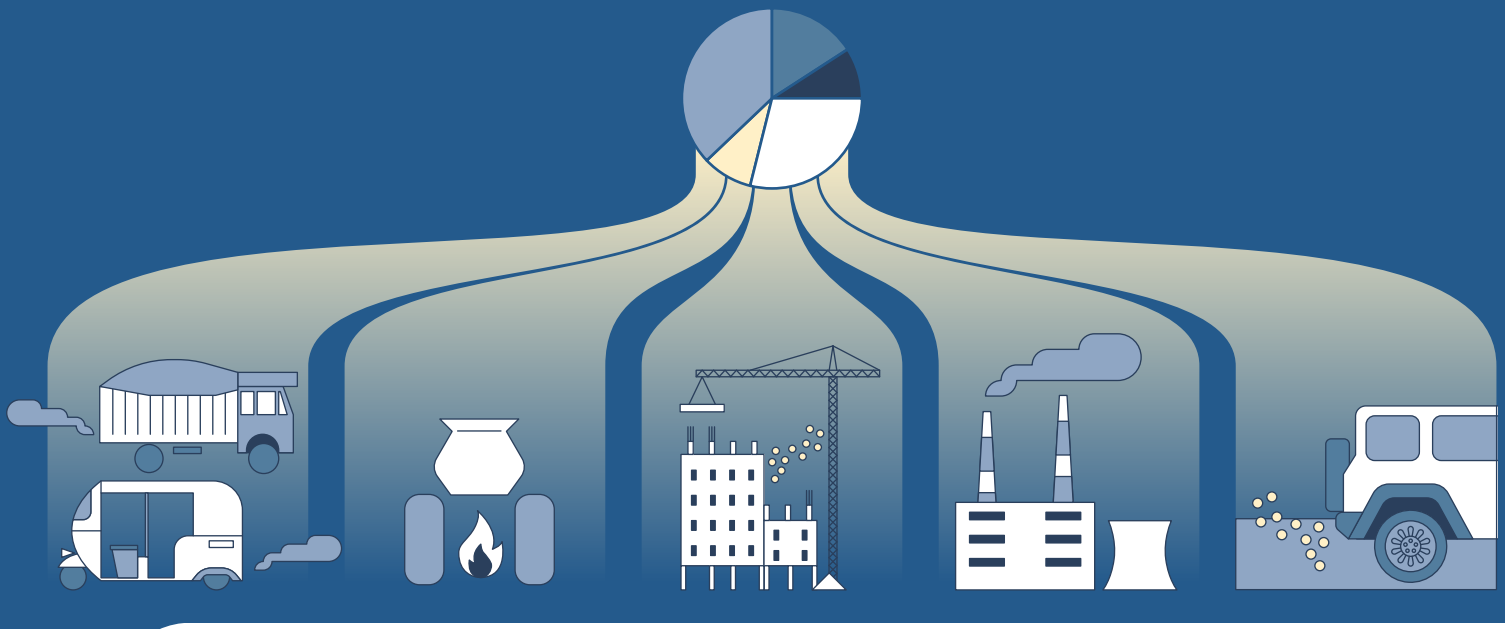

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SUSTAINABLE FUTURES COLLABORATIVE

Strengthening the Scientific Foundations of NCAP

Building a Standardised Framework for Source Apportionment and Emission Inventories

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1. Introduction

India's first comprehensive action plan for air quality management in cities, the National Clean Air Programme (NCAP), was launched by the Ministry of Environment, Forests, and Climate Change (MoEF&CC) in 2019. The programme initially aimed to achieve a 20–30% reduction in PM_{10} and $PM_{2.5}$ concentrations by 2024 across 102 identified cities with an emphasis on $PM_{2.5}$ due to its significant health impacts. In 2022, the Non-Attainment Cities (NACs) list was revised to include 130 cities. In parallel, PM_{10} was designated as the pollutant of interest, with its reduction as the metric of progress, due to limitations in $PM_{2.5}$ baseline data. The programme goal was revised to achieve a 40% reduction in PM_{10} levels, or attainment of national ambient air quality standards (NAAQS), by 2025–26 in the NACs.

