JANAAGRAHA

Air Quality in Indian Cities

An Assessment of Outcomes of the XVth Finance Commission Funding for Cities with Learnings and Recommendations

Janaagraha is a Bengaluru-based not-for-profit institution working to transform the quality of life in India's cities and towns. It defines quality of life as comprising quality of infrastructure and services, and quality of citizenship. To achieve its mission, Janaagraha works with councillors and citizens to catalyse active citizenship in city neighbourhoods, and with governments to institute reforms to city-systems. Janaagraha has worked extensively on urban policy and governance reforms for over two decades, including on JnNURM, and with XIII, XIV, XV Finance Commissions, and the Comptroller and Auditor General of India. Janaagraha's current portfolio of work includes engagements with the XVI Finance Commission, Ministry of Housing and Urban Affairs, NITI Aayog, Capacity Building Commission, state governments of Odisha, Assam, and Uttar Pradesh, and the 5th State Finance Commission of Karnataka.

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This report is an initial output, and the study allows us at Janaagraha to develop city-systems thinking at the intersections of Air Quality, a critical agenda for India, and its citizens and urban local governments.

Contents

Acknowledgements....3
Contents....4
Executive Summary....5
I. Introduction....8
II. Our Approach....16
1. Objective....16
2. Research Questions....16
3. Methodology....17
4. Limitations....19
III. Data - Trends and Overview....21
IV. Primary Data (City-level aggregated) from the Field....28
V. Overall Insights....33
VI. Lessons and Learnings from Global Cities....37
1. Case Study: Beijing....37
2. Case Study: Mexico City....39
3. Case Study: Accra....41
4. Case Study: Paris....42
5. Case Study: London....44
VII. Key Challenges, Pathways and Specific Recommendations....46
A. Challenges in Air Quality Governance: A Diagnostic Framework....46
B. Pathways to Clean Air for Indian Cities....50
C. Recommendations....53
1. Recommendation to CFC and SFCs - Financial Institutions....53
2. Recommendations to MoEFCC and PCBs - Domain Institutions....58
3. Recommendations to State Governments and ULGs – Urban Governance....61
Conclusion....65
Annexure I - Data validation conditions applied to PM10 and PM2.5....66
Annexure II - PM10 reduction targets for 82 non-MPCs....67
Annexure III - Convergence of Schemes of Central/ State Government....70
Abbreviations....71
References....74
A. References for the Report....74
B. References for the Global Case Studies....75

Executive Summary

Air pollution in urban India has now taken centre-stage getting attention from citizens, the judiciary and civil society and the discourse has clearly shifted from a predominantly technical issue to being rooted in coordination, governance and demanding systemic change. There have been significant investments in monitoring infrastructure, research, clean air action plans, and performance-based funding mechanisms such as the National Clean Air Programme (NCAP) and the Fifteenth Finance Commission (XV FC). Nevertheless, despite the increasing focus and funding, air quality in the majority of Indian cities continues to be poor with some of our cities faring the worst globally.

This study started in December 2025 with the **objective of assessing why the outcome-based air-quality funding from the 15th Finance Commission** (XV FC) under a million-plus cities challenge, working with the National Clean Air Program **did not translate into sustained air quality improvements across Indian cities.**

The work started with **secondary analysis** of air quality trends and fund flows under NCAP and XV FC from the Prana portal and other CPCB sources. This was carried out for 130 non-attainment cities (2019 onwards) including the million-plus cities covered by the XV FC air quality grants as well as other non-attainment cities under NCAP. We assessed changes in PM_{10} and $PM_{2.5}$ concentrations, timing and amounts of fund allocation, release, and utilisation. This was to see patterns and plan primary research to select cities as per broad categories of performance. **Domain experts** at National level were also consulted for confirming the research and approaching field study. **Field visits** were then conducted across seven million-plus cities (viz. Patna, Varanasi, Chennai, Mumbai (incl. Navi Mumbai and Thane as part of the Mumbai Urban Agglomeration), Pune, Vadodara, and Bengaluru. In addition to interactions with officials from the cities, SPCBs, and local organizations working on Air Quality, this included an **examination of clean air action plans, emission inventories and source apportionment studies**. The analysis tried to focus on several governance indicators such as inter-departmental collaboration, decision-making processes, and the implementation challenges that cities face.

This prompted inquiry into how other cities across the world have addressed similar challenges, and **global case studies** were conducted (this report has only the summarized versions for reasons of focus), of 5 cities that have shown turnaround results in air quality.

The result was that **the study evolved into a more comprehensive, field-informed evaluation of governance framework, institutional capacity, and incentive structures that influence city-level responses to air quality**

objectives.

It moved beyond technical lacunae (like monitoring stations, data or equipment) to identify structural and administrative bottlenecks that limit the effectiveness of current funding mechanisms.

The lessons were shared in an **expert roundtable** in December 2025 with 27 participants from government, academia, research institutions, philanthropy, and civil society, who engaged on the findings and gave further feedback to improving air quality management and specific focus areas. This report presents a glimpse of the roundtable as well.

The findings and learnings have been revealing, to put it mildly. A central contradiction: while NCAP and XV Finance Commission introduced performance-linked grants to incentivise cleaner air outcomes, **the emphasis of actions taken was primarily driven by utilisation of funds without prioritising impact on air quality improvement or absolute emission load reduction**. A few key learnings:

1. To begin with there was NO correlation between fund utilisation and air quality outcomes. Of 69 cities with usable PM10 data, only 10 cities (14.5%) achieved their reduction targets for 2024-25, whereas 31 cities (45%) encountered deteriorating air quality despite significant spending. Of 32 cities with over 80% utilisation, only 6 achieved targets. The way money is spent is much more important than how much is spent or how quickly it is spent.
2. City-level actions were largely shaped by existing administrative priorities towards visible short term local exposure reduction strategies. Fund utilisation prioritised initiatives that were familiar, visible, and under direct municipal control such as road paving, mechanised sweeping, water sprinkling, and equipment procurement. Air quality grants effectively supplemented routine municipal functions, blurring the line between air pollution management and routine urban service delivery.
3. Air quality management was clearly not yet embedded as a specialised function within most urban local governments. Responsibilities are delegated as additional charge to officials whose primary focus lies in other regular duties. The consultants deputed to cities appointed by CPCB through NCAP funding lacked decision-making authority.
4. Governance remained fragmented across departments. Emission sources beyond municipal jurisdiction like regional industry, power generation, and peri-urban activities have remained largely outside the scope of action despite their significant influence on urban air quality, due to funds going to the ULG only and challenges of reporting and hierarchy.

We crystallize the above challenges in Air Quality Governance into six broad **Challenge areas:**

1. **The Knowledge Gap:** Emission Inventory & Source Apportionment Studies
2. **The Accountability Vacuum:** Emission Sources
3. **The Institutional Void:** Human Resource Capacities
4. **The Implementation Gap:** ULG Actions & Performance Tracking
5. **The Financing Dysfunction:** Fund Usage
6. **The Coordination Failure:** Work with Other Ministries

These are detailed in the report in terms of context, current status in cities and the details of the challenge itself.

Basis the above, we evolved **Pathways to Clean Air for Indian Cities**, and see **three interdependent pillars** that create the conditions for effective governance:

A. Evidence-based Action
B. Institutional Capacity
C. Accountable Governance

The steps under each of the above are detailed in the report

Operationalising the above Framework:

Translating the above three pillars into practice needs specific institutional processes and governance framework. The following operational requirements specify how:

i. Source-Based Accountability
ii. Data-Driven Decision Making
iii. Institutional Permanence
iv. Multi-Level Coordination
v. Transparent Performance Tracking
vi. Performance Measurement Framework

Specific steps under each are detailed in the report.

The report then crystallizes our learnings into **institution-specific recommendations** for Finance Commissions (Union and State), Environment and Pollution control bodies (Union & State), and State Government and ULGs.

A key planned output from this engagement was a formal submission of **recommendations to the XVIth Finance Commission.** This happened in two formats: A. As a part of Janaagraha's larger recommendations on devolutions to urban and focus on governance, and B. independent air-pollution specific recommendations through the public consultation process.

I. Introduction

Air pollution is a major concern for Indian cities as it poses serious public-health risks, undermines quality of life and imposes economic burden by way of lost human productivity. Nearly 200 Indian cities exceed the nationally set standards for concentration of $PM_{10,}$ while more than 100 cities exceed the standards for $PM_{2.5}$ [1]. As India urbanizes rapidly, addressing air pollution becomes essential not only for protecting public health but also for ensuring liveable, economically competitive, and climate-resilient cities.

Air pollution in India comes from a variety of sectors including industries, transport, power, construction, residential, and agriculture. While different studies estimate a varied percentage of contribution from these sectors to ambient air pollution, broader sectors remain the same. Recent studies lists major contributors to $PM_{2.5}$ and PM_{10} as residential combustion (39%) and industries (36%), with transport sector emissions being more concentrated in urban centres[2], while PM_{10} is a result of vehicular emissions (24%), industries (15%), combustion (7%), agricultural activities (6%), fossil fuel combustion (6%), with dust and biomass burning together contributing 42%[3]. The Indo-Gangetic Plain (IGP) region in North India that spans Uttar Pradesh, Delhi, Haryana, Punjab, Chandigarh, Bihar and West Bengal is particularly vulnerable to air pollution, with vehicular emissions, fossil fuel oxidation and residential heating being the leading contributors to $PM_{2.5}$.[4]

In efforts to address the rising air pollution problem across the nation, the National Clean Air Program (NCAP) was launched in 2019 by the Ministry of Environment, Forest and Climate Change (MoEFCC) to improve air quality in 131 cities, identified as non-attainment cities (NAC), where the concentration of particulate matter ($PM_{2.5}$ and PM_{10}) exceeded the nationally set standards or those were highly populated urban centres identified as million plus cities (MPC).

The NCAP was the outcome of a collaborative effort involving multiple stakeholder consultations with other Central Government departments, State Governments, and Local Governments. Later, with the integration of the XV Finance Commission grants, NCAP also became the first instance of performance-based grants being used to reduce air pollution. Initially, NCAP aimed for 20-30% reduction by 2024 in $PM_{2.5}$ and PM_{10} concentration over baseline year 2017. Subsequently in 2022, the

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[1] *Tracing the Hazy Air 2026: Progress Report on National Clean Air Programme (NCAP)*. Centre for Research on Energy and Clean Air (CREA)

[2] Sharma, S., Kumar, A., Datta, A., Mohan, I., Das, S., Mahtta, R., Lakshmi, C. S., Pal, S., Malik, J., (2016). Air pollutant emissions scenario for India. ISBN 978-81-7993-639-9

[3] Unveiling the elemental composition, sources and health impacts of PM10 over the central Indo-Gangetic plain (IGP) of India, Physics and Chemistry of the Earth, Parts A/B/C, Volume 136, 2024, 103752, ISSN 1474-7065, https://doi.org/10.1016/j.pce.2024.103752.

[4] *Study identifies sources, health effects of PM2.5 in Northern India*. The Hindu. (2025, March 3)

target was revised to achieve reduction in PM_{10} level up to 40% or achievement of national standards (60 µg/m3) by 2025-26 compared to 2019-20 baseline levels[5].

(i) History of Air Quality Governance and Financing in India

The turning point for environmental regulation in India came with the establishment of the Central Pollution Control Board (CPCB) in 1974. The control and prevention of air pollution were added to CPCB's powers under the Air (Prevention and Control of Pollution) Act, 1981 (Air Act). Judicial interventions by courts, prompted by civil society mobilisation have also played a key role in bringing about regulatory change

The first national ambient air quality standards (NAAQS) were introduced in 1981, later amended in 1994 and 2009. The NAAQS sets the permissible concentrations of different pollutants beyond which the air quality is considered to cause adverse impacts on public health, vegetation and property by CPCB[6]. Cities which exceed the NAAQS for 5 consecutive years and have a minimum of 3 air quality stations are identified as Non-Attainment cities (NACs), and 123 such NACs are under NCAP.[7]

Information about the pollution concentration through accurate measurement is key to planning an effective mitigation strategy. The CPCB initiated the National Ambient Air Quality Monitoring Programme (NAMP) in 1984, a nation-wide network of ambient air quality monitoring[8]. India's network presently consists of 996 manual and 556 Continuous Ambient Air Quality Monitoring stations[9] (present, covering more than 500 cities in 28 States and 7 Union Territories (UT). Of the 131 cities under NCAP, only 102 have installed CAAQMS (as of January 2026). Data from these monitors reveals that PM_{10} and $PM_{2.5}$ levels[10] across most Indian cities, with particular focus on areas lying in the IGP.[11]

With respect to the regulation of industries, CPCB has classified total 419 industrial sectors and sub-sectors under Red (125), Orange (137), Green (94), White (54) and Blue (9) categories based on a methodology that focused on polluting potential and gave equal weightage to all three pollutant groups - Air, Water, and Waste. The State Pollution Control Boards (SPCBs)/ Pollution Control Committees (PCCs) were directed to adopt this classification, and the industries have been directed to install

[5] Press Information Bureau. MoEFCC. March 23, 2023
[6] National Ambient Air Quality Status & Trends 2019. Central Pollution Control Board, MoEFCC.
[7] Strategies to control the rising pollution in the country. Press Information Bureau. December 07, 2023
[8] The NAMP monitors four main pollutants i.e. Sulphur Dioxide (SO2), Oxides of Nitrogen as NO2, Respirable Suspended Particulate Matter (RSPM / PM10) and Fine Particulate Matter (PM2.5).
[9] Ambient Air Quality Monitoring Network (Manual) under NAMP as on 19.11.2024 as listed on CPCB's website and CAAQMS tracked on Central Control Room for Air Quality Management - All India portal.
[10] Ibid.
[11] National Clean Air Program. Ministry of Environment, Forest & Climate Change Government of India, 2019

online continuous emission/effluent monitoring system and ensure connectivity of data to SPCBs/PCCs and CPCB servers.[12]

(ii) Funding air quality outcomes: Road to XV FC's performance-based grants

MoEFCC administers the CoP scheme (introduced in 2018) and utilises funds allocated thereunder under the Union Budget. These funds flow primarily to CPCB and to state PCBs to support pollution monitoring and mitigation efforts, and accounts for about 25% of MoEFCC's total allocation. However, the utilisation for FY 2024-25 was less than 1%.[13]

With the NCAP, the focus moved to cities as centres of action for implementing air pollution measures, by creating a channel of funding via Finance Commission (FC) grants.

Historically, FC grants to ULGs began as largely unconditional. A significant turning point came with the XIII FC, which introduced a two-tier grant structure for ULGs:

1. Basic grants (65%), continuing the untied tradition, and
2. Performance grants (35%), linked to compliance with nine reform criteria.

Performance-based grants are allocated to ULGs based on their achievements against pre-defined benchmarks in key areas like sanitation, education, or fiscal management. These performance grants, while untied in usage, were conditional on states and ULGs meeting procedural and institutional reform requirements. The Ministry of Housing and Urban Affairs (MoHUA) observed that these rigid conditions led to poor absorption and thereafter recommended a shift toward outcome-based performance measures focused on revenue, productivity, and service delivery rather than complex procedural compliance.

The XV FC marked a paradigm shift by introducing a differentiated grant architecture based on ULG typologies, acknowledging that metropolitan cities face different challenges and opportunities from smaller towns. The XV FC sought to tailor grant mechanisms to different ULG sizes with a focus on improving service delivery outputs. Recognizing India's urban heterogeneity, it classified ULGs into:

- Category I: Urban agglomerations or cities with a population exceeding one million (MPCs); and

[12] CPCB Directions under section 18(1)(b) of the Water (Prevention & Control of Pollution) Act, 1974 and the Air (Prevention & Control of Pollution) Act, 1981 regarding harmonization of classification of industrial sectors under Red, Orange, Green, White and Blue categories dated February 12, 2025. CP-18/1/2023-IPC-VI-HO-CPCB-HO.

[13] *Environment Ministry spent less than 1% of Rs 858 crore pollution control fund in 2024-25: "shocked" parliamentary panel calls for introspection*. The Indian Express. (2025, March 25).

- Category II: Cities and towns with a population below one million (Non-Million-Plus cities or NMPCs).

MPCs received 100% performance grants tied to outcome- improvements in air quality, water, and sanitation. This marked a departure from the one-size-fits-all approach of previous FCs and aligned with the vision of metropolitan areas under Article 243P of the Constitution (74th Amendment Act, 1992).

(iii) Air Quality grants - Review of grant design and architecture

For FY 2020-21, the XV FC recommended INR 4,400 crores for improving ambient air quality, which was to be released in two equal instalments:

- First instalment to be used for air quality improvement measures, including capacity building of ULGs within the MPCs/ UAs, and for meeting additional needs of SPCBs to assist ULGs in monitoring the ambient air quality.

The XV FC also recommended that the MoEFCC should expedite the establishment of an ambient air quality monitoring network, ensure source apportionment studies and periodic updating of air quality data for the MPCs.

