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Air Pollution Governance in Megacities: A Comparative Public Policy Analysis of Delhi and Beijing

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Abstract

This paper compares air pollution governance in Beijing and Delhi between 2005 and 2025 to explain their divergent air quality outcomes despite sustained policy attention. Using policy frameworks, institutional analysis, and air quality trends, the study traces each city's shift from episodic crisis responses toward longer-term governance strategies. The findings show that Beijing's success in reducing PM 2.5 stemmed from centralized authority, legally enforceable mandates, and regional airshed coordination, while Delhi's fragmented and litigation-driven approach yielded limited and inconsistent improvements. The analysis demonstrates that effective air pollution control depends on governance capacity and enforcement credibility rather than policy intent alone. By contrasting these trajectories, the paper highlights how institutional structure shapes environmental outcomes and draws policy-relevant lessons for strengthening air quality governance in Delhi–NCR.

Keywords: Air Pollution Governance, Delhi–NCR, Beijing, PM 2.5, Comparative Policy Analysis.

Introduction

Pollution in Delhi has evolved from a periodic winter phenomenon into one of the most persistent public policy challenges confronting urban governance in India. The city consistently records high PM 2.5 levels, contributing to severe public health risks, economic losses, environmental degradation, and governance stress. Beyond an environmental crisis, Delhi's air pollution problem reflects a deeper structural realities, which include fragmented institutions, weak enforcement mechanisms, limited regional coordination, and sectoral emission pressures driven by transport, industry, and rapid urban expansion. Beijing, once globally synonymous with hazardous smog, provides a benchmark to us as it has achieved measurable and sustained reductions in fine particulate matter, whereas Delhi continues to struggle with episodic spikes and reactive interventions. The central research problem lies in the chronic deficit of governance capacity and enforcement credibility within the Delhi-NCR compared to the centralised institutional design of Beijing.

The purpose of this paper, therefore, is to analyse why Beijing succeeded in achieving structural improvement in air pollution governance while Delhi continues to struggle with episodic and reactive measures, and to identify policy options that can realistically be adapted to the Delhi–NCR context.

The study is guided by the following sub-objectives:

1. To compare institutional structures and governance mechanisms in Delhi and Beijing.
2. To analyse differences in enforcement, monitoring, and policy implementation.
3. To evaluate the role of regional coordination and sector-specific interventions in achieving sustained pollution reduction.

Methodology and Limitations

This study adopts a qualitative comparative policy analysis approach, utilizing secondary data from government documents, international environmental reports, and academic scholarship to trace the evolution of air pollution governance in Beijing and Delhi between 2005 and 2025.

This paper examines Delhi's air pollution challenge through a comparative lens. It focuses on Beijing as the primary reference. Beijing has been selected as it represents one of the most relevant and empirically successful example of air pollution control measures adopted by a city. It also once resembled Delhi in terms of severity, socio-economic pressures, scale of urbanization, and governance complexity.

Beijing and Delhi were selected for this comparison based on three primary criteria that align their socio-economic and environmental profiles:

1. Both cities are among the most populous urban centres globally. Beijing is a metropolitan area of 21,953,846 permanent residents as of 2024. Delhi-NCR is an urban agglomeration with a population estimated at 35,134,264 by 2025. This extreme scale creates unique governance challenges regarding infrastructure density, transit demands, and domestic energy consumption. (World Population Review, 2024)
2. Both cities shared extreme baseline conditions of pollution during their respective phases. Beijing's long-term (2-year) average PM 2.5 concentration was 83 µg/m3 during the 2013–2014 period. In comparison, Delhi's annual average PM 2.5 reached 104.7 µg/m3 in 2024, more than double India's national ambient air quality standard of 40 µg/m3. (Lang et al., 2017) (Centre for Science and Environment [CSE], 2025)
3. Air pollution in both megacities is fundamentally a regional airshed issue rather than a localized municipal problem.

In Delhi, approximately two-thirds (60–70%) of winter PM 2.5 originates from transboundary sources such as agricultural residue burning and industrial emissions in neighbouring states like Punjab and Haryana. Similarly, Beijing's air quality is heavily influenced by transboundary emissions from the surrounding Beijing-Tianjin-Hebei (BTH) region, including the provinces of Hebei and Shanxi. (United Nations Environment Programme [UNEP],2007)

The difference in air quality trajectories between Beijing and Delhi can be theoretically explained through the logic of urban governance proposed by Xuefei Ren. Beijing operates under a territorial logic, where the state maintains vertical control through territorial institutions and authorities. In this model, the municipal government and local officials are the primary actors, and their career progression is increasingly tied to achieving environmental targets set by the central government. This alignment of bureaucratic incentives with environmental outcomes creates a powerful mechanism for enforcement. Conversely, Delhi operates under an associational logic, where air pollution control is largely driven by an alliance between environmental non-governmental organizations (NGOs) and the judiciary. (Ren, 2020)

