

The Herculean Task of Improving Air Quality: The Case of Delhi and NCR

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ABSTRACT Air quality in India's capital city of Delhi and its surrounding region (or the National Capital Region, NCR) is poor during most months of the year. Various factors contribute to the worsening pollution, including human activities and a deficit in planning and governance. This brief examines the causes for declining air quality in the NCR as well as the mitigation measures that have been put in place by the government at different periods of time. The state of four human activities that contribute to air pollution – construction, transport, industry/power plants and agriculture – is analysed. The brief argues that plans and projects by the government have only partially been implemented, and in the face of various obstacles, the achievements on the ground have been largely insignificant. The brief offers suggestions for overcoming the hurdles and improving air quality in NCR.

INTRODUCTION

Air, essential for survival, is available in abundance on Earth. Air quality, however, varies: at remote places, air is cleaner, while closer to habitation, it is usually less so.

The quality of air at any given place is determined by prevailing climatic conditions, as well as the varied nature of human

activities. Strong winds sometimes bring dust and various types of emissions from nearby and distant regions, which temporarily cause air pollution. More threatening are the various human activities, at either local or regional level, which are responsible for the deterioration in air quality. These activities lead to the release of toxic fumes and dust in

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the environment. While the problems created by powerful natural forces may often be beyond human control, there is scope for eliminating harmful human activities.

Many governments have taken steps to prevent and control air pollution. Broadly, these range from the formulation and implementation of improved policies, laws, rules, schemes, and norms, to air quality monitoring and forecasting, institutional reforms, application of technologically advanced sectoral solutions, and awareness building.

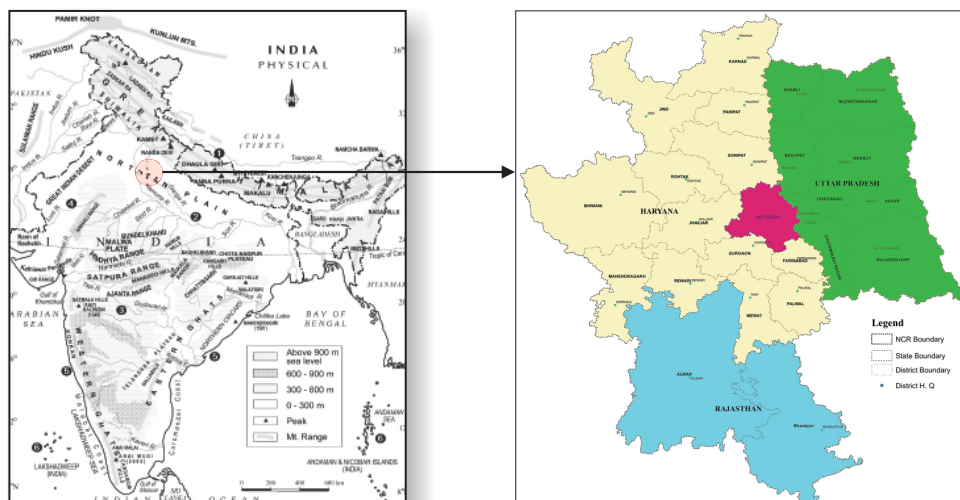
The positive impact of various reform measures is already being seen in various cities across the globe where air quality profiles are improving. Other places continue to grapple with air pollution despite huge investments and introduction of mitigation measures. In India's NCR, the situation has reached severe levels, impacting the people's health and the environment. In turn, the health and environmental impacts of air pollution are causing a strain on the region's progress.

Purpose and Scope

The purpose of this brief is four-fold: (a) to describe the causes for the decline in air quality in India's national capital region, and the sources of air pollution; (b) to appraise policies, regulations and schemes introduced by the national government and various state agencies to combat air pollution; (c) to understand the difficulties involved in overcoming the problem of air pollution in the NCR; and (d) to offer suggestions for improving air quality in the region.

The brief does not cover the harmful effects of poor air quality on human health, environment, and the economy. A note is also in order: The case of the NCR is being examined in view of the alarmingly high levels of air pollution in these areas, and the dense population in the region. Indeed, NCR is the largest and most populated region of India. It is spread over a geographical area of 53,817 sq. km., and the total population of the region is more than 46 million. This region includes Delhi and 23 districts of neighbouring states of Haryana, Rajasthan and Uttar Pradesh (Figure 1). Numerous villages and towns lie in the region.

Figure 1: Location of NCR in India and NCR Constituent Areas



Source: (i) Physical features map of India: <http://random-gs.blogspot.com/2012/06/physical-features-map-of-india.html>;
 (ii) NCR map: National Capital Region Planning Board.

NCR was delineated after 1985 to relieve the capital city, Delhi, of some of the pressure of massive population growth and the upsurge of economic activities. Since then, varied efforts by the central government have been aimed at supporting social, economic and infrastructure development in rural and urban settlements situated in the region surrounding Delhi. The measures introduced over time have shown favourable results. For one, Delhi has experienced declining population growth rates in recent years. This is because as settlements near Delhi are developing, they are able to offer more work opportunities, thereby attracting migrants in large numbers.

