SUSTAINABLE FUTURES COLLABORATIVE

SFC Perspectives

Environmental Governance and Policy

Systemic transformations to limit the health burden of air pollution

Bhargav Krishna | Shibani Ghosh | Arunesh Karkun | Annanya Mahajan

SFC Perspectives are intended to stimulate discussion by providing an overview of key issues and avenues for action to inform India’s sustainable development trajectory.

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Context

Air pollution is the largest risk factor for ill health in India, ahead of high blood pressure, tobacco smoking, and poor diets, contributing to ~1.7 million deaths in 2019. Home to several of the most polluted cities in the world, India has witnessed a doubling of death rates from air pollution between 1990 and 2019. The associated economic burden of this high air pollution was pegged at 1.36% of GDP or ~INR 2 lakh crores in 2019[1]. By any metric, air pollution is a national emergency, and while some important first steps have been taken over the last few years, there is a long way to go before India achieves acceptable air quality levels.

At the Sustainable Futures Collaborative (SFC), we view reducing air pollution not only as a technical challenge, but also as a structural one that requires re-thinking our approach and the institutions thatare tasked with addressing it. Systematically addressing air pollution requires a long-term, strategic, goal-oriented, health-protecting framework that also integrates short-term implementable technical solutions, all executed by a capable state. Reshaping India's air pollution policy framework to that end, we believe, will require (1) making health the basis for crafting mitigation priorities, (2) strengthening regulatory institutions in the ecosystem, (3) executing nested, coordinated, data-driven planning and action from local to airshed levels, and (4) focusing on root causes, not symptoms.

India is at a pivotal moment in its quest to reduce the harms of air pollution and this reshaping of the policy framework is an opportunity to build state capacity and ameliorate health harms while integrating air pollution concerns more deeply into the country's development goals.

Systematically addressing air pollution requires a long-term, strategic, goal-oriented, health-protecting framework that also integrates short-term implementable technical solutions, all executed by a capable state.

[1] Anamika Pandey et al., "Health and Economic Impact of Air Pollution in the States of India: The Global Burden of Disease Study 2019," The Lancet Planetary Health 0, no. 0 (December 21, 2020), https://doi.org/10.1016/S2542-5196(20)30298-9.

Where Have We Made Gains?

Over the last two decades, the way India manages air quality has fundamentally changed. The state's response to public demand for action on air pollution during this time may be summarised using three, somewhat overlapping, generations of action. The first generation was largely driven by citizen-led public interest litigation (PIL) followed by court directions. This led to the transition of public transport in the national capital from diesel towards compressed natural gas, and the relocation or closure of polluting industries.

The second generation was characterised by selective sectoral action on what were seemingly the largest contributors not just to local but regional air quality. This included two technological transitions - the leapfrog in emissions norms for vehicles from Bharat Stage IV to VI, and the introduction of the Pradhan Mantri Ujjwala Yojana (PMUY). The PMUY is a government scheme aimed at providing rural households with cleaner burning gas cookstoves and subsidised cooking gas to replace traditional and more polluting cookstoves reliant on wood, dung or coal.

