Asian and Pacific Centre for Transfer of Technology

Assessment Report

City Action Plans and Technology Adoption Strategies in Gurugram, India

ESCAP
APCTT
Asian and Pacific Centre
for Transfer of Technology

*The shaded areas of the map indicate ESCAP members and associate members.**

The Economic and Social Commission for Asia and the Pacific (ESCAP) is the most inclusive intergovernmental platform in the Asia-Pacific region. The Commission promotes cooperation among its 53 member States and 9 associate members in pursuit of solutions to sustainable development challenges. ESCAP is one of the five regional commissions of the United Nations.

The ESCAP secretariat supports inclusive, resilient and sustainable development in the region by generating action-oriented knowledge, and by providing technical assistance and capacity-building services in support of national development objectives, regional agreements and the implementation of the 2030 Agenda for Sustainable Development.

**The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries*

City Action Plans and Technology Adoption Strategies in Gurugram, India

ESCAP
APCTT
Asian and Pacific Centre
for Transfer of Technology

The views expressed in this document are those of the authors and do not necessarily reflect the views of the Asian and Pacific Centre for Transfer of Technology (APCTT) of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). The designations employed and the presentation of the materials in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This publication follows the United Nations' practice in reference to countries. Where there are space constraints, some country names have been abbreviated. Mention of a commercial company or product in this publication does not imply endorsement by ESCAP-APCTT.

This publication is issued in English only.

Links contained in this publication are provided for the convenience of the reader and are correct at the time of issue. The United Nations takes no responsibility for the continued accuracy of that information or for the content of any external website.

United Nations publication

Printed in New Delhi
ESCAP/2-PB/52

This publication should be cited as: *United Nations, Asian and Pacific Centre for Transfer of Technology, United Nations Economic and Social Commission for Asia and the Pacific (2024). City Action Plans and Technology Adoption Strategies in Gurugram, India.*

This document has been issued without formal editing.

FOREWORD

It is with great pleasure that I introduce this document: *City Action Plans and Technology Adoption Strategies in Gurugram, India*.

The Asian and Pacific Centre for Transfer of Technology (APCTT) of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), has long been dedicated to fostering innovation and facilitating the transfer of technology across our diverse member countries. APCTT's key mandate is to strengthen the technology transfer capabilities in the Asia- Pacific region and to facilitate exchange of new, emerging and environmentally sound technologies between the member countries.

This document was produced under the project "Enhanced capabilities to adopt innovative technologies for city air pollution control in select countries of the Asia Pacific" supported by the Korea ESCAP Cooperation Fund. The project objective was to support three ESCAP member States (Bangladesh, India and Thailand) to strengthen policies and city level action plans to facilitate adoption of innovative technologies for controlling air pollution. The project aimed to improve the availability of technical knowledge regarding innovative technologies, and good practices and enabling policies for air pollution control in three cities (Bangkok, Dhaka and Gurugram).

This report, a collaborative effort involving experts and stakeholders, presents a detailed analysis of existing measures and proposes strategic approaches for technology adoption. The findings herein serve as a valuable resource for policymakers, city planners, and technologists in Gurugram and other cities providing insights into the effectiveness of current initiatives and recommending future policy pathways for enhancing air quality. We hope that this report significantly advances our understanding of air quality dynamics and stimulates further discourse and evidence-based actions for a cleaner and more resilient urban environment in Asia Pacific.

Preeti Soni
Head
Asian and Pacific Centre for Transfer of Technology
Economic and Social Commission for Asia and the Pacific

This document: *City Action Plans and Technology Adoption Strategies in Gurugram, India* is part of a set of reports developed under the project "Enhanced Capabilities to Adopt Innovative Technologies for City Air Pollution Control in Select Countries of the Asia-Pacific" funded by the Korea ESCAP Cooperation Fund. It has been prepared under the overall guidance and direction of Dr. Preeti Soni, Head, Asian and Pacific Centre for Transfer of Technology (APCTT) of the Economic and Social Commission for Asia and the Pacific (ESCAP).

The publication was prepared by Dr. Ajay A. Deshpande under a consultancy assignment with ESCAP-APCTT. Mr. Subhash Yadav of Gurugram Metropolitan Development Authority played a valuable role in providing key information and insights for the study. The report benefited from comments and suggestions from Mr. Satyabrata Sahu and Mr. Pankaj Kumar Shrivastav from the ESCAP-APCTT.

We gratefully acknowledge all of the above.

