bharat CLIMATE FORUM

Council for International Economic Understanding | Dalberg

# Aironomics 2025

## Unlocking India's Blue Skies Economy

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

# What Gets Measured Gets Breathed

## Building the Air Intelligence Layer

## Context and rationale

**Air quality monitoring plays a foundational role in understanding and managing India's air pollution crisis, with the country having laid down solid institutional infrastructure.** The Central Pollution Control Board (CPCB) has issued comprehensive guidelines for setting up Continuous Ambient Air Quality Monitoring Systems (CAAQMS) in India, covering the selection of monitoring locations, approved sensor technologies, calibration methods, data reporting standards, and compliance requirements. Over 450 Continuous Ambient Air Quality Monitoring System (CAAQMS) and 800+ manual stations operate under CPCB's National Air Quality Monitoring Programme (NAMP) and State Pollution Control Boards (SPCBs), covering more than 300 cities, towns and villages. This institutional network captures key pollutants including $PM_{2.5}$, $PM_{10}$, $NO_2$, $SO_2$, CO, and $O_3$, and feeds into the National Air Quality Index (AQI) system to inform the public on daily pollution levels.[1]

**The effectiveness of this infrastructure hinges on three critical enablers: robust monitoring infrastructure, timely and granular data, and institutional capacity to translate data into targeted action.** Robust physical infrastructure ensures continuous, accurate measurements across priority geographies and pollution sources, while timely and high-resolution data captures pollution variability across time and space—essential for real-time interventions, forecasting, and source attribution. However, infrastructure and data are insufficient without institutional capacity to interpret and act on this data at multiple governance levels, from central pollution control agencies to municipal bodies and public health departments. Data must not only be collected but also analyzed, communicated, and embedded into decision-making frameworks—whether for triggering emergency responses, shaping urban planning, or designing mitigation strategies.

**Monitoring systems face critical challenges related to limited infrastructure, network functionality, equipment quality, and long-term sustainability.** The capacity of monitoring that exists in India as of 2023 barely adds up to 6-8% of the minimum monitoring recommended as per IS 5182: Part 14.[1] A large share of stations suffers from frequent downtime due to poor maintenance, limited access to spare parts, and underfunded operations. According to CSE, CAAQMS stations in several non-attainment cities report less than 60% data availability annually, falling short of CPCB's reliability standards. Less than half of the manual stations have PM2.5 monitors and only 7% of the stations meet the 104 days of minimum monitoring. Equipment procurement is often fragmented, with states selecting

[1] Somvanshi, Avikal & Kaur, Sharanjeet & Roychowdhury, Anumita. (2023). Status of air quality monitoring in India: Spatial spread, population coverage and data completeness.

different vendors, leading to inconsistent data quality across the network.[1] Furthermore, most SPCBs lack dedicated technical staff for station calibration and upkeep, resulting in a heavy dependence on outsourced vendors with limited local presence.