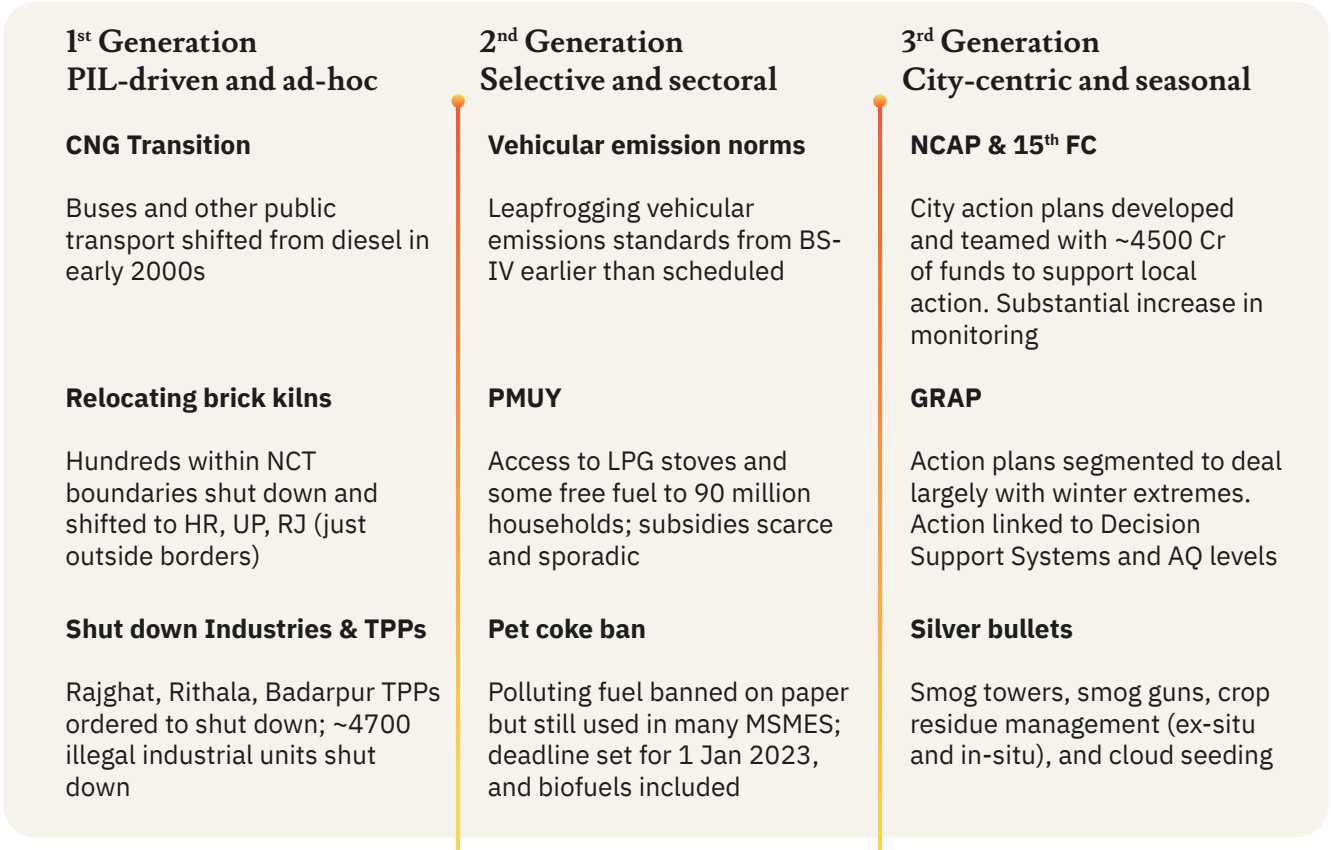


Figure 1: Three generations of air pollution policy actions (Source: author generated)

The third generation of action, epitomised by the National Clean Air Program (NCAP) launched in 2019, arose from increased media discourse over the past decade on the state of air quality in Delhi and much of the Indo-Gangetic Plain (IGP) with air pollution featuring more prominently on the policy agenda and gaining increased visibility in parliamentary debates[2]. The NCAP has brought some structure to air pollution policy making by focusing on 131 cities that do not meet the National Ambient Air Quality Standards (NAAQS). The edifice and financing provided by the NCAP, along with the 15th Finance Commission (FC) grants to 40 cities, have spurred action. In particular, funding for air quality action has enabled many cities to move from being reliant solely on cumbersome filter-based monitoring to online continuous ambient air quality monitoring systems (CAAQMS) that produce real-time data[3]. Coupled with the proliferation of satellite-generated air pollution data, we now have a reasonable idea of the current air quality in most parts of the country. The widespread availability of data has also served to highlight what researchers had long been articulating – a Delhi-centric approach so far had ignored the vast swathes of the country that were experiencing air quality that was often as bad or even worse.

State actions through these three generations have been guided, and sometimes shaped, first by the Supreme Court-appointed Environment Pollution (Prevention & Control) Authority (EPCA), and then by its successor, the Commission for Air Quality Management (CAQM). Established initially through an ordinance that was later replaced by an act of Parliament, the CAQM's wide-ranging powers allow it to direct state governments in the National Capital Region to take specific actions on air pollution centred primarily around the implementation of the Graded Response Action Plan (GRAP)[4]. It remains to be seen whether the CAQM's role as a regional regulator translates into effective and coordinated action across the region.