TABLE OF CONTENTS

ACRONYMS

ASG	Anti-Smog Gun
CAP/CAAP	City Action Plan/ City Air Action plan
CAAQMS	Continuous Automatic Ambient Air Quality Monitoring Station
CAQM	Commission of Air Quality Management for NCR
CEMS	Continuous Emission Monitoring system
CNG	Compressed Natural Gas
CPCB	Central Pollution Control Board
DEP	District Environmental Plan
EPCA	Environment Protection and Control Authority
GMC	Gurugram Municipal Corporation
GMDA	Gurugram Municipal Development Authority
GRAP	Graded Response Action Plan
HSPCB	Haryana State Pollution Control Board
LCS	Low Cost Sensors
MoEFCC	Ministry of Environment and Forest and climate Change, Govt. of India
NCAP	National Clean Air Programme
NCR	National Capital Region Territory of Delhi
PM2.5	Particulate matter less than 2.5 micron size
PM10	Particulate matter less than 10 micron size
SPCB	State Pollution Control Board

1. INTRODUCTION

Globally, air pollution is acknowledged as a prominent environmental health hazard. According to the latest data from the Global Burden of Disease (GBD) study, 6.7 million deaths in 2019 were attributed to air pollution, with the Asia-Pacific region contributing about 70% of these fatalities (Dey, 2023). Airborne pollutants encompass particulate matter and gaseous elements, originating either directly from various sources (referred to as primary pollutants) or emerging in the atmosphere through chemical reactions (referred to as secondary pollutants). Predominant air pollutants in the Asia-Pacific regions include particulate matter with an aerodynamic diameter smaller than 10 μm (PM10) and 2.5 μm (PM2.5), sulphur dioxide (SO2), nitrogen oxides, ozone, carbon monoxide (CO), lead, and nonmethane volatile organic compounds (NMVOCs).

Air quality control actions aim to bring an airshed into air quality attainment and protect human health and the environment. The essential element of this planning is development of an air quality action plan that provides a framework for addressing specific air pollution problems.

Air quality action plans provide a mechanism by which the local authority, in collaboration with national agencies and others, state their intentions for working towards the air quality objectives through the use of powers they have available. In some cases, the air quality action plan also works as a tangible milestone and blueprint of actions to attract financial resources for implementing various mitigation measures. The plans must focus on effective, feasible, proportionate and quantifiable measures that will contribute to reducing levels of air pollution within city limits and ensure that air quality objectives are achieved within the shortest possible time.

1.1 Regulatory Interventions

India has a robust legislative and regulatory framework for environment protection, including air pollution. Indian Constitution has accorded a fundamental right to its citizens to have a clean and pollution- free environment through its Article 21. India enacted specific legislations in terms of the Air (P revention and Control of Pollution) Act in 1981 and a comprehensive legislation named Environmental (Protection) Act in 1986. The National A mbient A ir Quality Standards (NAAQS) have been notified under the Air Act, and there are several enabling regulations that have been notified either under the Air Act or EP Act, including Waste Management Rules, industry- specific emission standards, environmental impact assessment regulation, regulations for clean fuel, etc.

1.1.1 These regulations are enforced through a well- articulated institutional mechanism. The Ministry of Environment and Forest (MoEFCC) is the overall authority for environmental protection and conservation in the country. At the state level, the Department of Environment coordinates state level activities. The Central P ollution C ontrol Board (CPCB) is responsible for improving the air quality in the country through development of action plans and technical interventions. Each state also has a State Pollution Control Board (SPCB), which is responsible for the enforcement, compliance, development and execution of action plans.. However, it is well recognised that air pollution is a multi-faceted problem and, therefore, there are several government departments; for example, the Department of Urban D evelopment deals with waste management ; the Department of Transport deals with automobile pollution; the Department of Highways deals with by-passes and urban infrastructure, etc. These departments proactively work towards air pollution control through their operational mandate.

1.1.2 Air pollution in and around Delhi and some other major cities has been under the scrutiny of judiciary since 2002; several directions have been passed by the Hon'ble Supreme Court and EPCA, which include, but are not limited to, the use of clean fuel for transportation, stringent emission norms, science- based approach, etc. CAQM enlists several legal directions issued to various stakeholders for the control of air pollution on their website[1], which inter alia includes measures for construction and demolition waste management, cleaner fuel, uninterrupted power to reduce use of DG sets, crop residue burning, use of remote sensing for air quality assessment, etc.