The existing research on pollution in Delhi is largely concentrated on finding emission sources, technological solutions, and short-term policy or regulatory measures. While this is valuable in understanding pollution levels and public health impacts, it offers a limited understanding of the persistent inability of policies to create lasting improvements in Delhi. Systematic comparative analysis, which examines how differences in governance structures influence long-term pollution in megacities, remains limited. Using a comparative governance approach, therefore, allows us to assess air pollution control in a more structural way, instead of focusing only on policy measures.

The study also acknowledges certain limitations. Differences in the political systems of India and China constrain the direct applicability of Chinese policy approaches to the Indian context. Additionally, the reliance on secondary data limits the ability to capture informal practices, primary-level insights, and ground realities in full detail.

Nevertheless, the objective of this research is not to replicate policies mechanically, but to derive relevant governance lessons that can inform more effective strategies for addressing air pollution in the Delhi–NCR region.

Background and Literature Review: Evolution of Air Pollution Governance in Delhi and Beijing (2005-2025)

The period between 2005 and 2008 marks a foundational phase in the long-term evolution of air pollution governance in Beijing and Delhi. During these years, both cities were already among the most polluted megacities in the world, but their trajectories were shaped by drastically different political incentives, institutional architectures, governance capacities, and global pressures. (Rizwan, Nongkynrih, & Gupta, 2013). With the coming of the Olympic Games in 2008, air pollution in Beijing attracted the attention of the government and people (Dube, 2008).

According to a report of the USC US China institute, during 2006-2007, particulate matter (PM) levels often exceeded WHO guidelines, with PM10 frequently more than double the recommended limits (Narain & Krupnick, 2007). International analyses, domestic environmental yearbooks, and Beijing's own environmental quality reports documented the physical severity of pollution and also its emerging public health implications, including respiratory illness, cardiovascular risks, reduced visibility, and long term mortality burdens (World Bank 2007; WHO 2006; SEPA 2006; SEPA 2007). Thus, pollution transitioned from environmental degradation to a policy emergency, compelling the government to act decisively.

Scholars note that environmental governance in Beijing during this time became tightly linked to state performance, crisis management, and the demonstration of strong governance capacity (OECD 2008; UNEP 2007). Policy framing began to emphasize regulatory enforcement and administrative interventions. The Environmental Protection Law, Ambient Air Quality Standards, and evolving national 5 regulatory frameworks provided legal authority (Jin, Andersson, & Zhang, 2016).

From late 2006 onward, Beijing moved toward intense command-and-control governance explicitly oriented toward achieving "blue sky days" during the Olympics. (Jin, Andersson & Zhang, 2016). Key administrative and regulatory actions of Beijing included Odd-Even License Plate Restrictions to reduce vehicle flow, banning high-emission and older vehicles from circulation, Temporary shutdowns of factories, relocation of polluting industries, Construction halts during critical Olympic periods, Sharp reductions in coal consumption within the Beijing jurisdiction, etc. (Liu & Ogunc, 2023).

Beijing's governance structure combined the Municipal Government Authority, State Environmental Protection Administration, and Beijing Municipal Environmental Protection Bureau (SEPA 2006; SEPA 2007). While Beijing reported air quality data through the Air Pollution Index (API) system, later scholarship criticized data transparency and credibility, suggesting under-reporting and selective disclosure practices (Chen, Jin, Kumar, & Shi, 2011).

Delhi, on the other hand, confronted a situation where earlier gains from its Compressed Natural Gas (CNG) transition had begun to plateau while explosive vehicular growth, dieselisation, and urban expansion gradually eroded improvements. (Saxena, Bharadwaj, & Ghosh, 2012). Delhi's pollution profile differed structurally from Beijing's. Whereas coal and industrial power dominated Beijing, vehicular emissions were Delhi's dominant source, responsible for a major share of urban pollution according to empirical studies (He, Huo, & Zhang, 2002) (Gurjar, Butler, Lawrence, & Lelieveld, 2008).

The years 2009–2012 marked a transition in global and national discourse on urban air pollution governance. During this phase, Beijing and Delhi moved from episodic crisis management toward more sustained policy engagement, although to vastly different degrees. In China, this period overlaps with the Eleventh Five-Year Plan (2006–2010) and Twelfth Five-Year Plan (2011–2015). Both of which embedded environmental performance, energy efficiency, and pollution reduction as governance indicators linked to bureaucratic accountability and state legitimacy (Zhang et al., 2012).