[2] Santosh Harish, Mandakini Chandra, and Sahithi Uppalapati, "Airing Differences? Reading the Political Narrative on Air Quality Management in India" (New Delhi, India: Centre for Policy Research, November 26, 2021), https://cprindia.org/workingpapers/airing-differences-reading-the-political-narrative-on-air-quality-management-in-india/.

[3] Tanushree Ganguly, Kurinji L. Selvaraj, and Sarath K. Guttikunda, "National Clean Air Programme (NCAP) for Indian Cities: Review and Outlook of Clean Air Action Plans," Atmospheric Environment: X 8 (December 1, 2020): 100096, https://doi.org/10.1016/j.aeaoa.2020.100096.

[4] Santosh Harish, Shibani Ghosh, and Sharon Mathew, "The CAQM Act 2021: An Overview" (Centre for Policy Research, September 17, 2021), https://cprindia.org/briefsreports/the-caqm-act-2021-an-overview/.

Where Do We Need Further Improvements?

Despite three generations of action focused on air pollution mitigation, several parts of India still experience some of the worst air quality in the world. Technological transitions, fuel bans, and even the creation of new institutions have met with limited success. This stalled progress can be attributed to several factors:

Seasonal attention: Attention to air quality concerns is sporadic with a lot of the focus still restricted to winter months in North India. We know from published data that air quality in most of the IGP is poor throughout the year. Yet the restrictions under the GRAP are often utilised in reactive mode, that too only in winter months. The seasonal regulatory coverage, largely focused on Delhi, also obscures the national extent of the problem. A similar level of regulatory scrutiny is required across much of the country. Recent spikes in Mumbai's air pollution levels, aided in part by climate-induced weather disruptions[5], serve to reinforce this point.

Rural and peri-urban areas ignored: While the introduction of the NCAP and 15th FC grants have directed substantial funding towards 131 non-attainment cities and led to the formulation and implementation of city action plans, there has been little action beyond the PMUY on addressing rural and peri-urban air quality. The PMUY was salient in this regard as its goal was to mitigate the harmful effects of cookstove smoke within homes, which particularly harm women and young children who are the most exposed. While the expansion in access to LPG cookstoves has been rapid with over 90 million additional rural households being provided LPG connections under the PMUY, sustained and exclusive use of LPG (a fundamental health goal) has remained elusive[6]. This has not been aided by the almost complete phase-out of LPG subsidies in May 2020. While some subsidies have returned in recent months, their quantum is insufficient, ensuring LPG remains unaffordable to most rural households.

Low institutional capacity: Policymaking has also not taken stock of institutional capacities to implement mitigation strategies, with the central omission being the failure to equip our frontline

[5] Beig, Gufran, V. Anand, N. Korhale, S. B. Sobhana, K. M. Harshitha, and R. H. Kripalani. "Triple Dip La-Nina, Unorthodox Circulation and Unusual Spin in Air Quality of India." The Science of the Total Environment 920 (April 10, 2024): 170963. https://doi.org/10.1016/j.scitotenv.2024.170963.

[6] Aashish Gupta et al., "Persistence of Solid Fuel Use in Rural North India," Economic and Political Weekly 55, no. 3 (January 18, 2020): 55–62.

[7] Bhargav Krishna et al., "The State of India's Pollution Control Boards: Who Is in the Field?" (New Delhi, India, October 2022), https://cprindia.org/workingpapers/the-state-of-indias-pollution-control-boards/.