1 https://caqm.nic.in/index1.aspx?lsid=1070&lev=2&lid=1073&langid=1

1.1.3 Pursuant to the Hon'ble Supreme Court's order, dated December 02, 2016, in the matter of M. C. Mehta vs. Union of India, regarding air quality in the National Capital Region of Delhi, a Graded Response Action Plan has been prepared for implementation under different Air Quality Index (AQI) categories, namely: Moderate & Poor, Very Poor, and Severe, as per the National Air Quality Index. A new category of "Severe+ or Emergency" has been added. The Ministry of Environment, Forests & Climate Change has notified the implementation of Graded Response Action Plan through Environment Pollution (Prevention & Control) Authority, vide S.O. 118 (E), dated January 12, 2017. Basically, GRAP is supposed to be implemented when the air quality deteriorates. The GRAP is applicable for the entire NCR area, including Gurugram.

1.1.4 GRAP is an emergency response plan; it is supposed to be implemented only when the quality of air goes below a certain threshold. It is to be noted that the plan is exclusive of other measures taken by the various authorities during the course of the year. Those measures will continue, and this is only an emergency plan. The GRAP is incremental in nature, which means that, depending on the air quality index (AQI), several steps and measures are to be taken by the designated bodies/agencies.

1.2 Science-based Policies and Planning

Urban policies and planning play a critical role in overall sustainable development of the city, including its air quality. In metro cities, air pollution is prevalent mainly due to heavy vehicle emission, solid waste mismanagement and construction activities. The n umber of private vehicles can be reduced by intervention of public transport facilities with classified zero- mile connectivity. The d uration of vehicles on the road can be reduced only by removing encroachment from roads and junction improvements.

Urban p lanners can propose an effective land use transportation model to reduce the carbon emission and the solid waste exposed to air, which will result in reduction of air pollution. However, it is the urban administration that has to take strong initiatives based on the raised concerns.

Long-term plans for urban planning and transportation always work. In the next 10 years, the urban population is expected to increase by 30%. Provisions for this huge increase, along with the required replacement of obsolete infrastructure, will provide a significant opportunity to rationally plan and build to reduce air pollution impacts. If this opportunity is to be grasped, careful consideration of local land development policies, transport plans and new implementation methods, as well as increased receptivity to the regulation of private vehicles, will be needed.

In India, various components are being incorporated into the planning of Smart Cities to address these concerns. These include sufficient green belts, green building designs, efficient public transport systems, walk-to-work concepts, robust systems for solid waste management, etc. Some important policies required for a city are:

- Parking policy
- Public transport policy
- Green construction policy
- Construction and demolition waste management strategy
- Plantation policy
- E-vehicle policy including support to public charging stations
- Solar power policy
- Low emission zone policy
- Supply of clean fuel for enterprises and urban poor

2. REVIEW OF CITY ACTION PLANS IN INDIA

2.1 India has been developing Air quality action plans since the year 2005, when 16 cities in the country were first identified as cities with high levels of air pollution, and the city-wise air quality action plans were prepared in compliance with the orders of the Supreme Court of India. Subsequently several initiatives, including 6-city source apportionment studies[2] have been carried out by CPCB in Mumbai, Pune, Delhi, Bengaluru, Chennai and Kanpur. These studies provided a comprehensive assessment of the air pollution sources and their relative contribution in the city air quality. There seems to be a general consensus among the researchers that the Particulate matter (PM) is a pollutant of concern and, more importantly, the contribution of secondary particulates is estimated to be increasing significantly in the NCR region. India has also developed an Air Quality Index (AQI) which has contributed significantly in creating awareness amongst people about air quality status. It has been receiving significant press and media coverage as well.

2.2 With increased public and judicial scrutiny, there have been regular interventions by the regulators, and the government has also attempted to set up a regulatory mechanism, specially for Delhi and its surroundings in response to consistently deteriorating air quality in the region. Initially, a separate authority called Environment Pollution (Prevention & Control) Authority[3] for the National Capital Region was formed in 1998 with a mandate to take steps to mitigate air pollution in the NCR region. Subsequently in 2020, a separate statutory authority[4] named 'Commission for Air Quality Management in the National Capital Region and Adjoining Areas' has been constituted with significant overarching powers to mitigate air pollution in the NCR and adjoining areas. The commission has been constituted by a Special Act[5] of the Parliament, `The Commission for Air Quality Management In National Capital Region And Adjoining Areas Act, 2021: No. 29 Of 2021'. The Commission has statutory and regulatory powers to take effective steps for the control of pollution in the specified area under which the city and district of Gurugram falls.