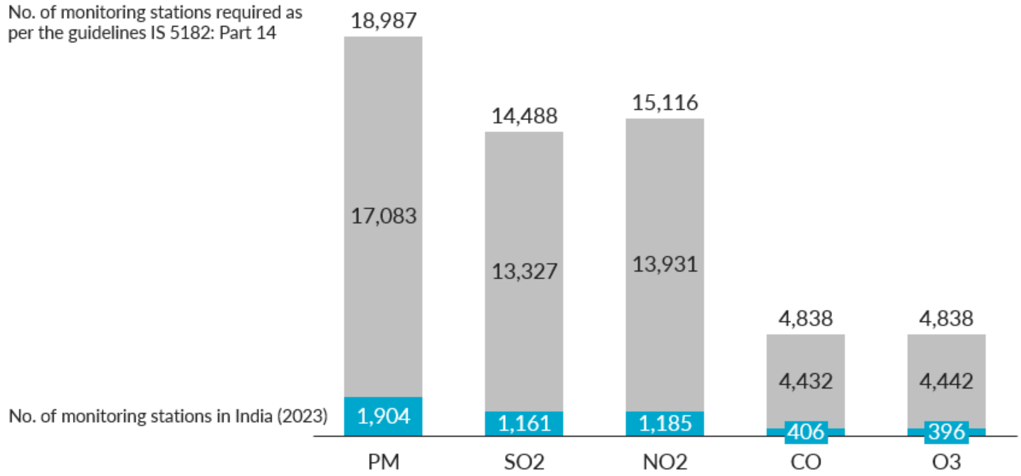


*Figure 1: Comparison between the no. of monitoring stations required as per the guidelines IS 5182 and the no. of monitoring stations present in India as of 2023. Source: CSE Analysis based on CPCB data.*

**Timely and granular data generation is constrained by technical fragmentation, lack of standardization, and poor integration across platforms.** There is currently no unified national platform that consolidates real-time data from regulatory monitors, low-cost sensors, satellite systems, and mobile sensors. Calibration protocols and QA/QC standards for low-cost sensors are not yet formalized, which limits their use in official assessments or enforcement. Manual monitoring stations provide only 2–3 readings per week[2], making them unfit for dynamic interventions. Moreover, the absence of interoperable metadata (e.g., meteorology, traffic, emissions inventory) restricts the ability to build predictive models or conduct meaningful source apportionment in real time.

**Translating air quality data into targeted policy action is impeded by weak institutional linkages and accountability mechanisms.** While air quality data from CAAQMS networks is transmitted to central and state pollution boards, it rarely reaches Urban Local Bodies (ULBs) in actionable formats, leaving frontline agencies unaware of real-time pollution levels.[3] This disconnect is significant, given that ULBs are responsible for executing local interventions such as traffic diversions or construction bans. Further, 74% of (sampled) non-attainment cities lack effective coordination between SPCBs and ULBs to operationalize CAAPs, including translating AQI levels into enforcement triggers.[4] Additionally, despite the NCAP

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[2] NAMP guidelines specify that manual stations collect 24-hour integrated samples twice a week, totaling 104 samples per year at each location. This translates to 2 readings per week (on pre-specified, non-consecutive days)

[3] CSE (Centre for Science and Environment). (2022). Urban India has strategies for clean air but needs stronger implementation and enforcement

[4] CAG (Comptroller and Auditor General). (2021). Performance Audit on Air Pollution Control by CPCB, SPCBs and Committees. Report No. 20 of 2021.

mandating action plans for 132 non-attainment cities, only 30% have defined emergency response protocols linked to AQI fluctuations.[3]

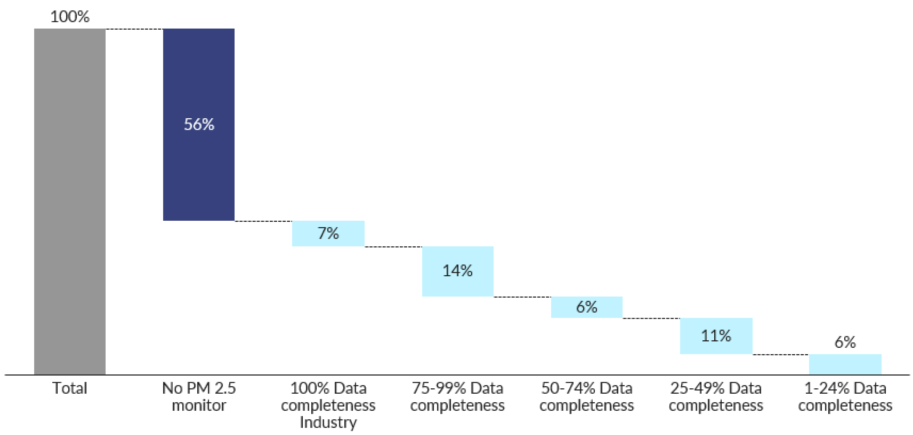


*Figure 2: Station-wise PM2.5 data completeness for manual ambient air quality network (NAMP) for 2019. Source: Urban Lab - Centre for Science and Environment Analysis*