The 130 NACs were chosen based on an analysis of 2017 manual monitoring data from the National Ambient Air Quality Monitoring Programme (NAMP). Among these, more than 40 cities with over a

million residents received air quality performance grants through the 15th Finance Commission's Million-Plus City Challenge Fund. The remaining cities are supported under the 'Control of Pollution' budgetary head of the MoEF&CC. Consequently, cities lacking functional monitoring stations or those that did not fulfil the requirement (cities that exceeded NAAQS for five consecutive years from three monitoring stations) were excluded from the NAC classification. This has resulted in the omission of several other polluted cities (such as Ranchi and Howrah) from the NCAP non-attainment list.

The NCAP vision document also outlined a vision for "comprehensive, multi-scale, and cross-sectoral" action to address not only sources within the remit of the MoEF&CC but also those outside it. It also sought to mainstream air pollution action through existing programmes such as the Smart Cities Mission. Additionally, it aimed to convene sector-specific working groups (such as with the Ministry of Power (MoP) to focus on emissions from thermal power plants and the Ministry of Road Transport and Highways (MoRTH) on vehicular emissions) to promote broader action on pollution mitigation. However, there has been little documented progress on the constitution of these working groups, the development of sectoral action plans, or the integration with other programmes.

Based on NCAP goals, the 130 non-attainment cities prepared city action plans detailing source-specific interventions categorised as short-, medium-, and long-term measures, which the CPCB subsequently approved. These city action plans, meant to be backed by analyses that determine source-specific emissions, form the basis for how cities are supposed to approach air quality action under the NCAP. However, five years into the programme, most cities have yet to complete their source apportionment (SA) or emissions inventory (EI) studies, and their role in determining city-level actions remains unclear. In this brief, we highlight the significance of SA and EI studies as the backbone of effective air quality management, and explain why India needs to strengthen its approach to conducting these studies to integrate them into policy actions.

2. How do Indian cities currently understand what pollutes their air?

A clear understanding of what pollutes urban air in India is primarily derived from SA and EI studies. Both studies serve as the core diagnostic tools for quantifying pollution sources, assessing their relative contributions, and informing targeted mitigation strategies. While both approaches complement each other, they address different questions. SA studies analyse the actual concentration of pollutants (such as $PM_{2.5}$, PM_{10}, CO, NO_x, SO_x, etc.) to determine their source-wise contribution. EI estimates source-specific emissions based on activity data (such as

vehicle kilometres travelled, type of fuel used, fuel consumed, or amount of waste burned) and emission factors (amount of pollutant emitted per unit of activity).

Conducting robust SA and EI studies is crucial for all cities, as they provide the evidence for designing targeted, city-specific mitigation strategies. Since pollution sources vary spatially and temporally, the need for updated SA and EI studies is vital in framing air quality management strategies for cities. They help policymakers identify which sources contribute the most to particular pollutants and the ambient air, enabling more effective urban air quality management interventions. The CPCB's 2010 draft guidelines, 'Conceptual Guidelines and Common Methodology for Air Quality Monitoring, Emission Inventory, and Source Apportionment Studies', serve as a guidance document for the development of these studies. These outline key protocols, including ambient air quality monitoring methods, pollutant-specific emission inventory development, chemical speciation of PM_{10} and $PM_{2.5}$, and the use of receptor/dispersion modelling.

The current status of SA/EI in the PRANA (Portal of Regulation of Air Pollution in Non-Attainment cities) dashboard shows that out of 130 non-attainment cities, 44 have 'completed' SA/EI, 46 have 'completed and peer reviewed', and 40 are 'under progress' (as on 30 Dec 2025). While several cities have completed the exercise through Institutes of Repute (IoRs), it remains unclear whether all studies adhered to the CPCB's methodological guidelines. Instead, as we further detail in this brief, cities have used a diversity of approaches that make cross-comparisons challenging.