At the global level, scientific recognition of the health burden of fine particulate pollution deepened considerably during this period, particularly due to epidemiological analyses of PM2.5 exposure and associated mortality (Bell et al., 2011). Although China did not officially add PM2.5 to national ambient standards until 2012 but independent monitoring and international research demonstrated hazardous exposure levels in Beijing (Bell et al., 2011; Zhang et al., 2012).

By 2012, particulate air pollution in China showed persistent urban concentration spikes, confirming that urban air remained dangerously polluted despite earlier interventions (Zhang et al., 2012). Seasonal dynamics also played a dominant role. Winter coal combustion from residential and district heating contributed substantially to particulate accumulation, while summer months witnessed enhanced photochemical ozone formation, driven by reactions between volatile organic compounds (VOCs) and nitrogen oxides (Bell et al., 2011). This duality meant Beijing faced not just particulate control challenges but also complex atmospheric chemistry requiring deeper regulatory sophistication. (Hernandez, M. 2015)

Key mechanisms in Beijing included Strengthening Vehicular Regulation, Beijing advanced mandatory adoption of stricter emission standards, moving toward China IV levels, which introduced tighter emission limits on NOx and particulate emissions, representing one of the strongest regulatory vehicle environments globally at the time (Zhang et al., 2012). Vehicle Ownership Controls, Recognizing that expanding motorization threatened all future air quality gains, Beijing restricted annual vehicle registration growth through quota-based systems, fundamentally changing the trajectory of urban car ownership (ICCT White Paper, 2015).

Industrial Restructuring like Major pollution-intensive industrial units were relocated, the technologically upgraded, or shut down, was implemented. This was done not merely through negotiated mechanisms, but via hard administrative enforcement, supported by clear state authority. Coal and Energy System Controls-Coal consumption reduction initiatives expanded, laying the groundwork for the massive coal-to-gas transitions that would dominate post-2013 policy frameworks.

Beijing recognised regional governments and explicitly acknowledged that pollution could not be solved through municipal action alone. Emissions from Hebei, Shanxi, Inner Mongolia, and other neighboring regions significantly affected Beijing's air quality, necessitating inter-jurisdictional environmental management coordination (Zhang et al., 2012). Between 2009 and 2012, India experienced rapid economic growth without a commensurate strengthening of environmental governance institutions.

Delhi's pollution crisis deepened within a fragmented regulatory landscape, reactive policymaking tendencies, and limited administrative coherence (Ministry of Environment and Forests, 2010–2012). Although India lagged behind China in building comprehensive air quality monitoring infrastructure, expanding public health research, and media discourse increasingly framed Delhi's deteriorating air quality as a public health emergency rather than merely an environmental concern (Gurjar et al., 2010).

During this period, Delhi’s responses were largely incremental rather than transformative. Mechanism included the tightening of Bharat Stage III and IV vehicular emission norms, expansion of metro rail infrastructure, and industrial regulatory controls. However, these developments did not constitute a unified or city-wide clean air governance framework comparable to Beijing’s systematically planned interventions (Centre for Science and Environment, 2015).

Also, two characteristics particularly defined Delhi’s governance approach during this period. First was policy fragmentation as there was no unified clean air strategy with binding targets and timelines. Second was judicial dominance over executive leadership, where pollution control measures continued to rely heavily on litigation and court-driven directives instead of proactive state policy planning (CSE, 2015; Hernandez, M., 2015).

Institutional complexity further weakened policy execution. Multiple agencies, including CPCB, DPCC, NCR State Boards, the Supreme Court, EPCA, and municipal authorities, had shared overlapping mandates. Leading to blurred accountability and contested administrative authority (CSE, 2015; Kumar et al., 2015).(Sinha & Kumar, 2019; Amann et al., 2017; Bhanarkar et al., 2018). Consequently, despite rising environmental awareness, governance remained reactive, piecemeal, and structurally weak.

By 2013, Both Beijing and Delhi were no longer confronting air pollution solely as an environmental management issue, but it also evolved into a governance and political legitimacy challenge with deep developmental implications. Beijing responded to escalating public pressure following the severe “Airpocalypse” episodes by launching the Air Pollution Prevention and Control Action Plan (2013) along with the Beijing Clean Air Action Plan (2013–2017). These were binding, well-financed, and institutionally enforced. (Greenstone & Hanna, 2014). Thus, 2013–2015 marks a turning point where Beijing transitioned from episodic interventions to institutionalized environmental state capacity, while on the other hand, Delhi continued under fragmented and litigation-dependent arrangements.