[8] Shibani Ghosh et al., "The State of India's Pollution Control Boards: Who Is at the Helm?" (New Delhi, India, October 2022), https://cprindia.org/workingpapers/the-state-of-indias-pollution-control-boards/.

environmental regulators – the State Pollution Control Boards (SPCBs) – with the necessary technical capacity and finances. Many SPCBs have not hired full-time technical personnel in many years. In the absence of this vital technical capacity, they are unable to effectively execute even their basic mandate of regulating industrial emissions, let alone guide the design and implementation of complex multi-sectoral plans to improve air quality. A series of working papers published in 2022 showed how under-capacitated the SPCBs in the 10 IGP states and Union Territory are:

- SPCBs lacked adequate skilled personnel, with the rate of vacancies across technical positions ranging from ~20-80%;[7]

- Their leadership was either not appropriately qualified according to their own recruitment rules, and/or was not in their positions long enough to execute meaningful long-term strategies to reduce air pollution;[8]

- They lacked sufficient fiscal capacity and functional autonomy to implement mitigation strategies;[9]

- The Board composition did not include the necessary expertise and largely comprised representatives from government departments and industries, which in many cases are polluters themselves.[10]

[9] Annanya Mahajan et al., "The State of India's Pollution Control Boards: Are They in the Green?" (New Delhi, India, April 2023), https://cprindia.org/workingpapers/the-state-of-indias-pollution-control-boards/.

[10] Arunesh Karkun et al., "The State of India's Pollution Control Boards: Who Has a Seat at the Table?" (New Delhi, India, October 2022), https://cprindia.org/workingpapers/the-state-of-indias-pollution-control-boards/.

The working papers reinforced findings from the Union Government's own analyses as well as those conducted by external agencies.[11] The inability of the SPCBs to effectively deliver on their existing mandate portends a future punctuated by marginal gains in air quality, unable to keep up with India's rapid industrialisation.

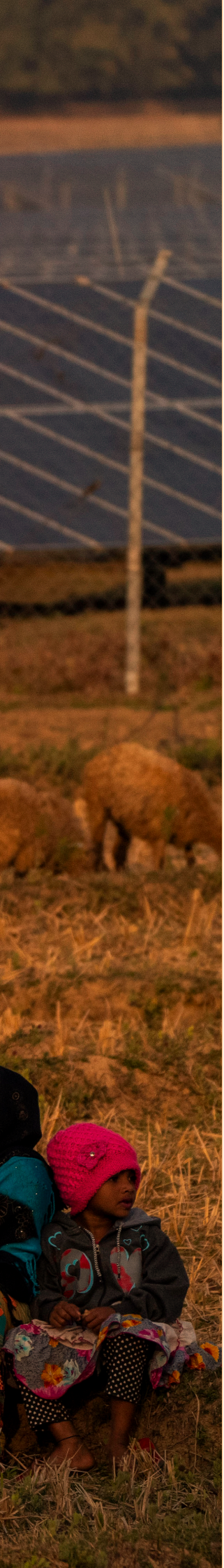
Missing health frame: The other critical flaw in India's air pollution policy making is the absence of a health "frame".[12] Although the NCAP was designed primarily as a health-promoting venture, the NCAP's shift in focus from fine to coarse particles (PM2.5 to PM10) partly due to the lack of an adequate baseline to measure progress on PM2.5, means the sources most harmful to health are left largely unaddressed. Public health professionals – through the generation of epidemiological evidence, and physicians – through their anecdotes – have been successfully highlighting why a health frame is needed while making policies to mitigate air pollution. But what the translation of a normative health frame into practice would look like is yet to be clearly articulated by all parties involved.
In the present policy landscape that gives primacy to seasonal actions, lacks technically capable and adequately staffed institutions, and does not centre health, there has been a proliferation of proposed silver bullets that are likely to fall significantly short of addressing such a complex issue. These include the installation of outdoor air filters or smog towers and the implementation of water-spraying trucks on major thoroughfares, with little to no evidence available a priori showcasing their utility or efficacy. In fact, these experiments could prove to be costly failures with a recent evaluation of the Delhi smog tower showing minimal effect from an investment of ~INR 20 Cr[13].

[11] Central Pollution Control Board, "Report of the Performance Audit of State Pollution Control Boards / Pollution Control Committees" (New Delhi, India: Central Pollution Control Board, September 18, 2020), https://cpcb.nic.in/pcp/report-performance-audit.pdf.

[12] Bhargav Krishna et al., "The Bad Science Choking India," The India Forum, February 10, 2022, https://www.theindiaforum.in/article/bad-science-choking-india.