2.3 The Government of India's National Clean Air Program (NCAP)[6] is a powerful step in acknowledging and resolving the problem of deteriorating ambient air quality. The NCAP has set a time-bound goal for improving air quality across the country, with a focus on around 132 'non-attainment' cities where air quality standards are not being met. The NCAP provides the cities an overall framework for developing air quality management plans, with guidance on policies across a range of sectors. NCAP incorporates various technological aspects for the control of air pollution and also enables the individual cities to try and adopt innovative technologies and measures for location-specific air pollution control measures. The important features of the NCAP include provisions of fiscal support for the implementation of air quality action plans and linking such fiscal support with the performance of the cities to reduce the air pollution load.

2.4 Implementation of NCAP: The NCAP is institutionalised by respective ministries and organised through inter-sectoral groups, which include, in addition to the related ministries, the Ministry of Finance, Ministry of Health, NITI Aayog, CPCB, experts from the industry, academia, and civil society. The Apex Committee in the Ministry periodically reviews the progress of these components. The a nnual performance for individual cities are periodically reported. Appropriate indicators have evolved for assessing the emission reduction benefits of the actions.

City Action Plans (CAP) of 132 cities are to be implemented by the coordinated action of the state government and its agencies at the state and city level. Non-attainment cities (NAC) are declared so if over a 5-year period they fail to meet the National Ambient Air Quality Standards (NAAQS) for PM 10 (Particulate matter that is 10 microns or less in diameter) or N02 (Nitrogen Dioxide) consistently.

2 https://cpcb.nic.in/source-apportionment-studies/

3 https://epca.org.in

4 https://caqm.nic.in/index.aspx

5 https://caqm.nic.in/WriteReadData/LINKS/dc454d5d-6d9f-4f3b-8f8d-8ab1e634aa4e.pdf

6 https://moef.gov.in/wp-content/uploads/2019/05/NCAP_Report.pdf

2.5 Some of these action plans have been reviewed and compared in a brief Issue Paper prepared by NRDC with CEE in 2020, titled `Clearing The Air: A Review Of 10 City Plans To Fight Air Pollution In India[7]. The methodology of the report included analysis of CAP documents for ongoing and planned sector-specific mitigation actions for each of the 10 cities, with a specific focus on key emissions sectors, which include: i. transportation; ii. stationary sources (power plants and industries); and iii. construction and demolition (C&D); iv. waste collection and processing, including municipal solid waste (MSW), C&D waste, and industrial waste and diesel generator (DG) sets. The common actions under the transportation sector include: i. restriction on older vehicles; ii. infrastructure for CNG and e- mobility; iii. cleaner fleets for public transport, first and last mile connectivity using clean fuel; iv. in-use emission control, including installation of removable sensor-based Pollution Under Control (PUC) system; v. intelligent traffic management systems; vi. v ehicle demand management–parking policy, walking policy, mobility policy and fiscal measures. However, there is a significant difference in the adoption of these actions in different cities, as reported in their CAP.

In the power plant and industrial sectors, the report finds that the proposed actions were very specific and included i. The regulation and closure of older power plants within 300 km radius of the non-attainment city; ii. Implementation of the 2015 emission standards for PM, NOX and SOX for thermal power plants (TPPs); iii. Mandates, incentives and citing restrictions for clean fuels; iv. Conversion of brick kilns to induced draft zig-zag technology; v. Implementation of fiscal measures, including an emissions trading scheme (ETS). Similarly, the report notes that in solid waste management, the CAPs included the following actions; i. Implementation of the MSW Rules, 2016, to comprehensively address emissions from domestic waste; ii. Limiting the use of DG sets to restrict emissions; iii. Recycling of C&D waste; iv. Control of C&D dust from construction hotspots.

Based on the preliminary review of international air management plans, the report recommends that sector- specific intervention details should include: 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 capacity building within these agencies to implement successful strategies.

2.6 Another research paper, `National Clean Air Programme (NCAP) for Indian cities: Review and outlook of clean air action plans'[8] by Tanushree Ganguly, L. S. Kurinji, Sarath Guttikunda, December 2020[9], mentions the following key highlights on the comparis on of 102 CAPs :

a. Transport and road dust together cover 50 per cent of the action points, followed by interventions for the industries. Domestic cooking and heating are mentioned as a source only in 42 plans for a total of 2 per cent of the action points.

b. Institutional nature of the interventions was observed in 74 per cent of the action points, using the language 'overseeing, planning, proposing, preparing, investigating, identifying, ensuring, strengthening, training, studying and engaging'.

c. Only 25 per cent of the plans integrated information on the relative source contributions to formulate control strategies. However, this information does not translate into prioritising actions listed in the plan.

