



SLOW MURDER **CONTINUES**

India's suffocating journey
of knowing and forgetting the
deadly air pollution



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Centre for Science and Environment



Centre for Science and Environment (CSE), founded in 1980, is a public interest research and advocacy organisation based in New Delhi. CSE researches into, lobbies for and communicates the urgency of development that is both sustainable and equitable.

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Environmental management is built on two principles: the balance principle and the precautionary principle. Economic growth, it is now widely recognised, creates environmental problems. Therefore, the state, while promoting economic growth, must use its regulatory and fiscal powers to strike a balance with environmental harmony. What is the point, after all, of owning and moving around in a motor vehicle if you are soon to die of cancer? And, the second principle demands that this balancing action be taken before the environmental damage begins and not after.

Anil Agarwal

'Slow Murder, The Deadly Story of Vehicular Pollution in India', 1996

FOREWORD

Particle by Particle



THE TOXIC journey begins in the womb. When mothers are exposed to polluted air during pregnancy, the foetus is at serious risk. The risk escalates into a massive disease burden for infants, children and adolescents, lasting a lifetime. The problem has reached alarming proportions in the Global South, with India bearing the infamy of accounting for a quarter of the global infant deaths—within the first month of birth. Well-established science has defined the biological pathways through which pollutants enter the body and damage organs. These estimates consider not only lower-respiratory

infections affecting children but also a much broader range of health impacts. Additionally children from poorer households are at greater risk.

Foetuses exposed to toxins in the womb have lower chances of survival. Exposure to toxins also leads to stillbirth, preterm birth and low birth weight. It predisposes foetuses to a range of diseases later in life, including endocrine and metabolic disorders, such as diabetes. If air pollution affects the mother's respiratory health, oxygen and nutrient delivery to the foetus can be reduced. Impaired lung development *in utero* increases the risk of airway diseases. Scientists explain that particulate matter can trigger a maternal inflammatory response, reduce maternal immunity, and increase the risk of infection and of poor neurological development. Babies born too small are more vulnerable to, and less able to cope with, the risks of lower-respiratory infections, diarrhoeal diseases, brain damage and inflammation, blood disorders and jaundice.

In children under five, exposure to polluted air poses severe risks. It impacts lung function, can lead to obesity, and affects brain and neurological development, resulting in conditions such as attention deficit hyperactivity disorder (ADHD), reduced intelligence and impaired neurodevelopment. Even at lower levels of exposure, children can develop lasting deficits in lung function, which makes them vulnerable to chronic lung diseases in adulthood and affects their quality of life. ■

No Breather

Consistent rise in pollution levels in India's cities highlights a deep-rooted air quality crisis



EVERY BREATH in India kills, slowly but certainly. In the 2009-19 decade, about 3.8 million deaths were attributed to air pollution above the country's air quality guidelines of 40 micrograms per cubic metre ($\mu\text{g}/\text{m}^3$), according to a study by Sweden-based medical university Karolinska Institutet. 'Compared to the stricter guidelines recommended by the World Health Organization (WHO)—only 5 micrograms per cubic metre—the figure rises to 16.6 million deaths. That's almost 25 per cent of all mortality during the study period,' said the university. The entire population of India lives in

areas where $PM_{2.5}$ (fine particulate matter with a diameter of $2.5\ \mu m$ or less) levels exceed WHO guidelines, the study highlighted. The Natural Resources Defense Council, an international advocacy group, offers a context to $PM_{2.5}$, 'For the sake of comparison, most bacteria are at least five microns across. The diameter of a red blood cell is six microns. A strand of hair is around 70 microns wide. You could fit several thousand $PM_{2.5}$ particles on a period.' Every $10\ \mu g/m^3$ increase in $PM_{2.5}$ concentration led to an 8.6 per cent increase in mortality among people of 655 Indian districts between 2009 and 2019, the Karolinska Institutet study warned.

In this most populous country in the world, almost every citizen is exposed to deadly pollution while performing the most basic existential activity: breathing. And it adds to their disease burden. Various studies point out that $PM_{2.5}$ concentrations continue to increase in many areas. Moreover, $PM_{2.5}$ particles can travel hundreds of kilometres, bringing the spectre of pollution to larger geographies.

Air pollution is a major concern across Indian cities, with significant variations in air quality levels between large metropolitan areas and smaller cities. A new and alarming trend has emerged—smaller cities, once considered relatively cleaner, are now experiencing dangerously high pollution levels. Byrnihat, a small industrial town on the Assam-Meghalaya border, has emerged as India's new

pollution hotspot, surpassing even Delhi in annual $\text{PM}_{2.5}$ levels. According to the Central Pollution Control Board (CPCB), Byrnihat in 2024 recorded an alarming average $\text{PM}_{2.5}$ concentration of $133.4 \mu\text{g}/\text{m}^3$, exceeding the national standard by a staggering 3.3 times. This marks a significant shift in India's air pollution crisis, as smaller towns are now registering pollution levels once thought to be a problem only for metro cities. The air quality in Byrnihat has deteriorated to such an extent that a drastic 70 per cent reduction in $\text{PM}_{2.5}$ levels is required to meet the annual standard. In comparison, Delhi, which has long been in the spotlight for its hazardous air, recorded an annual average $\text{PM}_{2.5}$ concentration of $104.9 \mu\text{g}/\text{m}^3$, reflecting a 4 per cent increase from the preceding 2024's $101 \mu\text{g}/\text{m}^3$. The most polluted cities in India, as highlighted in an air quality report released by Swiss air quality technology company IQAir along with CPCB data, revealed alarming $\text{PM}_{2.5}$ concentrations. The notion that air pollution is a 'big city problem' is rapidly crumbling. The data indicates that smaller towns and industrial hubs are now at the frontline of India's air pollution crisis.

The consistent rise in pollution levels across cities highlights the deep-rooted air quality crisis that extends beyond the metros. Other highly polluted cities include Gurugram, Haryana ($91.7 \mu\text{g}/\text{m}^3$); Sri Ganganagar, Rajasthan ($87.2 \mu\text{g}/\text{m}^3$); Faridabad, Haryana ($84.7 \mu\text{g}/\text{m}^3$); Greater Noida, Uttar Pradesh ($83.6 \mu\text{g}/\text{m}^3$); and Muzaffarnagar, also in Uttar

Pradesh ($83.4 \mu\text{g}/\text{m}^3$). The data indicates that industrial belts and rapidly urbanising regions are bearing the brunt of escalating emissions. The air quality trends also suggest that smaller cities, previously overlooked in national air pollution discourse, are becoming critical zones requiring urgent intervention. A report from IQAir echoed these findings. While there are slight variations in numbers, the underlying message remains the same: India's air pollution problem is expanding in scale and intensity, engulfing newer regions in a worsening crisis.

Irrespective of their diverse geographic and climatic contexts, the megacities of India—Delhi, Mumbai, Kolkata, Bengaluru, Hyderabad and Chennai—experienced worsening $\text{PM}_{2.5}$ levels during the winter of 2024-25 (October 1, 2024-January 31, 2025), according to Delhi-based advocacy non-profit Centre for Science and Environment (CSE). This has emerged from a new analysis of real-time $\text{PM}_{2.5}$ data in these cities during the winter period. While Delhi, located in the land-locked Indo-Gangetic Plains (IGP) with adverse meteorology, had recorded the highest level of pollution during winter, Kolkata—also at the tip of IGP—ranked second. The megacities outside IGP—Mumbai, Chennai, Hyderabad and Bengaluru—despite having more advantageous climatic conditions and natural ventilation, also experienced increases in average $\text{PM}_{2.5}$ concentrations. Other

than Delhi and Chennai, all other megacities recorded city-wide winter averages that were comparatively lower than the average of the past three winters; but the concentrations across different locations had been high, leading to high exposures. The peaking of pollution during winter in any climatic zone is a sign of the underlying problem of persistent air pollution in these rapidly urbanising and motorising cities. While Delhi's winter air quality often dominates public discourse, rising pollution levels in other megacities remain largely overlooked. Despite some improvement in seasonal pollution trends, winter pollution continues to remain high or rise locally.

A four-year analysis (2021-24) of air quality in 11 metropolitan cities by Respirer Living Sciences, a Delhi-based climate technology startup, shows alarming levels of particulate pollution across India's major urban centres. It found that all 11 metropolitan cities monitored consistently breached the National Ambient Air Quality Standards for PM₁₀, with pollution levels remaining stubbornly high despite various policy interventions. The most severe conditions were observed in northern India, where cities like Delhi, Patna, Lucknow and Chandigarh recorded particularly dangerous air quality. Delhi's Anand Vihar monitoring station measured PM₁₀ concentrations of 313.8 $\mu\text{g}/\text{m}^3$ in 2024, while Patna's Samanpura area saw levels reach 237.7 $\mu\text{g}/\text{m}^3$ —all exceeding the national

safety standard of $60 \mu\text{g}/\text{m}^3$.

Even cities traditionally considered to have better air quality failed to meet standards. While some southern and coastal cities like Bengaluru, Chennai and Hyderabad showed modest improvements at certain monitoring sites, none managed to achieve consistent compliance with safety norms over the four-year period. Ronak Sutaria, founder and chief executive officer (CEO) of Respirer Living Sciences, said, 'This isn't about occasional spikes—we're seeing chronic, year-round pollution that exposes urban populations to dangerous particulate levels on a sustained basis.' He added, 'Our data shows no evidence of a meaningful, long-term downward trend in most locations.'

Rural areas are also reporting high levels of air pollution. In 2022, the annual average of $\text{PM}_{2.5}$ was as poor in rural India as urban India, according to an analysis carried out by non-profit Climate Trends based on satellite-based data generated by scientists with the Indian Institute of Technology (IIT), Delhi. According to the analysis, in 2022, the average annual $\text{PM}_{2.5}$ level was $46.4 \mu\text{g}$ in rural India, barely below the urban level of $46.8 \mu\text{g}$. (The national limit is $40 \mu\text{g}$.) The urban and rural levels of $\text{PM}_{2.5}$ in India since 2017 showed almost similar pollution concentration, with hardly any differences within the two sets of figures, said the report.

'A deep insight into state-level aerosol pollution in India: Long-term (2005-2019) characteristics,

source apportionment, and future projection (2023)', a paper by Abhijit Chatterjee of the Bose Institute, Kolkata, said, 'The air pollution issue in the country in the recent decade would not be resolved unless we take the rural parts into account.' In India, 47 per cent of the population lived outside the air quality monitoring network and 62 per cent did not have access to daily alerts on the local air quality index. The entire rural India stands outside the purview of the air pollution network.

Incidentally, according to another analysis by CSE, the rural population suffered more than its urban counterpart in terms of lifespan lost due to exposure to $PM_{2.5}$. CSE's analysis showed that village inhabitants, on average, lost over five years and two months of lifespan due to air pollution exposure, while city dwellers lost about four years and five months. While the analysis records a lifespan loss of over eight years for rural residents in Uttar Pradesh, in Bihar and Haryana, village-dwellers are found to lose over seven years on average.

The severity of air pollution in India can be gauged from this fact. In 2018-21—a period traversing three phases of the COVID-19 pandemic (pre, during and post)—India witnessed the maximum levels of human-induced air pollution, notwithstanding the lockdown and drastic reduction in movements and economic activities. This was according to a study published in journal *Nature* on May 17, 2023. This period saw a

surge in air pollution owing to the development of transportation, industrial power plants, green space dynamics and unplanned urbanisation in the country, notes the study. Researchers Bijay Halder, Iman Ahmadianfar, Salim Heddami, Zainab Haider Mussa and Leonardo Goliath carried out machine-learning-based country-level annual air pollution monitoring using Sentinel-5P satellite and Google Earth Engine (GEE). Sentinel-5P monitored the atmospheric air pollutants and chemical conditions from 2018 to 2021, while the cloud computing-based GEE platform was used to analyse air pollutants and chemical components in the atmosphere. The years 2020 and 2021 saw drastic changes in Air Quality Index (AQI), whereas 2018 and 2019 saw low AQI throughout the year. Delhi, Kolkata, Mumbai, Pune and Chennai recorded huge fluctuations in terms of air pollution during the study period.

It is not just particulate matter that is polluting India's air. A study by CSE revealed a disturbing trend: Ground-level ozone pollution is on the rise across India's major cities. This invisible gas, unlike the more familiar fine particulate matter, poses a serious health threat, particularly to those with respiratory problems. Ground-level ozone is not directly emitted from any source. It is produced from complex interaction between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) that are emitted from vehicles, power plants, factories, and other combustion sources and undergo cyclic

reactions in the presence of sunlight to generate ground-level ozone. VOCs can also be emitted from natural sources, such as plants. Those with respiratory conditions, asthma, chronic obstructive pulmonary disease, and particularly children with premature lungs and older adults, are at serious risk. This can inflame and damage airways, make lungs susceptible to infection, aggravate asthma, emphysema, and chronic bronchitis and increase the frequency of asthma attacks leading to increased hospitalisation.

The CSE report, 'Air Quality Tracker: An invisible threat', analysed metropolitan areas of Bengaluru, Chennai, Kolkata, Mumbai and Pune. It looked at data for Delhi-National Capital Region (NCR), Greater Ahmedabad, Greater Hyderabad, Greater Jaipur and Greater Lucknow. All 10 areas studied witnessed exceedances of the national ozone standard, with Delhi being the most affected. Smaller cities like Ahmedabad and Pune are experiencing a particularly rapid increase in ozone pollution, the report found.

CSE researchers tracked trends from the period between April 1 to July 18, covering the years 2020 to 2024. Between April and July 2024, Delhi-NCR recorded 176 days of ground-level ozone exceedances, the highest among the 10 metropolitan areas studied. The analysis was based on granular, real-time data (15-minute averages) from CPCB. Mumbai and Pune both had 138 days, followed

by Jaipur with 126 days and Hyderabad with 86 days. Kolkata had 63 exceedance days, Bengaluru 59, Lucknow 49 and Ahmedabad 41. Chennai had the fewest exceedances, with just nine days. Comparing the number of exceedances in July 2024 with July 2023, showed an increase in 7 out of 10 metropolitan areas analysed in this study. Smaller metropolitan areas had shown the most increase with Ahmedabad, registering a 4,000 per cent jump in the number of exceedances. Pune follows with 500 per cent increase and Jaipur 152 per cent increase. Hyderabad registered 115 per cent rise in number of exceedance days. The Mumbai Metropolitan Region (MMR) and Bengaluru registered 18 per cent and 1 per cent increase respectively. Delhi-NCR and Lucknow reported a change of less than 5 per cent, with the Kolkata Metropolitan Area (KMA) and Chennai had seen a drop in number of exceedances by 19 per cent and 40 per cent respectively.

Contrary to expectations, ozone levels were elevated even at night, with Mumbai recording the most instances of night-time exceedances. The duration of ozone exposure is concerning, lasting an average of 12-15 hours across most cities, the researchers find. High-end and green neighbourhoods, with lower levels of other pollutants, are ironically more susceptible to ozone buildup. While summer is the peak season for ozone, the problem persists year-round in many areas, particularly in sunnier southern cities.

Furthermore, ozone accumulates not only in metropolitan areas but also travels long distances, creating a regional pollutant that demands both local and regional action. Currently, insufficient monitoring, limited data, and ineffective trend analysis methods have hampered understanding of this growing public health risk, the report adds. The complex chemistry of ground-level ozone makes it a difficult pollutant to track and mitigate. Due to its highly toxic nature, the national ambient air quality standard for ozone is set only for short-term exposures (one-hour and eight-hour averages), with compliance measured by the number of days that exceed these standards. This necessitates early action, the researchers underlined.

Indoor pollution is another persistent threat. India's poor indoor air quality can impair cognitive development in children less than two years, when brain growth is at its peak, according to a study published in the journal *eLife* in April 2023 by the researchers from the University of East Anglia (UEA). The negative impact on children's brain development could have long-term consequences for life, warned the study. Indoor air quality is primarily linked to cooking fuels.

This study was the first to establish an association between poor air quality and cognitive problems in infants under two. 'Prior work has shown that poor air quality is linked to cognitive deficits in children, as well as to emotional and behavioural problems,

which can have a severe impact on families,' said John Spencer, lead researcher from UEA's School of Psychology. The team collected in-home air quality data from rural India, focusing on PM_{2.5} levels. The researchers worked with families from various socio-economic backgrounds in Shivgarh, a village in Uttar Pradesh. They observed poor air quality in households that used solid cooking materials such as cow dung cake. Infants from these houses had lower visual memory scores at six and nine months of age. They also had slower visual processing speeds from six to 21 months. Very small particulate fragments in the air are a major concern as they can move from the respiratory tract into the brain, Spencer adds.

According to the 'State of Global Air, 2019' report, India has reduced its proportion of households cooking with solid fuels from 76 per cent in 2005 to 60 per cent in 2017 due to improved access to liquefied petroleum gas. Yet solid fuel use remains high among the lower income groups. This still accounts for about two-thirds of the PM_{2.5}-related neonatal disease burden.

India also has a considerable gender-based air pollution exposure disparity. Due to unequal access to basic social goods, mortality is worsened when women have a lower socio-economic status. Moreover, women from the lower income class use traditional indoor stoves for cooking and heating with very poor ventilation, especially in urban areas.

These are fuelled by biomass and produce carbon monoxide, hydrocarbons and particulate matter and account for 24 per cent of ambient air pollution from PM_{2.5}. These women, disproportionately exposed to indoor air pollution and due to their pre-existing poor nourishment, face greater threat to their respiratory, cardiovascular and reproductive health.

Climate change caused by global warming is a new disrupter in our lives. Scientists are unequivocal now that the atmospheric changes will have profound impacts on air pollution. For a Delhite, or for that matter any resident of a polluted city, it has become an unconscious habit during the winter months to keep looking at the trees for signs of leaves swaying in the wind. This is the way of knowing if there is wind in the city to blow away and lighten the heavy blanket of smog that wraps Delhi and the entire IGP during winter. Stillness of air is bad news. Every winter, the deadly smog in Delhi and IGP takes the centre-stage of public attention when changes in atmospheric conditions trap massive swathes of pollutants close to our nose level. The complex interplay of wind and temperature that contributes to this serious health crisis is often not well understood.

The killer smog experienced every winter is the result of what is commonly known as 'winter inversion'. Cooler earth surfaces during winter reduce temperatures near the ground, and prevent



the air from rising up to disperse. The upper layer of warmer air caps and traps the cold air beneath. This leads to a massive trapping of pollution under the inversion layer. In such a situation, the wind is the only saviour. Pollution can disperse only if the wind blows in the city and the region. Wind speed and direction, combined with the changes in air temperature; influence the pollution concentration across the land surface. The temperature changes in the air cause air pressure differences. The warm air rises and moves, and leaves behind low pressure areas. The gases move from high to low pressure areas and disperse pollution. While gases are less dense in low pressure areas, they are highly concentrated in high pressure ones.

The insidious link between wind patterns and pollution concentration came out starkly from a study carried out by CSE during the winter of 2023-24 in Delhi. The crop fire incidents in Punjab and Haryana during that winter had not changed much compared to the previous winter, and there was no other unusual increase in episodic pollution activities in the region. At the same time, there were considerable rains during that season. But the concentration of $PM_{2.5}$ still increased in Delhi, impacting the overall annual levels. The contributory factor was change in wind speed. During November, the average surface wind speed in Delhi was about 9.8 metres per second, which was the slowest average speed recorded compared

to the previous six years. The wind speed was about 21 per cent slower during that period. While the vertical movement of air and pollutants was already restricted due to the inversion, the horizontal movement of pollutants also got restricted due to slower wind speed. This contributed towards an increase in annual average level of $PM_{2.5}$, undoing the longer term downward trend in Delhi pollution. This was a deadly combination of very high pollution levels in the region and slowing down of wind speed.

Such an overwhelming influence of atmospheric conditions also came out very sharply in the Mumbai region during the 2023 winter, when the pollution episode in the city hit the headlines. Mumbai otherwise has a natural advantage of a coastal geography, where comparatively higher surface wind speeds enable faster dispersion of pollutants. Also, wind reversal helps blow away the pollutants. Gufran Beig, a noted atmospheric scientist formerly with the Indian Institute of Tropical Meteorology, has observed on several occasions that a large-scale disturbance in weather systems has been noted in the region since 2022. This, combined with growing local pollution, has impacted the urban air quality of the city and the region. During October-November 2023, the surface wind speed had slowed down in most parts of western India that led to the accumulation of pollutants. Also, delayed retreat of the monsoon in 2023 and anticyclone circulation

impacted the trend.

Scientists have now cautioned that the growing global warming that is expected to impact the weather systems worldwide will also have a significant impact on pollution concentration across different local geographies. Local evidence of such an impact has begun to emerge even in India. Scientific studies carried out in IGP show that increase in carbon dioxide (CO_2) emissions and the attendant warming tend to reduce the surface wind speed in IGP. This, in turn, is expected to result in higher winter-time fine particulate. Thus, meteorological changes associated due to global warming can aggravate the pollution challenge in IGP, requiring more accelerated reduction in pollution. Another study published in the journal *Advancing Earth Space Sciences* in September 2022 showed a similar correlation between $\text{PM}_{2.5}$ concentration and the trend in heat-trapping CO_2 emissions in IGP. The study estimates the reduction of surface wind speed with increasing CO_2 . This was expected to result in higher average winter-time $\text{PM}_{2.5}$ concentrations (1 per cent per Kelvin of global warming) and more frequent high-pollution events. A reduction in the frequency and intensity of western disturbances with increasing CO_2 may contribute to the reduction in the surface wind in IGP. This is a double whammy.

Of late, short-lived climate pollutants (SLCPS) have been under debate from a global warming

perspective. Black carbon is the most prominent of them. The Intergovernmental Panel on Climate Change (IPCC) has long recognised methane, nitrous oxide and hydrofluorocarbons as greenhouse gases, but in the mid-2000s it also included black carbon, which is a product of incomplete combustion of carbonaceous fuels due to low temperature. Black carbon is the solid carbonaceous fraction of PM_{10} or $PM_{2.5}$, which strongly absorbs light and converts that energy to heat. Black carbon is short-lived, lasting up to minutes, hours, and a week or a little more in the atmosphere. In contrast, CO_2 emitted today can impact future climate for a range of 30 to more than 100 years. Black carbon is emitted from combustion processes, dust-generating activities and secondary particulates like nitrates and sulphates. Some of the early evidence on the characterisation of diesel and petrol emissions shows a much higher share of the black carbon fraction in finer particulate emitted from diesel vehicles than in petrol vehicles, and more in pre-Euro VI vintage vehicles (manufactured before the implementation of the Euro VI emission standards). The composition of black carbon varies with the type of fuel used, combustion process, and emission control technologies or practices.

IPCC's Sixth Assessment Report (AR6) provides details on a range of impacts of black carbon, including warming, snow melt and effect on precipitation, among others. As per literature, black carbon absorbs light, converts it into heat and

warms up the surrounding atmosphere. Scientists calculate the potential to cause global warming in terms of 'radiative forcing', which is the difference of sunlight absorbed and energy radiated back in watts per square metre of surface. The IPCC AR5 report, while quantifying the warming potential of each pollutant, states that black carbon can be 900 times more warming than CO₂ in a 20-year time horizon. IPCC's estimates of radiative forcing are said to be conservative compared to others in the published literature. Nonetheless, SLCPs such as black carbon absorb substantially more heat than CO₂ to spike the global warming curve in the near term. As emissions and concentration of black carbon are not uniform across all regions, their effect is also more regional compared to the global impact of the more ubiquitous CO₂. As long as they are in the atmosphere, their effects on the climate can be strong. Scientists point out that there is uncertainty in the emission metrics such as Global Warming Potential (GWP) and Global Temperature Change Potential (GTP) of black carbon and its potential to cause climate change. This may lead to variability in quantification of effects of black carbon on climate systems in different regions of the world. But overall, its impacts are undeniable.

Black carbon can also accelerate ice melt when it settles on snow. Bright snow surfaces reflect a high amount of solar energy back into space. But black carbon absorbs a substantial fraction of this

energy and re-emits it as heat. The Arctic and the Himalayas are therefore hugely vulnerable. Black carbon on glacial snow can alter the melt cycle of glaciers and affect the water balance and water supply through seasons. These regional impacts affected by the local trend of pollution and movement of pollution are a matter of concern. Black carbon is also known to interfere with cloud formation and rainfall patterns, and may change precipitation and surface visibility. Scientists explain that emissions can suppress convection and stabilise the atmosphere in ways that may impede normal precipitation patterns. Scientists describe this as dimming of the earth's surface, which reduces patterns of evaporation that make clouds. If black carbon heats up the layer of the atmosphere where clouds are forming, for example, the clouds will evaporate. Not being able to reflect sunlight back into space, soot-laced clouds end up warming the atmosphere. But black carbon that hangs above low-lying clouds stabilises the layer of air on top of the clouds, promoting their growth. These clouds, like shields, block incoming sunlight. As a result, black carbon also ends up cooling the planet.

There are now several studies and evidence that provide insight into the varied impacts of black carbon. Regional level impacts on cloud formation, rainfall pattern and weather, snow melt and water systems can be high and varied. As IPCC AR6 points

out, in the northern hemisphere black carbon is likely to lead to early springtime snow melt but the magnitude is uncertain. In South Asia, absorbing particles may be influencing precipitation patterns. In the Tibetan Plateau, it may cause changes in circulation and darkening of snow and contribute towards glacier melting, though the magnitude is not clear. All these effects will require locally appropriate action. The US-based Scripps Institution of Oceanography has further pointed towards trans-boundary movement of black carbon on the basis of aircraft-based studies and modelling. It finds that as altitude increases, the fraction of total black carbon that originates in Asia also increases. When pollution reaches the boundary layer, it becomes stable and travels long distances. At ground level, black carbon is more from local sources. ■

Black Deposits that Cannot be Removed

Indians are dying early due to foul air, and the impact begins even before a child is conceived



AIR POLLUTION was the second largest killer globally after blood pressure, recording a dubious tally of 8.1 million deaths in 2021. Of this, a staggering 2.6 million deaths occurred in South Asia alone. To this is added debilitating chronic diseases and a range of ill health. With a population over 1 billion, India recorded 2.1 million deaths, including 237,000 ozone-pollution related deaths. The bigger shocker was the deeply worrying tally of more than 700,000 deaths among children under five years, making air pollution the second leading risk factor after malnutrition globally. As many as 500,000 of these child deaths were linked to household air pollution

from cooking indoors using dirty fuels in Africa and Asia. More than 260,600 of these child deaths were yet again reported in South Asia. The air pollution-linked death rate in children under the age of five in South Asia was 164 deaths per 100,000 in contrast to the global average of 108 deaths per 100,000. This death tally remained high despite the 53 per cent drop in death rate since 2000, due to growing access to clean energy for cooking, improved healthcare, nutrition and awareness. Polluted air is a big trigger for pneumonia and other respiratory infections and allergic diseases in children.

These grim results were from the 'State of Global Air 2024' (soga), a collaborative assessment by the US-based Health Effects Institute (HEI) and Institute for Health Metrics and Evaluation's Global Burden of Disease (GBD) project. These results were linked to the disease burden estimated for 2021 in about 200 countries. 'This new report offers a stark reminder of the significant impacts air pollution has on human health, with far too much of the burden borne by young children, older populations, and low- and middle-income countries,' said Pallavi Pant, HEI's Head of Global Health who oversaw the sogA report.

While the spotlight of this annual tracker of health impact of air pollution continues to be on PM_{2.5} (fine particulate matter with a diameter of 2.5 µm or less) and ozone, nitrogen dioxide (NO₂) were also added in this risk assessment for the first time.

Even though $PM_{2.5}$ (both ambient and household) accounts for more than 90 per cent of the total air pollution disease burden, NO_2 and ozone are the growing risk factors globally. The new spotlight on the exposure to NO_2 brings out the importance of the growing risk from traffic exhaust in densely populated urban areas. This is a leading risk factor for the development of childhood asthma. About 55 per cent of 194 countries studied did not yet meet the annual World Health Organization's (WHO's) Air Quality Guidelines of $10 \mu g/m^3$, resulting in 42 per cent of the world's population being exposed to unacceptable levels. The report pointed out that in contrast to $PM_{2.5}$, seven of the 10 countries with the highest NO_2 exposures were high-income countries in West Asia (including Bahrain, Qatar, Kuwait, Lebanon, and the United Arab Emirates). Russia and Turkey also experienced high NO_2 levels. The highest exposures to NO_2 had been noted in countries with high socio-development index, including Singapore, Japan and Canada.

In 2021, exposure to NO_2 was linked to 177,000 healthy years of life lost for children and adolescents. There is a strong connection between long-term exposure to traffic-related air pollution and early death due to cardiovascular diseases and lung cancer, asthma onset in children and adults, and acute lower-respiratory-tract infections in children. NO_2 is also a catalyst for formation of ozone, yet another very harmful gas. NO_2 reacts with other chemicals

in the atmosphere to produce both particulate matter and ozone. According to the SOGA report, nearly 490,000 deaths were linked to ozone, and countries in West Asia (Qatar, Bahrain, Kuwait, Saudi Arabia, and Iraq), South Asia (Nepal, India, Bangladesh, and Pakistan), and East Asia (Republic of Korea) reported the highest average ozone exposures in 2020.

Ozone levels have also increased in South Asia. In 2021, ozone was responsible for 56 per cent of all global ozone deaths reported in the region. The report further notes that the US, partly due to its sizable population, widespread ozone pollution and relatively high rates of Chronic Obstructive Pulmonary Disease (COPD), saw 14,000 deaths in 2021, higher than any other high-income country. Since 2010, the overall number of ozone-linked COPD deaths has risen by nearly 20 per cent. This is expected to increase as the population gets older.

