume fraction) • 16/12 = Molecular weight ration CH4/C (ratio) • DDOCm = Mass of decomposable DOC deposited, Gg • W =Mass of waste deposited, Gg • DOC = Degradable organic carbon in the year of deposition, fraction, Gg C/Gg • $DOC_{f\ =}$ Fraction of DOC that can decompose (fraction) • MCF= CH4 correction factor for aerobic decomposition in the year of decomposition (fraction) • T=Inventory year • $DDOC_{ma,T}$= DDOCm accumulated in the SWDS at the end of the year T, Gg • $DDOC_{ma,T-1}$=DDOCm accumulated in the SWDS at the end of the year T-1, Gg • $DDOC_{md,T}$=DDOCm deposited in the SWDS in the year T, Gg • $DDOC_{m\ decomp,T}$=DDOCm decomposed in the SWDS in the year T, Gg • k=Reaction constant, $k = \ln(2)/t_{1/2}$ (y^{-1}) • $t_{1/2}$=Half life time (y)
	$DDOC_m = W \times DOC \times DOC_f \times MCF$	
	$CH_4\ generation\ pontential, L_o = DDOC_m \times F \times \frac{16}{12}$	
	$DDOC_{ma,T} = DDOC_{md,T} + \left(DDOC_{ma,T-1} \times e^{-k}\right)$	
	$DDOC_{m\ decomp,T} = DDOC_{md,T-1} \times \left(1 - e^{-k}\right)$	

Survey Methodology

Transect Survey

- Transect routes were selected based on land-use categories (hill settlements, commercial, residential, slums) identified through field visits, research papers, and the GMDA Master Plan
- Transects were walked/driven for 3 days during morning and evening to identify open-burning incidents
- Each incident was recorded with GPS location, estimated waste quantity, time, and probable cause
- Burning frequency and total waste burned were estimated by converting these observations to ward-level totals
- Emissions were calculated using total waste burned, waste composition, and standard emission factor

Residential Survey

- **Disproportionate stratified random sampling** to reflect settlement typologies: Formal–Plain/Mixed, Slum/Informal, Hilly Settlements
- **Target sample size**: 400 households (120 formal, 140 slum, 90 hilly, 50 peri-urban).
- **Geographic Coverage**
  - **Slum/Informal clusters (LIG areas)**: Rajabari, Athgaon, Manipuri Basti, Fatasil, Tokobari, Lakhtokia, Santipur East, Gandhibasti, etc.
  - **Hilly wards**: 8, 12, 13, 27, 34, 35, 38, 40.
  - **Flood-prone areas flagged**: Anilnagar, Nabin Nagar, Chandmari, Khanapara, Boragaon, etc.
- **Key Data Collected**
  - Fuel type & monthly quantity (LPG, wood, kerosene, dung, crop residue).
  - Cooking behaviour: frequency, duration, seasonal changes.
  - Heating practices during winter (fuel, appliance, location – indoor/outdoor).
  - Waste handling & open burning practices

Commercial Survey

Sampling Approach

- **Stratified commercial categories**:
  - Informal eateries: tea stalls, momo stalls, fast food, ice cream vendors.
  - Formal small-scale eateries: restaurants, bakeries, sweet/meat shops.
  - Large establishments: hotels, banquet halls.
- **Sampling method**:
  - Random-walk in market clusters (informal).
  - Zone-wise random sampling (formal).
  - Purposive sampling (large establishments).
- **Geographic Coverage :** Major commercial hubs: Fancy Bazaar, Pan Bazaar, Paltan Bazaar, Chandmari, Beltola, Ganeshguri, Six Mile, Zoo Road, Lokhra, Maligaon, Khanapara, Basistha, Uzanbazar, Bhangagarh.
- **Key Variables Measured**
  - Fuel type: LPG, kerosene, charcoal, coal, wood, electricity.
  - Fuel quantity and cooking hours/day.
  - Type of cooking device: LPG stove, tandoor, open grill, mud stove, induction/electric.
  - Presence/absence of any filtration or ventilation structure.
  - Waste handling