[13] IIT Bombay, "Pilot Study for Assessment of Reducing Particulate Air Pollution in Urban Areas by Using Medium Scale Air Cleaning System" (New Delhi, India: Delhi Pollution Control Committee, September 30, 2023), https://www.dpcc.delhigovt.nic.in/uploads/news/f412092752035c05ce21d22a74e96232.pdf.

Charting the fourth generation of air pollution policymaking requires us to take the long view by moving beyond limited and discrete actions towards systemic reforms.



Toward a Fourth Generation Focused on Systemic Reforms

Charting the fourth generation of air pollution policymaking requires us to take the long view by moving beyond limited and discrete actions towards systemic reforms. This necessitates a fundamental rethinking of how we approach the design, development, implementation, and evaluation of policies impacting air quality. It also requires us to think deeply about the institutional capacity necessary to execute these reforms at various levels of government, and integrate sectoral actions on air quality within frameworks that serve broader developmental goals. These reforms will need to consider exposure to air pollution as a continuum from the household to the outdoor, from city to regions, and from rural to urban. The following ideas for discussion flesh out this approach:

1. Make Health the Basis for Crafting Mitigation Actions

The principal approach to regulating ambient air quality has been to focus on which sources contribute to ambient concentrations and prioritise actions accordingly. This approach, while somewhat practical, ignores the differential health impact of various sources in two ways. First, fixed monitors across a handful of locations in a city are not capable of capturing the spatial variability in air pollution exposures[14], especially in a country like India where diffuse sources such as local biomass burning contribute substantially to $PM_{2.5}$ emissions. Second, focusing on particle size (e.g. $PM_{2.5}$ or PM_{10}) rather than composition means we ignore the wealth of data we have on differential toxicity of particle components. $PM_{2.5}$ is not an unvarying singular metric and comprises elemental and organic carbon, ammonia, sulphates, nitrates and silicon, among others. These components are variably toxic, with the byproducts of combustion considered the most toxic to human health.

So, what would a health-focused air pollution strategy look like, one that includes health expertise at every stage from policy development to evaluation? This question has already been answered in part by the Union Ministry of Health's Steering Committee report on air pollution published in 2016[16] . The report deviated from conventional thought and outlined a novel approach that prioritises exposures over ambient concentrations. Focusing on exposures and associated metrics - population-weighted exposures and intake fractions - provides a much clearer understanding of the sources to which people are most exposed. Prioritising those sources would thereby yield the greatest health gains. While this does not negate action on large point sources such as industry or power plants, which require urgent attention, it increases emphasis on sources most prevalent in our population centres.

Centering health in air pollution policymaking would also mean integrating health evidence in decisions around standard-setting, and introducing health impact assessments (HIAs) in industry consent mechanisms. HIAs are already widely used globally and should be mainstreamed in India. Ultimately, health will have to move from being merely one of several equally relevant facets towards becoming a central feature and eventually the function of air pollution policymaking, as enshrined in the objective of the laws under which these pollutants are regulated[17] .

[14] Siddhartha Mandal et al., "Ensemble Averaging Based Assessment of Spatiotemporal Variations in Ambient PM2.5 Concentrations over Delhi, India, during 2010–2016," Atmospheric Environment 224 (March 1, 2020): 117309, https://doi.org/10.1016/j.atmosenv.2020.117309.

[15] George Thurston et al., "Are All Air Pollution Particles Equal? : How Constituents and Sources of Fine Air Pollution Particles (PM 2.5) Affect Health," Text/HTML (Washington DC: The World Bank, June 16, 2022), https://documents.worldbank.org/en/publication/documents-reports/documentdetail/810141630705865331/Are-All-Air-Pollution-Particles-Equal-How-Constituents-and-Sources-of-Fine-Air-Pollution-Particles-PM-2-5-Affect-Health.

[16] Kalpana Balakrishnan et al., "Report of the Steering Committee on Air Pollution and Health Related Issues" (Ministry of Health and Family Welfare, August 2015), https://mohfw.gov.in/sites/default/files/5412023661450432724_0.pdf.