While South Asia, including India, continues to bear the biggest brunt of particulate pollution-related health impacts, the proportion of population experiencing high ozone exposures is also increasing in India, Nigeria, Pakistan, and Brazil. These countries have noted increases of more than 10 per cent in ambient ozone exposures in the last decade. With populations of over 1 billion each, India and China had recorded 2.1 million and 2.3 million deaths respectively, and together accounted for nearly 55 per cent of the total global

disease burden from particulate matter. In 2021, nearly 50 per cent of all ozone-related COPD deaths were in India, followed by China and Bangladesh.

The soGA report highlighted what is called ‘the climate penalty’. It noted that the chemical reactions that form ozone increase when the air is warmer, especially during heatwaves. Evidence showed that ozone, also a greenhouse gas, spiked during heatwaves in China and Europe. Exposure to ozone is associated with an increased risk of both acute and chronic respiratory illnesses like COPD. Ozone also impacts plants, crops and vegetation. Ozone can reduce crop yields, damage biodiversity and undermine food security and nutrition. Climate change can exacerbate the health burden of non-communicable diseases, including heart and lung diseases, during heatwaves.

In India, there is an insidious link between outdoor and household air pollution. The 2015 report of the Steering Committee on Air Pollution and Health under the Union Ministry of Health and Family Welfare estimated that household air pollution could contribute up to 25-30 per cent of outdoor air pollution in India. Several epidemiological studies are available in the country on the effect of household air pollution. The first ever ‘mother-child’ cohort study was carried out by Kalpana Balakrishnan and her team from Sri Ramachandra Medical College, Chennai. They followed the cohort over time to investigate the

link between exposure to PM_{2.5} during pregnancy and low birthweight in an integrated rural-urban setting. This showed that a 10 µg/m³ increase in exposure to PM_{2.5} during pregnancy could decrease birthweight by 4 g, lead to a 2 per cent increase in the prevalence of low birthweight and cause 70 g decrease in birthweight in households using solid fuels. However, according to a global study 'Global, regional, and national burden of ambient and household PM_{2.5}-related neonatal disorders, 1990-2019', published in March 2023, the global neonatal disorders burden attributable to household PM_{2.5} decreased by 38.35 per cent in the past 30 years. This is mainly due to the decrease in the household PM_{2.5}-related neonatal disorders burden, which dropped by 52.33 per cent during the period, according to the study published in *Ecotoxicology and Environmental Safety*. According to the 'State of Global Air 2019' report of IHME, India had reduced its proportion of households cooking with solid fuels from 76 per cent in 2005 to 60 per cent in 2017 due to improved access to liquefied petroleum gas. Yet solid fuel use remained high among the lower income groups. This still accounted for about two-thirds of the PM_{2.5}-related neonatal disease burden.

Air pollution caused more than 100,000 premature deaths in some of India's largest cities in 2005-18, according to a research published in *Science Advances* on April 8, 2022. Bengaluru(93.9),

Hyderabad (96.4), Kolkata (82.1) and Pune (73.6) recorded the highest number of such deaths per 100,000 population, respectively, during this period. Mumbai saw 65.5 premature deaths per 100,000 populations, Surat 58.4, Chennai 48 and Ahmedabad 47.7. 'We wanted to evaluate fast-growing cities in the tropics, which are projected to transform into megacities by 2100, and eight of these cities are in India,' said Karn Vohra, lead author of the research paper and research fellow from the University College London. The team wanted to quantify long-term changes in air quality in cities which lack extensive surface monitoring networks. Vohra and his colleagues relied on instruments aboard the US National Aeronautics and Space Administration (NASA) and the European Space Agency satellites to gather data on air pollutants in the tropical regions between 2005 and 2018. Vohra said, 'The tropics are the next frontier in air pollution. They are experiencing population growth at an unprecedented pace. Also, most countries in the tropics are yet to implement policies and set up infrastructure to mitigate air pollution.' Their analysis observed significant yearly increases in pollutants worldwide. In tropical cities, nitrogen dioxide (NO₂) concentration in the atmosphere rose up to 14 per cent and that of fine particles (PM_{2.5}) rose 8 per cent, the report shows. In 2005, Kolkata had recorded 39,200 premature deaths, Ahmedabad 10,500, Surat 5,800, Mumbai 30,400,

Pune 7,400, Bengaluru 9,500, Chennai 11,200 and Hyderabad 9,900, the team observed. In 2018, the figures rose to 54,000 for Kolkata, 18,400 for Ahmedabad, 15,000 for Surat, 48,300 for Mumbai, 15,500 for Pune, 21,000 for Bengaluru, 20,800 for Chennai and 23,700 for Hyderabad. Overall, India had 123,900 premature deaths from long-term exposure to $PM_{2.5}$ in 2005, which increased to 223,200 in 2018.

Indians are indeed losing on life expectancy due to foul air. Worsening air pollution is robbing a decade of the life expectancy of those living in Delhi, the capital city regarded as the world's most polluted, according to an analysis by the University of Chicago published in 2022. Indians, on average, are losing about five years. The Energy Policy Institute at the University of Chicago (EPIC)'s Air Quality Life Index (AQLI), in its India factsheet released in July 2022, noted that these figures were 'relative to what (the life expectancy) would be if the World Health Organization (WHO) guideline regarding fine particulate pollution ($PM_{2.5}$) of 5 microgram per cubic metre ($\mu g/m^3$) was met.' In comparison, 1.8 years of life are lost due to child and maternal malnutrition, while smoking robs nearly two years of life expectancy in India. The report noted that the country's entire population—all 1.4 billion—breathes air with particulate pollution level well above the WHO guideline. Also, more than 63 per cent breathe air worse than the national air



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quality standard of $40 \mu\text{g}/\text{m}^3$. Nearly 40 per cent of India's population residing in IGP—which includes Bihar, Chandigarh, Delhi, Haryana, Punjab, Uttar Pradesh and West Bengal—were set to lose some 7.6 years of life expectancy. Those in Lucknow will lose 9.5 years if current pollution levels persist, the report says. Uttar Pradesh, Bihar, Haryana and Tripura had the most years to gain—8.2 years, 7.9 years, 7.4 years and 6 years respectively—if pollution levels met the WHO standard, according to the report. 'Since 1998, average annual particulate pollution has increased by 61.4 per cent, leading to a further reduction in average life expectancy of 2.1 years. Since 2013, about 44 per cent of the world's increase in pollution has come from India,' the report notes.

A plethora of local and global evidence, thus, builds the case for urgent action to control air pollution. Despite the mounting evidence, people often do not understand how air pollution triggers health conditions that lead to death and illness. This was evident when nine-year-old Ella Kissi Debrah died due to an acute asthma attack in south London in 2013 and her mother moved the court challenging that air pollution was responsible for her child's death. The incident ultimately led to the landmark judgement and coroner's report in 2020 that made Ella the first person in the world to have air pollution cited as a cause of death. Kalpana Balakrishnan of Sri Ramachandra Medical College,

Chennai, pointed out, 'Gaps in evidence never close in science. There is already enough evidence on exposures to rest the case. Also remember, absence of evidence is not the evidence of absence.' And in India we witness that every moment: slow murder by breathing toxic air.

On November 3, 2023 as night descended over Delhi, hundreds of children, coughing and gasping, thronged the out-patient department and emergency ward of Chacha Nehru Bal Chikitsalaya. Soon, the super specialty paediatric government hospital in east Delhi ran out of nebulisers and beds. Doctors at the hospital had been dreading the prospect since the last week of October, when the average air quality in the national capital remained in 'very poor' category for six consecutive days before plummeting to 'severe' category on November 3, with AQI value reaching a staggering/hazardous 468. AQI values over 100 are considered unhealthy. Doctors in the national capital and in adjoining areas are familiar with this seasonal plague. As the region chokes on dust and smoke in winter every year, hospitals receive an exceptionally large number of patients with respiratory problems. Ajay Shukla, director and medical superintendent of Atal Bihari Vajpayee Institute of Medical Sciences and Dr Ram Manohar Lohia (ABVIMS-RML) Hospital, one of the country's premier hospitals run by the Union government, said the hospital records a 30 per cent rise in respiratory-related illnesses during

severe pollution days. But this episode of pollution was overwhelming, even though expected.

On November 6, 2023, ABVIMS-RML opened a dedicated weekly Pollution Out-Patient Department, a first-of-its-kind in the country, to cater to patients suffering from the impact of unhealthy air. Shukla said the initiative was to ensure that all the pollution-related cases—from cough to eye infection to headache—could be seen by doctors of different departments at one place. In Vallabhbhai Patel Chest Institute (VPCI), another prominent hospital in north Delhi, hospital staff shared worrying data: between November 2 and November 10, 2023, the hospital on average received 50 new cases of respiratory illnesses on a daily basis. What's perturbing was that most patients visiting the hospitals with respiratory ailments were under 14 years. Ambavasan A, a senior resident doctor at the emergency ward of ABVIMS-RML, said the hospital was flooded with children with respiratory problems, and their number and severity of the condition varied as per the pollution level. Medha Mittal, endocrinologist at Chacha Nehru Bal Chikitsalaya, said, 'Delhi's air pollution is resulting in a rapid increase in respiratory illnesses among children.'

There are reasons children are more vulnerable to air pollution than adults. Since the respiratory system is not completely developed in children, particularly in newborns and infants, they breathe

faster than adults to ensure adequate provision of oxygen into the blood. Children also have high metabolic rate—the rate at which they use up energy—and therefore have a higher oxygen demand, which in turn results in higher respiratory rate than adults. Studies estimate that children typically breathe 40 times in a minute, which is more than double the respiratory rate of adults. ‘As they breathe more air per body size and have smaller airways than adults, they are at an increased risk of developing respiratory diseases and exacerbation of asthma,’ stated a study by researchers from Germany and the Czech Republic, published in *Urban Climate* on June 4, 2022. Of the many air pollutants that children breathe, the dreaded one is the fine inhalable $PM_{2.5}$ that originates from different local combustion sources such as vehicles, industries and burning of waste, and is laced with toxins. Since the particulate matter is smaller than the red blood cells, studies have established that it can go deep into the lungs, escape to the bloodstream and also breach the blood-brain barrier, with hundreds of known and unknown health effects. The German and Czech Republic researchers examined the potential differences of $PM_{2.5}$ exposure between children and adults in an urban area and found that the concentration of $PM_{2.5}$ decreased with increasing height above ground. Since the breathing levels of children are closer to pollutants emitted near ground, it makes

them more vulnerable to emissions by traffic-related exhausts and whirled up fine particles.

Arvind Kumar, chairperson of Institute for Chest Surgery-Chest Onco Surgery and Lung Transplantation, Medanta, Gurugram, and founder of Lung Care Foundation, shared a few photographs of lungs with *Down To Earth* magazine to show the impact of air pollution on respiratory health of those living in areas with poor air quality. 'Healthy lungs look absolutely pink. However, we regularly see black deposits in the lungs of most non-smoker adults and children up to 14 years of age who come to us with respiratory illnesses. These black deposits cannot be removed and eventually damage the lungs,' said Kumar, adding that children are inhaling more toxic air than adults.

The impact of air pollution on children's health begins even before they are conceived. It starts by impairing the fertility of both men and women. Research shows that exposure to air pollution affected ovarian reserve in women. A study conducted on women in China showed that the level of anti-müllerian hormone—a predictor of ovarian reserve—changed by -8.8 per cent, -2.1 per cent, -1.9 per cent and -4.5 per cent per 10 $\mu\text{g}/\text{m}^3$ increase in PM_{10} , $\text{PM}_{2.5}$, PM_{10} and NO_2 . 'Theoretically, PM with smaller size and larger surface area volume ratio, e.g. PM with diameter $\leq 1 \mu\text{m}$ (PM_{10}), is more likely to penetrate through the alveolar capillary barrier and then impact directly

the ovarian function via blood circulation,' noted the paper published in *Environmental Research* on February 1, 2023. Though the underlying mechanism of female fertility decline caused by air pollutants remains unclear, limited evidence speculates that oxidative stress and inflammatory response caused by air pollution may be one crucial pathway, the researchers say. Similarly, a study in China on 33,876 men shows that exposure to PM_{2.5} and PM₁₀ decrease total and progressive sperm motility. The findings were published in *JAMA Networks* on February 17, 2022.

If the child is conceived against all odds, air pollution can hinder their development in the uterus as pollutants can cross the placenta into the baby's blood. In a study published in the *Journal of Family and Reproductive Health* in June 2017, the researchers from Iran found an inverse relationship between the exposure to air pollution in the first trimester of pregnancy and the weight of placenta, which sustained the development of the foetus. A comprehensive review of studies, published in *The Lancet Planetary Health*, reported the presence of black carbon particles in cord blood which enter foetal liver, lungs and brain. The presence of the pollutants continued to harm the growing foetus so much that it tended to increase the risk of preterm birth. This, in turn, could increase the chances of stillbirth, low birthweight, underdeveloped lungs in the baby, and death of the baby during or shortly

after birth. Sudhir Gupta, former chairperson of the department of gynaecology at Baba Raghav Das (BRD) Medical College, Gorakhpur, Uttar Pradesh, explained how air pollution affects the development of foetus, 'Due to pollution, pregnant women cannot get enough oxygen from the ambient air, which affects the natural development of the foetus. Furthermore, the higher the sulphur contents in the air, the greater the risk of miscarriage,' he said. Bhupendra Sharma, chairperson of the paediatrics department of BRD Medical College, said, 'Air pollution can also lead to anaemia in expectant mothers, which greatly reduces the chance of delivering a healthy baby.'

Even if the child survives the onslaught of pollutants *in utero*, multiple studies show that the exposure before and after birth could impair their neurodevelopment skills, such as intellectual functioning, memory and learning, attention and executive functions, verbal language, numerical ability and motor and/or sensor motor functions. 'The pollutants that seem to represent the greatest risk are PM_{2.5}, NO₂ and PAHs [polycyclic aromatic hydrocarbons],' states a review of 30 research papers, published in *Neuroscience & Behavioral Reviews* in May 2022. Just like in adults, the child's blood pressure is known to shoot up due to exposure to air pollution during pregnancy—higher the mean PM_{2.5} and black carbon exposure during the third trimester, higher the newborn's systolic

blood pressure. Exposure to air pollution *in utero* can also lead to congenital heart defects in children, making survival difficult. Lungs, too, are not spared from the onslaught. It has been observed that higher the exposure to air pollution during infancy, lower the lung capacity. Acute respiratory infections too seem to affect children who are more exposed to PM_{2.5}. A survey of under-five children indicated that 10 µg/m³ increase in PM_{2.5} was associated with greater chances of contracting an infection.

Gut health too gets affected—pollutants inhaled during the first six months of life adversely affect the composition of gut microbes which could increase risk of allergies, obesity and diabetes, and even affect brain development. A 2020 study published in *Gut Microbes* stated that these microbes and their by-products shaped appetite, insulin sensitivity, immunity, mood and cognition, and a poor mix of microbes could leave the child prone to asthma, type 2 diabetes and other chronic illnesses. Exposure to air pollution in the womb can also change the protein activity of the baby. For example, pollutants have been found to affect cell processes such as autophagy, ‘self-eating’ of damaged cells that usually occur in response to stress, according to a study presented at the European Respiratory Society International Congress in Milan, Italy, on September 12, 2023. Exposure to higher NO₂ was linked to decreased levels of sirtuin1 (SIRT1), a protein that plays a

protective role in stress resistance, inflammation and ageing. Evidence is also mounting around the impact of pollution sources on health. Studies in Europe have investigated the impact of vehicular emissions on child health and impact on neuron development along the highways. In 2013, a study found correlation between early exposure to traffic pollution and several childhood cancers.

And as if to complete the circle of destruction, exposure to air pollution also impacts the reproductive health of adolescent girls. Higher exposure to particulate matter *in utero* and throughout childhood has been implicated in the early onset of menarche because these particles seem to have endocrine-disrupting properties.

Health experts in India are already generating evidence to implicate air pollution in the high mortality and poor health of children in the country. In November 2023, the Collaboration for Air Pollution and Health Effect Research, India (CAPHER India), a national research network focused on air pollution and health effects steered by All India Institute Of Medical Sciences Delhi (AIIMS), New Delhi, and the Indian Institute of Technology (IIT), Delhi, released a policy brief, which said that air pollution was the third leading risk factor for deaths in under-five children in the country. For children under 14 years, it was the second leading risk factor for deaths. Since 2010, Delhi, Punjab and Haryana had seen the highest

percentage of deaths in under-five children related to outdoor $PM_{2.5}$ exposures, according to the policy brief which had reviewed key Indian studies on the issue.

One of the studies published in April 2022 in *Science of the Total Environment* provided evidence that $PM_{2.5}$ impacts infant mortality primarily through neonatal mortality. Another study points towards a link between air pollution and stunting. The study by Germany's Heidelberg University and France's University of Rennes, published in the *Journal of Environmental Economics and Management* in May 2022, estimated that the percentages of stunted and severely stunted children in India would drop by 10.4 and 5.17 percentage points, respectively, if average pollution levels were reduced to WHO-recommended levels. A large-scale study by the Population Council, New Delhi, and the International Development Department, University of Birmingham, UK, published in the journal *BMJ Global Health* in July 2020, confirmed that exposure to PM_{10} not only affected children but also pregnant women resulting in premature birth. This indicated that the probability of newborn mortality increased by 6 per cent for every 10-unit increase in PM_{10} levels.

Another study found a significant correlation between the chemical components of $PM_{2.5}$ and low birthweight, anaemia and acute respiratory infections in children aged below five years. The

study, 'Cumulative effect of $PM_{2.5}$ components is larger than the effect of $PM_{2.5}$ mass on child health in India', published in *Nature* on October 31, 2023, showed that for every $10\mu\text{g}/\text{m}^3$ increase in $PM_{2.5}$ exposure, the prevalence of anaemia, acute respiratory infection and low birthweight increased by 10 per cent, 11 per cent and 5 per cent among children under five in India. $PM_{2.5}$ is a mixture of various components with different sources and toxicities. The study showed the cumulative effect of $PM_{2.5}$ components—ammonia (NO_3^-), fine ammonium (NH_4^+), elemental carbon (EC) and organic carbon (OC)—to be larger than the effect of $PM_{2.5}$ mass on child health in India. Another Delhi-based study, published in April 2022, also established a link between acute exposure to $PM_{2.5}$ chemical species and mortality during winters. 'There might be differences in the methods of studies and study design, including time series, cross-sectional, exposure based health outcomes and many more. However, an interesting fact is that in both these studies NO_3 showed the highest impact,' said Ekta Chowdhary, researcher and author of the *Nature* study.

Yet another area of investigation is childhood cancer. While there is enough evidence to show that exposure to air pollution can lead to cancer in adults, it is not studied adequately in children. There is some indication. Studies have identified air pollutants such as benzene, NO_x and

particulate matter as culprits in childhood Non-Hodgkins Lymphoma, a type of cancer that begins in the lymphatic system which is part of the body's immune system. A study published in January 2023 in *Nature* found an association between exposure to PM_{2.5} level and risk of acute lymphoblastic leukaemia among children, which is a cancer of blood and bone marrow. But this correlation is not studied adequately in India.

The latest available data by the National Cancer Registry Programme is only from 2012 to 2016. But it showed a pattern. The proportion of childhood cancers relative to cancers in all age groups in different cities varied between 0.7 per cent and 3.7 per cent. Delhi was the worst affected among places with a cancer registry—the country had 28 Population Based Cancer Registries between these years. Here, as many as 203.1 boys per million were affected by all the broad kinds of cancers compared to just 12.2 per million in Pasighat in Arunachal Pradesh. Patiala's cancer registry reported 121.2 cases per million boys. Mumbai, which too is facing a pollution challenge, stood at 10th place. In case of girls in the age group of 0-14, the number was 125.4 per million in Delhi compared to 12.1 in East Khasi Hills District. Patiala stood at 9th position with 74 cases per million. The data from India's National Cancer Registry Programme showed that Delhi was badly affected by leukaemia too—as many as 84.2 boys per million, between the

ages of 0-14 are affected compared to just 7.3 per million in Meghalaya. For girls, this number stood at 47.2 cases per million, the second-highest after Imphal West district in Manipur, compared to just 4.9 per million in Cachar district of Assam. In case of lymphomas, the number stood at 30.7 per million for boys in Delhi, much lower than the 2.3 per million cases seen in Meghalaya. For girls, Delhi had the third highest cases of lymphomas which stood at 10 per million. The report also showed that among the Asian countries studied for boys, Delhi had the highest cases per million followed by China's Jianmeng. In case of girls, Delhi had the sixth highest number of cases. For all countries included in the study, Delhi had the 6th highest number of cancer cases for boys and 10th highest in case of girls.

A person living in the sprawling IGP, spread across northern India (as well as eastern Pakistan, southern Nepal and most of Bangladesh), will live seven years less than people in other parts of the country. That means if a resident of the states and Union Territories of Bihar, Chandigarh, Delhi, Haryana, Punjab, Uttar Pradesh and West Bengal, will on average have a shorter life than their counterparts in the rest of country, as per a 2019 study by University of Chicago's EPIC.

There are various reasons for this. Smoke from crop fires is one of the main reasons, but not the only one. As per NASA, influxes of dust from the

Thar Desert to the west, motor vehicle emissions, industrial and construction activity, fireworks, and fires for heating and cooking also produce particulate matter and other pollutants. 'Geography and weather can exacerbate the region's poor air quality. Temperature inversions are common in November and December as cold air rolls off the Tibetan Plateau and mixes with smoky air from the Indo-Gangetic Plain. An inversion can function like a lid, with warm air trapping pollutants near the surface. The low-hanging haze becomes hemmed in between the Himalayas to the north and the Vindhya Range to the south,' according to NASA. And that is not good news for those who live in this region. IGP is home to 9 per cent of the global population. India occupies most of the region, and 40 per cent of its population lives on the plain. Air pollution in the region has soared 72 per cent from 1998 to 2016, as per the University of Chicago study, and did not meet the WHO guideline for fine particulate pollution.

Doctors point to a steep rise in respiratory illnesses among children across the Indo-Gangetic region, where air quality remains in the "poor" category almost throughout the year. Air quality analysis by Pune-based climate technology firm Respirer Living Sciences Pvt Ltd showed that the Indo-Gangetic region had seven of the 10 most polluted cities in the country. In 2018, non-profit Climate Agenda studied 14 districts of Uttar Pradesh

and found that small cities like Gorakhpur and Mau were more polluted than the national capital Delhi and state capital Lucknow. Air pollution plagues rural areas as well and the entire state of Uttar Pradesh is under a 'health emergency', stated the non-profit's report, 'Air Kills'. An analysis of Bihar's air quality in the winter season, from October 2022 to February 2023, by Centre for Science and Environment (CSE) showed that the $PM_{2.5}$ levels in at least 10 towns in the state were substantially worse than that of Delhi.

This is alarming. According to the Census of India, 2011, the Indo-Gangetic states—Punjab, Haryana, National Capital Territory of Delhi, Uttar Pradesh, West Bengal, Assam and Bihar—are home to almost half of the children (in the age group of 0-14 years) in the country and two-thirds of under-five children who are most vulnerable to air pollution. Mohan P George, scientist with CSE, said, 'In the Indo-Gangetic region, a month-old infant with a weight of 4 kg and breathing 40 cycles a minute will inhale 184 μg of $PM_{2.5}$ a day.' George's calculation was based on the annual average of 100 μg of $PM_{2.5}$ level in the region's air. The impact is palpable. At a national conference, organised by the Indian Academy of Paediatrics in Kolkata in November 2023, pulmonologists point out that one in every two children in the metropolitan city suffered from respiratory disorders triggered by air pollution. 'I treat children in northern fringe of city



and can safely vouch that the number of patients has increased several times in the past few decades, though the actual impact, both long- and short-term, is difficult to be spelt out due to inadequate data,' said Subhamoy Mukherjee, a paediatrician practising in Kolkata for more than three decades.

Arup Halder, another pulmonologist in Kolkata, said that first-generation asthma patients among children are on the rise. 'Earlier, asthma patients usually had a family history of the condition, but now a sizable number of children seem to be developing asthma because of exposure to air pollution. The problem increases especially in the winter when the air quality worsens,' said Halder. In Bihar, there have been widespread reports of children suffering from respiratory infections, breathlessness and allergies, particularly during the winter months when the air quality hits the lowest points. Athar Ansari, professor, paediatric department at Nalanda Medical College and Hospital, a state government-run hospital in Patna, said that roughly a third of children and even some infants coming to the hospital suffered from difficulty in breathing. 'Manifestation of allergies is increasing among children due to air pollution,' said Ansari. Jayant Prakash, head of paediatrics department at Indira Gandhi Institute of Medical Sciences, Patna, said, 'We have come across cases where newborns do not cry immediately after delivery and have difficulty breathing due to shortage

of oxygen in their hyperactive airways because of pollution.'

The way that wind disperses pollution is a determining factor in the overall air quality management in regions. This not only needs to look at the local sources of pollution but also the pollution brought to the area from outside sources by wind. The downwind areas will be more impacted by the major pollution sources in upwind areas. Pollutants can travel long distances making it tougher for the downwind states to meet the clean air standards. Already, evidence suggests that a city like Delhi receives nearly 60 per cent of its pollution from outside the city, while Delhi itself contributes about 40 per cent of the winter particulate pollution in downwind Noida, Uttar Pradesh. This phenomenon has become a major concern in the IGP area due to its unique meteorology, landlocked ecosystem and high pollution and population. The National Green Tribunal in its directive dated September 9, 2021, took cognisance of the high particulate pollution in IGP compared to other regions and sought advanced air pollution abatement measures.

This led to an integrated assessment of IGP and a regional emissions inventory by the expert committee under the Central Pollution Control Board. It highlighted that Uttar Pradesh was the highest PM_{2.5} emitter in the region followed by West Bengal, Bihar, Punjab and Haryana. The

industry sector alone accounted for 48.5 per cent of the total emissions in the region. Solid fuels for household cooking contributed as much as 19 per cent with highest contribution from Uttar Pradesh, Bihar and West Bengal. Affordable cooking energy sources remain a challenge. The main contributors to transport pollution are the metropolitan cities like Delhi, Kolkata, Lucknow and the industrial areas.

It is challenging for any city or town in IGP to meet the clean air targets if the regional cleanup is not achieved. The framework for a formal adoption of integrated management of airshed is not yet in place. This requires an aligned and coordinated action across the airshed that may have several administrative and political overlaps. This will require an operative framework and state council. Such a precedent has now been set in Delhi and the National Capital Region (NCR). Public movement, judicial intervention and the subsequent setting up of the Air Commission for the Delhi-NCR and beyond has established the principle of regional integrated planning for four states in NCR. This needs to be leveraged to create a framework for all other regions. Globally, national governments have begun to develop such a framework for management of transboundary pollution within the country and between countries.

‘Air pollution is the biggest public health challenge,’ said Maria Neira, head of WHO’s work on

climate, environment and health. During the 28th Conference of Parties (COP28) to the UN Framework Convention on Climate Change (UNFCCC) held in Dubai in November-December 2023, as many as 123 countries signed a new declaration on climate and health to recognise the linkage between climate change and public health. The COP28 Presidency and WHO together issued the 'COP28 UAE Declaration on Climate and Health', which aimed to accelerate action to protect public health and communities from the growing climate impacts and strengthen healthcare systems to cope with the effects of extreme heat, air pollution, infectious and zoonotic diseases and environmental risk factors. The declaration stated that devastating health impacts were already evident from the almost 9 million annual deaths from air pollution and exposure of 189 million people to extreme weather events annually. This indicated that the protection of health had to become central to climate action. This new declaration sought policy intervention to build more climate-resilient health systems, cross-sectoral collaboration to reduce emissions, maximise the health benefits of climate action and increase finance for climate and health solutions. Signatories also committed to incorporate health targets in their national climate plans and improve international collaboration to address the health risks of climate change and monitor progress in all global forums including future COPs and

health ministerial. The significant aspect of this initiative is the effort made to get commitments on finance. Collectively, a wide range of partners and stakeholders committed to dedicate US \$1 billion to meet the growing needs of the climate-health crisis.

Efforts to integrate climate action with health protection started way back in 2016. That is when WHO along with the Government of France, which then held the COP presidency, had jointly hosted the second global conference on health and climate to build healthier societies through implementation of the Paris Agreement. There was a plea to use the Paris climate treaty also as a public health treaty. WHO had warned that, as per the 'Global Burden of Disease' study, 23 per cent of the global deaths were linked to the environment including air pollution that was worsened by climate change. Moreover, climate change was likely to kill an additional 250,000 or more people each year by 2030. Most of these deaths would occur due to climatic stress, food insecurity and vector-borne diseases. Deaths and devastation from extreme weather events would magnify the health burden several times in the developing world and would erode economic gains especially in low income countries and island nations. The spotlight was on air pollution that kills around 9 million globally and is also a climate rogue.

If health is integrated with climate action, it

can help target opportunities for mitigation and adaptation across sectors, promote integrated health mitigation strategies, strengthen core public health systems and scale up more aligned decarbonisation action. More evidence based action on health risks and benefits can support decision making. Global governance can work more effectively for the larger public good and well-being. This can not only facilitate the global finance flow but also influence national budgets and action to address the high health costs from climate change. Clearly, health can be a powerful lever to mainstream equity across multi-sector solutions.

The UN Environment Programme (UNEP) has already convened the Climate and Clean Air Coalition with support from other global agencies and multilateral bodies that have membership of a large number of countries for joint action on short-lived climate pollutants (SLCPS). WHO has further underscored the importance of this linkage and action. This effort requires a more effective interface with the UNFCCC process for comprehensive mitigation measures to maximise air quality, public health and welfare gains while fast-tracking CO₂ reduction and building climate resilience.