Institutional transformation became the defining feature of Beijing’s trajectory during this period. Authority was consolidated, with the Beijing Environmental Protection Bureau (BEPB) which emerged as the primary implementing institution. (ICCT, 2015; CAAC, 2015). Its powers were further reinforced by the 2014 revision of China’s Environmental Protection Law, enabling local governments to suspend industrial operations, impose escalating penalties, shut down non-compliant facilities, and pursue administrative and legal sanctions (CAAC, 2015a; 2015b).

Environmental policy execution was integrated with transport, energy, finance, and urban management departments, supported by clear accountability chains and named officials responsible for outcomes. Strong coordination of BEPB with national institutions such as the Ministry of Environmental Protection (MEP) and the National Development and Reform Commission (NDRC) further strengthened its legitimacy and execution capacity (ICCT, 2015).

Beijing also developed a vertically integrated and horizontally coordinated environmental governance regime that linked policy targets to bureaucratic performance (ICCT, 2015; Hernandez, 2015; CAAC, 2015). By contrast, such measures remained largely absent in Delhi, reinforcing divergent governance trajectories and outcomes between the two cities. In Delhi by 2015, civil society produced the most coherent plan rather than the state itself.

The Delhi Clean Air Action Plan (CSE 2015) provided a comprehensive 12-point strategy including: emergency responses, diesel vehicle restrictions, Euro VI advocacy, public transport expansion, dust suppression and regional air-shed governance. But it remained advisory rather than binding as Delhi lacked the structural enforcement capacity that Beijing had institutionalised. (CSE, 2015; Greenstone & Hanna, 2014).(Kumar et al. 2017)

By 2016, Beijing entered a phase where air pollution policy was no longer experimental or crisis-reactive but institutionalised under national priority frameworks. Beijing governance framework showed consistent enforcement backed by inspections, fines and political accountability (Sinha & Kumar, 2019). Enforcement capacity significantly expanded because pollution mitigation was framed as essential to health, social stability, and a matter of national reputation (Zhang et al., 2019).

Governance in 2016 reflected hierarchical policy discipline: Multi-agency enforcement aligned centrally, Regional coordination increased to manage transboundary pollution transport affecting Beijing from Hebei and Tianjin. and Command techniques were combined with structured planning, industrial emission cuts, and coal reductions.

Technology strengthened policy credibility. Beijing significantly expanded real-time monitoring, integrated satellite and remote sensing, and deployed model-based attribution systems to evaluate whether observed air quality changes were driven by real emission reductions or favourable meteorology (Zhang et al., 2019; Xu et al., 2017).

Implementation was backed by legal penalties, administrative coercion, and infrastructural alternatives. Compliance was not voluntary persuasion but institutional compliance derived from political authority and material enforcement power (Sinha & Kumar, 2019).

Outcomes by year-end 2016 were measurable and improving, although PM2.5 remained above WHO standards. Event-based analyses showed that periods of intensive control significantly reduced concentrations (Zhang et al., 2019). Beijing demonstrated that if structural control windows and enforcement are sustained, PM2.5 declines.

Delhi in 2016 represents one of the most dramatic governance failures in global urban environmental management. The defining episode was the November 2016 Great Smog, widely recognised as a public health emergency. Instrument monitors hit their maximum measurable values, and several documented observations recorded PM2.5 peaking at values around 999 $\mu g/m^3$, indicating catastrophic pollution exposure (Sinha & Kumar, 2019). Findings suggest that nearly 60% of Delhi's PM2.5 originates outside NCT Delhi, meaning that air pollution cannot be solved within city boundaries alone (Amann et al., 2017). Therefore, pollution was not a "Delhi policy problem" but a regional governance failure.

Beijing used coordinated regional approaches, again reflecting scientific evidence that regional emissions significantly influence urban PM2.5. (Xu et al., 2017). This scientific validation prevented political denialism and strengthened policy legitimacy. (Guo et al., 2018).

Post 2016, represents a consolidation phase for Beijing's air quality governance. By this time, Beijing was operating within the centrally mandated Three-Year Action Plan for Winning the Blue Sky Defense Battle (2018–2020). 2019 outcomes empirically validate governance effectiveness. Beijing recorded an annual PM2.5 average of ~42 $\mu g/m^3$. Though still above China's national standard of 35 $\mu g/m^3$ and far above the WHO guideline, this was a policy-driven record improvement, representing sustained success of structural reforms rather than episodic decline (Ministry of Ecology and Environment; Beijing Environment Bureau Bulletin).(Zhang et al., 2019).