**Emerging technologies like low-cost sensors, Air Quality Decision Support Systems, and satellite monitoring offer a pathway to transform India's fragmented air quality monitoring ecosystem into an integrated, next-generation intelligence network.** These tools can fill spatial and temporal data gaps, delivering hyperlocal, real-time insights at a fraction of the cost of traditional systems, particularly in regions underserved by CAAQMS coverage. Delhi already has an Air Quality Decision Support System where data from satellite-borne sensors, monitoring stations and air quality models is available (AQEWS), with 6 additional cities having similar systems. India can scale such Air Quality Decision Support Systems, unify disparate data streams through a national open-access platform, and institutionalize AQI-linked action protocols at the ULB level. Programs like PM Gati Shakti and NCAP provide the policy scaffolding, while financing models such as Results-Based Financing (RBF) and CSR-backed community monitoring can catalyze innovation and unlock cleaner air at scale. At the same time, while these can provide insights at a much lower cost, it is important to highlight that these cannot substitute regulatory-grade monitoring but can be used for qualitative insights. These instruments can be used for a 'first-pass' assessment that can be followed by some form of regulatory-grade monitoring using manual or mobile monitors.

**The system can be further strengthened by embedding citizen engagement as a core layer—expanding data accessibility and fostering public ownership of air quality action.** Globally, apps like Plume, AirVisual, and OpenAQ have democratized access to air quality data; in India, platforms like Sameer (by CPCB) and SmartAQ.net (a collaboration led by University of Chicago's EPIC India and IIT Kanpur) have enabled real-time citizen access. However, citizen science in India remains limited to pilot zones. With appropriate training, residents' associations, schools, and RWAs can effectively operate low-cost monitors, increasing spatial granularity and building public ownership over pollution control.

This roundtable **'*What Gets Measured Gets Breathed: Building the Air Intelligence Layer*'** aims to bring together key stakeholders across government, research institutions, industry, and civil society to explore how technology, policy, and finance can strengthen air quality monitoring systems and unlock their full potential as enablers of targeted clean air action.

## Potential Opportunities and Challenges

India has an opportunity to build a next-generation air quality monitoring ecosystem that is real-time, high-resolution, and actionable. Unlocking this potential will require overcoming systemic challenges across financial, policy, operational, technological, and environmental domains.

- **Unlocking a ~$380 million air quality monitoring economic opportunity through blended finance and community deployment**: India's growing demand for granular air pollution data—driven by NCAP mandates, smart city programs, and ESG-linked reporting—can catalyze a domestic market estimated at $380 million by 2030 for sensors, data platforms, and analytics services.[5] This market potential includes localized monitoring networks, mobile monitoring vehicles, emissions monitoring in industrial clusters, and data solutions tailored for government, corporates, and citizens.
- **Mainstreaming air quality data into digital public infrastructure and sectoral regulations:** Integrating monitoring into platforms like PM Gati Shakti and urban digital twins can guide infrastructure planning, while embedding emissions monitoring in construction, transport, and industrial policies can institutionalize data collection and improve compliance.
- **Decentralizing monitoring through local governments:** Dedicated O&M budgets like the ₹58.17 crore NAMP allocation (FY22) and trained citizen volunteers can enable sustainable, locally managed networks. Embedding technical staff in ULBs ensures data is operationalized for planning and enforcement.
- **Partnering with private players and platforms to integrate air quality information into everyday services:** Collaborations with major tech players like Google and Apple can embed real-time air quality data into widely used platforms such as Google Maps and search engines, enhancing public engagement, driving behaviour change, and increasing demand for localized, credible monitoring networks.
- **Scaling sensor networks and Air Quality Decision Support Systems for real-time insights:** Low-cost sensors calibrated to achieve 85–90% accuracy can combine with satellite and meteorological data to power AI-driven dashboards for real-time hotspot detection, forecasting, and risk alerts—building on models like China's Blue Sky and the U.S. AirNow.
- **Driving health action and climate co-benefits through real-time attribution:** High-resolution monitoring can trigger targeted responses (e.g., school closures, traffic controls) and help cities meet NCAP's 40% PM2.5 reduction target by 2026, while enabling source attribution and access to performance-based climate finance.