Countries are already shaping their clean air and climate programmes, policies and implementation strategies to meet clean air targets. Interlinking the learning from these programmes at local

and global level and strategic support can have a multiplier effect. A growing number of countries have started to include air pollution in their reporting on nationally determined commitments (NDC) to UNFCCC, and plan to revise NDCs in 2025. This needs to include assessment of public-health benefits and low-carbon gains. Countries that are reporting on clean air action to capture the learning curve and promote cross learning must be engaged and convened.

Several global platforms and forums have been established alongside the COP process for more advanced action in several sectoral areas, including clean energy transition, clean cooking, and zero emissions vehicle (ZEV) transition that can be leveraged to accelerate SLCP action in different regions. Some of these platforms include the Declaration on 100 per cent transition to zero emissions by 2030-40, the ZEV Transition Council, which represents 50 per cent of the global car market and Solar Alliance.

Global and national networks should be convened to sensitise them about SLCPs and the linkage between clean air and climate action and cross learning should be promoted. This can support local action in the Global South with science, good data and best practice approaches. There is considerable opportunity in the early stages of motorisation and industrialisation to be preventive and avoid pollution-intensive pathways.

Engagement to influence global climate finance mechanisms must be built and additional finance including bilateral and multilateral funding need to be unlocked and mainstreamed with appropriate indicators to assess the co-benefit outcomes from the investments.

Campaigns to improve public visibility of these issues must be designed and public and policy understanding of science, policy and action related to SLCPs deepened to help build the new narrative. This requires creative communication on good practices and innovations, to influence opinion and mobilise opinion makers and local stakeholders in different regions. Building a global database and inventory of greenhouse gases and SLCP sources and emissions must be enabled and local institutional capability be strengthened to inform action. ■

Some suffer more

Air pollution has disproportionate impacts on socio-economically disadvantaged groups



RIGHT TO clean air is about inter-generational equity. Traditionally, the health impacts of air pollution have been understood in terms of the relation between dose and response at an undifferentiated population scale. But over the years, more nuanced approaches have evolved to investigate the modifiers and specific impacts on groups differentiated by age, gender, socio-economic and nutritional status, and a range of other factors that define the vulnerabilities and underpin marginalisation.

Evidence is stark on infant deaths during the first month of life due to lower respiratory infections; low birth weight and preterm births affected by

air pollution (refer to preceding chapters). Foetal exposure to pollutants is on the rise, as many harmful substances can easily pass through the placenta. Children are especially at risk because their respiratory systems are still developing. Furthermore, their immature immune systems hinder their ability to cope with these exposures.

There is mounting evidence from several studies in different regions indicating disproportionate impacts of air pollution on vulnerable groups. There is no absolute definition of a vulnerable population. Several attributes are considered to define vulnerability and susceptibility to air-pollution-related risks. These include age, gender, socio-economic inequalities, nutritional status, occupational exposures and geographical location that determine proximity of the communities to pollution sources. It is now quite widely understood that children, the elderly and women, especially pregnant women across all socio-economic groups, and socially disadvantaged communities are disproportionately impacted by air pollution. It is necessary to understand the nature of these widely different risks.

Several epidemiological studies are available in India that bear out special vulnerability of poor and marginalised women to household air pollution. This is one of the direct manifestations of poverty and lack of access to clean cooking energy. India also has a considerable gender-based air pollution

exposure disparity. Due to unequal access to basic social goods, mortality is worsened when women have a lower socio-economic status. Moreover, women from the lower income class use traditional indoor stoves for cooking and heating with very poor ventilation, especially in urban areas. These are fuelled by biomass and produce carbon monoxide, hydrocarbons and particulate matter and account for nearly 24 per cent of ambient air pollution from PM_{2.5}. These women are disproportionately exposed to indoor air pollution and due to their pre-existing poor nourishment, face greater threat to their respiratory, cardiovascular and reproductive health.

It is now widely understood that older people are more susceptible to environmental risk factors because with age they have more underlying health conditions, including hypertension, diabetes, heart disease and slower metabolic rates. In fact, with age, air pollution can further aggravate heart disease, stroke and lung diseases, including chronic obstructive pulmonary disease and asthma and diabetes. The elderly are also more vulnerable to weakened immunity, neurological disorders including Parkinson's disease and Alzheimer's, and a range of compromised mental health problems. These require increased healthcare, emergency hospital admission, and increased cost of medication. Ageing also means long-term and lifetime exposures to air pollution, with a range of health outcomes.

Global evidence indicates that countries with large and ageing populations have higher levels of deaths and illness due to air pollution. India is moving in that direction of demographic transition. The combination of a very large population, ageing population and socio-economic disadvantages make the risk even more daunting.

The disproportionate impact of health burden on the poor is significantly more pronounced due to their weak health status, nutritional deficiency, weak coping capacity and high exposure levels. Even though evidence on health impact on low-income groups has begun to emerge, this has not been well investigated or integrated in policies. There is a sprinkling of studies in India and these definitely point towards the special vulnerability of the low-income groups and the associated health inequity. A 2021 Yale University study found that the mortality risk from indirect sources falls disproportionately on lower-income households in India. This suggests that industry-wide pollution controls can reduce inequity in the impacts of ambient air pollution. However, as low-income households face an order of magnitude higher mortality risks from indoor air pollution, clean cooking fuels remain the most effective way to reduce the number of premature deaths from air pollution in India. A 2023 global study, “Global Air Pollution Exposure and Poverty”, published in *Nature Sustainability* found that about 716 million of the world’s lowest income people

(living on less than US \$1.90 per day) live in areas with unsafe levels of air pollution. Air pollution levels are particularly high in lower-middle-income countries, where polluting industries and technologies dominate. This study shows that high-income Indian households contribute maximum to the outdoor air pollution due to emissions from manufacturing, transport and products they consume. But low-income households are nine times more vulnerable to premature deaths than the high income counterparts. A 2022 World Bank study reiterates that about one in 10 people exposed to unsafe levels of air pollution live in extreme poverty. For the extreme poor, the air pollution level means increased severe health risks compared to higher income households. The effect of air pollution is aggravated by poverty and inadequate access to health care.

A very serious concern that has been indicated in a few studies is the cancer risk among the marginalised. The end point of all toxic risk is cancer. A very early survey conducted by the Department of Preventive Oncology, Tata Memorial Centre, Mumbai about two decades ago had found high incidence of cancer in the slum areas and air pollution was envisaged as one the probable contributory factors. The implication of this for the poor is ominous. In fact, in the early years the Harvard Centre for Cancer Prevention, USA, found a larger occurrence of lung cancer among the poor.

The American Cancer Society had issued a report to the nation that highlighted the key issues related to the cancer risk among the poor, including the magnitude of suffering, high healthcare cost, access to healthcare and health insurance, and lack of awareness.

With a very large urban population and dominance of urban poor, this can emerge as a serious public health agenda. The urban landscape in India is dominated by the informal settlements where the marginalised communities and poor live. As per one CSE estimate, at least one in every six urban Indians resides in informal settlements. Moreover, six in 10 persons in informal settlements live in close proximity to unsanitary drains and every sixth person lacks access to treated water as per the assessment based on Census 2011. These bring out the compromised coping capacity during illness.

Further review has found close proximity of informal settlements to pollution hotspots prone to waste dumpsites, open burning, traffic choke points, small scale construction sites and informal industrial units. In fact, some indicative vulnerability mapping by an ongoing CSE study in a few cities such as Jaipur and Kolkata found that the overlaps between pollution hotspots, heat hotspots, flood hotspots and location of the informal settlements. This is a serious matter, given the burgeoning population in informal settlements with growing urbanisation. It is estimated that while urban population increased

by 32 per cent, population in informal settlements increased by 131 per cent during 2001–11. About 11 out of 47 cities with more than million populations have on an average as much as 30 per cent of the population living in informal settlements. This population may double in the coming years. The enormity of this problem also emerges from the fact that most of the informal settlements are located and are growing in marginalized areas around the urban periphery that are least serviced and remain mostly outside the orbit of municipal services, transport connectivity and healthcare services. For a long time, even the housing policies focussed on relocation and resettlement of the informal settlements from the city centre, which has further compounded the disadvantages. Recent policies on public housing schemes are now also focusing on in-situ development with amenities inside the cities. The World Health Organization (WHO) observes that although all populations are affected by air pollution, the distribution of burden of consequent ill-health is inequitable. The poor and disempowered and those living near roads or industrial sites are often exposed to high levels of air pollution and this is worsening in cities.

Most exposed are those who have to work outdoors or in close proximity to specific pollution-generating activities and industrial processes. This is yet another dimension of vulnerability. Evidence has emerged on the vulnerability of informal workers to

outdoor air pollution and extreme weather events. The International Labour Organisation has always highlighted the risk of occupationally exposed groups to a range of environmental risk factors. This matter has become the focus of new investigations in India as well. A 2022 study by the Delhi-based non-profit Chintan Environmental Research and Action Group assessed the relationship between the respiratory illness of low-income, outdoor workers, including waste pickers, municipal sweepers and security guards. They investigated the socio-demographic characteristics, lifestyle, knowledge on air pollution and health issues experienced by workers. They also examined respiratory health in terms of pulmonary function and assessed the relationship between the incidence of respiratory illness and socio-demographic and working environment factors.

This study was conducted at selected locations in Delhi. Waste pickers in Bhalaswa landfill, Ghazipur landfill, Mahipalpur and Vivekanand Camp and municipal sweepers of South Delhi Municipal Corporation (SDMC), New Delhi Municipal Council (NDMC) and East Delhi Municipal Corporation (EDMC), New Delhi Municipal Corporation (NDMC) and Khan Market were studied. The study specifically reviewed security guards in Safdarjang Hospital, CAG building, ITO, Reliance Building, Chandni Chowk etc. For comparison, it considered a control group in several neighbourhoods of central Delhi, and carried out pulmonary function

or respiratory function and spirometer tests among these groups. The study showed that among waste pickers, air-pollution-related illness dominated at 86 per cent. The lung function among waste pickers was significantly lower compared to other groups. The severity of obstruction and restriction impairments for waste pickers can be as high as 57 per cent. Female waste pickers are 3.9 times more likely to have respiratory illness.

Among the municipal sweepers, 97 per cent of the participants were exposed to air pollution during their jobs while 37 per cent did not have enough protection from the cold during winter. Approximately 23 per cent reported major illnesses such as fever, headache and blood pressure in the preceding one year. Only 11 per cent, however, visited hospitals for treatment. Female sweepers were approximately six times more likely to have respiratory illnesses. Among the security guards, about 45 per cent faced health issues such as cough, sore throat, burning sensation in eyes, headache etc. About 86 per cent had abnormal lung function.

Another study published in *Environmental Science and Pollution Research Journal* in 2022, which focussed on auto-rickshaw drivers, street vendors and sweepers, found that most of those surveyed complained of headaches/giddiness, nausea, and muscular cramps. Auto-rickshaw drivers reported the highest prevalence of ophthalmic symptoms, including eye redness and eye irritation due to

exposure to vehicular pollution. Vendors reported a higher prevalence of headaches and eye redness due to increased exposure to vehicular emissions. The majority of auto rickshaw drivers, vendors and sweepers believed that air quality was impacting their health. Most of them had restricted lung function.

Construction sites in cities can be a significant source of exposures. A review by CSE showed that key sources of dust in construction sites include sand, grit, conveyor system, truck movement, soil excavation, site clearance, material handling and storage, bulldozers, crane, crushers, piling, building demolition, and concrete batching. Every stage of construction can be a source of toxic dust. This can exist as silica dust from sand, stone, rock, sandstone, brick, concrete and mortar that contains crystalline silica. Dust from masonry work, tunnelling, road milling and mixing of cement and concrete can affect workers. Mining dust from cutting and drilling can have adverse impacts. Other sources include stone crushing dust while making aggregates, stone polishing dust and wood dust. Demolition of old buildings has more lead and asbestos that are highly toxic. Serious health risks are associated with construction-waste-related particles, which cause lung cancer, silicosis, chronic obstructive pulmonary disease and asthma. In fact, a 2023 global study on exposures of construction workers in construction sites brings out the pattern of

exposures in different phases of construction. For example, workers engaged in pit-bottom operations in building foundations; steel bar processing in the main structure; and plastering, masonry, and putty workers engaged in installation and decoration are at the highest risk in construction sites. A survey carried out by the Help Delhi Breathe and Mahila Housing Trust in Delhi found that informal workers, especially those who live close to the landfill sites, face very high exposure. Unfavourable working conditions, harsh climatic conditions like extreme cold winters or heatwaves, unsafe work sites and inequity compound the problem. Informal workers who work in polluting industries or in construction sites face the challenge of job loss if clean air action is directed at the polluting activities and industries. These snapshots of evidence help to establish a range of risks from outdoor air pollution, and location disadvantage of where these communities live.

The emerging evidence points towards inequity due to economic backwardness that is inherent social structure making it difficult for the vulnerable groups to negotiate solutions for themselves. This inequity can be associated with social caste structures. There is a study that has mapped the air pollution exposure disparity in rural parts of India and found a strong correlation between the exposure distribution and socio-economic status. Integrating some of these indicators may help to improve investment patterns to maximize welfare

and health gains by targeting the most vulnerable and targeted communities. As already seen, there are evidences on location of polluting industries and power plants that are more heavily concentrated in poor, socially disadvantaged villages.

One of the studies – “High-Resolution PM2.5 Emissions and Associated Health Impact Inequalities in an Indian District” published in the journal *Environmental Science and Technology* - conducted in Saharanpur district of Uttar Pradesh with an urban and rural context, showed that there are greater contribution-exposure gaps between socio-economic classes. Rural areas account for 68 per cent of annual premature deaths. Low-socioeconomic-status groups suffer 6 per cent, 7 per cent, 7 per cent and 26 per cent higher premature mortality from PM2.5 exposure due to industries, domestic cooking fuel burning, open waste burning and transportation, respectively, compared to their contribution to air pollution. Most disability-adjusted life years (DALYs) in the research domain are found in worker groups with lower socio-economic status.

Even though there aren't specific environmental justice laws in India, there are various legal provisions, policies and judicial decisions that have underscored the environmental justice principles and protection of environmental rights. In public interest litigation (PIL) cases on air pollution, the judiciary has upheld the Constitutional provisions aimed at ensuring environmental protection and

the right to life. These include Article 48A, Article 21 and Article 51A(g) of the Indian Constitution. Article 21 guarantees the right to life and personal liberty, which has been interpreted by courts to include the right to a clean and healthy environment. The judiciary has interpreted this article expansively to include the right to a clean and healthy environment as an integral part of the right to life. This interpretation has led to numerous landmark judgments where courts have intervened to protect the environment and ensure environmental justice. Through Article 21, citizens have the right to approach the courts to seek relief against environmental degradation or violations that threaten their right to a healthy environment.

Additionally, Article 48A mandates the protection and improvement of the environment. This article is a directive principle of state policy, which mandates that the State shall endeavour to protect and improve the environment and to safeguard forests and wildlife. It emphasises the duty of the state to ensure environmental protection as part of its governance responsibilities. While directive principles are not enforceable by courts, they serve as guiding principles for the State in policy making and legislation. Article 48A underscores the importance of environmental conservation and sustainable development in the national agenda.

While Articles 21 and 48A protect the environmental rights of the citizen, Article 51A(g)

of the Indian Constitution outlines the fundamental duties of the citizen towards the environment. It states that every citizen of India must protect and improve the natural environment, including forests, lakes, rivers, and wildlife, and to have compassion for living creatures. Article 51A(g) emphasises the role of citizens in environmental conservation and sustainable development and places a responsibility on every citizen to contribute to the protection and enhancement of the environment, thereby promoting environmental justice at the grassroots level.

Together, these constitutional provisions create a framework for environmental governance in India. While Article 48A guides the state in formulating policies and laws related to environmental protection, Article 21 ensures that individuals have the right to a clean and healthy environment and can seek legal recourse in case of violations. Article 51A(g) reinforces the notion that environmental protection is not only the responsibility of the state but also the duty of every citizen. This combined approach helps in achieving environmental justice by balancing environmental conservation with developmental needs while safeguarding the rights of citizens.

Apart from the constitutional provisions mentioned above, environmental legislations like the Environment (Protection) Act, 1986, and the Air (Prevention and Control of Pollution) Act, 1981

also have a few provisions within their framework to reduce air pollution exposure of the inequitably impacted population. The Air (Prevention and Control of Pollution) Act, 1981, through its regulatory framework, pollution-control measures, public-participation provisions, compliance monitoring and legal remedies contributes to ensuring environmental justice indirectly by aiding pollution exposure assessment and participation of the vulnerable population and further enforcing the penalties on the violators.

The Air Act has measures that can aid public participation in the formulation and implementation of pollution control measures. Section 21 of the Air Act, which empowers the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) to take measures for the prevention, control, and abatement of air pollution, indirectly provides avenues for public involvement. These boards often conduct public hearings, seek public comments on proposed regulations, and may involve the public in the monitoring and reporting of air quality data.

While the Air Act of 1981 does not have explicit provisions akin to modern environmental legislation that mandates public participation, the establishment of the boards (that typically include representatives from various stakeholders, including government agencies, industry, environmental organizations, and sometimes members of the public) and their functions create mechanisms through which public

involvement can occur in matters related to air pollution control and management.

Along with having provisions for public participation, the Air Act also provides for legal remedies and penalties for non-compliance with pollution-control measures. It allows affected individuals and communities to seek recourse through courts in case of environmental violations. By providing avenues for legal redress, the Act empowers citizens to protect their right to a clean and healthy environment. Hence, even though the Air Act does not have any explicit environmental justice mandate, it has some provisions within its framework that follow the principles of environmental justice and can act as a policy lever to further the environmental justice legalese.

However, due to a lack of proper guidelines and mandates, the application of these provisions, concerning justice principles, is left to the discretion of the enforcer and the polluters. Under the polluter pays principle, the offending industry might just find paying the fine levied more economically reasonable than mitigating the emissions. Such loopholes potentially add to the burden of the pollution exposure of the socioeconomically marginalized community due to their lack of either awareness or political clout to contest effectively.

Another similar Act that entails ensuring a clean environment for the people by empowering the central government to take measures to protect and improve

the environment is the Environment (Protection) Act, 1986. Even though most of the provisions within the ambit of the Environment Act that resemble the principle of environmental justice are similar to that of the Air Act, the mandate for Environment Impact Assessment (EIA) is noteworthy. India's Environmental Impact Assessment (EIA) process for industries does not explicitly include provisions labelled as 'environmental justice'. However, the EIA notification issued by MOEFCC outlines several mechanisms that indirectly contribute to promoting environmental justice. These mechanisms aim to ensure that environmental concerns and the interests of affected communities are adequately addressed in the process of granting environmental clearance to industrial projects.

If used and amended correctly, EIA can become a lever for promoting environmental justice as it mandates assessing the impact of all the pollution generating development projects like thermal power plants, mining etc. on the neighbouring environment and population as a part of the environment clearance procedure. The state governments assess the environmental effects before project approval, often involving public consultation. Public hearings and consultations are conducted to provide affected communities with an opportunity to express their concerns, opinions and grievances regarding the proposed project. Along with a role in the overall decision-making process,

EIA equips the stakeholders with comprehensive information on the environmental, social and economic impacts of proposed projects. This provision to include communities and stakeholders in decision-making gives them a medium to voice their concerns regarding potential project impacts, both environmental and socio-economic.

The environment impact checklist of EIA sometimes includes, socio-economic aspects, along with environmental aspects. In certain cases, the EIA notification requires the preparation of a Social Impact Assessment (SIA) report to assess the potential social implications of industrial projects on local communities. It requires collecting data on whether and how a proposed project will change the neighbourhood demographic structure, the current social infrastructure around the project and the potential impacts on the local communities.

The SIA evaluates the socio-economic characteristics of affected communities, identifies potential impacts on livelihoods, access to resources and social infrastructure, and proposes measures to mitigate adverse effects to aid in addressing socio-economic inequalities caused or aggravated by proposed projects. If collected correctly and diligently, this information will help the vulnerable stakeholders make informed choices that weigh the long-term implications of development on both the environment and communities. Moreover, with a wider view, the EIA legislation of 2006 has the

potential to address environmental injustices by ensuring fair distribution of project burdens and benefits across society. It prompts decision-makers to consider potential disproportionate impacts on vulnerable or marginalised communities, thereby promoting equity in decision-making processes.

There have been ongoing debates and critiques regarding the effectiveness of the EIA process in ensuring genuine participation and protecting the rights of marginalized communities. While the flexibility of the 2006 legislature was a provision to integrate the new sciences and requirements, it seems to have been exploited to undermine the entire purpose of EIA. The EIA 2006 Notification defined the sectors and projects that require going through the process of public hearing or public consultation to acquire project approval and appraisal. It had outlined the entire procedure of both public hearing and public consultation. Public consultation is a broader process of engagement with stakeholders throughout the EIA process, aiming to gather input and feedback on the proposed project. Public hearings, on the other hand, are specific events within the public consultation process where stakeholders have the opportunity to provide oral testimony and express their views on the project before a designated authority.

There were certain sectors, like the ones pertaining to 'national defence' that were exempt from public consultation. However, over the years the list of

exempt sectors and industries has only increased. In July 2023, the Ministry issued a notification exempting all the standalone re-rolling units or cold rolling units with valid Consent to Establish and Consent to Operate from the requirement of public consultation during its Terms of Reference (TOR) application provided the application is made within a year of the notification. In October 2021, the ministry issued an office memorandum permitting a 20 per cent increase in production for mining operations of minor minerals such as iron, manganese, bauxite and limestone, based solely on public consultation. Furthermore, the public hearing process for legacy mining projects granted environmental clearance under the 1994 EIA notification was further relaxed. These projects are now only required to undergo public consultation rather than following the entire public hearing process outlined in the 2006 EIA notification. Relaxation on public consultation and data accessibility will not only further undermine the potential of EIA to enable environmental justice but also obfuscate the basic principle behind EIA—protection of people and environment and a participatory justice that gives voice to the voiceless.

The Ministry of Environment, Forest and Climate Change launched the National Clean Air Programme (NCAP) in January 2019. Its aim is to ‘improve air quality in 131 cities (non-attainment cities and Million Plus Cities) in 24 States/UTs by engaging all stakeholders... to achieve reductions

up to 40% or achievement of National Ambient Air Quality Standards for Particulate Matter¹⁰ (PM₁₀) concentrations by 2025-26.’ NCAP includes provisions aimed at addressing air pollution and its adverse impacts. It is broadly designed to improve the ambient air quality. However, as stated earlier, one of the requirements of the NCAP programme is the identification of pollution hotspots and prioritisation of actions in areas with high levels of air pollution. Though this provision does not directly hint at environmental justice, this provision created the opportunity to alleviate the disproportionate exposure faced by communities in the pollution hotspots.

NCAP emphasises the importance of inclusive stakeholder engagement, including participation from affected communities, civil society organisations and local authorities. This participatory approach can be leveraged to integrate the concerns and perspectives of marginalised communities in the planning and implementation of air quality improvement measures. The NCAP programme also includes initiatives aimed at building the capacity of local authorities and communities to address air pollution effectively. This includes raising awareness about the health impacts of air pollution, providing training on air quality monitoring and management and empowering communities to take action to improve local air quality. NCAP includes provisions for conducting health impact assessments to

evaluate the adverse health effects of air pollution on vulnerable populations, including children, the elderly, and individuals with pre-existing health conditions. Moreover, NCAP seeks robust air-quality monitoring and reporting systems to track progress towards air quality improvement goals by providing transparent and accessible air quality data.

The NCAP programme needs further reform to make more explicit provisions on integration of tools and indicators that align with vulnerability assessment of communities that are disproportionately exposed to air pollution and live in close proximity to polluting sources. It must also provide for integration of indicators of impact assessment of infrastructure and industrial projects on communities and seek adequate safeguards and protection, calibrate all mitigation measures to minimise livelihood disruption. Already NCAP has provided sector-wise indicators to cities to report progress across key sectors of pollution. These needs to include equity indicators as well.

Currently, the air-quality monitoring network is limited, and there are large data shadow areas in regions and cities of India. As of October 2023, there are 931 manual stations under the National Ambient Air Quality Monitoring Programme; 516 are real-time Continuous Ambient Air Quality Monitoring (CAAQM) stations. Of these, 512 manual stations and 344 CAAQM stations are in National Clean Air Programme (NCAP) cities. But there are

large tracts of land and population that are not covered by the monitoring network. While this is not a constraint to scale up clean air action across the regions, there is still inadequate understanding of the spatial profile of air quality impacts on vulnerable communities. This could be widely dispersed as polluted industrial zones and areas of power generation; congestion hotspots; highway traffic; waste dumpsites and waste-to-energy plants; slums and squatter settlements; unauthorised colonies outside the municipal governance; and sensitive areas, including schools, hospitals and old age homes, among others.

It is not cost effective to expand regulatory monitoring to cover all data-shadow areas and where most vulnerable communities live. It is necessary to adopt alternative monitoring methods including satellite- based monitoring and sensor based monitoring for a multi-dimensional approach. The Central Pollution Control Board has permitted sensor-based monitoring for monitoring of pollution hotspots but not for regulatory compliance. Similarly, it is possible to do granular mapping of areas with the help of satellite data. It is necessary to provide air quality data to communities to understand the risks and action. Under the NCAP programme, the cities designated as non-attainment have been mandated to identify and implement hotspot action plan to address local pollution. These are currently defined based on dispersed pollution sources like waste

burning, road dust, construction etc. But there is no policy to combine the pattern of exposures of the local communities as criteria to define hotspot action. This approach needs to be redefined for local action and for protection of targeted communities close to the pollution sources. To illustrate the point, about 13 hotspots—which subsequently increased to 18— were originally identified in Delhi. These include industrial areas like Okhla Phase 2, Dwarka, Ashok Vihar, Bawana, Narela, Mundka, Punjabi Bagh, Wazirpur, Rohini, Vivek Vihar, Jehangirpuri and Mayapuri; high-traffic nodes like Anand Vihar (including Mandoli), Shadipur, ITO; and residential and recreational areas including R.K. Puram, Mandir Marg, Nehru Nagar, Patparganj, Sonia Vihar, Dhyan Chand Stadium, and Moti Bagh.

The hotspot plans of these areas show mapping of sources like road dust, construction sites, traffic congestion and open burning of waste. But these plans have not indicated the nature of exposure of the local communities, nature of their vulnerability and coping capacity, or the expected local benefits from clean air action. In fact, due to data gaps, communities who live near highly toxic landfills do not usually get included in these plans. There is considerable scope of reframing the hotspot action to make it more community oriented. However, some of the action taken in terms of controlling open burning of plastic waste in Mundka area in 2018 has the potential to reduce toxic exposure

of the local workers and communities. It is also important to note that some exposures related to traffic congestion and waste burning may not be possible to address locally and may require city-wide systemic intervention.

The current limitation of the air quality management approach is the singular focus on ambient air quality in the Air Act, 1981. There is no legal recognition of 'exposure' that determines the health risk that communities face due to close and direct exposures to pollution sources. The only policy mandate has come from the '2015 Report of the Steering Committee on Air Pollution and Health Related Issues of the Union Ministry of Health and Family Welfare.' This has stated that it is more important to know how close people are to the pollution source, what they are inhaling, how much time they are spending close to the pollution source than what occurs generally in the air that is influenced by climate and weather. It is necessary to shift from concentration management to exposure management. Ambient concentrations do not always well represent human exposures and are not a good surrogate for total air pollution risk as this cannot indicate exposure and health outcome. This principle will have to be integrated in the framework of NCAP and clean air action plans of the cities, states and regions, and needs to be leveraged to make local action more community oriented.

Multi-sector clean air action requires

infrastructure development to enable sustainable choices for the larger population. But the planning and design of the new infrastructure or urban renewal may not have adequate safeguards to protect vulnerable communities. This is evident in the infrastructure plans in the transport sector. Currently, all clean air action plans have included affordable zero-emission travel modes, including walking and cycling. These are the modes of the urban poor, which are also part of the solution to air pollution. But this needs to be mainstreamed as a mode of choice for higher-income groups. But the infrastructure projects to enable mass-scale walking and cycling are often neglected in the planning and execution of clean air action plans.

Similarly, several steps are being taken to scale up formal and modern public transport systems like metro and modern bus systems to clean air and climate action. But public transport services are not being planned and deployed equitably and affordably. A 2018 study by CSE found that globally, spending more than 10-15 per cent of household income on transportation is considered unaffordable. The lowest 20 per cent of households typically spend no more than 10 per cent of their income on transport. Nearly one-third, or 34 per cent of Delhi's population was excluded from basic non-AC bus services, highlighting a significant gap in access to affordable public transportation. Higher spending on transport leads to lower spending on housing,

health and education and hampers inclusive growth.

Several state governments, however, do come up with policies to keep bus fares free for targeted groups like women. But there is no strategy to develop sustainable financing model—funding strategy for viability gap funding, tax reforms, revenue generation from other sources, etc. at the state level. Innovative strategies for the long term are needed for affordability and sustainability of the public transport system. On the other hand, development and modernization of public transport infrastructure— metro, bus rapid transit systems etc.—can also push the poor out of the city and disrupt their livelihood, increase travel distances and costs of living. A study by the TRIPP found that the Delhi Metro had displaced slums. For the majority of the relocated households, cycling and bus distances had increased by several kilometres as had the journey time. Similarly, average distances to services and number of trips had also increased. This had led to the decline in the share of walking and cycling for the community. Yet another study by CEPT shows that the share of transport cost in the household budget increased significantly for the bottom 50 per cent of the population, and that education and health had stagnated due to the BRT metro project. Along with this, the BRT Ahmedabad had also displaced nearly 2,000 vendors. This further aggravated the structural inequity that weakens the coping capacity of communities. Pro-poor mobility

and housing needs to be aligned with air pollution-control measures to allow diverse livelihood choices and make the labour market efficient.