For Delhi, 2019 is a foundational baseline year. India launched the National Clean Air Programme (NCAP) in January 2019, described officially as a “time-bound, nationwide, comprehensive” air quality policy framework (MoEFCC; Ganguly et al., 2020). NCAP aimed to reduce PM2.5 and PM10 concentrations by 20–30% by 2024 relative to 2017 levels. Delhi, classified as a “non attainment city,” became a core focus city. The policy included: City specific clean air action plans, Source apportionment, Monitoring expansion and Institutional coordination mechanisms (Ganguly et al., 2020; CPCB city action frameworks).

Delhi’s 2019 PM2.5 level remained extremely high, and unlike Beijing, Delhi still lacked a legally binding reduction mandate and a single executive enforcement authority covering its airshed. 2020 represents the year of unplanned policy intervention. The sudden COVID-19 lockdown in India suspended transportation, industry, and construction, effectively functioning like a national emergency pollution intervention experiment. Delhi’s PM 2.5 concentrations dropped significantly in 2020 due to reduced anthropogenic emissions, producing air quality levels not typically seen in non-lockdown years. However, this decline was not a policy success, but a contextual shock. It lacked institutional durability, financial mechanisms, implementation architecture, and planned enforcement. Therefore, while 2020 provides empirical evidence for possible improvement, it simultaneously exposes that Delhi’s chronic pollution crisis persists because governance systems cannot achieve what lockdown did involuntarily.

In contrast, COVID in Beijing occurred inside an already effective environmental governance system. Beijing’s 2020 PM2.5 level declined further to ~38 $\mu g/m^3$, continuing downward trajectory established before the pandemic. In short, COVID validated Beijing’s policy anchored environmental trajectory, whereas in Delhi it exposed policy insufficiency compensated temporarily by mobility suppression.

2021 becomes the realism test year. As lockdown restrictions eased, Delhi’s emissions resurged because underlying structural pollution drivers remained unchanged. NCAP implementation accelerated, the Commission for Air Quality Management (CAQM) became institutionalized as the single high-authority governance body supervising NCR air quality management. The Graded Response Action Plan (GRAP) was repeatedly enforced seasonally to respond to episodic winter crises. Despite these measures, data demonstrate only marginal PM2.5 improvement compared to 2019 baseline. For example official assessments and Times of India reporting noted limited change (e.g., annual PM2.5 values shifting from ~108 $\mu g/m^3$ to ~102 $\mu g/m^3$). Delhi remained among the world’s most polluted cities despite significant planning and institutional attention.

Delhi in 2022 exists inside a fully activated NCAP ecosystem, enhanced monitoring, and matured GRAP reform framework, under CAQM oversight. Numerous policy instruments like diesel bans, construction dust controls, CNG infrastructure, PNG industrial conversion, truck entry fees, EV policy expansion tackled air pollution issue. However, NCAP reviews reveal a critical governance paradox, Delhi ranks high in policy implementation but Delhi ranks low in actual air quality improvement. NCAP explicitly states Delhi “performed well on policy effort but scored zero in PM10 improvement assessments”. According to NCAP Agenda Report, Core barriers noted include NCR transboundary contribution which stand at 23–24% annually and 70% in winter, Biomass dependency in surrounding regions, Funding and infrastructural constraints, Lack of GST reform for natural gas, Weak PM2.5-focused performance incentives, PRANA portal lacking granular measurable reporting etc.

In contrast, During this phase Beijing reached what policy scholars would define as environmental governance maturity. The Beijing Municipal Ecology and Environment Bureau Report (2022) documents that PM2.5 reduction to 30 μg/m³ (Historic Low in PM2.5), 66.5% PM2.5 reduction since 2013, 88.7% reduction in SO_2,58.9% decrease in NO_2 and 50% reduction in PM_{10}(Beijing 2022 Environmental Report). For example in an effort to reduce nitrogen oxide emissions, a cumulative number of 610,000 new energy vehicles have been put on road. Winter Olympics "Blue Sky" Success documented this achievement.

During the 2022 games, the city fulfilled its commitment to air quality, with PM2.5 levels averaging just 23 μg/m³. Institutionalized Policy frameworks included: One Microgram" Campaign (targeting NO_x, VOCs),1+N Carbon Neutrality Framework, Green Beijing Strategy which focuses on a green transition for the economy and society, Carbon emissions trading a market-based mechanism and Regional Beijing-Tianjin Hebei cooperation which facilitates regional collaboration to manage pollution that crosses provincial borders. (2022 Beijing ECO Report)

Beijing's environmental governance rests on a coherent policy triad: Legally enforceable authority, Infrastructure-embedded compliance and regional environmental sovereignty. However, Beijing now faces a new pollutant frontier — ozone (O_3). Reports show a 14.8% increase in ozone, reaching 171 μg/m³, a major policy challenge (Beijing ECO Report 2022). Additionally, border pollution remains higher and roadside nitrogen dioxide persists 65.2% above background levels. Inter-provincial Border Pollution, Areas near the southern and southeastern borders of Beijing suffer from much higher PM2.5 levels than the city-wide average. Traffic-heavy areas continue to have significantly higher concentrations of nitrogen dioxide (65.2% higher) than the rest of the city. This shows Beijing evolving from PM crisis governance to advanced pollutant governance, signifying a new policy phase.

