NRDC
INDIAN INSTITUTE OF PUBLIC HEALTH GANDHINAGAR
CEE
Centre for Environment Education
FEBRUARY 2022
Issue Brief

CLEARING THE AIR: PRIORITY POLLUTION CONTROL AND MONITORING STRATEGIES BASED ON EFFORTS IN AHMEDABAD

Executive Summary

With dangerously high air pollution levels and continued respiratory threats from COVID-19, the need to protect public health in India is urgent. Aiming to fight air pollution, India's Ministry of Environment, Forests and Climate Change (MoEF&CC) announced plans in late 2021 to strengthen clean air programs as part of a new national mission, "Clean Air for All." Beyond the significant damage it inflicts to public health, air pollution also contributes to ecosystem degradation, worsens agriculture and crop yields, and impairs visibility.[1] Delivering on India's clean air ambitions can help to secure a cleaner, safer, and healthier environment for all.

As part of the new mission's efforts to intensify clean air efforts, cities such as Ahmedabad are working to strengthen local air quality programs. To support Ahmedabad's Clean Air Plan (CAP), local and international experts conducted an assessment to identify a set of priority actions to strengthen air pollution control strategies and monitoring systems.

The main pollution control strategies used in India include, but are not limited to transportation, power plants, industries, and waste and biomass burning.

For air pollution control strategies, the expert assessment recommends the following priority actions in the near-term based on similar practices in other Indian cities.

1. **Transportation -** Identify and retire highly polluting vehicles from operation (pre-Bharat Stage IV (BS-IV) vehicles that have high utilization rates).
2. **Power Plants -** Expedite compliance of power plants in the Ahmedabad airshed with the pollution emission standards notified in 2015, including a combination of penalties and incentives that are supported by the National Clean Air Program (NCAP) steering, monitoring and implementation committees.
3. **Industries -** Shift from fossil fuels to cleaner fuels and renewables, and implement emission control technologies, including support for Micro, Small, and Medium Enterprises (MSMEs).
4. **Air Quality Management (AQM) -** Operationalize departmental and inter-ministerial coordination on AQM through operation of NCAP governance committees and the AQM cell that can digitize inventory, identify gross polluters, and enhance accountability at the airshed level with performance indicators aimed at improved governance and compliance. Finance should be made available to the impacted stakeholders, cost estimates provided, and finance mechanisms or schemes for cleaner energy transitions.

For more information, please contact:
Anjali Jaiswal: ajaiswal@nrdc.org or **Polash Mukerjee:** pmukerjee@nrdc.org

Table 1: Summary of pollution control actions to support Ahmedabad's CAP (source: NRDC analysis, 2022).

Sector	Pollution control actions	Related policies	Effectiveness at reducing PM	Costs	Timeline to implement	Similar programs in other cities
Transportation	BS-IV and older vehicles immediate phaseout, with priority on high-use vehicle segments (e.g., commercial & passenger)	National scrappage policy; BS-VI standards; fiscal disincentives on older vehicles; in-use emission control laws - Gujarat and Central Motor Vehicles Rule	High, within the city	Low cost to AMC (limited costs to vehicle owners given incentives)	6 months	New Delhi, Gurugram, Faridabad, and other districts, and Kolkata
Power Plants	Expedite 2015 emission standards	Emissions standards for coal based thermal power plants notified and subsequent amendments by the MoEFCC	High to Medium	No cost to AMC (power plant operators will have higher costs for upgrades to come into compliance)	12 - 18 months	New Delhi and Mumbai
Industries (stack & area emissions)	Shift from fossil fuels to cleaner fuels & renewables; implement compliance mechanisms and emission control technologies	Emission standards for SO_x, NO_x, and PM for individual industries; PM emission trading scheme. Pradhan Mantri Ujjwala Yojna (PMUY) scheme by Ministry of Petroleum & Natural Gas	High to Medium	Medium cost to AMC (for organized sector costs are lower and for MSMEs costs are higher)	6 - 12 months	New Delhi and Kolkata
Governance	Operationalize inter-departmental coordination	NCAP; FC funding for air quality and related guidelines issued by MoEFCC and Ministry of Housing & Urban Affairs	Medium	Low (focus on strengthening city management and operation for air quality)	3 - 6 months	Bengaluru

The assessment included prioritizing the pollution control strategy in terms of pollution reduction, effectiveness, costs, and near-term feasibility (Table 1). In addition to stronger pollution control strategies, better monitoring systems are needed to reach NCAP targets, which aim to reduce particulate matter (PM) concentrations by 20 to 30% by 2024 compared to 2017 concentrations.[2] Under NCAP, cities are expected to strengthen their monitoring network and raise public awareness. Currently the monitoring systems in Ahmedabad, as well as in most regions in India, need to be expanded and updated to better assess the pollution levels regarding NCAP's targets.

Three main studies relevant to Ahmedabad have assessed air pollution levels and sources.[3] Like other parts of India, these studies show that PM and fine PM ($PM_{2.5}$) continue to plague Ahmedabad. Gujarat Environmental Management Institute (GEMI) projects alarming increases in air pollution levels in Ahmedabad for the next decade.[4] Figure 1 shows the projected increase in emission load under a business as usual (BAU) scenario for 2024 and 2029 for PM, sulfur dioxide (SO_2), nitrogen oxide (NO_x) and carbon monoxide (CO). Assumption under the BAU scenario used projected Census department population estimates for 2024 and 2029 for the estimation of emissions and assumes that a normal growth rate in population would result in a proportionate increase in different sectors, as well as fuel consumption.[5] The scenario does not account for any interventions to abate air pollution levels except BS-VI regulations for all categories of vehicles from the year 2020.

Figure 1: Percent increase in emission load under BAU scenario for 2024 and 2029 (source: GEMI, 2020).[6]

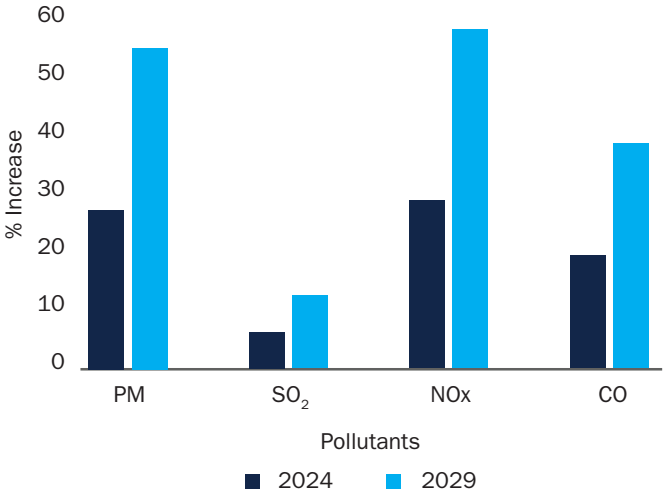
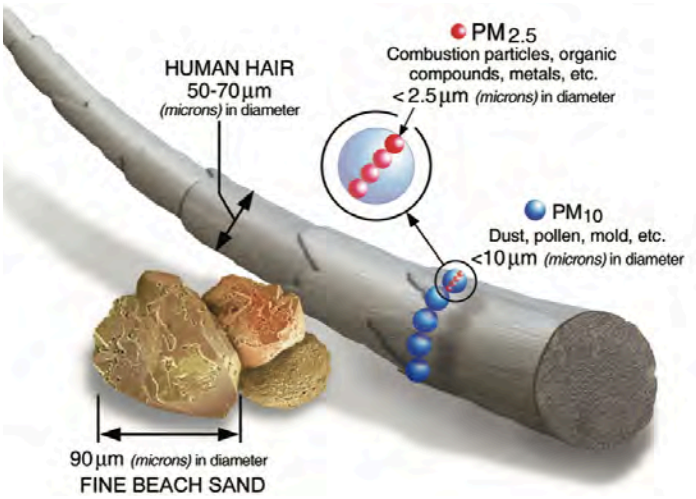