This analysis is important because the region is recording extremely high levels of air pollution for most of the year. There has been concern over the issue since the early 1980s when the Air (Prevention and Control of Pollution) Act, 1981 was enacted by parliament. Despite the law, however, the problem of air pollution has only worsened. In 2010, a study by the World Health Organisation (WHO) ranked Delhi as the world's most polluted city.¹ By 2016, Delhi's position improved slightly to sixth amongst the 20 most polluted cities in the world in terms of PM_{2.5} concentrations.² Other NCR cities in the WHO list were Faridabad (ranked second) and Gurugram (11th).

Air pollution severely impacts health. A recent report presented in the Indian parliament reveals 981 deaths in Delhi due to Acute Respiratory Infection (ARI) between 2013 and 2017, and more than 1.7 million people were affected with ARI in Delhi alone.³ Health experts also observe adverse impacts on brain, lungs, heart, and cognition skills. A

smartphone application launched in April 2018 in Paris to calculate air quality in relation to cigarette smoke shows Delhi's air is equivalent to smoking 7.7 cigarettes a day.⁴

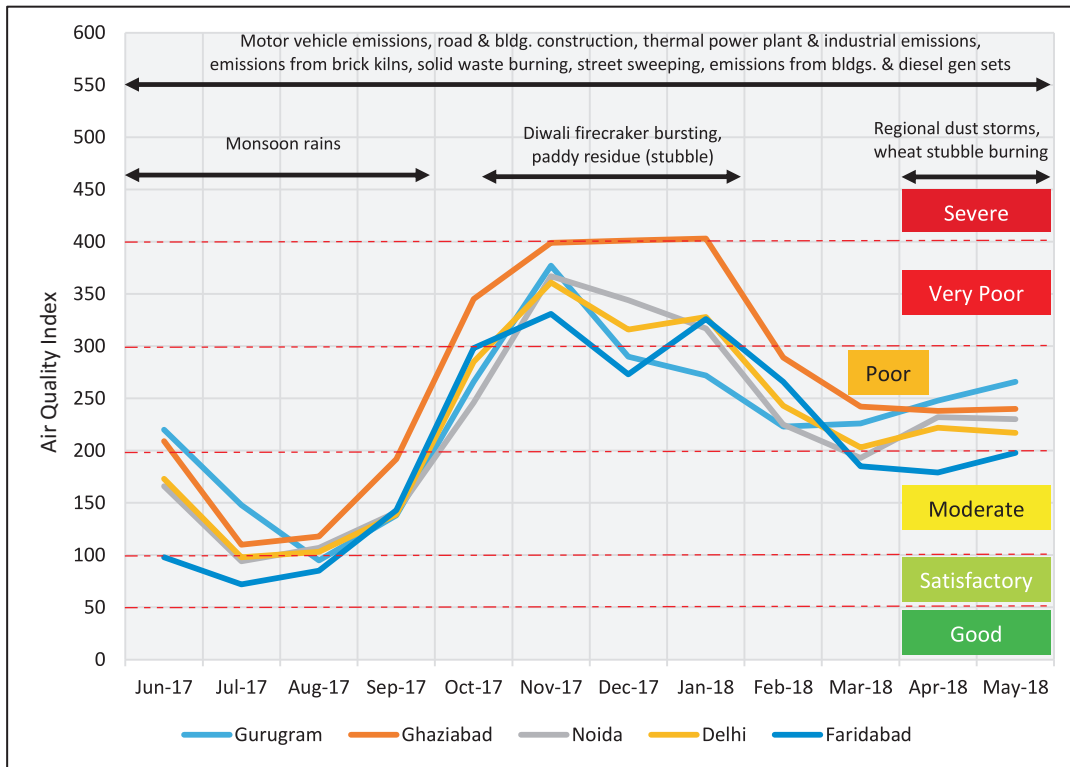
AIR QUALITY IN NCR: A SNAPSHOT

Air quality is monitored from stations set up at various locations in the NCR. Some of these stations are automated and able to generate real-time data; others are manual and fed data manually to obtain values. To gauge how polluted the air is, the National Ambient Air Quality Standards (NAAQS) of various parameters/pollutants are used by the Central Pollution Control Board (CPCB).⁵ If the recorded value of a parameter is more than the defined standard, it means the air is polluted.

The three most common parameters on which data are analysed are AQI, PM_{2.5}, and PM₁₀. AQI (Air Quality Index) is calculated using air quality data of eight parameters – ground level ozone (O₃), particulate matter (PM_{2.5} and PM₁₀), carbon monoxide (CO), sulphur dioxide (SO₂), nitrogen dioxide (NO₂), ammonia (NH₃), and lead (Pb). There are, at times, limitations in calculating AQI due to insufficient data on individual parameters. PM_{2.5} are fine particles present in the environment up to 2.5 micrometres (or microns) in diameter; PM₁₀ are coarse dust particles between 2.5 and 10 microns in diameter. PM_{2.5} particles are very small and pose the maximum risk of causing serious health problems.

AQI values (monthly averages) of the most populated cities in NCR are examined for a one-year period from June 2017 to May 2018 (see Figure 2). The values show a recurring

Figure 2: Climatic Conditions, Sources of Air Pollution, and Air Quality Index (AQI) in NCR Cities, June 2017 to May 2018



Source: Author's illustration based on AQI data from the Central Pollution Control Board and literature review.

trend of poor air quality during many months of the year.