7 A brief Issue Paper prepared by NRDC with CEE in 2020 titled `Clearing The Air: A Review Of 10 City Plans To Fight Air Pollution In India'

8 Ganguly, Tanushree, Kurinj L. Selvaraj, Sarath K. Guttikunda. 2020. "National Clean Air Programme (NCAP) for Indian cities: Review and outlook of clean air action plans."Atmospheric Environment: X, Vol 8. https://doi.org/10.1016/j.aeaoa.2020.100096

9 https://doi.org/10.1016/j.aeaoa.2020.100096

d. The absence of source information has resulted in plans being replicated for the cities within a state. Nine states with multiple non-attainment cities have used the same set of action points and timelines across all cities.

e. Disproportionate allocation of activities to ULBs is problematic due to India's underdeveloped municipal finances.

f. Estimates suggest that 30 per cent of the PM 2.5 concentration comes outside the boundary, highlighting the need for more regional collaboration for cleaner air. While most city plans include the recommended measures, there are no clear guidelines on establishing regional coordination.

2.8 It is therefore observed that an effective clean air action plan is a powerful tool for achieving clean air for cities, comprising a list of short-term and long-term mitigation measures for identified major air pollution sources. Most of the non-attainment cities are facing various challenges in developing in terms of organis ational and individual capacity with skilled workforce and scientific understanding to design and implement these action plans. The current clean air action plan is jointly developed and deemed to be implemented by the State Pollution Control Boards and the concerned local bodies. Both these organisations have multiple responsibilities and a small workforce capacity, which generally results in limited attention to the clean air action plans. The effective design of an action plan and ensuring its efficient execution requires sound air quality data, which is a major challenge. Most air pollution sources lack primary activity data required for developing source-specific strategies. As air pollution sources are not limited to city boundaries, clean air plans need to consider both the city (core) and the surrounding region (buffer) for effective mitigation strategies with an airshed approach, which they lack as of now.

2.8 It is found that the CAP under NCAP has developed a synergy amongst various stakeholders including ULBs, regulators, city governments and academia. However, there is a strong need to engage the local people constructively in all phases of CAP, including its design, implementation, evaluation and updation. A similar need exists to engage medical professionals with coordinated studies for developing India-specific data in air quality health linkages. Though some cities have proposed the same in their CA, it does not include extensive and corroborative studies. The NCAP has also for the first time introduced financial support for pollution- related action plans, which has also contributed to its adoption by all stakeholders.

3. CITY ACTION PLANS FOR GURUGRAM

3.1 Historical Perspective: India has been working on control of air pollution in major cities since 2005. Initially, 16 cities across the country were identified as cities with high levels of pollution, and an action plan for those 16 cities was prepared by CPCB with the aid and assistance of SPCBs. It was then realised that there is a need to strengthen the air quality monitoring network, which expanded with introduction of continuous ambient air monitoring stations and manual air monitoring stations. With regular data on air quality available in multiple cities, it was noted that the problem of air pollution persists in many more cities, and presently 132 cities have been identified as non-attainment cities. The action plan for air quality improvement in these cities has been prepared under the guidance and framework provided by CPCB. Gurugram falls in the National Capital Region of Delhi (NCR). Earlier, an authority named Environmental Pollution Control Authority (EPCA) was constituted under the orders of Hon'ble Supreme Court of India, which had formulated a comprehensive air quality action plan for the NCR region. Subsequently, the Government of India, realising the necessity of having a specialised body to regulate the air quality issues in NCR and surrounding areas, established a Commission for Air Quality Management[10] in NCR and surrounding area (CAQM); in 2022, the commission notified a policy[11] to curb air pollution in the National Capital Region in July 2022.

10 https://caqm.nic.in

11 https://caqm.nic.in/WriteReadData/LINKS/Policy%20to%20curb%20air%20poluutio n%20in%20NCR_8bc1ddf1-b34a -4506-b29f-34390650e053.pdf

3.2 The city of Gurugram is not included in the 132 non-attainment cities, mainly due to the fact that there was not enough air quality monitoring data available for the city, and, therefore, it is not covered under the National Clean Air Plan (NCAP) Program of India. NCAP has also developed a framework for air quality management and improvement in those cities, and these action plans are available on CPCB website. It would be necessary to consider the framework of these action plans in order to understand the air quality initiatives proposed for the city level efforts across the country. There is also an emergency action plan called Graded Response Action Plan (GRAP) which has been notified by the CAQM for the Delhi NCR area and is rolled out by the Commission as and when the air quality deteriorates substantially. It is noted that the action plan prepared by EPCA and the Commission do have a statutory status and its compliance is statutorily mandatory, whereas the NCAP action plans are essentially a policy document promoting and facilitating the air quality initiatives at the city level.