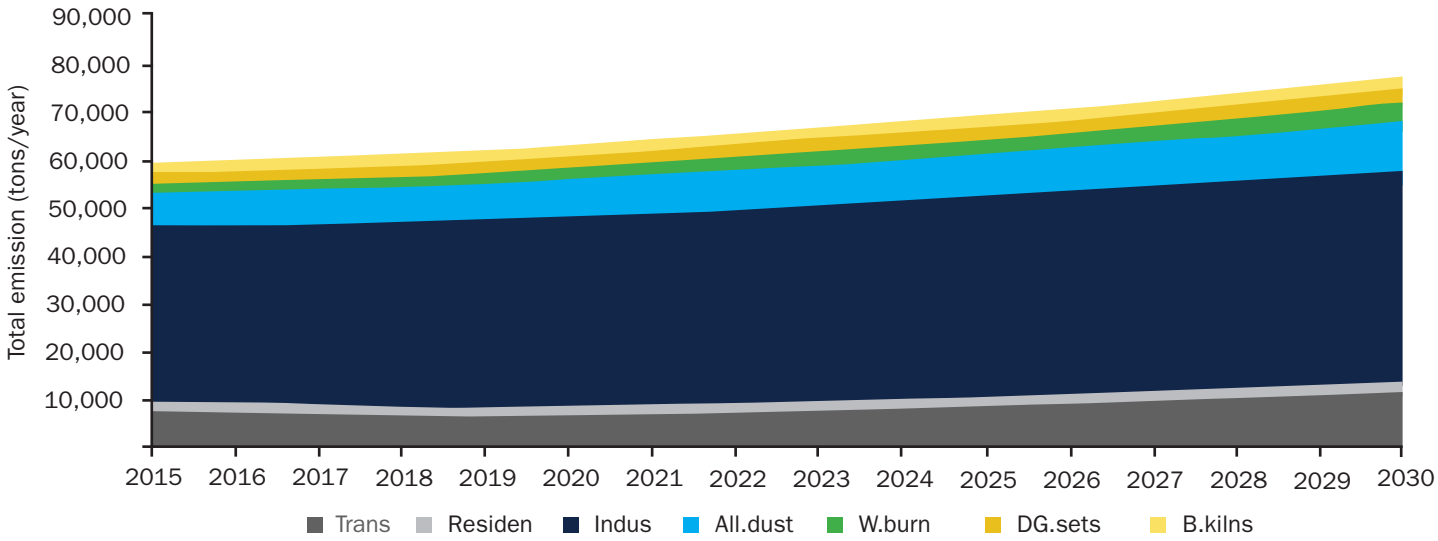
Figure 2: size comparisons for PM particles (source: U.S. EPA)



Fine particle pollution, $PM_{2.5}$, is already major public health concern because it can penetrate deep into the respiratory tract (disrupting heart and lung function) and already regularly exceeds safe levels in Indian cities. Due to its microscopic size, $PM_{2.5}$ can lodge deep in the lungs and cause irreparable respiratory harm, especially in children.

$PM_{2.5}$ projections to 2030 under a BAU scenario by Urban Emissions show the pollutant continuing to plague Ahmedabad and sector-wise contributions to $PM_{2.5}$ emissions.[7] Projections to 2030 under the BAU scenario were influenced by the city's social, economic, land use, urban, and industrial layout and hence the projected rates assumed.[8]

Figure 3: Total $PM_{2.5}$ emissions by sector 2018 to 2030 under BAU scenario (source: Urban Emissions, 2019).[9]



TRANS = transport emissions from road, rail, aviation, and shipping (for coastal cities); RESIDEN = residential emissions from cooking, heating, and lighting activities; INDUS = industrial emissions from small, medium, and heavy industries (including power generation); ALL. DUST = dust emissions from road re-suspension and construction activities; W.BURN = open waste burning emissions; DG.SETS = diesel generator set emissions; B.KILNS = brick kiln emissions (not included in the industrial emissions).

Table 2: Air pollution control actions identified in city CAPs across key sectors (source: NRDC analysis, 2022).[10]

Sector and Intervention Details		Ahmedabad	Bangalore	Delhi	Hyderabad	Kanpur	Kolkata	Mumbai	Nagpur	Patna	Pune	Surat
Transportation	Restriction on older vehicles	Partial	Partial	Yes	Partial	No	Partial	Partial	Partial	Partial	Partial	Partial
	Infrastructure for compressed natural gas (CNG) & e-mobility	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Cleaner fleets & fuels for public transport, transportation network companies, & 1st/last mile connectivity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	In-use emission control, & installation of remote sensor-based pollution under control (PUC) system	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes
	Intelligent traffic management systems	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
	Vehicle demand management - parking policy, walking, & non-motorized transport, & fiscal measures	Yes	Yes	Yes	No	Partial	Yes	Yes	Partial	Partial	Yes	Yes
Stationary sources: thermal power plants (TPPs) & industries	Regulation & closure of TPPs within 300 km radius	No	No	Partial	No	No	No	Partial	No	No	No	No
	Implementation of TPP emission standards for PM, NOx, and SOx	No	No	No	No	No	No	Partial	No	No	No	No
	Clean fuels - mandates, incentives, & siting restrictions	No	Partial	Yes	Partial	No	Partial	Partial	Partial	Partial	No	No
	Conversion of brick kilns to induced draft zig- zag technology	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	No	No
	Fiscal measures, including emission trading schemes	No	No	No	No	No	No	No	No	No	No	Yes
Solid waste, construction & demolition (C&D), & diesel generator (DG) sets	Management of landfill sites & implementation of municipal solid waste rules	Partial	Yes	Partial	No	Partial	Partial	Partial	No	No	No	Partial
	Limits on use of DG sets	No	No	Yes	No	No	Partial	No	Partial	No	No	No
	C&D waste recycling	Partial	Yes	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial
	C&D dust control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

To prevent these dire air pollution projections from becoming reality, strong leadership and ambitious actions at the city-level can help deliver transformative and lasting improvements for public health in India's fight against dangerous air pollution and climate change.

Air Quality in India: Renewed Ambition To Address A Widespread Challenge

In India, 132 cities currently experience unhealthy levels of air pollution that exceeds national health-based limits.[11] In 2019, more than 980,000 deaths in India were linked to outdoor (ambient) PM pollution.[12] Beyond the significant damage it inflicts to public health, air pollution also contributes to ecosystem degradation, worsens agricultural crop yields, and impairs visibility.[13] These effects impose a major drag on India's overall economy. A recent analysis estimated that in 2019, the lost output from premature deaths and morbidity caused by air pollution accounted for losses of $28.8 billion (₹ 2,141.54 billion) and $8.0 billion (₹ 595 billion), respectively.[14] This annual total loss of $36.8 billion (₹ 2,736 billion) equates to 1.36% of India's gross domestic product.

The Indian Government launched NCAP in 2019 to improve air quality in the country's most polluted cities.[15] NCAP provides a roadmap to reduce air pollution with specific metrics and speed targets. It requires states and cities to take urgent action to reduce outdoor concentrations of deadly PM pollution. In a major advancement in late 2021, the Indian government announced the national mission, "Clean Air for All." Moving NCAP to "mission mode" the government plans to launch stronger targets to reduce PM from 2017 levels. The targets are expected to change from the original goal of a 20 to 30% cut by 2024 to an enhanced 35 to 50% cut by 2025 to 2026.[16]

Under NCAP, cities with air pollution levels that exceed the country's National Ambient Air Quality Standards (NAAQS) are required to draft and implement city-level Clean Air Plans (CAPs) to reduce pollution levels. More than 100 cities across India have developed CAPs that are in various stages of implementation.[17] In 2020, the government's Finance Commission (FC) increased funding to cities to support enhanced air quality management. To implement the funds in 2021, the government conducted regional NCAP workshops, including in western India, to facilitate knowledge sharing on pollution control strategies.

Key Recent Reports on Air Quality in India

The Health Effects Institute's Global Burden of Disease from Major Air Pollution Sources (GBD MAPS) found that the combustion of fossil fuels (coal, oil, and natural gas) contributed to an estimated 800,000 deaths in South Asia or East Asia, 80% of the global total.[18] The report also estimated that fossil fuel combustion contributed an annual population-weighted mean $PM_{2.5}$ exposure level of 80.2 μg/m^3 across India, which is sufficient by itself to exceed the country's national limits (40 μg/m^3).