Air quality at any given place is considered 'good' if the recorded AQI value is between zero and 50; it is 'satisfactory' in the range of 51 to 100; and 'moderate' between 101 and 200. Air quality deteriorates further to 'poor', 'very poor', and 'severe' as the values cross the 200-mark. The AQI trend for one year presented in Figure 2 shows that the monthly averages of select NCR cities exceeded the permissible limits, and the conditions are worst during the autumn and winter months from October to February.

Further, an assessment of daily AQI values for the summer month of May 2018 reveals poor air quality in NCR cities for majority of

those days. In a three-year assessment (2016-18) of air quality in NCR, CPCB observed a gradual improvement, i.e., the number of 'satisfactory' days (AQI categories of 'good', 'satisfactory' and 'moderate') went up from 74 (2016), to 113 (2017), and further to 118 (2018).

CAUSES AND SOURCES OF AIR POLLUTION

Studies on Delhi's air^{6,7} reveal that air quality is greatly influenced by variable climatic conditions in the city during the five seasons: summer (early April to end of June), monsoon (end of June to September), autumn (October to November), winter (late November to February), and spring (February to March). Further, the geographical location of Delhi

(see Figure 1) plays an important role in Delhi's climate and air quality, with the mighty Himalayan ranges in the north and the Thar Desert in the northwest influencing weather conditions in the region. In addition, every land use/activity (such as housing, transportation, industry, recreation) has its own environmental impact.⁸

Variable Climatic Conditions

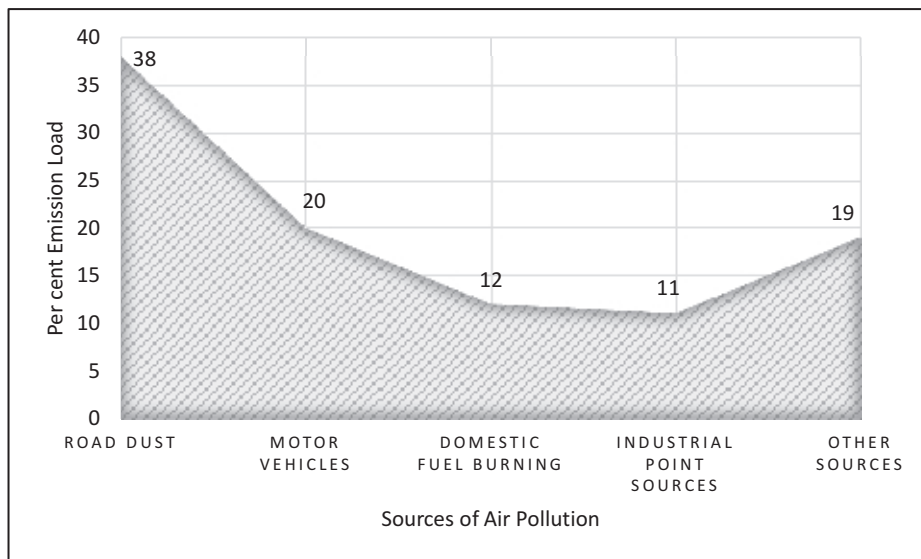
Climatic conditions in the Delhi region are unique in many ways. In the summer, wind velocities increase occasionally, causing dust storms that result in poor visibility. The dust settles with the onset of monsoon, when air quality in the region is at its relative best. The summer and monsoon seasons also witness the occurrence of storms that originate in the Mediterranean region and bring rain and dust to north-western India, including NCR. There are also dust storms from the desert areas in the Arabian Peninsula and Rajasthan, coupled with high humidity. Thereafter, from autumn until the end of winter, the moisture in the air drops, wind speeds decline, and the temperatures go down—such weather conditions lead to the trapping of air (that contains dust and emissions) in the lower atmosphere. Fog is a common phenomenon during the winter months (latter part of December and early January). It is also during this (autumn/winter) period when the national festival of lights or Diwali is celebrated; the burning of firecrackers to celebrate the occasion, causes toxic smog.⁹ It is also the time when farmers in various Indian states (including those surrounding Delhi) burn crop residue (or stubble) to clear their fields for sowing, which causes a suffocating smog in the entire region.

In addition to these seasonal activities, air pollution is caused by others that take place throughout the year (see Figure 2). Examples include the running of motor vehicles, industrial/power plants and brick kilns on inferior fuels; road and building construction without dust-control measures; removal of vegetation for new construction; burning of solid waste including plastic, rubber and dry leaves; street sweeping; and use of diesel generator sets due to frequent power cuts. The toxic effects of these human activities, as mentioned earlier, are worsened by the climatic conditions particularly in the autumn, winter, and summer months (see Figure 2).

Air Pollutants

A study by IIT Kanpur over two seasons (winter, 2013-14; summer, 2014) found that particulate matter (PM_{2.5} and PM₁₀) are the most prominent pollutants in Delhi and neighbouring areas.¹⁰ The chemical composition of PM reveals the sources of pollution: road dust, motor vehicles, domestic fuel burning for cooking, and industrial point sources are the top four contributors to PM_{2.5} (see Figure 3). Together, these sources account for over 80 percent of the total emission load in Delhi. Other pollutants are concrete batching¹¹ (6 percent), burning of municipal solid waste (3 percent), hotels and restaurants (3 percent), construction and demolition (2 percent), diesel generator sets (2 percent), industrial areas (2 percent), and aircraft, cremation, medical incinerators, , and agricultural soil dust (at < 1 percent each). Subsequently, the share of these various sources fluctuates with the occasional introduction of new laws, governance practices, and technologies.

