BRIEFING NOTE

5 JUNE

AT THE CROSSROADS

Centre for Science and Environment

Writers: Anumita Roychowdhury, Vivek Chattopadhaya, Gaurav Dubey, Swati Singh Sambyal, Avikal Somvanshi, Shambhavi Shukla and Tanushree Ganguly

Editor: Archana Shankar

Design and layout: Kirpal Singh

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Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: sales@cseinida.org
Website: www.cseindia.org

1. TOWARDS THIRD GENERATION ACTION FOR CLEAN AIR

The conversation on this year's World Environment Day is about the killer air—it has to be.

Air pollution is a health emergency in India. This conversation has to grow to make more people aware and build public and policy support for solutions.

Solutions are known. But they need to be fast tracked for transformative changes. This World Environment Day will be a lasting reminder that implementation of third-generation action is non-negotiable.

First-generation action, a decade ago, was more about immediate relief in a few cities. In Delhi, polluting industrial units were shifted out, diesel public transport moved to CNG, older vehicles were phased out and emission standards were improved incrementally, bringing temporary and partial relief.

Second-generation action thereafter led to a spate of new policies. In the transport sector, India decided to leapfrog to Bharat Stage VI emissions standards in 2020 and initiatives such as Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) schemes created incentive for electric mobility. The National Urban Transportation Policy, National Transit Oriented Development Policy, and National Habitat Standards sought clean and low carbon transport and compact urban design. In the industry sector, standards for thermal power plants and guidelines for brick kilns were tightened. SOx and NOx standards were notified for 34 groups of industries. In the waste sector, Solid Waste Management Rules and Regulations 2016, and Construction and Demolition Waste Rules and Regulations 2016 were notified. The Ujjwala scheme was implemented to improve access to clean household energy.

The second phase ended with the National Clean Air Programme (NCAP) that asked for a 30–35 per cent reduction in particulate pollution nationally by 2024. City-based action planning has taken root. Delhi and National Capital Region (NCR) have taken the lead to notify the Graded Response Action Plan for emergency action and comprehensive clean air action plans for sustained longer-term action. Supreme Court interventions have accelerated this pace of change. There are still considerable knowledge gaps in strategy development and weaknesses in the compliance mechanism to meet the planned targets.

Third generation: Where do we go from here? The move towards clean air can slow down if solutions do not work in reality and they are not implemented on a scale that can make a difference. The next mantra is about implementation, enforcement, compliance, institutional capacity to govern and plan and address design-rich solutions across all key sectors of pollution.

Even as the crisis takes on a national proportion, Delhi is the microcosm of change that has thrown up important lessons for others. The country requires a massive transition in mobility, to clean energy and technology, and to reducing waste to help meet clean air targets across the regions.

But are we prepared for third generation action for clean air?

2. BUILD ADEQUATE KNOWLEDGE ON NATIONAL AIR QUALITY

Not enough monitoring stations: How much do we know about our air quality? Currently, a small part of the country is under air quality surveillance. Under the National Air Quality Monitoring Programme (NAMP) of the Central Pollution Control Board (CPCB), there are 731 monitoring operating stations covering 312 cities and towns. These stations monitor four pollutants—sulphur dioxide, nitrogen dioxide, respirable suspended particulate matter (PM10) and fine particulate matter (PM2.5). These monitoring stations cover only 5 per cent of the total 6,166 census cities and towns.

Most of these monitors are manual and monitor air only twice a week, with 104 observations in a year. They also underestimate air pollution. There are only 168 continuous real-time monitors covering 102 cities, a mere 1.7 per cent of the total cities. This means that most of urban population cannot even access air quality information on a daily basis and most of India is not monitored. The national air quality reporting is done based on manual monitors. Real-time data is not analysed regularly for comprehensive reporting on annual trends.

Interestingly, approximately 48 per cent of real-time monitoring stations in the country are in Delhi, Uttar Pradesh and Haryana. This shows acute deficit in real-time monitoring data in most parts of the country. Only Delhi has made substantial progress to increase to 34 its monitoring stations that track air quality continuously and relay real-time information.

The time lag in reporting of data from manual monitors does not allow immediate policy action or self protection. Due to heavy dependence on manual monitoring, data on PM2.5—which is tinier and more harmful—is not available for most cities.

Without real-time monitors, it is not possible to leverage Air Quality Index (AQI) for daily relay of air quality information to people. However, there is a progress. CPCB started reporting AQI in 2015. Since then, the number of cities that report AQI gradually increased from eight cities in 2015, to 16 cities in 2016, 36 cities in 2017, 63 cities in 2018 and 99 cities in 2019.

Alternative methods of monitoring—low-cost sensors: It will not be easy to have a dense grid of regulatory monitors across the country as that is very expensive. There is lot of interest in leveraging low-cost sensor-based monitors and several citizens groups have established networks to generate local baseline data to sensitize people and policymakers as part of citizen science. However, regulatory application of these technologies has not yet started anywhere. Several experiments are going on to correlate their data with regulatory monitors for standardization. It is encouraging that the Bureau of Indian Standards (BIS) is talking of the initiative to find method to standardize them.

In the meantime, these monitors can be deployed to map exposure from different sources and assess the impact of local mitigation, especially in areas that do not have regulatory monitors. For instance, the Centre for Science and Environment recently carried out exposure monitoring to understand the impact of pedestrianization on roadside exposure and found exposure on adjacent congested street was 35 per cent higher.

Satellite mapping of air pollution: The scientific community has started to use satellite data to map pollution across regions. Although CPCB is expanding the air quality monitoring grid, it is time for alternative surveillance methods. Satellites have greater spatial coverage than ground-based monitors. In India, most ground-based monitors are located in urban areas, thereby rendering the rural areas inadequately monitored. Also, the composition of PM2.5 in rural areas differs widely from that of the urban areas monitored. If health studies were to rely solely on ground-based measurements, researchers would have to resort to assigning the same exposure level to all the people living within 20 km of a monitoring station.

In the absence of ground-based observations of particulate matter (PM) concentrations, scientists have often resorted to near-real-time satellite data to arrive at ground-level particulate concentration from satellite-observed aerosol optical depth (AOD). AOD is a measure of aerosols like urban haze, smoke particles, desert dust and sea salt distributed within a column of air from the earth's surface to the top of the atmosphere. Empirical factors are used to convert AOD to PM2.5. The correlation between AOD and PM2.5 levels depends on background particulate concentration, meteorology-depth of the boundary layer being most important, and local emission strength. It has now become possible to assess even 1 km/1 km grid.

Satellite-derived atmospheric products also include SO_2, ozone, NO_2 and potentially other atmospheric species. For instance, such maps are available from different sources like that from Windy.com (see *Map 1: Satellite mapping of pollution: Dust engulfs most of India in May, 2019* and *Map 2: SO_2 mass over India*). Available maps show that they forecast values of SO_2 mass, CO concentration and ozone across the country. It is important to understand that this data is not directly observed satellite data, but re-analysis data—in other words, simulated or modelled data. While it might not be accurate, it is indicative of the spatial trend of a pollutant. If one were to look at the SO_2 map, the SO_2 hotspots clearly align with industrial areas that could potentially be using coal.

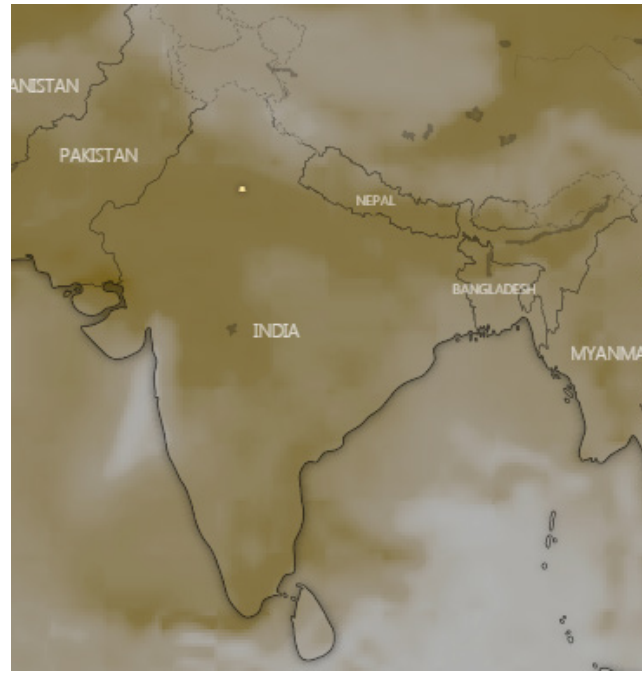
Satellite data can be especially useful in generating annual estimates of PM2.5 for looking at long-term trends of particulate pollution and for assessing health impacts stemming from exposure to particulate pollution.

Regulators can use satellite data to track episodic events such as worsening air quality due to windblown dust, smoke from crop burning and wildfires, and to assess how changing meteorology and ground emissions affect air quality. Satellite data will in turn also help assess the impact of regional contribution of pollution on a city's air quality. Look at the snapshots of satellite mapping (see satellite mapping of pollution). Often regulatory monitors show very low local concentration of SO_2. But satellite shows drift in SO_2 mass that with sometime in the air forms secondary particulate and increases particulate levels. If tracked this can change approach to air quality management. Satellite shows dust plumes that if recognized can transform the greening initiative in the country.

In India, ISRO is developing satellite monitoring of pollution. This is the time for CPCB to come up with a protocol for use of satellite data for assessment of air quality of regions and the country.

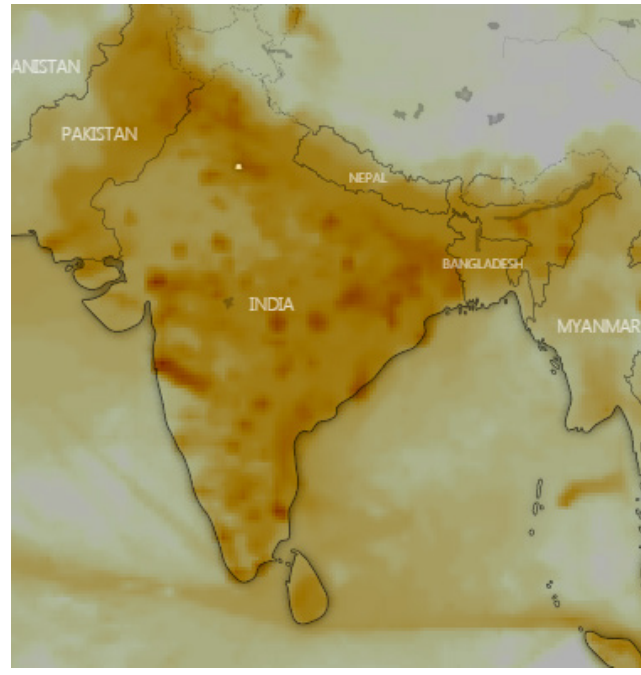
Map 1: Satellite mapping of pollution

Dust engulfs most of India in May 2019



Source: Dust mass forecast by Windy.com; available at https://www.windy.com/-Show-add-more-layers/overlays?dustsm,23.161,86.133,4,p:off as accessed on 30 May 2019 at 4:04 p.m.