Cost Effectiveness of Interventions For Control of Air Pollution in Delhi by The Energy and Resources Institute (TERI) found that despite the existing emission control policies in the region, air pollution in Delhi was expected to exceed national limits by 2030.[19] To improve Delhi's air quality and meet these targets, researchers estimated the effectiveness of sectoral interventions across the whole airshed. Some of the $PM_{2.5}$ control strategies identified for cost-effectiveness are cleaner cooking fuel, a transition to electric two-wheel and three-wheel vehicles, cleaner brick kiln technology, clean fuel transitions in industry and power plants, and fleet modernization for trucks and buses. The study estimates that full implementation of these control strategies can avoid over 14,000 deaths by 2022 and 12,000 by 2030 in the Delhi region, delivering economic benefits of ₹ 45,000 crore (~$5.95 billion) by 2030.

Advancing Clean Air Goals in Ahmedabad

In 2021, the Ahmedabad Municipal Corporation (AMC) and partners continued to develop and implement the CAP, despite COVID-19. The XVth FC allocated an initial installment of funding of ₹ 182 crores ($24 million) to the Ahmedabad urban agglomeration (UA) to improve air quality improvement. The FC funding for Ahmedabad totals approximately ₹ 500 crore ($67 million) for 2021 to 2026 for air quality management.

To protect public health, the city and partners continued to conduct health risk communication outreach to alert communities when the Air Quality Index (AQI), a summary metric translating pollution concentrations into color-coded health advisories, reached unhealthy levels.[20] The city acted to reduce pollution by addressing emissions from the Pirana landfill, initiating tree planting, expanding deployment of electric buses, and limiting road dust. Local experts also examined the CAP and identified strategies beyond the initial set of initiatives. The city partnered with local institutions to update and expand local air monitoring data to inform air quality management efforts.

To strengthen its outreach on health risks from air pollution, the city incorporated the strategies developed in the Ahmedabad Air Information and Response (AIR) Plan into the CAP.[21] These strategies include email alerts and text messages notifying government agencies and school officials of unhealthy air pollution levels. The further pollution awareness and protect children, the city's AIR plan includes an AQI "school flag" program, in which a colored flag corresponding to the daily AQI color code is displayed at schools. The city also deployed public messaging through outdoor dynamic billboards at prominent locations to educate communities on how to protect themselves on high pollution days, such as staying indoors and avoiding exercise. The local news media published daily AQI levels informing the public on strategies to protect vulnerable populations, including children, from the health hazards of air pollution exposure.

As part of its CAP, Ahmedabad is working to reduce emissions from its largest landfill in Pirana. The landfill has exceeded its waste storage capacity and is a significant source of PM, volatile organic compounds, and greenhouse gases (e.g., carbon dioxide and methane). Ahmedabad has reduced waste at the Pirana dump freeing it from garbage.[22] To offset emissions from the landfill, the city is part of the "Mission Million Trees" for urban greening, and recently planted hundreds of trees near Pirana.[23]

Ahmedabad has also used a portion of the ₹ 10 crores ($1.3 million) funding it received under the NCAP towards road dust management, through the procurement and operation of mechanical road sweepers, which help to control fugitive dust (the source of about 20 percent of the city's $PM_{2.5}$ pollution).[24] The city is electrifying its bus fleet; JBM will supply 180 electric buses, of which 50 have been delivered, and Tata Motors will supply 300 electric buses, of which 60 have been delivered.[25]

To further strengthen the interventions for air quality improvement, in 2020, Ahmedabad initiated an air pollution emission inventory and source apportionment study through the Gujarat Environment Management Institute (GEMI), Gandhinagar. Gujarat Pollution Control Board (GPCB) announced plans to scale up the PM Emissions Trading Scheme (ETS) piloted in Surat to industries in and around Ahmedabad. This is significant since the number of industrial sources in this area is much larger - up to 1,500 units. The ETS in Ahmedabad is expected to be rolled out in a phased manner.

Groups Working to Improve Air Quality in Gujarat

The Ahmedabad Air Quality Expert Working Group works to support the city's clean air efforts on health risk communication, monitoring, and CAP implementation through research, analysis, recommendations, and implementation. Participants of the group are from the Institute of Public Health-Gandhinagar (IIPH-G), Centre for Environment and Education (CEE), Indian Institute of Management-Ahmedabad (IIM-A), LG Hospital, Ahmedabad Municipal Corporation (AMC), Pandit Deendayal Petroleum University, CEPT University, Gujarat Energy Research and Management Institute (GERMI), Mudra Institute of Communications (MICA), Gujarat National Law University, International Council on Clean Transportation (ICCT), Sarabhai Community Science Centre, All India Disaster Management Institute (AIDMI), National Institute of Occupational Health (NIOH) and the Natural Resources Defense Council (NRDC).

Indian Institute of Public Health, Gandhinagar (IIPH-G), Centre for Environment Education (CEE), and the Natural Resources Defense Council (NRDC) are working with Ahmedabad to strengthen the city's Clean Air Plan by prioritizing pollution control strategies for specific sectors. IIPH-G and NRDC worked with Ahmedabad to develop the first of its kind health-risk communication plan on air pollution, the Air Information and Response (AIR) Plan, that has now been implemented into the CAP.[54] IIPH-G and NRDC are also partnering on an air quality and climate health study in Ahmedabad for 2030.

Doctors For Clean Air (DFCA) works to create awareness among doctors, the public, and governing bodies on the health effects of air pollution on health. DFCA is developing a Gujarat chapter, which will focus on vulnerable populations air pollution such as children.

Mahila Housing Trust (MHT) is assessing the effects of pollution on female construction workers. MHT is providing female construction workers with technical training on the AQI. By increasing their awareness on air quality, these women will be better informed and equipped to raise concerns.

ICLEI South Asia is working with Ahmedabad as part of its air quality cell. ICLEI is analyzing the air quality information received from local air monitoring stations within the Ahmedabad. They are identifying critical hotspots, where air quality standards were not met between 2017 to 2020. Then a micro-level action plan will be developed and implemented in the city.

Energy Policy Institute at University of Chicago (EPIC) - India has worked with the GPCB to strengthen the institutional structure for industrial air pollution management. EPIC is providing technical assistance to the GPCB to complete the market design for the emissions trading scheme (ETS) system in Ahmedabad.

The Energy and Resources Institute (TERI) and World Resources Institute (WRI) are working with the city of Surat on formulation and implementation of a clean air action plan. They are developing a decision support system for Gujarat.

Assessment of Ahmedabad CAP Air Pollution Control Strategies and Emissions Monitoring

To improve air quality in Ahmedabad, IIPH-G, NRDC and local experts conducted a two-part analysis on the state of air quality management policy and available data. The first focused on improving and expanding pollution control strategies to be implemented as part of the CAP. The second focused on emissions inventory and air quality monitoring. As part of the ongoing work, IIPH-G, NRDC, and local experts discussed and presented the analysis summarized in this issue brief at a December 2021 virtual stakeholder workshop.[26]

CAP Air Pollution Control Strategies

To further strengthen the city's CAP, experts reviewed Ahmedabad's CAP documents, drafted in 2020 and revised in 2021, for ongoing and planned sector-specific control strategies, with a specific focus on key emissions sectors.[27] The four key sectors are: (1) transportation and mobile sources; (2) point (stationary) sources, including power plants and industrial operations; (3) household sources and MSMEs; and (4) area sources and fugitive emissions, including waste collection and processing, including municipal solid waste (MSW), construction and demolition (C&D) waste, and industrial waste, and diesel generator (DG) sets.

The expert team also analyzed air management plans in other Indian cities, including New Delhi, Kolkata, Mumbai, and Bangalore, to evaluate the adequacy of control strategies for Ahmedabad (Table 2). The analysis identified common aspects of control measures, including: the sector of intervention, specific air pollution control plan or planned intervention, expected air quality impact, degree of technical feasibility, costs and expected benefits, implementation period, proposed deadline for implementation, and identification of responsible agencies for implementation, as well as plans for capacity building within city agencies.