Figure 3: PM_{2.5} Emission Load of Different Sources in Delhi



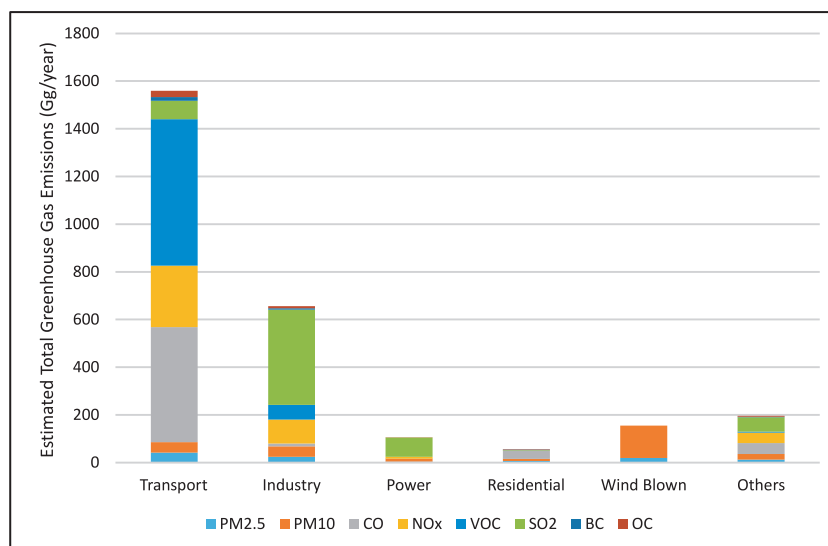
Source: IIT Kanpur, 2016.

Another study, this time by IIT Madras during the winter months of 2016-17 and 2017-18 in Delhi, also found dust and motor vehicle emissions as the primary causes of air pollution in the city.¹²

More recently, an emission inventory by the Ministry of Earth Sciences reported that the transport and industrial sectors were the two biggest sources of air pollution in NCR

(see Figure 4).¹³ Other pollutants are thermal power plants, residences, and windblown dust, as well as human activities like burning solid waste and cow dung cake, and brick-making using inferior fuels. The same inventory found a drastic decline in residential emission between 2010 and 2018, reportedly due to the penetration of LPG connections in slums and households, resulting in reduced use of pollutive means of cooking.

Figure 4: Emissions of Air Pollutants by Sectors in Delhi and Surrounding Region



Source: Ministry of Earth Sciences, 2018.

Abbreviations: PM_{2.5} and PM₁₀: particulate matter; CO: carbon monoxide; NOx: nitrogen oxide; VOC: volatile organic compound; SO₂: sulphur dioxide; BC: black carbon; OC: organic carbon.

PREVENTION AND MITIGATION MEASURES: AN APPRAISAL

The national government has initiated various measures for controlling air pollution at

different time periods. So have the governments of Delhi and the adjoining states (Haryana, Punjab, Rajasthan, Uttar Pradesh), as well as city-level environment agencies (see Figure 5 and Table 1).

Figure 5: Government Measures for Controlling Air Pollution

Legal, Regulatory, Institutional	Financial	Monitoring	Plans, Schemes	Sectoral
<ul style="list-style-type: none"> • Air Act • Environment Act • NAAQS • EPCA • NGT 	<ul style="list-style-type: none"> • ECC • EPF 	<ul style="list-style-type: none"> • RFID system • NAMP • CEMS • Pollution hotspot quadrants 	<ul style="list-style-type: none"> • GRAP • CAP • NCAP 	<ul style="list-style-type: none"> • Construction • Transport • Industry/Power Plants • Agriculture

Source: Author's own.

Abbreviations: NAAQS: National Ambient Air Quality Standards; EPCA: Environmental Pollution (Prevention & Control) Authority; NGT: National Green Tribunal; ECC: Environment Compensation Charge; EPF: Environment Protection Fund; RFID: Radio-frequency Identification; NAMP: National Air Quality Monitoring Programme; CEMS: Continuous Emission Monitoring Systems; GRAP: Graded Response Action Plan; CAP: Comprehensive Action Plan; NCAP: National Clean Air Programme.