- Second instalment was to be released based on year-on-year improvement in air quality[14]

For the five-year award period (FY 2021-22 to 2025-26), the XV FC recommended that INR 12,139 crore be earmarked for Ambient Air Quality under the Million-Plus Cities Challenge Fund (MCF), with release of grants linked to the performance of the MPCs/ UAs in reducing air pollution.

Initially, the city-wise distribution/ allocation of grants was recommended based on population levels as per Census 2011. For the first financial year of the grant period (2021-22), cities/UAs were required to put in place air quality improvement measures, including capacity building of the local bodies within the MPC/ UA.

(a) Performance criteria for evaluating grant eligibility

The assessment of city performance on air quality was based on four parameters (with different weightage for 2021-22 and 100% weightage to parameter (D) from 2022-23 onwards)[15]:

A. Strengthening of pollution monitoring mechanism

[14] Fifteenth Finance Commission. *Report for the Year 2020-21*. November 2019

[15] Operational guidelines for implementation of Ambient Air Quality grants to Urban Local Bodies issued by Department of Expenditure (FC Division) dated August 10, 2021. No. 15(2)FC-X V/FCD/ 2020-25.

B. Source-wise cause analysis for air pollution
C. Progress on action plans and compliance of statutory guidelines
D. Quantification of air quality improvement

Under Parameter (D), improvement in air quality is quantified through two core criteria which are:

(i) Reduction of PM_{10} concentration by 15%, and
(ii) Achieving more 'good air quality days', i.e. days with Air Quality Index (AQI)< 200.

Based on their grading (as 'High' or 'Low') on the above 2 metrics, a combined performance factor for Air Quality is evaluated for the cities/ UAs as follows:

Reduction in PM_{10}	**Increase in good air days**	**Performance Factor**
High (≥15%)	High (≥15%)	100
Low (<15%)	Low (<15%)	75
High (≥15%)	High (≥15%)	50
Low (<15%)	Low (<15%)	25

Based on their above performance factor scores, funds would be released proportionally to cities each year during the award period.

(b) Role of MoEFCC as nodal Ministry

MoEFCC is the nodal Ministry for administration of this scheme tasked with the following responsibilities:

- Handhold and monitor ULGs in strengthening the pollution monitoring mechanism and building their infrastructure capacities to control air pollution;
- Formulate the template for tripartite Memorandum of Understanding (MoU) to be executed between MoEFCC, State Governments, and ULGs;
- Setting city-wise and year wise targets for improvement in PM_{10} concentrations in base year 2019-20;
- Schedule periodic submission of proposals by the cities/UAs for their performance assessment;
- Constitute a National level Committee for considering the proposals/recommendation received from the State Level Screening Committees;

- Recommend quantum for city-wise distribution of grants based on consultations with the Ministry of Housing & Urban Affairs (MoHUA), State Governments, and different Committees set up under NCAP;
- Monitor the implementation of the XV FC's recommendations, including utilization of the recommended grants;
- Recommend the distribution of undisbursed grant to eligible cities/UAs as per prescribed procedure.

(c) Fund flow mechanism

The funds are released to the States by the Department of Expenditure, Finance Commission Division on the MoEFCC's recommendation. On receipt of the grants, the State Finance Departments transfer the same to the concerned MPCs/ UAs within 10 working days through the State Urban Development Department.

Conditions to be met by ULGs/ Actions to be taken by States to access XV FC grants

As per the operational guidelines for the MCF, each State Government and ULG had to sign a MoU with the MoEFCC that detailed a year-wise action plan, agreed outcomes to be achieved and the quantum of funds to be released. Such an action plan should contain city-wise details of sources of air pollution and the proposed measures to be taken by them such as deployment of sweeping machines, promotion of non-motorised transport (pedestrian and cycle), etc.

In addition to the performance linked conditions as detailed above, ULBs/ States had to comply with below general entry level conditions as recommended by the XV FC for release of grants[16]:

S. No	Grant Conditions
1	Publish provisional and audited annual financial statements
2	Signing of MoU between State, ULG, MoEFCC
3	Notify property tax floor rates
4	Consistent improvement in collection of property taxes in tandem with growth rate of state's own GSDP (from 2023-24 onwards)
5	Constitution of State Finance Commission and laying of Action Taken Report (ATR) in the state legislature on or before March 2024
6	Linking of ULB account for FC-XV Grant with PFMS or with any other e-governance system fully integrated with PFMS
7	Duly elected local bodies in the state

[16] Operational guidelines for implementation of recommendations of Fifteenth Finance Commission on urban local body grants dated July 28, 2021 issued by Department of Expenditure (FC division), Ministry of Finance. No. 15(2)FC-XV/FCD/ 2020-25

*To be fulfilled by state government

(d) Scheme governance: Monitoring, Evaluation and Reporting

MoEFCC developed a web-based portal 'PRANA' – Portal for Regulation of air pollution in Non-Attainment cities - for online monitoring of NCAP implementation. It supports tracking of physical as well as financial status of the implementation of the city's air action plan and disseminates to the public information on air quality management efforts under NCAP.

Governance framework

- At the **national level**, the following committees/units were envisaged under NCSP:
  - Apex Committee under the chairmanship of the Minister (Environment, Forest & Climate Change) to provide policy direction.
  - Steering Committee under Secretary (EF&CC) and Monitoring Committee under Joint Secretary to oversee implementation of the programme.
- At the **state level**, each state/UT was expected to set up:
  - State Level Steering Committee under the Chief Secretary/Principal Secretary (Environment)
  - State Level Monitoring Committee under the Secretary (Environment) to monitor city CAPs.
- At the **city/district level**, each target city was expected to have:
  - City Level Committee (or Implementation Committee) under the Municipal Commissioner / District Collector to review and implement the City Action Plan.

While the mandated governance structure is multi-tier (national → state → city) with committees and monitoring units, in practice the institutional set-up is uneven, under-resourced, and suffers from weak mandate and coordination. Many states/cities have not fully constituted the committees, or they are not meeting regularly. There is overlap and ambiguity in roles: for example, state PCB vs state steering committee vs city committee – leading to unclear accountability. The lack of a legal mandate for city-action plans under NCAP also leaves enforcement gaps.

(iv) Study Rationale

Despite the progress made under NCAP, India's MPCs continue to experience $PM_{2.5}$ and PM_{10} concentrations far exceeding national standards, posing substantial public health, economic, and environmental risks. While the XV FC's performance-based grants were intended to incentivize scientifically grounded action plans, efficient

institutional coordination, and measurable air quality improvements, the actual effectiveness of these performance-linked financial incentives remains inconclusive. Under NCAP, performance targets were universally set for cities - without factoring in differentiation on account of geography, cities' varying administrative capacities, monitoring infrastructure, and ability to implement multi-sectoral interventions. A systematic evaluation from a governance perspective is therefore necessary to determine whether the XV FC grants have catalysed meaningful progress toward NCAP goals or whether structural, institutional, and technical barriers have limited their impact.

Such assessment is crucial not only for understanding how cities performed against defined air quality improvement metrics, but also for identifying gaps in planning, implementation, and monitoring that may be inhibiting outcomes. By analysing trends in air quality, the utilization of funds, and the enabling conditions that influenced performance across MPCs, this study will generate evidence to inform future financial and governance mechanisms aimed at urban air quality management. As the country prepares for subsequent Finance Commission cycles and continues advancing NCAP objectives, evidence on what worked, what did not, and what will be essential for designing more effective, accountable, and equitable funding frameworks capable of driving sustained air quality improvements

II. Our Approach

1. Objective

This report aims to examine the design and implementation of the Fifteenth Finance Commission's (XV FC) Million-Plus Challenge Fund for air quality management, as well as to develop insights that can be used to shape air quality funding under the Sixteenth Finance Commission's (XVI FC). It aims to identify factors that have shaped city-level actions, fund utilization, and air quality outcomes, as well as to make actionable recommendations to other key stakeholders in air quality governance domain across Indian cities.

The study specifically aims to:

- Evaluate how the XV FC Million-Plus Challenge Fund was structured, accessed, and utilized by cities, as well as how institutional processes influenced its adoption and implementation.
- Examine how funding has translated into on-the-ground interventions towards sustained air quality improvements, with a focus on governance and decision-making mechanisms.
- Highlight both enabling factors and persistent challenges by documenting differences in planning, monitoring, and coordination amongst urban local governments, State Pollution Control Boards and other implementing departments.
- Review financial, governance and institutional mechanisms adopted by cities in the Global North and South to identify lessons that can be adopted by Indian cities towards air quality improvement.
- Outline actionable insights for the Sixteenth Finance Commission, the Ministry of the Environment, Forests, and Climate Change (MoEFCC), Central Pollution Control Board (CPCB), State Governments, State Pollution Control Boards (SPCB) and Urban Local Governments to improve implementation and institutional coordination for cleaner air in Indian cities.

2. Research Questions

- Is there a differentiation in the trends of air pollution levels and financial allocations vs spending between million–plus and non-million plus cities under NCAP?
- Did XV FC funding lead to measurable improvements in air quality? What worked or didn’t in different cities? Why?

- What were the factors that influenced the success or failure of the XV Finance Commission's outcome-based financing in different cities, and how effective was it?

3. Methodology

The analysis uses a diagnostic and mixed-method approach, integrating quantitative analysis, field-based qualitative interviews and secondary literature, institutional frameworks and policy analysis. It further examines how performance-linked air quality grants for cities under the Fifteenth Finance Commission's Million-Plus Challenge Fund have been designed, utilised, and monitored within the larger context of the National Clean Air Programme (NCAP).

The methodology design consists of data-based evaluation, institutional mapping, and city-level analysis, all supported by a comprehensive review of official documents, reports, and secondary literature.

(i) Quantitative Analysis

For all 130 non-attainment cities including the 48 million-plus cities, data from the CPCB, and PRANA portal, along with meeting minutes and reports shared by selected cities as well as available online were analysed.

The following indicators were examined: population, PM_{10} and $PM_{2.5}$ trends since 2017, and financial metrics including allocation, release and utilisation (up to July 2025).

Both population and performance categories (improvement or worsening of PM_{10} and $PM_{2.5}$) were used to categorise cities. Patterns between fund utilisation and air quality outcomes were identified through a comparative analysis.

For data trends analysis of PM_{10} and $PM_{2.5}$, we downloaded the hourly data from CPCB which was further cleaned using following steps:

The data was first cleaned by

- Removing 0 and negative values
- Removing the middle value if middle values if < equal to 50% of previous +next/2
- Removes values above 2000 for PM_{10}
- Removing values for $PM_{2.5}$ and PM_{10} both, if $PM_{2.5}$ values were greater than PM10

Once the primary cleaning of the data was done, the following operations were deployed to remove skewness of data at daily, monthly and annual interval levels:

- Daily average of a station was only calculated if the 75% of the hours in a day had valid data for the station after primary cleaning steps were deployed
- Monthly average of the station was only calculated if the 75% of the days in a month had valid data for the station after primary cleaning steps were deployed
- Annual Average was only calculated as 75% of the months in a year had valid data for the station after primary cleaning steps were deployed while no two consecutive months had missing data in a year.

(ii) City Selection and Field Inquiry

The study conducted in-depth field enquiries to comprehend the institutional, financial, and operational dynamics that underline city-level performance following the preliminary quantitative analysis. To capture the nuances in air quality management, eleven million-plus cities/UAs were chosen based on

- Population size (1 to 2 million, 2 to 5 million, 5 to 10 million and more than 10 million),
- Air quality outcomes (Worsened, Improved (>0 to 30%), Improved (30 –60%), Improved (60-90%)),
- Fund release as a share of fund allocated (<20%, 20-50%, 50-80%, 80-100% and >100%), and
- Fund utilized as a share of fund release (<20%, 20-50%, 50-80%, 80-100% and >100%).

Further, one city amongst the eleven selected cities didn't have a Continuous Air Quality Monitoring Station (CAQMS) and was chosen to represent other 28 cities without a CAAQMS as of July 2025.

In the selected cities, we visited 9 cities (Patna, Varanasi, Bengaluru, Mumbai, Navi Mumbai, Thane, Pune, Chennai, Vadodara) and conducted semi-structured discussions and interviews with key stakeholders, such as State Pollution Control Boards (SPCBs), nodal departments, and parastatals. We further gathered project details and minutes from city-level committees from the cities wherever available and reviewed expenditure data with respect to air quality activities under NCAP and convergence fund subject to availability.

(iii) Institutional and Governance Analysis

To understand the coordination between different tiers of governments and departments, and fund-flow mechanisms, the roles of MoEFCC, CPCB, State

Governments, SPCBs, and ULGs were mapped. The performance criteria and progress monitoring on the ground were examined through data analysis from CPCB, PRANA, the review of minutes of the meetings of existing relevant committees under NCAP and stakeholder interviews and discussions.

(iv) Global Case Studies

We also examined the strategies across cities which are on the trajectory to clean the air or have made significant gains over past decades from both the Global North and South to determine what worked and what didn't and the reasons behind it through secondary analysis of literature. This review offers broader lessons and highlights potential approaches that could inform policy and institutional reforms for urban air quality management in India.

(v) Synthesis and Recommendations

Insights from quantitative analysis, city-level investigation, institutional mapping and global case studies were combined to produce practical insights and recommendation aimed at the XVI Central Finance Commission, the Ministry of Environment, Forest and Climate Change (MoEFCC), the Central Pollution Control Board, State Governments, State Finance Commissions and the Urban Local Governments (ULGs).

These recommendations are aimed at improving fund flow efficiency, inter-agency coordination, and strengthening the outcome-based funding framework for the next phase of air quality management financing.

4. Limitations

- Initially, eleven million-plus cities/UA were chosen, but field visits could only be completed in seven, with Thane and Navi Mumbai covered as part of the Mumbai UA resulting in nine cities being effectively investigated.
- The availability and quality of financial and air quality data varied considerably across cities, affecting the scope and comparability of analysis.
- Critical documents at the ULG level, both primary and secondary, were not uniformly accessible. These included Source Apportionment Studies, minutes of city-level committee meetings, detailed expenditure statements, and data on fund convergence from other schemes.
- No city provided complete documentation across all categories, and the types of missing data varied by location. This inconsistency limited the ability to conduct standardized comparisons and required reliance on available information, supplemented by direct interactions with officials.

- The city selection was done based on the data available till April 2025 further, the secondary analysis is based on data available by November 2025, and further updates may affect utilization or performance estimates.
- While the selected cities constitute a wide sample, the findings are intended to show broader trends rather than reflect each of the million-plus cities covered by NCAP.
- Variation in stakeholder profiles and institutional arrangements across cities affected the uniformity of interviews.

III. Data - Trends and Overview

Analysis of PM_{10} performance of cities under NCAP

We analysed the PM_{10} levels monitored using CAAQMS in 100 out of the 130 cities covered under NCAP (30 cities are yet to have CAAQMS installed). Among these 100 cities having CAAQMS, only 75 reported usable data after the data cleaning/ validation process adopted in our study; of which 6 are clubbed with bigger cities as they form part of UAs, i.e., Navi Mumbai, Thane, Ulhasnagar, Badalapur with Greater Mumbai UA; Raniganj with Asansol UA; and Howrah, and Barrackpore with Kolkata UA. Thus, the assessment of PM_{10} level reductions in the current study has been done for 69 cities/UAs which are tracked and directly funded under NCAP for annual disbursal of the grants (Table 1). The data validation included applying specified criteria to remove anomalies in the reported data and only use continuously available data to enable reliable annual comparison. A summary of the criteria applied is provided in Annexure I.