The assessment was discussed during a December 2021 virtual stakeholder workshop Priority Actions in the Immediate Term to Improve Air Quality in Ahmedabad.[28] Based on the roundtable, the following sectoral-specific priorities for short-term action under the CAP (six months to two years) to reduce PM pollution were identified:

1. **Transportation -** Identify and retire highly polluting vehicles from operation BS-IV vehicles that have high utilization rates).
2. **Power Plants -** Expedite compliance of power plants in the Ahmedabad airshed with the pollution emission standards notified in 2015, including a combination of penalties and incentives that are supported by NCAP steering, monitoring and implementation committees.

3. **Industries -** Shift from fossil fuels to cleaner fuels and renewables, and implement emission control technologies, including support for MSMEs.
4. **AQM -** Operationalize departmental and inter-ministerial coordination on AQM through operation of NCAP governance committees and the AQM cell that can digitize inventory, identify gross polluters, and enhance accountability at the airshed level with performance indicators aimed at improved governance and compliance. Finance should be made available to the impacted stakeholders, cost estimates provided, and finance mechanisms or schemes for cleaner energy transitions.

Transportation - retire pre-BS-IV vehicles

Following effective examples from other cities, the Ahmedabad CAP should identify and retire highly polluting vehicles (pre-BS-IV vehicles) that have high utilization rates from operation. These highly polluting and highly utilized vehicles should be scrapped under the national-level scrappage policy of 2021 and replaced by BS-VI compliant vehicles or electric alternatives.

TERI's recent analysis of pollution control strategies in Delhi shows that transportation electrification and fleet modernization can significantly decrease $PM_{2.5}$ emissions.[29] The electrification of buses leads to a reduction of 6% and 23% in $PM_{2.5}$ emissions from transport sector in 2022 and 2030, respectively, compared with to 2019 BAU. Corresponding reductions in emissions due to shifting two- and three-wheelers to electric are 22%, and 53% respectively. Fleet modernization (replacing older vehicles with BS-VI) in trucks and buses leads to 32% and 6% reductions in $PM_{2.5}$ emissions in the National Capital Region in 2022 and 2030, respectively.

Vehicles adhering to emission standards older than BS-IV emit much higher levels of permissible emissions than currently applicable BS-VI standards - up to 5,687.5% higher NO_x and hydrocarbons and up to 3,600% higher PM (for heavy duty diesel vehicles).[30] Vehicles with higher utilization, heavy duty vehicles, public transport and passenger vehicles, taxis & three-wheelers, as well as older vehicles (pre-BS-IV), need to be identified, prioritized, and then phased out from operations. These maybe replaced by BS-VI compliant vehicles, or by electric alternatives through the provision of a one-time incentive. The SAFAR emissions inventory shows between 80 and 86% of vehicles adhere to pre-BS-IV standards in 2016.

In addition to retiring and phasing out pre-BS-IV vehicles, the CAP should continue to include robust measures for public transportation, shared mobility, and electric vehicle programs. Furthermore, as regional transport offices retire older vehicles (or do not renew licenses) and enforce the phase-out, there should be mechanisms to efficiently de-register and decommission engines, provide financial support, and incentivize scrapping.

The potential for PM reduction is high for this transportation related control strategy. An estimated reduction up to 97.22% in PM load contribution for heavy commercial vehicles and buses and similar segments.[31] The costs are limited, depending on phased manner of implementation for targeted vehicle segments. The timeline for CAP implementation is short, six months. New Delhi and Kolkata are examples of cities with programs to retire pre-BS-IV vehicles.

Power Plants

As of 2021, only one-third of power plants had taken serious initiatives to meet the new norms.[32] Aligning with NCAP goals, the Ahmedabad CAP should expedite compliance of power plants in the local airshed with the emission standards notified in 2015 in accordance with the Ministry of Power and Pollution Control Board purview. In 2021, the MoEFCC updated requirements for power plants to achieve the 2015 standards. A task force disaggregated coal thermal power plant units into three categories: A, B and C.[33] The Torrent plant was identified as category A, which requires compliance by 2022, and the Gandhinagar plants was identified as category C, which requires compliance by 2024.[34] As part of compliance efforts the CAP could include a combination of incentives and penalties that are supported by NCAP steering, monitoring, and implementation committees.

An estimated reduction up to 97.22% in PM load contribution for heavy commercial vehicles and buses and similar segments.

Power plants are significant sources of $PM_{2.5}$, as well as SO_X and NO_x. In addition, secondary PM formation is an important source of PM as related to power plants. This control strategy related to power plants also create an opportunity to shift to clean energy and alternate fuels, such as solar and wind energy, energy efficiency, biomass, and crop residue. Shifting to clean energy also supports India's climate goals.

The potential for PM reduction is high to medium. Estimates show that 70% of source specific PM emissions and 50 to 80% NO_x, SO_x, and secondary particulates can be reduced.[35] The initial costs for the power plants can be significant, however, are balanced given the public health benefits, climate benefits, and improved plant operation facilities. The timeline is 12 to 18 months. New Delhi and Kolkata are cities with similar programs for power plants.

Industrial Operations

Given the economic opportunities with industries, the Ahmedabad CAP should shift from fossil fuels to cleaner fuels and renewables. Industries are the largest contribution to SO_x, and significant contributions to NO_x and PM. The air pollution control strategies for industries would also include improved accountability and implementation of emission control technologies for major industries and MSMEs, such as clustered solar concentrators and electric boilers. In New Delhi, switching solid and liquid fuel to gaseous fuel in industries can decrease $PM_{2.5}$ emissions.[36] Maximum reduction in emissions of $PM_{2.5}$ can be achieved by completely switching solid and liquid fuel to gaseous fuel in industries, with reduction of 99% in $PM_{2.5}$ emissions by 2022 compared to 2019 with respect to BAU. Simple technologies, such as wet scrubbers and low NO_x burners, can reduce $PM_{2.5}$ emissions by 55.4% and 54% in 2022 and 2030, respectively compared to 2019 levels.

To implement pollution control strategies for industries, the Ahmedabad CAP needs to include an industrial emission reduction plan that includes compliance through Online Continuous Emission Monitoring System (OCEMS) installation and real-time dashboard. A phased plan to transition away from solid (e.g., coal, wood, petroleum coke) and liquid fuels (e.g., diesel, light diesel oil, low sulfur heavy stock, furnace oil) through incentives and penalties for transitioning to electricity/hydrogen natural gas-based boilers has been effective in other cities. In the absence of a fuel transition, the installation of emission control equipment such as SO_2 scrubbers have been mandated. A specific focus on MSMEs and small industries is needed to support compliance for this sector.

The potential for PM reduction is high for this pollution control strategy for industries. The costs range from low to high depending on the technology. financing mechanisms to support MSMEs to switch to clean energy would help accelerate the transition. The timeline for implementation is medium (6 to 12 months). Cities with similar programs include New Delhi and Kolkata.

Air Quality Management and Governance

To strengthen implementation, the CAP needs to increase existing capacity on AQM through a dedicated and centralized cell charged with air quality management and coordination for the Ahmedabad urban area. The AQM cell would function within the existing three-tiered NCAP committees, under the implementation committee. It should operationalize inter-ministerial coordination on AQM through regular operation of NCAP governance committees.

The AQM cell can work to digitize inventory, develop incentive and compliance programs, identify gross polluters, and introduce mechanisms that build accountability. This can facilitate identification of key performance indicators and improve governance and compliance. The cell can monitor air quality and data in real-time, utilize technology-enabled compliance, coordinate AQM research, and develop mechanisms to ensure compliance with stakeholder engagement.

The AQM cell should adopt an airshed management approach and look at pollution sources outside the jurisdiction of the urban local body (ULB), such as sources around Ahmedabad. TERI's analysis showed that the effect of regional scale pollution was pronounced in Delhi's $PM_{2.5}$ concentrations. Therefore, regional level air quality planning and implementation is recommended for effective control of pollution in an entire region. The AMC is working with ICLEI as the city air cell to analyze information from the air quality monitoring stations and to help coordinate between state agencies and implement the action plan to improve Ahmedabad's air quality.[37] The recommendations could be added to existing activities by the AMC and ICLEI to improve air quality management, governance, and compliance under the CAP.