Survey Locations

Figure 1 : Map Showing All Transect Routes Surveyed

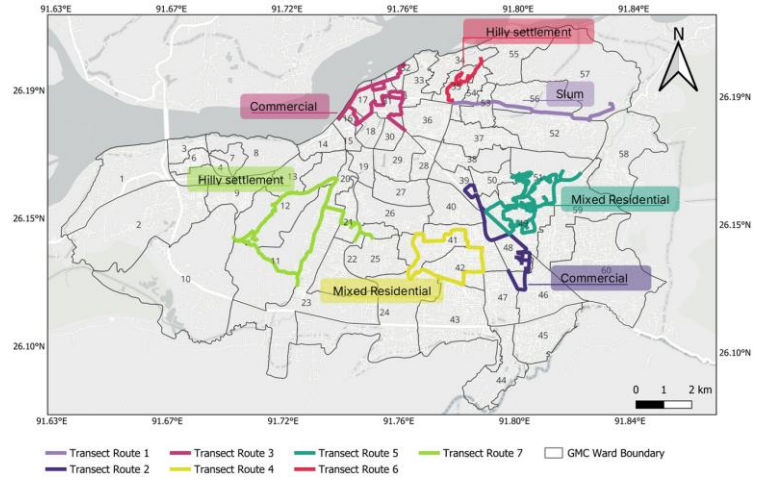


Figure 2 : Map Showing Industrial Clusters

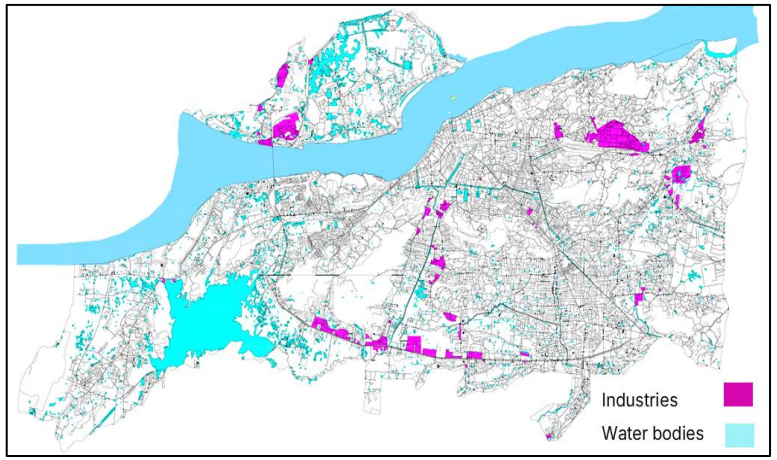


Figure 3 : Map Showing All PUC Sites Surveyed

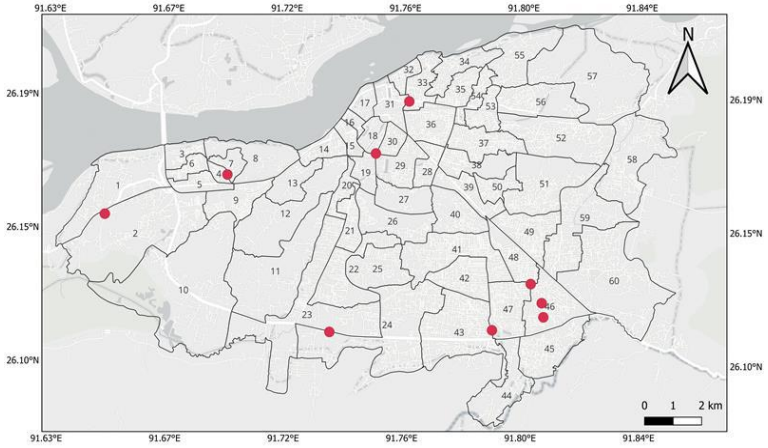
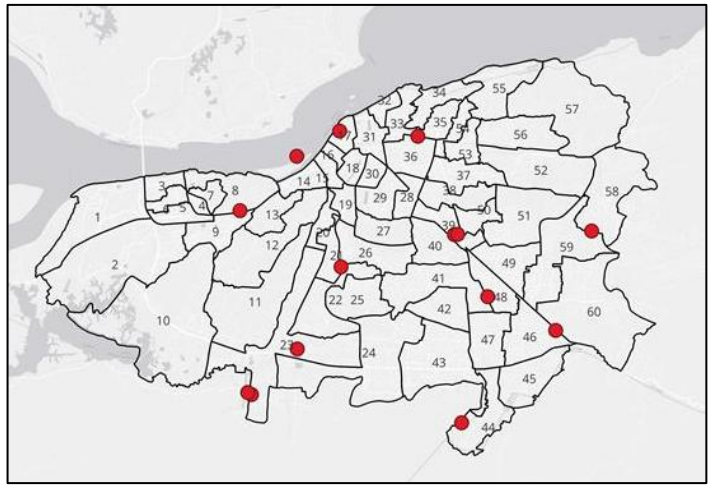