Several transportation policies have taken shape, which if implemented properly, can address inclusive planning. For instance, the Transit Oriented Development Policy requires compact urban form near transit nodes that include mixed-use and mixed-income development with improved accessibility. Institutional measures for efficient delivery are needed. National and state-level policies for pro-poor planning need to be sensitised. ■

Delhi: Quick to Leapfrog

Lessons from Delhi's legal fight against air pollution remain extremely relevant



1996: THE air of Delhi was black with smog. The city did not know what had engulfed it. It was breathing in poison. It did not know that dirty air had crept upon it. There was no information about air pollution and its hazards. All assumed it was just dark winter days. Nearly three decades ago, in November 1996, the Centre for Science and Environment (CSE) published *Slow Murder—The Deadly Story of Vehicular Pollution in India*. The book started with an investigation into the pollution-under-control (PUC) certificate system; it asked if Delhi or any city could clean its air by checking the tailpipe emissions of each car. It asked

if the city needed more measures—from emission technology to fuel quality. This was the first such enquiry and it brought results.

Slow Murder launched CSE's campaign to clean Delhi's air. Remember, this was the time when air pollution was not on the discussion table. It was not on anyone's agenda. In fact, the question CSE was asked often was: 'Why are you so worried about some black air?' The then lieutenant governor of Delhi had said that it was only dust, nothing to be worried about! The then health minister said air pollution was not a health concern.

Naming the book *Slow Murder* was a verdict on the capital city's air emergency. Pollution does not kill instantly, but leads to the suppression of the body's immune system, destroying lung function or adding to the cancer and cardiovascular disease burden. 'It was slow, but murder nevertheless.' The book delved into the nexus of the government and industry that smothered thousands into slow death. Reporting on the book, *Down To Earth* magazine put three faces on the cover of its November 15, 1996 edition: the Union Minister of Environment and Forests (there was no climate change in the ministry's title then) Jai Narain Prasad Nishad; the Union Minister of Petroleum (there was no natural gas then) T R Baalu; and Rahul Bajaj, the owner of Bajaj Motors—India's leading two- and three-wheeler manufacturer of the time). And the cover had the headline: 'Nailed! for slow murder'.

Why? Because CSE's research showed that proposals for vehicular standards were being shuffled between agencies. This was the time when India had no Bharat Stage (BS) I or II vehicle emission standards. The proposal for cleaner fuels was being bandied about, without any resolution. This was the time when sulphur in fuel was 10,000 parts per million (ppm) and above (currently, with BS VI, sulphur is down to 10 ppm).

Rahul Bajaj was on the cover because of the extremely polluting 2-stroke technology that two- and three-wheelers used. Bajaj had a monopoly on vehicles at the time—this was before the advent of 4-stroke technology, which saw the rise of Hero Honda, and personal car mobility, which saw the rise of Maruti-Suzuki and then other companies. CSE's fight was to bring policy for fuel-technology standards and to use this to drive out polluting vehicles. This is what is now called the first generation reform. The then Vice President of India, K R Narayanan, released the book at his official residence. It brought attention. CSE followed this with a public meeting at the capital's FICCI Auditorium in November 1996.

But as it happens, nothing really moved. A year went by. The automobile industry pushed against any reform and the government shuffled papers. In 1997, CSE again went to the public. This time, it had data to show the number of deaths because of pollution. CSE analysis (based on a World Bank model) showed that in just four years—between 1991

and 1995—there had been a shocking 30 per cent increase in the number of premature deaths because of air pollution. Cardiologist Naresh Trehan shared two photographs of lungs. He said when he operated he knew where the patients hailed from through the colour of their lungs. The first photograph was that of a Delhite, Trehan said. The second, showing pink lungs, was of a resident from Himachal Pradesh. Even non-smokers from Delhi had black lungs. All this spurred action. In December 1997, then Union Minister of Environment and Forests (MOEF), Saifuddin Soz, issued a white paper Delhi's pollution, which became the basis of an action plan. In January 1998, MOEF constituted the Environment Pollution (Prevention & Control) Authority (EPCA) for the National Capital Region (NCR).

In June, 1998, EPCA released its first report on priority actions in which it detailed steps that were needed to clean Delhi's air. These included control on diesel vehicles and a move towards Compressed Natural Gas (CNG). In July, the Supreme Court's top bench, then headed by chief justice A S Anand, issued directions based on EPCA's report with deadlines. It set a deadline for conversion of all three-wheelers and diesel buses to CNG. Delhi was now on schedule for a clean-up. But even as the Supreme Court proposed, the government disposed. Powerful vested interests reigned. They did not allow anything to move. Why? Because diesel had big friends.

This was also the time when science had discovered the real pollution villain—small particulates. Till then, we had only one pollutant in our lexicon, Suspended Particulate Matter or SPM. Now, evidence showed that what was really toxic was the smaller particulates, then called Respirable Suspended Particulate Matter (RSPM), because they are small enough to inhale. The first survey of RSPM—later called PM 10 and then PM 2.5, as the size of the particulate became clearer and its deadly toxicity better understood—was done in 1998. Monitoring by the Central Pollution Control Board (CPCB) showed that the level of RSPM in Delhi was five times above the national 24-hour standard. This was deadly. But where did RSPM come from?

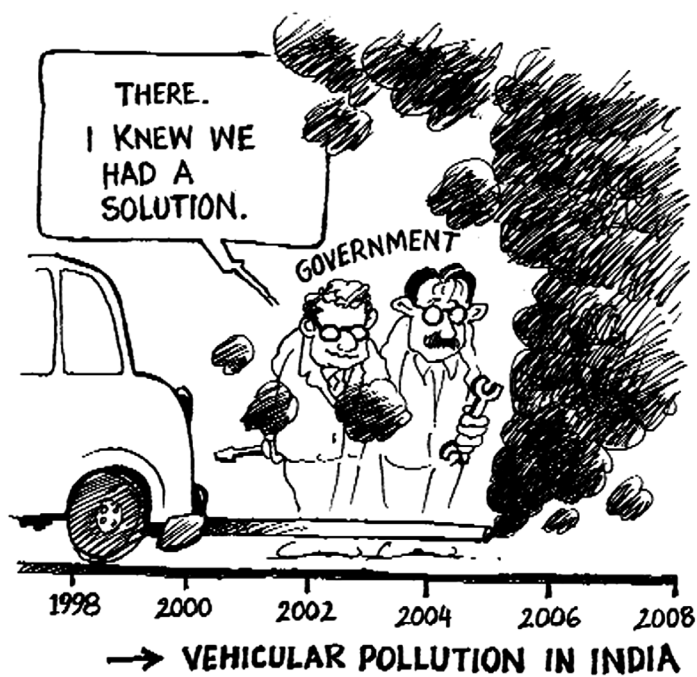
Global research was pointing at diesel—depending on the size and toxicity of the particulate; and explaining not just on how the fuel was burnt, but also the nature of the fuel itself. Studies had found that 90 per cent of the exhaust from a diesel vehicle was below 1 micron in size and that it was coated in highly carcinogenic poly-aromatic hydrocarbons (PAH) and other toxins. In 1998, after a decade of work, the California Air Resources Board formally designated diesel particulates as toxic air contaminants. This was followed by studies from Japan, which discovered the most potent carcinogen in diesel exhaust. The news was unpalatable to the automobile industry. They hit back and things got messy.

In 1998, the car industry was about to bloom—old players like Hindustan Motors, with its Ambassador car, were being edged out by the zippy Maruti Suzukis and Hyundais of the world. And waiting in the wings was Telco, or now Tata Motors, which till then, had a grand presence only in the commercial truck and bus segments. Tata Motors had worked out a scheme to break into the Japanese-Korean-dominated car industry with a product that was not only savvy, but also cheap. How? It would use diesel, which was till then reserved for public transport. It was just about to launch the diesel-powered Sumo. This was unacceptable to pollution control activists. EPCA (with CSE's founder director, the late Anil Agarwal, as a member) had already petitioned the Supreme Court asking for diesel to be banned for use in buses. CSE wanted the fleet to move to cleaner CNG. CSE could not want cars to start using the dirty and toxic diesel.

Soon, another report was released by CSE in 1999 provocatively titled 'Engines of the Devil—why dieselisation of the private automobile fleet should be banned'. Tata Motors was not amused. In April 1999, Tata Motors sued CSE for defamation, slapping us with a case of ₹100 crore for writing an article in business newspaper *Business Standard* on the toxicity of diesel. CSE took the matter to the public. Tata withdrew the notice, but the fight moved underground. Tata Motors hired a public relations firm, Burson-Marsteller Roger Pereira

Communications, to campaign for diesel. Soon pamphlets (this was before the age of the Internet) on myths and facts about diesel, which quoted anonymous experts, appeared on the tables of decision-makers. Many non-profits sprung up to defend diesel, one of which was, ironically, called 'Citizens Against Pollution' and had a one-point agenda to defend diesel. Disinformation became the name of the game.

In April 1999, EPCA submitted a report to the apex court on restrictions for plying diesel-driven (private) vehicles in NCR. It called for a ban based on emerging public health issues and the extent of pollution in Delhi. The Supreme Court was listening. The court-appointed amicus curiae, Harish Salve, took up the matter asking for the 'forthwith suspension of registration of diesel vehicles until further orders'. The learned judges of the country's apex court concurred, saying that the 'very right to life of the citizens is at stake'. The government was asked to respond. The fight became dirty; personal attacks on CSE's director Anil Agarwal, who was then battling a serious form of cancer, became common. The automobile industry, led by Tata Motors, used their full might to defeat this move. In court, Tata Motors lawyers, F S Nariman and Arun Jaitley, P Chidambaram for Fiat and Kapil Sibal for Maruti argued that particulate matter was not dangerous. Tata Motors' affidavit in court said, 'I deny that smaller the particulate, the more harmful



it is' and 'I deny that RSPM is more deadly because they are breathed deep into the lungs and lodged there'. This was the refrain.

The Supreme Court, faced with this barrage of opposition from the industry, decided that instead of banning diesel for private cars, it would push for a drastic improvement in fuel and emission standards. Meanwhile, the government believed it was not its war at all. So in April 1999, the apex court gave its sentence. It said that only those vehicles that were Euro I compliant could be registered in NCR as of June 1999; but it gave only one year for the transition to Euro II. It directed that from April 1, 2000, only Euro II vehicles could be registered. In the interim period—May 1, 1999 to April 1, 2000—it set a quota for 250 diesel cars per month and 1,250 petrol cars per month to be registered in NCR on a first-come-first-served basis. In one stroke, the apex court introduced emission standards for vehicle technology and fuels, and gave the automobile industry six months to make the transition.

Industry lawyers argued for 'more time', saying the industry would be hit. The court answered: 'People cannot breathe and you are asking for more time.' The industry's argument that people were registering cars not conforming to emission standards outside NCR, made the judges say, 'There are no limits to ingenuity.' They stood firm, saying to automobile lawyers, 'Whether you speak one or two sentences, we will only pass a sentence.' The rest is

history. The automobile industry met the deadline. The oil industry provided cleaner fuel. The air of Delhi benefitted. But we had lost the critical fight—private diesel cars zoomed ahead. Clean air benefits were squandered away. But then came another turn, a rather pivotal one.

On February 16, 2001, the court of the Chief Justice of India was the centre of attention. The final deadline of April 2001 for converting all buses, autorickshaw and taxis to CNG to reduce toxic diesel particulate pollution was very close. The Delhi government wanted the deadline to be extended by another three years. The court rejected the plea. This was just the beginning of the shadow of things to come. Delhi was turning into a battlefield to block CNG implementation. Anyone impatient with the inaction today must know what it takes to push for action. Every excuse to delay implementation was put forth in the court. The disinformation campaign made claims of unreliability of the 'untested' CNG technology and unavailability of gas and cylinders. But the judges were firm on the deadline. They said: 'We are conscious of the fact that from April 1, 2001, inconvenience is likely to be caused to commuting public, but this 'urban chaos' (to use the expression of the administration) which may arise... is creation of the administration and private operators.' The judges said giving a 'blanket extension would amount to putting a premium on the lapses and inaction of the administration and private transport

operators.' Only a limited extension was granted till September 30, 2001, but with rigid conditions. The then principal secretary, transport, was made personally responsible for compliance; diesel buses would be allowed to ply only with his authorisation.

As diesel buses were decommissioned, violence erupted on April 3, 2001. Angry commuters resorted to arson and set buses ablaze. Politicians too started the blame game for the rioting. 'Anti-CNG lobby does a war dance' was the headline in *The Indian Express* on the morning of April 7, 2001. Media quoted lawyers saying that the matter was leading to a constitutional crisis. On April 4, the apex court said it was 'distressed at... defiant attitude on the part of the Delhi administration to comply with our orders. The attitude is wholly objectionable and not acceptable.' Fearing contempt proceedings, the Delhi government filed an affidavit on April 18, 2001, saying it was committed to implement the court's directions. The contempt proceedings were dropped on April 27, 2001.

The matter was reduced to a puerile high school debate on CNG v diesel. Saboteurs started a game of zeroes to block CNG. Detractors advocated the use of ultra low sulphur diesel, with less than 0.005 per cent sulphur, as an alternative to CNG. But when asked to make a recommendation to the court, through EPCA, it quietly mentioned low sulphur diesel (0.05 per cent), which is the BS II fuel standard. Deleting a zero was clever; to confuse the court with an alternative

that did not exist. Then came the bogey that there was no gas, and that CNG was unworkable. CNG was portrayed as anti-poor. The plight of bus and autorickshaw drivers waiting in long queues made hearts bleed. This was used to whip up anger against CNG. The government claimed the city's transport could not run on one fuel, because any hitch in the pipeline could bring the city to a halt, and demanded that EPCA recommend 0.05 per cent sulphur diesel as a world standard clean fuel. Detractors spawned myths claiming that CNG is unsafe and emits more ultrafine particulates; that CNG causes cancer, and not diesel. A study conducted for a bus and truck engine manufacturer in the US got baptised as a Harvard study, and found its way to every policymaker to debunk CNG. CSE had to counter this disinformation to clear the smokescreen of lies.

Everyone seemed to have missed the point that the Supreme Court was not promoting CNG or any specific fuel, but only trying to clean up the air. The original order of July 28, 1998, had asked for CNG and other clean fuels. Following directions, the EPCA defined clean fuels in 2001, and specified CNG, LPG, unleaded petrol with low benzene used with catalytic converters, and clean diesel with 10 ppm sulphur used with advanced particulate traps, as alternatives. The Union government then submitted a hurried interim report of the newly-constituted Auto Fuel Policy Committee to the court, asking it not to prescribe fuels and technology, but only

set emissions standards. Such an approach would not work because Euro II diesel buses emitted 46 times higher particulate matter than CNG. It is diesel emissions that the World Health Organization (WHO) had branded as a carcinogen for its clear links with lung cancer. The only hope for public health in the face of a sustained campaign to sabotage the move to CNG was the firm stand taken by the Supreme Court, which refused to give in to pressure tactics. The court said: 'No diesel. No diesel. No diesel.'

After several missed deadlines, Salve reacted in the court in March 2002: 'This is the fifth time that the Union and state governments were coming to court with the prayer that diesel buses be allowed. If this was a private party, it would amount to abuse of process and the party would be made to pay the costs.' In April 2002, the court brought down the curtains on the capital's diesel buses. It imposed a penalty of ₹1,000 per diesel bus per day, and slapped a penalty on the Union government for repeatedly seeking a modification of the CNG order. This helped change the focus from resistance to implementation. Bus operators threatened to protest, but this time the state government did not back down. Sensing that the government had changed its mood, bus operators were back on the roads, paying fines and buying new CNG buses. On December 1, 2002, the media reported: 'Finally its bye bye diesel buses.' The CNG crisis had affected everyone in Delhi. Once

implemented, there was palpable public recognition that CNG had improved the capital's air quality. Before the Delhi assembly elections in 2003, political parties vied with each other to take credit for CNG. Delhi's democracy had matured.

While the clean fuel and technology agenda remained unfinished, the exploding number of cars and two-wheelers threatened to undo the incremental gains. The game of pollution control cannot be won by simply catching up, but only by leaping ahead. The court directives had helped to stabilise air pollution levels. But the breathing space that Delhi had gained could be lost if vehicle numbers and congestion increased overwhelmingly. In 2004, the apex court heard for a firm action plan for an integrated public transport strategy and vehicle restraint measures. Salve converted the statement of concern into an interim application. The chief justice bench served a notice to the Delhi government for a strategy to control vehicle numbers and congestion. For the first time, the Delhi government submitted a plan for an integrated network of metro and bus rapid transit networks, and light rail, specifying agencies and timelines for implementation. CSE then pitched for a parking strategy and vehicle taxation to restrain car numbers and usage.

October 2015 was yet another turning point. The Supreme Court stepped in once again to combat Delhi's deadly winter pollution. Through successive winters, the capital was waking up to more wheeze,

cough and suffocation. CSE was continuously tracking evidence on pollution trends, health and sources to raise fuss and push for action. This time the science was stronger. A new source inventory and apportionment study by the Indian Institute of Technology (IIT), Kanpur, ranked key polluters in the city, and also found diesel cars responsible for 70-80 per cent of $PM_{2.5}$ from vehicles. This allowed better source-wise decisions. The Supreme Court cracked the whip on toxic diesel emissions from trucks, cars and taxis; waste burning; construction and road dust; and, called for enhancing public transport, walking and cycling infrastructure. The focus now shifted from the local to the regional air-shed of Delhi. The court's directives now included not only Delhi, but the entire NCR. This helped nail the episodic problem of farm fires in Punjab and Haryana.

The court rulings also finally established that diesel cars are more polluting. Misuse of low-taxed diesel by cars came under fire. The apex court, in its ruling of December 16, 2015, said: 'It is noteworthy that diesel vehicles of 2,000 cc [cubic centimetres] and above and SUVs [sports utility vehicles] are generally used by more affluent sections of our society and ...more prone to cause higher levels of pollution.' It imposed a temporary ban on big diesel cars and SUVs for the winter. History repeated itself when the car industry opposed the court's move to nail diesel cars with the 'polluter pays' principle. The

judges said this will make people aware that they are buying more polluting vehicles. While the pending proposal from EPCA shows that diesel cars should pay at least 20 per cent of the car value to pay for the extra fuel tax that petrol cars pay over lifetime, the diesel car industry got away by volunteering a mere 1 per cent environment compensation charge to escape the ban.

The car industry once again led the charge in the courtroom to plead that diesel cars are clean. On January 5, 2016, the then chief justice T S Thakur said: 'You are saying diesel vehicles pollute less. So are your vehicles emitting oxygen? People's lives are at stake and you are interested in selling cars.' The heat on diesel catalysed the momentous step taken by the Union government on September 16, 2016, to skip Euro V and directly leapfrog to Euro VI emissions standards by 2020. Only at this level do petrol and diesel emissions nearly equalise. This was a game-changing decision.

The fact that Delhi could succeed once again in slowing the pollution peaks during winter kindled hope. But the momentum lost steam post winter. The post-Diwali smog in 2016—the worst in 17 years—showed that the city was still not prepared. Standing in the Supreme Court on November 8, 2016, CSE heard the observation of the chief justice, 'The limit has gone beyond human tolerance... It has become dangerous for human life. It is a disaster and you must have a disaster management plan for this.'

The time has come when you have to have a policy; a concrete plan.'

Today, Delhi has an ambitious plan for e-buses but it is just not taking the shape or progressing at the speed required so that the growth of private vehicles can be stemmed. In 2023, the number of private vehicles registered in the city doubled over the previous year; this in spite of the fact that petrol and diesel prices are up and a substantial share of the household budget is spent on transportation. The explosion of personal cars not only adds to the congestion but also negates all the expenditure on increasing roads, building flyovers and highways, and improving technology and fuel. There are old vehicles that are still polluting; Delhi's scrappage programme has not been effective. And even if new vehicles are cleaner, add too many of them and the benefits are lost. It is simple maths!

The key source in this battle for clean skies and clear lungs is the fuel that we burn—from household *chulhas* to factories to thermal power plants. In most cases, it is biomass or coal. The Supreme Court banned the use of pet coke—the dirtiest of such fuels and the Delhi government banned the use of coal, which was later extended to the entire NCR. It was also agreed that thermal power plants would clean up or shut down. Action on this has been patchy to say the least. The lesson from the transition to CNG is that people need alternatives for a ban to be effective. When diesel buses were stopped, CNG

supply had to be assured. It also had to be feasible in terms of cost. The Supreme Court agreed that this needed fiscal measures to keep clean fuel cheaper than dirty fuel. Now, even as coal is banned, the price of natural gas makes industry uncompetitive. It will not work.

However, Delhi seems to be at risk of losing its long-term air quality gains. As assessment of the annual trend in $\text{PM}_{2.5}$ during 2024 by CSE showed persistent and consistent rise for the second consecutive year since 2022. This cannot be seen as an annual aberration due to meteorological factors. Consistent rise indicates the impact of growing pollution in the region. The annual $\text{PM}_{2.5}$ concentration had increased to $104.7 \mu\text{g}/\text{m}^3$ in 2024—a 3.4 per cent rise from 2023—and this was more than twice the national ambient air quality standard of $40 \mu\text{g}/\text{m}^3$. The $\text{PM}_{2.5}$ levels had increased after consistent decline and stabilisation between 2018 and 2022. Local and regional sources of pollution including vehicles, industries, open burning of waste, use of solid fuels, construction and dust sources had offset the gains—undermining the longer term progress over the past decade.

Delhi cannot hide behind the smoke screen of farm fires any more. Despite a 71.2 per cent drop in stubble fire incidents during the October–December 2024, the winter pollution had remained elevated, upsetting the annual trend. Real-time data from Delhi's monitoring stations for the winter period

(October 1-December 31, 2024) revealed a troubling 26 per cent surge in peak pollution levels compared to the previous year during the early phase of winter. The city experienced 17 days of severe or worse air quality, alongside two extended smog episodes with average smog intensity of $371 \mu\text{g}/\text{m}^3$ and $324 \mu\text{g}/\text{m}^3$, respectively which kept the average levels elevated.

This 2024 round up assessment of the annual $\text{PM}_{2.5}$ trends came as a resounding warning about the heightened risk from the rising air pollution levels and loss of air quality gains from the past actions. Delhi could stabilise annual $\text{PM}_{2.5}$ levels since 2018 (if the existing air quality monitors are considered) and even recorded a declining trend since 2013 (if the oldest five stations are considered) following the implementation of the directives from the Supreme Court on energy transition in transport and industry sectors.

A steady rise in total number of vehicle registrations in Delhi was observed up until 2016, increasing by about 33 per cent compared to 2011-12. Yearly registration started to drop between 2016 and 2021, by about 35 per cent, due to a combination of slumping automotive sector and the COVID-19 pandemic. Motorisation made a strong recovery in the year 2022-23, when numbers rose by a staggering 47 per cent. Two-wheelers dominated the numbers, after having fallen by about 42 per cent during the pandemic in 2020-21, while private cars faced a slight decrease of 13 per cent between 2019 and

2021. Passenger segments, cabs and autorickshaws faced severe decline, going down 90 per cent and 65 per cent, but bounced back to increase by 84 per cent, and 99 per cent respectively in 2021-22.

During financial year (FY) 2011 and FY 2023, the mix of vehicle segments remained the same—two-wheelers continued to dominate, with a share greater than 60 per cent a year, followed by cars, claiming a substantial 30 per cent share, losing merely 1.9 percentage points after 10 years. Cabs formed less than 1 per cent share. Goods carriers increased by only 1.8 per cent, and formed a minor share of less than 4 per cent. Passenger three-wheelers had a 3.2 per cent share, 0.5 per cent lower than the last decade. Other categories (such as commercial two-wheelers, buses and off-road) collectively comprised less than 1 per cent of the total mix. Two-wheeler share had never reduced below the 60 per cent mark, peaking at 74.8 per cent in 2018-19. However, the two-wheeler market was heavily hit by the pandemic, reducing to 66.5 per cent in 2021-22. Cars, however, took a very different trajectory, seeing a relative increase in their share during the pandemic period, peaking for the first time in 11 years in 2021-22 at 33.46 per cent. Coincidentally the same year the two-wheeler sales slumped, indicating a clear shift towards cars among commuters.

As a soft measure to check rampant increase of on-road vehicles, especially personal vehicles in the state, Delhi's transport department (GNCTD)

deregistered 48, 77,646 old petrol and diesel vehicles in January 2022. This was done in accordance with the National Green Tribunal's (NGT) direction to ban 10-year-old or older diesel vehicles and 15-year-old or older petrol vehicles to ply on NCT of Delhi's roads. According to the 'Economic Survey of Delhi 2022-23', as a result of the deregistration drive, the number of registered vehicles in the state dropped by 54.76 per cent, from 79,17,898 to 1,22,53,350. This included 1,300,000 cars and 2,900,000 two-wheelers. The transport department noted that although the vehicles have been deregistered, not all of them have stopped operating on the roads. About 700,000 vehicles in 2024 had taken a no-objection certificate for re-registrations in other states, and about 100,000 had been scrapped. In addition, if the Traffic Police in Delhi spots these deregistered vehicles plying on the roads, they will be impounded and scrapped.

Delhi state's electric vehicle (EV) share stood at 11.78 per cent out of all newly registered vehicles in FY 2023-24, from a non-existent market in 2011-12 with total registrations of just 723. While the state was unable to meet its state EV policy target of 25 per cent electrification by FY 2023-24, Delhi was one of India's first states to cross the 10 per cent mark in FY 2022-23 and had the highest electric vehicle share. The state implemented its comprehensive EV policy in 2020 featuring an ambitious target, supported by purchase subsidies and tax rebates for

both private and commercial vehicles. It included scrappage incentives for replacing old vehicles with EVs and supported retrofitting companies to convert conventional vehicles. Notably, Delhi was the first to include battery-swapping station operators in its policy, offering direct financial aid for setting up charging stations and managing battery sales. Its widespread charging network covered over 97 per cent of developed areas in 3 km x 3 km grids.

What emerged as a worrying trend is the increasing dependence on private vehicles. Since 1994, the modal shares have steered more towards private transport. In 1994, private mode (two-wheeler and car) share was 17 per cent, and bus share was 42 per cent. In 2007, the private vehicle share rose to 23 per cent while public transport (bus and metro) share dropped to 30 per cent. In 2018, 29 per cent trips were made on private modes, and 24 per cent using a bus or a metro. The number of trips in the capital had gone up by 94 per cent since 2008, and more than five times in the last 40 years. Average per capita trip rate (PCTR) had increased from 1.38 in 2007 to 1.55 in 2018, a 12 per cent increase. For motorised trips (excluding walking and cycling), PCTR was 0.905 in 2018, up from 0.87 in 2001 and 0.72 in 2018. Additionally, the average trip length in Delhi has increased from 6 km in 2007 to 10.9 km in 2018, as a result of the growth of regional centres, and increase in accessibility of these centres through roads and public transport. This marks an

81 per cent rise in the average trip length in 10 years.

In conclusion, commuters in Delhi are travelling more and for longer distances, and the rise has been exponential in the last few years. According to the National Institute of Urban Affairs, Delhi, 52 per cent of the trips carried out in Delhi are work-related, 15.4 per cent are recreational trips, and 14 per cent are education trips. Metro has the highest trip length of 16.7 km, defining its role in long-distance commute. Two-wheelers, cars, and buses are used for medium-distance commute between 8 km and 14 km. All trips longer than 5 km are made using motorised modes.

As more people choose personal vehicles, the road space becomes increasingly congested, further straining public transport systems like buses. Buses, already suffering economic losses and inadequate service quality, face the brunt of congestion, making them slower, less reliable, and more unattractive to potential users. This vicious cycle of private vehicle preference exacerbates congestion, which in turn worsens public transport performance, making it even less competitive against personal vehicles. Congestion, thus, becomes more than just a symptom of personal vehicle dependency—it actively tips the scales in favour of private transport. As public transport vehicles are stuck in traffic, journey times lengthen, reliability decreases, and the overall cost of public transport, both in terms of time and money, rises. The result is that public transport



becomes less viable for commuters who can afford to switch to personal vehicles, perpetuating a cycle of private vehicle growth. And this results in a pollution spike.

Traffic congestion and prolonged vehicle idling are significant contributors to urban air pollution, emitting various harmful pollutants such as nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM), and volatile organic compounds (VOCs). The mechanics of internal combustion engines (ICE) under idle or stop-and-go conditions are less efficient, leading to incomplete fuel combustion, which directly results in higher levels of these emissions compared to free-flowing traffic. Additionally, pollutants from idling are released close to the ground, exacerbating ground-level ozone formation, which can severely impact respiratory health, especially in densely populated urban centres. Emissions from vehicles idling in traffic also contribute significantly to secondary organic aerosols (SOAs), which have been associated with cardiovascular and respiratory conditions. The composition of these SOAs often includes ultrafine particles (UFPs) that are small enough to penetrate lung tissue and enter the bloodstream, compounding the health risks associated with prolonged exposure to urban traffic emissions.

In high-congestion scenarios, the cumulative effect of multitude of vehicles idling or accelerating intermittently generates hot spots of pollution,

particularly in enclosed spaces such as the 'tunnel like effect' caused by tall construction on both sides of road segments or near intersections. Scientific evidence around emission rates of pollutants during idling suggests many fold increases compared to when the vehicle operates at optimal speeds (which is said to be 40-60 kmph).