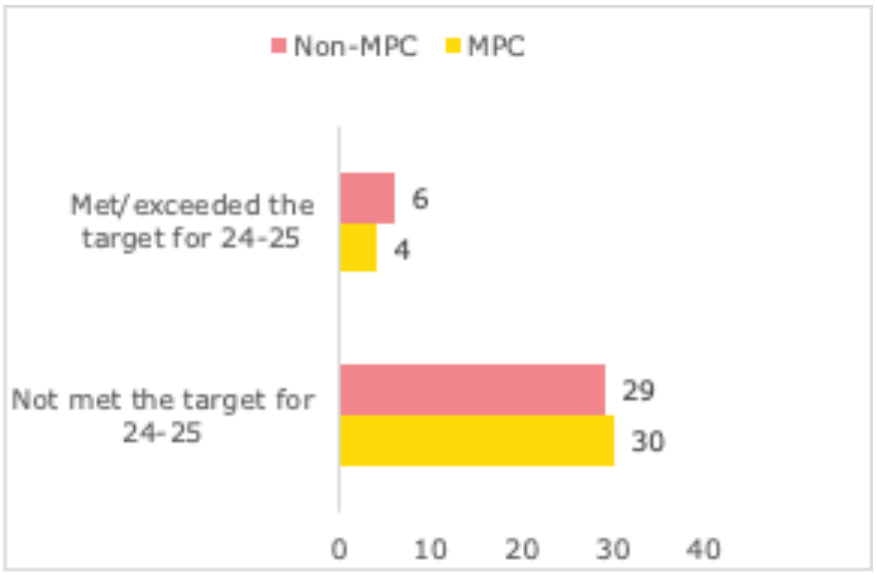
Table 1: PM_{10} data availability and exclusions

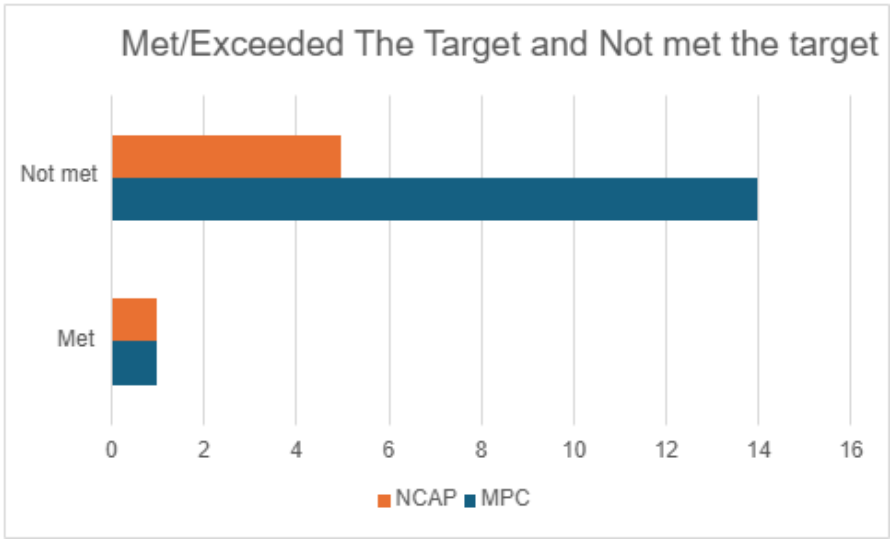
Particulars	**MPC**	**Non-MPC**	**Total**
Total number of cities covered under NCAP	**48**	**82**	**130**
Cities with no CAAQMS	4	26	30
Cities where CAAQMS data did not meet quality checks/ conditions for continuous availability	4	21	25
Cities not separately considered because they form part of UA	6	-	6
Cities where PM_{10} data is usable for final analysis	**34**	**35**	**69**

As part of the assessment under XV-FC grants, the MPCs had to reduce their PM_{10} levels by 15% every year, starting from base year 2019-20. The non-MPCs on the other hand were set targets for reduction of PM_{10} levels for every FY covered under NCAP (reduction targets for 82 non-MPCs is provided in Annexure II). On comparing the respective PM_{10} targets for both MPCs and non-MPCs, only 10 of the 69 cities analysed met or exceeded the target PM_{10} levels. However, 38 cities (21 MPC and 17 non-MPCs) have shown overall decrease in 2024-25 levels when compared to base year 2019-20 (Figure 2.1 and 2.2).

For $PM_{2.5}$, only 23 cities had usable data for PM2.5 in 2019-20 after applying all data cleaning conditions of which only 21 had data for 2024-25, hence the analysis for PM2.5 is limited to those cities. Only 13 of the 21 cities showed improvement in PM2.5 levels in 2024-25 compared to 2029-20. By applying the same reduction targets as those set for PM10, the analysis shows that only 2 of the 21 cities were able to meet/ exceed such targeted levels (Figure 2.1 and 2.2).

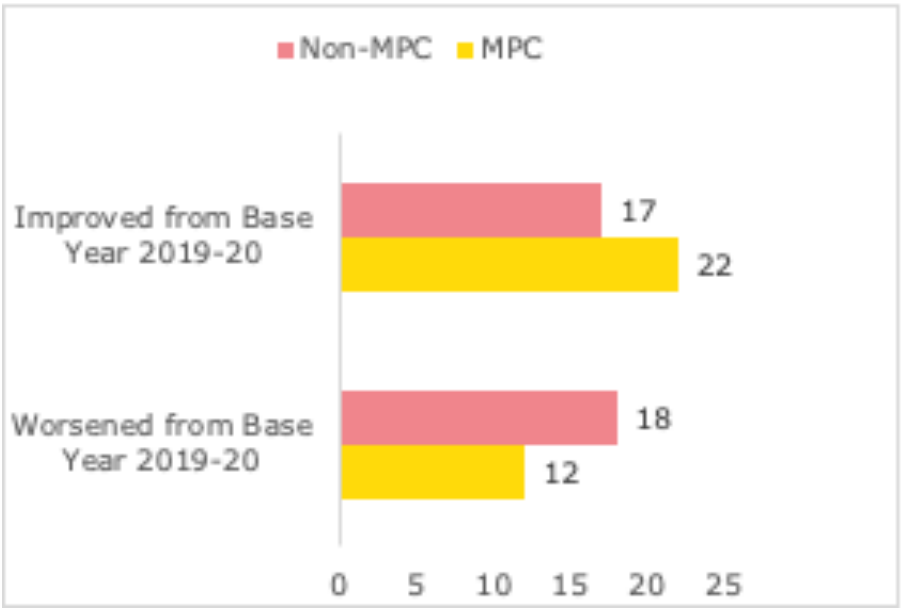
Figure 2.1 - Comparing actual vs target PM_{10} and $PM_{2.5}$ levels for 2024-25

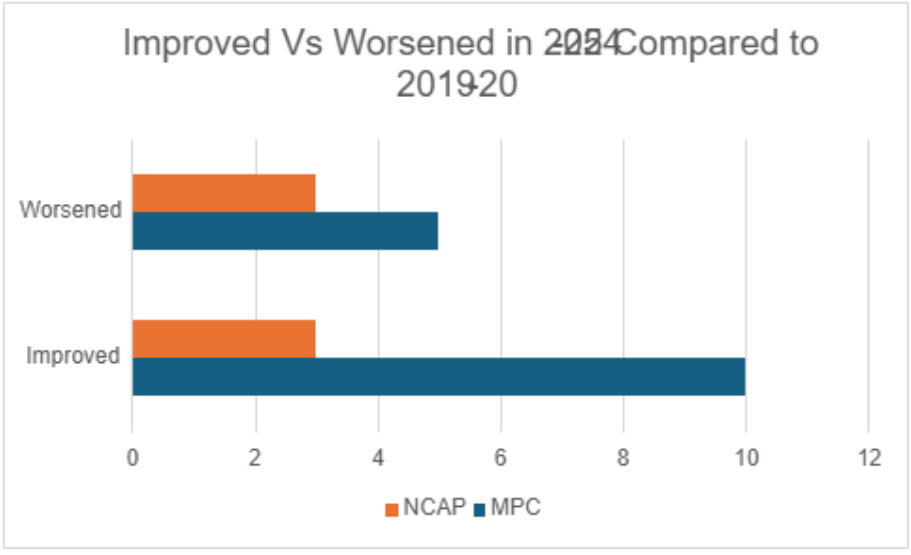




Source: PM10 Data from PRANA Portal and PM2.5 Data from CBCB Dashboard

Figure 2.2 - Comparing PM_{10} and $PM_{2.5}$ levels in 2024-25 with respect to Base Year 2019-20



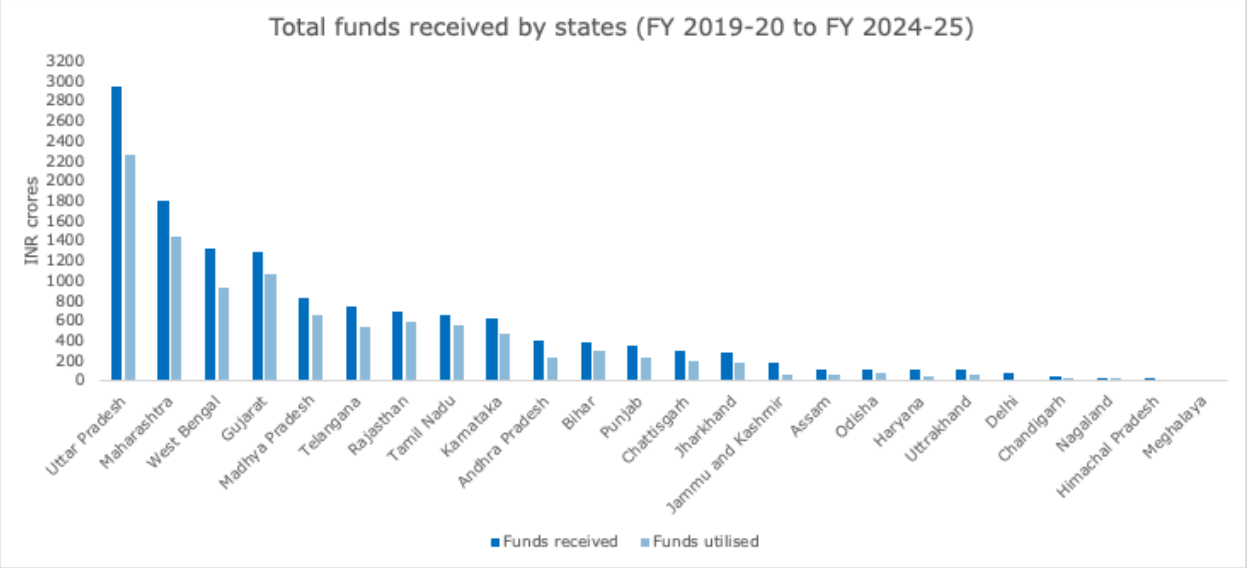


Source: PM10 Data from PRANA Portal and PM2.5 Data from CBCB Dashboard

Analysis of funds utilisation by cities under NCAP

Under NCAP, a total of INR 20,130 crore was allocated from FY 2020-21 till 2025-26, of which INR 16,539 crore was meant for the million plus cities (82%) under MCF (48 cities across 42 UAs) as part of XV FC grants, and remaining INR 3,591 crore (18%) was allocated under MoEFCC's Control of Pollution (CoP) Scheme[17] the remaining 82 cities. Of the allocated amount, INR 13,415 crore (66%) was released to cities (as of September 2025) and only 9,929 crore[18] was the utilized amount.[19] The city-wise breakdown of grant utilisation vis-a-vis funds received is captured in Figure 4 (MPCs) and Figure 5 (Non-MPCs).

Figure 3: State wise release and utilisation of funds



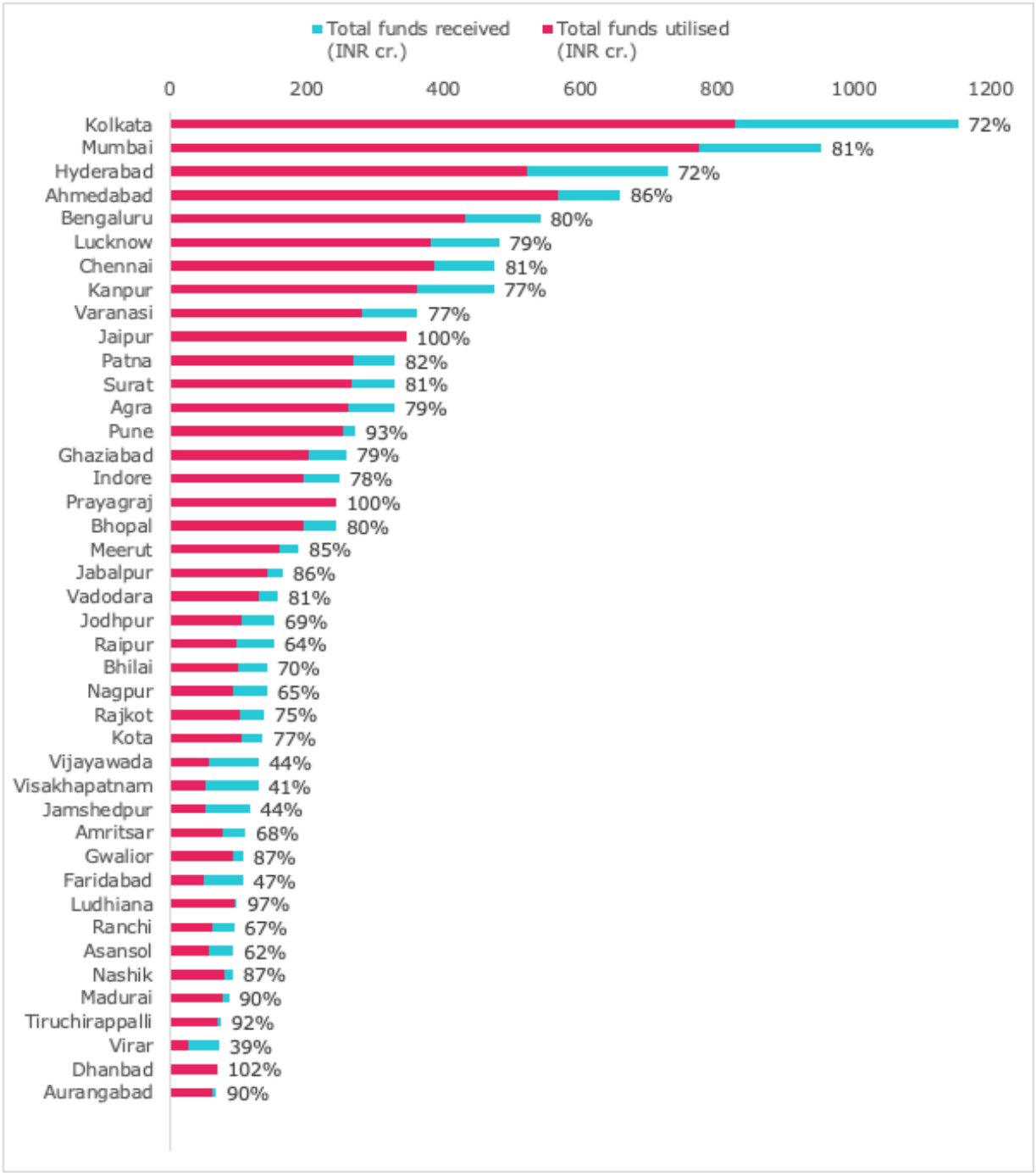
Source: Janaagraha's analysis of city-wise fund received and utilised figures as reported on PRANA portal

[17] Minutes of 15th meeting of NCAP Monitoring Committee dated 15.09.2025

[18] Ibid.

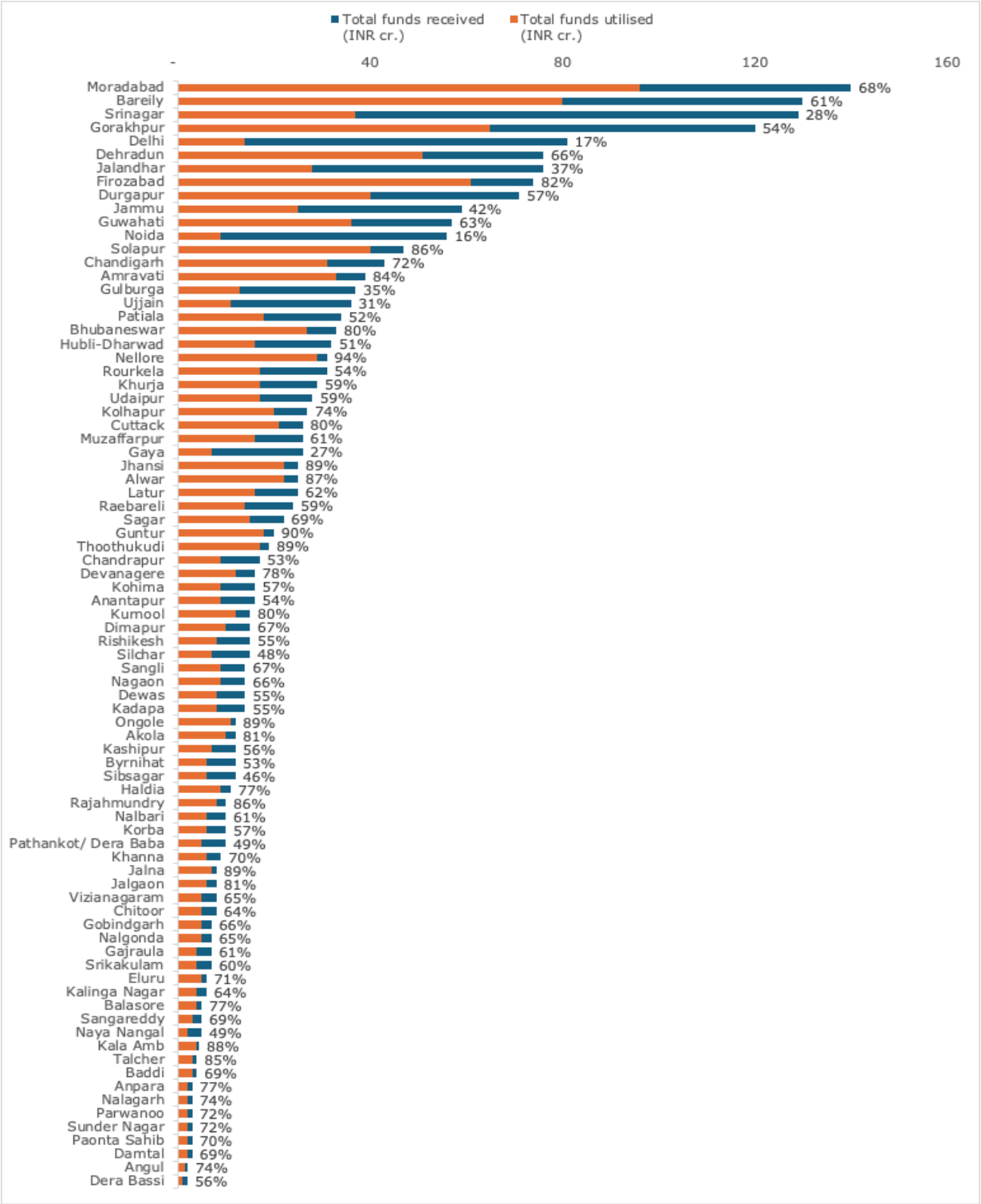
[19] Minutes of 19th meeting of Implementation Committee under National Clean Air Programme held on October 15, 2025

