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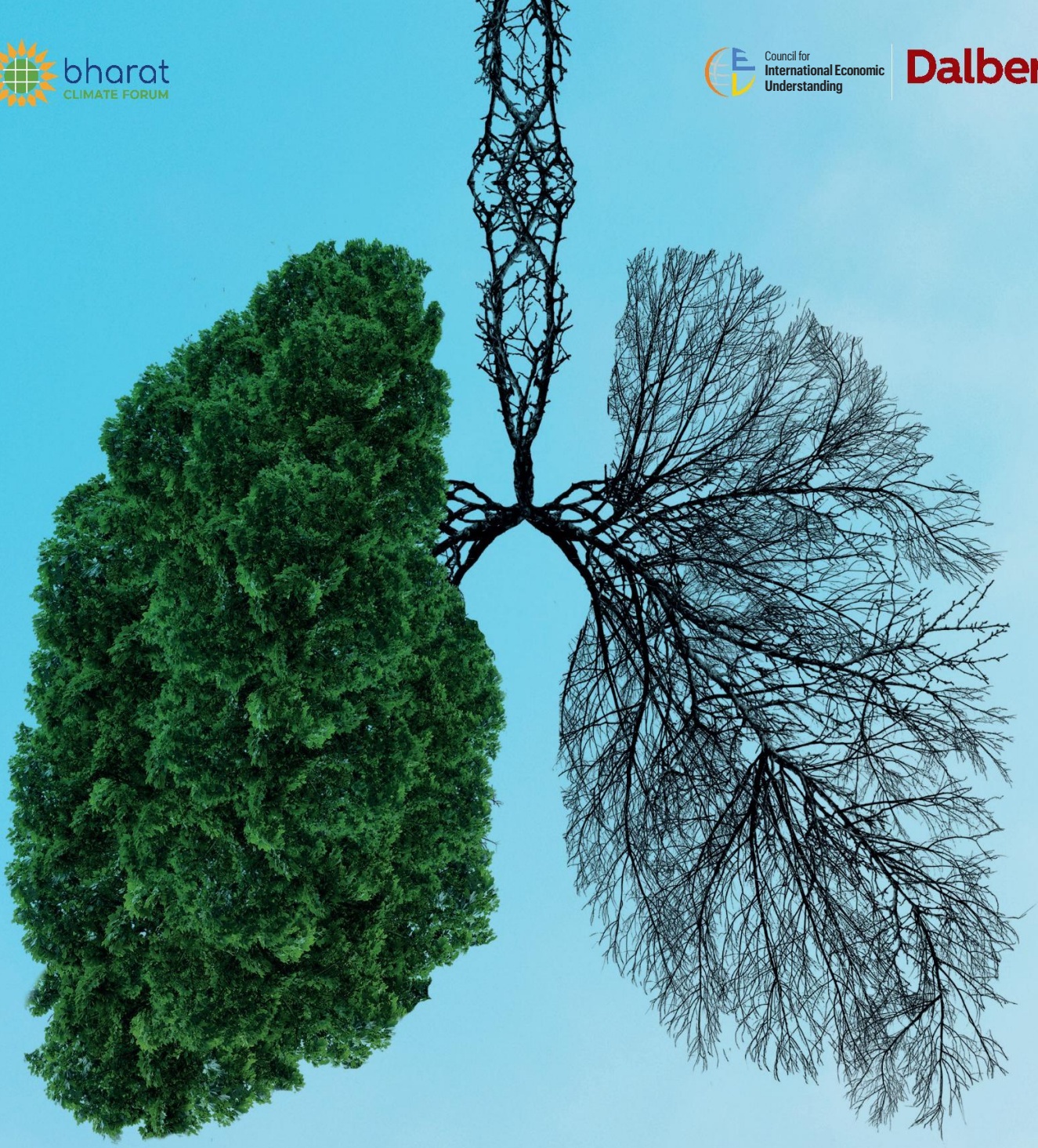