Literature review cited in CSE's report 'Anatomy of Delhi's Congestion' published in February 2025, showed emissions to be three to seven times higher in congested traffic than in free-flowing conditions, with specific pollutants like NO₂, CO and CO₂ experiencing dramatic increases. The CSE report cited a 2024 study that shows during congestion emissions are three times higher than in free-flow conditions. Another 2023 study showed that due to congestion, PM_{2.5} increases by 3.5 µg/m³ and ozone (O₃) increases by 1.1 parts per billion. Yet another 2016 study cited showed that the percentage increase in pollutants in three sets of runs between delay and non-delay: NO₂ (166 per cent), HC (100 per cent), CO (180 per cent) and CO₂ (71 per cent).

Economic costs due to congestion are also substantial. Projections estimate congestion would cost Delhi around US \$14.7 billion by 2030, including pollution and fuel wastage. Daily fuel losses due to idling alone are estimated at millions of dollars. The CSE report quoted studies that projected traffic congestion cost was (including pollution+fuel) US \$14,658 million for the year 2030. Vehicles

caught in congestion and idling can spew pollutants several times higher than their normal emissions on roads. Since vehicles are the dominant sources of NO_x levels, there is a strong correlation between vehicles and hourly changes in NO_x levels. The data for seven days in Delhi (September 10-16, 2024) presented the correlation between NO_2 and speed reduction compared to free-flow speed. The data indicated that during peak hours on working days (October 27-30, 2024), when travel speeds dropped, NO_2 levels were notably high. The correlation coefficient for speed reduction and NO_2 levels for peak hours was -0.534 which indicated a moderate negative relationship between the two with a variance of -0.28. This means that when speed decreases, NO_2 levels increase, and for the data recorded during the week, about 28 per cent of the variance in NO_2 could be explained by the changes in the speed. ■

Passenger in India Emits More Than Ever

India adds seven new cars, 23 two-wheelers a second and loses space to walk



HOW AN Indian moves decides the quality of the air s/he breathes. Every three seconds (the time it would have taken an average reader to read the previous sentence), 20 cars and 70 two-wheelers are registered in India. On an average, these 20 cars together will emit 3.15 kg of carbon dioxide (CO₂) for every kilometre they are driven (157.5 g CO₂ per km was the corporate average for cars in 2021-22) for the rest of their operational life. Every quarter-minute, India needs a parking space equivalent to the size of a standard soccer field to accommodate the new registrations.

Personal vehicles dominate urban mobility. India registered 25.5 million vehicles in the financial year 2024-25. More than 88 per cent of these vehicles were personal vehicles, two-wheelers and cars. A review of the available information on motorised

modal share from different sources, including city mobility plans and independent research, indicated that on an average the share of personal vehicle usage ranged 35-45 per cent, that of intermediate public transport (IPT) was about 10 per cent and public transport modal share a mere 25 per cent in Indian cities. To top it off, cities are witnessing an increase in travel demand and distances. The average per capita trip rate has increased by 17.5 per cent and the average trip length has gone up by 28.6 per cent in the last 10 years, studies showed. A country-wide reportage of mobility covering over 30 cities/towns, undertaken by *Down To Earth* magazine in May-June 2025, brought out the perilous state of transport, which invariably pushed people to opt for their own vehicles, and the proportionate increase in air pollution load.

Take the case of Aizawl, Mizoram's capital city. Nestled in lush green hills, it rarely makes national headlines; yet the city has become familiar to many across the country through social media for its remarkable traffic discipline. Photographs and videos of two-wheelers moving in harmony alongside long lines of vehicles, without honking or chaos, have gone viral. Widely shared by news platforms and several travel vloggers, Aizawl has earned a reputation as India's only 'silent city'.

But behind this serene image of disciplined traffic lies a troubling reality that residents endure every day—relentless traffic jams. Aizawl, an unplanned

city, has a terrain ill-suited to a growing population. Built on a hill, the city's rugged topography has houses clinging to steep slopes, leaving limited space for roads and often have narrow paths barely wide enough for two vehicles. It is the fastest-growing city in the state and serves as its political, commercial, educational and cultural centre. As the administrative headquarters, it is home to key government institutions, including the State Assembly and the Secretariat. The city spans almost 130 sq km and contains approximately 429 km of road within its municipal limits. However, only 40 per cent of this road network has a Right of Way (row) exceeding 10 metres.

Lalmuanpuii, a pharmacist at Aizawl Adventist Hospital, drives her two-wheeler for over 30 minutes each day to reach her workplace. 'In total, I drive for an hour to and fro due to the traffic jam and winding roads. I try my best to cover my face while driving because of the pollution. As I sometimes have to attend church-related programmes such as choir practices late into the night, the journey gets quite weary,' she said. The distance she covers is around nine kilometres, according to Google Maps, she said.

To understand the traffic in Aizawl, a comparison can be made to Bengaluru. The Karnataka capital is the second slowest city in the world, as a car covers, on average, only 10 km in 29 minutes and 10 seconds, according to a report by TomTom, a Dutch multinational developer of location technology.

A fitting comparison of the two cities was made in a video that went viral by Caleb Freisen, a Canadian living in Aizawl. He compared Aizawl and Bengaluru during rush hour, highlighting differences in sound pollution—Aizawl being silent while Bengaluru’s rush hour was filled with honking. Another key point he raised was that the traffic congestion was the same. ‘I know you’re thinking Aizawl has a pretty small population, right, and honking just isn’t required here like in other Indian cities where there’s more competition on the road, but guess what, traffic here in Aizawl is actually worse than in Bengaluru,’ he said.

Prior to the 2018 Mizoram Legislative Assembly elections, Zoramthanga—who would go on to become Chief Minister—promised to make Aizawl “traffic-jam free” as part of his campaign. A major initiative under this promise was the Parking House Support Scheme (PAHOSS), inaugurated on February 6, 2019. Under the scheme, the government was to provide financial assistance for constructing parking spaces to individuals, non-profits and Local Councils. Based on the government data, PAHOSS received a total of 1,462 applications. A minister, responding to a query during a budget session in March 2024, disclosed that 188 beneficiaries were still in the process of completing their parking spaces, despite having been sanctioned a total of ₹9.52 crore for initial and second instalments. On March 13, 2025, the state government announced

the scheme's discontinuation. An official, speaking on condition of anonymity, said the scheme failed because parking sites were built in non-congested individual areas, providing minimal relief from overall traffic congestion. 'If the initiative had been effective, the current government would have continued it. The locations were poorly chosen and did not meet the public's parking needs. Although intended for public parking, political favouritism meant politicians handed out benefits to favoured individuals. From what has been built so far, there are no visible major results. Some used the scheme to complete personal house construction, simply designating the upper floor as a parking lot. While this could have served a dual purpose, personal ambitions appear to have overshadowed the public interest,' said the official.

Another measure taken was the 'odd-even rule'. Implemented on June 1, 2019, the rule was introduced following a Coordination on Traffic Management meeting held on April 25. The then Home Minister Lalchamlana announced the decision, which remains in effect. Under the rule, vehicle movement is restricted based on the last digit of the number plate—vehicles ending in 1 or 2 are not allowed on Mondays, those ending in 3 or 4 are not allowed on Tuesdays, and so on. However, even this measure has drawn criticism. Noel Chawilena Jongte, a driver who has worked for a private school for over 10 years, said, "The only ones benefiting from this scheme are

vehicle dealers, especially those selling two-wheelers. With loans easily available, people simply buy an extra two-wheeler to use on days when their primary vehicle is restricted. Some families even own more two-wheelers than they have members. This has not eased traffic at all.’ Another Aizawl resident, a government employee, commented on the rule on condition of anonymity, saying, ‘The odd-even rule has only increased the number of vehicles in the city. The traffic jam worsened after its introduction because everyone now has an extra vehicle to use.’

Between 2020 and 2023, a total of 75,162 new vehicles were registered in Mizoram, of which 51,569 were in Aizawl alone—making up over 68 per cent of total vehicle registrations in the state. The total number of registered vehicles in Aizawl district stood at 193,976 in May 2025. Despite the volume of traffic, public transport is not an option for many. In Lalmuanpuui’s case, who had to ride for over an hour daily through rain and shine, the bus was not viable. ‘If I took the bus, with the wait time and the frequent stops at every intersection, coupled with the heavy rush-hour traffic, it would take me at least two hours for a round trip,’ she said. Ratnamala, a professor in the Mass Communication department of the Mizoram University, a central university in Aizawl about 10 kilometres from the city centre, said, ‘There is no public transport to take one to the city, so I feel very handicapped, like I am unable to move. If I want to

go to the city, attend events or programmes, I have to ask for favours. I have missed so many events—book talks, concerts—that I would have loved to attend, but I had no option.’ Her only option is to ask her husband to drive her, but parking in the city is another major issue. Alternatively, she can ask a student to drive her to town, for which she has to cover their petrol and food. Even to access the nearest two-wheeler or transport link, she has to travel to a locality five minutes away by scooter.

Despite traffic woes and poor public transport, a small population of cyclists and walkers remains hopeful. Miller B Renthlei, a mountain biker and lawyer based in Aizawl, rides his cycle to work whenever possible—on days when he has fewer files and the weather is favourable. ‘It is both a practical transport mode and a way to relieve stress. Sometimes, I take a detour on the way home just to enjoy riding,’ he said. While he avoids rush hour, he notes that cyclists can integrate smoothly into the traffic flow. ‘Because there is a strong sense of discipline and people follow rules, it is easy for cyclists to ride safely. If we were in metro cities where traffic laws are often ignored, it would be harder. Here, it almost feels like a dedicated cycle track,’ he added.

With Aizawl having some of the best air quality in India, walking is also gaining popularity. One resident, Lalhrualtuanga Chhangte—an author and journalist—is known for being a ‘walking citizen’.

He walks everywhere, avoiding any vehicle unless absolutely necessary. 'Ever since I was young, I have enjoyed walking—it lets me observe the world. It is a chance to talk to friends. We often say we never see our families anymore, but that is just materialism. Materialism makes us believe we need a vehicle even for short trips. But when we walk, we meet friends, say hi to neighbours, see people drying their clothes, and chat for a bit,' he said.

Moving to Ludhiana, an industrial town in Punjab that has virtually no public transport system. Chandrama Prasad, a migrant labourer in an auto parts manufacturing unit in Ludhiana, has been cycling to work for the past 18 years. Since 2007, his daily commute includes a distance of a couple of kilometres, which ideally should take no more than 20 minutes. But Chandrama spends around 40–45 minutes during morning hours and nearly an hour returning home during peak evening hours. 'The traffic is unimaginable. With no dedicated cycling tracks, it takes a lot of time to navigate through big vehicles, two-wheeler traffic, and congestion to ensure a safe journey to work and back. It also becomes more exhausting because of the traffic,' he said.

In Ludhiana, there are about 0.12 million medium- and small-scale enterprises employing nearly a million workers—mostly migrants—who form the backbone of these industries, says Upkar Singh Ahuja, president of the Chamber of

Commerce and Industry (CCI). As per government estimates, the city's population was 1.6 million in 2011, which the website *World Population Review* has projected to have increased to over two million. It is the largest city in Punjab in terms of area—spread across 159.37 sq km—and population.

Just like Prasad, the majority of labourers use bicycles as their preferred mode of transport. In the absence of a public transport system, these workers, earning around ₹300 a day, cannot afford to commute by auto or cab. Rahul Verma, an expert working closely with the traffic police, says that this workforce—nearly 50 per cent of the population—occupies the least road space but suffers the most.

According to the Comprehensive Mobility Plan (CMP) published by the Ludhiana Municipal Corporation, a modal split survey conducted in 2009 showed that 31.5 per cent of trips to work were made by walking, 43.4 per cent by two-wheelers, and bicycles accounted for 21.8 per cent (excluding walking). Santosh Kumar, another migrant labourer in a tyre manufacturing company, says toxic fumes from vehicles worsen the situation. 'We contribute the least to air pollution, but are the most exposed to it,' he said. Akash Gupta, coordinator of Clean Air Punjab, a city-based initiative to improve air quality, said his travel time has doubled and fuel needs nearly tripled due to long traffic jams. 'Vehicle maintenance has also gone up. I have to constantly shift gears, which puts pressure on the clutch

and brakes. My servicing costs have increased by almost 20 per cent,' he noted. The Comprehensive Mobility Plan (CMP) drawn in 2014 noted that work trips made up 49 per cent of total trips, 26 per cent were for education and the remaining 25 per cent were for other purposes.

With no public transport system in place, the main mode of travel for residents remains autorickshaws. Shalini Dhindsa, a 46-year-old homemaker, says locals avoid autorickshaws due to safety concerns. "The drivers are unruly and charge high fares. People prefer private vehicles or cab services like Ola and Uber. Autos are usually used only when someone returns from outstation," she said. IPT vehicles—comprising auto-rickshaws, taxis and cycle rickshaws—remain central to passenger transport. CMP noted a gradual yearly increase in the number of IPT vehicles. Verma said diesel autorickshaws were banned in 2009 by Supreme Court orders, but many continued to operate illegally. "There is a need to regulate the uncontrolled mushrooming of autorickshaws,' he said.

Consequently, private vehicle ownership in Ludhiana has risen sharply in recent years. Government data shows that vehicle registrations increased from 48,143 in 2021 to 70,486 in 2022—a rise of over 46 per cent. In 2024, registrations stood at 115,122, a jump of more than 45 per cent from 79,144 in 2023. As per April 2025 data, there were nearly 1,663,071 vehicles in Ludhiana. The 2014

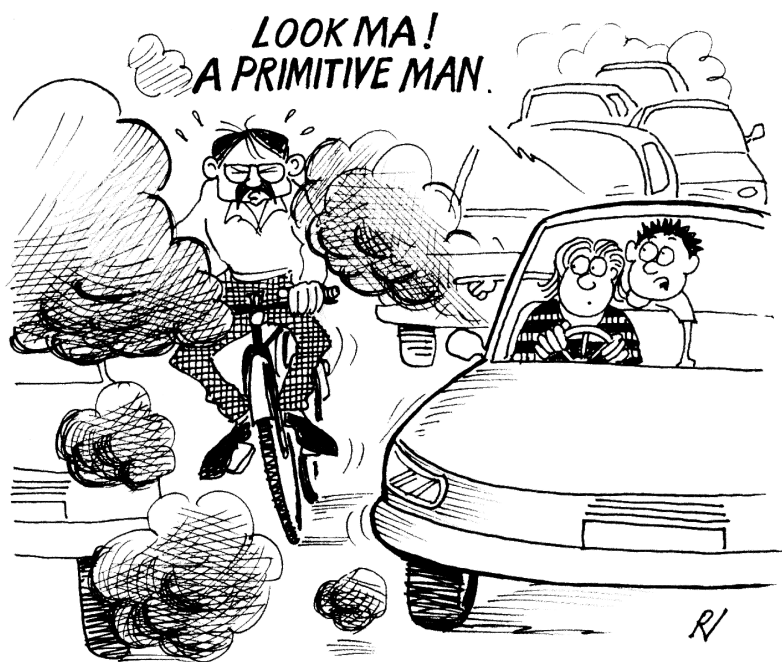
CMP reported that 62 per cent of households had at least one scooter/motorcycle, about 35 per cent had one bicycle, and only around eight per cent owned a car. Another major issue is that road widths have stayed the same over the years with many still being quite narrow. Large vehicles—especially larger SUVs—occupy more space, worsening the traffic. With poor infrastructure and rising vehicle numbers, road accidents remain a major concern. According to the government's 'Road Crashes and Traffic in Punjab 2023' report, Ludhiana reported 504 accidents, 402 fatalities, and 52 cases of serious injuries in 2023. Of the victims, 47 per cent were two-wheeler users and 32 per cent pedestrians. Trucks accounted for 34 per cent of accidents, followed by cars, taxis, and LMVs at 33 per cent. Two-wheelers caused 15 per cent of the accidents. A total of 89 accident black spots were identified in the police commissionerate's jurisdiction.

Ludhiana's route patterns and large number of industrial units have also led to rising air pollution, making it one of the 10 most polluted cities in India. According to the Central Pollution Control Board (CPCB), average PM_{2.5} levels rose from 51 in 2018 to 61.1 in 2024. Municipal Corporation officials said nearly 49 per cent of the pollution was due to industries, 30 per cent from road dust, and about 11 per cent from vehicles. 'The air quality has not improved. Two monitoring stations—at Punjab Agricultural University and Verka Milk Point—show

air quality index (AQI) levels consistently at 300, worsened by the flyover construction going on over the past three years,' an official said. Another station in the industrial area never reported AQI values below 400, while the old city market area fluctuated between 250–280 AQI. As per air quality norms, any AQI value above 200 is considered unhealthy, and readings over 300 are hazardous, triggering emergency health warnings. A 2010 study in the *Indian Journal of Public Health* found that reduced visibility due to poor air quality was statistically linked to increased daily mortality. For every kilometre drop in mid-day visibility, mortality from natural causes increased by 2.4 per cent, the study reported.

Meanwhile, the ambitious CMP proposed over a decade ago to solve traffic woes, improve mobility and establish a public transport system, has largely been ignored. The CMP aimed to shift 60 per cent of all trips to public transport and cover 90 per cent of the population, with a focus on pedestrian and non-motorised transport. It also recommended freeing footpaths from encroachments and improving parking infrastructure. But officials from the Punjab administration and traffic department admitted the CMP has remained mostly on paper. 'Some elevated roads and flyovers have eased traffic. Only one outer ring road to bypass the city is under construction,' said an official from Greater Ludhiana Area Development Authority (GLADA).

How choking cities can impact overall mobility



and what are the ripple effects can be seen in Ahmedabad, a major city of Gujarat. When Ahmedabad launched its flagship riverfront beautification project in 2010, it came with a promise of providing modern housing and better services for the evicted. But in areas like Odhav, where many of the displaced were relocated, public transport was left out of the plan—leaving residents isolated and struggling to survive. In 2010, Babli and her husband Ramesh Solanki were among hundreds of families evicted from informal settlements along the banks of the Sabarmati river. Promised permanent housing within a 5-km radius, they were instead relocated to Odhav, a peripheral area roughly 15 km from the city centre. While they received concrete flats under the Basic Services for the Urban Poor (BSUP) scheme, the couple discovered that essential services like public transport were no longer in their reach.

‘We used to sell vegetables,’ said Babli, now in her early 50s. ‘Every morning, we would get up at 4 am, buy vegetables from the local market and sell them door to door. But after we were shifted to Odhav, everything changed.’ She described waking up at 3 am and walking nearly 1.5 km to the main road in the hope of catching an autorickshaw to Jamalpur Sabzi Mandi. ‘Often, I would get there late and the vegetables would be gone. Some days I had to return empty-handed. Other days, I could not even find an auto,’ she said. The situation worsened

over time. With her children missing school due to the commute and her husband's vegetable business faltering, the family slipped into debt. 'He could not take the pressure. About four years ago, Ramesh died by suicide. He drank phenyl,' she said quietly. Babli now works as a bailiff at a city court. But commuting remains arduous. 'There are no transport options after 8 pm,' said Lalita Ben, her colleague. 'We change three rickshaws each way. It costs ₹70 one way, which is not affordable for many.' Residents said the lack of connectivity had forced others to change occupations or buy two-wheelers on loan. 'Most people from our colony used to work in the vegetable trade. But the commute became so difficult that they either changed jobs or took on debt to buy scooters,' said Sunil Chavan, a local youth. 'Now their first concern every day is to afford fuel.' Public transport options in the area are scarce. 'Ahmedabad Municipal Transport Service (AMTS) buses come only in the morning and evening. There is no fixed timing. They are always full,' said Chavan, calling for more buses and regular service.

The Union Territory (UT) of Chandigarh is another example of how India's towns and cities are moving to private mode in absence of public transport systems. Two decades ago, Chandigarh's broad avenues and sparse traffic left many wondering if the city had been overbuilt. In 2025, the narrative had reversed. The number of registered vehicles in Chandigarh had surpassed

its human population, making it the city with the highest per capita vehicle density in India. The UT had a population of 1.25 million, but a vehicle count of 1.32 million, according to the Annual Report on Road Safety in Chandigarh, 2023. This motorisation boom has brought the city's famed gridiron layout under severe strain. Travel times have increased sharply, say residents. 'A trip of 3 km used to take five to six minutes a few years ago. Now it takes 15 to 20 minutes,' said Gurnaaz Kaur Boparai, a 39-year-old resident who drives to work. She blamed the extended traffic signal durations—some now up to 120 seconds—and lower speed limits for the slowdown. 'It is shameful that in a well-planned city like Chandigarh, it takes one 20 minutes to cover just 3 km,' added Harman Sidhu, a road safety activist.

Fuel consumption has also risen. 'Earlier, 15 litres of petrol lasted me 15 days. Now I need to refuel every 10 days, thanks to the traffic and longer waits,' said Taranjit Singh, a local cab driver. According to data from the Chandigarh administration, residents commuting on two-wheelers consume 20-45 litres of petrol per month, while cars use approximately 200 litres per month.

The city, spread across 114 sq km at the foothills of the Shivalik range, has seen a steady rise in vehicle ownership. In 2022 alone, 52,996 new motor vehicles were registered—up from 36,867 in 2021, according to the 2023 road safety report.

Of these, 94 per cent were private vehicles: 54.2 per cent four-wheelers and 40 per cent were two-wheelers. Public and commercial transport such as buses, autorickshaws, taxis, e-rickshaws and goods vehicles accounted for just 6 per cent. In 2022, the upward trend in vehicle registrations continued, with 16,129 more vehicles registered compared to 36,867 in 2021. According to the data, registrations had declined during the COVID-19 pandemic, dropping from 42,616 in 2019 to 29,518 in 2020. However, the numbers have risen sharply since then.

Uncontrolled development has undermined Chandigarh's original gridiron system, designed by French architect Charles-Édouard Jeanneret, known as Le Corbusier, in the 1950s to ensure safe pedestrian mobility and smooth vehicle flow while avoiding congestion and pollution. Although much of the original road network remains, the rise of private cars has led to the very problems the city's design sought to prevent. Today, pedestrians and cyclists are the most vulnerable and can no longer navigate the city safely.

Chandigarh's public transport system is struggling to remain relevant. As per data with Chandigarh Transport Undertaking, the public transport unit of the Chandigarh administration, the average fleet size dropped from 565 buses in 2016-17 to 534 in 2018-19, with a corresponding decline in passenger numbers to 554,000 from

569,000 in the same period. Though the fleet grew again to 635 by 2022-23, ridership failed to recover, dropping to 131,000 that year from 219,000 in 2021-22. Officials with the transport department say that rise in private vehicles numbers and the longer journey times required by buses make public transport a less attractive option. The relocation of the central bus terminal from centrally-located Sector 17 to Sector 43 on the city's periphery has only compounded the problem. Residents complain of lengthy and cumbersome commutes involving multiple bus changes and long walks. 'Travelling 3-5 km by bus can require at least two changes of buses and a 600-m walk. A car can do the same in half the time,' said Pramod Sharma, a resident. Chandigarh's original design featured a seven-type road system to segregate pedestrian and vehicular flows. Today, that vision is faltering. Footpaths and cycle tracks are frequently encroached for parking, and pedestrian safety is in decline.

The influx of vehicles has also led to chronic congestion and a rise in road crashes, the traffic report notes. Data shows pedestrian fatalities rose from 35 per cent in 2019 to 42 per cent in 2023; while cyclist fatalities nearly doubled—from 10 per cent to 18 per cent—in the same period. In 2023, about 90 per cent of road crashes were caused by over speeding—predominantly by private cars. A majority of pedestrian deaths and injuries in road crashes in Chandigarh were reported from areas

lacking basic infrastructure, according to the traffic report. Twenty-five pedestrians lost their lives due to the absence of pedestrian infrastructure, while three others were killed while using zebra crossings, it noted.

The increase in vehicles has gone hand in hand with a steady rise in air pollution levels. According to Central Pollution Control Board (CPCB) data, fine particulate matter PM_{2.5} levels more than doubled to 70 micrograms per cubic metre ($\mu\text{g}/\text{m}^3$) in 2024 from 33 $\mu\text{g}/\text{m}^3$ in 2020, far above the national safe standard of 40 $\mu\text{g}/\text{m}^3$. A reduction of 43 per cent would be required to meet this target. A 2020 study by the University of Chicago's Air Quality Life Index indicated that residents of the region could be losing up to 5.9 years of life expectancy due to long-term exposure to air pollution. Navneet Kumar Srivastava, additional director at the department of environment, Chandigarh administration, attributes the poor air quality primarily to vehicular emissions, noting that the city had no major industrial areas. J S Thakur, professor at the Post Graduate Institute of Medical Education and Research, says worsening air quality had led to a marked increase in cases of chronic obstructive pulmonary disease. 'Among the cancer cases we see, lung cancer—primarily caused by smoking and compounded by air pollution—ranks first. In 2017-18, lung cancer accounted for 11.5 per cent of total cancer cases, which is significant,'

he adds. He also notes a rise in tuberculosis and respiratory illnesses among children.

Officials in the transport department admit that the city's Comprehensive Mobility Plan, 2031—which includes proposals for metro rail and a Bus Rapid Transit system—remains largely unimplemented. 'Work on the outer ring road and other major infrastructure projects under the CMP has not materialised. There are concerns that additional construction may worsen the city's air quality and disrupt its existing planned grid layout,' one official said. To address the crisis, the administration is focusing on curbing the growth of private vehicle numbers and promoting electric vehicles (EV). 'The new policy prioritises electric mobility, especially given that many residents are reluctant to use public transport in a city with a radius of just 10 km,' said Srivastava. Union government's Department of Science and Technology introduced an EV policy in September 2022, which included subsidies and waived registration fees. As a result, EV penetration rose to 15 per cent—the highest in the country, claimed Srivastava. The administration now aims to increase this to 18 per cent by 2025-26 and to 70 per cent by 2035. While subsidies of ₹4,000 were also introduced for electric bicycles, officials admit that uptake has been poor.

Sidhu warned that shifting from petrol cars to EVs without reducing car usage would not solve

congestion. 'There is no point in moving out of a private car only to travel in another private car. The traffic woes will persist,' he said.

Sharma remains cautiously optimistic. 'Chandigarh still has the potential to recover. Unlike other metros that may be beyond repair, we can restore the city's original charm. Making it pedestrian- and cyclist-friendly is key, just as Le Corbusier envisioned. He believed people would come to Chandigarh to see nature, not cars.'

Given the magnitude of car and two-wheeler registrations and the number of trips undertaken using private transport, the average passenger in India is emitting more. That's because a private vehicle carries 1-2 persons at a time in most cases, whereas a shared mode of transport such as bus, metro and IPT modes are capable of carrying a much greater number of passengers in a vehicle. If those same 20 individuals chose not to drive and instead boarded a CNG bus, their combined emissions would drop to just 1.06 kg of CO₂ per km. That's about 53.1 grammes per person per km, less than a third of what they would emit driving. And yet public transport remains an unpopular choice among commuters, not due to lack of awareness about environmental benefits of public transport, but due to the poor service levels.

Delhi-based think tank Centre for Science and Environment (CSE) has studied 19 major state transport undertakings (STU) which run public

buses, including 12 state corporations and seven municipal undertakings to understand the extent of the problem. These include the states of Maharashtra, Andhra Pradesh, Uttar Pradesh, Telangana, Karnataka, Gujarat, Delhi, Rajasthan, Himachal Pradesh, West Bengal and Bihar. During 2014-2019, these 19 STUs reported a mere 4.6 per cent increase in bus fleet. Bus fleet not keeping up with population and travel demand results in longer waiting times, making buses inconvenient. Consequently, the ridership declined by 5.8 per cent during the same period. This decline in ridership led to heavy losses across all STUs. Between FY 2014-15 and FY 2018-19, on an average, the losses have tripled across 19 STUs. The combined loss of the 56 State Road Transport Undertakings was ₹17,932 crore. Of this, the state corporations had the biggest share of 57.39 per cent, followed by state-owned companies (23.73 per cent), municipal undertakings (10.33 per cent) and governmental departmental undertakings (6.56 per cent).

On the other hand, metro rail systems in India face two major challenges: (i) Ridership is lower than the projected estimates; and (ii) the systems lack integration and poor last mile connectivity. Also, most systems are not networks but corridors that increase journey time, interchanges and costs. Add to these, the doubtful financial sustainability.

Sixteen cities in India have an operational metro rail system, with a collective network length of 862

km (reported network lengths until 2024). A study by the Indian Institute of Technology (IIT)-Delhi in 2023 concluded that the metro rail systems in Indian cities had only been able to achieve about 25-35 per cent of the projected ridership. Delhi Metro Rail Corporation (DMRC) has achieved the highest ridership, and it is less than half of the projected (47 per cent). This is largely because Delhi has been created as an extensive network, as opposed to single to double corridors in most other cities that do not address an important aspect of planning a public transport system—to plan for wider connectivity, and travel flexibility. Of the 16 cities with a metro rail system, 15 are corridor based. Delhi is the only city that has an operational network of 10 lines spread over 395 km across the city.

Further, metro rail systems in India have failed to leverage non-fare box revenue (revenue generated by metro rail systems from sources other than ticket sales). High dependency on fare box revenue leads to significant losses in the case of service disruptions, such as during the COVID-19 pandemic, and therefore having a higher share of non-operational sources of revenue is important. Metro systems have great potential to make use of these sources due to their robust ecosystem approach. Global best practices such as the Hong Kong MTR and Singapore's SMRT have reported non-farebox contributions as high as 58 per cent and 28 per cent respectively, compared to Bengaluru, Mumbai and

Chennai seeing 6 per cent, 11 per cent and 16 per cent (as reported in 2021). Poor financials lead to limited action towards improvement, which leads to loss in confidence among commuters, which, in turn, leads to a failing public transport system and dependence on more convenient modes of transport, such as private cars.