Figure 4: Release and utilisation of funds - MPCs and UAs



Source: Janaagraha's analysis of city-wise fund received and utilised figures as reported on PRANA portal

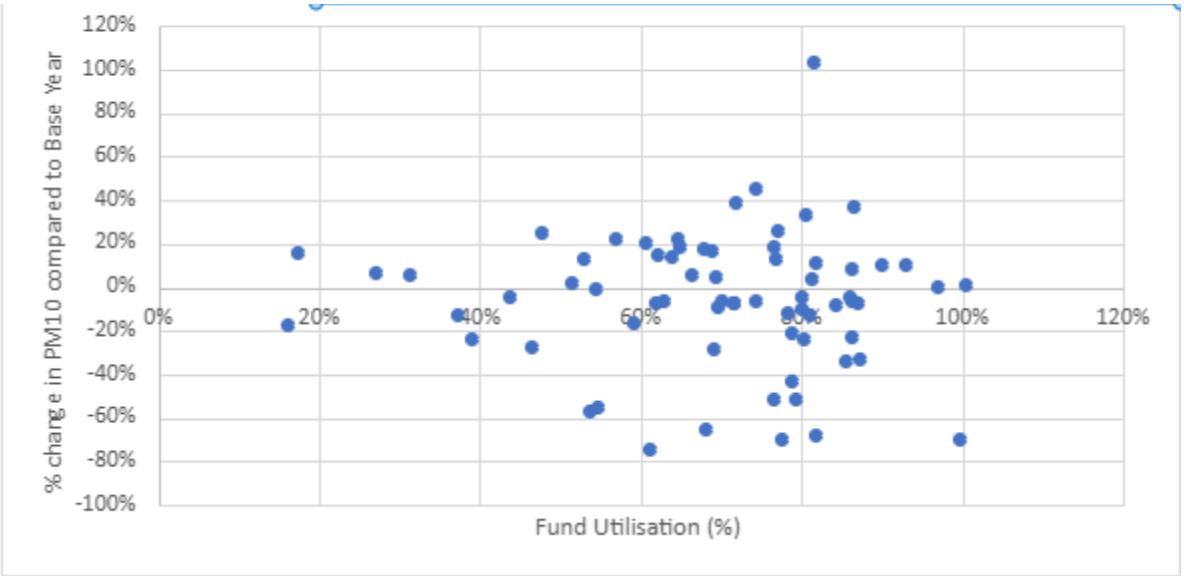
Figure 5: Release and utilisation of funds – Non-MPCs



Source: Janaagraha's analysis of city-wise fund received and utilised figures as reported on PRANA portal

However, the cities with high funds utilisation (as a % of total funds released from FY 2019-20 to FY 2024-25) have not necessarily recorded significant improvement in PM_{10} concentration since base year levels in FY 2019-20 (Figure 6). Thus, there is no clear correlation between funding and outcomes in terms of air quality improvement.

Figure 6: Correlation between fund use and PM_{10} performance – NCAP cities (MPCs and Non MPCs)



In addition to the scheme-specific performance-linked funding from XV-FC and MoEFCC, the NCAP guidelines stipulate that ULGs must mobilize funds through the convergence of resources from various Central Government schemes (refer Annexure III) as well as resources from State/UT Governments and agencies like Municipal Corporations and Urban Development authorities[20]. As of January 2024, it is estimated that INR 4,54,230 crores has been allocated through convergence of such schemes[21]. However, the nature of spending from these schemes is not publicly disclosed and hence does not form part of our analysis.

[20] Overview of NCAP and XV-FC MPCCF and convergence of central schemes/programmes for air quality improvement in identified cities. MoEFCC.
[21] Malhotra, P., Kapur, A., and Rana, T. (2025) Trends in Finances for the National Clean Air Programme, Budget Insights 2024-25, Volume 2 Issue 6, Foundation for Responsive Governance, New Delhi, 6 February 2025.

IV. Primary Data (City-level aggregated) from the Field

The field visit to 7 out of 42 million-plus UAs/cities (Patna, Varanasi, Bengaluru, Mumbai, Pune, Chennai, and Vadodara) along with Navi Mumbai and Thane, that are part of Mumbai urban agglomeration under National Clean Air Programme provides a detailed picture of how air quality actions under the XV FC grants are planned and executed on the ground. The observations are based on interactions with officials from the ULG, SPCB, and other line departments, minutes of meetings of city level committees, budget documents, activities list, and details on fund convergence etc. When seen together, the field insights and data confirm recurring patterns across different cities, regardless of geography, institutional size, or administrative set-up. This chapter consolidates those patterns, focusing on the core questions that guide the larger study: what works, what needs attention, where the bottlenecks are, what needs to be revamped, what needs to be done differently, and what is missing from the existing system to ensure sustainable systematic gains in air quality.

Urban local governments are integral to the current version of NCAP's objective, yet they continue to operate with longstanding structural and institutional constraints. The experiences across the cities demonstrate the efforts put in by the city governments and the practical challenges they faced while implementing the actions to reduce pollution levels.

- **Funding Allocation and Utilization Patterns**

Across the seven million-plus cities/UAs (as well as Navi Mumbai and Thane as part of Mumbai UA) examined the 15th Finance Commission allocation ranged from Rs. 195 crores in Vadodara and Rs. 1832 crores in Mumbai including Navi Mumbai, Thane, Ulhasnagar and Badalapur) for the period between FY 2020-21 to FY 2025-26. These allocations were based on the population as per Census 2011.The fund release varied from Rs. 158 crores in Vadodara and Rs. 929 crores in Mumbai between FY 2020-21 to FY 2024-25 and fund utilization varied from Rs. 127 crores in Vadodara and Rs. 565 crores in Mumbai between FY 2020-21 to FY 2024-25.

First instalment of FC grants was released to all million-plus cities for the FY 2020-21 because it wasn't linked to any performance criteria being the first trench of support through XV FC. Most cities didn't utilise the amount released for the FY 2020-21 within that financial year due to multiple reasons, late receipt of funds being one of the main limitations.

The grants being performance linked since FY 2021-22 showed varied release for the cities against the allocated amount based on their performance against the set criteria. Between FY 2020-21 to FY 2024-25 (full year fund release and utilization

data was not available for FY 2025-26), Varanasi received 153% of their allocated amount and Patna received only 49% of the allocated amount. Field visit revealed that utilization rates reflect complex interactions between the timing of fund release, performance metric design, governance bottlenecks, institutional capacity constraints, as well as delay in municipal elections.

All cities received funds under the XV FC mandate but reported delays in one or more financial years. In several cases, cities shared that fund releases were temporarily withheld during periods when elected municipal councils were not in place. This applied to five of the nine cities visited, including Navi Mumbai and Thane, where municipal elections had not been conducted in recent years.

In several cities, multiple years of funds were released together (which two years also varied between cities), or release timelines were extended due to procedural checks or performance assessments. Where delays occurred, cities noted that projects were either initiated later than planned or were implemented within compressed time windows that coincided with monsoon or procurement constraints. Cities continued to follow the procedural requirements while adapting project execution to when funds were made available.

- **Planning and Target Setting Challenges**

Across the nine cities, target setting under the NCAP followed a uniform path. Cities were not actively involved in the decision-making process for air pollution reduction targets, and this created limitations for those with geographical, meteorological and bioclimatic differences that are crucial to meeting the air quality targets. Cities shared that achieving a fixed reduction target was difficult as regional emissions, weather patterns and legacy infrastructure play a very crucial role.

All cities prepared City Action Plans (for Air Pollution) using the formats and guidance shared by CPCB and State Pollution Control Boards. They also mentioned that action plans were largely guided by the NCAP list of actions approved by CPCB, and they did not explore innovation for the risk of disapproval of city action plans and funding. However, there were considerable variation among the cities with respect to:

- Some cities constituted committees for plan preparation, other cities worked with empanelled institutions
- Some cities mentioned that action plans were largely guided by CPCB-approved lists and there was not much scope for innovation.
- The coordination of the city governments with different state departments and parastatals as required by the process
- The involvement of various departments (where they existed) within the city governments in the preparation of the plan

Information on yearly allocations of XV FC air quality grants was available, but many cities shared that fund release details were not always available before their municipal budget preparation timelines, which led to adjustments being made after plans were already finalised. As a result, planning and budgeting sometimes had to be carried out in parallel rather than in sequence, and the alignment between financial approvals and implementation cycles differed from city to city.

Cities followed the performance assessment mechanism outlined under the XV FC and submitted the required information for evaluation. Cities shared that when performance criteria were not fully met, the full allocation for that year was not released and only a portion of the funds was released for utilisation. In one of the cities, where yearly targets were achieved, it received their allocated funds along with incentive grants, as it demonstrated consistent year-on-year improvements based on monitoring data. Officials across cities frequently mentioned that achieving measurable improvements in air quality depends on several factors that are beyond the immediate control of ULGs, including seasonal variations, regional contributions and baseline infrastructure conditions which can affect measured performance even when interventions are implemented as planned.

- **City Actions and Interventions**

The types of interventions undertaken by cities under the XV FC grants were broadly similar. These included mechanised sweeping and cleaning operations, road and footpath improvement works, plantation activities, EV bus fleets and charging infrastructure, construction and demolition waste management facilities, dust suppression measures and traffic management works in some locations. A few cities also reported upgrading crematoria from wood-based systems to PNG. While the categories of interventions were similar across cities, the proportion of funds allocated to each type varied depending on local priorities, availability of existing infrastructure and the feasibility of implementation within established municipal systems. In cities where funds have been used to purchase equipment (such as sprinklers and smog guns, etc.) almost no city has considered how to provide for their maintenance/ repairs, which was discussed only in one city. There were several instances of machines lying unused in some cities due to lack of maintenance/ upkeep/ manpower.

All cities indicated that multiple departments within the ULG as well as parastatals were involved in air quality related work. Larger municipal corporations had some departments equipped to manage activities directly, while in other cities key functions such as transport, road development, electricity and water supply were managed by parastatals, which increased coordination requirements. Cities shared that while interdepartmental engagement was ongoing, responses and approvals

sometimes took longer when several authorities were involved. One city reported that timelines for broader development works undertaken by different state departments at the city-level were not always aligned, and this affected air quality outcomes when completed works had to be done again resulting in recurring construction activity.

- **Financial Management and Tracking**

Cities maintained fund utilisation records as per reporting requirements and submitted utilisation certificates and progress updates to State and national authorities. Under the XV Finance Commission structure, cities receiving the million plus challenge grant were required to maintain separate accounts for the air quality and solid waste components. Not all cities have dedicated bank accounts for the air quality grant under million-plus challenge grant under 15th Finance Commission. This made financial tracking more complex.

- **Monitoring Infrastructure**

Monitoring infrastructure varied across the nine cities. Most cities had continuous ambient air quality monitoring systems that were being used for reporting and compliance, with routine calibration and maintenance undertaken as per guidelines. One city did not have a CAAQMS station in place and relied on manual monitoring. Several cities highlighted that the current number of monitoring stations was determined based on older city boundaries and population figures. Since municipal limits have expanded in recent years, the existing monitoring network is now concentrated largely within the older areas. Cities also mentioned that identifying suitable locations for installing new stations has been challenging because the systems are costly and require secure sites to avoid damage, theft, or interference while still meeting technical siting requirements. Proposals for network expansion were under consideration in multiple cities. Routine calibration and maintenance were taken up in accordance with guidelines.

- **Public Outreach and Awareness**

Cities conducted various public outreach activities, including environmental awareness campaigns and school programmes. In a few cases, initiatives were specifically focused on air pollution and its health impacts. Other cities carried out broader environmental events in which air quality was one of several themes addressed.

- **Institutional Capacity Constraints**

Most cities expressed that they currently do not have dedicated capacity to manage air quality as a specialised subject area. In many ULGs, the designated nodal officers were civil engineers or other technical staff already handling SWM and air quality responsibilities were assigned in addition to their existing roles. In cities where environmental departments existed, these teams were often given additional charge of air quality management as they were initially primarily focused on waste management etc. Under NCAP, specialised consultants were provided to support cities, primarily for data management, coordination and reporting. However, these consultants did not hold decision making authority and, in several cities, were also engaged in other ongoing municipal functions when specific air quality tasks were limited. Cities additionally indicated that NCAP consultant engagements were on yearly contract, however it was seen that the extensions were delayed, and consultants continued their work despite interruptions in contract renewal and salary payments. In one city, the consultant had to undertake dual responsibilities, including temporarily assisting State Pollution Control Boards in absence of a state consultant, therefore diminishing their time and concentration at the local level. Another city reported a lack of NCAP consultants as the one assigned to the city had resigned. The main municipal corporation of the urban agglomeration was allocated a dedicated consultant, although the other constituent municipal corporations did not receive comparable assistance. In one constituent city of the UA, this deficiency was mitigated by utilising their own resources to hire a consultant, but this provided even less clarity on roles, autonomy, and authority, ultimately serving as proxy assistance rather than enhancing institutional capacity.

One city reported that the transfer of the single officer responsible for air quality work resulted in a temporary gap in continuity, as institutional knowledge was concentrated in only one or two individuals. Cities noted that long term staffing, technical training and dedicated teams would support more stable internal systems and strengthen data driven decision making and implementation.

V. Overall Insights

The previous chapters have provided a quantitative analysis of air quality trends and fund utilisation in 130 non-attainment cities (Chapter 3) and qualitative observations from field visits to nine cities (Chapter 4). This chapter integrates numerous data streams and on field insights to elucidate the patterns, contradictions, and institutional deficiencies that account for changes in air quality across cities while utilising the performance-based funding under the NCAP and XV Finance Commission.

- **Disconnect Between Funding and Air Quality Outcomes**

The evidence from air quality trends and insights from city-level data and discussions on implementation of actions under NCAP points to a central contradiction in the current approach to financing air quality in India. While the NCAP and XV Finance Commission introduced performance-linked grants with the explicit intent of incentivising cleaner air outcomes, the observed results indicate that while air quality improvements were a key indicator in disbursing the allocated amount, emphasis of the actions taken was primarily driven by utilisation of funds without prioritising impact of actions on air quality improvement or absolute emission load reduction. Across the cities analysed, improvements in air quality were uneven and limited, even where substantial funds were released and spent. This suggests that the challenge lies less in the availability of resources and more in how performance is defined, incentivised, and translated into action.

The quantitative analysis indicated that there is **no statistically significant correlation between fund utilisation and air quality outcomes.** Of the 69 cities having usable PM_{10} data, merely 10 cities (14.5%) achieved or exceeded their reduction targets for 2024-25, whereas 31 cities (45%) encountered deteriorating air quality despite a significant percentage of the money spent under NCAP and XV-FC funding. Cities that utilised over 80% of released funds did not uniformly attain improved air quality results compared to cities with lesser utilisation rates; of the 32 cities with more than 75-80% utilisation of the allocated funds, only 6 achieved the stipulated 2024-25 targets. This paradox exists because the way money is spent is much more important than how much is spent or how quickly it is spent.

- **Fund Utilisation and City-level Action Selection**

City-level actions towards air quality management were largely shaped by existing administrative priorities and towards visible short term local exposure reduction strategies in form of stopgap measures. This was evident in the pattern of fund

utilisation, which prioritised initiatives that were familiar, visible, and under direct municipal control, such as road paving, mechanised sweeping, water sprinkling, and equipment procurement. Although these actions may have provided immediate short-term reductions in particulate exposure at certain locations, they do not address the underlying cause. The repetition of similar interventions across years and cities suggests that cities have prioritised predictable utilisation rather than adaptive approaches. In the cities visited, air quality grants were utilised to effectively supplement routine municipal functions, thereby blurring the line between air pollution management and routine urban service delivery.