SO_2 mass over India



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3. NATION-WIDE AIR QUALITY TRENDS—CRITICAL CHALLENGE

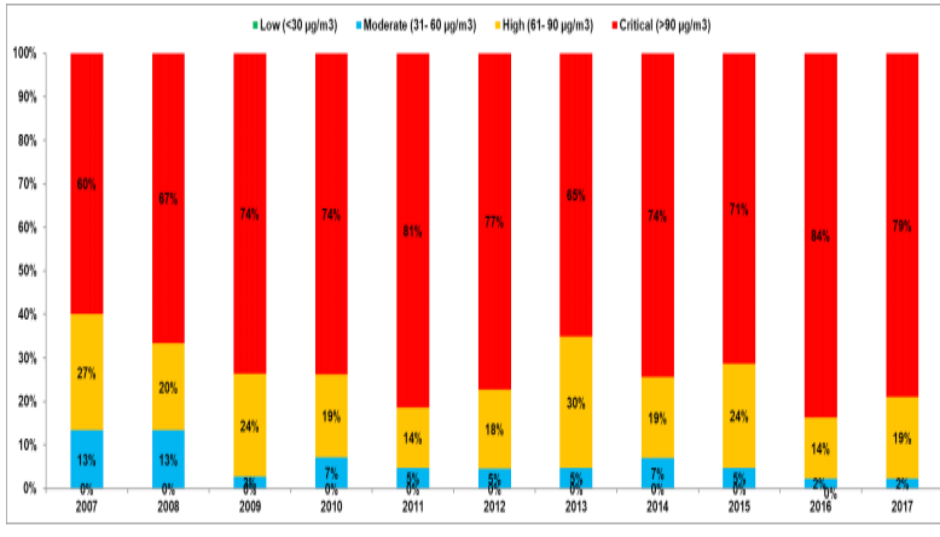
What we monitor shows the scale of the problem. The Central Pollution Control Board (CPCB) Environmental Information System (ENVIS) centre provides annual average concentration data of all the cities where monitoring is being conducted. The data is available from 2007 to 2017. However, this data is not available after 2017. CPCB classifies annual average pollution levels in terms of low (50 per cent less than the standard), moderate (meeting the standards), high (1.5 times the standards) and critical (more than 1.5 times the standards) (see *Graph 1: Categorization of cities based on PM10 concentration from 2007 to 2017*). It shows:

- **PM10 profile of all monitored cities:** The PM10 data is available only for 300 cities for 2017. Nearly 76 per cent of the cities exceeded the standard in 2017. None of the cities comply with the WHO annual PM10 standard. Around 44 per cent of the cities are in the critical category, with their respective annual average levels more than 1.5 times the standards.

- **Cities with population of a million-plus:** The share of cities in the critical category has increased from 60 per cent in 2007 to 79 per cent in 2017. In 2007, 13 per cent of the cities complied with the standard that dropped drastically to 2 per cent in 2017. Close to 40 per cent of the **urban** population lives in 44 cities with population of more than a million. The highest PM10 levels have been found in cities with population greater than 10 million. This makes urban population extremely vulnerable to pollution and illness.

- **Smaller cities are more polluted**: Out of 300 cities there are several cities that are smaller than but are more polluted that Delhi. The most polluted cities are Jharia, Ghaziabad, and Dehradun where the annual PM10 levels are four to five times higher than the standard, followed by Lucknow, Varansai.

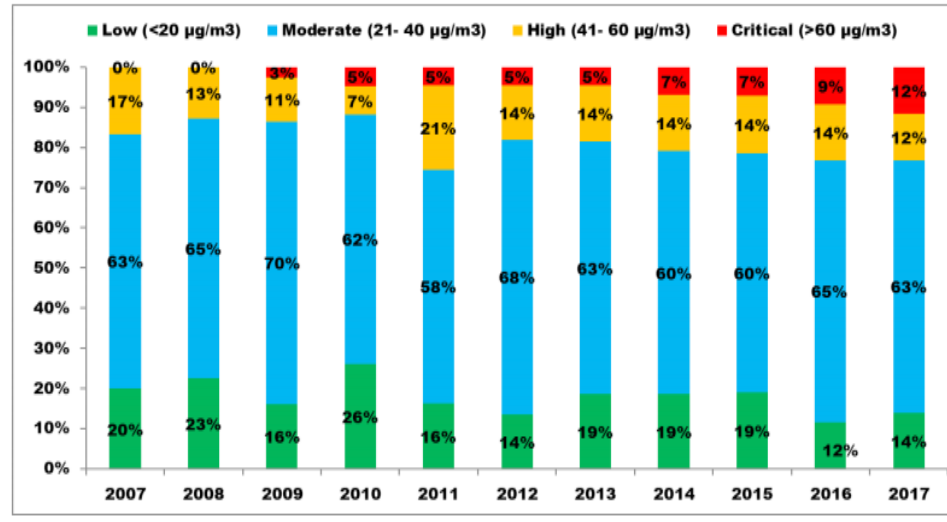
Graph 1: Categorization of cities based on PM10 concentration from 2007 to 2017



Source: CSE's analysis of CPCB air quality data present on ENVIS centre

New pollutants adding to risk: Along with particulate matter, gaseous pollution has also started to increase in several cities. Among the million-plus cities, the number of cities with nitrogen dioxide levels exceeding the annual average standards increased from 17 per cent in 2007 to 24 per cent in 2017. In 2007 not a single city had critical NO_2 levels (or with levels more than 1.5 times the standard); in 2017 critically polluted cities accounted for 12 per cent of the cities. Nitrogen oxide is very toxic and also contributes to the formation of very harmful ozone. Cities with critical NO_2 levels are Delhi, Howrah, Kalyan Dombivali, Pimpri Chinchwad and Pune (see *Graph 2: Categorization of cities based on NO2 concentration from 2007 to 2017*).

Graph 2: Categorization of cities based on NO_2 concentration from 2007 to 2017



Source: CSE's analysis of CPCB air quality data present on ENVIS centre

Ozone is new rogue: Rising NOx levels is creating new problems. Ozone is not yet monitored widely in the country. But Delhi foreshadows the change. Analysis of the daily ozone data of CPCB for the period 1 April to 31 May shows that the average ozone levels for the city exceeded the prescribed standard on 13 per cent of the days (exceeded eight-hourly average standards of 100 microgram per cum) in 2019 as opposed to 7 per cent of the days during the same period in 2018. Only during May 2019, the levels exceeded the standard on 20 per cent of the days. The number of days exceeding or crossing the standard have certainly gone up this summer. Ozone is not directly emitted from any source but it is formed in the atmosphere from the reaction between gases (NOx and volatile organic compounds) under the influence of sunlight and temperature. The increased heatwave this summer is worsening this trend.

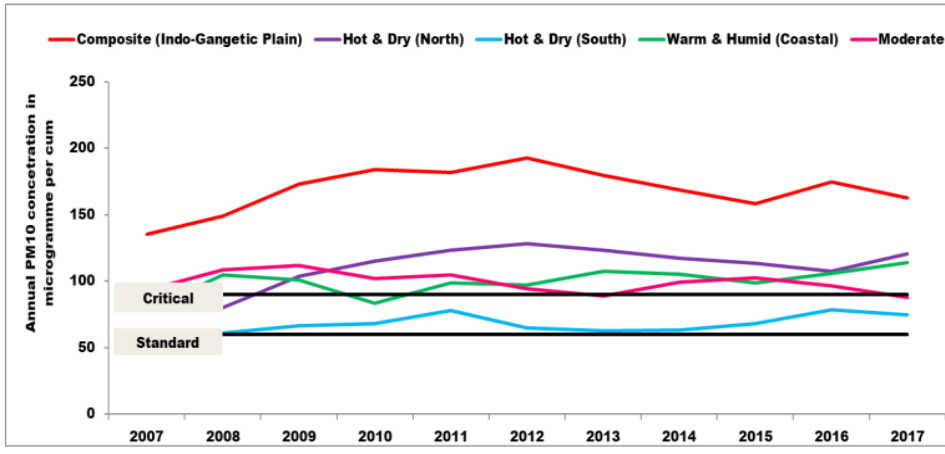
In several hotspot locations of Delhi, ozone exceeded standards on almost a daily basis. While the average level in Delhi has exceeded the standard on 13 per cent of days during this summer, this share of days exceeding the standard is substantially higher in several hotspots: Bawana—75 per cent, Jahangirpuri—73 per cent, Najafgarh—93 per cent, and Narela—81 per cent. Even prominent residential areas show more exceedence: Siri Fort—80 per cent, Sri Aurobindo Marg—87 per cent, RK Puram—55 per cent, JLN Stadium—72 per cent, and Dwarka Sector 8—69 per cent. Other areas include Nehru Nagar—77 per cent, Rohini—80 per cent, Vivek Vihar—77 per cent and Major Dhyan Chand—50 per cent. This indicates increased exposure.

This is of concern as ozone is a highly reactive gas and can have immediate adverse effect on those suffering from asthma and respiratory conditions. To control ozone we need stringent action to cut gaseous emissions from vehicles and industry. In fact, according to the System of Air Quality and Weather Forecasting and Research (SAFAR) study of 2018, vehicles in Delhi are responsible for 62.5 per cent of NOx load from all sources; the 2018 TERI-ARAI study puts the figure at 81 per cent. NOx is a key ingredient in the ozone recipe. Even as Delhi is battling serious particulate pollution, newer rogues are beginning to rear their ugly heads, adding to the health risk. We need strong preventive action to cut gaseous emissions from combustion sources.

Regional differences in pollution levels influenced by climate and meteorology: There are strong regional differences in pollution concentrations. Therefore, it is often not possible to compare pollution levels of cities from one region with another. As northern India is landlocked, pollution build-up in the northern belt is always much higher compared to other regions. In the coastal cities of south and west India, strong sea breezes lower the concentration of pollution.

CSE has compared cities separately for different regions with the regional average and the standards. The Indo-Gangetic Plain has the highest pollution levels, which is followed by Hot and Dry (North). But all the regions have had PM10 levels above the annual standard since 2007 (see *Graph 3: Region-wise trend of PM10 concentration*).

Graph 3: Region-wise trend of PM10 concentration



Source: CSE's analysis of CPCB air quality data present on ENVIS centre

- **Composite (mainly Indo-Gangetic Plain):** This region includes 22 cities that have population of one million-plus, including Delhi, Allahabad, Amritsar, Lucknow, Nagpur, Patna, etc. The average regional PM10 concentration was 135 microgram per cum in 2007, which is already 2.25 times higher than the annual average PM10 concentration whereas in 2017, the regional average concentration is 162 microgram which is 2.7 times higher than the annual average concentration.

  In 2007, cities such as Kanpur, Lucknow and Ludhiana, showed very high values of PM10 concentration that was 1.5 times higher than the regional average standard of 135 microgram per cum. In 2017, cities such as Delhi, Ghaziabad, Kanpur, Lucknow and Varanasi are showing very high values approximately 1.5 times higher than the regional average of

162 microgramme per cum and four times higher than the annual average PM10 concentration.