Aironomics 2025

Unlocking India's Blue Skies Economy

Date: May 31, 2025 | **Location:** ITC Maurya, New Delhi

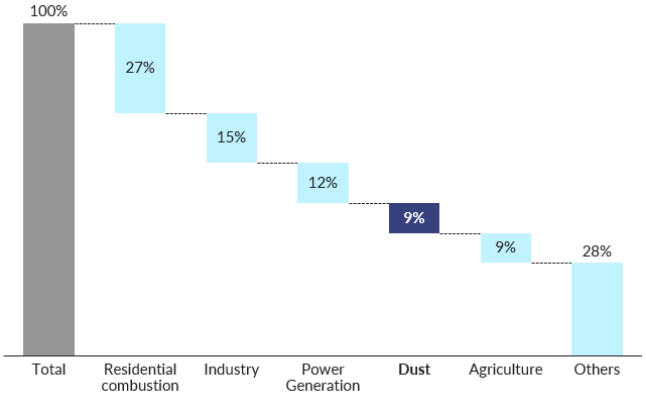
Designing Out Dust

Rethinking Urban Planning for Clean Skies

Context and rationale

Dust is one of the largest contributors to air pollution in India. Dust contributes to ~9% of PM 2.5 emissions in India, making it the fourth largest contributor of air pollution (along with agriculture).[1] In cities like Delhi, this number is as high as ~30%.[2]

Figure 1: Contribution of dust to PM 2.5 in India



Dust-related air pollution is largely attributable to broken or unpaved roads and poor handling of construction and demolition (C&D) activities and waste, with transboundary dust accelerating the problem. Vehicles stir up dust from potholes and unpaved roads, releasing harmful PM 2.5 particles into the air. Currently, ~50,000 issues relating to broken potholes and footpaths and unpaved roads and parking lots remain unresolved in Delhi, contributing to 18% of the city's PM 2.5. [3] C&D waste materials like debris also contribute to the pollution (8% in Delhi)[4] as they contain PM 2.5, which becomes airborne when disposed improperly and left in open roadside piles. In addition to the mismanagement, a lack of appropriate safeguards at C&D sites such as screens, green sheets, and water sprinkling, contributes to dust pollution. Transboundary dust further contributes to the problem in cities like Delhi where dust is carried in from distant regions such as the Thar Desert and

[1] Environmental Science & Technology, Source Contributions to Fine Particulate Matter and Attributable Mortality in India and the Surrounding Region
[2] TERI, Cost effectiveness of interventions for control of air pollution in Delhi
[3] APAG
[4] Ibid.

even the Middle East, especially during the summer when higher wind velocities increase long-range dust transport.

A range of solutions is being deployed by governments to manage road dust, in the form of mechanized road sweepers (MRS), smog guns, afforestation, and green landscaping. MRS collect and remove settled dust from roads before it is re-suspended by traffic. In contrast, smog guns, afforestation, and green landscaping help settle airborne dust—smog guns by spraying fine mist to suppress particulates, and green cover by stabilizing soil and reducing wind-blown dust. For instance, during March 2025, the government of Delhi deployed 86 mechanical road sweepers, 200+ water sprinklers, along with 500+ anti-smog guns.[5] The government also plans to plant 70 lakh trees in 2025 as a part of its greening efforts.[6] Emerging technologies such as chemical dust suppressants, soil-binding agents, and geomembrane covers are also being piloted in some cities to tackle loose dust in high-risk areas like construction sites and road shoulders.

MRS in particular has emerged as a commonly deployed intervention due to its direct impact potential. Unlike smog guns or green cover, which primarily settle airborne dust, MRS offer a proactive solution by physically removing dust from road surfaces before it becomes airborne. The use of water sprinklers along with MRS can magnify the impact, with studies indicating over 90% reduction in deposited dust loads.[7] In Indore, PM 10 and PM 2.5 levels reduced by 8.3% and 5% respectively, between 2018 and 2019, due to MRS operations.[8] The National Clean Air Programme earmarked Rs 68 crore for the procurement of MRS across 27 cities in its first year.[9]

However, high capital costs and inefficient deployment of MRS limit its effectiveness. The cost of MRS machines ranges from Rs 15 lakh to Rs 1 crore per unit, depending on the size,[10] indicating a huge capital expenditure of ~Rs 50 crore by municipalities like the Municipal Corporation of Delhi for deploying large ~60 MRS across the city. Delhi requires an additional ~Rs 250 crore for smaller, four-wheeler and hand-drawn MRS machines.[11] Even where machines are deployed, operational inefficiencies reduce their impact. Route optimization is poor, with a significant portion of shift time wasted on travel, dumping dust, maintenance, and traffic. GPS tracking systems often fail to measure key metrics, such as whether sweeping was performed, sprinkling was effective, or the machine's brush was operational. Moreover, staff need to be properly trained as dust often re-enters due to poor dumping practices, avoiding the use of the central brush, and improper use of sprinklers.