The adoption and implementation of uniform performance targets further constrained city action. Actions implemented for the reduction in particulate matter pollution were largely consistent across cities regardless of differences in geography, bio-climatic conditions, baseline pollution levels, or exposure to regional emission sources. Field interactions indicated that many cities perceived these targets as top-down and only partially within their control. Seasonal meteorological conditions, long-range pollution transport, and existing municipal infrastructure frequently influenced outcomes, weakening the causal relationship between interventions and measured performance. Under such conditions, cities had limited incentive to pursue complex, cross-sectoral measures whose outcomes might not be immediately visible in annual monitoring data which subsequently influences the release of funds.

- **Fund Release Timing and Implementation Constraints**

The timing and predictability of fund release emerged as another crucial factor influencing outcomes. The fund allocation to the cities was already known, however the information on annual fund release was often unavailable by the time most cities started preparing their municipal budget for the following financial year. As a result, planning and budgeting frequently occurred in parallel, with adjustments made after financial years had begun. Delays in release, bunching of funds across years, pauses linked to administrative factors and funds not being released due to delay in municipal election affected implementation. These uncertainties resulted in interventions that could be implemented immediately once funds were released, as opposed to longer-term solutions that required phased implementation or sustained coordination.

- **Institutional and Governance Constraints**

The institutional constraints at the city level had a considerable impact on how funds were utilised. Air quality management is not yet embedded as a specialised function within most urban local governments. Responsibilities are frequently delegated as an additional charge to officials whose primary focusses lie elsewhere,

reducing strategic focus and continuity. The NCAP consultant model addressed certain technical and coordination gaps issues but did not translate into institutional ownership or decision-making authority. Consultants lacked decision-making authority, had contract and remuneration delays, and were often tasked to cover multiple factions simultaneously. In urban agglomerations, the differential support to the main municipal corporation further weakened coordination across constituent municipal corporations / non-attainment cities and cantonment boards, despite air pollution mitigation requiring actions at level of shared airshed.

The fragmentation in governance further exacerbated these challenges. Air quality improvements rely on coordinated efforts across transportation, construction, industry, waste management, energy and power systems. However, implementation has continued to remain siloed across departments and parastatals. Even with monitoring and implementation committees functional at city level, they were frequently limited to information sharing rather than joint decision-making. Misalignment between infrastructure development timelines and pollution control actions caused repeated construction activity and dust generation in several cities. The absence of statutory backing for city action plans further diluted accountability and limited enforcement leverage.

Monitoring and data systems, although expanded, primarily served compliance and reporting functions rather than aiding city-level actions. Monitoring networks were unevenly distributed, often reflecting older municipal boundaries instead of the expanded municipal boundaries. While data availability improved, it was rarely used to continually modify interventions or prioritise high-impact sources. Instead, monitoring outputs are largely fed into performance assessments, reinforcing a compliance-oriented approach rather than evidence-based actions.

- **Understanding System Incentives and Their Consequences**

Taken together, these factors reveal that the performance-based grant framework incentivised spending certainty over outcome uncertainty. Cities responded rationally to the signals embedded in the system by prioritising interventions that were administratively safe, auditable, and under direct municipal control. Emission sources beyond municipal jurisdiction, including regional industry, power generation, and peri-urban activities, remained largely outside the scope of action, despite their significant influence on urban air quality. As a result, local efforts were often insufficient to shift measured outcomes at the city scale.

The learnings from NCAP and XV Finance Commission highlights that performance-linked funding without differentiated targets, institutional strengthening, and governance reforms, has limited ability in achieving sustained improvements in air quality. The key lesson is not that performance-based funding

is ineffective, but that its effectiveness depends critically on how performance is defined, how incentives align with the capacities of the ULG, and how governance structures enable or constrain actions. Without addressing these structural elements, future funding cycles risk perpetuating current utilisation patterns rather than providing cleaner air to breathe for those living in the cities.

On analysing expenditure details for select cities using information collected during field visits, the major areas cities have spent maximum portion of the grants on can be identified as follows:

- Mitigation of road and construction dust by undertaking road paving works, purchasing sweeping machines, water sprinklers, smog guns etc. - For e.g. as high as **80% in one of our selected cities with the lowest utilisation of 40% (activity-wise spending data was only made available for 4 cities of the 9 visited).**

- After road dust mitigation, cities have spent most funds on various activities broadly falling under municipal solid waste management – these activities range from routine waterworks and sewer line expansion, purchase of vehicle/ equipment for SWM department 34% to 50% across the visited cities which supplied data.

- There are also anomalies observed where it appears that regular municipal service delivery is being funded from XV FC grants meant for air pollution – for instance, One of the visited cities spent INR 323 crores (almost **67% of total funds spent** during the entire XV FC grant period) on transport and collection of municipal solid waste.

- It was also observed in multiple instances that a significant amount of funds was spent on activities that **do not directly lead to emissions load reduction at source**, i.e. anti-smoke guns/fog-canons, smoke towers, water fountains etc.

- Under NCAP, cities were also expected to leverage funding through **convergence of various central government schemes** (Amrut 2.0, SBM, Nagar Van Yojana, etc.). It was observed that cities have spent substantially more from these funds than from the XV FC grant, but the reporting on utilisation of these funds remain opaque and patchy, at times leading to reporting of non-air pollution related spending under NCAP fund convergence.

- While the interventions may be in the right direction, the proportion of funds spent on these activities alone is quite high and repeatedly allocating funds to the same activity each year (for e.g., Approving purchase of additional sweeping machines) would not result in sustained improvement in the long term.

VI. Lessons and Learnings from Global Cities

This chapter reviews a set of global case studies on urban air quality management. It includes four cities that have demonstrated clear progress in reducing pollution through sustained policies and implementation, such as Beijing, London and Mexico City. It also includes one city where progress has been limited, to understand the factors that hinder effective action.

By looking at both successful and less successful experiences, the chapter aims to show the range of strategies, institutional arrangements and practical challenges that have shaped outcomes for different cities. These cases help illustrate what supports long term improvement and what creates persistent barriers. The insights from this chapter contribute to the broader set of recommendations as well. Detailed case studies for cities are available in the accompanying document, *Clearing the Air - Global Case Studies in Urban Air Quality Management.*

1. Case Study: Beijing

Introduction

Beijing's change in air quality is the outcome of more than 20 years of consistent policy efforts through three of pollution management measures. The first phase from 1998 to 2008 introduced the city's initial air pollution control programme focused on primary pollutants and major sources such as coal, industry, vehicles and dust. The second phase from 2009 to 2012 started moving from end of pipe controls to broader structural adjustments. The third phase from 2013 to 2017 concentrated on reducing $PM_{2.5}$, supported by a revised national standard and the Beijing Clean Air Action Plan.[22]

By the 1990s, Beijing faced severe air pollution across all major pollutants due to rapid economic growth, heavy coal use, industrial activity and rising motorisation. Annual average concentrations reached about 3.3 mg/m³ for CO, 120 µg/m³ for SO_2, and 74 µg/m³ for NO_2, while PM_{10} levels routinely exceeded 150 µg/m³. Although systematic $PM_{2.5}$ monitoring began later, annual concentrations were already close to or above 90 µg/m³ in the early 2010s, far exceeding the national standard of 35 µg/m³. The crisis peaked in 2013, when $PM_{2.5}$ concentrations exceeded 500 µg/m³ during severe smog episodes.

Beijing's strategy addressed multiple areas including legislative enforcement, transportation reforms (electric vehicle transition, license restrictions, stricter emission standards), industrial and energy controls (coal reduction, heating system

[22] United Nations Environment Programme. (2019). *A review of 20 years' air pollution control in Beijing.* https://wedocs.unep.org/bitstream/handle/20.500.11822/27645/airPolCh_EN.pdf?sequence=1&isAllowed=y

upgrades, industrial restructuring), monitoring (advanced sensor networks, satellite tracking), economic incentives, and regional coordination (Beijing-Tianjin-Hebei coordination, unified planning), and environmental improvements (afforestation, urban greening, ecosystem restoration), that drove Beijing's transformation from severe pollution to marked improvement. Here we will examine three critical interventions in detail i.e. monitoring systems, vehicle emission controls, and regional coordination

Focus Interventions:

1. Monitoring Systems
Following 2013, Beijing implemented a comprehensive set of measures under the Clean Air Action Plan (2013–2017). Monitoring capacity expanded rapidly, with ambient stations increasing from 8 to 35 and deployment of over 1,000 $PM_{2.5}$ sensors. Enforcement was strengthened through real-time emissions reporting from power plants and factories (made publicly available online), remote sensing, and continuous monitoring of over 1,700 construction sites and 155 concrete mixing plants.

2. Vehicle Emission Controls
Vehicle emissions were addressed through stringent local standards introduced ahead of national timelines, fuel quality upgrades, license plate quotas (limited new registrations to 20,000 monthly) with lottery systems favouring electric vehicles, and large-scale scrappage programmes. Between 2013 and 2017, 1.7 million high-emitting vehicles were phased out. The city deployed 6,584 electric buses and offered subsidies up to RMB 66,000 (60% of purchase price), resulting in over 1 million New Energy Vehicles by 2024. Infrastructure improvements included subway expansion to 700 kilometres, diesel truck rerouting from populated areas, and bike-sharing programs.

3. Regional Coordination
In 2015, China introduced the Plan for the Coordinated Development of the Beijing-Tianjin-Hebei Region to strengthen environmental governance across the region. This framework established unified emission standards, coordinated enforcement mechanisms, and joint pollution response protocols. The coordination extended to emergency response measures during heavy pollution episodes, with synchronized production restrictions and traffic controls across cities. Regional cooperation also addressed coal consumption, with collective targets for the Beijing-Tianjin-Hebei area that recorded negative growth in total coal use between 2013-2017.

Current Status

Beijing's sustained interventions have yielded dramatic improvements. Annual average $PM_{2.5}$ concentrations fell from 89.5 μg/m³ in 2013 to 58 μg/m³ in 2017, representing a 35.6% reduction. Between 2013 and 2021, air pollution dropped by

42.3%. Days with good air quality increased from 114 in 2013 to 290 in 2024.[23] Annual average $PM_{2.5}$ concentrations declined from 89.5 μg/m³ in 2013 to 58 μg/m³ in 2017, a 36% reduction, while regional $PM_{2.5}$ levels fell by nearly 25%. The heavily polluted days decreased from 58 to just 2 i.e. a 96.6% reduction. Over two decades (1998-2018), SO_2, NO_2, and PM_{10} concentrations declined by 93.3%, 37.8%, and 55.3% respectively.

2. Case Study: Mexico City

Introduction

Mexico City's air quality improvement is the result of over 30 years of sustained policy efforts beginning in 1990. Once labelled the world's most polluted city by the United Nations in 1992, the Metropolitan Area of the Valley of Mexico (ZMVM) faced severe pollution from rapid population growth (3.1 million in the 1950s to 14 million by the 1980s) and industrialization, compounded by its high-altitude basin geography (2,200-2,800 meters) surrounded by mountains that trap pollutants. The city's approach evolved across successive air quality management programs: Integrated Program against Atmospheric Pollution (PICCA) (1990-1994) introduced initial controls on fuel quality and vehicle emissions; ProAire 1995-2000 established air quality improvement targets focusing on ozone reduction; ProAire 2002-2010 expanded measures and introduced Mexico's first $PM_{2.5}$ standard (2004); PROAIRE 2011-2020 strengthened enforcement; and ProAire Megalopolis 2017-2030 extended coordination across six states covering 224 municipalities.

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[23] Xinhua. (2025, June 9). *From smog to sunshine: Beijing's decade-long clean air campaign pays off. Qiushi English Edition.* https://en.qstheory.cn/2025-06/09/c_1099081.htm

Focus Interventions:

1. Monitoring and public information systems
Mexico City began monitoring in the 1970s with 22 manual stations for SO_2 and TSP, transitioning to automatic monitoring in the late 1980s. The Atmospheric Monitoring System (SIMAT) now operates 44 stations across the metropolitan region. Air quality standards were established in 1994 for O_3, CO, NO_2, SO_2, Pb, and PM_{10}, updated in 2014 for O_3, PM_{10}, and $PM_{2.5}$. The city alerts the public 20 hours before high pollution events and disseminates hourly bulletins via social platforms.

2. Vehicle Emission Controls
Oxygenated gasoline was introduced in 1989, unleaded gasoline in 1990, with complete leaded fuel phase-out by 1997, progressive reductions in fuel sulphur content, mandatory catalytic converters, and a citywide vehicle inspection and maintenance programme linking emissions performance to driving restrictions. Large investments were made in public transport, including the introduction of the Metrobus Bus Rapid Transit system in 2005, alongside expansion and modernisation of the metro network and promotion of non-motorised transport.

3. Institutional Coordination
Governance arrangements were strengthened through metropolitan coordination bodies, culminating in the creation of the Metropolitan Environmental Commission (CAM) in 1992 to coordinate federal and local agencies. In 2013, it evolved into the Megalopolis Environmental Commission (CAMe), covering Mexico City and 224 municipalities across five states (Hidalgo, Mexico, Morelos, Puebla, Tlaxcala). CAMe's governance includes a high-level body (Minister of Environment, five state governors, Mexico City's Chief of Government), an Executive Commissioner, and a Scientific Advisory Committee.

Current Status

Mexico City has achieved substantial air quality improvements since 1990. $PM_{2.5}$ concentrations fell from nearly 40 µg/m³ in the early 1990s to below 25 µg/m³ by 2015. PM_{10} levels decreased by 60% between 1990 and 2015, dropping from 110 µg/m³ to below 45 µg/m³. Ambient ozone levels fell from over 130 ppb to around 80 ppb over the same period. The Metropolitan Air Quality Index (Imeca) dropped from about 300 in the 1980s to under 150 by 2016, while ozone levels declined from around 500 ppb to roughly 120-150 ppb. Days with severe pollution fell from 344 in 1994 to 118 in 2012. During PROAIRE III (2002-2010), annual emission reductions included 5,078 tons of PM_{10}, 506 tons of SO_2, 817,132 tons of CO, 64,779 tons of NO_x, and 85,706 tons of VOCs. The city also reduced 7.7 million tons of carbon emissions between 2008 and 2012, surpassing its 7 million ton target.

3. Case Study: Accra

Introduction

Accra's air pollution challenge is shaped by rapid urbanisation, high commuter inflows, and geographic and climatic factors such as Harmattan dust. The Greater Accra Metropolitan Area hosts over 4 million residents and receives around 2.5 million daily commuters, intensifying exposure to particulate pollution. Air pollution levels are exacerbated by seasonal Harmattan winds transporting Saharan dust, resulting in extremely high $PM_{2.5}$ and PM_{10} episodes. Approximately 40% of Accra's $PM_{2.5}$ concentrations are linked to road transport emissions, while unpaved roads and industrial activities contribute significantly to particulate matter levels.

Air pollution poses a major public health risk. In 2019, Ghana's annual average $PM_{2.5}$ concentration was nearly 11 times the WHO guideline, contributing to approximately 3,000 premature deaths. While Ghana has pursued gradual air quality interventions over the past two decades, persistent governance, monitoring and enforcement gaps continue to limit sustained improvements. This case study examines three areas of intervention i.e. monitoring and data systems, transportation sector controls, and household energy interventions to understand why, unlike Beijing and Mexico City, Accra has achieved limited progress in improving air quality despite two decades of policy efforts.

Focus Interventions:

1. Monitoring and Data Systems
Policy responses in Accra evolved incrementally, shaped by limited institutional capacity and reliance on external support. Early efforts focused on establishing basic air quality monitoring, with manual PM_{10} stations later complemented by automated systems. A major shift occurred with the deployment of low-cost sensor networks under the GHAir Project, significantly improving spatial coverage and near–real-time data availability for $PM_{2.5}$.

2. Transportation Sector Controls
About 70% of daily commuters rely on 'Tro-tros' (private minibuses), mainly older high-emitting vehicles. The World Bank-funded Urban Transport Project (2007) aimed to reduce emissions through public transport regulation and Bus Rapid Transit (BRT) introduction. Following lead phase-out from gasoline, EPA Ghana and the National Petroleum Authority (NPA) reduced diesel sulfur from 5,000 ppm to 3,000 ppm in 2014. The Ghana Urban Mobility and Accessibility Project enhanced services through Tro-tro regulation and metro/bus network expansion. In 2024, import duty elimination on electric vehicles for commercial transportation until 2032 was proposed.

3. Household energy interventions
About 70% of Ghana's population relied on solid fuels for cooking; by 2015, over half of urban and 90% of rural households used solid fuels, though usage declined 20% since

2005. The Energy Commission partnered with the Global Alliance for Clean Cookstoves to provide clean cooking solutions to 50% of population by 2020. Electricity access doubled (1990-2012). By 2021, 96.1% of Greater Accra households used electricity for lighting and 68.2% used LPG for cooking.