- **Hot and Dry (North):** This region includes Bhopal, Jodhpur, Kota, Rajkot, Surat and Vadodara. The regional average PM10 concentration in this region is 83 microgramme per cum in 2007 (1.4 times higher than the annual standard) and 120 microgramme per cum in 2017 (double the annual standard). In 2007, Surat and Bhopal were one point higher than the regional average concentration. During 2017, Jodhpur and Kota has shown high values of PM10 concentration approximately 1.1 to 1.5 times higher than the regional average concentration of 120 microgramme per cum.

- **Warm and Humid (Coastal):** This region includes cities such as Chennai, Kolkata, Mumbai, Navi Mumbai, Thane, Vijayawada, Kalyan Dombivali and Visakhapatnam. The regional average PM10 concentration is 78 microgramme per cum in 2007 (1.3 times the standard) and 114 microgramme per cum in 2017 (double the standard). In 2007, cities such as Kolkata, Mumbai and Vijayawada have 1.1 to 1.3 times higher annual average PM10 concentration than the regional average while in 2017, cities like Kolkata, Mumbai, Kalyan Dombivali and Thane had PM10 concentrations that were 1.1 to 1.5 times higher than regional average concentration.

- **Hot and Dry (South):** The region comprises three cities with a million-plus population—Coimbatore, Hyderabad and Madurai. The average concentration of this region has increased from 54 microgramme per cum in 2007 to 75 microgramme per cum in 2017. The concentration was below the annual PM10 standard in 2007 whereas it was 1.25 times higher than the annual standard in 2017. In 2007, the PM10 annual concentration was within the standard for two cities except in Hyderabad where the levels were 1.4 times higher than the regional average. In 2017, only one city—Coimbatore—was in compliance with the standard whereas Hyderabad experienced 1.44 times higher annual PM10 concentration compared to the regional average and 1.8 times higher than the annual standard. The PM10 concentration in Madurai was below the regional average but was 1.2 times higher than the annual standard.

- **Moderate:** This region includes Bangalore, Jabalpur, Pimpri Chinchwad and Pune. The regional average PM10 concentration in 2007 was 93 microgramme per cum (1.6 times the standard) and in 2017 it was 88 microgramme per cum (1.5 times the standard). In 2007, Jabalpur and Pune levels were higher than the regional average concentration by 1.2 times while in 2017, Bangalore and Pune levels were higher than the regional average by 1.2 times.

However, this needs a rider. Often it is difficult to explain the trend-based ground-level action in most cities. Sometime even changes in location of monitoring stations or selection of monitors to report air quality data can influence information and herefore trend.

4. BUILD CAPACITY FOR POLLUTION SOURCE ASSESSMENT

As part of the New Car Assessment Programme (NCAP), more funding support will be provided by the Ministry of Environment, Forest and Climate Change (MoEFCC) to about 20 of the cities to prepare source apportionment studies to support action planning. It is not clear if this will also include source inventory studies. While this is a good move, it is important to assess the capacity in the country to carry out such studies, especially the laboratory support that is needed for such studies.

The government would be well advised to also invest in such facilites and capacity to enable studies and also set up an oversight body for quality control and assistance of such studies. Without this supportive infrastructure, only investing in studies will not give the desired results.

Moreover, it is important to make preparation of the invetory of pollution source mandatory for the State Pollution Control Boards. This is the first crucual step that is needed to quantify the pollution sources by sector to define mitigation strategy. Even though several emissions inventory studies have been carried out in India, the details of the pollution sources are not available in the public domain. Such inventories should not be part of one-off studies but a routine practice of the Pollution Boards as this is important for designing of mitigation strategies.

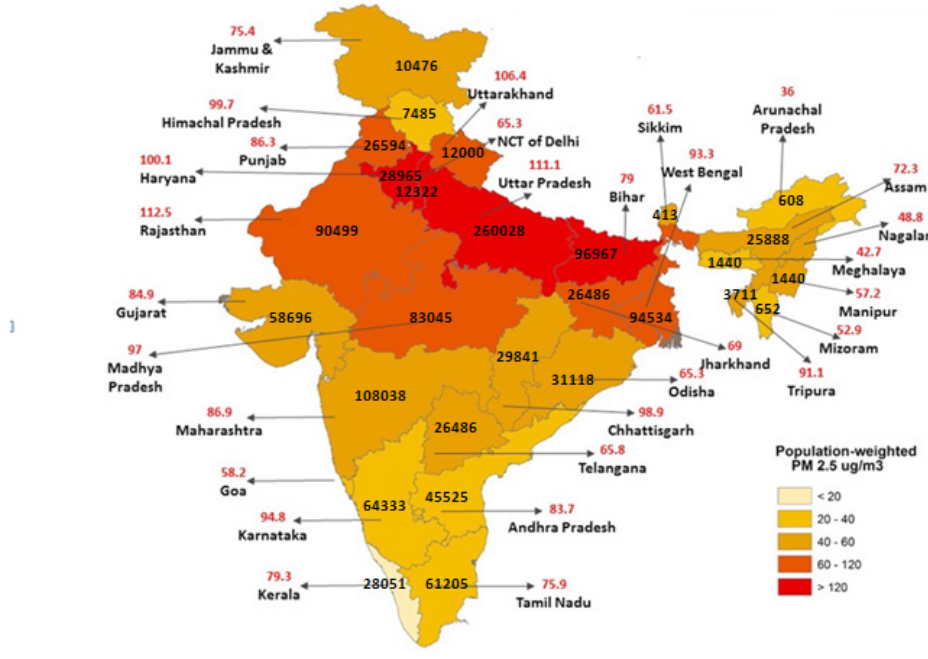
5. HEALTH RISK: NO ONE IS SAFE

The public discourse so far has led citizens to believe that air pollution is a hazard only in the states situated along the Indo-Gangetic basin and other regions—southern, western, and eastern—are relatively safe. Health statistics indicate another story.

Look at the Indian map in another way based on the 2017 report jointly authored by the Indian Council of Medical Research, Public Health Foundation of India and Institute of Health Metrics and Evaluation titled *India: Health of Nation's States—The India State-Level Disease Burden* that identified air pollution as the second leading risk factor causing disease burden in India as a whole. There are differences in the absolute number of premature deaths due to air pollution-related diseases across Indian states. When they are brought on a scale of risk per 10,000 population, the deaths per 100,000 population is—with some variation—quite widely distributed, which make regions comparable.

According to this study, while the population-weighted exposure concentrations appear to be significantly higher across the northern states compared to the southern states, the particulate pollution-related death toll is actually comparable. For instance, the death rate—i.e. number of deaths per 100,000 population—in Bihar, which is plagued by very high levels of particulate pollution, is lower than that in Kerala, which potentially has the cleanest air in the country. For example, even though Kerala has a bigger population than Delhi and six times less particulate pollution, risk per 100,000 population is higher.

Map 2: Particulate pollution and health risk in India



Note: The figures in red represent the death rate per 100,000 population and the figures in black, written inside the state borders, represent the absolute number of deaths in the state.

Source: The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017, available at https://www.thelancet.com/action/showPdf?pii=S2542-5196%2818%2930261-4 as accessed on 28 May 2019.

This could stem from the fact that while the southern states might enjoy relatively lower levels of particulate concentration, the minimum level at which significant health impacts are observed is exceeded in all the states. Reiterating the finding of *The State of Global Air 2019 Report*, the entire Indian population is breathing M2.5 concentrations above the WHO Air Quality Guideline of 10 µg/m3.

Even low levels of particles can be deadly, says American Lung Association in their communiqué on particulate pollution in 2019. It cites a 2016 study that found that people aged 65 and older in New England faced a higher risk of premature death from particle pollution even in places that met current standards for short-term particle pollution. Another study in 2017 looked more closely at Boston and found a similar higher risk of premature death from particle pollution in a city that meets current limits on short-term particle pollution. Looking nationwide in a 2017 study, researchers found more evidence that older adults faced a higher risk of premature death even when levels of short-term particle pollution remained well below the current national standards. This was consistent whether the older adults lived in cities, suburbs or rural areas.

This alerts that Indian needs action at a scale across sectors and across India to reduce health risk.

Mounting evidences of health risk: This year has seen mounting evidence on the impact of air pollution on public health. According to the State of Global Air 2019 estimates, over 1.2 million Indians died early due to exposure to unsafe air in 2017. Air pollution is now the third-highest cause of death among all health risks, ranking just above smoking, in India. This is a combined effect of outdoor PM2.5, ozone and household air pollution. Due to this combined exposure South Asians including Indians are dying early—their life expectancy has reduced by over 2.6 years. This is much higher than the global tally of reduced life expectancy by an average of 20 months. While globally a child born today will die 20 months sooner on average than would be expected without air pollution, in India they would die 2.6 years earlier.

Out of the 1.2 annual premature deaths 673,100 deaths were due to exposure to outdoor PM2.5, and more than 481,700 deaths due to exposure to household air pollution in India. While exposure to outdoor PM accounted for a loss of nearly one year and six months in life expectancy, exposure to household air pollution accounted for a loss of nearly one year and two months. Thus, together Indians lose 2.6 years. Also, household air pollution contributes about a quarter of the outdoor air pollution in India. The deadly tally broken up by diseases shows that chronic obstructive pulmonary disease (COPD) due to air pollution, at 49 per cent, is responsible for close to half of deaths, followed by lung cancer deaths at 33 per cent, diabetes and ischaemic heart disease at 22 per cent each, and stroke at 15 per cent. It is disturbing how COPD, lung cancer and ischaemic heart disease dominate the dubious tally.

This study has, for the first time, accounted for risks from type 2 diabetes linked to air pollution. This has serious implications for India where type 2 diabetes has taken an epidemic form. Epidemiological studies in Asia, Europe and North America, supported by toxicology research, have provided strong evidence that exposure to ambient and household PM2.5 contributes to type 2 diabetes incidence and mortality. In the *Global Burden of Disease Study* 2017 analysis, exposure to PM2.5 was found to be the third-leading risk factor

globally for type 2 diabetes deaths and disability-adjusted life years (DALYs), after high blood sugar and excessive body weight. Exposure to PM2.5 pollution contributed to 276,000 deaths and 15.2 million DALYs from type 2 diabetes in 2017 worldwide.

A 2018 *Lancet* article titled 'The impact of air pollution on deaths, disease burden, and life expectancy across the states of India' stated: While approximately 80 percent of Indians breathe air that is worse than the levels recommended by National Ambient Air Quality Standards, the entire population of the country lives in areas with PM2.5 concentrations above the WHO Air Quality Guideline of 10 μg/m^3. According to a 2018 WHO publication titled *Air Pollution and Child Health: Prescribing Clean Air*, India records the highest premature deaths of children under five years due to toxic air. Over 1 lakh children under the age of five fell victim to air pollution. In 2016, for almost every ten deaths in children under the age of five, one was due to air pollution.

Two review papers by scientists from the Forum of International Respiratory Societies published in the journal *Chest* said that air pollution can harm acutely as well as chronically, potentially affecting every organ in the body. According to the study, ultra-fine particles pass through the lungs, are taken up by cells and carried via the bloodstream to expose virtually all cells in the body. Air pollution may be damaging every organ and virtually every cell in the human body, according to a comprehensive new global review recently reported. The research shows head-to-toe harm, from heart and lung disease to diabetes and dementia, and from liver problems, brain, intelligence, abdominal organs, reproduction, and bladder cancer to brittle bones and damaged skin. Fertility, foetuses and children are also affected by toxic air.