3. How do cities utilise the data they generate, and why does it often fail to guide their action plans?

In principle, SA and EI studies help cities build a near-complete picture of which sources contribute how much ambient air pollution, with a view to then formulating targeted strategies as part of their city action plans (CAP). However, based on available data on the PRANA portal, cities have either struggled to translate existing SA/EI data into their CAPs or have formulated their CAPs without any prior information on source contributions. Only a few cities had prior SA/EI assessments, while most had to initiate these studies from scratch. For cities without a prior basis for their CAPs, actions to mitigate air pollution were based on a generic understanding of sources contributing to ambient air pollution (such as dust, vehicles, and industries), largely to meet deadlines for submitting their CAPs to the CPCB. As a result, the logical sequence of urban air quality management was reversed, with CAPs being developed first. SA/EI studies were either conducted in parallel or much later. Delhi, Ghaziabad, and Ahmedabad were exceptions, with their SA

study pre-dating NCAP (Figure 1). Little city-specific prioritisation was carried out in the submitted CAPs, and a series of common measures, such as mechanised road sweeping, water sprinkling, and construction dust regulation, were prescribed uniformly, despite significant inter-city variation in pollution sources. This also led to minimal focus on combustion-related emissions, such as those from vehicles, biomass

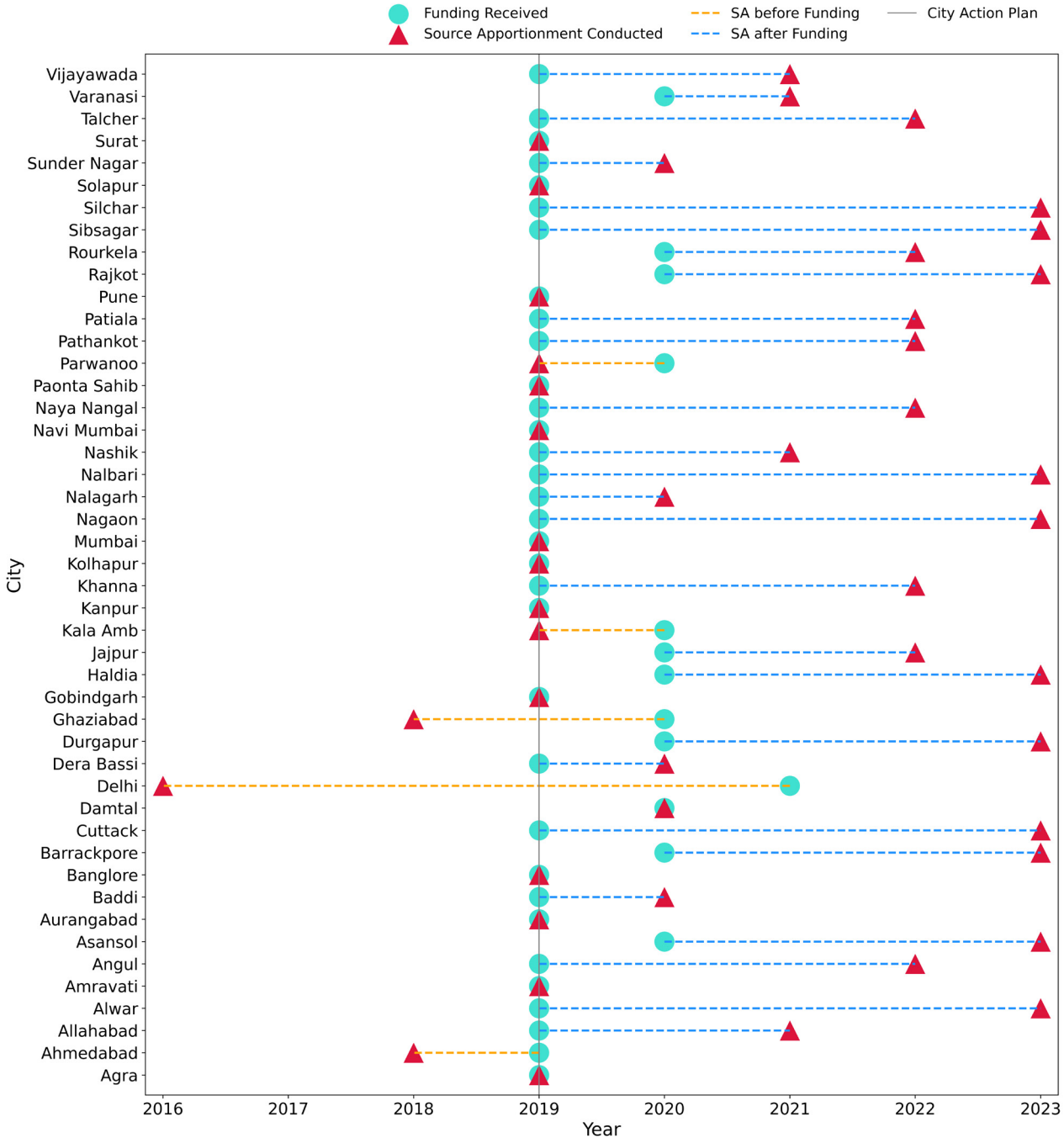

Figure 1: Timeline of when cities received funding, conducted Source Apportionment studies, and submitted their city action plans[1]

Source: Authors' analysis based on data from PRANA

1 Note: The figure includes initial SA and CAPs with revised cities CAPs according to the PRANA portal (Dated: 30 Dec 2025). However, without access to earlier SA and CAPs it is unclear to what the revision years correspond to. Detailed analysis is available online.

and waste burning, and thermal power plants, which are more toxic. As a result, most city strategies resembled a 'least common denominator' approach to air pollution management, favouring quick fixes and less harmful, low-hanging fruit.