Current Status

Accra's air quality management efforts reveal significant implementation gaps and systemic challenges. Most critically, Ghana lacks a unified national air quality management (AQM) framework despite Air Quality Management being outlined in EPA Act 1994 and Environmental Assessment Regulations 1999. Subsequent policies like National Environmental Sanitation Strategy and Action Plan (2010), National Environmental Policy (2014), and National Action Plan for Short-Lived Climate Pollutants (2018) has remained fragmented without coordinated enforcement.

The key failure and ongoing challenges are that the air quality monitoring remains limited to a few locations, mostly in the capital, with inadequate coverage despite GHAir (2019) and low-cost sensors (2018). 70% of commuters still rely on high-emitting Tro-tros with minimal regulation; the proposed BRT has not materialized at scale. Fuel sulfur reduction from 5,000 to 3,000 ppm (2014) remains insufficient compared to international standards. Electric vehicle incentives (2024) have yet to show impact. Extensive unpaved roads continue contributing to $PM_{2.5}$ levels. Nearly 60% of households still use charcoal and wood for cooking despite clean cookstove initiatives; while 68.2% of Greater Accra households used LPG by 2021, rural and lower-income urban areas remain dependent on solid fuels. Industrial activities (11% of pollution) lack stringent controls, biomass fuels in power generators add to $PM_{2.5}$, and seasonal Harmattan winds cause uncontrollable $PM_{2.5}$ and PM_{10} spikes.

In 2019, $PM_{2.5}$ remained eleven times WHO guidelines, with 3,000 premature deaths annually. Accra's experience demonstrates that institutional frameworks and policy declarations without adequate funding, enforcement capacity, infrastructure investment, and unified coordination cannot achieve meaningful air quality improvements. Unlike

4. Case Study: Paris

Introduction

Paris's air quality improvement demonstrates targeted interventions over the past decade since 2014. Transportation is the largest contributor to Paris's air pollution, accounting for approximately 45% of nitrogen oxide emissions, and diesel vehicles contributing nearly 40% of total emissions with residential and commercial building

emissions adding to overall levels. High population density compounds pressure through heating and transportation demands.

Paris's strategy addressed multiple intervention areas: cycling infrastructure expansion, shared mobility systems (Vélib bike-sharing and Autolib electric car-sharing with free access), low-emission zones (Crit'Air vehicle classification system), traffic reduction measures (elimination of 50,000 parking spots), and the Climate Plan 2024-2030 targeting European Union's 2030 climate goals and 2050 sustainability objectives. Beginning in 2025, all French cities with more than 150,000 residents are required to establish Crit'Air low-emission zones. This case study examines three critical interventions in detail i.e. low-emission zone implementation, cycling infrastructure development, and shared mobility systems, that have driven Paris's transformation, with nitrogen dioxide levels falling by 45% between 2014 and 2024 and $PM_{2.5}$ dropping by 55% since 2005.

Focus Interventions:

1. Low-Emission Zone (Crit'Air) Implementation
Under Crit'Air, vehicles in France are classified into six color-coded categories based on pollutant emissions. The sticker displays on the windscreen and remains valid for the vehicle's lifetime. The system is practiced across more than 300 European cities. Higher polluting vehicles are denied access to certain areas and during elevated pollution episodes. Motorists must display color-coded air quality certificates linked to emission levels. Trucks and cars with Crit'Air 5 registration (registered 1997-2000) were banned from July 2017. During record heatwave conditions, more than half of cars in the Paris region faced restrictions. The city council plans to tighten regulations through 2030, with the objective of only electric and hydrogen-fueled cars running on Paris roads by that year. Diesel-fueled motor vehicles, which contribute approximately 40% of total emissions, are primary targets for phase-out.

2. Cycling Infrastructure Development
Paris added 1,279 bicycle parking spaces in 2014 and planned installation of 1,400 km of cycle lanes by 2020. The city promoted cycling as a primary mode of transport through infrastructure expansion and the flagship Vélib' self-service bike-sharing scheme. Free access to Vélib' was provided to encourage adoption. Under Mayor Anne Hidalgo's leadership since 2014, 50,000 parking spots were eliminated to reduce car dependency and create space for cycling and pedestrian infrastructure. These measures aimed to shift modal share away from private vehicles toward sustainable transport options.

3. Shared Mobility & Traffic Reduction
Paris improved its flagship self-service schemes: Vélib' (bike-sharing) and Autolib' (electric car-sharing). Free transportation and free access were provided to both systems to maximize uptake. The Climate Plan 2024-2030 outlines policy agenda toward 2050 sustainability targets, meeting EU climate targets for 2030. Traffic reduction measures included parking spot elimination (50,000 removed), vehicle access restrictions during pollution episodes, and promotion of shared mobility over private car ownership. The comprehensive approach combined regulatory restrictions with accessible alternatives to facilitate behavioral change.

Current Status

These actions resulted in sustained improvements. Between 2014 and 2024, nitrogen dioxide concentrations declined by approximately 45%, driven largely by reduced traffic emissions. Fine particulate matter ($PM_{2.5}$) levels declined by around 55% since 2005. Public health outcomes improved in parallel, with deaths attributable to air pollution declining from approximately 10,350 in 2010 to 6,220 in 2019. Paris's experience demonstrates how transport regulation, urban redesign and political commitment can substantially reduce pollution in dense metropolitan settings.

Paris's experience demonstrates that focused interventions targeting the primary pollution source (transportation at 45% of NO_x emissions) combined with accessible alternatives (cycling infrastructure, shared mobility) and strict enforcement (Crit'Air bans, parking elimination) can achieve rapid improvements within a decade.

5. Case Study: London

Introduction

London's air quality transformation has been shaped by decades of regulatory reform, public health advocacy, and transport-focused interventions. The city's experience is rooted in one of the earliest environmental crises of the modern era i.e. the Great Smog of 1952 which caused between 4,000 and 12,000 casualties and triggered long-term policy action. Since then, London's air quality governance has evolved through successive regulatory frameworks, technological shifts, and behavioural interventions.

While early efforts focused on **controlling domestic coal combustion**, recent decades have concentrated on **reducing emissions from road transport, particularly nitrogen dioxide (NO_2)**. The **expansion of Low Emission Zones (LEZ) and the Ultra Low Emission Zone (ULEZ)**, alongside investments in cleaner transport systems, have driven measurable improvements in air quality across the city. This case study examines three critical interventions in detail i.e. emission zone implementation, monitoring systems, and vehicle transition support.

Focus Interventions:

1. Emission Zone Implementation
The Congestion Charging Scheme launched in central London in 2003. The Low Emission Zone (LEZ) was introduced citywide in 2009, initially charging heavy goods vehicles, then extended to all commercial vehicles not meeting Euro IV standards. The Ultra Low

Emission Zone (ULEZ) was introduced in 2019 and expanded in 2021 and 2023 to cover the whole of Greater London. Vehicles emit over 97% of carbon monoxide and around 75% of NO_x in London, with diesel vehicles accounting for 40% of all NO_x. A King's College London study suggested reducing diesel cars in inner London to 5% of the fleet could bring 99.96% of London into legal NO_2 compliance. Low Traffic Neighbourhoods (LTNs) lowered car ownership and reduced NO_2 levels. Speed restrictions focused on schools, hospitals, and sensitive areas. Today, 95% of vehicles driven in London daily meet ULEZ standards.

2. Monitoring Systems & Air Quality Networks
SO_2 monitoring began in January 1954 following the Great Smog. The London Air Quality Network (LAQN) was established in 1983 at King's College London. Ambient air quality standards were established in 1980 under the Mayor's Air Quality Strategy. The Environment Act 1995 mandated a national air quality strategy. The Breathe London programme launched with 400 air quality sensors across the city, providing real-time data for policy decisions and public awareness.

3. Vehicle Transition & Financial Support
The Mayor's £27 million Air Quality Fund was supplemented by over £20 million from boroughs and partners. Since 2019, £271 million has been provided to help residents scrap or retrofit non-compliant vehicles. Installation of 19,000 electric vehicle charging points facilitated the transition to electric vehicles. Electric and hybrid bus promotion complemented personal vehicle transition efforts.

Current Status

The impact has been substantial. Between 2016 and 2024, nitrogen dioxide concentrations fell by approximately 65% in central London, 53% in inner London, and 45% in outer London. The number of monitoring sites exceeding legal NO_2 limits declined from 56 in 2016 to five by 2023. $PM_{2.5}$ concentrations have declined by over 50% since 2005, demonstrating how strong legal frameworks, monitoring and enforcement can deliver rapid improvements in large, high-traffic cities.

VII. Key Challenges, Pathways and Specific Recommendations

A. Challenges in Air Quality Governance: A Diagnostic Framework

Effective air quality governance requires clarity on three fundamental questions: who is responsible, for what actions, and how will performance be measured? The current system faces accountability diffusion, where multiple entities share overlapping mandates without clear demarcation of responsibilities or consequences for inaction. This section identifies the core governance challenges that impede effective air pollution mitigation across Indian cities.

(i) Emission Inventory & Source Apportionment Studies: The Knowledge Gap

Context: Scientific studies mandated under NCAP are intended to ensure targeted pollution mitigation actions through evidence-based planning.

Current Status: Source Apportionment Studies are entirely outsourced to empanelled academic and research institutions. Of 130 cities, 79 have completed studies (45 peer-reviewed, 34 completed), while 51 remain in progress. Carrying capacity studies, though proposed, have not been initiated for any city.

Core Challenge: The absence of dynamic emission inventories creates a critical knowledge gap. Most cities lack the capacity to update baseline inventories with quarterly activity data, making it impossible to track whether interventions are actually reducing emission loads. Without this tracking capability, cities cannot establish clear logic chains from source analysis to intervention design to measurable outcomes. Actions remain disconnected from evidence, and performance assessment becomes speculative rather than data-driven.

(ii) Emission Sources: The Accountability Vacuum

Context: Air quality in cities is affected by sources both within and outside ULG boundaries i.e. vehicular emissions, dust pollution, construction and demolition waste, industrial emissions, municipal solid waste burning, agricultural waste burning, and household emissions. Additionally, meteorological factors like wind speed, dust storms, and rainfall lie outside any entity's control.

Current Status: Accountability for emissions from different sources is fragmented across transport departments, pollution control boards, urban development authorities, and agriculture departments. No single entity has comprehensive authority or responsibility.

Core Challenge: The current system suffers from fundamental attribution errors. ULGs are assessed on outcome indicators like PM_{10} reduction and good air quality days despite having limited control over many emission sources (industries, vehicular fleet composition, agricultural burning) and no control over meteorological conditions. This creates perverse incentives—cities may be penalized for pollution originating beyond their jurisdictions or from weather patterns, while entities with actual control over emission sources face no accountability for their contributions to poor air quality.

(iii) Human Resource Capacities: The Institutional Void

Context: Most ULGs lack dedicated environment departments, and where they exist, staff expertise in air quality management is severely limited. CPCB appointed NCAP consultants at ULGs often get assigned additional responsibilities such as solid waste management, causing air quality work to be deprioritized.

Current Status: The current provision of City Air Quality Monitoring Cells exists in structure but not in substance. These cells lack permanent technical staff, operate without dedicated budgets, and have no authority to coordinate across departments.

Core Challenge: Air quality management requires specialized expertise in environmental engineering, emissions modelling, GIS mapping, and data systems—knowledge that cannot be rebuilt with each administrative transfer. The absence of permanent technical cadres means that institutional memory evaporates, planning cycles restart with each personnel change, and sophisticated interventions remain perpetually beyond reach. Cities are expected to manage complex technical challenges with generalist administrators who may be transferred within months of developing relevant expertise.

(iv) ULG Actions & Performance Tracking: The Implementation Gap

Context: ULGs receive air quality grants but often lack clear frameworks for prioritization, implementation, and performance monitoring.

Current Status: Cities have undertaken various actions such as municipal solid waste management, mechanized road sweepers, pavement management, dust suppressants, water sprinkling, e-buses, PNG for crematoriums, and Miyawaki forests. However, the May 2025 Monitoring Committee noted that cities need to shift from broad sectoral actions to bridging critical gaps through targeted interventions.

Core Challenge: Two fundamental disconnects plague implementation. First, **the evidence-action gap**: cities take ad-hoc steps to utilize grants rather than prioritizing interventions based on emission inventories and source apportionment studies. A city where vehicular emissions contribute 40% of pollution may spend

60% of its budget on dust suppression simply because mechanized sweepers are easier to procure. Second, **the infrastructure-operations gap**: cities invest in equipment and systems but lack budgets for operations and maintenance. Mechanized sweepers sit idle for want of spare parts, monitoring stations remain non-functional due to calibration delays, and water sprinklers and mechanical sweepers operate without protocols. Additionally, the absence of public dashboards and transparent tracking systems means that neither citizens nor higher authorities can assess whether planned actions are being implemented or whether they are producing intended results.

(v) Fund Usage: The Financing Dysfunction

Context: Adequate, flexible, and timely fund flow is essential for implementing air quality measures, both within and beyond ULG jurisdictions.

Current Status: The current system suffers from delayed fund releases, delayed utilization certificate submissions, and rigid performance-linked funding mechanisms. Many ULGs receive grants towards the end of the financial year, leaving insufficient time for planning, tendering, and implementation.

Core Challenge: The financing architecture contains three critical flaws. First, **timing dysfunction**: late fund disbursement forces cities to prioritize high-expenditure visible projects over systematic emission reduction actions, creating rushed procurement and suboptimal outcomes. Second, **jurisdictional mismatch**: cities are funded to control pollution but lack resources to address emission sources in surrounding industrial clusters, brick kilns, and peri-urban areas that significantly impact their air quality. Third, **performance paradox**: the current outcome-based assessment penalizes cities for factors beyond their control while failing to reward cities that build institutional foundations, establish coordination mechanisms, or implement processes that will yield results over longer timeframes. Cities that achieve targets may see funding withdrawn precisely when they need sustained support to maintain gains, while cities struggling with governance capacity may not receive the upfront institutional investments they need to succeed.

(vi) Work with Other Ministries: The Coordination Failure

Context: Air pollution mitigation is inherently cross-sectoral, requiring coordination among multiple ministries beyond environment departments and pollution control boards. NCAP identifies seven ministries as part of the central coordination mechanism, but implementation shows significant gaps.

Current Status: Currently, only cities, State Environment Departments, and CPCB are meaningfully involved in air quality work. The Ministry of Earth Sciences (MoES) and Ministry of Health and Family Welfare (MoHFW), despite being identified as

implementing agencies under NCAP, are absent from coordination mechanisms. Intersectoral planning and coordination remain inadequate.

Core Challenge: Air quality governance fails at the coordination layer. Vertical integration from central ministries through state departments to ULGs lacks formalized mechanisms with clear meeting schedules, decision-making protocols, and escalation procedures. Horizontal coordination across departments at each level remains ad-hoc, with no mandatory agreements specifying deliverables, timelines, or consequences for non-performance. The absence of ministry-specific emission reduction targets means that transport, agriculture, power, and housing ministries, which control major emission sources operate without accountability for air quality outcomes. When pollution spikes, the environment department bears sole responsibility despite having limited authority over the primary emission sources. This diffusion of responsibility without corresponding authority creates a governance structure where everyone shares blame but nobody has the mandate or capacity to drive coordinated action.

B. Pathways to Clean Air for Indian Cities

This section outlines the foundational pillars and operational mechanisms necessary to transform current governance gaps into institutional strengths. The framework described here builds the conceptual structure for the specific recommendations detailed in the next section.

Sustainable improvement in urban air quality rests on three interdependent pillars that together create the conditions for effective governance:

- **Evidence-based Action:** Every intervention must be grounded in emission inventories and source apportionment studies. Cities must shift from convenient, visible projects to targeted actions that address their specific pollution profiles. This requires completing source apportionment studies for all 130 non-attainment cities and building dynamic emission and activity tracking systems that cities can update and use for planning.

- **Institutional Capacity:** Clean air requires dedicated institutions with permanent technical personnel, clear mandates, and multi-departmental coordination mechanisms. The establishment of Clean Air Cells at ULGs and state levels must become the institutional backbone of air quality governance, equipped with environmental engineers, data managers, and urban planners working exclusively on-air pollution.

- **Accountable Governance:** Performance assessment must move beyond outcome-only indicators like PM_{10} reduction, which are heavily influenced by meteorological factors and emissions beyond ULG control. A composite framework evaluating input, process, and output indicators will ensure fair assessment and drive systemic improvements even when pollution reductions take time to materialize.

Operationalising the Framework

Effective air quality governance requires clarity on three fundamental questions: who is responsible, for what actions, and how will performance be measured? The current system faces accountability diffusion, where multiple entities share overlapping mandates without clear demarcation of responsibilities or consequences for inaction. Translating the above three pillars into practice needs specific institutional processes and governance framework that address the inadequacies found in how things are currently implemented. The following operational requirements specify how the three pillars work in practice

- **Source-Based Accountability:** Responsibility for each emission source must be assigned to specific institutions with the legal mandate and technical capacity to act. Vehicular emissions fall under transport/urban mobility

departments, industrial emissions under pollution control boards, construction dust under urban development authorities, and agricultural burning under agriculture departments. Performance assessment must align with jurisdictional control, recognizing that ULGs cannot be held solely accountable for pollution from sources beyond their boundaries or meteorological factors outside any entity's control.