To understand the phenomenon further, CSE has studied travel diaries of commuters (who use different combinations of transport modes to complete their primary trips) across Delhi. Respondents were asked to provide a step-by-step account of their daily journeys, listing each mode of transport used. This included all segments of the trip, such as walking to the bus stop, taking the bus, taking an intermediate para-transit mode, and walking again to reach their destination. The sample was spread evenly across all income groups. The idea was to quantify the disparities between trips made solely on private transport, and trips made using public transport, or any other form of shared transport, and in the process test the hypothesis of whether public transport is truly cheaper than private transport.

Of the sample, nearly half (49 per cent) of people used private transport, with most parking close to home. Among private vehicle users, 60 per cent of car users and 75 per cent of two-wheeler users commuted directly to their destinations, while a smaller portion combined driving with metro

use. The metro was used as a second mode by 20 per cent of commuters, and was accessed via walking (7 per cent), private vehicles (7 per cent) or autorickshaws. Another 5 per cent used it as a third mode, often reached by walking, private vehicle or connecting metro lines. Cab users typically completed journey by cab, with rare exceptions due to service limitations. Buses were used by 9 per cent of commuters, mainly as a second or third mode, accessed by walking or cycling. According to the analysis based on the travel data, when only fuel and fare costs were included for journey costs, public transport was cheaper—the median value of public transport fare is ₹2.97 per km, significantly lower than the median of fuel cost for private transport journey was ₹6.36. This makes sense given that one of the basic principles of designing a public transport system is affordable fares, aiming to make transportation accessible to the majority.

However, the factors that increase the journey cost of public transport systems are interchange mode fare costs for first and last mile, interchange time cost, as well as the increased journey time cost due to congestion (for buses). For context, in Delhi, more than 50 per cent of the bus stops have a waiting time of 10 minutes. This is both a consequence of congestion and poor scheduling, which leads to bus bunching and lost revenue for the operator. Congestion can cause abysmal delays for public transport during peak hours, especially

for buses. During weekdays, Delhi sees an average speed reduction of 41 per cent in morning peak hours and 56 per cent during evening peaks. Over weekends, morning traffic is slowed down by 27 per cent and evening traffic by 42 per cent (analysis for September 2024).

Speed reduction was calculated with respect to free-flow speed or the speed during the early hours of morning when the traffic is negligible. So, when journey cost included the components of time during interchanges and travel in public transport, along with additional cost fare for first and last mile, the scales tipped in favour of private modes financially. Time cost had been calculated based on income, daily working hours and working days in a year. In the unit of share of annual journey cost in annual income, the median value for public transport trips for the sample was 18 per cent, with the interquartile range (IQR, refers to the middle spread of the data sample) between 12 and 32 per cent. For private transport, the median value was 12 per cent, while IQR is 6 to 18 per cent. Interestingly, metro trips were more expensive than buses, and the highest among all modes, when considering the total journey cost due to the increased costs of first and last mile due to lesser coverage of metro stations compared to bus stations. Additionally, the time taken for boarding and alighting metro trains was also substantial due to factors such as navigating through often crowded platforms,

queues for security posts, among others.

This financial feasibility is important to study because it directly influences commuters' choices and can either encourage or discourage the use of public transport. If public transport is perceived as more costly—not just in fare but also in time and inconvenience—people are more likely to opt for private vehicles, which worsens congestion and pollution. And the cycle goes on. But here is how to break it. Private transport is not going away. There is a need for ambitious technology pathways that support cleaner fuels and regulate strict fuel economy standards for vehicles to cut emissions at the source. Service-level benchmarks for public transport need to be revised and studied in mobility plans. Interventions need to be backed by iterative research, commuter and vehicle data, and scientific knowledge. Further, walking and cycling infrastructure and formal feeder systems must be expanded to strengthen last-mile connectivity. At the same time, private transport demand must be managed by discouraging excessive use through parking reforms, congestion pricing, low emission zones and fair taxation. Urban planning should focus on compact development that keeps homes, jobs and services close—especially near transit hubs. Budget priorities must shift from car-centric infrastructure to public and zero-emissions transport, backed by innovative financing tools like land value capture and climate funds. ■

Capitalise on the Shift to Electric Vehicles

The twin action agenda for air pollution control
is to make the transition to clean vehicles and
to reduce the vehicle numbers



AIR POLLUTION, public health hazards and climate change are the trio of killers created by modern internal combustion engine (ICE) vehicles. The Indian automotive industry is almost a century old and a large exporter of vehicles. The first time that a vehicle came on the road in India was in 1897. Nobody knew back then what was to ensure—that a harmless means of convenience will become such a menace of modern times. The International Energy Agency's (IEA's) latest report tells us that road transport accounts for 12 per cent of India's energy-related CO₂ emissions and is a key contributor to urban air pollution.

These are the exciting and disruptive times in India. To solve this existential crisis, automotive innovators have devised zero-emission vehicles (ZEV). Replacing the deeply entrenched ICE with electric drive train is transformative.

The most unexpected and early disruption came around 2012 from the informally made battery-operated E-rickshaws. These affordable zero-emission vehicles (ZEVs) of the masses destabilised the autorickshaw of the original equipment manufacturer (OEM). Piggybacking on the success of e-two wheelers and e-three wheelers, e-passenger cars and now even e-trucks are scripting their own glorious stories in India. In 2019, the Government of India's think tank, NITI Aayog, laid out the country's electric vehicle (EV) ambition—by 2030, EV sales penetration would be 70 per cent of all new commercial cars, 30 per cent of private cars, 40 per cent of buses and 80 per cent of two- and three-wheeled vehicles. The country is still far from this. As of mid-2025, the only segment that was surging in EVs is three-wheelers, with close to 60 per cent of new registration being electric. These are mostly non-branded, locally built three-wheelers that crowd roads but provide an affordable commute. The rest of the EV fleet transition was too little to speak about—just 5-6 per cent of the new registrations of cars, two-wheelers or even buses are EVs.

Science shows that replacing ICE that power our diesel and petrol cars can eliminate toxic tailpipe

emissions, along with significantly lowering heat-trapping carbon emissions from fuel combustion. Global trends show that this shift from ICE to EV is inevitable as carbon and pollution reduction become more aggressive over the next few decades. Electric cars use new generation technology, which is much simpler than the technology used in ICE vehicles. To begin with, e-cars have simpler architecture. Compared to ICE vehicles that have almost 2,000 moving parts, an e-car has about 20 moving parts. With fewer parts, it is far easier and cheaper to maintain. Simpler technology reduces the hassle and cost of routine maintenance. This is very different from a highly complex diesel vehicle meeting Bharat Stage VI (BS VI) emissions standards. Diesel car technology, already packaged with common rail direct injection, turbocharger and exhaust gas recirculation, combined with advanced diesel oxidation catalyst, now has more complex emission control systems like diesel particulate traps with regeneration options and selective catalytic reducing system for NO_x control (that requires regular urea refill at extra cost), among other complex techniques.

EVs typically have a smaller carbon footprint than petrol and diesel vehicles, even when accounting for the electricity used for charging and the carbon footprint of manufacturing batteries. Electric vehicles are also more efficient in terms of the energy they can translate into propulsion. EVs can convert about 59 per cent to 62 per cent



of the electrical energy from the grid to power the wheels. In comparison, conventional petrol vehicles can only convert 17 per cent to 21 per cent of the energy stored in petrol to power the wheels. While it could be argued that electricity generated for electric vehicles also leads to carbon pollution, the amount varies directly with how the local power is generated. India has ambitions to achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy sources by 2030. Studies in Europe have shown that petrol or diesel vehicles emit three times more carbon dioxide than an equivalent EV, even when considering the carbon footprint of charging.

A recent study by the Indian Institute of Technology (IIT)-Roorkee and the International Council on Clean Transportation (ICCT), a Washington DC-based international non-profit public policy think tank, found that Battery Electric Vehicles (BEVs) in India emit up to 38 per cent less carbon dioxide equivalent (CO₂e) per kilometre compared to ICE vehicles in the passenger car segment. However, the study also highlighted that three key factors—grid carbon intensity, laboratory test assumptions, and real-world driving conditions—collectively accounted for nearly 75 per cent of the variability in car emissions. This research is one of the first meta-analyses of life cycle greenhouse gas (GHG) emissions for passenger vehicles in India, synthesising six prominent studies

to provide a comprehensive view of emission drivers and mitigation pathways. The analysis synthesised findings from six previously conducted life cycle GHG emission assessments of passenger cars in India. It identified that differences in grid mix and efficiency could cause emissions to vary by up to 368 g of CO₂e per kilometre. This variation was equivalent to the carbon footprint of driving two to three petrol cars for every kilometre. The study emphasised that BEVs consistently outperform ICE and Hybrid Electric Vehicles (HEVs) in terms of life cycle GHG emissions. Their advantages were best captured when analyses avoided unrealistic energy consumption assumptions and reflected real-world performance. The research warned against delaying BEV adoption in anticipation of a cleaner grid, as ICE vehicles purchased today will remain on the roads for 10-15 years, emitting consistently, while BEVs benefit from gradual grid improvements. Furthermore, the study pointed out that many assessments fail to include land-use change in their evaluations, underestimating emissions from biofuels. For instance, diesel production emissions varied widely from 8 g to 22 g of CO₂ per kilometre, depending on whether land-use change was considered.

Amit Bhatt, India Managing Director at ICCT, emphasised the importance of BEVs in reducing emissions, 'Electric vehicles are more efficient than ICE vehicles and become increasingly cleaner as India's power grid decarbonises. Delaying the adoption

of battery electric vehicles risks locking in long-term emissions from ICE vehicles.’ Sunitha Anup, researcher at ICCT and co-author of the research, recommended that future life-cycle assessments in India account for the evolving electricity grid over a vehicle’s lifetime, real-world energy use, and land-use emissions from biofuels to better inform clean transport policies. She noted, ‘It shows that what we assume today shapes the climate impact tomorrow.’ Additionally, Namita Singh, researcher at ICCT and co-author of the research, added, ‘India’s road transport decarbonisation pathway toward its net-zero target is incomplete without the accelerated adoption of battery electric vehicles. To fully realise their emissions reduction potential, assessments must account for the evolving grid mix and reflect the government’s ongoing efforts to decarbonise the electricity sector.’

Two recent developments in the EV space have stirred a lot of interest. One is the announcement of the new EV policy in March 2024 to attract global investments and promote EV manufacturing, with adequate value addition in the electric car segment. The other is the new reports on a very significant suggestion included in the working paper of the Economic Advisory Council to the Prime Minister (EAC-PM), co-authored by EAC-PM chairman Bibek Debroy and director Devi Prasad Misra, to fix an EV output quota for automobile companies. While the new EV policy has evoked a mixed reaction in the

industry over the potential impact of competition from foreign players and imported vehicle models, the on-boarding of the idea of fixing e-vehicle quota annually by the EAC-PM awaits much deeper support to make this a reality and a game changer.

The new EV policy is asking for a minimum amount of ₹4,150 crore to attract foreign investments. It will use this to set up manufacturing facilities in three years and target for commercial production to reach 50 per cent of domestic value addition within five years. There will be a sharp reduction in customs duty from 100-70 per cent to 15 per cent on imported vehicles, with a minimum cost insurance freight value of \$35,000 and above for five years. The duty foregone on the total number of permitted EV imports is limited to ₹6,484 crore (equal to incentives under the production-linked incentive scheme), whichever is lower. This policy allows the import of completely built EVs at a concessional duty, on condition of setting up manufacturing facilities later. A maximum of 40,000 EVs at no more than 8,000 per year for five years is allowed if the investment is \$800 million. This is targeting global car makers and those aiming to make India an EV export hub.

It is not clear yet how this policy will play out and how the takers will respond. There is speculation about the new competition. Market watchers expect new model entries in the expensive high-end car segment, which has a smaller market share in

India with only a few models of domestic manufacturers. It is not known how the targeted localisation will eventually impact the affordable car space and the mass market dominated by domestic players. Domestic players are reportedly worried about the competition at this early stage of electrification, when the EV production base is nascent, cost curves are high, volumes are low and the market is yet to mature.

They will have to step up to bring in advanced, better performing and diverse technologies quicker to survive the competition from foreign investors who have to meet the 50 per cent localisation target within five years. This also means that domestic players, who are still sitting on the fence on the electrification agenda, have to fast pace their slow track. Clearly, this new policy is part of the larger strategy to promote and support local manufacturing in order to leverage a low carbon strategy for a larger economic spin-off. Already, production-linked incentives for advanced chemistry batteries and state-level EV policies have offered a slew of incentives for local manufacturing facilities. But for these to deliver on their intended objective, more effective levers are needed for sustained scalability of the market to reduce uncertainty.

This makes the suggestion of EAC-PM working paper—to set an annual target or quota for EV sales for the manufacturers—very significant and important. Just relying on demand incentives as

part of the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) strategy and state-level incentives to create an assured, scalable market is not adequate. More is needed to address the barriers of 'upfront cost, range anxiety, lack of model options, unknown resale value and early stages of technology development', as reported to have been highlighted in the EAC-PM working paper.

This also needs a regulatory target for sustained fleet electrification and zero emission supply mandate for EV manufacturers. Reliance on only demand incentives makes consumers compete for a limited number of EV models in the market, which may increase cost pressures. But a supply mandate for manufacturers to produce and sell a certain share of their annual vehicle production as EVs and also to meet their fuel economy target can put downward pressure on the cost curve, as they will have to compete for the market to meet their targets. This competition can drive innovation and product diversification, increase choices for consumers and build consumer confidence. This actually works in the interest of domestic manufacturers.

Usually, it is assumed that the auto industry will not accept such a strategy. But a stakeholder opinion survey conducted in 2022 by New Delhi-based non-profit think tank Centre for Science and Environment (CSE) had shown that OEMs are actually not unwilling to accept the ZEV supply mandate, but are conservative about targets. Predictably,

their preferences for indicative targets vary across segments, depending on their expected growth in the segment. While two/three-wheeler OEMs are open to potentially higher regulatory targets, car OEMs advocate a minimal target. But it is still important to begin quickly—even with a conservative target. This can give a reality check to Society of Indian Automobile Manufacturers' (SIAM's) own voluntary EV target of 40 per cent and to the Centre's own intended aspiration of transformative electrification in the timeframe of 2030-40. This can put all policy accelerators in full gear.

The ZEV supply mandate and regulatory targets, along with stronger fuel economy standards and credit trading mechanisms, can enable better leveraging of all policies in place—including demand incentives, production-linked incentives as well as state policies—for quicker acceleration. Resultant economies of scale and lower costs can, in turn, reduce subsidy burden subsequently and allow the EV initiative to be more revenue neutral.

More assured and sustained market development can also accelerate supportive national battery development programmes for large-scale cell production and commercialisation of mature cell technologies, development of new cell chemistries, stronger, reliable and affordable supply chain of critical minerals and higher levels of technology readiness in India. Be it localisation, mobilisation of foreign investments, or India's own effort to secure

minerals from overseas and domestic mining to support domestic manufacturing—tying up such massive investments can become more viable and catalytic, if industry has a regulatory target and ZEV supply mandate for a long-term policy visibility of a scalable market.

Finance Minister Nirmala Sitharaman in her speech on the Union Budget 2025-26, underscored the need for localisation of EV manufacturing and raw material security for battery production. This signalled a firmer policy thrust on industrial development and employment generation around EV production in India. This can be an opportunity to co-join climate and clean air action with an industrial strategy to accelerate clean energy transition in the automotive sector. The budget proposal has further connected electrification, with upscaling of mass commuting modes of electric buses to maximise the energy and emissions saving gains. The cornerstones of the spending priority outlined in the Union budget are as follows:

- Support and incentives for EV manufacturing with custom duty exemptions on 35 capital goods for EV battery manufacturing; support for domestic manufacturing of motors, controllers and other critical components; and integration of EV manufacturing with clean technology manufacturing programmes.
- There is a committed budget for the PM E-drive with a sizable allocation of ₹4,000 crore to upscale

electrification of the two-wheeler and heavy-duty vehicle segments.

- PM e-Bus Sewa Payment Security Mechanism for procurement and operations of e-buses by public transport authorities to upscale and sustain electric bus services during their service life to decarbonise mass commuting in cities.
- There is continued support for the Production Linked Incentive (PLI) schemes for advanced chemistry cell manufacturing.

This time, several pieces of EV ecosystems have come together relatively more cohesively to take an ecosystem approach to localisation of the industry. The rationale for this composite basket of incentives and allocation was outlined in the Economic Survey 2024. The Survey, while reiterating the importance of electric mobility in mitigating road transport emissions (amounting to nearly 75 per cent of the emissions from the transportation sector) to meet the Net Zero goals by 2070, has expressed urgency to expand local manufacturing to de-risk the EV strategy. It has expressed deep concerns around the import intensity of EV production—especially from countries with whom India has large trade deficits and has asked for rapid indigenisation of technology and raw material processing to fend off China's dominance.

It has made an explicit connection between the success of the ongoing schemes, including FAME India, PLI Scheme for Automobile and Auto

Component Industry and Advanced Chemistry Cell batteries, and the Scheme for Manufacturing of Electric Passenger Cars in India, among others, with the strengthening the domestic supply chains. If not addressed, the risk of material insecurity can be enhanced. Manufacturing of an EV in relation to an ICE car requires nearly six times more minerals to produce and this should be available for processing in India, states the Survey. It further cites the International Monetary Fund to suggest that if the trade of critical minerals is disrupted, investment in EVs and renewable energy can be lower by as much as 30 per cent by 2030 compared to an unfragmented market.

If the lithium-ion batteries market in India is expected to grow at a Compound Annual Growth Rate of 23 per cent by 2030, de-risking this supply chain will be a necessity. The Union Ministry of Mines has identified 33 critical minerals needed for material security but found that 24 are at high risk of supply disruptions due to China's dominance of the global supply chain.

If de-risking of the supply chain becomes the primary focus of the EV transition, and the budget aims to contribute to that direction, a self-reliant ecosystem will require increased investments and institutional capacity for R&D in advanced battery technologies. The Survey states that this will require more R&D capacity for sodium-ion and Solid-State Batteries, securing intellectual property,

and efforts towards battery recycling for material security. CSE has been arguing in its studies on this aspect that an accelerated localisation strategy can be an opportunity for focused cell and battery development programmes to build competence, capability and capacity for scaling up India's EV transition. A national battery development programme can facilitate large-scale cell production and commercialisation of mature cell technologies, development of new cell chemistries, strengthening of material security through circularity, and technology development to achieve higher levels of technology readiness for commercialisation and market maturity.

However, it is also important to emphasise once again that the new budgetary initiative will also require much stronger framing of the national EV policies to include binding regulatory targets for time bound electrification, zero emissions mandate for supply side management, and strengthening of the regulatory enablers like stringent fuel economy standards for a strong market pull. Otherwise, without a committed demand for EVs in the domestic market, the expected upscaling of localisation can remain suboptimal.

It is also necessary to not to lose sight of the continued budgetary support for the electric bus programme in the new budget. While PM e-bus Sewa is an opportunity to upscale bus service in a larger number of cities and towns, the explicit underpinning

of the importance of public transportation for viable energy transition and reducing import dependence in the Survey needs to be taken forward. It is stated that 'expanding the public transportation network is another avenue of reducing dependence on overseas supply chains that E-Mobility entails'. Such an approach 'instead of private e-mobility solutions' can be more equitable to ensure benefits of clean mobility for all and for 'more resilient and equitable energy transition'. It is now a matter of 'wait and watch' to see how localisation and EV transition will accelerate in India.

Clearly, there is no scope of turning back to stop India from developing an EV programme as a self-reliant industrial policy to meet the needs of climate and clean air action, industrial development, and clean energy transition in the automotive sector. Vehicles are the top contributors to the toxins we breathe. The problem is not just with the different categories of vehicles that add to pollution, but also with their numbers on the road that add to congestion and in turn to pollution. So, the twin action agenda for air pollution control is to make the transition to clean vehicles and to reduce the vehicle numbers. When Delhi transitioned to compressed natural gas (CNG) in the early 2000s, it targeted gross polluting vehicles such as buses, taxis and auto-rickshaws. This category of public and commercial vehicles has the highest mileage of travel in any city, particularly Delhi, and the science of pollution is clear that the longer the

travel, the greater the emissions. In addition, a public subsidy given for replacing the old with newer CNG vehicles was directed towards upgrading the public transport system—providing space for people to move and not vehicles.

But Delhi's story went wrong—a policy mistake must not be repeated because it negates the gains of clean air and wastes public investment. Delhi, in the two decades following its CNG revolution, has not been able to sufficiently improve its public transport in a way that it restricts the growth of vehicles on the road. Delhi adds some 1,800 new personal vehicles to its roads each day, of which over 500 are private cars. The country on the whole adds over 10,000 private cars onto its roads every day. This explosion of vehicles on our roads, despite all the new flyovers and road networks, has meant that we are stuck in traffic and speeds are down. The correlation between hours spent in traffic and growing air pollution is well established. But the story gets worse. Another study by CSE finds that since buses get stuck in the same traffic, the chronic delays mean that bus ridership goes down as people shift to the more dependable private transport. The Delhi metro, which has an incredible reach now, is also losing because of the lack of last-mile connectivity, the associated costs and other hassles. ■

I have a game
changer. Let's
ban breathing in
the existing air and
get it replaced by
fresh air



A National Priority

Despite significant progress, substantial gaps
persist in the country's ongoing battle
against air pollution



TACKLING AIR pollution is an urgent national priority. Over decades, legislations and policies have been adopted for air quality management in India. Even though the Air (Pollution and Control of Pollution) Act, 1981, and the National Ambient Air Quality Standards (NAAQS) have been in existence for a considerable length of time, there was never a clear executive strategy for nationwide air quality management to enable meeting of the NAAQS across all regions. Only sectoral emissions regulations have been adopted. But there is no cohesive strategy to improve ambient air quality by

linking a range of sectoral actions and solutions in cities and regions to meet the clean air targets.

This has led to a considerable policy debate over the decades seeking adoption of global good practices in air quality management to meet the air quality targets. The legal framework for such an approach in several countries, including the US and Europe, were under scrutiny. For instance, in Europe, the Air Quality Directive sets limits for the levels of various pollutants and corresponding margins of tolerance and time limits for compliance. Each EU country is required by the Air Quality Directive to define 'zones' and 'agglomerations' to which pollutant limits will apply. There is an absolute obligation on member states to ensure that the limits and margins of tolerance for air pollutants are not exceeded in any zone or agglomeration after the deadline. Similarly, in the US, the areas that did not meet the US National Ambient Air Quality Standards and violated their Clean Air Act requirements were given time-bound air quality targets. So, there was a need for a national framework for air quality management with a compliance strategy.

The Union Ministry of Environment, Forest and Climate Change (MOEFCC) launched the National Clean Air Programme (NCAP) in January 2019. This national programme is the first-ever effort to set clean air targets for 131 cities designated as non-attainment cities due to consistently high

particulate levels exceeding NAAQS. These cities are required to reduce particulate concentration by 20-30 per cent by 2024 from the base year of 2017. This target has been further revised to achieve up to 40 per cent reduction by 2025-26 with respect to the base year of 2019-20. This is also the first instance of performance-linked funding for improving air quality. Cities have to demonstrate improvement in air quality to access this fund.

A lot of money has flowed in to fund clean air action plans. There are three key approaches to this fund flow: fund allocated by MOEFCC to 82 cities under the NCAP programme; direct funding from the 15th Finance Commission (XV-FC) grant to the 42 cities and seven urban agglomerations with more than a million population (also called the Million-Plus Cities Challenge Fund); and accounting of the convergence funding, which is, alignment of separate funds for sectoral schemes to deliver on clean air objectives. As much as ₹19,711 crore has been earmarked for 131 cities from FY 2019–20 to FY 2025–26, as stated in a 2023–24 MOEFCC report. Of this, about ₹3,172.00 crore has come to 82 cities under NCAP and about ₹16,539.00 crore to 42 million-plus cities and seven urban agglomerations under the XV-FC grant. Initially, 102 cities were designated as non-attainment. Subsequently, 22 more cities were added to this list. Of these, 42 are million-plus cities or urban agglomerations. Among these 42 million-plus cities, 34 cities are included in the

NCAP list of non-attainment cities. Additionally, eight new cities, all million-plus but not non-attainment cities, were included in the programme. Later, Asansol and Raniganj were combined into a single entity, resulting in a final count of 131 non-attainment cities. The eight new million-plus cities include Faridabad, Meerut, Chennai, Vasai–Virar, Jabalpur, Ranchi, Jamshedpur and Rajkot. Under NCAP, annual targets have been given by the Central Pollution Control Board (CPCB) to 82 cities for reduction in PM₁₀ (PM is particulate matter) concentrations by 3–15 per cent, aiming for an overall reduction of up to 40 per cent by 2026. Additionally, 49 cities under the XV-FC air quality grant have been assigned an annual target to reduce PM₁₀ concentrations by 15 per cent and increase the number of good air quality days—Air Quality Index (AQI) below 200.

While NCAP funding is channelised through state pollution control boards (SPCBs) to the concerned departments, the XV-FC funding is routed through state finance ministries and subsequently to urban local bodies (ULBs). The funding is performance-linked. Though the criteria for performance assessment have been evolving over time, currently they require cities to demonstrate improvement in ambient PM₁₀ levels. Additionally, XV-FC cities must also show an increase in the number of good air days (AQI below 200). The financial allocation is a performance-based supplemental grant for

funding of activities approved under the city action plans and city micro action plans. Cities are also expected to report progress under other sectoral schemes and programmes that are funded by the Union government or state governments. These are classified as convergence funding—the idea being that all relevant sectoral schemes need to be aligned to deliver on clean air indicators.

By 2024, 24 states and Union Territories (UTs) have prepared state action plans and 131 cities have prepared city action plans. At the national level, MOEFCC is also seeking to create a national level action plan that will seek convergence of schemes and programme of seven line ministries including Ministry of Power, Ministry of Road Transport and Highways, Ministry of Housing and Urban Affairs, Ministry of New and Renewable Energy, Ministry of Petroleum and Natural Gas, Ministry of Heavy Industries, and Ministry of Health and Family Welfare.

To assess NCAP's performance, in 2024, Delhi-based think tank Centre for Science and Environment (CSE) carried out a rapid review of the performance-linked planning and funding to understand the gaps and further needs for a more robust and expanded programme. It finds that, given the nationwide air pollution and associated public health challenges, this programme needs strengthening at the national as well as state levels for deeper institutionalisation and resource

mobilisation for upscaled multi-sector action. To enable sustained action and its funding, it is necessary to tap the learning curve from the ongoing phase of implementation.

MOEFCC has initiated discussions with state governments regarding the next phase of funding. It is proposing to establish an Air Quality Challenge Fund under NCAP, which is to be allocated to cities based on their population and pollution load. The initiative may require cities to commit to mitigating air pollution by fulfilling specific criteria for implementation of prescribed sectoral action. Distribution of funds is expected to happen based on performance against annual air pollution reduction targets. The criteria will combine the added reform-based challenges. Any future funding initiative therefore requires tapping of the learning curve so far.

While significant amounts of funds have been released to cities for clean air action, the level of utilisation is not up to the mark and utilisation is a lot less in NCAP cities compared to XV-FC cities. According to the Sixteenth meeting of the Implementation Committee for National Clean Air Programme held in May 2024, an amount of approximately ₹10,566.47 crore was released to the 131 cities between FY 2019–20 and FY 2023–24 (till May 3, 2024) under both NCAP and XV-FC. The overall utilisation of funds fell short of target. The 82 NCAP cities had utilised only ₹831.42 crore

of the ₹1,615.47 crore released until May 3, 2024, or 51 per cent of the total released funds. The 42 cities and seven urban agglomerations had utilised ₹5,974.73 crore of ₹8,951 crore, which was about 67 per cent. This indicated that the scale and speed of action were yet to catch up. Clearly, utilisation of the available funding falls short of the targets—more so in the smaller NCAP towns. It is therefore necessary to understand what is slowing down fund absorption, how the money is being spent, and the gaps in planning and implementation.

To enable performance-linked funding, CPCB has set up a monitoring and reporting mechanism. This has also been directed by the National Green Tribunal (NGT). CPCB has provided a detailed sector-wise indicator to track progress. All concerned cities are expected to report progress against each of these indicators every quarter. These indicators cover multiple sectors that include air quality monitoring; pollution source assessment; public outreach on air quality; road dust, construction and demolition (C&D) waste; solid waste management; industry; and vehicular pollution, including on-road and old vehicles, public transport, non-motorised transport, parking and freight. The total number of indicators adds up to about 258. These are distributed as follows—capacity building, monitoring network and source apportionment (related to air quality): 12; public outreach: 7; road dust: 23; waste and biomass which include municipal solid waste:

33; construction and demolition: 13; vehicles: 42; industries: 119; air quality data: 9.

The cities are required to report progress in action directly on the Portal for Regulation of Air-pollution in Non-Attainment cities (PRANA) created by CPCB. This portal is a single-window platform that provides real-time information on city-wise pollution levels and actions. SPCBs and ULBs have direct access to PRANA for reporting purposes. The information filed in the portal is the basis of performance evaluation.

Every quarter, cities are required to coordinate to provide the status of action on each of the targets on the portal; indicate progress against targets for each indicator; state the deviation from the targets (if any); and provide details on funds allocated, released and utilised; and fund requirements for implementation of each action. Cities are required to provide supportive material, evidence and information as attachments for verification of action. This elaborate process requires a systemic response.

While under the NCAP programme, cities need to demonstrate improvement in PM_{10} levels to access funds, there is yet another parallel programme, Swachh Vayu Survekshan (SVS), introduced by the MOEFCC in 2022 to rank cities based on the level of policy measures implemented. These cities (classified based on population—above 1 million, 0.3–1 million, and under 0.3 million) are ranked

based on policy measures implemented in multiple sectors including biomass, municipal solid waste, road dust, dust from construction and demolition waste, vehicular and industrial emissions, other emissions, public awareness, and improvement in PM_{10} concentration.