Outsourced models to MRS contractors can be deployed instead of capital outlay to ease the financing burden. Instead of upfront capital investment by municipalities, MRS

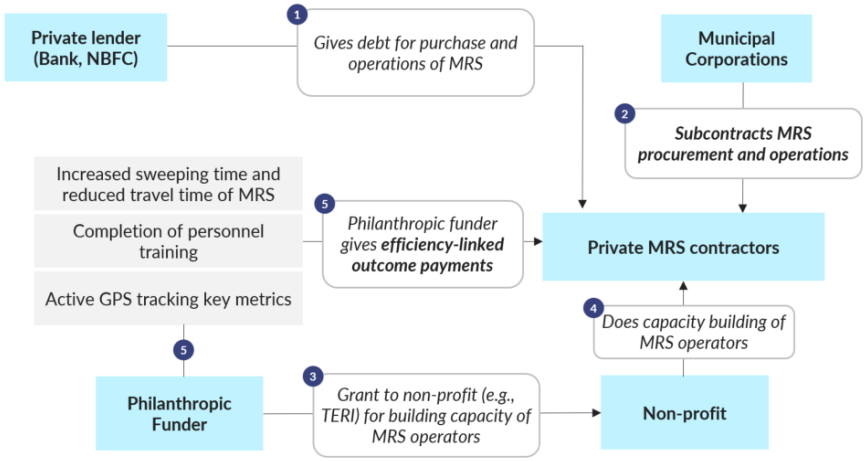
[5] Management interventions to mitigate air pollution in Delhi, Dept. of Environment, Govt. of NCT of Delhi
[6] Delhi CM unveils plans to combat pollution, boost public transport, The Tribune
[7] Centre for Low Emission Construction, Street Cleaning
[8] International Journal of Engineering Research and Technology, An Audit of Mechanized Road Sweeping Operations in National Capital of India- A case Study
[9] Legal Initiative for Forest and Environment, Swept Under the Carpet
[10] Dalberg analysis
[11] Dalberg analysis

contracts can be outsourced to private vendors who procure and operate the machines, recovering costs through long-term operational contracts. Indore has successfully adopted this model by contracting MRS procurement and operations to the International Waste Management Company for Rs 7 lakhs per month per machine, reducing respirable suspended particulate matter by almost half from 2014 to 2017. Such a model could replace the upfront Rs 250 crore required by the Municipal Corporation of Delhi with an annual outlay of Rs 40 crore.

Figure 2: Case Study: Indore Municipal Corporation (IMC) subcontracting MRS

MRS contractors can be incentivized with efficiency-linked payments from results-based funders. Results-based financing can be layered onto outsourced models to drive efficiency of MRS operations. Grants from philanthropic funders can flow to nonprofits to build the capacity of MRS operators, with the funder providing outcome payments to the contractor on achieving key indicators like completion of training, increased sweeping coverage and active GPS tracking. Alternatively, government contracts with MRS vendors can be performance-linked, with disbursement of funds on achievement on pre-determined targets.

Figure 3: Outcome-linked payments can drive efficiency of MRS operations



Adopting these models can help scale solutions for dust management, unlocking a massive economic opportunity. With cities like Delhi requiring Rs 250 crore to invest in MRS, scaling MRS deployment through public-private contracts could unlock significant economic activity for MRS contractors and generate new jobs in MRS operations, maintenance, and monitoring.

This roundtable, "***Designing Out Dust: Rethinking Urban Planning for Clean Skies",*** will bring together public and private sector leaders to identify scalable models, unlock innovative financing pathways, and chart a roadmap for integrating road dust management into India's clean air and urban development agenda.

Potential Opportunities and Challenges

The potential to mitigate dust-related air pollution in India, especially through MRS is underscored by multiple emerging opportunities, driven by supportive government action, innovative financing models, and performance-based implementation.

- **Reducing PM 2.5 through targeted dust mitigation interventions:** Dust accounts for ~30% of PM 2.5 emissions in cities like Delhi and high-impact interventions such as deploying self-propelled machines, which offer greater efficiency (e.g., ~5% PM 2.5 reduction by MRS), should be tailored to specific road types to maximize effectiveness.
- **Leveraging ongoing government action to drive enforcement and scale impact:** While ongoing government efforts, such as deployment of MRS, anti-smog guns, paving/greening of roadsides, and repair of road potholes provide a strong base to scale dust control efforts, strengthened enforcement can amplify impact. This can be done by conducting regular inspections to ensure continuous operations of MRS and anti-smog guns. Accountability mechanisms can also be expanded, like the DPCC"s Dust Pollution Control Self-Assessment web portal for construction sites above 500 square metres, which is currently active in Delhi UP but not yet clearly implemented in Rajasthan and Haryana, despite CAQM's mandate for all NCR states.
- **Unlocking alternate financing mechanisms to ease capital burden:** The capital-intensive nature of MRS (Rs 15 lakh to Rs 1 crore per unit) can be addressed through outsourced delivery models, as adopted by Indore Municipal Corporation, where contractors procure and operate equipment and are paid through long-term service contracts.
- **Driving operational efficiency through performance-linked mechanisms and capacity building:** MRS contracts can be paired with outcome-based financing, where philanthropic or government funds are disbursed based on verified indicators like sweeping coverage and GPS tracking compliance to incentivize efficient operations. This can be supported with capacity-building programs by organizations like TERI which can train contractors and staff on the correct usage of brushes, sprinklers, and dust disposal methods.
- **Creating employment across MRS operations and allied services:** Expanding MRS deployment and operations can generate jobs across procurement, operations, maintenance, and monitoring, especially as municipalities transition to performance-based contracts. There is additional potential to create employment by integrating