Table 1: Air Pollution Control Reforms

Year	Institution	Measures
1981	Government of India	The Air (Prevention & Control of Pollution) Act, 1981
1982	Central Pollution Control Board (CPCB)	National Ambient Air Quality Standards (NAAQS), 1982 (standards revised by CPCB in 1994, and in 2009)
1984	CPCB	National Ambient Air Quality Monitoring Programme (NAAQM), 1984 [renamed as National Air Quality Monitoring Programme (NAMP)]
1986	Government of India	The Environment (Protection) Act, 1986
1996	Supreme Court	Closure of polluting industrial units in Delhi, and their relocation in NCR
1998	Supreme Court	Environmental Pollution (Prevention & Control) Authority (EPCA) for NCR
2001	Supreme Court	Switchover to CNG as automotive fuel for all public transport vehicles
2005	National Capital Region Planning Board	Proposal for increasing the number of air quality monitoring stations in NCR

Year	Institution	Measures
2014	CPCB	Installation of Continuous Emission Monitoring Systems (CEMS)
2015	National Green Tribunal (NGT)	Ban on overloaded trucks, old vehicles, burning of leaves, manual sweeping
2015	Supreme Court	Imposition of environment compensation charge (ECC) on diesel vehicles entering Delhi; installation of RFID system at city entry points
2015	Ministry of Environment, Forest & Climate Change (MoEF&CC)	Stricter standards for coal-based thermal power plants
2016	Delhi government	Odd-even car number plate scheme (implemented in two phases)
2016	Supreme Court	Environment Protection Fund (EPF)
2017	Supreme Court, CPCB, EPCA	Graded Response Action Plan (GRAP) for NCR
2017	MoEF&CC	Regional project to tackle stubble burning
2018	MoEF&CC, CPCB, EPCA	Comprehensive Action Plan (CAP) for Air Pollution
2018	Delhi government	Green Budget: 26 point plan for reduction of emissions
2018	Ministry of Petroleum & Natural Gas (MoP&NG)	Switch over to Bharat Stage VI grade fuels
2018	CPCB	Design of quadrants of pollution hotspots in Delhi
2018	MoEF&CC	National Clean Air Programme (NCAP)
2018	NITI Aayog	15-point draft action plan

Source: Literature survey.

Legal, Regulatory and Institutional

The Air (Prevention & Control of Pollution) Act, 1981 empowers Central and State Pollution Control Boards to issue directions to concerned authorities for maintaining standards in emissions from automobiles, industrial plants, and other sources, as well as to take necessary action (penalties, imprisonment) against those who fail to comply. The law also provided for the framing of air quality standards and as such, the Central Pollution Control Board (CPCB) issued the National Ambient Air Quality Standards (NAAQS) in 1982. The standards define permissible limits of various air pollutants for: (a) industrial, residential, rural and other areas; and (b) ecologically sensitive areas.

Another important legislation is the Environment (Protection) Act, 1986, which empowers the national government to take necessary measures to control environmental pollution. These may include execution of a national programme, examination of processes that are likely to cause pollution, inspection of premises, as well as closure, prohibition or regulation of any industry emitting pollutants in excess of prescribed standards.

The Supreme Court also pushed for the setting up of an Environment Pollution (Prevention & Control) Authority (EPCA) for the National Capital Region in 1998. EPCA is a representative body with members from government departments and non-

government organisations. Since its establishment, EPCA has been engaged in studying pollution trends and offering recommendations. More recently, in 2015, the National Green Tribunal (NGT), a body established in 2010 to handle environmental disputes, proposed the banning of overloaded trucks, old vehicles, burning of leaves, and manual sweeping.

Financial

In response to a Supreme Court order of 2015, an Environment Compensation Charge (ECC) was imposed on commercial vehicles entering Delhi to discourage them from using these roads as a short-cut to other locations outside the capital.¹⁴ The measure meant to reduce emissions from diesel vehicles. The installation of Radio-frequency Identification (RFID) systems (includes smart sensors and HD cameras) was also proposed to record the number of commercial vehicles entering Delhi. This has been delayed, however, resulting in the underreporting of trucks entering the national capital, and the consequent huge loss in collection of ECC. The first such system, out of 13, is expected to be operational at Aya Nagar (in south Delhi bordering Haryana) in October 2018. A private company (Tecsidel) has been engaged by the Delhi government's transport department and the south Delhi municipal corporation for carrying out the installation.

Another Supreme Court order of August 2016 led to the creation of an Environment Protection Fund (EPF). For raising revenues, a one percent pollution charge on sale of diesel SUVs was imposed, and by 2018 over INR 750 billion has been collected under the fund.

However, there has been a delay in utilisation of collected funds, and it is proposed that the money be utilised for implementing pilot projects, such as installation of air filters at traffic intersections and on bus rooftops, and using chemicals to suppress dust at construction sites.

Monitoring

A nationwide programme of monitoring ambient air quality and meteorological parameters (e.g., wind speed and direction, relative humidity, and temperature), was executed by CPCB in 1984. The measure facilitated the establishment of monitoring stations across the country. The programme also aims to generate knowledge for developing preventive and corrective measures.

In 2014, CPCB issued directives to all State Pollution Control Boards in the country to ensure that all highly polluting industries install online Continuous Emission Monitoring Systems (CEMS) and connect these to the Boards servers. However, in what is a familiar refrain, the installation has been delayed. Further, up-to-date emissions data on open platforms are not available.

The Delhi Pollution Control Committee (DPCC), constituted in the Environment Department of Delhi government, has also taken steps in this regard, conducting monthly source monitoring of all thermal power stations in Delhi. Moreover, continuous ambient air quality monitoring stations have been installed at critical locations in the city, and real-time data are available on the DPCC website.

While the number of stations in NCR has increased, the number is still far less than required, leaving air quality at many places unmonitored. Further, between cities, there are significant variations. Delhi has 48 stations, Noida and Faridabad have two each, and Gurugram and Ghaziabad have only one each. The installation of stations often gets stalled due to shortage of funds,¹⁵ the non-availability of land, and bureaucratic hurdles.