Air Quality Monitoring In India

India has approximately 804 total air quality monitoring stations.[38] Only six percent of cities and towns (344 out of 6,166) are monitored. Many rural areas are yet to be covered under the National Air Quality Monitoring Program (NAMP). Only approximately one quarter (208 of India's 804 monitoring stations) are continuous real-time monitoring stations (CAAQMS) and less than two percent of cities (114 out of 6,166) have CAAQMS installed. The other (non-CAAQMS) monitoring stations are manual, which means that they do not allow for daily reporting of real-time air quality data.

CAAQMS monitors record, transmit, and display data within minutes of observation and their automated technology can reduce the errors associated with manual monitoring.[39] Daily levels of air pollution is important for public awareness, especially for those who suffer from illnesses caused by exposure to air pollution. PM_{10} is regularly monitored at all NAMP locations (both CAAQMS and manual stations). $PM_{2.5}$ is monitored at 317 manual stations covering 147 cities in 20 states and is being added to the monitoring network under NAMP.[40]

The Government of India is working to rapidly increasing the network of air quality monitoring stations to better assess air pollution levels across states. NCAP includes ramping up the number of urban and rural monitoring stations, technology support, awareness and capacity building initiatives, certification agencies for monitoring equipment, and source apportionment studies.

NCAP maps out a process for identifying and validating alternative cost-effective technology for source and ambient air quality monitoring.[41] Parallel efforts are ongoing at the national-level to develop a protocol for the integration of a network of sensor-based monitors to maximize granularity of air quality data. Satellite-based monitoring, when combined with verification from ground-based monitoring stations, has the potential to be the most cost-effective method.

Air Pollution Monitoring in India

India's NAAQs include eight criteria pollutants: NO_x, CO, black carbon (BC), organic carbon (OC), $PM_{2.5}$, PM_{10}, SO_2 and volatile organic compounds (VOCs). The NAAQs were last revised in 2009 and are being reviewed in 2022 based on the WHO Air Quality Guidelines.

India's ambient air quality standards are less strict than the World Health Organization (WHO) standards, which recently revised its standards. For example, WHO's upper limit of annual $PM_{2.5}$ for the 2005 standards was 10 µg/m^3 and in 2021 was revised to 5 µg/m^3.[42] India's NAAQs, last revised in 2009, specify an annual limit of 40 µg/m^3 for PM $_{2.5}$ annually. Secondary particulate conversion is a risk. PM in major cities in India can have a sulphate component up to 40 percent.[43]

Table 3: IITM-SAFAR air quality descriptors, AQI numeric values, and corresponding air pollution concentration thresholds and temporal averaging periods.[44]

Air Quality Descriptor	AQI Value	$PM_{2.5}$ (µg/m^3) 24-hr Average	PM_{10} (µg/m^3) 24-hr Average	O_3 (ppb) 8-hr Average	NO_2 (ppb) 24-hr Average	CO (ppm) 24-hr Average
Good	0-100	0-60	0-100	0-50	0-43	0-1.7
Moderate	101-200	61-90	101-250	51-84	44-96	1.8-8.7
Poor	201-300	91-120	251-350	85-104	97-149	8.8-14.8
Very Poor	301-400	121-250	351-430	105-374	150-213	14.9-29.7
Severe	401-500	251-350	431-550	375-450	214-750	29.8-40

Ground level ozone (O_3) is one of the major constituents of photochemical smog. It is formed by the reaction with sunlight of pollutants such as NO_x and VOCs. As a result, the highest levels of ozone pollution occur during periods of sunny weather. Excessive ozone in the air can have a marked effect on human health. It can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases. In 2019, 0.17 million deaths in India were attributable to ambient ozone pollution.[45]

Summary of Monitored Data in Ahmedabad

NCAP targets for Ahmedabad and other non-attainment cities are a 20 to 30% reduction in $PM_{2.5}$ and PM_{10} ambient concentrations by 2024. Beyond this, a definite target with intermediate milestones for performance assessment in terms of air quality improvement is yet to be defined. A major reason for this is inconsistencies in monitoring infrastructure and methodology across cities, as well as between the national, state, and city regulators.

SAFAR operates 10 continuous monitoring stations in Ahmedabad and Gandhinagar; eight stations are under NAMP and two are under the State Ambient Air Quality Monitoring Program (SAMP).[46] Three emission inventory studies have been done for Ahmedabad by IITM SAFAR (2017), GEMI (2020), and Urban Emissions (2019).[47] An emissions inventory is a database that lists, by source, the amount of air pollutants discharged into the atmosphere during a year or other time period.[48] Methods to determine emissions include continuous monitoring of emissions from a source and short-term emission measurements that are

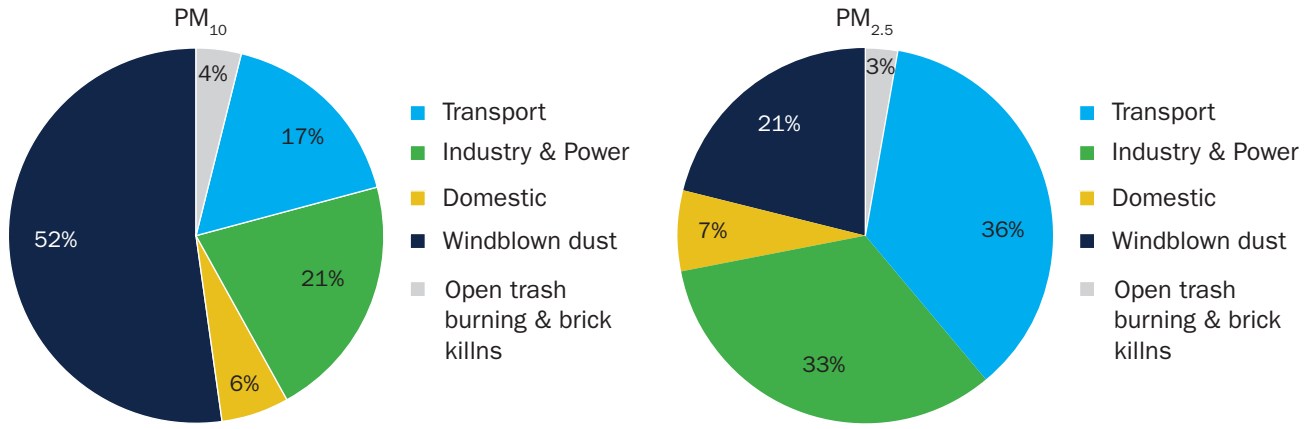
extrapolated to a longer period. Emissions inventories can be used to help target actions for pollution reduction and raise public awareness.

IITM SAFAR Emissions Inventory - 2017

The System of Air Quality and Weather Forecasting and Research (SAFAR) as part of India Institute of Tropical Meteorology, Pune (IITM) along with the Indian Meteorological Department (IMD) monitors and forecasts an AQI in four cities in India, including Ahmedabad. Emission inventories, which identify key contributors to air pollution for application in pollution forecasting, have been developed in Ahmedabad. An emissions inventory for Ahmedabad was developed in 2017 for major air pollutants, as shown by sectoral breakdown in Figures 4 and 5.[49]