Significant inconsistencies across SA and EI studies further compound these planning gaps, limiting their reliability and usefulness for informed decision-making. Across cities, SA and EI assessments were conducted without a standardised methodology or reporting format, making comparisons difficult. For example, Ahmedabad, in its SA/EI study, reported particulate matter emissions in an aggregated format, i.e., "PM". The lack of distinction between PM_{10} and $PM_{2.5}$ makes it challenging to assess which fraction dominated and how mitigation strategies were identified. In some cases, inventories have not considered major gaseous pollutants. For instance, cities such as Dera Bassi and Patiala in Punjab have developed emission inventories that omit gaseous pollutants such as NO_x, SO_2, and CO from key sectors, thereby reducing the comprehensiveness of the pollution profile. Including gaseous pollutants is critical, as they not only have direct health impacts but also act as precursors to the formation of secondary particulate matter and ground-level ozone. Similarly, Ghaziabad (Uttar Pradesh) has unsegregated sectors, highlighting only $PM_{2.5}$ and PM_{10} as the major contributors.

Some states have taken a more deliberative approach in their SA and EI development, as is the case with Himachal Pradesh. Their approach accounts for six criteria pollutants across various sectors, setting a better precedent for emission estimation. Table 1 below presents inconsistencies in the pollutants measured under SA across these various source categories for a handful of cities. Many pollutants were either not measured (for example, in Patiala and Ghaziabad, no gaseous pollutants were measured) or not properly segregated (for instance, in Ahmedabad, $PM_{2.5}$ was not measured only from transport and industry, which has serious health implications).

Table 1: Pollutant-wise distribution for non-attainment cities

Cities	PM load	$PM_{2.5}$	PM_{10}	NO_x	SO_x	CO
Ahmedabad	•			•	•	•
Surat		•	•	•	•	•
Patiala		•	•			
Baddi		•	•	•	•	•
Ghaziabad		•	•			

'•' indicates the cities with their pollutants measured

Source: Authors' analysis based on data from PRANA

The inconsistencies carried through to reporting on sector-wise distribution as well, with various common sources missing in some SA/EI reports (Table 2). When aggregating information from these studies into a standardised reporting format, we observe that road dust was absent in Patiala's analysis, and Ghaziabad omitted dust from construction and demolition activities and residential sources.