Existing literature extensively focuses on emission sources and health impacts in both cities, but comparatively fewer studies examine how differences in institutional authority, enforcement design, and regional governance structures explain sustained policy outcomes. This study positions itself within that gap.

Policy Options for Delhi–NCR based on Learning from Beijing

Addressing Delhi's persistent air pollution crisis requires a systemic, multi-layered strategy that strengthens institutions and enforcement. It should also include data-driven governance and should tackle the city's principal emission sectors. Drawing upon lessons from Beijing's successful clean-air transition, four mutually reinforcing policy options are proposed to reshape Delhi and NCR's air governance architecture.

Strengthening Institutional Mechanisms & Regional Airshed Governance

A foundational requirement is restructuring Delhi's governance framework to eliminate structural enforcement gaps. Beijing's integrated environmental authority enforcement framework has significantly contributed to air pollution reduction. Beijing's enforcement success is driven by a Vertical Management System that eliminates "local capture" where local officials protect polluting industries for economic gain (Li et al., 2025). A recent study on institutional reform in China found that centralizing management authority over grassroots environmental bureaus led to a 25.1% decrease in the Air Quality Index. (United Nations Environment Programme, 2019) This improvement is attributed to reducing the influence of local interest groups on front-line regulators and aligning the incentives of local officers with their central administrators. In the year of implementation, this vertical management model reduced concentrations of PM2.5 by 15.4%, PM10 by 15.5%, and SO2 by 9.7% (Chi et al.2026)

Complementing this is the Environmental Police Team, which facilitates immediate administrative detention for environmental crimes, ensuring that "wars on pollution control" launched by the State Council are executed without local interference. For instance, a specialised Environmental Police Force was created in Beijing's case and it was empowered to impose immediate administrative sanctions, ensuring compliance without any bureaucratic delay. In 2018, Chinese authorities approved the arrest of 15,095 individuals for environmental crimes, a 51.5% increase from the previous year, demonstrating the impact of high-powered enforcement. (Congressional-Executive Commission on China [CECC], 2019).

In contrast, Delhi's CAQM remains operationally dependent on state level agencies in surrounding states like Punjab, Haryana, and Uttar Pradesh. This limits its overall enforcement capacity (Economic Times, 2023). Audit evidence highlights the consequences of this weakness, including extremely low implementation of directives such as vehicle deregistration orders (LiveMint, 2024); between 2018 and 2021, only 2.98 lakh out of 47.51 lakh overage vehicles (just 6.27%) were actually deregistered.(Live Mint, 2025). Strengthening CAQM through an independent enforcement cadre and direct field presence is therefore critical.

Reflecting the transboundary nature of pollution, it is equally essential to shift from city-centric control to regional airshed governance. Beijing–Tianjin–Hebei (BTH) framework successfully coordinated with multiple provinces and ministries, achieving environmental targets (International Council on Clean Transportation 2015). This regional framework enabled coordinated action across an airshed of approximately 2.2 lakh sq km (Bhushan, n.d.) Beijing utilised a "Twinning-based Cooperation Mechanism" where the capital provided direct financial and technical support to neighbouring cities like Baoding and Langfang for the elimination of small coal-fired boilers and control of large coal-fired boilers.

On the other hand, the current financial architecture for air quality in India is fragmented into restrictive silos. Delhi's resources cannot be used to fund high-impact solutions like industrial fuel shifts in Haryana or crop-residue management in Punjab (The Hindu, 2024). To bridge this gap, the CAQM should exercise its powers under Section 12(1) of its Act to institutionalize a Regional Airshed Fund (RAF) (Commission for Air Quality Management Act, 2021). This "Common Purse" would allow for an Airshed approach, enabling the region to pool resources and fund large-scale infrastructure (like unified CNG networks) that individual states cannot afford alone. Beijing's own investment in this war against pollution saw its budget jump from 3 billion yuan ($434 million) in 2013 to over 18 billion yuan ($2.6 billion) in 2017. (United Nations Environment Programme [UNEP])