CPCB also designed quadrants of pollution hotspots in NCR in February 2018 and intends to intensify site visits to keep track of air quality. The agency has deployed 41 teams across NCR cities to monitor sources of air pollution. The local-level agencies are taking similar steps. In Gurugram, the local government has constituted a committee and several teams to keep a strict check on any violations in waste management and dumping, construction, among other pollutive activities, and to penalise those found violating the norms. The information thus generated will help NCR authorities in developing targeted action plans and applying appropriate solutions.

In addition to these measures, the Ministry of Earth Sciences in October 2018 launched an Air Quality Early Warning System¹⁶ capable of forecasting air quality three days in advance. This will help in preparing for pollution spikes caused by adverse meteorological conditions and pollutive human activities such as exploding firecrackers and stubble burning. This is an improvement from the present system, namely SAFAR (System of Air Quality and Weather Forecasting and Research)¹⁷ which issues forecasts only of the next day's air quality.

Plans and Schemes

Air quality in NCR is particularly severe during the winter months. An attempt was made in 2017 to address the matter by implementing a Graded Response Action Plan (GRAP). GRAP was prepared following a Supreme Court order, and under the supervision of the MoEF&CC. Following notification, the EPCA was tasked to ensure implementation of the plan, which is a set of measures aimed at combating air pollution. Depending on the AQI category (i.e., severe+, severe, very poor, etc.), a certain set of measures are to be implemented. For example, if the AQI value is in severe+ category, the state-level implementation agency would be required to do the following: stop the entry of trucks into Delhi and cease construction activity; introduce odd-even private car number plate scheme; and close schools. The higher the AQI value, the more stringent are the measures.

The response of NCR states to GRAP has been weak. The NGT, therefore, has asked the states to submit compliance reports, as well as monthly air quality information from CPCB, DPCC, and State Pollution Control Boards. In addition to GRAP developed by MoEF&CC, another version of GRAP was designed by NGT in December 2017. The NGT plan also recommends measures to control air pollution, such as sprinkling water to prevent dust from spreading; and ban on crop residue burning, construction work, and thermal power plants. Further, NGT has called for the integration of the two GRAPs.

MoEF&CC also prepared and notified a Comprehensive Action Plan (CAP) in 2018 in consultation with various stakeholders to tackle air pollution in NCR, with CPCB being

charged with issuing directions to dust and emission generators, and monitoring compliance. Reducing particulate pollution by at least 74 percent is one of the targets under the plan. To achieve this target, the plan recommends a series of measures, such as expansion of air quality monitoring station network in the region, satellite-based monitoring of stubble burning, introduction of battery-operated vehicles, increasing the number of public transport buses, and permanent closure of Badarpur thermal power plant. The plan has been criticised for not having any time-bound targets.

The proposed National Clean Air Programme (NCAP) of MoEF&CC is the most recent effort aimed at reducing air pollution by 70-80 percent from current levels over the next 10 years in 100 Indian cities. The plan, set to be launched towards the end of 2018 with assistance from the World Bank, has a goal of meeting the prescribed annual average air quality standards at all locations in the country in a stipulated timeframe. Suggested measures include expansion of monitoring stations, establishing air information systems, and strengthening implementation mechanisms.

For its part, NITI Aayog, the Indian government's policy think tank, has formulated a 15-point draft action plan and has suggested timelines expected to be incorporated in the NCAP. Some of the measures recommended are: phasing out of diesel vehicles by 2022; central government office vehicles older than 15 years to be replaced with electric vehicles by 2021; prioritise decommissioning of thermal power plants around polluted cities in five years; and

incentivise waste processing and mechanised dust removal by 2019.

At the city level, the elected government in Delhi, the Aam Aadmi Party, passed what it claims to be a 'green' budget for 2018-19 that includes a 26-point plan for reducing emissions.¹⁸ These include engagement of electric buses, strengthening pollution under control (PUC) system, encouraging tree plantation, and promotion of solar energy.

SECTOR ISSUES AND INITIATIVES

Construction

As economic activities in the region outside Delhi are expanding, demand for housing and infrastructure has grown too, which explains the rush of construction activities in NCR settlements of Faridabad, Ghaziabad, Gurugram, Kundli, Manesar, and Noida. These construction activities generate enormous amounts of dust, adversely affecting air quality particularly during the autumn and winter months when the climatic conditions lead to the trapping of these particles in the air. Most construction companies fail to comply with dust-control measures set by government: there are no on-site green barriers nor is water sprinkling done, and trucks carrying building material are uncovered.^{19, 20} In Delhi, a construction project was halted and a fine of INR 500,000 was imposed on the builder by the South Delhi Municipal Corporation for violating dust pollution norms.²¹

Transport

The deficiencies in public transportation systems across NCR has led to a phenomenal

growth in the number of private motor vehicles. Delhi alone has seen a four-fold increase in the volume of private motor vehicles in the last ten years—from 2.5 million in 2000 to over 10 million in 2018. Nearly 95 percent of the total vehicles registered by the Transport Department of Delhi government in 2018 are private vehicles (i.e., motor cycles/scooters and cars). The numbers are also high in the neighbouring cities of Faridabad, Ghaziabad, Gurugram and Noida.