At the same time, several financial, technological and operational challenges limit the scalability and effectiveness of air quality monitoring systems in India:

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[5] Grand View Research. (2024). India air quality monitoring system market size & forecast.

- **Insufficient budget allocation and lack of monetizable models undermine monitoring scale-up:** Air quality monitoring remains underfunded, receiving <2% of NCAP allocations, with most funds going to mitigation infrastructure. High setup and maintenance costs also limit replication in smaller cities. Meanwhile, the absence of monetizable services (e.g., energy sales or user tariffs) makes private investment difficult, unless bundled with analytics, consulting, or ESG reporting platforms.
- **Ambiguous data governance and poor enforcement dilute impact and accountability:** India lacks a national protocol on data ownership, usage rights, and interoperability, making it difficult for cities or regulators to use third-party data for compliance. While industries are required to self-report stack emissions, these disclosures are seldom audited or published, leading to widespread underreporting and minimal consequences. Additionally, a notification by the CPCB banning the purchase of CAAQM stations using NCAP funds discouraged cities from expanding their monitoring networks.
- **Capacity gaps and fragmented mandates constrain on-ground performance:** ULBs and state departments often lack the technical expertise to install, calibrate, and interpret monitoring data. In many cities, equipment lies idle due to staffing shortages or procurement delays. Moreover, the overlapping roles of SPCBs, municipalities, and state environment departments create accountability confusion, leading to duplication in some areas and blind spots in others.
- **Lack of QA/QC protocols and sparse regional coverage limit data credibility and usability:** Despite improved accuracy, low-cost sensors remain outside the regulatory framework, due to the absence of formal calibration standards, QA/QC protocols, and data fusion guidelines. This limits their use in enforcement or permitting. Additionally, large swathes of India—particularly the Indo-Gangetic Plain and remote tribal regions—have minimal sensor density, impairing the ability of AI models to generate reliable, high-resolution forecasts.
- **Weak attribution systems and disconnected health protocols hinder impact realization:** Air quality improvements under city action plans are rarely linked to specific interventions due to a lack of baseline and counterfactual data. This undermines transparency and performance tracking.
- **Misaligned incentives and limited control over data use complicate partnerships with large digital platforms:** Collaborations with global tech companies often require concessions on data ownership, branding, and monetization, which may conflict with government or local agency priorities. Without clear frameworks on data processing at granular level, data sharing, attribution, and revenue models, these partnerships can stall or deliver limited value to public monitoring objectives.

## Key Focus for Discussion

- What are the **key barriers** preventing the wider deployment of **low-cost sensors**, satellite monitoring, and Air Quality Decision Support Systems , and how can these technologies be made acceptable for regulatory or policy use?
- What **technical standards**, such as calibration protocols and QA/QC guidelines, are needed to **ensure the credibility and usability** of data from emerging technologies like low-cost sensors and Air Quality Decision Support Systems?

- What **institutional reforms** or **capacity-building initiatives** are needed to **empower ULBs** and state agencies to **manage, maintain**, and **act on air quality data** at the local level?
- What **policy reforms** are needed to **ensure** that air quality data is routinely integrated into **infrastructure planning, permitting**, and **sectoral regulations**, such as construction and transport approvals?
- Can **community-based monitoring models**, such as those involving RWAs or schools, **meaningfully complement government networks**, and what incentives or safeguards are needed for these models to succeed?
- What role can **industries**—such as **construction, transport,** and **manufacturing**—play in strengthening air quality monitoring networks, and how can data-sharing **mandates** or **incentives** encourage their active participation?

***CIEU and Dalberg Advisors acknowledge and thank the Council on Energy, Environment and Water (CEEW) for their valuable support and contribution in building this pre-read issue note to shape the roundtable discussion.***