Thus, Delhi lacks an equivalent regional mechanism for the NCR region. A fragmented governance architecture prevents cross-state resource utilisation in tackling the issue efficiently. Establishing a Regional Airshed Fund and mandating participation of key sectoral ministries under CAQM would replicate Beijing's coordinated, economy-wide governance model and enable large scale structural transitions across NCR. (Centre for Science and Environment [CSE], 2024)

Non-Technical Enforcement Reforms and Administrative Accountability

Delhi's effective control of air pollution depends strongly on non-technical enforcement mechanisms such as administrative authority, institutional accountability, and the consistency of penalties (Kanaujia et al., 2022). Beijing's experience shows that long term improvement in air quality was not achieved only through better policies or monitoring systems, but through routine enforcement embedded within everyday administrative functioning.

OECD assessments note that enforcement in China was effective because regulators had clear legal authority, predictable sanctions, and the ability to act without having to depend on lengthy judicial processes (OECD, 2020). In India, despite the presence of environmental regulations, enforcement remains weak mainly due to limited executive powers and poor deterrence. In Beijing, municipal officers were given direct enforcement powers. They could impose fines, suspend operations, and shut down the industries that were polluting the air when violations were detected (Sinha & Kumar,2019). This reduced delays in enforcement and made it harder for industries to ignore compliance requirements or violate norms repeatedly (Xu et al., 2017; Zhang et al., 2019). Environmental progresses were also tied to bureaucratic evaluation. Indicators such as PM2.5 reduction were linked to the career assessment of officials, leading to a system where over 18,000 local government officials were disciplined for violating environmental regulations.

In India, enforcement problems are often less about the absence of rules and more about weak administrative enforcement. Pollution Control Boards have limited executive authority and enforcement outcomes rarely have an effect on bureaucratic performance. Performance audits show that 24% of diesel vehicles checked at Delhi's Pollution Checking Centres had no recorded test values, and thousands of vehicles were issued "Pass" certificates despite failing emission limits. (Comptroller and Auditor General of India [CAG], 2021)

To rectify these systemic lapses, India must transition toward an accountability-driven governance model similar to Beijing's. This involves empowering Pollution Control Boards with direct executive authority to bypass judicial delays and linking air-quality targets directly to official performance reviews, such as the Annual Performance Appraisal Report (APAR) system. By institutionalizing these administrative consequences and fostering rigid inter-state coordination within the National Capital Region, Delhi can convert passive environmental guidelines into an, enforceable mandate that matches the urgency of its air quality crisis.

Technical Enforcement and Data-Driven Air Quality Governance

In Delhi non-technical enforcement must be reinforced through a robust technical enforcement infrastructure to enable objective monitoring and real-time compliance. Beijing’s clean-air transition was backed by the expansion of Continuous Ambient Air Quality Monitoring Networks (Zhang et al., 2019). In 2012, Beijing operated 35 monitoring stations for 20.7 million people, while Delhi had only 11 stations for a population of 22 million. (Almendron, 2015). These networks were integrated with unified digital platforms and were linked directly with the regulatory agency, enabling swift and targeted action.

India has also expanded its CAQMS under NCAP, but integration with enforcement remains limited. Hence, strengthening these institutional linkages is essential (OECD, 2020). Current efforts aim to bring the total number of CAAQMS in Delhi-NCR to 157 to ensure a dense spatial coverage of one station per 25 sq km in urban grids. (Press Information Bureau [PIB], 2025)

Further, Continuous Emissions Monitoring Systems (CEMS) played a decisive role in Beijing’s industrial emission control by transmitting air pollution data directly to the regulatory authority by 2014, China required real-time disclosures from 15,000 enterprises. (Columbia University,2015)

However, in India, fragmented deployment and weak standardisation limit overall effectiveness. Reports indicate that 2,254 highly polluting industries in Delhi-NCR have not yet connected their monitoring systems to the central server. (Business Standard, 2025)

To close these gaps, a mandatory, verified CEMS regime aligned with centralised regulatory dashboards would enhance compliance and transparency. (Central Pollution Control Board (CPCB), 2018) By leveraging remote-sensing technologies and automated detection systems, Delhi can achieve scalable solutions for vehicular emissions, construction dust and seasonal burning. (Central Pollution Control Board [CPCB], 2022). Finally, the integration of predictive analytics can shift governance from reactive emergency responses under GRAP toward anticipatory action and mitigate pollution spikes before they occur.