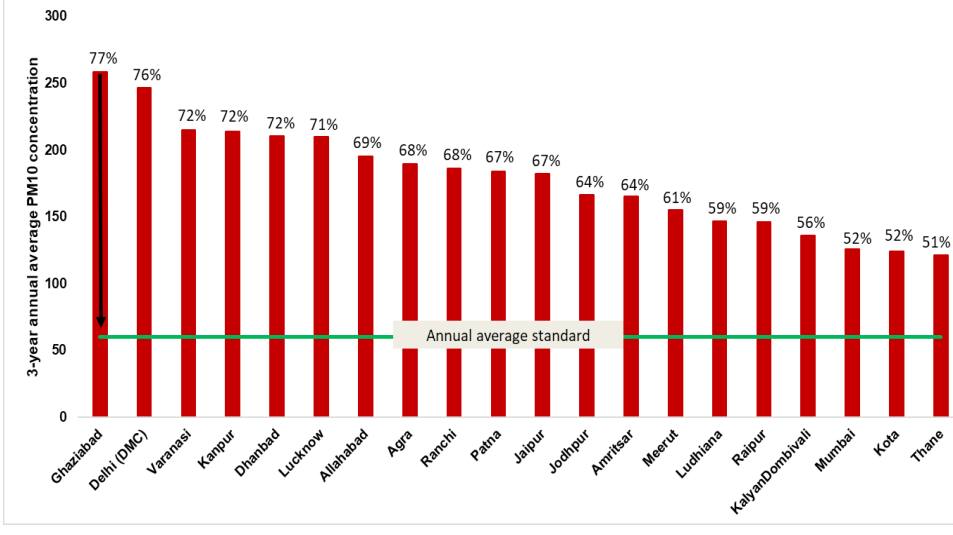
6. TOWARDS ACTION: HOW SOON CAN INDIA BEND THE POLLUTION CURVE?

Need ambitious target for pollution reduction: The National Clean Air Action Plan (NCAP) aims to reduce particulate pollution by 30–35 per cent by 2024 and has earmarked 102 cities that have pollution levels higher than the standards. Among them, 20 cities will get more strategic support. These number of non-compliant cities can be fluid and can change from year to year as science has proven there is need for more regional solutions.

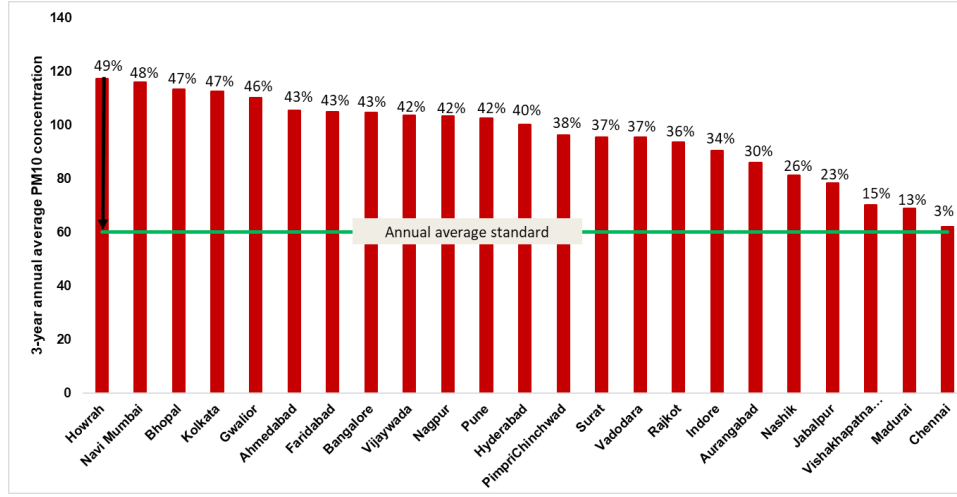
However, the review of city-wise air quality data also shows that the actual reduction target needed in most cities is much higher than the NCAP target. Fairly large number of cities need to reduce PM10 levels by over 50 per cent to meet the standards. Delhi needs to reduce its PM2.5 by at least 76 per cent to meet the standards. This defines the level of stringency needed to meet the clean air standards and that has to inform all sectors of mitigation (see *Graphs 4 a* and *b: Reduction target for particulate pollution in selected cities A and B*).

The NCAP will have to be reinvented to be on mission mode for well-aligned action across sectors with clear budgetary provision, clearer role of the Central government, stronger reporting, monitoring and compliance mechanism for on-ground changes.

Graph 4 a: Reduction target for particulate pollution in selected cities



Graph 4b: Reduction target for particulate pollution in selected cities



What it takes to bend the pollution curve? Lesson from Delhi: There is barely any evidence in the country that can demonstrate reduction in pollution because of action. Only Delhi, which still has high elevated levels of pollution, has shown early signs of stabilization. This is a learning curve for other cities that are shaping their action plans now. Earlier some specific action has shown appreciable impact, as in Kolkata, where after the phase-out of old commercial vehicles in 2009 particulate pollution showed appreciable decline.

Delhi and the National Capital Region have been the first to begin implementation of comprehensive action plan and emergency action plan to mitigate air pollution. Even though action in Delhi spans over two decades, it has gathered momentum after 2015 after an initial lull. This has triggered wide-ranging action in different sectors.

In the transportation sector CNG programme has been scaled up, emissions standards have improved to BSIV level and is poised to move to BSVI in 2020, 10 ppm sulphur fuels have already been introduced in Delhi and NCR. To curb diesel emissions, there is ban on entry of trucks that are over ten years old and each truck has to pay an environment compensation charge. Big diesel cars and SUVs have to pay environment pollution charge and diesel cars that are over ten years old are banned.

In the industry and power plant sector, steps have been taken to shut all coal-based power plants in Delhi. The approved fuel list has banned dirty fuels, including petcoke, furnace oil, and coal, in all sectors in Delhi. The ban on use of furnace oil and pet coke has been extended across three other states, including Uttar Pradesh, Haryana and Rajasthan. This has further triggered notification of SOx and NOx standards for 34 groups of industry in the country and ban on import of petcoke. About 400 brick kilns in the region have moved to improved zigzag technology to reduce emissions. Several industrial units in Delhi have moved to natural gas.

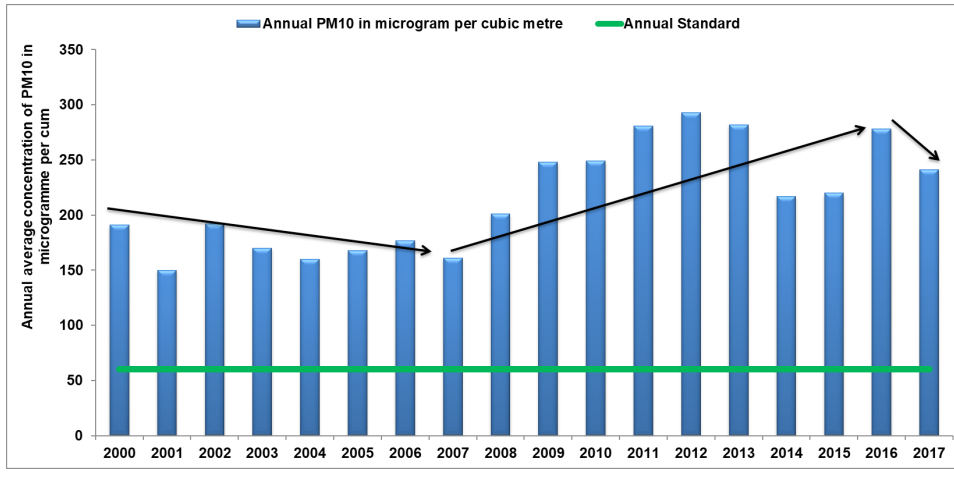
The nature of this action is not small. But it has helped stabilize the problem and also slightly bent the curve. This only indicates how much more will have

to be done at a scale and effectiveness across the region to make a difference. Comprehensive and analysed data for all stations has not been released yet by CPCB for 2018 and 19. The last available data shows stabilization in Delhi through the levels are still very high (see *Graph 5: Long term PM10 trend graph for Delhi* and *Graph 6: Long-term PM2.5 trend for Delhi*).

Even though Delhi's pollution is high and remains elevated, there is tapering off of the pollution peaks. A quick comparison of PM2.5 average of four key monitoring locations of Delhi Pollution Control Committee—Anand Vihar, RK Puram, Mandir Marg and Punjabi Bagh—show that the daily peak levels of PM2.5 are also slowly coming down. The highest 24-hour average concentration was observed in 2016 at 759 microgram per cum when the levels were 12.7 times higher than the standard. In 2017, the highest recorded level was 683 microgram per cum, 11.4 times higher than the standard. In 2018, the highest PM2.5 level was up to 467 microgram per cum, which is 7.8 times higher than the standard.

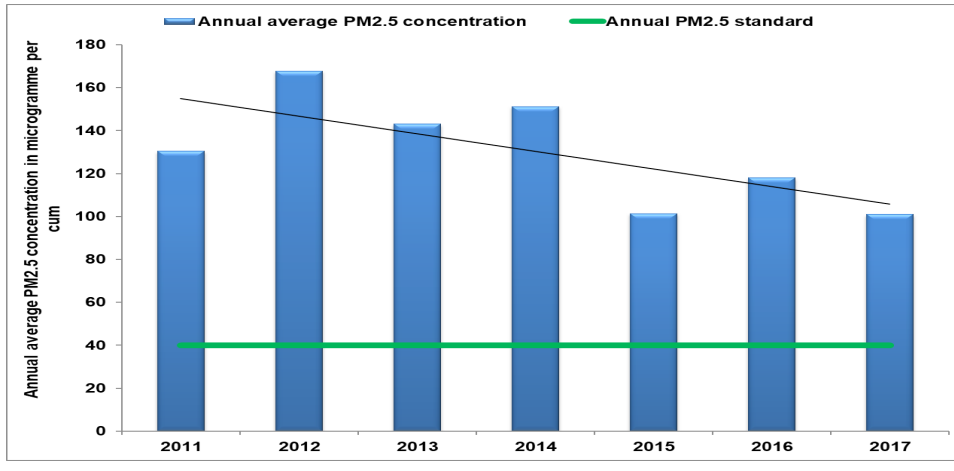
The DPCC data shows that the annual average PM2.5 level has reduced by 11 per cent since 2016 (see *Graph: 7 Long term trend of PM2.5 concentration from 1 January 2016 to 28 February 2019*).