3.3 EPCA in 2017 submitted an action plan[12][13] prepared in consultation with concerned States for air quality improvement in the NCR region before the Hon'ble Supreme Court. The EPCA noted that the plan has listed a combination of short, medium and long term actions for each source of pollution and has indicated agencies responsible for implementation. However, in cases where the actions are long term, the timeline for implementation has not been detailed out. This is because the state governments were working out the detailed strategies with dates and timeline. The continuous monitoring of this plan, to be done by the state level committees under the Chief Secretary, would progressively improve time-bound implementation. This action plan was mandatory for all the states in the NCR region, and Gurugram, by virtue of being in this NCR region, was expected to follow this action plan. This plan is titled `Comprehensive Action Plan for Air Pollution Control with the objective to meet ambient air quality standards in the National Capital Territory of Delhi and National Capital Region, including states of Haryana, Rajasthan and Uttar Pradesh'.

3.4 The above action plan listed a combination of short, medium and long term actions for each source of pollution and has indicated agencies responsible for implementation. However, in cases where the actions are long-term, the timeline for implementation was not detailed out. Guiding principles for this comprehensive action plan, which are required to be understood while reviewing the action plan, have been reported as:

- Meet clean air standards in a time-bound manner
- Take action on all sources of pollution to meet clean air targets
- Reduce integrated exposure to protect public health
- Public health risk from air pollution is grave and growing
- Address quantum vs toxicity
- Adopt a regional approach for a common air shed
- Enforce emergency action to control and minimise exposure on a daily basis
- Address both consistent and seasonal sources of pollution
- Address secondary particulates that are formed in the air by gases

The action plan delineates source-wise clean air action plan and compliance strategy for Delhi and NCR to meet air quality standards for the following points:

- Air quality monitoring
- Actions to reduce vehicular emissions

12 https://www.ccacoalition.org/en/resources/comprehensive-action-plan-air-pollution-controlling-national-capital-ter ritory-delhi-and

13 EPCA: Report No. 71: Comprehensive Action Plan for air pollution control with the objective to meet ambient air quality standards in the National Capital Territory of Delhi and National Capital Region, including states of Haryana, Rajasthan and Uttar Pradesh: April 2017

- Strategies to reduce vehicle numbers on roads
- Non-motorised transport network
- Parking policy to reduce congestion and pollution
- Traffic management
- Power plants and industries
- Diesel generator sets
- Open burning including solid waste and agricultural residues
- Domestic *chulha* burning and open eateries
- Control measures for road dust
- Control measures for construction dust.

The action plan also describes the institutional arrangements for its implementation. The action plan has been devised to reduce the annual average concentration of pollutants; for example, for PM 10 the expected reduction needs to be from 60–74%. Similarly, the expected reduction for PM 2.5 is targeted at about 70%. Percentage reduction in O3 levels is also from 2% – 38% in general. These values are calculated based on the reduction required to meet the annual average standards, considering the average pollutant concentration data available from the CPCB and SPCB.

3.5 The action plan mainly relies on the existing institutional framework of state government and SPCBs to implement the actions, while the role of central government was mainly focused on policy formulations and guidance. The action plan does not provide for the financial avenues for implementation of action plans, but it was left to states to provide suitable finances for various actions. This has resulted in this action plan being mainly on paper rather than actual implementation of various actions. Though the monitoring was left to the states, there is hardly any data on actions taken and their effectiveness in reducing the air emission and/or improvement in air quality.

3.6 CAQM had published Policy to Curb Air Pollution in the National Capital Region in July, 2022[14]. The scope of this plan is to control air pollution primarily in Delhi and NCR. Owing to a deficit in infrastructure and systems across sub-regions of the NCR, wide variations in baseline actions, and varying levels of urbanisation, a differentiated approach and timeline have been suggested for the sub-regions. These sub-regions include :

- The NCT of Delhi
- The NCR districts near Delhi — Gurugram, Faridabad, Sonipat, Jhajjar, Rohtak, Ghaziabad, Gautam Buddha Nagar and Baghpat
- Other NCR districts
- The entire state of Punjab and the non-NCR districts of Haryana, primarily for addressing episodic events of stubble burning

3.7 This policy takes into account the Hon'ble Supreme Court's series of directions and orders from the past, as well as the reports of the EPCA, which have contributed towards improvement in the air quality in Delhi-NCR. The policies and programmes of the Central government, the NCR State governments/ GNCTD, directions of the Hon'ble NGT, steps taken by the Pollution Control Boards/Committee, including the Comprehensive Action Plan to abate Air Pollution in Delhi-NCR, have also contributed to the cause of abating air pollution in the region. Large numbers of statutory directions, orders, advisories and guidelines have also been issued from time to time by the CAQM since its inception.