The fuel emissions from these motor vehicles has been a major contributor to air pollution in the NCR. The situation is aggravated by inefficiencies in traffic management. The Supreme Court in 2001 took cognizance of the matter and passed an order for the compulsory conversion of all public transport vehicles (buses, taxis, auto rickshaws) plying in Delhi from diesel to compressed natural gas (CNG) based system. Emissions from CNG are miniscule when compared with petrol and diesel, and the order was expected to help alleviate the problem of air pollution. A study reveals that while the conversion of commercial passenger vehicles to CNG did help in reducing air pollution, over time, these gains were negated by the increase in diesel-fuelled cars.²²

In 2016, the Delhi government implemented the odd-even number plate scheme for private vehicles, in two phases for 15 days each in January and April. The aim was to reduce the number of on-road private cars running on petrol and diesel, and thus reduce harmful vehicle emissions. The scheme was enforced seriously, resulting in less cars plying during the period.²³ However, given the gaps in public transport, the scheme caused difficulties for a large population of NCR.

Recently, in February 2018, the Ministry of Petroleum and Natural Gas (MoP&NG) suggested shifting from BS-IV to BS-VI grade fuels for motor vehicles to reduce emissions from petrol/diesel vehicles in NCR. All 397 petrol pumps in Delhi are reportedly selling BS-VI grade fuel from April 2018, and efforts are being made to provide the fuel across NCR by April 2019. Automobile experts suggest upgrading motor vehicle technologies to yield maximum benefits. There is also a move towards using hydrogen-CNG (H-CNG) instead of BS-VI fuel in Delhi buses, as H-CNG is seen as a cleaner version of CNG. A pilot project of Indian Oil Corporation Limited is underway.

Another effort is to phase-out old motor vehicles plying the Indian cities as they cause more pollution. Many old government vehicles, such as the city buses, as well as private and commercial vehicles, have been banned only in the last four years. The NGT, in April 2015, had put a ban on 10-year-old diesel vehicles in NCR because their emissions are found to be carcinogenic. Subsequently, in July 2016, NGT ordered the de-registration of 15- to 10-year-old diesel vehicles in Delhi in a phased manner. Further, the 2018 guidelines for scrapping of motor vehicles in Delhi prepared by the city's transport department provide that diesel, petrol, and CNG vehicles more than 15 years old are to be scrapped. With the passing of these orders, old vehicles are largely now off Delhi roads. There are reports of many such vehicles being sold in states adjoining Delhi.

The latest addition to the reforms in the transport sector is the introduction of electric and other alternative fuel vehicles. The Indian

government is drafting a policy that supports investments in manufacturing of such vehicles, development of efficient battery systems, and establishment of smart charging facilities. A proposal for shifting to 100-percent electric vehicles by 2030 has been announced. Mercedes Benz is evaluating the market and infrastructure readiness for electric vehicles in the country.²⁴ For its part, Volvo Auto India is of the view that a direct shift from pure internal combustion engines (diesel/petrol) to electrified ones may not be easy, and suggests the use of hybrids. Some experts hold the view that electric vehicles might not be able to address the issue of air pollution, as these would still produce tiny pollution particles from brake and tyre dust.²⁵ They recommend less use of motor vehicles, more cycling and walking, and better transit systems.

Industry and Power Plants

There are many industries and power plants emitting toxic fumes in NCR. In Delhi, the Supreme Court, in light of the Environment (Protection) Act, 1986, in 1996 ordered the closure and relocation of 168 polluting industrial units outside Delhi in the nearby region. Subsequently, DPCC and NGT also proposed for such relocation. Recent reports, however, point to the existence of over 51,837 illegal polluting industries in Delhi, and NGT has directed CPCB to take action against the violators.²⁶ CPCB has also made it mandatory for industrial units to install online continuous emission monitoring systems to measure air pollution. In Haryana, 10 out of 80 industrial units have not set up such systems, and a decision has been taken by the State Pollution Control Board to close down such

units if the required steps are not taken within the deadline of 25 November 2018.²⁷

Meanwhile, with regards to coal-based thermal power plants in NCR, the MoEF&CC notified stricter standards in 2015 to minimise pollution by December 2017, and suggested the use of superior technology. The deadline has been extended. The National Thermal Power Corporation (NTPC) is retrofitting old power plants in Delhi from 2018 onwards to meet the revised stringent standards by 2022. The government is also considering the closing down of old polluting plants, such as the one in Badarpur area of Delhi,²⁸ and replacing them with power substations.

A related area of concern is the pollution caused by pet coke, which is commonly used as a fuel in industries and thermal power plants in and around NCR. Pet coke is an imported commodity, found to be more polluting than coal. Therefore, there is a proposal for imposing a ban on import of pet coke. Some industries have switched from pet coke to coal and from furnace oil to low sulphur heavy stock liquid fuel, but these are also considered as polluting fuels.