All NCAP cities are assessed under SVS as well based on a scoring framework and information provided by the cities/ULBs on PRANA every financial year. For the purpose of this ranking under SVS, weightages have been attributed and quantitative performance targets have been set for each sector. This framing is important to drive implementation and deepen the scope of action while improving compliance. While these assessment frameworks are steps in the right direction, there are serious questions about the metrics used to benchmark progress in cities and their implications for real improvement. Under the different programmatic approaches of NCAP, XV-FC and SVS, the cities are judged based on different metrics. The effectiveness of ranking and performance evaluation will depend on the method of assessment; benchmarks considered for tracking progress in each sector that defines the nature, scope and scale of action; ability of the states to design action that can make a difference; the uniform spread and deepening of priority action across all key sectors; and the tracking method for air quality improvement.

The CSE rapid review has pointed out some

critical performance glitches. Even though the NCAP programme was originally planned to reduce both PM_{10} and $PM_{2.5}$ concentrations in non-attainment cities, in practice, only PM_{10} concentration is being considered for performance assessment. PM_{10} is the coarser fraction of the particles and is largely influenced by wind-blown dust. But $PM_{2.5}$, which is a tinier sub-set of PM_{10} and a more harmful fraction emitted largely from combustion sources, gets neglected. $PM_{2.5}$ poses a greater health risk as it penetrates deeper into the lungs, entering the bloodstream and affecting nearly all organs (*refer to preceding chapters*). One of the reasons for the initial focus on PM10 was the inadequate PM2.5 monitoring network across the 131 non-attainment cities. However, the situation has changed considerably now. All million-plus cities under the XV-FC grant have $PM_{2.5}$ monitors and can immediately graduate to $PM_{2.5}$ -linked performance funding.

This focus on PM_{10} is impacting the sector-wise spending under NCAP and XV-FC grants. Review of the spending under NCAP shows that as much as 64 per cent of the total funds has gone into road paving and widening, pothole repair, water sprinkling, mechanical sweepers, among other things. Comparatively, a far lesser amount of funds have been allocated for combustion sources that emit more harmful pollutants—only 14.51 per cent of the total funding is used for controlling biomass

burning, 12.63 per cent for vehicular pollution control and a mere 0.61 per cent for industrial pollution control. The primary focus of the funding is thus road dust mitigation. Tying up such an enormous amount of funds only for road dust control can make the interventions for controlling toxic emissions from combustion sources sub-optimal.

According to the CSE assessment, some combustion sources, including waste-burning and vehicles, are getting partially addressed through the convergence funding or funding earmarked for specific sectoral schemes for waste management programmes like Swachh Bharat Mission 2.0, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Smart City programme, Faster Adoption and Manufacturing of Electric Vehicles in India (FAME-II), and others. While this is an important strategy to align action and spending across sectors around the clean air indicators, the funds dedicated for NCAP and XV-FC grants must be linked with more priority measures across transport, industry, waste and use of solid fuels.

Most of the emissions inventory and source apportionment studies carried out in cities that assess the relative contribution of pollution sources to the ambient air quality, show a high share of road dust that can also be carrier of toxic substances. Therefore, road dust control needs to be part of the efforts but not overwhelm the efforts. Moreover, the

results of the source apportionment and inventories also need to be understood along with a wider set of scientific criteria. Air pollution science has matured considerably in this regard. In its 'Report of the Steering Committee on Air Pollution and Health Related Issues' (2015), the Union Ministry of Health and Family Welfare stated that ambient concentration is not a good surrogate for total air pollution related to public health risk and cannot indicate exposure and health outcomes. It is the proximity and duration of exposure to the pollution source and inhalation of pollutants that determine the health risk. Therefore, along with pollution concentration management, human exposure management becomes important. Studies such as those carried out by the US-based Health Effect Institute show the differentiated health impact of particulate matter. For instance, particles from coal and diesel combustion are more harmful than windblown dust. The World Health Organization (WHO) has emphasised on the need for regulating tinier particles.

Going forward, the impact of policy action on PM_{10} levels will be more difficult to establish, as it is also highly impacted by wind-blown dust from outside the city, loose sub-soil from farmlands, and dust storm events. However, PM_{10} is released largely by specific dust sources like mining and construction. Therefore, the focus on PM_{10} monitoring should be more source-specific.

Currently, WHO is assessing the ways to address and account for dust and dust events that are of different nature.

The benchmark for performance-linked funding under NCAP should be $PM_{2.5}$, which is a more relevant health indicator to assess improvement in air quality. As an immediate strategy, performance assessment for all million-plus cities should be linked with $PM_{2.5}$. All these cities have real-time monitors for $PM_{2.5}$ data generation, which is why they are also required to show an increase in good air quality days as per AQI, which is estimated based on real-time data. The review of the available $PM_{2.5}$ source apportionment studies from different cities shows that the contribution of road dust to $PM_{2.5}$ concentration can be high in northern cities, but in most cases, the contribution of combustion sources to $PM_{2.5}$ concentration—including industry, vehicles and waste burning—is substantial.

Equally important to note is the share of secondary pollutants formed from nitrogen oxides, sulphur dioxide and other gases. During the winter, when pollution levels peak in nearly all cities, the share of road dust reduces significantly while that of combustion sources increases dramatically. In the overall $PM_{2.5}$ concentration, the share of secondary particulates can be considerably high. In Delhi, it can be as high as 30 per cent during winter. The regulatory focus needs to shift towards $PM_{2.5}$ now to mitigate emissions from combustion sources

including industry, vehicles, open burning, solid fuels for cooking, incineration, diesel-generator (DG) sets, among others. While setting targets for $PM_{2.5}$ reduction for cities ensures a larger clean up across the region and the airshed, as is the global good practice, both $PM_{2.5}$ and secondary particulate matter are influenced by the transboundary movement of pollution across the regional airshed. This, therefore, calls for a strong interface between city and state-level clean air action plans to meet both local and regional air quality targets.

Most of the future expansion of the air quality monitoring grid will happen based on real-time monitoring. This creates an opportunity to make $PM_{2.5}$ the basis of benchmarking progress in air quality in all cities. If this is not corrected, a significant part of the spending and efforts will get diverted from the critical sources of toxic emissions like industry and vehicles.

The cities that score high for taking sectoral action under svcs can paradoxically be the worst-performing cities for not improving PM_{10} concentration under the NCAP and XV-FC grant ranking. There is no way to establish the link between action and improvement in PM_{10} levels. The comparison of the two systems (PM_{10} improvement in NCAP, XV-FC cities and level of action along with the PM_{10} improvement under svcs) shows that they do not always correspond. For instance, in 2022–23, Agra, Delhi, Ghaziabad,

Meerut and Jabalpur performed well under svS in the applicable population category of more than one-million, but performed poorly under NCAP and XV-FC categories for reducing PM_{10} . Delhi ranked 9th under svS for implementing policy measures but is at the bottom under the NCAP assessment, with a score of 0, for not improving PM_{10} levels.

In the 0.3-1 million population category, Amravati, Guntur and Rajahmundry are the best performers for taking action under svS but are at the bottom, scoring zero, under the NCAP assessment. In the population category of below 0.3 million, cities like Kala Amb, Angul and Talcher ranked at the top under svS for taking action but at the bottom in the NCAP assessment.

However, there are several cities that have performed well both under the svS as well as under the NCAP/XV-FC verticals. For instance, in 2022–23, Indore, Srinagar, Bhopal and Trichy (with populations of more than one million) ranked best under both svS and NCAP/XV-FC assessments. Similarly, Moradabad, Firozabad, Ujjain and Bareilly (0.3-1 million population) are at the top under both svS and NCAP. Among the smaller cities (population less than 0.3 million), Parwanoo and Raebareilly are at the top under both svS and NCAP assessments.

On the other hand, there can be large variability in annual PM_{10} levels due to meteorological factors. The annual PM_{10} levels may reduce or increase due



to dust events and impact of other windblown dust sources. This may not adequately mirror the impact of action across all key sectors including industry, transport, waste and solid fuels on PM_{10} levels. Annual changes in PM_{10} can be highly influenced by meteorology, dust storms and heatwaves. It is therefore necessary to demonstrate the scale and nature of action needed in targeted sectors to achieve effective reduction in pollution concentration. Not enough details are available about the scale and depth of policy measures implemented in cities and the larger region to understand what makes a difference to the air quality and why. This needs to be addressed to avoid the risk of attributing success in reducing annual PM_{10} level inadvertently to meteorological and atmospheric changes. It is necessary to convey the scale and nature of action that are contributing to the air quality changes.

With the current focus on dust control, the key combustion sources including transport, industry and use of solid fuels in households and open eateries often do not receive adequate priority to build ambitious pathways. Due to city-specific action and hard lines drawn around the municipal boundaries, most industrial sources and power plants remain outside the orbit of the city action plans. The small- and medium-scale units that exist in the non-conforming areas of cities are often not considered.

The CSE rapid review in states showed that these

sectors face the maximum challenge in accelerating action more holistically. Diversity of issues like lack of well-funded specific schemes to support action, technology transformation and design changes, and the complexity of new generation policies, are slowing down action in these sectors.

The progress reports of cities have minimal information on the indicators developed by CPCB for transport sector interventions requiring improvement in on-road emissions management, old vehicle phaseout, vehicle electrification, public transport improvement, non-motorised transport and parking policy as a demand management measure. These strategies are not well-developed—quantitatively or qualitatively—for implementation, funding and reporting. For the management of on-road emissions, for instance, information is largely confined to the business-as-usual Pollution Under Control (PUC) *challans* and limited action on old vehicle phase out. But these have not translated into renewal and scrappage policies in line with the scrappage and fleet renewal notifications of the Union Ministry of Road Transport and Highways. Even where states have proposed advancement in on-road emissions monitoring with remote sensing monitoring of vehicles in their city action plans, this cannot proceed as the central rules have not been notified by the ministry. There is also no strategy to phase out old heavy-duty vehicles that are significant contributors among the vehicle

segments.

Moreover, the CPCB indicators related to parking policy as a demand management measure are not well understood. Cities often take this as a supply-side management issue to plan for provisions of more parking to meet insatiable parking needs and report only on construction of multi-level car parks. Such actions are not aligned with the provision of National Urban Transport Policy or National Transit Oriented Development Policy, or the Union Ministry of Housing and Urban Affairs' National Mission on Sustainable Habitat for transport and service-level benchmarks. These policies already underscore demand management and restraint principles. This means that while meeting the requirement of parking, area-wide planning must be undertaken to reduce demand for parking by limiting and demarcating legal parking areas, penalising illegal parking, introducing dynamic variable parking rates, and eliminating free parking through parking area management plans. There is no clarity at the city level about why parking is a clean air action.

Only if a non-attainment city is an industrial city/town, do some additional steps on industrial pollution control get reported. But even this is not done uniformly and exhaustively. Industrial pollution control remains largely business-as-usual, with minimal reporting. Pollution control in the industry sector is largely reported based

on the regulatory function and requirements of stack emissions inspection, *challans* and closure notices, and notification of approved fuel list to promote cleaner industrial fuels. But this does not capture the status and scale of fuel change in industry, adoption of emissions control technology and cleaner processes by types of industries on ground. Detailed status of large-, medium- and small-scale industries and red and orange categories of industries is not usually available. There is little information in city progress reports on the impact of the approved fuel list and any upscaled action to accelerate clean fuels and technology transition.

Increasingly, assessments of pollution sources have shown the impact of solid fuels for cooking in households and open eateries. This fuel is a significant source of emissions and ambient concentration. In fact, it emerges as among the top polluters in the pollution inventory done for the seven states of the Indo-Gangetic Plain by a CPCB committee. Even though Union government programmes including the Ujjwala scheme have increased use of liquified petroleum gas (LPG) nationally, a lot more is needed to make a difference. This will require focussed attention. There are states like West Bengal which is taking steps to replace solid fuel stoves with LPG stoves in Kolkata and also distributing smokeless *chulhas* to control emissions.

The current funding system under the XV-FC grant will come to an end in 2025–26. It is not yet

known to what extent the central allocation for the NCAP programme is scalable and how the proposed Champion Fund is expected to be designed and funded in the next phase. There is a proposal to introduce a challenge fund that is likely to be earmarked for specific sectoral strategies. This needs to be designed well for scale of implementation across the states.

In the next phase, a more structured approach is needed to mobilise and align resources for clean air action. Year-wise budget forecasts for ongoing and new schemes at least up to 2030 need to be aligned. Schemes should also be aligned with the short and long-term targets and associated indicators of the action plan that are defined by the central and state level policies, regulations and service-level benchmarks. New schemes need to be defined for the full scope of scalable action.

A few studies have also pointed out the not-so-impressive impacts of NCAP. Sixteen Indian cities, despite receiving close to ₹1,000 crore, collectively, over the last eight years to counter air pollution, have been listed within the 50 most polluted cities of the world. It is a finding that has put NCAP performance under a microscope. Environmentalists claimed that the efficacy of the costliest air pollution control programme ever taken up in India, and one of the biggest globally, has come under further scrutiny as the programme has been found to be non-existent within 19 Indian cities listed in the 'most polluted'

top 50 list. According to PRANA, which outlines NCAP performance, ₹11,541 crore has been released till March 14, 2025 to the non-attainment cities that were found to be polluted over a long period of time.

The study was carried out by IQAir, a Swiss air quality technology company, based on PM 2.5 data collected from more than 40,000 air quality monitoring stations across 8,954 locations in 138 countries, territories, and regions. A closer analysis of the result also showed that 10 of the 35 Indian cities within the most polluted 50 global ones were both under NCAP as well as Smart Cities. It is a finding that raises questions about the urban developmental paradigm pursued in the country.

‘India saw a 7 per cent decline in PM_{2.5} concentrations in 2024, averaging 50.6 µg/m³ compared to 54.4 µg/m³ [microgram per cubic metre] in 2023; yet six of the world’s ten most polluted cities are in India ... India ranked as the world’s fifth most polluted country, down from third the previous year but air pollution remains a significant health burden in India, reducing life expectancy by an estimated 5.2 years,’ said Armen Araradian of IQAir. ‘Severe pollution episodes persisted in 2024, particularly in northern states. January air quality was especially poor in Delhi and Himachal Pradesh. The city of Baddi, in southwestern Himachal Pradesh, saw a January monthly PM_{2.5} average of 165 µg/m³. Air quality

deteriorated sharply in Manipur in October, while November saw extreme pollution levels in Delhi, Punjab, Chandigarh, Haryana, and Himachal Pradesh with crop stubble burning remaining a major contributor to PM_{2.5} levels, accounting for 60 per cent of pollution during peak periods. Overall, 35 per cent of Indian cities reported annual PM_{2.5} averages exceeding ten times the WHO guideline,' he further explained. Despite governmental measures, such as NCAP aiming to reduce pollution levels, challenges persisted due to inconsistent policy implementation and inadequate infrastructure.

Patna and Chandigarh, both NCAP and Smart Cities, were prime examples. While Patna spent ₹233 crore for air pollution control under NCAP since 2017-18, or 78 per cent of its allotted 299 crore; Chandigarh spent around ₹30 crore, or 93 per cent of the released amount of ₹33 crore, during the period. However, both recorded worsening air pollution over the period. Patna's PM10 value, a key pollutant considered for assessing air pollution status under NCAP, rose 3 per cent in 2023-24 compared to 2017-18; while the same rose 2 per cent in Chandigarh during the period. Incidentally, Angul in Odisha, an NCAP city, recorded the highest increase in PM 10 level within the Indian cities in the top 50 list—a whopping 72 per cent. Overall, the NCAP cities in the global top 50 list had been found to reduce 16 per cent of their PM 10 pollution in the past seven years.

Air pollution experts admit that everything was not right with NCAP, and maybe, NCAP 2.0 needs to be pursued. 'It is worrisome that several cities under NCAP for over five years continue to feature in the global top 50 most polluted cities; equally concerning is the fact that some Indian cities not yet covered under NCAP also rank among the world's 50 most polluted,' observed Sunil Dahiya, an air pollution expert and founder of Envirocatalysts, a data and research organisation that works on clean air, decarbonisation and just transition. Dahiya called for 'an urgent revision of NCAP to include more cities and regions, with a systematic, time-bound approach to reducing emissions.' It can be inferred that if pollution levels were rising in some of the NCAP cities, it meant that the spending of the clean air funds was not well aligned with the priority measures that needed to be implemented at a scale. If non-NCAP cities were also polluted, that signalled proliferation of newer pollution hotspots due to lack of regional or airshed based approach to prevent the spread of pollution.

Abhijit Chatterjee, an advisor to NCAP and a scientist with Bose Institute, Kolkata, pointed out that as the focus of NCAP is to reduce PM_{10} , controlling the construction and demolition dust as well as road dust has been prioritised. 'While focusing on larger dust emissions, ultrafine particles emitted from biomass and solid waste burning remained out of surveillance. Therefore, $PM_{2.5}$

emissions are going beyond control,' he explained. 'Air pollution is not restricted to non-attainment cities. Satellite-derived information suggests that the entire Indo-Gangetic Plain is non-attainment. Data also suggest that a large contribution of pollution in non-attainment cities comes from outside the city jurisdiction. Therefore, unless sector-specific mitigation measures are implemented with strict compliance and accountability in regional airsheds, the battle against air pollution cannot be won,' observed Sagnik Dey, a scientist with the Centre for Atmospheric Sciences, Indian Institute of Technology (IIT), Delhi.

India had seen a decline in particulate matter pollution since 2016, but this drop was likely not due to a key government policy like NCAP designed to tackle air pollution, according to a study published in the journal *Science Advances* in January 2025. 'We find a declining trend in average PM_{2.5} concentrations since 2016-2018, particularly in northern India, and confirm that these reductions are not attributable to meteorological variability nor to NCAP,' the researchers wrote in their study. 'In India, there is a lack of air pollution exposure data, which is crucial for researchers to conduct population-based and nationwide studies on the various impacts of ambient air pollution,' said Ayako Kawano, Doerr School of Sustainability from Stanford University. To overcome this, researchers used a machine learning model to analyse daily

PM_{2.5} dataset for India over 2005-23, with data from remote sensing. This data, Kawano said, could help researchers and policymakers investigate and address the impacts of ambient air pollution in India.

The analysis found that much of India saw substantial increases in PM_{2.5} concentrations between 2011 and 2016, compared to 2005-2010, barring Jammu and Kashmir, Punjab and Rajasthan. In 2017-22, this increase was moderated. The most notable decreases in PM_{2.5} levels were seen in Jammu and Kashmir, Punjab, Haryana, Delhi and Rajasthan. These findings were consistent with previous studies that found PM_{2.5} levels dropped by 43 per cent in 2020 compared to 2017-2019 in urban areas. Other various air quality control policies in India, including the implementation of Bharat Stage (BS)-VI emission standards and the closure of power plants near Delhi, might have contributed to this decline. Of the cities analysed, the average New Delhi resident had consistently faced the highest population-weighted average of PM_{2.5} concentrations, with 88.67 µg/m³ in 2022, more than double of India's annual national air quality guideline of 40 µg/m³. Residents of Kolkata and Mumbai had also experienced PM_{2.5} levels exceeding national limits. Still, residents in all mega-cities have experienced a moderate decline in PM_{2.5} exposure since 2016-18, with Mumbai seeing the most substantial decline of 10 per cent, followed

by 8 per cent in New Delhi between 2020 and 2022, the study highlighted.

The declining trend in $PM_{2.5}$ concentrations from 2016 to 2022 was likely partly influenced by meteorological variability like precipitation and relative humidity in the southern regions, but not in the northern regions. Prior to 2015, increased anthropogenic activities and not meteorological conditions drove high concentrations of the pollutant. The team also assessed how implementing NCAP had impacted ambient $PM_{2.5}$ concentrations to date. They compared changes in sub-districts in targeted and non-targeted areas (where NCAP was not implemented), before and after initiation of NCAP. They found no evidence to support that NCAP contributed to reducing $PM_{2.5}$ concentrations in 2021 and 2022. Instead, the decline could be due to COVID-19 pandemic lockdown and other air quality control policies in India, including the implementation of BS-VI emission standards that mandate vehicles to adhere to emission limits and the closure of power plants near Delhi.

So, there is no real link between the progress that cities have supposedly made to reduce PM_{10} with the action that they must have taken to get this done. In fact, there is often an inverse relationship—cities that rank high on reducing levels of pollution are at times the lowest in terms of action taken. This mismatch leads to policy confusion; it tells us nothing about what must be done to combat

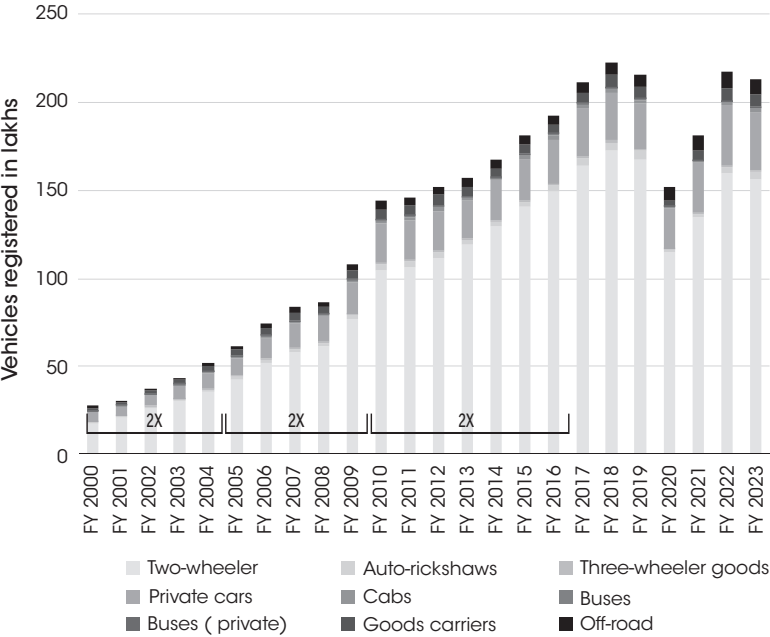
pollution and what is working and where.

What we now know is that air pollution is deadly for our health. This is no longer a question of debate. Most of us who live in the gas-chamber that our cities have become feel the pain of this air that is not fit to breathe. The question is what are we doing about this? This is where the news gets even murkier than the air we are forced to inhale. The much-heralded 'governmentalisation' of the air pollution agenda cannot become an exercise to move the files and tick the boxes. It must be about action. This is about our air; the air we breathe. And, to be clear, air pollution is a great equalizer; the rich and the poor are impacted. This is not the case of water pollution, where the rich can move to cleaning the quality in-house or use bottled water. This is about air, which we will need to breathe and all the air purifiers of the world cannot help us. This is about our health and the health of our children. ■

ANNEXURE

1

India's motorisation trend of annual new registrations, 2000–2024

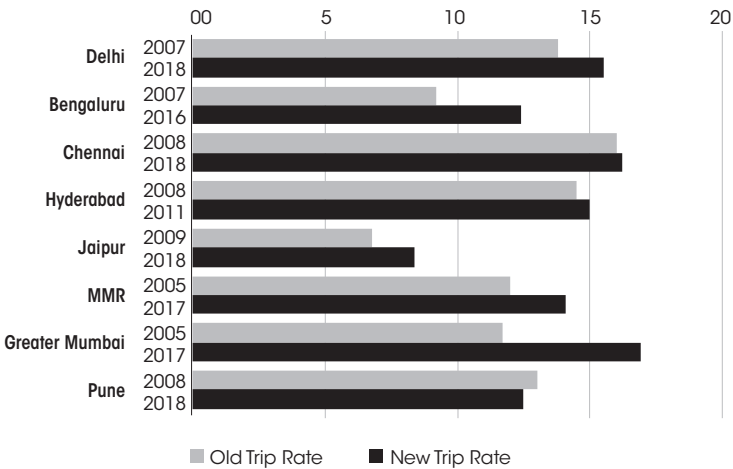


Source: Vahan Database, 2024

2

With growing urban population and urban sprawl, cities are witnessing a high number of trips, and increasing trip length. The available data shows that the average per capita trip rate has increased by 17.5 per cent in cities and the average trip length has gone up by 28.6 per cent in the last 10 years. This implies increase in travel demand and increase in travel distances. In this context if the dependence on personal vehicles continue to grow this will lock in more pollution and carbon.

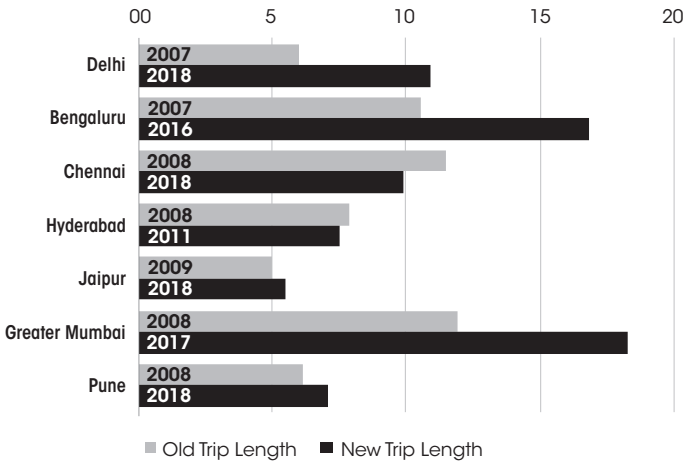
Per capita trip rate in the last decade



Source: Respective city CMPs and CTTS studies, NIUA, IIT-Delhi, Wilbur-Smith Associates

3

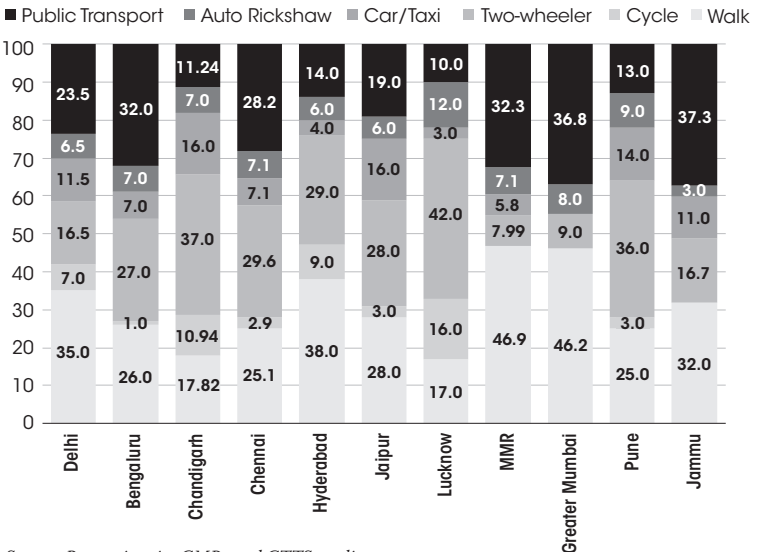
Average trip length in the last decade



Source: Respective city CMPs and CTTS studies, NIUA, IIT-Delhi, Wilbur-Smith Associates

4

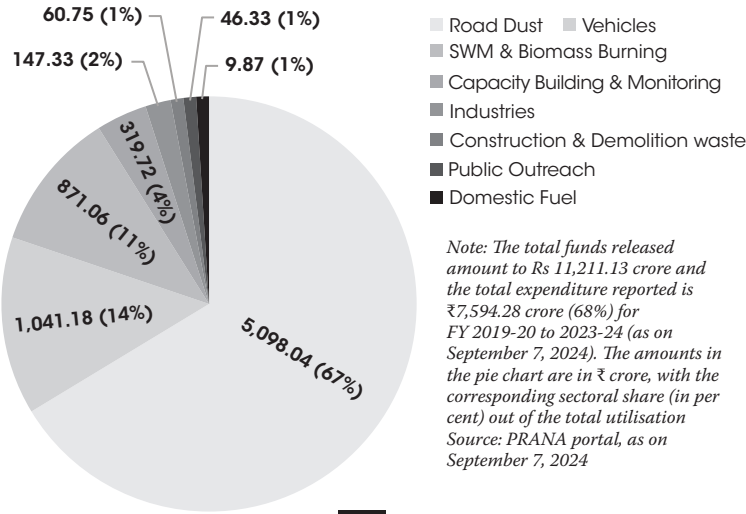
Modal shares in Indian cities show heavy private vehicle dependence



Source: Respective city CMPs and CTTS studies

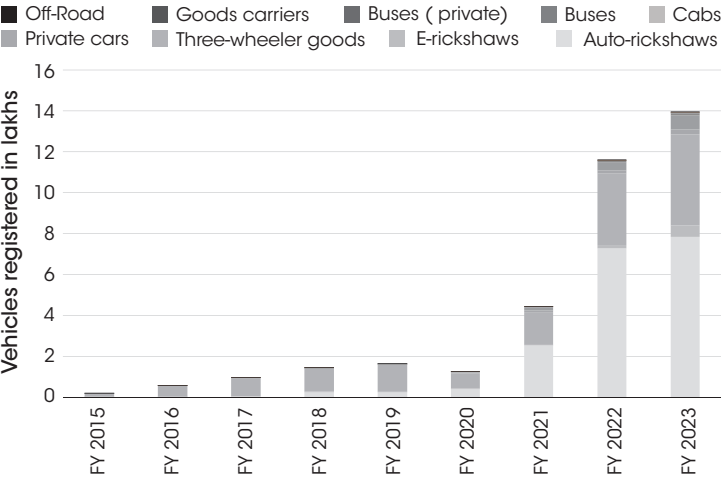
5

NCAP: Sector-wise fund utilisation (in ₹ crore),
FY 2019-20 to 2023-24



6

India's motor vehicle electrification trend in new annual registrations, 2015–2024