[17] Bhargav Krishna and Sagnik Dey, "Making Health the Focus of Air Pollution Policy," The Hindu, November 15, 2022, sec. Comment, https://www.thehindu.com/opinion/op-ed/making-health-the-focus-of-air-pollution-policy/article66140242.ece.

Focusing on exposures and associated metrics - population-weighted exposures and intake fractions - provides a much clearer understanding of the sources to which people are most exposed. Prioritising those sources would thereby yield the greatest health gains.

2. Build Future-Ready Environmental Regulators

Strategies to reduce air pollution can only be effective when implemented by technically capable and well-staffed institutions that are financially sound. As laid out earlier in this paper, this is currently not the case with human resource shortages and several other challenges rendering the SPCBs severely hampered in their ability to deliver sustained improvements in air quality. If they are constrained in executing their existing mandate effectively, then how do states move forward to equip our regulators appropriately for the 21st century?

- Raise staffing levels with a special focus on increasing the number of environmental engineers and scientists. This can be fast-tracked by creating pathways to employment for environmental engineering and environmental management graduates from our top technical institutions such as the IITs and NITs.

- Scale up the deployment and use of technology while ensuring the availability of adequately trained personnel to calibrate these instruments and utilise the data generated effectively.

- Market-based mechanisms for regulating air pollutants must be cognizant of the political economy of various industries, and cannot be deployed in the absence of mechanisms for monitoring emissions. They cannot also be seen as a substitute for the installation of basic pollution control equipment.

- The posts of Chairperson and Member Secretary are more effective when they are held by individuals of high technical competence and that are independent from government. The practice of serving IAS and IFS officials holding multiple concurrent positions including a role in an SPCB negates the fundamental autonomy of the regulator. Further, they must be supported by a Board that has strong academic representation.

3. Plan and Execute Nested Policy Actions from Airshed to Local Levels

Emissions inventories and source apportionment studies conducted across dozens of cities around the country identify the contribution of local as well as regional sources to air quality. However, city-level action plans focus largely on local sources contributing primarily to dust emissions. The focus on regional sources and looking beyond cities is essential, especially in airsheds like the IGP where over 20% of ambient concentrations are from sources lying outside city boundaries[18]. Similar principles hold if we were to view this at the level of states.

The current regulatory framework is focused primarily on point sources within state and city administrative boundaries, with little to no coordination between agencies across states. Adopting an airshed or regional approach to air quality management would address some of the gaps in this framework by fostering a nested approach to regulation that spans local to regional scales[19]. Doing so will require

- delineating multiple airsheds across the country (other than the IGP);
- notifying adjoining areas falling within the same airshed but in different states as air pollution control areas under the Air (Prevention and Control of Pollution) Act 1981 with the aim of regulating all such areas similarly; and
- constituting multi-stakeholder institutions to effectively manage each airshed under the Environment (Protection) Act 1986 as outlined in Figure 2.

[18] Sarath K. Guttikunda, K. A. Nishadh, and Puja Jawahar, "Air Pollution Knowledge Assessments (APnA) for 20 Indian Cities," Urban Climate 27 (March 1, 2019): 124–41, https://doi.org/10.1016/j.uclim.2018.11.005.

[19] Shibani Ghosh, Bhargav Krishna, and Abinaya Sekar, "Regulating Air Quality at an Airshed Level in India" (Delhi, India: Centre for Policy Research, August 2, 2023), https://cprindia.org/workingpapers/regulating-air-quality-at-an-airshed-level-in-india/.