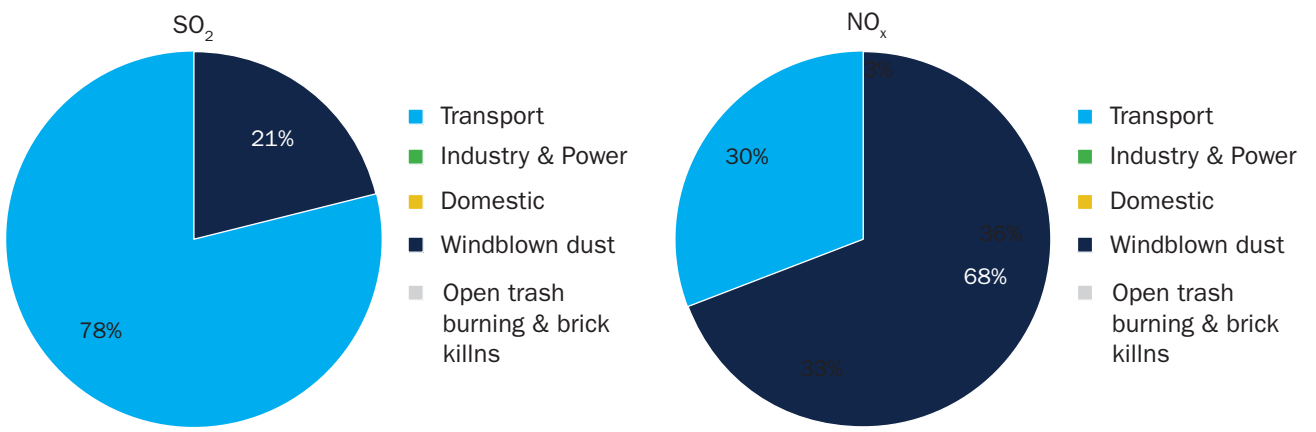
The inventory indicates that the transport and industrial sectors (industries and power) play a major role in primary $PM_{2.5}$ emissions, contributing around 36% and 33% respectively to total annual emissions. These sectors are followed by windblown dust, which contributes around 21% to the total annual $PM_{2.5}$ emissions. The estimated total emissions of $PM_{2.5}$ for Ahmedabad Metropolitan Region (AMR) was 18.66 gigagrams per year (Gg/yr). Windblown dust was the primary source of PM_{10}, which contributed 52% to the total emissions. Industries were the second largest source of PM_{10}, contributing 21% to the total emission followed by transport (17%). The total PM_{10} emission over AMR from all sectors was 56 Gg/yr. The estimated total CO emissions from all the sources was 150.46 Gg/yr. The transport sector contributed the most to the total CO emissions, around 63%, followed by domestic sector (31%) which involved cooking and heating activity in slums, hotels, and restaurants.

Figure 4: Sectoral emissions for particulate matter for Ahmedabad (source: SAFAR, 2017).[50]



For SO_2, the industrial sector dominates contributing 78% to the total emissions. This is followed by transport sector with contribution of about 21%. Industrial coal and other fuels consumption play an important role in SO_2 emissions. The total SO_2 emissions over the Ahmedabad region from all sectors was 62.52 Gg/year. For NO_x, transport is the dominating sector, responsible for 68% of total annual emissions. This is largely from vehicular activity. Transport is followed by emissions from the industrial sector, which contributes about 30%. The estimated total NO_x emission from all sectors was 102.94 Gg/yr.

Figure 5: Sectoral emissions for SO_2 and NO_x for Ahmedabad (source: SAFAR, 2017).[55]



Overall, the emissions inventory indicates that:

- Most of the gaseous pollutants, except SO_2, and including particle pollutant organic carbon (OC), are emitted from the transport sector.
- Most particle pollution, including $PM_{2.5}$ and black carbon (BC) are emitted substantially from both the transport and industries sectors.
- Mineral dust (wind-blown) contributes the most to coarse particle pollution (PM_{10}).

GEMI Emissions Inventory and Source Apportionment Study - 2020

The Gujarat Environment Management Institute (GEMI) conducted an emission inventory and source apportionment study in 2019 for Ahmedabad to develop a daily and annual averaged ground-level profile of several pollutants including PM_{10}, NO_x, SO_2, CO.[51] The emissions sources were categorized into three major groups: 1) area-sources: domestic sectors, hotels and restaurants, construction and demolition (C&D), and road dust; 2) line-sources: vehicles, locomotives, and aircrafts; and 3) point sources, including industries and crematoria.

The major sources from the city's 2019 emission inventory were road dust and domestic sectors for PM; industries for SO_2; vehicular and industries for NO_x; and domestic for CO. Road dust emerged as the highest contributor toward PM in the city, contributing 36%, followed by domestic (34%). Point sources were the largest contributor to SO_2 (93%). Line sources contributed to 52% of NO_x emissions followed by point sources at 34%. Most CO emissions were from domestic sources at 88%. The total daily emission load for the pollutants PM, SO_2, NO_x, and CO was 54 tons/day, 54 tons/day, 35 tons/day, and 154 tons/day respectively. From total emission load, highest pollution loads of CO, SO_2, PM, and NO_x were observed at the central part of the city with major commercial activities and high population and road densities.

GEMI also projected the emission inventory for Ahmedabad for 2024 and 2029. The projected emission load estimation under business as usual (BAU) scenarios indicate that by 2024, an increase of about 27%, 6%, 29% and 19% in PM, SO_2, NO_x, and CO respectively will take place when compared to 2019 levels. By 2029, the increase could be about 54%, 12%, 58% and 38% for PM, SO_2, NO_x, and CO, respectively (Figure 1).

Urban Emissions Study - 2019

Urban Emissions used special and temporal modeling to compile a multi-pollutant emissions inventory for the Ahmedabad region under the 2019 Air Pollution knowledge Assessments (APnA) city program.[52] The Urban Emissions study included compiling an inventory of major sources and data (including meteorology), computing emissions and their spatial and temporal allocation, and mapping pollution and estimating source contributions using a chemical transport model. Projections under a BAU scenario for the Urban Emissions study show that $PM_{2.5}$ emissions will increase between 2018 and 2030.

The three main emissions inventories in Ahmedabad highlight that pollution continues to plague Ahmedabad and levels are projected to remain high. The studies show industry - both large and small, transportation (e.g., two- and three-wheelers), and the older thermal power plants in and around Ahmedabad contribute significantly to pollution.

Planetary Health: Air Quality, Climate, and Health Co-Benefits

Climate change, extreme heat, and air pollution are all connected. With global temperatures soaring because of climate change, demand for electricity to keep people cool and safe from sweltering heat is critical. Air conditioning cools indoor spaces, protects our bodies from heat stress, and can save lives. However, if we power air conditioning by burning dirty fossil fuels, rather than by harnessing cleaner, renewable energy sources, we increase dangerous air pollution and contribute to the climate crisis. IIPH-G, NRDC, IITM, and GERMI are working on an air pollution co-benefit applied research study for the city of Ahmedabad. The study focuses on estimating the local air quality and public health benefits of climate response action plans at the city level in Ahmedabad.[53]

Leading scientists at GERMI are estimating Ahmedabad's electricity demand in 2030, accounting for increased demand for air conditioning. Experts at IITM and IIPH-G are working to model and compare air quality projections for two climate change response strategies to strengthen local resilience to climate threats: increasing the share of renewable solar energy in power generation (mitigation); and expanding cool roofs in Ahmedabad (adaptation). This work builds upon IIPH-G and NRDC's existing work on the CAP and incorporates health-risk communication strategies from the AIR plan with the AMC. The study then models the local health benefits from cleaner air in 2030. This local research with help to strengthen actions on climate change and air pollution and estimate potential near-term health improvements associated with responses to climate change. This work was supported by the Wellcome Trust [#216093/Z/19/Z].

Way Forward

Looking ahead to 2022 and beyond, Ahmedabad and other India cities must take strong and sustained action to improve air quality and to achieve the goals of the new national mission. Key priority control strategies across transportation, power plants, and industries need to be implemented in the short-term with strong government action through an enhanced air quality management cell and coordination. Robust monitoring systems, refinement of emissions inventories and source apportionment information, citizen engagement, and studies on the health impacts of air pollution in India are critical to help policymakers prioritize air pollution control strategies that can better protect public health, reverse environmental degradation, and achieve clean air for all.

ENDNOTES

1 Ioannis Manisalidis et al., "Environmental and Health Impacts of Air Pollution: A Review." Frontiers in Public Health, February 2020, https://www.frontiersin.org/articles/10.3389/fpubh.2020.00014/full; Anamika Pandey et al., "Health and Economic Impact of Air Pollution in the States of India: the Global Burden of Disease Study 2019," The Lancet Planetary Health, December 2020, https://doi.org/10.1016/S2542-5196(20)30298-9; Ravindran Chetambath and Jesin Kumar C., "Air Pollution in Delhi and the Health Emergency." The Indian Practitioner, November 2019, https://articles.theindianpractitioner.com/index.php/tip/article/view/869.