Graph 5: Long-term PM10 trend for Delhi

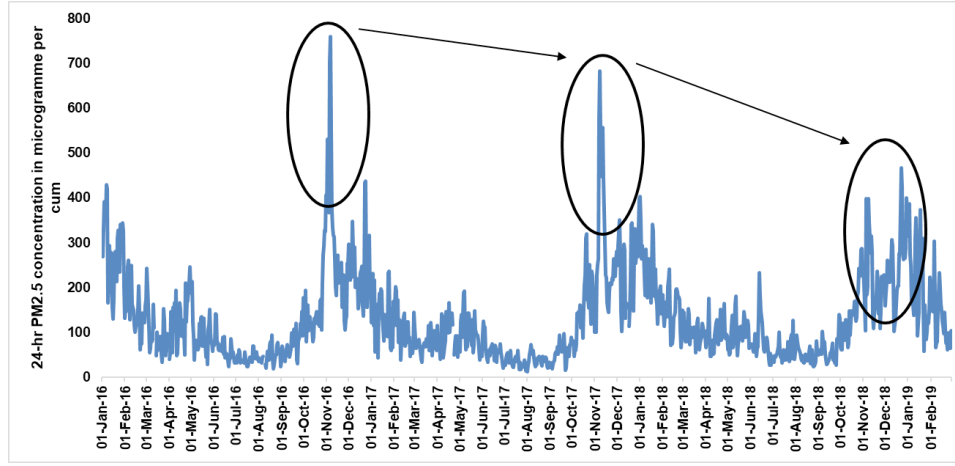


Source: CSE's analysis based on CPCB Envis centre

Graph 6: Long-term PM2.5 trend for Delhi



Graph: 7 Long-term trend of PM2.5 concentration from 1 January 2016 to 28 February 2019



Source: CSE's analysis based on the CPCB air quality data for four stations—Anand Vihar, Mandir Marg, RK Puram and Punjabi Bagh

Yet another lesson from Delhi and NCR is the gap in implementation and enforcement. The major gaps are in transport and mobility sector, waste sector and unorganized industrial sector. The city and the region are falling behind in addressing this matter. The city is in grip of crippling motorization and public transport deficit and it has not been possible to make any dent so far. Similarly, waste burning is inevitable when waste disposal systems are weak. Fugitive emissions from small-scale units is high as air pollution control measures are weak. Smoke from household-based cooking can be a problem without adequate access to clean fuels. Third-generation action will have to address this in Delhi and other cities.

7. TOWARDS THIRD-GENERATION ACTION IN DELHI

Delhi's struggle with air pollution only brings out what it takes to tame and control pollution. There have been some wins but also tough challenges. The areas that have proven to be most difficult and complex to move action are mobility and transport, clean energy and technology transition in key sectors, waste burning and dust control. Solutions are known and scripted in the comprehensive action plan. But how will this happen?

7.1 Mobility solutions: Slow

Even when vehicles are emerging as serious source of exposure in cities, solution at a scale has remained a challenge. This is a serious national issue as India is in the grip of a staggering pace of motorization. Consider the following fact: it took 60 years (1951 to 2008) for India to cross the mark of 105 million registered vehicles. But thereafter, the same number was added in a mere six years (2009–15)! The number of vehicles in India has increased 700 times—from 0.3 million in 1951 to 210 million in 2015. The number of cars registered in India between 1951 and 2005 stands at 10.3 million. Almost twice that number of cars was registered in just ten years—20 million from 2006 to 2015. The number of two-wheelers registered in India from 1951 to 2004 was 51.9 million. Almost twice the same number of two-wheelers was registered in ten years (2005–15)—102 million. In these 10 years, the growth in the cars and two-wheelers segments has been 10.5 per cent and 10.3 per cent, respectively. If cars and two-wheelers are combined, the personal motorization rate in India would exceed that of many advanced countries.

Automobile dependence will worsen exposure to toxic vehicular pollution. The situation is dire as adequate attention has not been paid to development of public transport systems and promotion of walkable and cycling environments. Cities have to move lakhs of travel trips a day, but without adequate public transport cities will lock in enormous pollution and carbon.

Delhi mirrors this challenge. The Delhi Master Plan 2020–21 has stated that by 2020–21 public transport ridership should be at least 80 per cent of all motorized trips. But as the report submitted by the Environment Pollution (Prevention and Control) Authority (EPCA) to the Supreme Court has shown, there is enormous shortfall in the current level of public transport services. The 2011 Census has estimated for Delhi that the combined share of bus, train and intermediate public transport (autos, taxis etc.) is about 44 per cent of all motorized trips and 30 per cent of motorized, non-motorized and walk trips. About 40 per cent of motorized trips are by personal modes—cars and two-wheelers—14 per cent by bicycle and 26 per cent by walk. Therefore, all together in 2011, walking and cycling trips were at a substantial 37 per cent of the city's travel trips.

This means the share of public transport will have to be doubled to achieve the MPD2020–21 target while the share of personal vehicle usage will have to be reduced simultaneously. Every trip made in a car or two-wheeler pollutes around seven to 14 times more than a trip made in a bus in Delhi. But bus ridership is declining and even pedestrians and cyclists are under pressure due to poor infrastructure and unsafe roads.

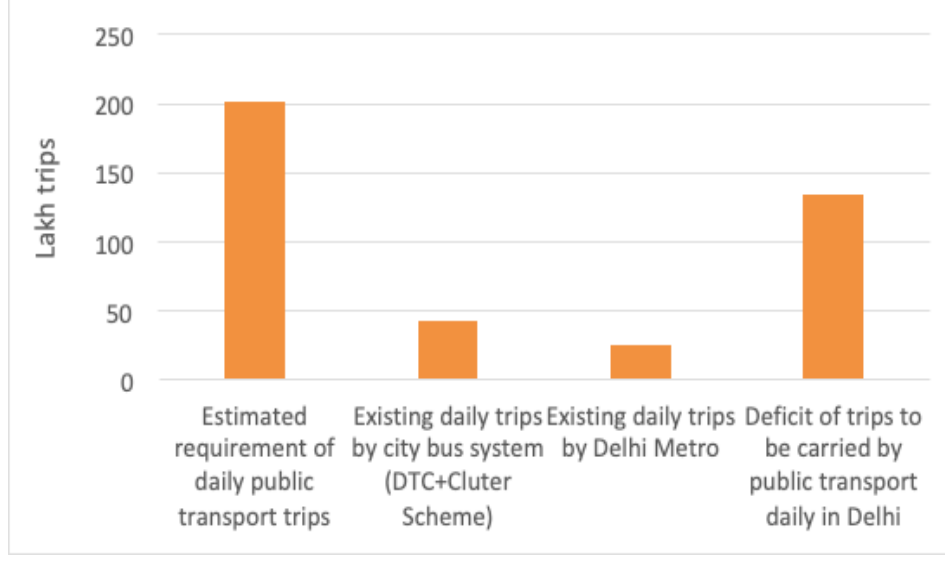
In a city with over 200 lakh (20 million) population, against the Census projected population of 240 lakh by 2021, given the need for travel, distance and the growth of employment and commercial centres in neighbouring regions, travel demand is exploding. The 2010 report by RITES estimated that the total demand for motorized travel in 2021 would be roughly 250 lakh daily, including city and inter-city trips. The Centre for Science and Environment has updated this estimate, based on current employment and population figures and it estimates that currently 400 lakh travel trips are generated daily in Delhi. This estimate includes walking and cycling. In Census 2011—the last estimate available for modal share— walk and cycle trips constituted some 37 per cent of the total travel trips in the city. This might have reduced the given unsafe roads. If walk and cycle trips are excluded, this would mean that there are some 252 lakh trips daily in the city. This is roughly close to the travel demand projected by the 2010 RITES report for 2021.

But the Delhi Metro caters to around 25 lakh trips daily (as of June 2018), 10 per cent of motorized commuters; DTC carries around 30 lakh trips daily (as of April 2018), 12 per cent of motorized commuters; and cluster buses carry 12 lakh trips (as of December 2018), 5 per cent of daily motorized commuter trips. Therefore, a total of around 67 lakh trips are being catered to by the conventional public transport system of Delhi that comprises the Delhi Metro and the city bus system—roughly 27 per cent of the daily motorized trips.

Private vehicles, which constitute 94 per cent of the vehicle fleet of the city, therefore constitute at most some 40 per cent of the daily commute trips in the city. This adds to pollution and congestion. The remaining trips, at least as per the 2011 Census, would be on cycle or by walking.

Given the current figures of 67 lakh trips catered to by buses and Metro, there is a deficit of almost 134 lakh trips (66 per cent) that needs to be catered to by public transport (see *Graph 8: Deficit of trips to be carried out by public transport*). Even if the 4 per cent trips by three-wheelers are added to this, the deficit remains huge.

Graph 8: Deficit of trips to be carried out by public transport



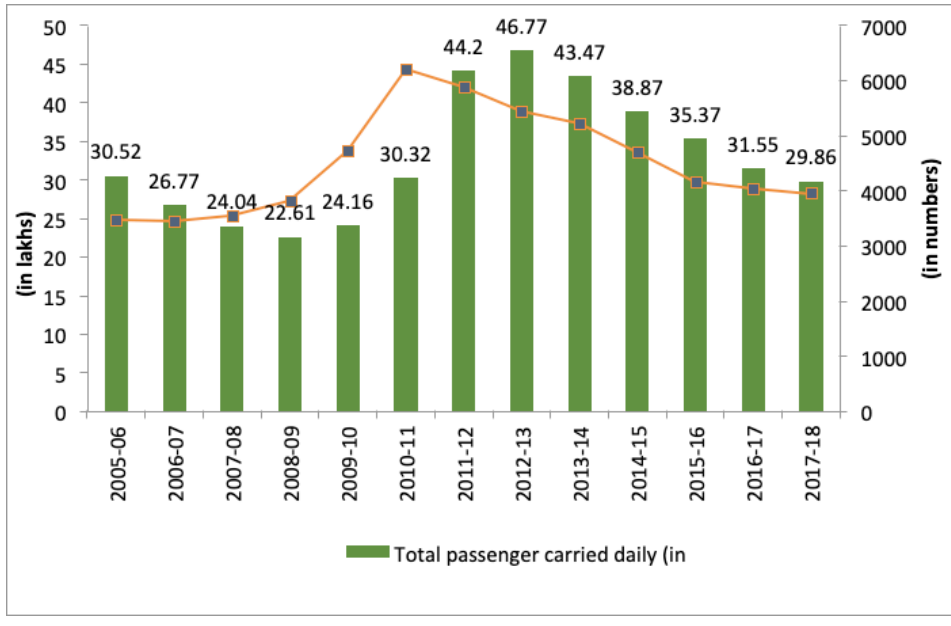
Source: Master Plan for Delhi 2021, DTC, DIMTS and DMRC

Currently, Delhi Metro makes up for 10 per cent of the daily travel trips. The 2010 RITES report on Transport Demand Forecast for Delhi had estimated that after the completion of all four phases of Metro lines, the system will cater to up to 20 per cent of the daily travel demand and would cater to some 50 lakh passenger trips each day. As the Metro plan has changed since the 2010 report of RITES, it is not clear if this projection of 50 lakh trips per day, which would mean a doubling from the current 25 lakh trips per day, is on track.

However, what is also certain is that metro ridership has increased over the years and that in spite of the dip that took place in 2017–18, the ridership is now close to 25 lakh trips per day. How can the Metro cater to a larger demand?

Buses need reinvention for clean air: Bus ridership is steadily declining in the city. DTC's statistics show that there was a ridership increase corresponding to the increase in fleet around the time of Commonwealth Games, but it depleted thereafter gradually (see *Graph 9: Ridership and fleet size of DTC over the years*).

Graph 9: Ridership and fleet size of DTC over the years



Source: Waiting for a bus, CSE, Delhi Transport Corporation Statistics

The overall trend shows that between 2011–12 and 2017–18, DTC lost 14.3 lakh riders. During the same period, the introduction of the Cluster Scheme brought in an additional 12 lakh passengers.