existing manual cleaning. For instance, in Indore, municipal staff is trained to sweep all dust and litter on pavements to the road before the MRS machines start on those routes. Appointing cluster-level supervisors to oversee daily cleaning work can further enhance accountability and job creation.

At the same time, several financial and operational challenges limit the scalability of MRS solutions:

- **Large capital investment required for MRS procurement**: MRS are expensive, with cost ranging from Rs 15 lakh to Rs 1 crore per unit, depending on the size. Delhi-NCR needs an additional ~400 MRS, requiring a capital expenditure of ~Rs 250 crore.
- **Underutilization and inefficient deployment of existing fleets:** Existing MRS are often underutilized, with only ~50% of MRS procured by the municipality functional in Bengaluru.[12] Further, those functional, are not deployed efficiently and have poor route planning, fail to monitor metrics around sweeping and water sprinkling, and are operated improperly due to a lack of training. In Hyderabad, for example, the MRS deployed skipped 40% of the arterial roads allocated to them for cleaning.[13]
- **Weak enforcement of construction dust and road repair norms undermines the effectiveness of MRS:** While MRS help remove settled dust, they need to be complemented with source reduction measures, with limited enforcement of dust control norms from construction sites and delays in road repairs reducing their overall impact. In November 2024, the Municipal Corporation of Delhi flagged ~400 construction sites for non-compliance, with closure notices to only three, highlighting the potential to scale inspections and penalties.[14] Additionally, ~50,000 complaints related to potholes, broken footpaths, and unpaved roads remain unresolved, contributing to 18% of Delhi's PM 2.5 levels.
- **Low utilization of funds earmarked for dust management under NCAP:** Despite funding for road dust management under NCAP, utilization remains low, preventing implementation of solutions at scale. Between 2021-23, ~Rs 34 crore was transferred to the Municipal Corporation of Delhi for purchasing MRS, water sprinkler/anti-smog guns, and pothole repairing machines, however only ~39% was utilized.[15]

Key Focus for Discussion

With the aim of unlocking clean air benefits by scaling MRS solutions for dust management, this session will explore:

- What is the **relative effectiveness and return on investment of different dust mitigation interventions**, such as MRS, anti-smog guns, afforestation, and green landscaping, and how should cities prioritize them based on context and road types?

[12] Legal Initiative for Forest and Environment, Swept Under the Carpet
[13] Ibid.
[14] The Times of India, Over 400 sites failed inspection this month
[15] Management interventions to mitigate air pollution in Delhi, Dept. of Environment, Govt. of NCT of Delhi

- What **emerging technologies, such as chemical dust suppressants, geomembranes, and soil-binding agents**, show promise for urban dust control, and how can cities integrate them into broader dust management strategies?
- What are the **contractual structures for procuring MRS** (e.g., service contracts, outright purchase) that best align financial viability with operational accountability, and how can these be standardized and adopted across municipalities?
- How can **operator capacity for effective MRS use be strengthened** through training on equipment handling, monitoring, and route management? Can models like **TERI's training programs be scaled** to build this capacity across cities?
- What are the appropriate outcome **metrics and benchmarks for structuring performance-linked contracts for MRS contractors** (e.g., sweeping coverage, GPS compliance, distance travelled, % of shift time spent on sweeping)?
- What **role can philanthropy play in scaling results-based financing**, especially to link payments to dust reduction outcomes or verified operational improvements?
- What are the enabling steps needed to **improve utilization of NCAP for dust mitigation**, particularly for procurement or outsourced service models for MRS?
- How can cities **account for and respond to transboundary dust**, particularly during high-impact seasonal events, in their air quality management strategies?

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