2 Government of India, Long-Term, Time-Bound, National Level Strategy to Tackle Air Pollution-National Clean Air Programme (NCAP), September 2020, https://pib.gov.in/PressReleasePage.aspx?PRID=1655203

3 IITM, Pune and SAFAR, Emission Inventory of Ahmedabad 2017, 2017, http://assets.nrdc.org/sites/default/files/media-uploads/safar-ahmedabad-ei-2017-full_report.pdf; GEMI, GEMI Source Apportionment Study of Ahmedabad City, November 2020, https://gemi.gujarat.gov.in/Projects/source-apportionment-study-of-ahmedabad-city-1; Urban Emissions, "City - Ahmedabad (Gujarat, India)," 2019, https://urbanemissions.info/india-apna/ahmedabad-india/.

4 GEMI, GEMI Source Apportionment Study of Ahmedabad City, November 2020, https://gemi.gujarat.gov.in/Projects/source-apportionment-study-of-ahmedabad-city-1.

5 Projection of point source emission assumes no further accountable growth in industrial cluster and thus the total emission for BAU 2024 and 2029 is considered with marginal increment of 5%. For line source comprising of locomotive and aircrafts a marginal growth for locomotives and aircrafts is considered, whereas, for vehicles 10% annual growth rate is considered for 2024 and 2029.

6 GEMI, GEMI Source Apportionment Study of Ahmedabad City, November 2020, https://gemi.gujarat.gov.in/Projects/source-apportionment-study-of-ahmedabad-city-1.

7 Urban Emissions, "City - Ahmedabad (Gujarat, India)," 2019, https://urbanemissions.info/india-apna/ahmedabad-india/.

8 For projections under BAU, Urban Emissions based the vehicle growth rate on the sales projection numbers; industrial growth on the gross domestic product of the state; domestic sector, construction activities, brick demand, diesel usage in the generator sets, and open waste burning on population growth rates and notes from the municipalities on plans to implement waste management programs. These estimates were used to evaluate the trend in the total emissions and their likely impact on ambient PM2.5 concentrations through 2030.

9 Urban Emissions, "City - Ahmedabad (Gujarat, India)," 2019, https://urbanemissions.info/india-apna/ahmedabad-india/.

10 The methodology builds on earlier analysis in Clearing The Air: a Review of 10 City Plans to Fight Air Pollution in India, January 2020, https://www.nrdc.org/sites/default/files/10-city-plans-fight-air-pollution-india-202001.pdf.

11 NCAP Tracker, accessed January 11 2022, https://ncaptracker.in/ncap/.

12 Anamika Pandey et al., "Health and Economic Impact of Air Pollution in the States of India: the Global Burden of Disease Study 2019," The Lancet Planetary Health, December 2020, https://doi.org/10.1016/S2542-5196(20)30298-9.

13 Ioannis Manisalidis et al., "Environmental and Health Impacts of Air Pollution: A Review." Frontiers in Public Health, February 2020, https://www.frontiersin.org/articles/10.3389/fpubh.2020.00014/full; Frontiers in Public Health, February 2020, https://www.frontiersin.org/articles/10.3389/fpubh.2020.00014/full; Ravindran Chetambath and Jesin Kumar C., "Air Pollution in Delhi and the Health Emergency." The Indian Practitioner, November 2019, https://articles.theindianpractitioner.com/index.php/tip/article/view/869; Sachin Ghude et al., Reductions in India's Crop Yield Due to Ozone, Geophysical Research Letters, August 2014, https://doi.org/10.1002/2014GL060930.

14 Anamika Pandey et al., "Health and Economic Impact of Air Pollution in the States of India: the Global Burden of Disease Study 2019," The Lancet Planetary Health, December 2020, https://doi.org/10.1016/S2542-5196(20)30298-9.

15 MoEFCC Government of India, National Clean Air Programme, 2019, https://urbanemissions.info/wp-content/uploads/docs/India-NCAP-Proposal-Final.pdf.

16 MoEFCC Government of India, First Meeting of National Apex Committee Under National Clean Air Programme Held, December 2021, https://pib.gov.in/PressReleasePage.aspx?PRID=1782722.

17 Tanushree Ganguly et al., National Clean Air Programme (NCAP) for Indian Cities: Review and Outlook of Clean Air Action Plans, Atmospheric Environment, December 2020 https://doi.org/10.1016/j.aeaoa.2020.100096.

18 Health Effects Institute (HEI), Global Burden Of Disease From Major Air Pollution Sources (GBD MAPS): A Global Approach, December 2021, https://www.healtheffects.org/publication/global-burden-disease-major-air-pollution-sources-gbd-maps-global-approach.

19 TERI, Cost Effectiveness Of Interventions For Control Of Air Pollution In Delhi, December 2021, https://www.teriin.org/sites/default/files/2021-12/Cost-effectiveness-of%20-interventions-for-control-of%20-air-pollution-in-Delhi.pdf.

20 SAFAR, Ministry of Earth Science, Government of India, Air Quality Index, accessed January 14, 2022, http://safar.tropmet.res.in/AQI-47-12-Details.

21 Vijay Limaye al., Development of Ahmedabad's Air Information and Response (AIR) Plan to Protect Public Health, International Journal of Environmental Research and Public Health, July 2018, https://doi.org/10.3390/ijerph15071460.

22 Solid Waste India, "From Dumpsite to Ecological Park -The Transformation of Pirana and Bopal Garbage Dumps," November 2021, https://solidwasteindia.com/exclusive-interview-from-dumpsite-to-ecological-park-the-transformation-of-ahmedabads-pirana-and-bopal-garbage-dumps/; Times of India, Ahmedabad Municipal Corporation Able to Reclaim 24% Of Pirana Dump, June 2021, https://timesofindia.indiatimes.com/city/ahmedabad/amc-able-to-reclaim-24-of-pirana-dump/articleshow/83215312.cms.

23 Times Now News, Ahmedabad: Dump Yard at Pirana Park to See Plantation Drive at Last, August 2021, https://www.timesnownews.com/ahmedabad/article/ahmedabad-dump-yard-at-pirana-park-to-see-plantation-drive-at-last/800541.

24 IITM-Pune and SAFAR, Emission Inventory of Ahmedabad 2017, 2017, http://assets.nrdc.org/sites/default/files/media-uploads/safar-ahmedabad-ei-2017-full_report.pdf.

25 Motor India, "JBM Delivers First Batch of ECO-LIFE Electric Buses to Ahmedabad," June 2021, https://www.motorindiaonline.in/jbm-delivers-first-batch-of-eco-life-electric-buses-to-ahmedabad/; Times of India, "Tata Motors Delivers 60 Ultra Urban Electric Buses to Ahmedabad Janmarg," December 2021, https://timesofindia.indiatimes.com/auto/news/tata-motors-delivers-60-ultra-urban-electric-buses-to-ahmedabad-janmarg/articleshow/88083932.cms.

26 NRDC, "Indian Cities Struggle for Clean Air," December 2021, https://www.nrdc.org/experts/Indian-jaiswal/Indian-cities-struggle-clean-air.

27 Gujarat Pollution Control Board (GPCB), Action Plan For Control of Air Pollution In Non-Attainment City of Gujarat (Ahmedabad), accessed January 16, 2021, https://cpcb.nic.in/Actionplan/Ahmedabad.pdf.

28 NRDC, "Indian Cities Struggle for Clean Air," December 2021, https://www.nrdc.org/experts/Indian-jaiswal/Indian-cities-struggle-clean-air.

29 TERI, Cost Effectiveness Of Interventions For Control Of Air Pollution In Delhi, December 2021, https://www.teriin.org/sites/default/files/2021-12/Cost-effectiveness-of%20-interventions-for-control-of%20-air-pollution-in-Delhi.pdf.

30 The Automotive Research Association of India (ARAI), Indian Emissions Regulations - Limits, Regulations, Test Cycles, Measurement of Exhaust Emissions and Calculation of Fuel Consumption, August 2021, https://www.araiindia.com/pdf/Indian_Emission_Regulation_Booklet.pdf

31 The Automotive Research Association of India (ARAI), Indian Emissions Regulations - Limits, Regulations, Test Cycles, Measurement of Exhaust Emissions and Calculation of Fuel Consumption, August 2021, https://www.araiindia.com/pdf/Indian_Emission_Regulation_Booklet.pdf

32 Centre for Science and Environment (CSE), Is Sulphur Dioxide a Problem in India's Ambient Air? April 2021, https://www.cseindia.org/is-sulphur-dioxide-a-problem-in-india-s-ambient-air—10807.