- **Data-Driven Decision Making:** All interventions must be justified through emission inventories showing the contribution of targeted sources. ULGs must maintain dynamic activity/emission tracking systems, updated quarterly, linking actions taken to changes in emission loads. Annual Clean Air Action Plans must demonstrate clear logic chains from source analysis to intervention design to expected emission reductions. Third-party validation of these plans should be mandatory before fund release.

- **Institutional Permanence:** Air quality management requires specialized expertise that cannot be rebuilt with each personnel transfer. Clean Air Cells must be staffed by permanent technical personnel on dedicated contracts, insulated from routine administrative transfers. These cells should include environmental engineers, data managers, GIS specialists, and urban planners, with mandatory capacity building programs and professional development pathways to retain talent.

- **Multi-Level Coordination:** Vertical integration from central ministries through state departments to ULGs must be formalized through coordination mechanisms with clear meeting schedules, decision-making protocols, and escalation procedures. Horizontal coordination across departments at each level requires mandatory MoUs specifying deliverables, timelines, and consequences for non-performance. State-level coordination committees should meet quarterly to review progress, resolve inter-departmental conflicts, and ensure alignment between city and state action plans.

- **Transparent Performance Tracking:** All ULGs must maintain public dashboards showing real-time air quality data, activity and emission load tracking, emission source contributions, planned interventions, budget allocation and utilization, and progress against targets. Quarterly reports should be published on ULG websites, including inter-departmental meeting minutes, departmental performance against MoU commitments, and analysis of why targets were met or missed. The PRANA portal must evolve from a reporting tool to an integrated performance management system with automated data flows from CAAQM stations, financial management systems, and departmental reporting mechanisms

- **Performance Measurement Framework:** A composite performance framework must balance outcome indicators with input, process, and output measures. Outcome indicators ($PM_{2.5}$ and PM_{10} concentrations, number of good air quality days) should carry reduced weight, recognizing external factors. Process indicators (emission inventory updates, CAAQM uptime, inter-agency meetings, public consultations) should reward systematic governance. Output indicators (sectoral emission reductions, implementation rates of planned actions, departmental compliance with MoUs) should measure direct institutional performance. Input indicators (budget allocation, technical staffing, training programs) should ensure foundational capacity is in place.

This framework shifts emphasis from optics to operational depth, rewarding cities that build institutional foundations even when pollution reductions take time to materialize due to factors beyond their control.

C. Recommendations

1. Recommendation to CFC and SFCs - Financial Institutions

The XVI Central Finance Commission and State Finance Commissions have a pivotal role in creating a sustainable financial architecture for air quality management. The current funding model has fundamental design flaws that undermine effective action. The following recommendations propose a comprehensive restructuring.

Recommendations 1.1 to 1.5 were formally submitted to the XVI Finance Commission while Recommendation A.6 for State Finance Commission are captured here and for future engagements with select State Finance Commissions.

Recommendation 1.1: Create a Dedicated Sector-Specific Air Quality Grant

The XVI Finance Commission should create a separate performance-based grant category for **'Air Pollution'**, distinct from the existing Million-Plus Challenge Fund (MCF). This grant should be designed as a **sector-specific performance grant**, in line with other FC grants to states.

Under this model:

- The **overall responsibility** for planning, monitoring, and delivering outcomes should rest with state governments, which can coordinate among relevant stakeholders across jurisdictions.
- Monitoring and performance assessment should apply only to those interventions falling **within the mandate of the respective entities**, with flexibility for states to determine internal coordination and accountability mechanisms.

Key features of this new sector-specific air pollution grant include:

(i) **Expand eligibility beyond population thresholds:** Prioritise regions with significant population growth, covering both million-plus ULGs and other ULGs with poor air quality, based on monitoring data, including those with less than 5 years of data to ensure newly monitored pollution hotspots are not excluded.

(ii) **Address emissions outside city limits:** Allocate funds to target pollution sources in surrounding areas such as industrial clusters, brick kilns, and construction sites. State governments should coordinate interventions in peri-urban and airshed regions affecting city air quality.

(iii) **Manage periphery and agglomeration areas independently:** Direct funds to eligible ULGs instead of routing them through larger metropolitan entities. This eliminates administrative bottlenecks and ensures smaller ULGs are not dependent on larger bodies for funding or approvals.

(iv) **Avoid conflating air pollution work with developmental and service delivery work:** Interventions for air pollution must leverage specialised knowledge from broader urban development programmes, allowing for targeted technological interventions instead of being diluted within wider municipal services.

Recommendation 1.2: Establish a Sub-Grant for Institutional Capacity

The XVI Finance Commission should establish specific sub-grants under the air quality grant framework to address the fundamental capacity that have hampered effective air quality management.

Challenges with air quality management often stem from insufficient institutional capacity at the ULG and state levels, rather than a lack of intent. A specific percentage of the air quality grants should be dedicated to capacity building and institutional strengthening in state and other responsible agencies to achieve the targets set in 2020-21, during early implementation.

Key Components of this sub-grant include:

(i) **Technical expertise development:** Recruitment of full-time technical experts including environmental engineers, data managers, and urban planners dedicated exclusively to air quality management.

(ii) **Establishment of Clean Air Cells:** To serve as the institutional backbone for proactive clean air governance within ULGs. These Cells must consist of permanent technical personnel, representatives of key line departments, and independent experts, and must facilitate multi-departmental coordination through:

- Regular training programmes on air quality planning, monitoring, and data systems management
- Public grievance redressal systems
- Establishment and maintenance of CAAQM stations
- Use of emission inventories and source apportionment data for planning, action and reporting on emission-load reduction indicators.

(iii) **Self-sustainability of Clean Air Cells:** Annual self-sustainability indicators and milestones should be linked to sub-grant allocation to build financial and institutional sustainability, for example:

- Creation and retention of trained staff
- Timely preparation and third-party validation of annual Clean Air Action Plans
- Integration of air quality into urban planning documents like master plans and transport strategies
- Inclusion of public health co-benefits into pollution management planning

- Rethinking framework for demonstrated convergence between SBM, AMRUT, STPs, and NCAP funds.

(iv) **Data Infrastructure Development:** Support transparent implementation, public reporting, and real-time monitoring systems.

This would address the governance vacuum and encourage ULGs to invest in administrative continuity, staff capacity, and planning systems that persist beyond individual tenures.

Recommendation 1.3: Continue Support for Target-Achieving ULGs

ULGs that have successfully achieved their air quality targets (new composite framework) should continue to receive performance-linked funds. Achieving clean air is not a one-time accomplishment but requires sustained effort to maintain progress and prevent reversal. Cities that reach targets often face continued pressure from population growth, economic development, and regional pollution sources. Withdrawing support from successful cities creates perverse incentives and risks undoing hard-won gains. The goal should be to level the playing field, ensuring smaller ULGs with genuine intent and plans are not handicapped by lack of upfront funding, while maintaining momentum in cities that have demonstrated success.

Recommendation 1.4: Address Delayed Grant Disbursement Through Process Reforms

Grants to several ULGs have been disbursed towards the end of the financial year, resulting in insufficient time for ULGs to plan work, issue tenders, and complete implementation. Late receipt of funds forces ULGs to prioritise large expenditures to project higher utilization rates rather than systematic actions to reduce emissions. This creates a rushed, inefficient approach that favours visible projects over effective interventions.

Disbursement to ULGs should be completed within two months of the beginning of the financial year. This requires process reforms including pre-approval of state and ULG action plans before the start of the financial year, streamlined central approval processes, conditional advance release based on previous year's performance to ensure sufficient time for planning and executing systematic pollution reduction actions.

Recommendation 1.5: Develop Additional Performance Parameters and Indicators

The XVI Finance Commission should revamp the current performance-linked grant framework for air quality, moving beyond outcome-only indicators that have proven inadequate, such as PM_{10} reduction or increase in good air quality days. The XVI FC should encourage the nodal ministry to develop a composite performance framework that evaluates cities on a mix of input, process, and output indicators, aligned with their contextual constraints.

Proposed Framework:

(i) Sectoral and departmental performance indicators: Allocate a portion of urban air quality grants to specific departmental contributions through mandatory MoUs between ULGs and key line departments within cities and at the state level. These MoUs should specify:

- Clear responsibilities and deliverables linked to emission load reduction
- Specific actions under City Clean Air Action Plans (CAAP) and State Action Plans (SAP)
- Performance targets informed by emission inventories and source apportionment studies
- Direct fiscal penalties for departments that fail to fulfil obligations.

(ii) Institutional capacity indicators:

- Inter-agency coordination mechanisms between ULGs, state departments, and regulatory bodies such as the Clean Air Cells.
- Install and maintain minimum 85% uptime of Continuous Ambient Air Quality Monitoring (CAAQM) stations
- Actively use emission inventories and emission source analysis for action planning and resource allocation
- Develop trained technical personnel and conduct regular capacity building programmes.

(iii) Process indicators: Transparency on budget utilisation through financial tracking.

- Establish and maintain **transparency on budget utilisation** through financial tracking systems that monitor fund allocation across air quality interventions, department-wise expenditure against MoUs, and quarterly cost variance analysis
- **Establish integrated reporting** through regular data updates on the PRANA portal, linking performance measurement to systematic reporting of indicators as per action plans and MoUs to ensure accuracy and regularity.
- **Enable transparency and accountability** by quarterly publication of performance data on ULG websites, including inter-departmental meeting minutes, departmental performance against MoU targets, budget utilisation reports, and air quality trend analysis with action taken

(iv) Output indicators:

- Restore focus on directly measuring both $PM_{2.5}$ and PM_{10} concentrations, while increasing the number of days with air quality within permissible limits, recognising that $PM_{2.5}$ poses greater health risks.

- Define sectoral emission reduction targets aligned with city-specific emission source analysis.

By rewarding structural and systemic progress, ULGs laying strong institutional foundations or tackling governance bottlenecks will remain incentivised even if pollution concentration reductions take time to materialize. This will shift focus from optics to operational depth and ensure that performance-linked grants drive meaningful change rather than cosmetic improvements.

Recommendation 1.6: Leveraging State Finance Commissions

The transboundary nature of air pollution requires a shift in focus towards airshed-based governance. This would also address the coordination issues emanating from the status quo and provide opportunity for more accountability at the state or regional level. State Finance Commissions (SFCs) are currently an underutilised lever to this end. Despite their constitutional mandate and contextual knowledge, SFCs remain removed from financial architecture for improvement of air quality. Their involvement could enable regionally coordinated, incentive-based financing, especially for smaller cities and rural areas that fall outside the current NCAP framework but contribute significantly to regional pollution.

Given that NCAP's design remains city-centric, it lacks mechanisms for airshed-level planning or funding. This limits the program's ability to address pollution sources that lie outside municipal boundaries. SFCs can act as a lever to strengthen mechanisms that enable regional/multi-state coordination (e.g. bodies to coordinate aggregating and/or leveraging capital across states, earmarking funds for multi-state efforts that affect development etc.) Further, SFC grants should also support operational and maintenance costs for air quality infrastructure, bridging gaps in ULG capacity for ongoing system management.

2. Recommendations to MoEFCC and PCBs - Domain Institutions

The Ministry of Environment, Forest and Climate Change, along with the Central Pollution Control Board and State Pollution Control Boards, must strengthen their technical, regulatory, and coordination roles to enable effective air quality management across India.

Recommendation 2.1: Complete and Utilize Scientific Studies

(i) **Complete source apportionment studies for all 130 non-attainment cities.** Currently, 79 cities have completed studies (45 peer-reviewed, 34 completed), with 51 still in progress. The remaining cities must prioritize completion within the next 12 months. These studies are the scientific foundation for targeted interventions and cannot be delayed further.

(ii) **Build dynamic emission inventories.** Develop a standardised template for emission inventories that cities can update quarterly with activity data. Provide technical support and capacity building to ULGs to maintain these inventories. Make emission inventories publicly accessible through the PRANA portal with visualisation tools that link emission sources to proposed actions.

(iii) **Conduct carrying capacity studies for cities.** While proposed under NCAP, these studies have not been initiated. Carrying capacity assessments are essential for understanding the maximum pollution load cities can handle while maintaining acceptable air quality. These studies should inform urban planning, industrial siting decisions, and regional coordination strategies.

Recommendation 2.2: Strengthen Central Coordination Mechanisms

(i) **Include MoES and MoHFW in the central coordination mechanism.** The Ministry of Earth Sciences and Ministry of Health and Family Welfare were identified as implementing agencies under NCAP but are absent from coordination mechanisms, underplaying their significance. MoES should provide forecasting capabilities and early warning systems, while MoHFW should track health impacts through district hospital data on respiratory illnesses and pollution-related health outcomes.

(ii) **Establish a robust inter-ministerial coordination system.** Create formal coordination protocols with clear meeting schedules (minimum quarterly), decision-making authority, escalation procedures for inter-ministerial conflicts, and public minutes documenting decisions and action items. Each ministry should have specific activity and emission reduction targets cascading from national to state to city levels.

(iii) **Define ministry-specific emission reduction targets.** Transport ministries should commit to vehicular emission reductions, agriculture ministries to crop residue management, power ministries to thermal power plant emission controls, and housing ministries to construction dust management. These targets should be measurable, time-bound, and publicly reported.

Recommendation 2.3: Improve CAAQM Network Management

(i) **Ensure minimum 85% uptime for all CAAQM stations.** Current uptime falls below acceptable standards, creating data gaps that undermine performance assessment and public trust. CPCB should establish service level agreements with station operators, implement real-time monitoring of station status, and enforce penalties for prolonged downtime.

(ii) **Expand monitoring coverage.** Increase the density of monitoring stations in large cities and establish stations in smaller cities showing signs of deteriorating air quality. Prioritize $PM_{2.5}$ monitoring given its greater health impacts. Integrate low-cost sensor networks with reference-grade stations to provide higher spatial resolution while maintaining data quality standards.

(iii) **Enhance data accessibility and visualisation.** Make real-time air quality data freely available through APIs and develop user-friendly visualisation tools showing trends, forecasts, and health advisories. Provide historical data for research and policy analysis.

Recommendation 2.4: Strengthen PCB/PCC Regulatory Capacity

(i) **Build technical capacity for industrial emissions monitoring.** PCBs require specialised equipment and trained personnel for continuous emission monitoring, stack testing, and compliance verification. Invest in modern monitoring equipment, training programs for PCB staff, and standardized protocols for emission testing and reporting.

(ii) **Improve enforcement mechanisms.** Develop clear escalation procedures for non-compliance, from notices to production closures. Implement automated monitoring systems for high-pollution industries with real-time data transmission to PCBs. Establish fast-track adjudication for environmental violations to reduce the time between detection and penalty.

(iii) **Clarify jurisdictional boundaries.** Address instances where certain waste types fall into regulatory gaps between ULGs and PCBs. Create clear protocols for waste categorization and responsibility assignment. Establish joint inspection mechanisms for activities requiring coordination between multiple regulatory bodies.

Recommendation 2.5: Standardise Operating Procedures

(i) **Develop comprehensive SOPs for ULG actions.** Current implementation shows significant gaps, such as one of the visited cities having no clear disposal protocols for collected road dust or guidelines for water usage in sprinklers. MoEFCC should develop standardised operating procedures covering road dust management and disposal, water sprinkling schedules and volumes, mechanised sweeping protocols, construction site dust control, and municipal solid waste burning prevention.

(ii) **Create technical guidelines for interventions.** Provide evidence-based guidance on the effectiveness of different interventions under various

conditions. Include cost-effectiveness analysis to help ULGs make informed choices. Develop sector-specific guidance for transport, construction, waste management, and industrial areas.

Recommendation 2.6: Transition Action Focus Based on Monitoring Committee Guidance

Following the May 2025 Monitoring Committee recommendations, cities should shift from broad sectoral actions to bridging critical gaps. Priority actions should include end-to-end road paving rather than piecemeal approaches, targeted dust management at pollution hotspots, strategic traffic management and parking reforms, green corridor development and urban forests in priority areas, stricter crematorium emission controls with monitoring, and mass awareness campaigns through schools, colleges, and MY Bharat volunteers.

MoEFCC should provide clear evidence to support the proposed directions and develop guidance on this transition, including revised funding priorities, technical specifications for priority interventions, performance metrics aligned with these actions, and timelines for implementation.

Recommendation 2.7: Enable Citizens and Community Action

(i) **Develop a national framework for awareness programs.** MoEFCC should create standardised guidelines and toolkits for ULGs to design awareness campaigns distinct from general environmental education. Develop evidence-based communication materials highlighting the link between specific behaviours (vehicle maintenance, avoiding waste burning, construction dust reporting) and measurable air quality impacts. Create model curricula for schools and colleges that can be adapted by State Government and ULGs based on local pollution profiles.