14 Policy to Curb Air Pollution in the National Capital Region July, 2022 published by Commission on Air Quality Management for NCR and Adjoining Areas 2022

3.8 The policy document mentions that most of the available information relates to the NCT of Delhi and, to some extent, the four cities of Gurugram, Faridabad, Gautam Buddha Nagar and Ghaziabad. Information on the other NCR areas is not adequate for assessment of local issues. The problem of data limitation and funding requirements in the sub-regions, thus, needs to be addressed. The policy to curb air pollution is primarily guided by the following principles:

- Clean air for all, good health, well-being and increased productivity
- Action for clean air requires speed, scale and urgency
- Equitous, inclusive, affordable, innovative approaches
- Scientific, technical and behavioural solutions
- Protect the vulnerable from the pollution risk
- Multi-sector policy response and a systems-based approach
- Air pollution management needs an airshed and a regional approach

3.9 The Policy describes that, broadly, the critical areas of transformation aimed for meeting the national ambient air quality standards include –

- Widespread access to affordable clean fuels and technology in industry, transport and households
- Mobility transition including mass transit, electrification of vehicles, walking and cycling infrastructure and reducing personal vehicle usage, etc.
- Circular economy for material recovery from waste to prevent its dumping and burning
- Dust management from C&D activities, roads/right of ways, and open areas with appropriate technology, infrastructure and greening measures
- Strict time-bound implementation, improved monitoring and compliance

3.10 Sector-Wise Action Plans For Abatement Of Air Pollution 1

- Strengthening air quality monitoring and source apportionment
- Abating industrial pollution
- Abating air pollution from Diesel Generator (DG) sets
- Abating air pollution from thermal power plants within 300 km of Delhi
- Abating air pollution from vehicles and the transport sector
- Clean fuels and electric mobility
- Abating air pollution through effective public transportation services
- Abating air pollution by effective road traffic management
- Abating air pollution through control on municipal solid waste burning
- Management of Construction and Demolition (C&D) activities to reduce dust
- Abating air pollution caused by crop residue burning
- Abating air and dust pollution from roads and open areas
- Abating air pollution through greening/plantation programmes
- Abating air pollution owing to bursting of crackers

3.11 The policy document focuses on individual sources and actions thereupon. The commission itself regularly monitors the performance of each state. As per the interaction with GMC officials every month, a detailed review is taken of all the important cities by the CAQM, thereby setting the benchmark for performance internally. Though there is no financial support form CAQM, the CAQM ensures that adequate finances are made available to these actions by the states through interactions with them in such reviews.

3.12 District Environmental Plan: District Environmental Plan (DEP)[15] is a comprehensive action plan prepared by all major stakeholders, i.e., GMDA, GMC, HSPCB, HSIDC, among others, to deal with all the identified environmental concerns for the Gurugram district, including air pollution challenges in Gurugram city. This document details all the relevant information about the district topographical, industrial, hydrological and developmental information, which forms the basis for developing a comprehensive action plan. The plan also lists out various actions to be taken by different stakeholders in a time-bound manner. A review of the air action plan of the DEP shows that the action plan has been prepared, down to every minute detail, and several actions under NCAP and CAQM policy have been integrated in the action plan. The action plan shows the necessity of engagement of various government departments and the development of their capacity for effective implementation of the action plan. Some of the important actions initiated for air quality improvement under DEP are:

- Commissioning of additional air quality monitoring stations, including the CAQMS and sensor-based systems, and web-hosting of the information
- Operationalising the mechanical road cleaning machines and procurement of some additional MRCM
- Making anti-smog guns (ASG) and water sprinkling mandatory for large constructions more than 4000 sqm built up area
- Effective implementation of CAQM directions on: a. clean fuel for industries b. banning pet coke and furnace oil
- Emphasis on public transport and e-mobility
- Solid waste management and banning refuse burning scientific community towards the same.