Figure 4 : Map Showing All Construction Sites Surveyed



Notes

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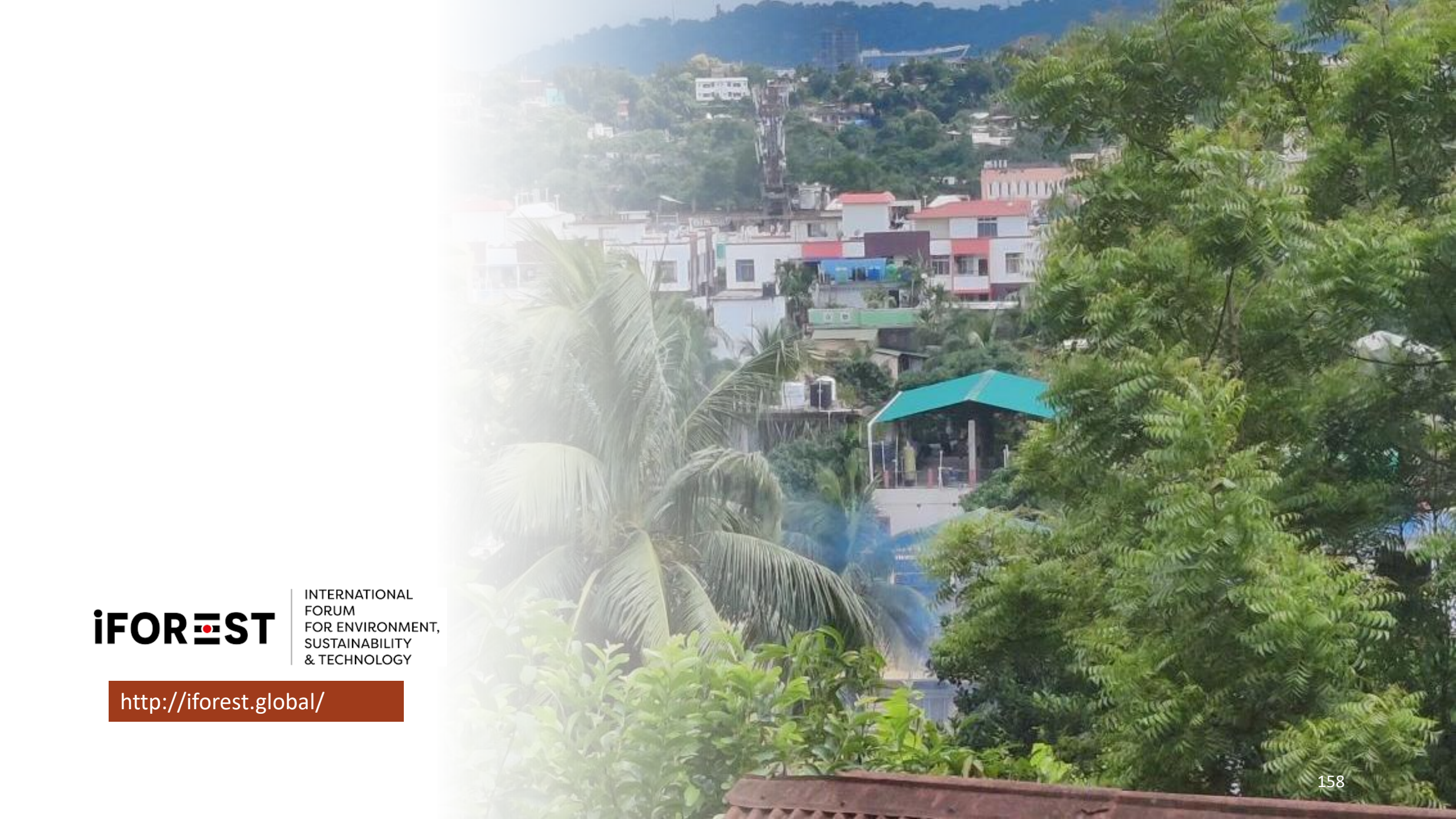

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