Table 2: Sector-wise distribution for non-attainment cities

Cities	Transport	Industry	Road dust	Construction & Demolition	Residential	Others
Ahmedabad	•	•	•	•	•	•
Surat	•	•	•	•	•	•
Patiala	•	•		•	•	•
Baddi	•	•	•	•	•	•
Ghaziabad	•	•	•			•

'•' indicates the cities with sectors having measurements

Source: Authors' analysis based on data from PRANA

Such inconsistencies undermine the effectiveness of mitigation measures and hinder the comparability of work across cities, not just in outcomes but also in the process. For instance, when cities lack a clear picture of pollutant loads – either due to data gaps or poorly structured inventories – their air quality management efforts could remain ineffective. It becomes challenging to track progress over multiple years and identify how specific actions in certain sectors have contributed to reduced emissions over time, as per a common sectoral action plan.

Where SA/EI studies have not been completed, action plans continue to focus on standard measures such as road dust suppression, which, while relevant, may not yield the most significant health benefit. This adherence to the least common denominator approach is evident in the disproportionate allocation of 67% of NCAP funding to dust management, while industries, domestic fuel, and public outreach each received ~1%. This gap results in inefficient resource use and policies that risk being ineffective in achieving the most significant health benefit.

4. How should this be changed for an NCAP 2.0?

Strengthening the scientific foundations of our CAPs is fundamental to meeting our goals of improving air quality and reducing health impacts. To that end, the lessons from this first phase of NCAP must inform NCAP 2.0 to sustain the city-level momentum generated so far. Our recommendations in this regard are as follows:

4.1. Revamping our approach to SA/EI studies

As the scientific backbone of city action plans, there is an urgent need to revamp how we conduct, report on, and utilise data from SA/EI studies. Most importantly, adopt standardised methods across all cities to enable cross-comparisons. This could be either the aforementioned CPCB guidelines or a new approach. Within these guidelines, the CPCB could also specify the open-access emissions factors and activity data to be used across all studies. Once developed, each city should then conduct new SA/EI studies that enable it to:

- Report emissions information for all criteria pollutants
- Specify unsegregated pollutant fractions clearly
- Detail sector-wise contributions in standardised formats

A technical review panel comprising experts from academia that reviews all SA/EI studies would also enhance the rigour, quality, and cross-compatibility of these studies.

4.2. Introduce periodic revisions based on new data

As our cities continue to grow and develop at a rapid pace, the utility of SA/EI studies conducted years ago will diminish. To address the evolution in source profiles, to track progress against source-specific emissions targets, and to ensure that CAPs remain responsive to these changes, cities should aim to:

- Revise existing city action plans as current SA/EI studies are completed and available to reflect their source contributions better
- Update SA/EI studies every 3-5 years, reflecting changes in spatial and temporal pollution dynamics
- Use up-to-date emissions factors as guided by the CPCB to ensure robust estimations of source contributions to emissions
- Strengthen city-level capacity to undertake SA/EI studies with support from the CPCB and SPCBs
- Establish long-term technical support arrangements with institutes of repute, universities, and think tanks to periodically update SA/EI studies and provide consequent feedback into CAPs

These changes would allow cities to move from generic, templatised action plans towards evidence-based mitigation strategies.

4.3. Enhance public engagement and transparency of data

In our analysis of SA/EI studies across cities, several lacked sufficient information used in their analyses, especially regarding emission factors and activity data. These are fundamental pillars in determining source contribution, and their temporal and spatial salience are essential factors in assessing the extent of uncertainty in these studies that have contributed to source estimates.

5. Conclusion

The success of the next phase of NCAP will need a solid foundation of scientific evidence that provides cities with the right tools and timely data to make informed decisions. Without robust and regularly updated SA and EI studies, cities risk 'flying blind' – developing plans without clear direction, and relying instead on generic approaches. Strengthening the scientific basis of clean air strategies is not just a technical necessity but an obligation to ensure that public finance and our collective efforts translate into measurable improvement in the air we breathe.

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