Source: Vahan Database

How India moves to work

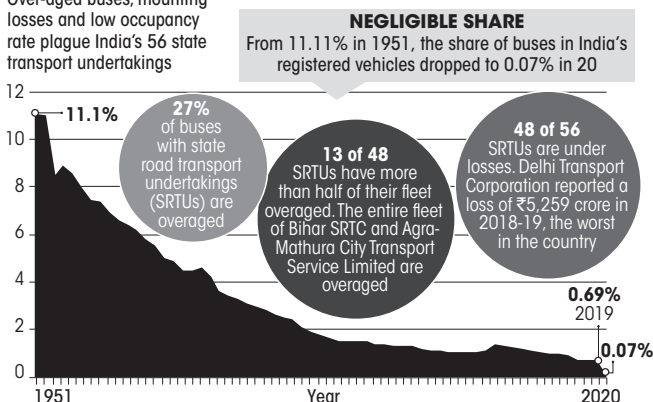
Twenty-three per cent of the working population in urban India walks to their jobs, as compared to 22 per cent in rural India

TRAVEL PREFERENCES (in million)

	Urban	Rural	Total
On foot	26.7	18.5	45.3
Cycling	15.1	11.2	26.3
Moped/Scooter/Motor Cycle	19.1	6.4	25.5
Car/Jeep/Van	4.2	1.3	5.5
Tempo/Autorickshaw/Taxi	3.9	2.1	6
Bus	13.2	9.7	22.9
Train	4.8	2.2	7
Water transport	0.2	0.3	0.5
Others	0.7	0.6	1.3
No travel	27.7	32.5	60.2
All modes of transport	115.7	84.7	200.4

Performance of state bus transport

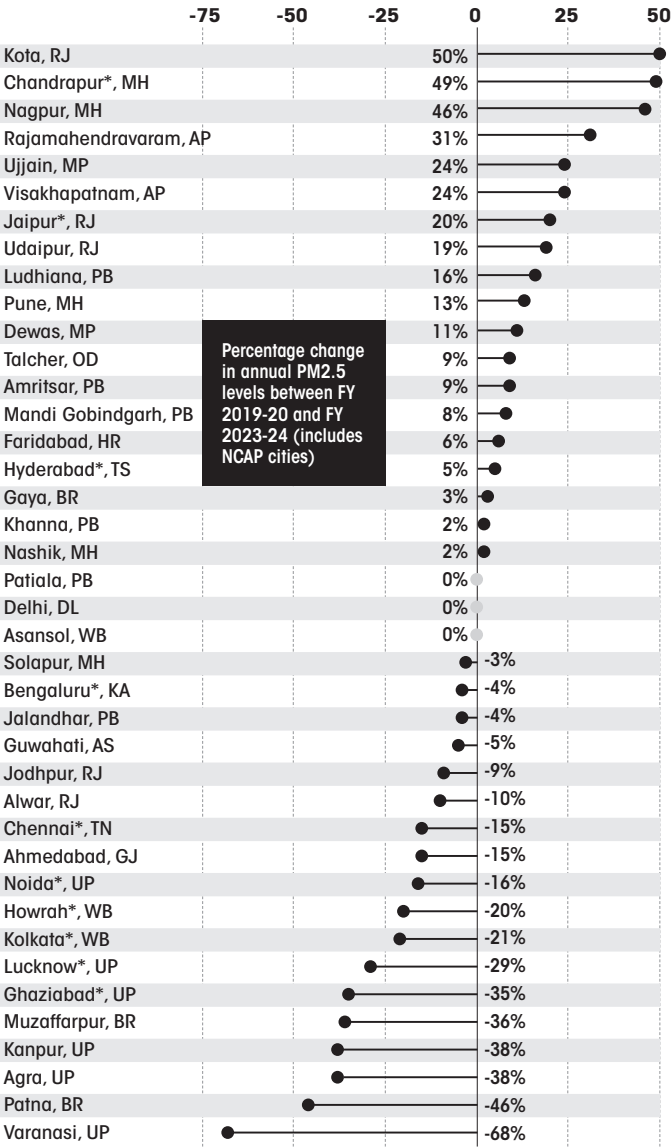
Over-aged buses, mounting losses and low occupancy rate plague India's 56 state transport undertakings

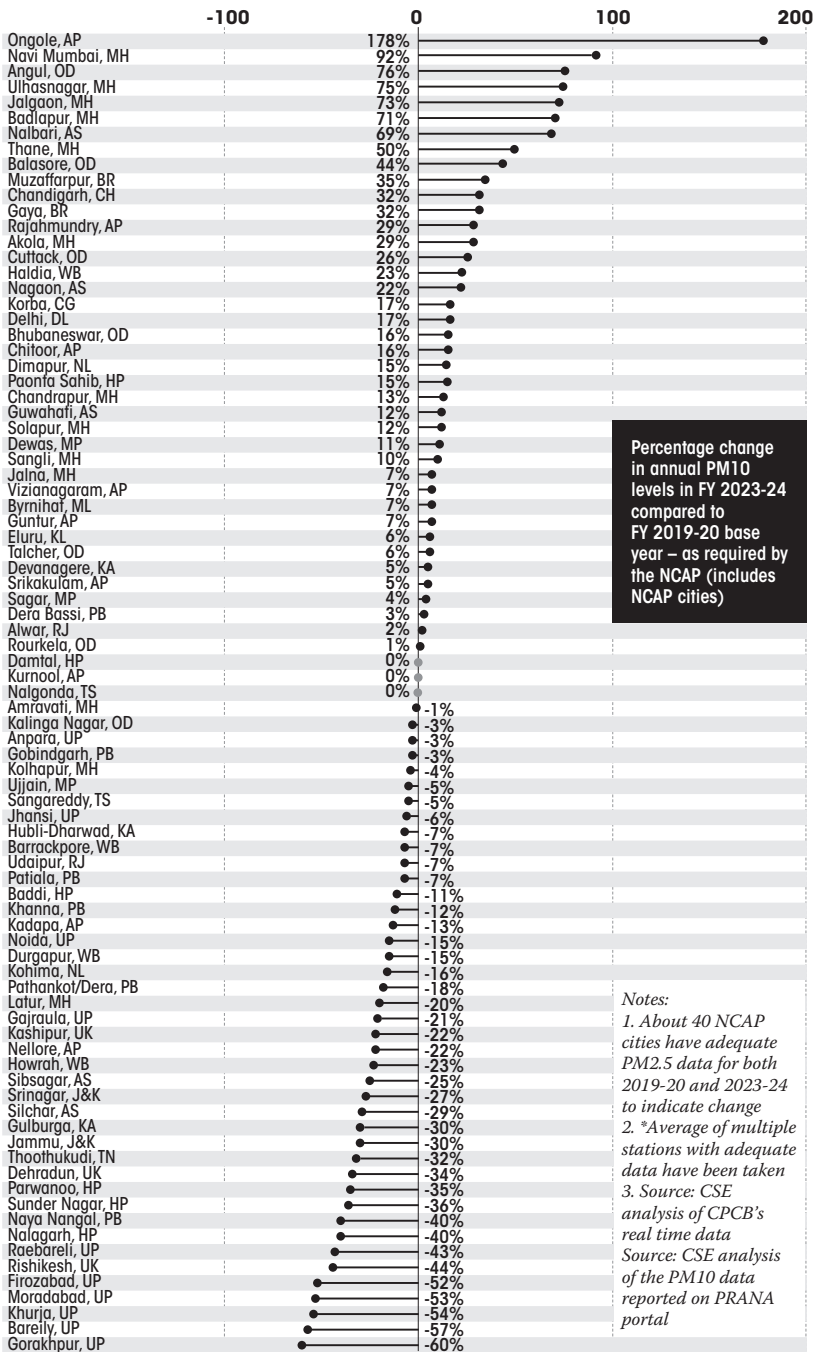


Source: Review of the Performance of State Road Transport Undertakings for 2017-18 & 2018-19 and Road Transport Year Book-2018-2019 & 2019-20, Union Ministry of Road Transport and Highways, June 2023

9

Air quality trends in non-attainment cities under the NCAP programme





10

BREATHING BAD

1.67 million Indians died due to air pollution in 2019. Half of these deaths were in just five states—Uttar Pradesh, Maharashtra, Bihar, West Bengal and Rajasthan. The economic cost was US\$ 36,803 million, which is equivalent to 1.36 per cent of India's GDP

00 Number of deaths attributable to air pollution (range)

00 % share of deaths attributable to air pollution to total deaths in 2019 (range)

00 Economic loss attributable to Air pollution in US\$, millions (range)

00 Economic loss as % of state GDP (range)

01. Andhra Pradesh

Deaths
62,808 (50,176-77,486)
15.6% (13.6-17.6)

Economic risk
1,349.50 (968.9-1,817.8)
1.09% (0.79-1.47)

02. Arunachal Pradesh

Deaths
789 (631-999)
11% (9.4-13.0)

Economic risk
26 (17.6-36.5)
0.74% (0.50-1.04)

03. Assam

Deaths
657 (483.1-864.7)
1.42% (1.04-1.87)

Economic risk
5,130.30 (3,816.0-6,616.1)
2.15% (1.60-2.77)

04. Bihar

Deaths
126,460 (105,308-148,310)
18.8% (16.4-21.1)

Economic risk
1,552.80 (1,153.4-2,022.5)
1.95% (1.45-2.54)

05. Chhattisgarh

Deaths
41,519 (34,890-48,091)
16.9% (14.9-18.8)

Economic risk
690 (512.1-893.8)
1.55% (1.15-2.01)

06. Delhi

Deaths
17,248 (14,625-20,057)
18.2% (16.4-19.8)

Economic risk
1,206.50 (906.2-1,554.8)
1.08% (0.81-1.39)

07. Goa

Deaths
1,396 (1,059-1,784)
13.3% (11.0-15.5)

Economic risk
79.9 (55.5-110.0)
0.72% (0.50-1.00)

08. Gujarat

Deaths
87,811 (71,947-104,322)
18.9% (16.7-20.9)

Economic risk
2,859.60 (2,157.9-3,667.0)
1.33% (1.00-1.71)

09. Haryana

Deaths
34,119 (28,096-40,443)
19% (16.9-20.7)

Economic risk
1,566.30 (1,187.9-2,009.1)
1.49% (1.13-1.91)

10. Himachal Pradesh

Deaths
10,383 (8,377-12,510)
18.5% (15.7-21.2)

Economic risk
253.8 (187.8-331.4)
1.16% (0.86-1.51)

11. J&K and Ladakh

Deaths
15,997 (13,108-19,295)
20.2% (17.3-22.7)

Economic risk
252.2 (188.1-326.7)
1.14% (0.85-1.48)

12. Jharkhand

Deaths
33,136 (27,642-38,553)
16.7% (14.5-18.9)

Economic risk
543.3 (398.2-714.9)
1.24% (0.91-1.63)

13. Karnataka

Deaths
89,184 (72,283-106,651)
16.6% (14.4-18.6)

Economic risk
2,680.70 (2,006.0-3,459.2)
1.22% (0.91-1.58)

14. Kerala



Deaths
36,392 (29,015-44,371)
14.3% (12.2-16.3)



Economic risk
1,090.50 (808.0-1,420.7)
0.98% (0.72-1.27)

15. Madhya Pradesh



Deaths
112,009 (92,397-131,581)
18.7% (16.2-20.8)



Economic risk
1,970.50 (1,479.8-2,541.8)
1.7% (1.28-2.20)

16. Maharashtra



Deaths
139,118 (113,462-166,562)
16.7% (14.9-18.5)



Economic risk
3,975.40 (3,003.6-5,079.6)
1.06% (0.80-1.35)

17. Manipur



Deaths
40.5 (28.8-54.7)
1.08% (0.77-1.46)



Economic risk
5,130.30 (3,816.0-6,616.1)
2.15% (1.60-2.77)

18. Meghalaya



Deaths
1,874 (1,504-2,321)
11.7% (10.0-14.2)



Economic risk
39.2 (27.0-54.7)
0.8% (0.55-1.11)

19. Mizoram



Deaths
770 (584-949)
11.3% (9.4-13.3)



Economic risk
22.4 (15.3-31.3)
0.7% (0.48-0.98)

20. Nagaland



Deaths
1,281 (1,016-1,566)
12.6% (11.0-14.2)



Economic risk
33.6 (23.0-46.9)
0.86% (0.59-1.20)

21. Odisha



Deaths
43,409 (33,936-55,732)
12.7% (10.9-15.6)



Economic risk
806.6 (573.6-1,088.1)
1.14% (0.81-1.53)

22. Punjab



Deaths
41,090 (33,548-48,366)
18.8% (17.2-20.5)



Economic risk
1,148.90 (862.2-1,474.4)
1.52% (1.14-1.96)

23. Rajasthan



Deaths
113,361 (89,003-135,976)
21.2% (17.2-24.0)



Economic risk
2,294.30 (1,673.8-2,996.2)
1.7% (1.24-2.22)

24. Sikkim



Deaths
488 (386-607)
14.4% (12.2-16.7)



Economic risk
25.5 (18.0-34.7)
0.67% (0.47-0.91)

25. Tamil Nadu



Deaths
84,587 (68,951-102,758)
13.8% (12.2-15.6)



Economic risk
2,529.10 (1,856.6-3,310.4)
1.06% (0.78-1.39)

26. Telangana



Deaths
35,364 (27,587-45,295)
15.5% (13.7-17.3)



Economic risk
1,115.90 (792.7-1,508.2)
0.91% (0.64-1.22)

27. Tripura



Deaths
4,925 (3,944-6,028)
19% (16.5-21.3)



Economic risk
91.1 (66.1-121)
1.26% (0.92-1.68)

28. Uttar Pradesh



Deaths
349,926 (286,430-411,973)
19.5% (16.7-21.8)



Economic risk
5,130.30 (3,816.0-6,616.1)
2.15% (1.60-2.77)

29. Uttarakhand



Deaths
16,989 (13,858-20,537)
18.6% (16.2-20.8)



Economic risk
526.6 (392.8-682.7)
1.5% (1.12-1.94)

Other small Union Territories



Deaths
2,688 (2,160-3,358)
13.3% (12.0-14.8)



Economic risk
120.3 (85.5-163.7)
0.79% (0.56-1.07)

30. West Bengal



Deaths
122,833 (100,633-143,817)
20.8% (18.3-22.8)



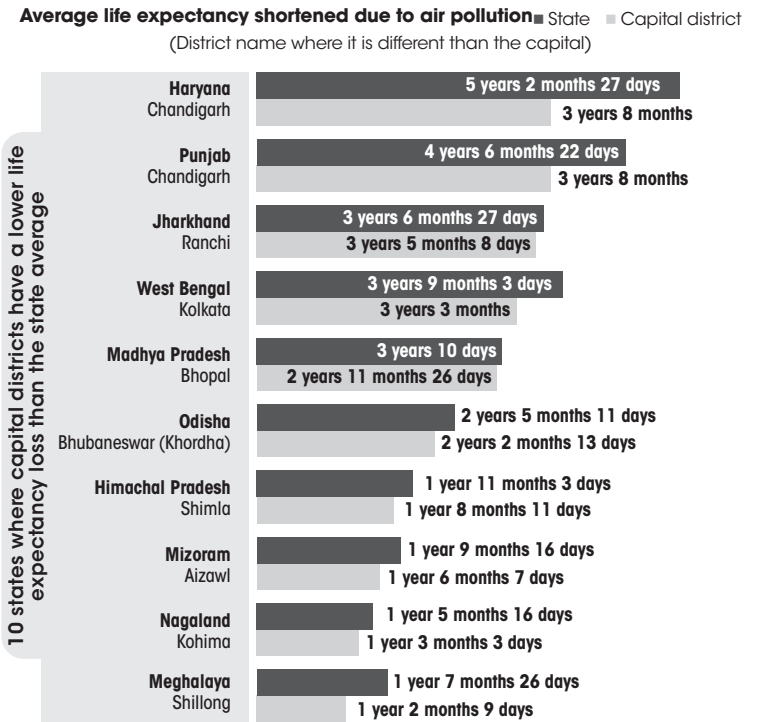
Economic risk
2,125.30 (1,622.8-2,676.8)
1.26% (0.96-1.59)

Source: Health and Economic Impact of Air Pollution in the States of India: the Global Burden of Disease Study 2019, Union Health and Family Welfare, published in Lancet in December 2020

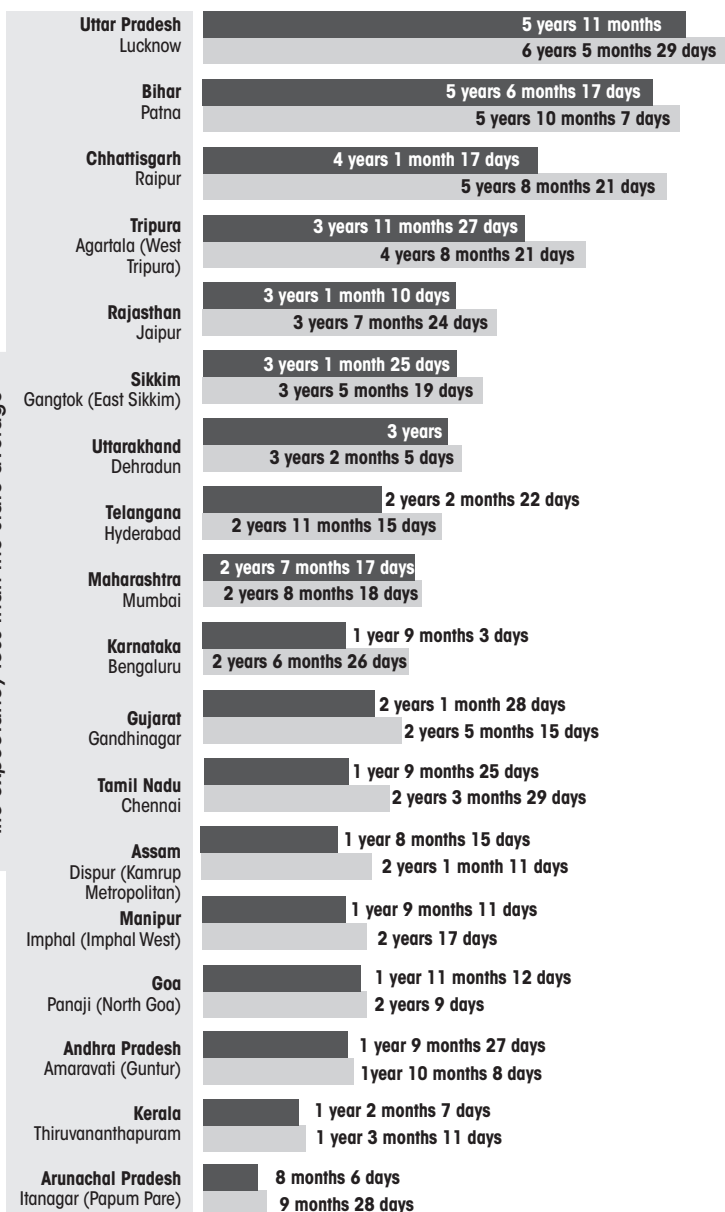
11

CAPITAL LOSS

The average life expectancy of an Indian is estimated to have shortened by 3 years and 6 months due to air pollution in 2022. The National Capital Territory of Delhi faces the worst scenario, with its population on track to lose 7 years and 9 months of life expectancy. Most state capitals are not far behind. Residents of capitals in 18 of 28 states are likely to have a higher reduction in life expectancy than the state average due to air pollution, the leading risk factor for mortality in India. For instance, a resident of Lucknow district is likely to lose 6 years and 5 months—6 months more than the state average of Uttar Pradesh (5 years and 11 months)



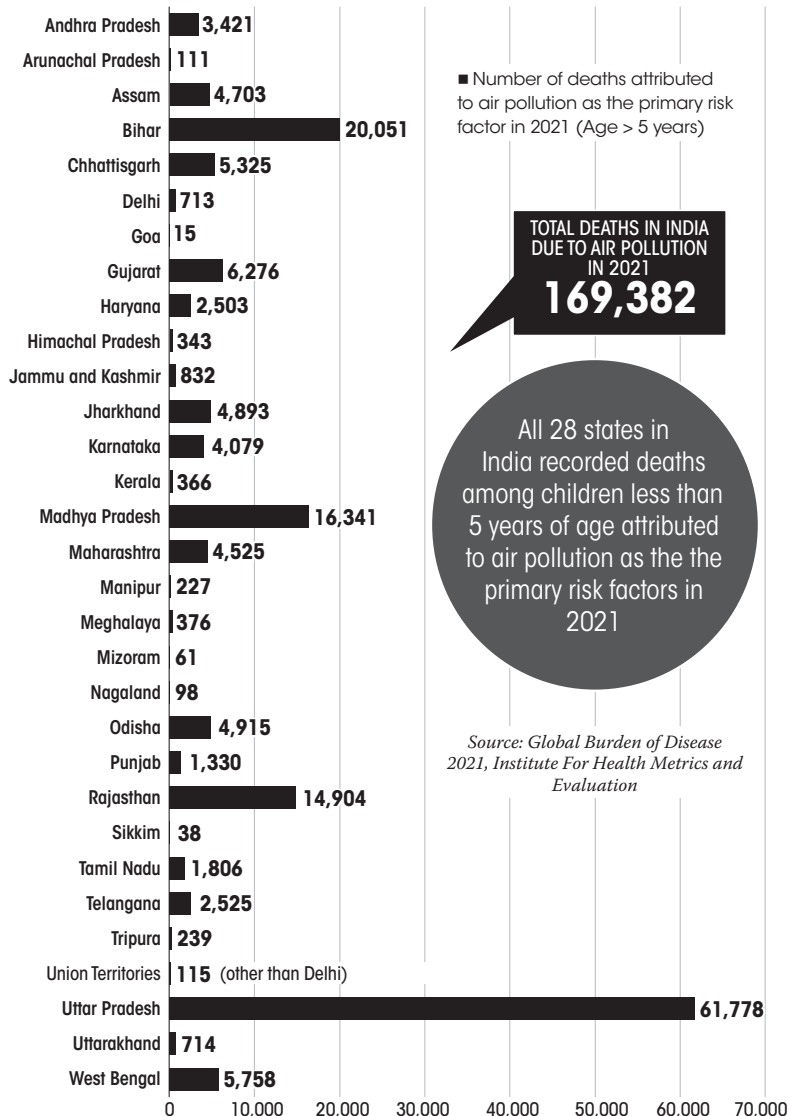
Source: The analysis is based on the district-level Air Quality Life Index (AQLI) released by Energy Policy Institute at the University of Chicago, US, released in 2024. The index estimates the relationship between PM2.5 air pollution and life expectancy, allowing users to view the gain in life expectancy they could experience if their community met World Health Organization (WHO) PM2.5 annual average guideline. All calculations are based on the average annual PM2.5 levels for 2022 and they are compared to the recommended PM2.5 levels of the World Health Organization, which is 5 µg/m3.



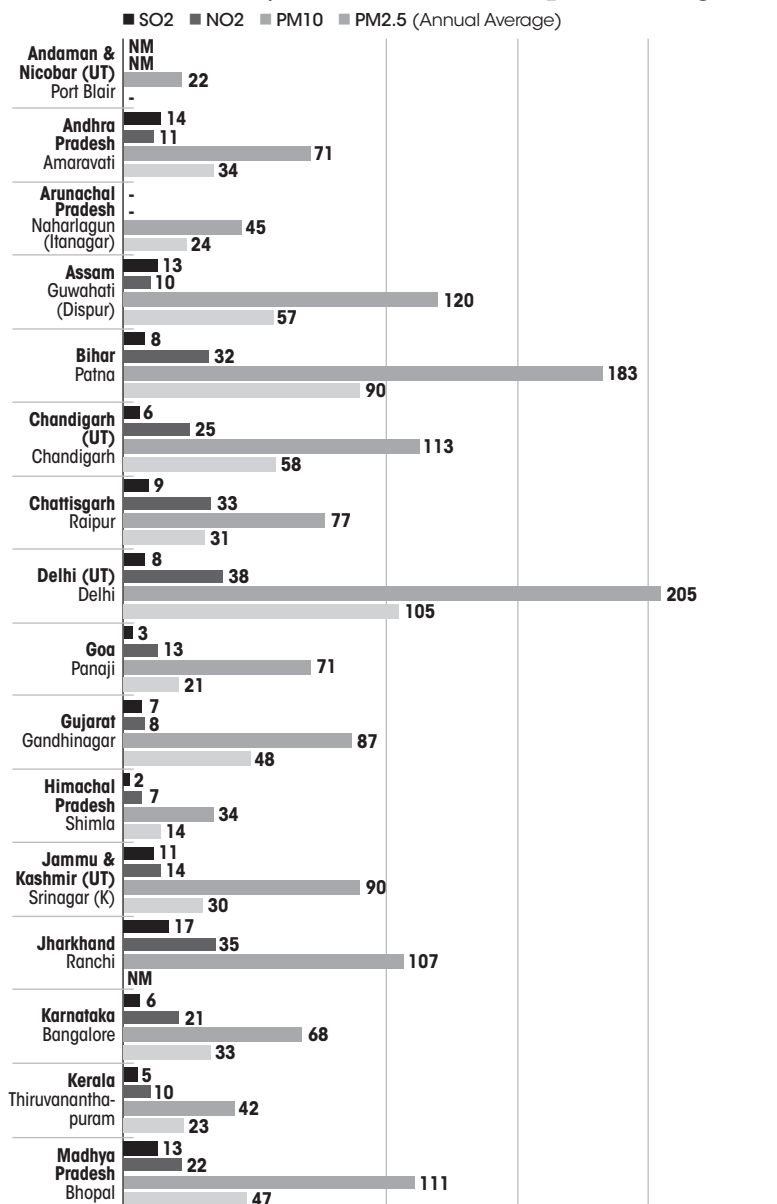
12

Deaths among children less than 5 years of age attributed to air pollution as the primary risk factors in 2021

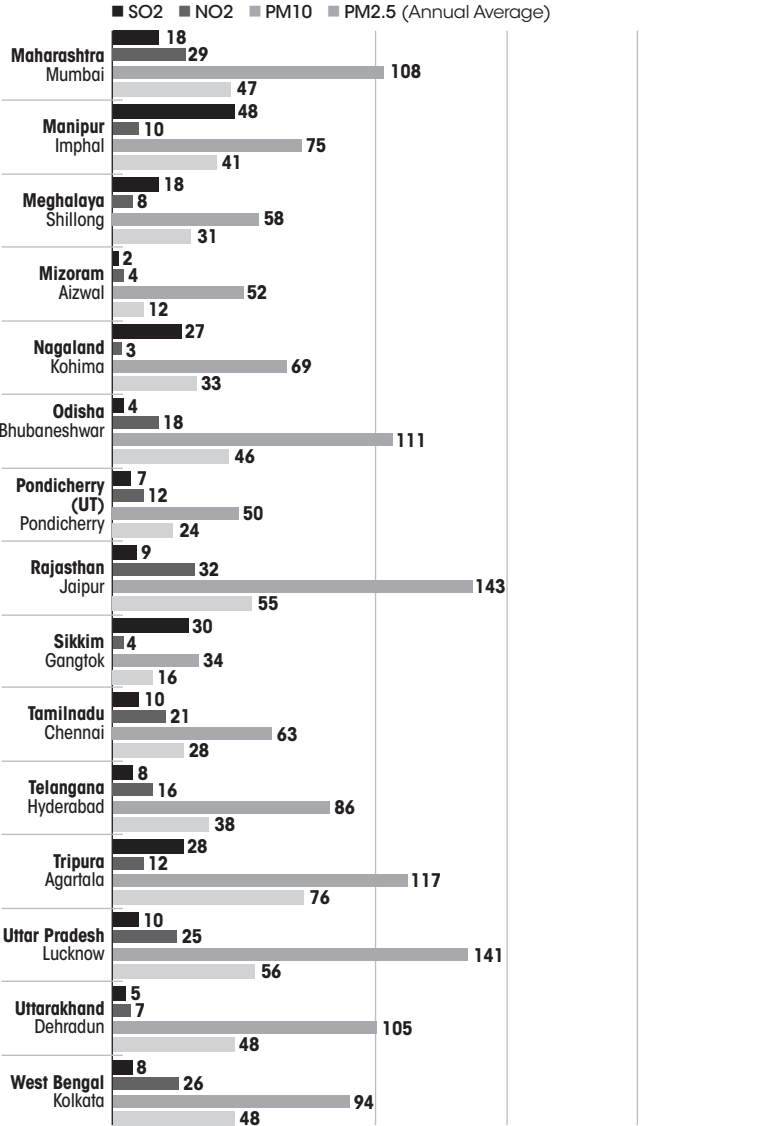
In 2021, at least 169,382 children under the age of five died due to air pollution. Almost 67 per cent of these deaths occurred in just four states—Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan



Ambient Air Quality status of the state capitals during 2023



SLOW MURDER CONTINUES



“Note: Dispur, the capital of Assam, is a suburb of Guwahati, for which data is available; Data is available for Naharlagun which falls in and is administered as a part of Arunchal Pradesh’s Itanagar” Source: Central Pollution Control Board

‘Every breath in India kills, slowly but certainly’



In this most populous country in the world, almost every citizen is exposed to deadly pollution while performing the most basic existential activity: breathing. And it adds to their disease burden. The notion that air pollution is a ‘big city problem’ is rapidly crumbling. Data indicates that smaller towns and industrial hubs are now at the frontline of India’s air pollution crisis. Rural areas are also reporting high levels of air pollution. Indians are indeed losing on life expectancy due to foul air.

This book is an account of India’s biggest public health threat: air pollution.