Agriculture

Over the recent years, the burning of paddy straw during the post-monsoon months of October and November, and wheat straw in April and May to clear the fields after harvest by farmers of Haryana, Punjab and Uttar Pradesh has intensified. These activities have been found to be a major source of air pollution. A study by NASA scientists based on analysis of satellite data over a 15-year period (2002-2016) establishes a link between straw

burning in Haryana and Punjab and increase in PM_{2.5} levels in Delhi.²⁹

To tackle the problem, the MoEF&CC has initiated a regional project on “Climate Resilience Building among Farmers through Crop Residue Management” in 2017. The project activities include awareness generation and capacity building, technological interventions, and creation of sustainable entrepreneurship models. The government is also offering subsidies of upto 50 percent to farmers for buying straw management machines, which can help in sowing plants without burning of residue. Further, the national government has announced a package of INR 11 billion for *in-situ* crop residue management in NCR, which involves retention of paddy residue in fields as mulch³⁰ for wheat crop.

Recent reports, however, indicate that the activity of straw burning might continue during 2018-19 as many farmers consider burning as a convenient and cheap option. In their opinion, the subsidised straw management machines run at a high cost.³¹

CONCLUSION

There is no dearth in evidence that across NCR, the air is polluted for most months of the year, and the persistent air pollution poses serious risks for human health and the environment. The CPCB generated supporting data for a one-year period (June 2017 to May 2018) on air constituents (and pollutants), and the factors influencing air quality in NCR, i.e., the variable climatic conditions, and harmful human activities that lead to the release of emissions and dust in the environment.

The chemical composition of one of the air constituents, i.e., particulate matter, reveals multiple contributors to air pollution in the region, including dust, motor vehicle emissions, and industrial emissions. Seasonal analysis of AQI values reveals certain human activities that worsen the situation, including burning of firecrackers and stubble burning during unfavourable autumn and winter seasons.

In the last four decades (1981-2018), important interventions have been made by the Supreme Court of India, the government of India, and state and local governments. These projects have only been partially implemented, however, and achievements on the ground are hardly significant, given many barriers in the way. While the CPCB has observed a gradual improvement in air quality in NCR in the past three years, other analysts are dissatisfied with the performance of government agencies and are of the view that pollution may in fact worsen further in the coming years.

This brief raises a fundamental question of whether the governments and the people of populous cities in India will succeed in the NCAP goal of “meeting the prescribed annual average air quality standards at all locations in the country in a stipulated timeframe.” In the NCR, the government agencies are relying heavily on the implementation of the Graded Response Action Plan (GRAP) whenever air quality deteriorates. Yet, some of the measures recommended in the GRAP are difficult to apply as neither the institutions nor citizens are prepared to make the suggested changes. The present conditions call for sustainable solutions. Table 2 summarises the recommendations of this brief.

Table 2: Air Pollution Governance Challenges and Suggestions

Challenges	Proposals
<p>1. Increasing concentration of population and economic activities in select NCR cities, and a management/governance deficit, is leading to deterioration of air quality.</p>	<p>Holistic development of villages, small and medium towns will reduce migration to large cities, reduce pressure on city agencies, and ensure a more balanced distribution of population.</p> <p>Greater public awareness about use of family planning methods will help in population control.</p>
<p>2. Natural resources (forests, green areas, Aravalli hills, surface water bodies) are being exploited for housing and infrastructure development.</p>	<p>Stricter monitoring of natural resources and timely disciplinary action against violators.</p>
<p>3. Several action plans prepared by stakeholders (MoEF&CC, CPCB, EPCA, NITI Aayog, state governments) create confusion among implementing agencies because of repetition of suggestions.</p>	<p>One plan for NCR with realistic targets should be made available (publicly and online) by the concerned central ministry. Any suitable changes suggested by stakeholders should be carried out in this united plan. This is necessary for keeping all stakeholders on the same page.</p>
<p>4. Frequent interventions by legal agencies (Supreme Court, NGT) affect their work progress on numerous other pressing matters.</p>	<p>Environment/pollution departments of concerned states should establish better coordination among themselves, sort out the problems at their own level, and take reasonable decisions.</p>
<p>5. Violation of laws, rules and regulations by the public is affecting the performance of agencies.</p>	<p>Better understanding of the reasons responsible for the occurrence of violations is needed. If alternatives are not provided, public will be left with no option but to violate the rules. For example, diesel generator sets will be used if adequate power supply is not made available.</p> <p>Awareness campaigns should be organised at the school/settlement level to sensitise societies about the adverse health effects of air pollution.</p>
<p>6. Administration agencies are inadequately equipped to deal with the problem; implementation is weak.</p>	<p>Manpower, finance, and equipment requirements of agencies need to be adequately understood and strengthened.</p> <p>Proper conditions should be created for the functionaries so that they are able to perform.</p>
<p>7. Deficiencies in city planning, management and development. For example, vacant patches of land with loose dust along roads and elsewhere in NCR causes massive dust pollution.</p>	<p>Vacant patches of land should be properly maintained by planting grass/bushes, and making footpaths on both sides of the road. Proper road and infrastructure designs should be implemented on all corridors.</p>

Challenges	Proposals
8. Phenomenal growth in private motor vehicles in the region; massive traffic jams.	A network of superior mass public transportation systems should be created; first/last mile connectivity gaps should be addressed; proper facilities for walking/cycling should be made available on a priority basis; and advanced technology should be used for traffic management.

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ENDNOTES

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