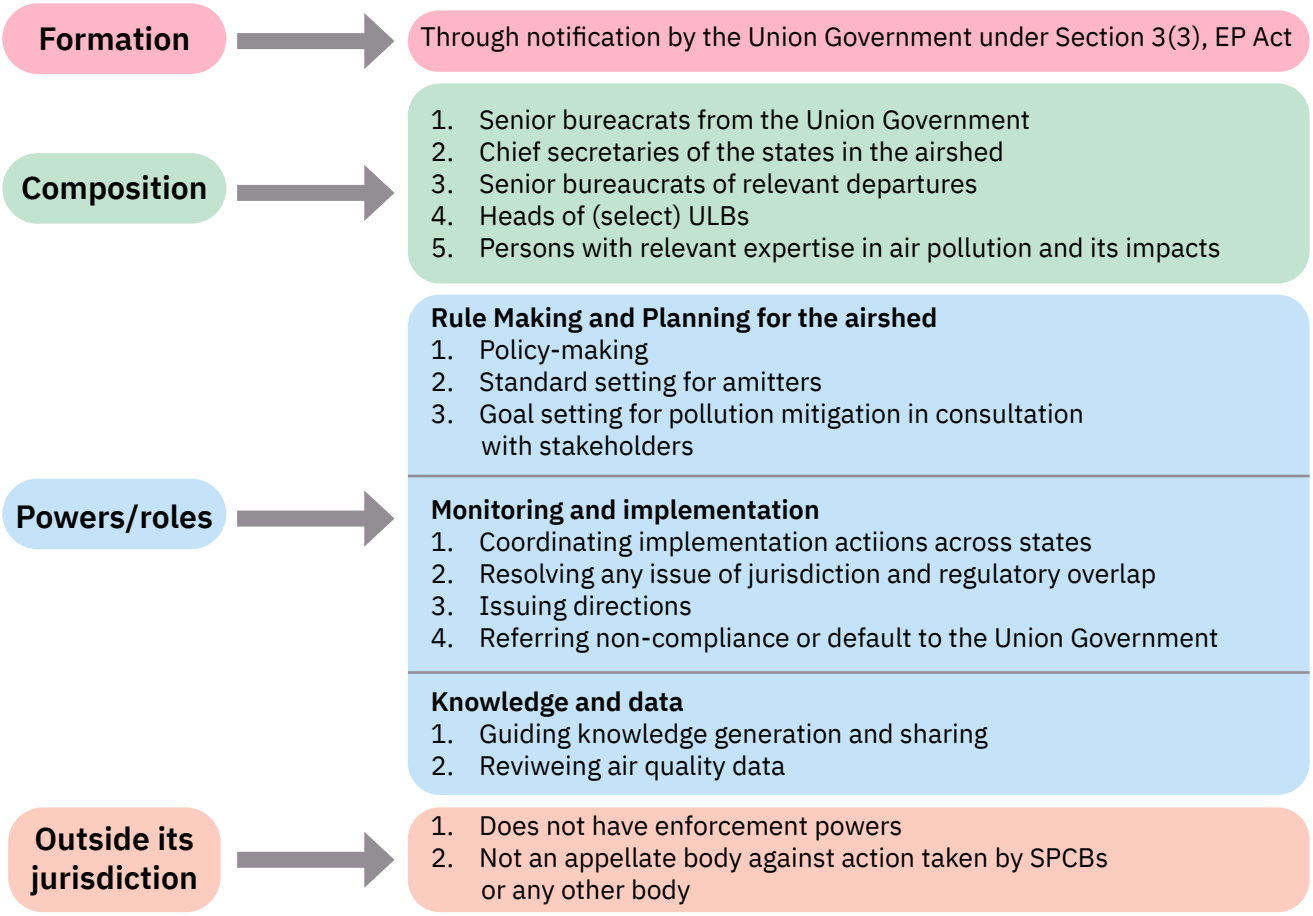


Figure 2: Functions, composition, and powers of the proposed airshed-level institution (Source: Regulating air quality at the airshed-level in India[20])

The role of airshed-level institutions would be to oversee rulemaking, policy development and evaluation, and standard-setting across the airshed. This would leave implementation and enforcement with the State governments and regulatory agencies who would have to work in coordination with these institutions in executing long-term air pollution reduction strategies. These institutions would also serve as the hub for region-wide knowledge generation and sharing, and the first port of call for any disputes that arise between states with respect to regulation or jurisdiction.

Supporting this form of regional, nested planning and action will also require the establishment of data structures that span micro to national levels. This can be facilitated using a diversity of monitoring techniques including low-cost sensors, regulatory monitors, and satellite data in a hybrid monitoring setup (Figure 3).

[20] Ghosh, Krishna, and Sekar.