(ii) **Create citizen science programs.** The CPCB should create technical standards and protocols for incorporating community monitoring data into official monitoring systems. Set up a national platform for low-cost sensor data collection and validation. Provide technical recommendations for mobile applications that allow users to report violations. Create training modules and certification programs for community organisations on air quality monitoring approaches that ULGs can use locally.

3. Recommendations to State Governments and ULGs – Urban Governance

State governments and Urban Local Governments are at the frontline of air quality management. Their capacity to translate policy into action determines whether clean air remains an aspiration or becomes reality.

Recommendation 3.1 (Urban Local Governments): Establish and Empower Clean Air Cells

(i) **Create dedicated institutional structures.** Transform the current provision of City Air Quality Monitoring Cells into robust Project Implementation Units with representatives from all concerned line departments and parastatals working exclusively on air quality. These cells should not be add-ons to existing environmental departments but dedicated units with their own staff, budget, and authority.

(ii) **Staff with permanent technical personnel.** Recruit environmental engineers, data managers, GIS specialists, and urban planners on specialized contracts insulated from routine administrative transfers. Provide competitive salaries and professional development opportunities to attract and retain qualified professionals. Cities should have a minimum team of 5-7 dedicated technical staff.

(iii) **Assign clear mandates and authority.** Clean Air Cells should have the authority to coordinate across departments, access financial resources, commission studies and consultancies, and report directly to city leadership. They should lead the preparation and monitoring of City Clean Air Action Plans, manage emission inventories and source apportionment data, coordinate with state agencies and PCBs, engage with citizens and stakeholder groups, and track performance against targets.

Recommendation 3.2 (Urban Local Governments): Prioritize Data-Based Action

(i) **Base all actions on emission inventories and source apportionment.** Cities must stop taking ad-hoc steps to utilise grants and instead develop action plans directly derived from their pollution profiles. If vehicular emissions contribute 40% of $PM_{2.5}$, allocate at least 40% of interventions and budget to transport sector solutions. If construction dust is the major source, prioritize road paving, construction site regulation, and mechanized cleaning.

(ii) **Maintain dynamic emission inventories.** Update emission inventories quarterly with current activity data. Link budget allocation and spending to

emission source profiles. Track emission reductions from implemented interventions. Make this data publicly available through city dashboards.

(iii) **Conduct annual action plan reviews.** Each year's Clean Air Action Plan should analyse previous year's performance, identify why targets were met or missed, adjust strategies based on lessons learned, and set realistic targets for the coming year. These reviews can include third-party experts and be made public.

Recommendation 3.3 (State Government): Formalize Inter-Departmental Coordination

(i) **Execute mandatory MoUs with line departments.** State should facilitate ULGs to sign formal MoUs with transport, public works, solid waste management, town planning, and other relevant departments. These MoUs should specify each department's emission reduction responsibilities, concrete actions with timelines, budget commitments, reporting requirements, and consequences for non-performance.

(ii) **Establish coordination committees.** Create standing committees with representatives from all relevant departments meeting monthly. The Clean Air Cell should serve as the secretariat, preparing agendas, tracking action items, and documenting decisions. Committee meetings should review progress on MoU commitments, resolve inter-departmental conflicts, and align on upcoming initiatives.

(iii) **Implement accountability mechanisms.** Link departmental budget allocations to air quality performance. Conduct annual performance reviews of each department's contribution to air quality goals. Make departmental performance data public. Establish fiscal penalties for departments consistently failing to meet commitments.

Recommendation 3.4 (Urban Local Governments): Address Operational and Maintenance Gaps

(i) **Include O&M costs in budget planning.** Many cities have invested in infrastructure like mechanised sweepers, air quality monitoring stations, and electric buses but lack operational budgets. Infrastructure without maintenance becomes non-functional, wasting initial investment. Cities should allocate at least 30% of air quality budgets to operations and maintenance.

(ii) **Develop comprehensive O&M plans.** For each piece of infrastructure, create detailed maintenance schedules, spare parts inventory, trained operator requirements, and performance monitoring protocols. Contract with reliable service providers for specialized equipment. Build in-house maintenance capacity for routine operations.

Recommendation 3.5 (Urban Local Governments): Implement Transparent Performance Tracking

(i) **Create public dashboards.** Each ULG should maintain a comprehensive dashboard showing real-time air quality data from all monitoring stations, emission source contributions updated quarterly, planned interventions with timelines and budgets, actual spending and implementation status, and performance against annual targets. These dashboards should be prominently featured on city websites and updated at least monthly.

(ii) **Publish quarterly performance reports.** Detailed reports should include air quality trends and analysis, actions implemented with costs and emission reductions, departmental performance against MoUs, challenges encountered and mitigation measures, and revised strategies based on performance. These reports should be presented to city councils and made available to the public.

(iii) **Integrate with PRANA portal.** Ensure regular data uploads to the national PRANA portal covering financial data, action plan status, monitoring station data, and emission inventory updates. Use PRANA not just for compliance reporting but as a performance management tool.

Recommendation 3.6 (State Government): Leadership and Coordination

(i) **Ensure timely fund transfers to ULGs.** State governments should transfer air quality grants to ULGs within two days (as mentioned in existing guidelines) of receipt from the central government. Late transfers undermine planning and force rushed spending. States should establish systems for automatic fund release upon receipt to eliminate bureaucratic delays.

(ii) **Coordinate actions beyond city limits.** State governments must address pollution sources in industrial clusters, brick kilns, and peri-urban areas affecting city air quality. Establish airshed management frameworks recognizing that air pollution crosses administrative boundaries. Coordinate between multiple ULGs and districts within the same airshed.

(iii) **Build state-level technical capacity.** Establish state-level Clean Air Cells with technical expertise to support ULGs. Provide training programs for city officials and technical staff. Commission state-wide studies on cross-cutting issues. Facilitate peer learning between cities through regular workshops and knowledge exchange platforms.

(iv) **Harmonize state policies with air quality goals.** Review industrial siting policies to prevent new pollution sources near cities. Align urban planning regulations to support air quality objectives. Ensure transport policies

promote public transit and non-motorized transport. Integrate air quality considerations into state-level infrastructure planning.

Recommendation 3.7 (Urban Local Governments): Strengthen Community Engagement

(i) **Develop targeted and localised awareness campaigns.** Move beyond generic environmental messaging to specific behavioural changes with measurable air quality impacts. This can be done using national guidelines and toolkits created by MoEFCC to design and execute city-specific awareness campaigns that address local pollution sources and target behaviours. Focus on vehicle maintenance and responsible driving, avoiding burning of leaves and waste, construction dust reporting, and participation in clean air initiatives. Use schools and colleges to reach diverse audiences with messaging tailored to the city's emission profile.

(ii) **Create feedback and enforcement mechanisms.** Establish city-specific helplines and deploy mobile applications (integrated to centralised platforms) for reporting violations such as construction dust, waste burning, and traffic pollution. Ensure rapid response to complaints with visible enforcement action by coordinating with relevant departments. Provide updates to complainants on actions taken.

(iii) **Build partnerships with civil society.** Engage with NGOs, resident welfare associations, and community groups in monitoring and advocacy. Support citizen science initiatives with technical guidance and integration of community data. Recognise and celebrate community contributions to clean air through awards and public acknowledgment.

Conclusion

As a short conclusion a **core insight** has been that air pollution in Indian cities is primarily limited by fragmented governance, weak accountability, and misdirected incentives, and not just because of data insufficiency, technology, or funding.

The core pathway for guiding funding is that Performance-linked funding without differentiated targets, institutional strengthening, and governance reforms has limited ability in achieving sustained improvements.

A key take-away for us reinforcing our public systems change focus with Janaagraha's city-systems framework, is that **effectiveness depends critically on how performance is defined, how incentives align with capacities of urban local governments, and how governance structures can be strengthened to enable impactful actions**. Without addressing these structural elements, future funding cycles risk perpetuating current utilisation patterns rather than providing for cleaner air to our citizens.

This work has provided a strong foundation for Janaagraha's future engagement with in-depth city-systems intersections for urban air quality management, which are likely to include working to take forward the final outcome recommendations of the 16th FC and monitoring the implementation of the same, preparation for recommendations to the 17th Finance Commission, working with select State Finance Commissions for contextual funding and closer monitoring, and targeted engagement with specific urban local governments.

Annexure I - Data validation conditions applied to PM10 and PM2.5

Source: PM10 data extracted from PRANA portal and PM2.5 data extracted from CPCB Dashboard

Step	Input	Output	Key Conditions
1. Raw → Raw Cleaned	Raw hourly data	Raw Cleaned hourly sheet	1. Remove ≤0 2. PM10 >2000 3. Adjacent spike (50%) 4. PM2.5 >= PM10 5. 3+ consecutive repetitive
2. Raw Cleaned → Daily	Raw Cleaned hourly	Per-station daily series	1. Group: 01:00 to 00:00 2. Past: ≥18 hours (75%) 3. Current: 75% of available hours 4. 10% rule (min <= 10% of max) 5. Spike + isolated removal
3. Daily → Final Daily	Per-station daily	Final Daily sheet	1. Combine stations 2. City Average from hourly city avg (75% rule) 3. Round to 0 decimals
4. Daily → Monthly	Daily series	Monthly series	1. Past: ≥75% days 2. Current: 75% of available days 3. City Average from daily city avg (75% rule)
5. Monthly → Yearly	Monthly series	Yearly series	1. Past: ≥9 months + no 2 consecutive missing 2. Current: 75% of available months 3. City Average from monthly city avg (75% rule)

Annexure II - PM10 reduction targets for 82 non-MPCs

City/ Town and population	Annual Average PM_{10} Concentration (µg/m3)	Target reduction in PM10 levels (µg/m3)				
		2021-22	2022-23	2023-24	2024-25	2025-26
Akola	67	3	3	4	3	3
Alwar	125	8	7	8	8	6
Amravati	88	5	4	5	5	4
Anantapur	60	3	3	3	3	2
Angul	95	5	5	6	5	4
Anpara	171	13	12	14	12	9
Baddi	133	9	8	9	9	7
Balasore	86	5	4	5	5	4
Bareily	178	14	13	14	13	10
Bhubaneswar	98	6	5	6	6	4
Byrnihat	98	6	5	6	6	4
Chandigarh	88	5	4	5	5	4
Chandrapur	90	5	5	5	5	4
Chitoor	52	2	2	3	2	2
Cuttack	102	6	6	6	6	5
Damtal	50	-	-	-	-	-
Dehradun	166	13	12	13	12	9
Delhi	178	14	13	14	13	10
Dera Bassi	99	6	5	6	6	4
Devanagere	63	3	3	3	3	2
Dewas	89	5	5	5	5	4
Dimapur	83	4	4	5	4	3
Durgapur	129	8	8	9	8	6
Eluru	64	3	3	3	3	2
Firozabad	205	18	17	18	16	12
Gajraula	211	19	17	19	17	13
Gaya	79	4	4	4	4	3
Gobindgarh	127	8	8	9	8	6
Gorakhpur	280	31	27	29	25	18
Gulburga	82	4	4	5	4	3
Guntur	57	3	2	3	3	2

Guwahati	106	6	6	7	6	5
Haldia	71	3	3	4	4	3
Hubli-Dharwad	76	4	4	4	4	3
Jalandhar	118	7	7	8	7	6
Jalgaon	56	3	2	3	3	2
Jalna	95	5	5	6	5	4
Jammu	146	10	10	11	10	8
Jhansi	102	6	6	6	6	5
Kadapa	47	2	2	2	2	2
Kala Amb	50					
Kalinga Nagar	104	6	6	6	6	5
Kashipur	126	8	8	9	8	6
Khanna	106	6	6	7	6	5
Khurja	236	23	21	22	20	15
Kohima	80	4	4	4	4	3
Kolhapur	90	5	5	5	5	4
Korba	52	2	2	3	2	2
Kurnool	56	2	2	3	3	2
Latur	82	4	4	5	4	3
Moradabad	247	25	22	24	21	16
Muzaffarpur	124	8	7	8	8	6
Nagaon	88	5	4	5	5	4
Nalagarh	115	7	7	7	7	5
Nalbari	75	4	3	4	4	3
Nalgonda	59	3	3	3	3	2
Naya Nangal	99	6	5	6	6	4
Nellore	67	3	3	4	3	3
Noida	203	18	16	18	16	12
Ongole	60	3	3	3	3	2
Paonta Sahib	78	4	4	4	4	3
Parwanoo	59					
Pathankot/ Dera Baba	70	3	3	4	3	3
Patiala	98	6	5	6	6	4
Raebareli	152	11	10	11	10	8
Rajahmundry	59	3	2	3	3	2
Rishikesh	135	9	8	9	9	7
Rourkela	110	7	6	7	6	5
Sagar	72	4	3	4	4	3
Sangareddy	85	5	4	5	5	4

Sangli	67	3	3	4	3	3
Sibsagar	55	-	-	-	-	-
Silchar	44	2	2	2	2	1
Solapur	86	5	4	5	5	4
Srikakulam	65	3	3	3	3	2
Srinagar	122	8	7	8	8	6
Sunder Nagar	68	3	3	4	3	3
Talcher	107	6	6	7	6	5
Thoothukudi	84	4	4	5	5	3
Udaipur	130	9	8	9	8	6
Ujjain	88	5	4	5	5	4
Vizianagaram	67	3	3	4	3	3

Annexure III - Convergence of Schemes of Central/ State Government

S. No.	Name of Ministry	Scheme
1	**Ministry of Housing and Urban Affairs**	SBM 2.0, Smart City Mission, Amrut 2.0 & PM E-Bus Seva Scheme
2	**MoEF&CC**	Nagar Van Yojana (3776 hectare in 64 cities; Rs. 142 crore)
3	**Ministry of Petroleum and Natural Gas**	SATAT (on bio-methanation)
4	**Ministry of Road Transport & Highways**	Vehicle Scrapping Policy
5	**Ministry of Heavy Industries**	FAME-II on mobility
6	**Ministry of New and Renewable Energy**	National Bio Energy Programme
7	**Ministry of Power**	Samarth (National Biomass Mission)

Abbreviations

API - Application Programming Interface

AQI - Air Quality Index

AQMP - Air Quality Management Plan

ATR - Action Taken Report

BRT - Bus Rapid Transit

CAAP - City Clean Air Action Plan

CAAQMS - Continuous Ambient Air Quality Monitoring Stations

CAM - Metropolitan Environmental Commission (Mexico)

CAMe - Megalopolis Environmental Commission (Mexico)

CAP - City Action Plan

CCAC - Climate and Clean Air Coalition

CNG - Compressed Natural Gas

CO - Carbon Monoxide

CoP - Control of Pollution (Scheme)

CPCB - Central Pollution Control Board

EPA - Environmental Protection Agency

EV - Electric Vehicle

FC - Finance Commission

GAMA - Greater Accra Metropolitan Area (Ghana)

GIS - Geographic Information System

GSDP - Gross State Domestic Product

IGP - Indo-Gangetic Plain

JnNURM - Jawaharlal Nehru National Urban Renewal Mission

LAQN - London Air Quality Network (UK)

LEZ - Low Emission Zone

LPG - Liquified Petroleum Gas

MCF - Million-Plus Cities Challenge Fund

MoEFCC - Ministry of Environment, Forest and Climate Change

MoES - Ministry of Earth Sciences

MoHFW - Ministry of Health and Family Welfare

MoHUA - Ministry of Housing and Urban Affairs

MoU - Memorandum of Understanding

MPC - Million-Plus City

NAAQS - National Ambient Air Quality Standards

NAC - Non-Attainment City

NAMP - National Ambient Air Quality Monitoring Programme

NCAP - National Clean Air Program/Programme

NMPC - Non-Million-Plus City

NO_2 - Nitrogen Dioxide

NO_X - Nitrogen Oxides

O&M - Operations and Maintenance

O_3 - Ozone

PCB – Pollution Control Board

PCC - Pollution Control Committee

PFMS - Public Financial Management System

PICCA - Integrated Program against Atmospheric Pollution (Mexico)

PM - Particulate Matter ($PM_{2.5}$, PM_{10})

PNG - Piped Natural Gas

PRANA - Portal for Regulation of Air Pollution in Non-Attainment Cities

PROAIRE - Air Quality Program (Mexico)

RSPM - Respirable Suspended Particulate Matter

SAP - State Action Plan

SFC - State Finance Commission

SIMAT - Atmospheric Monitoring System (Mexico)

SO_2 - Sulphur Dioxide

SOP - Standard Operating Procedure

SPCB - State Pollution Control Board

SWM - Solid Waste Management

THC - Total Hydrocarbons

TSP - Total Suspended Particles

UA - Urban Agglomeration

ULB - Urban Local Body

ULG - Urban Local Government

ULEZ - Ultra Low Emission Zone (London)

UT - Union Territory

WHO - World Health Organization

XV FC - Fifteenth Finance Commission

XVI FC - Sixteenth Finance Commission

ZMVM - Metropolitan Area of the Valley of Mexico

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