33 Down To Earth, Environment Ministry Finalises Coal Thermal Power Plant Categories: What Does It Say About Emission Norms Compliance, December 2021, https://www.downtoearth.org.in/news/pollution/environment-ministry-finalises-coal-thermal-power-plant-categories-what-does-it-say-about-emission-norms-compliance-80795

34 Economic Times, Coal Units in 10 States Asked to Install Anti-Emission Gear, December 2021, https://economictimes.indiatimes.com/industry/energy/power/coal-units-in-10-states-asked-to-install-anti-emission-gear/articleshow/88422515.cms?from=mdr.

35 Centre for Science and Environment (CSE), Meeting Emission Norms, October 2021, https://www.cseindia.org/meeting-emission-norms-10424.

36 TERI, Cost Effectiveness Of Interventions For Control Of Air Pollution In Delhi, December 2021, https://www.teriin.org/sites/default/files/2021-12/Cost-effectiveness-of%20-interventions-for-control-of%20-air-pollution-in-Delhi.pdf.

37 Times of India, Ahmedabad Municipal Corporation Sets Up Cell to Boost Air Quality, August 2021, https://timesofindia.indiatimes.com/city/ahmedabad/amc-sets-up-cell-to-boost-air-quality/articleshow/85222317.cms.

38 Central Pollution Control Board (CPCB), National Ambient Air Quality Status & Trends 2019, September 2020, https://cpcb.nic.in/upload/NAAQS_2019.pdf.

39 CPCB, National Ambient Air Quality Status & Trends 2019, September 2020, https://cpcb.nic.in/upload/NAAQS_2019.pdf.

40 CPCB, National Ambient Air Quality Status & Trends 2019, September 2020, https://cpcb.nic.in/upload/NAAQS_2019.pdf.

41 MoEFCC Government of India, National Clean Air Programme, 2019, https://urbanemissions.info/wp-content/uploads/docs/India-NCAP-Proposal-Final.pdf.

42 WHO, "New WHO Global Air Quality Guidelines Aim To Save Millions Of Lives From Air Pollution," September 2021, https://www.who.int/news/item/22-09-2021-new-who-global-air-quality-guidelines-aim-to-save-millions-of-lives-from-air-pollution; Business Standard, "More Stringent Air Quality Norms Needed, Say Experts After WHO Guidelines," September 2021, https://www.business-standard.com/article/current-affairs/more-stringent-air-quality-norms-needed-say-experts-after-who-guidelines-121092201366_1.html.

43 CSE, Is Sulphur Dioxide a Problem in India's Ambient Air? April 2021, https://www.cseindia.org/is-sulphur-dioxide-a-problem-in-india-s-ambient-air—10807.

44 Vijay Limaye et al., Development of Ahmedabad's Air Information and Response (AIR) Plan to Protect Public Health, International Journal of Environmental Research and Public Health, July 2018, https://doi.org/10.3390/ijerph15071460.

45 Anamika Pandey et al., "Health and Economic Impact of Air Pollution in the States of India: the Global Burden of Disease Study 2019," The Lancet Planetary Health, December 2020, https://doi.org/10.1016/S2542-5196(20)30298-9.

46 GEMI, GEMI Source Apportionment Study of Ahmedabad City, November 2020, https://gemi.gujarat.gov.in/Projects/source-apportionment-study-of-ahmedabad-city-1; Vijay Limaye et al., Development of Ahmedabad's Air Information and Response (AIR) Plan to Protect Public Health, International Journal of Environmental Research and Public Health, July 2018, https://doi.org/10.3390/ijerph15071460.

47 IITM, Pune and SAFAR, Emission Inventory of Ahmedabad 2017, 2017, http://assets.nrdc.org/sites/default/files/media-uploads/safar-ahmedabad-ei-2017-full_report.pdf; GEMI, GEMI Source Apportionment Study of Ahmedabad City, November 2020, https://gemi.gujarat.gov.in/Projects/source-apportionment-study-of-ahmedabad-city-1; Urban Emissions, "City – Ahmedabad (Gujarat, India)," 2019, https://urbanemissions.info/india-apna/ahmedabad-india/.

48 U.S. EPA, "Managing Air Quality - Emissions Inventories," accessed January 19, 2022, https://www.epa.gov/air-quality-management-process/managing-air-quality-emissions-inventories

49 IITM, Pune and SAFAR, Emission Inventory of Ahmedabad 2017, 2017, http://assets.nrdc.org/sites/default/files/media-uploads/safar-ahmedabad-ei-2017-full_report.pdf
The emission inventory covered the AMR, a 30 km x 35 km domain, which includes Ahmedabad, Gandhinagar city area, and the surrounding villages. The emission inventory used a bottom-up approach, with a high spatial resolution of 1.67 km x 1.67 km, for the year 2016 to 2017 using a GIS statistical model.

50 IITM, Pune and SAFAR, Emission Inventory of Ahmedabad 2017, 2017, http://assets.nrdc.org/sites/default/files/media-uploads/safar-ahmedabad-ei-2017-full_report.pdf

51 GEMI, GEMI Source Apportionment Study of Ahmedabad City, November 2020, https://gemi.gujarat.gov.in/Projects/source-apportionment-study-of-ahmedabad-city-1.

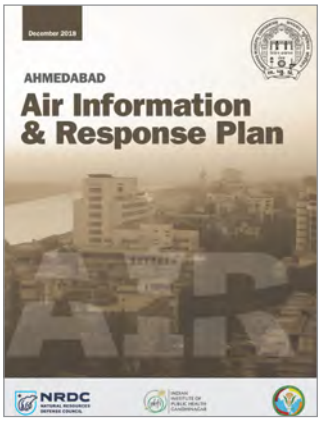
52 Urban Emissions, "City – Ahmedabad (Gujarat, India)," 2019, https://urbanemissions.info/india-apna/ahmedabad-india/; Urban Emissions, APnA City Program, July 2019, https://urbanemissions.info/wp-content/uploads/apna/docs/2019-07-APnA30city_summary_report.pdf.

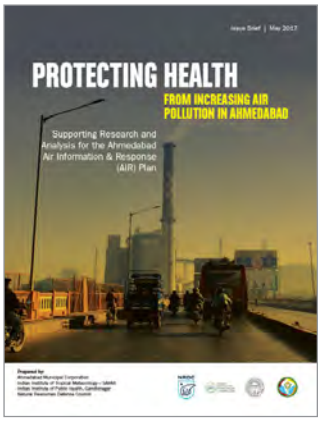
53 Ahmedabad Health Co-Benefits by 2030 Study Group and NRDC, Identifying the Health Benefits of Addressing Climate Change in Ahmedabad, India, 2021, https://www.nrdc.org/resources/identifying-health-benefits-addressing-climate-change-ahmedabad-india.

54 Vijay Limaye et al., Development of Ahmedabad's Air Information and Response (AIR) Plan to Protect Public Health, International Journal of Environmental Research and Public Health, July 2018, https://doi.org/10.3390/ijerph15071460.

55 IITM, Pune and SAFAR, Emission Inventory of Ahmedabad 2017, 2017, http://assets.nrdc.org/sites/default/files/media-uploads/safar-ahmedabad-ei-2017-full_report.pdf

Highlighted Reports





More NRDC Publication

India Clearing the Air Series:

https://www.nrdc.org/resources/clearing-air-review-of-city-actions-to-fight-air-pollution-india

India Air Quality and Public Health Series:

https://www.nrdc.org/resources/cutting-through-air-protecting-public-health-air-pollution-ahmedabad

India Health Benefits Series

https://www.nrdc.org/resources/identifying-health-benefits-addressing-climate-change-ahmedabad-india

NRDC

KNOWLEDGE IN ACTION phfi INDIAN INSTITUTE OF PUBLIC HEALTH GANDHINAGAR

CEE
Centre for Environment Education