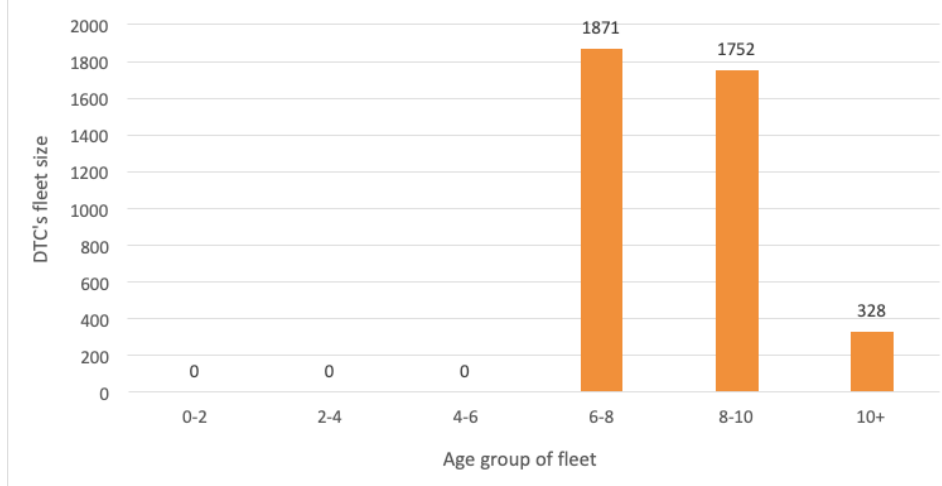
The bus transport system (DTC and cluster) caters to roughly 17 per cent of the daily motorized trips in the city. The Supreme Court directed way back on 28 July 1998 that Delhi should augment its bus fleet to 10,000 by 2002. But this target was never met. The current fleet is as follows—DTC: 3,849 (as of 31 March 2019); Cluster: 1,679 (as of 31 March 2019); Total: 5,528 (roughly half of what the Supreme Court directed in 1998). This clearly is woefully short of the target set over 20 years ago for a much smaller city population.

The Delhi government plans to add 3,000 buses by 2019–20. But this will only replace and substitute the buses to be phased out because of age. DTC as of 31

March 2019 has a total fleet of 3,849 buses. But what is not explained is that the fleet is depleting rapidly due to the age. Given that DTC's maximum age of buses is 12 years, or 7.5 lakh km, whichever is later, almost 2,080 buses will need to be replaced by March 2021, if not earlier (see *Graph 10: DTC's bus fleet distribution as per age of buses [as of 30 April 2018]*).

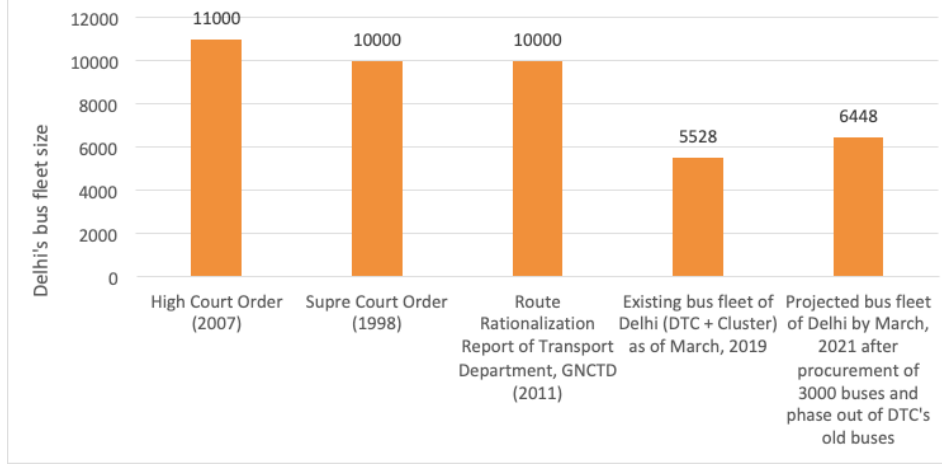
The proposed fleet augmentation of 1,000 buses for DTC, by the time they are on-road, will barely suffice to even replace the aging fleet. The proposed induction of 3,000 buses will largely get offset by the phase-out of DTC buses over the next two to three years. Induction of bus fleet has a huge bearing on the ridership levels.

Graph 10: DTC's bus fleet distribution as per age of buses (as of 30 April 2018)



Source: Delhi Transport Corporation Statistics, April 2018

Graph 11: Delhi's bus fleet shortage



Source: Delhi Transport Corporation and DIMTS

This means that the proposed augmentation of buses will only replace the current fleet and will not add substantial numbers of buses on the road. The city will, therefore, not be any closer to reaching the stated target of 10,000

buses. This, therefore, suggests that in order to meet the target the augmentation of the fleet needs to be massive or that there needs to be other methods of building public transport systems that are reliable, affordable, modern and safe so that we can see the transition away from private vehicles.

Falling short of global benchmark: Cities across the world have invested in developing huge metro networks as well as large-scale bus systems. In comparison, Delhi is very far off (see *Table 1: Comparison of public transport supply across cities in the world*). Even after building a metro, Beijing with comparable population has 107 buses per lakh population in contrast to 17 in Delhi. London, a developed-country city and with a much smaller population, has 90 buses per lakh of population.

Table 1: Comparison of public transport supply across cities

City	Metropolitan area		Bus		MRT		Bus fleet/ lakh population	MRT km/ lakh population
	Population persons ('000)	Area (km^2)	Fleet size	Daily ridership (million)	Km	Daily ridership (million)		
London	8,302	1,572	7,500	6.4	402	3.2	90	05
Singapore	5,312	716	4,212	3.5	167	2.2	79	03
Tokyo	13,277	2,189	1,462	0.6	305	2.2	11	02
Hong Kong	7,184	1104	5,743	3.8	178	4	80	02
Beijing	20,186	16,411	21,628	13.8	554	6.7	107	03
Shanghai	23,475	6,341	16,235	7.6	588	6.2	69	03
Seoul	10,442	605	7512	4.6	327	6.9	72	03
Delhi	26,720	1,483	4564	3.03	215	2.7	17	01

Based on this huge gap in the public transport/shared mobility segment, it can be assumed that there is a need for augmentation of all kinds of public transport vehicles that will meet this demand.

Reform bus system: As part of the clean air plan, Delhi needs to have an annual fleet audit policy whereby based on the age of the fleet, an annual assessment is carried out of the total fleet required to be added next year to maintain a stable fleet size. Further, additional parking space for buses has to be created by either creating new depots or making multi-level depots. Until February 2019, Delhi had not had any fleet procurement for the past seven to eight years. This needs to be clearly avoided if the city is serious about improving its air quality.

Steps have to be taken to upgrade the level of quality of service provided. This includes developing bus stop infrastructure across the city, developing a central control centre for tracking bus movement through GPS units installed in buses, creating passenger information systems through LED boards at bus stops to inform passengers about real-time ETA (expected time of arrival) of incoming buses, adopting technology for efficient utilization of fleet and avoid bunching (buses of the same route running behind each other) on roads, to name a few.

The launch of integrated fare payment system through a Smart Card has been a good step, but it is futile unless the fare policy itself is integrated. The smart card should enable one to undertake a full journey through various public transport modes in the city, without having to pay the minimum fare for each individual system (called interchange penalty), thus reducing the overall journey cost. Unless these steps are taken, augmentation of buses alone would not suffice to move trips to the city's bus system at a scale that is required to improve the air quality in the city.

Vehicle restraint measures are failing to take shape: As part of transport policy reforms mandated by the comprehensive action plan Delhi has already firmed up parking rules as demand management strategy. But this has not been implemented. Even when people are complaining about rising pollution levels, there is a push back on introducing parking management and pricing in residential areas. But a review by EPCA has shown that RWA-led parking management and pricing has already started in Delhi and people are using multi-level parking lots for residential parking by paying a charge. But this will have to be extended to all public spaces and roads to contain demand for parking.

Similarly, Delhi has already issued transit oriented development policy for mixed use and mixed income development with dense street density and accessible streets. This is needed to reduce travel distances and reduce pollution and energy intensity of travel. But urban redevelopment projects disregard these requirements and promote large gated developments that are counterproductive.

The early good sign of urban renewal is some of the initiatives to pedestrianize prominent commercial streets like Ajmal Khan Road and proposed efforts in Kirti Nagar, Kamla Nagar, Lajpat Nagar, and Chandni Chowk. This concept will now have to be taken forward to combine with low-emissions cones to regulate and restrict of polluting vehicles and promote walking and cycling in targeted areas that are also well connected with public transport. That will be consistent with the global trend. This will have to be scaled up across cities.

7.2 Clean fuel and technology transition

Clean fuel and vehicle technology roadmap: With countrywide implementation of BS IV emissions standards and the scheduled switchover to BS VI standards in 2020, emissions from all category of new vehicles will reduce substantially. This is expected to reduce emissions by 80–90 per cent from new vehicles. This is a success story in India. 10ppm sulphur fuels will be available nation-wide by 2020. This will not only allow use of advanced emissions control systems in new vehicles but also benefit on-road vehicles.

But as the dieselgate scandal proved, the next challenge is to maintain real-world emissions. India has adopted real-world emissions requirements but it as to quickly align with the latest or fourth package of Euro VI reforms in Europe to ensure that must benchmark for testing and monitoring of on-road emissions are adopted in India for the next phase of implementation from 2023 onwards. Also as diesel vehicles will be fitted with selective catalytic reducing system (SCR) for NOx control advance action is needed to set up proper urea refilling facilities and controls over autograde urea.

Also, the present method of vehicle inspection will be insufficient to check the vehicle emissions and to check operation of advance after treatment devices such as particle filters, SCR and de-NOx catalyst. Therefore, new inspection checklists for emission control systems in BSVI vehicles, must be put in place. This will require skilling of city/state level transport departments. This will require next generation emission testing and screening systems. Two cities Delhi and Kolkata have begun to pilot application of remote sensing devices (RSD) for vehicle emission monitoring and a method will have to be incorporated to make this screening method a valid method as a part central motor vehicle rules for enforcement. Other strategies like tightening of existing norms and procedures, incorporation of OBD checks as part of I&M for BS-VI vehicles will be needed to ensure that new vehicles operate with full efficiency of emission reduction.

Electric vehicle technology roadmap: Several policy statements have been issued over the last few years to make large scale transition from internal combustion engines to electric vehicles by 2024 and 2030. But policy intent and the incentive programme must be backed by zero emissions mandate. This is needed to push certain percentage of vehicle production to electric to transform the market along with ecosystem planning. Priority attached to linking electric mobility with public transport is a win-win.

The government in March 2019 has notified the second phase of the FAME India scheme with a Rs 10,000-crore outlay to encourage adoption of electric and hybrid vehicles. Timeline of FAME II is from April 2019 to April 2022. The key verticals of scheme include a) Demand incentives, b) Charging networks and c) Administration of Scheme. FAME I contained 2 additional verticals – Technology Development (R&D) and Pilot Projects. Total funding for FAME 2 is Rs 10,000 crore, of which 86 per cent is for demand incentive and 10 per cent for charging infrastructure. The share of different category of vehicles in demand incentive include 20 per cent allocated to two-wheelers, 25 per cent to three-wheelers, 5.5 per cent to four wheelers (including 0.3 per cent to SHEV[1]'s) and 35.5 per cent to buses.