Scale	Description	Monitoring approaches	Use case	Agencies
Micro	Concentration within an area ranging from <1 square kilometre to a few square kilometres.	Low-cost sensors (LCS), temperature and humidity sensors.	To identify the hotspots of pollution. Hyperlocal information on temperature can also be used for relevant heat wave policy development.	Resident welfare associations, panchayats, industrial associations, ULBS and SPCBs.
Zones and wards	Concentrations within a large, uniformly populated/ land-use area of the city with dimensions between a few square kilometres to tens of square kilometres.	LCS, mobile monitors, temperature and humidity sensors.	To generate spatially disaggregated data and identify potential localised sources for action.	ULBS, and SPCBs
Urban	Conditions that apply to the entire city, ranging from tens to hundreds of square kilometres.	LCS, mobile monitors, manual monitors, CAAQMS and temperature and humidity sensors.	These measures could be used to evaluate urban and peri-urban air quality trends and, in turn, the efficacy of air pollution action plans.	SPCBs
Regional/ Airshed	The topography is largely uniform over distances of hundreds to thousands of square kilometres.	LCS, mobile monitors, manual monitors, CAAQMS, supersites, satellite data and meteorological sensors (temperature, humidity, wind speed, wind direction, precipitation and others).	The data can be better used for conducting source apportionment, understanding the background levels, and regional transport of pollutants.	SPCBs, CPCB, and proposed new institution.
National	Concentrations that characterize the country.	LCS, Mobile monitors, manual monitors, CAAQMS, Supersites and satellite data.	To provide representative snapshot of air quality conditions at the national level.	CPCB

Figure 3: Proposed hybrid-monitoring network (Source: Regulating air quality at the airshed-level in India[21])

[21] Ghosh, Krishna, and Sekar.

4. Move from Palliative Actions to Root Cause-Driven Sectoral Transformations

India's air quality management strategies begin by identifying sectoral contributions through source apportionment studies, and then formulate strategies that are symptom-focused. Such an approach risks being rendered ineffective by ignoring the underlying structural causes. For example, within the transport sector, the focus has been on fuel substitutions (including electrification) and better emission norms. These fixes may reduce per vehicle emissions, but they do not reduce private vehicle ownership. Instead, strategies must be designed to also encourage modal shifts to clean public transport and active mobility, by improving urban design and enhancing last-mile connectivity.

Similarly, India's approach to crop residue burning has largely been aimed at addressing the act of burning itself, first by criminalising the act, and later through the provision of subsidies for technologies for in-situ and ex-situ management of crop residue. Successive crop burning seasons have shown us that the thousands of crores invested in these technologies have yielded limited results. A long-term solution to crop residue burning lies in the structural transformation of agriculture. This transformation has to take place in a phased and inclusive manner that acknowledges the potentially convergent interests of livelihoods, public finance, environmental conservation, climate resilience, public health and nutrition security[22] .

[22] Bhargav Krishna, "Addressing North India's Burning Issue Sustainably," The Hindu, October 20, 2022, sec. Comment, https://www.thehindu.com/opinion/op-ed/addressing-north-indias-burning-issue-sustainably/article66036962.ece.

Conclusion

SFC works on the principle that sustained, long-term gains in air quality can only be achieved by identifying and unlocking upstream policy levers which can activate downstream action at scale. Doing so requires the generation of foundational evidence necessary for rigorous policy making, foster constructive public discourse and engage with state and non-state actors on designing, prioritising, and implementing actions. The scale and impact of India's air pollution requires urgent reforms that build on the three previous generations of actions. The reforms we have outlined in this paper would put India at the forefront of action on air pollution globally by – centering health concerns in mitigation strategies, embracing technology in air quality regulation and management, and bolstering state capacity to meet the challenges that confront India not just today but twenty years from now. Implementing these reforms that drive systems-level thinking on a complex multi-sectoral issue are essential if India is to sustainably address this ongoing public health emergency.

About the Authors

Bhargav Krishna is Fellow and Coordinator, Shibani Ghosh is Visiting Fellow, Arunesh Karkun and Annanya Mahajan are Senior Research Associates, with the Environmental Governance and Policy vertical at the Sustainable Futures Collaborative.

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