Industrial and Energy Transition for Stationary Emission Reduction

Effective reduction of industrial emissions in Delhi requires a strong technical monitoring and enforcement framework to ensure compliance and enable data-driven energy transition (Ghosh,2001). Beijing's Clean Air Action Programme implemented structural reforms in industrial emissions, including shifting industries to cleaner fuels, relocating or shutting down non-compliant units, and incentivizing the adoption of low-emission technologies (Beijing Municipal Ecology and Environment Bureau, 2022). These measures resulted in a 35.6% drop in PM2.5 and a 70% reduction in SO2 concentrations between 2013 and 2017. (Beijing Municipal Government, 2020).

In Delhi, industrial emissions remain one of the largest contributors to pollution in the NCR, necessitating a similarly robust structural transformation. However, Delhi faces distinctive implementation constraints, including the need for multi-state coordination and resistance from industrial groups and the MSME sector due to financial limitations. One critical gap is the stringency of norms: the particulate matter standard for coal power plants in China is 10 mg/m^3 or lower, while in India it remains 3-10 times higher at 30-100 mg/m^3. (Bhushan, n.d.)

To emulate Beijing's success, this study recommends a mandatory, phased energy transition in polluting industries. This includes shifting from coal and biomass to cleaner fuels such as PNG, relocating persistently non-compliant units, and incentivizing low-emission technologies. While overall financial costs are significant, long term public health and productivity gains are projected to outweigh expenditures. To ensure social sustainability, reforms should be embedded within a Just Transition Framework, safeguarding workers, small industries, and vulnerable economic groups. Strong monitoring and enforcement systems will be essential to prevent pollution leakage to weaker jurisdictions.

Transport Sector Reforms and switching to safer Alternatives

The transport sector remains Delhi's most persistent emission source, contributing approximately 50% of the city's air pollution. (Clean Air & Global Governance [CAG India], n.d.). Beijing recognized motorization growth as a foundational driver of air pollution and embedded transport regulation within its broader clean-air governance framework. Its approach focused on controlling vehicle ownership, including implementing a license plate quota system that capped new vehicle registrations through lottery and auction mechanisms (Talukdar et al.,2021). The winning rate for these lotteries dropped from 1:10.6 in 2011 to 1:3120 in 2020. (Zhu et al., 2021).

To mitigate the disproportionate impact of high-emitters, Beijing reinforced ownership control by implementing peak-hour bans and Low-Emission Zones (LEZs) that restricted diesel truck entry based on fuel type and performance. This regulatory pressure was paired with a massive logistical effort to phase out over 2.1 million high-pollution vehicles, facilitated by generous scrappage compensation that ensured economic feasibility for owners. By proactively enforcing the stringent China VI (B) emission standards well ahead of the national timeline, the city successfully lowered the per-vehicle emission ceiling and decoupled urban growth from air quality degradation. (UNEP,2019)

These restrictive measures were complemented by substantial investments in public transport and electrified mobility, including metro expansion, bus rapid transit networks, and the electrification of buses and taxis. As of 2024, 98% of new city buses sold in China are electric. (NOW GmbH, n.d.) Delhi has also made progress, currently operating a fleet of 4,286 electric buses, making it the largest e-bus hub in India. (Hindustan times,2025)

To bridge the gap between current progress and air pollution targets, Delhi should transition from voluntary measures to a more aggressive, multi-pronged policy roadmap. This includes implementing compulsory phase-outs of high-pollution commercial fleets through targeted scrappage subsidies and establishing permanent Low-Emission Zones to penalize non-compliant diesel transit. By combining these ownership controls with an accelerated shift toward next-generation Bharat Stage standards and total public fleet electrification, Delhi can systematically dismantle its vehicular pollution crisis.

Conclusion

The comparison with Beijing highlights key lessons for Delhi–NCR. Effective air pollution control requires empowered regional governance, as Delhi's fragmented coordination and funding across neighbouring states limit action on transboundary pollution. Strengthening CAQM with an independent enforcement cadre and institutionalizing resource sharing mechanisms is essential. Enforcement-led accountability is equally critical, linking air-quality outcomes to administrative performance and granting regulators direct powers can reduce delays and ensure predictable compliance. Technology-driven monitoring through verified industrial CEMS, expanded ambient networks, remote sensing, and predictive analytics can shift governance from reactive to anticipatory action. Finally, sector-specific reforms in industry and transport, including phased energy transitions, stricter vehicle ownership controls, public transport expansion, and electrified mobility, are necessary to reduce emissions sustainably. Overall, this study concludes that durable air quality improvement requires institutionalized enforcement capacity and regional governance rather than incremental or crisis-driven interventions. Future research should examine the socio economic trade-offs of aggressive industrial transitions within India's large informal economy to ensure that environmental reforms are both effective and socially sustainable. Without structural governance reform, Delhi's air pollution crisis is likely to persist despite continued policy effort.

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