FAME 2 incentives are linked to performance indicators. Incentive will be applicable 'mainly' (not clear if exclusively) to vehicles used for public transport or commercial applications. Also the demand incentives will be based on battery capacity (Kw-Hr) instead of on a per unit basis. However, for buses, only tenders under operation model (net cost basis) will be supported under the incentive structure. CAPEX model/outright purchase of buses will not be incentivized. Further the incentives will be given only for vehicles using advanced batteries (lithium ion etc., definitions will be notified separately). Lead acid batteries excluded. Also price caps have been decided for different category of vehicles. Several state governments are also framing their respective policies to phase in electric mobility.

Clean fuels for Industrial pollution control: Transition towards clean fuels has just about started in India but this will have to be taken forward to clean up emissions. Following the exposé based on CSE's study and EPCA's submission to the Supreme Court that petcoke and furnace oil—the dominant industrial fuels—are among the dirtiest, with sulphur content as high as 24,000 ppm to 74,000 ppm and largely used without emissions control systems, these fuels have been banned in four states of Delhi, Haryana, Rajasthan and Uttar Pradesh by the Supreme Court. Even import of petcoke into India has been banned by the Supreme Court as per the recommendations of the EPCA Reports on the

subject. Only four categories of end-users—cement, calcium carbide, lime kilns and gasification—are allowed. In addition, aluminium, calciners and iron and steel manufacturers have also petitioned the Supreme Court to be allowed to import petcoke. The matter is pending in the courts.

The spin-off of this move is the notification of SOx and NOx standards for 34 groups of industry that is applicable nation-wide. The MoEF&CC has notified permissible SOx and NOx emission standards for 34 categories of industries in India. However, the implementation of these orders is something that remains to be followed up on, since SPCB's currently have limited capacity to monitor and ensure compliance.

In the meantime, Delhi has taken the lead to issue approved fuel list that bars use of coal or any other dirty fuel along with petcoke and furnace oil in any sector in Delhi.

Brick kilns are mandated to move to cleaner kiln technology. In fact, about 400 brick kilns in NCR have moved to zigzag technologies. But this process will have to be accelerated.

Clean fuel policy along with emissions control technology roadmap has become necessary to substitute dirty fuels across sectors. Clean fuel policy is needed for all sectors. There has to be a natural gas policy to address access, availability and pricing in all the critical sectors to replace diesel and coal. Simultaneously, strategies must be adopted for controlling fugitive emissions from small scale units. It is also necessary to regulate industrial emissions by setting load based targets and through a strong deterrence and compliance mechanism.

Power plant roadmap: New emissions standards that were notified by the MOEF&CC in 2015 are yet to be implemented. The proposed date for its implementation is 2022. The new standards need to be implemented by an early date. A transition plan can for each plant need to be drawn up to enable that process and ensure compliance. This will allow tighter regulations of emissions of particulate matter, nitrogen oxides, sulphur dioxide and mercury. The standards are designed to enable quicker uptake of much cleaner super critical technology. As there are plans to set up new power plants in many places and some are under implementation, progressive step is needed to design them based on the new standards so that high pollution can be prevented.

Also the plants found not meeting set emission reduction targets to be penalized. In addition, preparation of plan for full utilization of fly ash, monitoring, ans sprinkling of water (recycled) especially during summer months to curtail wind-blown ash should be immediately implemented.

In the medium to long term, progressively closing the older and more polluting thermal power plants and to move to cleaner natural gas should be the goal. For power sector government of India and respective states should prepare and implement a gas allocation policy. Further necessary changes in the merit order dispatch policy must be made so that cleaner plants operate in heavily polluted regions.

Clean household energy: A recent policy brief on the Contribution of Household Fuels to Ambient Air Pollution in India from Collaborative Clean Air Policy Centre, New Delhi, shows that household air pollution can contribute up to 30 per cent of particulate pollution in India with serious health consequences.

Therefore, controlling this is critical to meet the ambient air quality targets.

According to National Family Health Survey 2015 published in 2017, 78.3 per cent of urban households use LPG/natural gas as cooking fuel, whereas 23 per cent of rural households use the same. Rest of the households use wood, dung cake, kerosene, coal, agricultural residue etc. as fuel.

In the 2016 edition of the International Energy Agency's World energy outlook, it was estimated that more than 700 million people relied on inefficient burning of solid biomass for cooking and that more than 100 million lacked access to electricity, but these estimates are based on conditions in the early part of the decade. Since 2015, national liquefied petroleum gas (LPG) programmes have added an additional 60 million consumers (more than 120 million people) supplied by public sector oil marketing companies, and 99 per cent of the 18,452 census villages that had not been electrified by 2015 now have electricity, although this has not been verified by a reliable survey.

The Pradhan Mantri Ujjwala Yojana (PMUY) is an important policy effort to improve clean energy access. But while expanding the access of LPG to more beneficiaries, it must also ensure sustained use. Simultaneously, ensure access to reliable electricity— to substitute for other household pollution sources, such as water heating and kerosene lighting and to also promote induction stoves. There is also considerable scope to align clean air policies with renewable energy programmes to promote decentralized micro and mini grids or access to large grids to enable transition to cleaner and affordable electricity. Each of these will require well designed strategy and implementation plans.

7.3 Curbing waste burning

Air pollution control measures such as controlling waste burning or reducing dust that depend on efficient municipal services have been most difficult to implement across Delhi and NCR. This is a reality across cities. Also large number of people live outside the municipal boundaries. This is a concern across regions. Controlling open burning of municipal solid waste (MSW) in Delhi and NCR has remained most challenging. Waste burning contributes about 8.4 per cent of the PM2.5 in Delhi. Also fire erupts in landfill sites which matches with the high peak of pollution during summers and winter. Burning of MSW and horticulture waste is a serious concern, also the burning of waste on the open dumping/landfill sites. All municipal corporations in Delhi and NCR will have to internalise the key waste management solutions to address this problem at a scale and zero tolerance.

Capacity to dispose waste is weak and therefore burning becomes easiest way to dispose of waste. As per official data, the 5 MCDs of Delhi generate 10500 TPD of municipal solid waste. The city also has over 1,630 unauthorised colonies in three municipals alone where there is no waste management system in place. The corporations woefully lack capacities to enforce rules and to ensure compliance. There is dearth of infrastructure to support decentralized processing. The city has over 2,300 dhalaos—structures to collect and store waste. Over 80 per cent of the waste is processed through incineration, though studies show that the calorific value of Delhi's waste does not support incineration. Not only do these plants have received flak owing to NIMBY, but they have been contributors to air pollution as well due to lack of appropriate emission monitoring and compliance systems. Recently, Delhi fought a bitter battle to stop large-scale burning of plastics in Mundka area of Delhi that caused enormous poisonous gases.

Moreover, all the three existing dumpsites in Delhi—Okhla, Bhalswa and Ghazipur—exceeded their capacities way back in 2008. MCD has been asking for more land to process and dispose garbage.

Five municipal authorities are responsible for solid waste management in the city—the North Delhi Municipal Corporation (North DMC), South Delhi Municipal Corporation (SDMC), East Delhi Municipal Corporation (EDMC) the New Delhi Municipal Council and the Delhi Cantonment Board (DCB). The three corporations—North, East and South—alone manage 96 per cent of the total area of the city. MCDs have no clear idea about how much waste is generated in Delhi. As per information provided by MCDs, 10,050 TPD of municipal solid waste is collected in Delhi.

The status of segregation in the city is not more than 10 per cent and is restricted to a few institutions and colonies only. As per a recent NGT directive, 12 wards from different MCDs in Delhi have been selected as model wards. In North Delhi Municipal Corporation door-to- door collection of MSW in Rohini and Civil Line Zone is being done and waste is processed at engineered landfill site at Narela-Bawana. About 4,000 twin bins have been distributed to householders in one colony each in six zones to promote segregation. In five zones, private parties have been given the responsibility to comply with the segregation programme and to create awareness. To prevent littering 6,000 roadside twin bins have been procurted.

MSW is collected daily from storage/receptacles/collection centres (dhalaos/ dustbins) existing at different places in all statutory bodies of Delhi. This MSW does not include segregated waste picked up by waste pickers/kabariwala at the doorstep and collection centres. This waste generated by the citizens is deposited in the receptacles either by the citizens themselves or through private waste pickers and it is taken to various facilities for processing/disposal.

As per the 2021 Master Plan, community bins or dhalaos need to be provided in 100 sq. m of space for every 10,000 people; in addition to this, another 200 sq. m of space must be provided for segregation of non-biodegradable wastes. But the DDA does not provide adequate space for storage of waste in both existing and new colonies that are being planned. In SDMC area, all the dhalaos are being converted to fixed compactor transfer stations (FCTS) due to the menace and nuisance that dhalaos have created in the past. Also, in all the other MCDs, the plan is to phase out dhalaos. It has been proposed to either convert them to Material Recovery Facilities or FCTSs.

Considering Delhi's data made available by the MCDs, of the 65 per cent treatable material, 60–70 percent can be processed through composting or bio-methanation technologies, while 18–20 per cent (textile, cloth, rubber, LPV) can be thermally treated through incineration-based technologies. Presently, everything that is recyclable is also being incinerated; MCDs are encouraging mixed waste to be processed in the WtE plants.

As per information provided by MCDs there are two centralized composting plants—at Okhla and Bawana—together process about 1,200 TPD of biodegradable waste; however, the quality of compost obtained from these plants is highly compromised. Over 20–30 tonnes of city compost is lying in Bawana because it has no takers. The reason behind this poor efficiency of the plants is that they receive unsegregated waste.

All the three existing dumpsites of Delhi exceeded their capacities way back in 2008. The dumping sites in Delhi do not have any methanization or gasifiers to control the methane being produced naturally by the biodegradable garbage. There are no fire protection systems at these sites, thus making them a potentially flammable location. There is no landfill gas-collection system either. One LFG pilot project at Ghazipur has been established in 2013 by GAIL for extraction of landfill gas to reduce greenhouse gases. The project at Ghazipur is functional only a few days in a month due to unavailability of the gas.

Solid waste by-laws not implemented: It is more than a year since the Solid Waste Management Rules (SWM) byelaws were notified, but the MCD have not implemented them in true spirit. The expert committee (included CSE) setup by the Delhi High Court had submitted a detailed action plan in August 2017 on SWM. Based on the recommendations, the committee also prepared the draft by-laws on solid waste management which were notified in January 2018. All five municipal corporations are now bound to enforce the by-laws in their areas of jurisdiction.

By-laws mandate that waste be segregated at source into three streams—biodegradable (wet waste), non-biodegradable (dry waste) and domestic hazardous waste. These streams of waste have to be stored in separate colour-coded bins—green, blue and black, for wet, dry and domestic hazardous waste, respectively. Municipal corporations have to ensure collection and transportation of segregated solid waste. They have to publicize the time slots for waste collection for each area.

To avoid the mixing of segregated waste, all secondary storage points (dhalaos) have been mandated to have colour-coded containers to store wet, dry and domestic hazardous waste. Municipal corporations have to convert the existing dhalaos into recycling centres for further segregation of dry waste. Further, under the by-laws, they have to set-up a deposit centre for each ward to collect domestic hazardous waste.

To minimize transportation cost and avoid landfills, the by-laws mandate decentralized processing mechanisms such as biomethanation and composting in the colonies themselves. For waste-to-energy plants that incinerate directly, absolute segregation has been made mandatory. To fund the waste management infrastructure, corporations have been asked to fix and regularly collect a user fee. To ensure compliance with the by-laws, provision has been made for imposing a penalty for non-segregation, open burning and dumping of solid waste in vacant plots.

Infrastructure for segregation not in place: So far, no systems have been developed by MCDs to support segregation. Segregated waste is collected and sent to the dumpsite or the waste to energy plants. The segregation of the waste becomes futile if everything is ultimately dumped at a landfill. MCDs state land is an issue, however, the dhalaos could be easily converted into dry waste sorting centres or material recovery facilities. Moreover, the collector needs to be incentivized for the same.

Waste management in unauthorized areas and slums: Delhi has 1,634 unauthorized colonies in the MCD jurisdiction area. These unplanned colonies pose a major challenge for waste collection and transportation as well. Even though by the law the municipal bodies are responsible for extending waste management services to these households, these unauthorized colonies are

not developed in accordance with the city planning norms. In SDMC, there are 932 unauthorized colonies where a corporation provides sanitation-related activities only as of now. As per the orders of Government of National Capital Territory of Delhi, the development works in unauthorized colonies is entrusted the Delhi State Industrial & Infrastructure Development Corporation. Until road construction, drainage and other allied work are not undertaken, the waste collection also becomes a major issue. Moreover, no bins are placed in such areas.

Inventorization of waste not done: There is no clear idea about how much waste Delhi generates; figures do not keep into account the quantum of garbage managed by the informal sector.

Processing of mixed waste in WtE plants adds to pollution: As per the SWM Rules, 2016 and NGT order dated 22 December 2016, WtE plants cannot operate on mixed waste. So far, no systems established to ensure only segregated high calorific value non-recyclable waste goes to such plants. Delhi has three WtE plants—Okhla (2,000 tonnes, 16 MW) operated by Jindal Ecopolis, Ghazipur (1,300 tonnes, 14 MW) operated by IL&FS and Narela- Bawana (2,000 tonnes, 24 MW) operated by Ramky Enviro. Mixed recyclable and organic waste is fed into these plants in order to meet the required high calorific value of 1,400 kcal/kg. This is in contradiction with directions of NGT in its order dated 22 December, 2016 as well as SWM Rules, that have mentioned that no recyclables and mixed waste to be used in these plants. The Okhla plant has been in the news since its inception as its neighbours have taken the management of the plant to court, alleging pollution. After many legal battles, the case was finally heard at the National Green Tribunal, which, in its February 2017 order has directed Jindal Ecopolis to 'adopt better technology for segregation of waste before it is put in the furnaces' and also fined the proponent an environmental compensation of Rs 25 lakh. However, there is still no resolution as the residents remain unconvinced by these measures and have taken the case to the Supreme Court.

Lack of compliance and enforcement capacities: Lack of supervisory staff to oversee operations of waste management is a big challenge. Also, there is no task force or committee created to monitor the progress of waste management in the city, which is in accordance with segregation, efficient C&T systems, processing of segregated waste and proper disposal. Rag pickers/kabadiwallahs form a vital part of waste management in Delhi. But they are not authorized. MCD should rope in informal sector in their waste management systems to strengthen their collection systems.

Waste generation on roadside curbside by street vendors/hawkers: Hawkers and roadside eateries generate garbage throughout the day and dump them on the roadside. Poor vigilance and monitoring by the MCDs further aggravates the problem.

Waste from fruit and vegetable markets: No in-house treatment of wet waste generated in such mandis.

Act quickly to stop burning of waste:

- Implement by-laws on SWM with fines on open burning, littering and penalties for non-segregation. Proper collection and segregation of municipal solid waste and horticultural waste (biomass) and its disposal following composting-cum-gardening approach.

- Transport municipal solid waste, construction materials and debris in covered systems

- Ensure development of segregation incentive systems to cut down dependency on centralized technologies such as WtE or dumping

- DPCC and waste to energy plants must ensure monitoring of emissions from WtE plants especially dioxins, furans, chlorides on a weekly basis

- Promote implementation of composting in all public parks, housing societies, official buildings, schools, etc. MCD should provide subsidies to households/DDA flats/gated societies for adoption of composting/ biomethanation technologies for wet waste management at source. Horticultural waste (garden waste) generated in residential and commercial areas, public parks should be segregated and composted in garden or parks, wherever it is feasible

- Develop decentralized and semi-decentralized systems for appropriate processing and disposal.

7.4 Curbing dust from construction and construction waste

The government estimate for construction and demolition waste generation in the country had been stuck at 10–12 million tonnes a year. But CSE estimates in 2013 showed that this has to be at least 530 million tonnes. But after two years later another independent agency pegged the number at 750 million tonnes. Given the context of the construction boon and illegal sand mining crisis, this volume of building material being wasted and unaccounted for was nothing short of criminal. To make things worse, this was being dumped into rivers and wetlands further damaging our already endangered ecosystems. It was paramount to double murder of our rivers.

This waste is also a major contributor to air pollution. Dust is a major component of this waste which readily becomes air-borne due to mismanagement. Inert by nature but once these fugitive dust particles get coated with traffic exhaust and combustion emissions it becomes toxic as well. Its indiscriminate dumping on roads and sidewalks also degrades roads and traffic movement spiking emissions from that sector.

Situation is no better now, but it is officially on discussion table. Construction and Demolition Waste Management Rules were notified in 2016 that revised the estimate down to 160–180 million tonne in 2017 without giving much rational, but it is still a staggering number that sounds alarm for immediate action. Demand for action has also sprung from the clean air action plans that cities have started adopting since 2018.

2010 commonwealth game preparations got Delhi its first C&D waste recycling facility. Motivation for setting up of the plant at Burari in North Delhi was different but its expansion is been driven by the heightened concern for deteriorating air quality and protection of rivers. Currently the city has three recycling plants (at Burari, Shastri Park and Mundka) with combined capacity of 2,650 tonnes a day. Three more plants are in pipeline that will add 2,000 tonnes to existing capacity. All the plants are in North Delhi except one in Shastri Park. These are supported by a network of 168 collection points in the city, about half of them are in the jurisdiction of North Delhi Municipal Corporation. But there is a disparity here, South Delhi which is the richest

of the three municipal corporations of Delhi and arguably undergoing major redevelopment and densification (both planned and organic) doesn't have any recycling plant and its website doesn't even have information regarding where to send C&D waste being generated by its people.

Level of awareness is extremely poor among the citizens and efforts made by government agencies to change this is negligible. This reflected in uptake of recycled waste products that the C&D waste plants are manufacturing. BIS officially recognized recycled C&D waste as legal substitute to natural sand in concrete mix in 2016. Delhi government has issued advisory asking all public agencies to mandate 5 per cent use of such products for non-structural applications while examining and approving building plans. But they have nothing to show for it, in fact Delhi plants storages are over-flowing with unsold recycled products.

CPWD was one of the first government agencies to adopt a memorandum setting a target to mandatorily use 10–20 per cent recycled products in all its construction activities in Delhi-NCR. They followed it up in the construction of the Supreme Court Extension that used 1.8 million bricks made from recycled C&D waste sourced from the recycling plant at Burari. All the non-load bearing walls in the project are made using recycled C&D waste bricks. And it turned out to be cheaper and stronger than regular brick despite of higher GST rate imposed on recycled waste.

This is a resource which needs harnessing. The start has been made but more needs to be done.

Byelaws on construction and demolition waste not implemented: The amended by-laws have stated that this shall be the responsibility of the owner/ occupier of premises to store the construction material and construction and demolition (C&D) waste within the premises.

This shall be the responsibility of the owner/ occupier of premises to dispose C&D waste at a place designated by the MCD or to the nearest C&D facility. The C&D waste can be used for filling of low-lying areas provided it is done in an environmentally safe manner and with the permission and consent of the owner of the land.

MCD shall ensure collection and transportation of C&D waste generated from its own activities and activities of other government departments working in the municipal area to the nearest C&D waste treatment facility.

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In addition to the by-laws, it is necessary to ensure uptake of recycled material for construction. There are mandates that certain percentage of the construction material has to be recycled product.

This will have to be expedited very quickly.

Dust from construction

Construction sites are one of the major contributors to Delhi's dust pollution. They are usually the first industry that the air quality emergency mandates shut-down and by far the most severely fined for violating dust-control requirements. National Green Tribunal in 2015 imposed a Rs 50,000 fine on builders if their project were found non-compliant with dust-control measures outlined by the court. The fine was revisited in 2016 that made it telescopic in nature and even more pinching. Construction sites built on a plot area of more than 20,000 square metres (sq. m) were made liable to pay environmental compensation of R 5,00,000 per violation. Smaller sites built on a plot area of 100 sq. m to pay Rs 10,000, plots of 100 to 200 sq. m to pay R 20,000, plots of size 200 to 500 sq. m to pay Rs 30,000 while sites of 500 to 20,000 sq. m to pay Rs 50,000 as environmental compensation.

Almost all builders active in Delhi-NCR has been fined for non-compliance with dust-control over last few years. NBCC, a government construction agency doing most of redevelopment work in the capital is one of top repeat offenders. Their Kidwai Nagar Redevelopment project has been fined repeatedly with fine amounts running in multiple lakhs of rupees. Recently, courts order shut down of all their construction activities at their Pragati Maidan redevelopment site for gross non-compliance with dust-control.

Delhi is hotbed for demolition and construction. The city is undergoing rapid densification with even healthy buildings giving way for something taller, controlling dust from these activities is no longer a localized issue. With infrastructure projects like metro and large-scale redevelopment of old government residential colonies like East Kidwai Nagar, Nauroji Nagar, Netaji Nagar, Sarojini Nagar, Thyagraj Nagar, Kasturba Nagar, Srinivaspuri and Mohammadpur it would be foolhardy to assume that construction dust is not a city scale problem.

Construction is spread across the landscape posing serious enforcement challenge.

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Air pollution is a health emergency in India. Centre for Science and Environment (CSE) reviewed emerging evidences of air quality and health evidences to alert policymakers and the public about the third-generation challenge and action that India has to prepare for.

Delhi is a microcosm of change that throws up important lessons for the rest of India. CSE tapped into the city's learning curve to highlight the solutions: while first-generation action, a decade ago, was about immediate relief—such as CNG and shifting of industry—and second-generation action about formulating a spate of new policies, third-generation action is about implementing solutions on the ground on a scale that makes a difference.

But are we prepared for third-generation action for clean air? The solutions are known, but they must be fast tracked for transformative changes. This World Environment Day underscores that implementation of third-generation action is non-negotiable.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Ph: 91-11-40616000 **Fax:** 91-11-2995 5879
Email: cse@cseindia.org **Website:** www.cseindia.org