4. IDENTIFICATION OF IMPORTANT SOURCES OF POLLUTION

4.1 A detailed air emission inventory (EI) with a comprehensive list of pollutant sources and their emission load within a predefined geographical area is beneficial for developing clean air action plans. It can also be used to test the effectiveness of pilot interventions towards air quality abatement. Robust emission inventories are the foundation for understanding the primary sources of pollution and formulating targeted mitigation strategies. All non-attainment cities under the National Clean Air Programme are now working towards developing emission inventory studies. It is, however, worthwhile to highlight the tremendous work that has already been done by the scientific community towards the same goal.

4.2 Emission inventories generally classify emissions in terms of point, area, or mobile sources. The PM inventories are particularly complex because they include primary emission estimates for different PM size fractions. Inventories generally also include gaseous precursors (SO2, NOx, certain VOCs, and NH3) for particle production and the precursors that lead to oxidant formation in the air (NOx, VOC, and in some cases, CO and CH4).

The inventories are categoris ed according to their application, for example, as in the four levels used in the description of the U.S. Emissions Inventory Improvement Program (EIIP: U.S. EPA, 1997). In the context of implementing PM standards, a fifth level associated with air-quality modelling is added.

Level-1: Source specific, used for permitting and regulatory compliance programmes.

Level-2: Urban area, used for local population; cent re, state, regional or provincial planning (e.g, state implementation plans (SIPS) and tracking (trends)).

15 District Environmental Plan prepared by HSPCB, HUDA, GMDA, GMC SIIDC

Level-3: Industry-wide, used for applications such as large utility boiler characteris ation, control, or technology trends that do not necessarily drive regulatory concerns.

Level-4: Country-wide, used for national and international issues, including trends such as acid rain, or climate alteration from greenhouse gases and suspended particles.

4.3 CPCB has already published the national guidelines[16] for preparation of emission inventory for ensuring consistency and uniformity in city- specific emission inventories[17]. The guidelines state that the systematic collection and collation of detailed information concerning air pollution emissions in defined impact zones is defined as 'Emission Inventory'(EI). An inventory should contain as much information as possible on the types of sources as well as their relative contribution to air pollution in terms of composition and rates of discharge for individual pollutants. This should be supplemented by information on the number, geographical distribution of sources and a description of processes, raw materials & control measures.

4.4 There is no air pollution source identification and inventory studies specifically for Gurugram city, though such a study is being undertaken now by HSPCB. However, the city is a part of Delhi NCR, and the findings of some studies related to NCR can be used to get an idea about the air pollution sources and their contribution to ambient air quality.

4.5 TERI has studied[18] more than 200 Emission Inventories prepared in the country and further examined them critically on various technical and scientific grounds[19]. The study notes that several researchers continue to rely solely on secondary data sets and use only foreign emission factors. Such inconsistencies in the existing body of literature show the need for developing and implementing systematic approaches towards data collection and reporting. This will ensure that the EI reports are accurate and enable better source apportionment studies.

4.6 Key sectors identified in Indian Emission I nventories include: i. transportation; ii. stationary sources (power plants and industries); and iii. c onstruction and demolition (C&D); iv. waste collection and processing, including municipal solid waste (MSW), C&D waste and industrial waste; and v. diesel generator (DG) sets. The Indian emission inventories are typically developed for PM10 and PM 2.5, as they are the criteria pollutants for the air quality action plan. In fact, NCAP is designed for PM10, though any removal of PM 2.5 obviously reduces and mitigates the PM10.

4.7 A WWF report[20], 'Air Pollution in Gurugram-2020', deals with the aspects of air pollution in Gurugram. The report states that the typical sources of air pollution in Gurugram involve emissions from vehicles, industries, thermal power plants, DG sets, residential sources, among others. Other sources contributing to air pollution are the construction activities, road dust, waste combustion and seasonal stubble burning. Increasing dust from the Thar desert due to ongoing destruction of the Aravalli range is also a concern.

Vehicles: The limited public transport options in Gurugram result in high vehicle ownership and pollution. The city has one of the highest vehicle ownership rates in the country – 323 cars per 1,000 people, which is higher than Delhi's (88 cars per 1000 people). In Gurugram, 43 per cent of the households own two-wheelers and 33 per cent own cars. Bus numbers have not increased appreciably in the city and are 50 per cent less than the service level benchmark of 60 buses per lakh population (this was 31 per lakh in 2014-15).

16 CPCB draft guidelines on Conceptual Guidelines And Common Methodology For Air Quality Monitoring, Emission Inventory & Source Apportionment Studies For Indian Cities https://cpcb.nic.in/displaypdf.php?id=c291cmNlYXBwb3J0aW9ubWVudHN0dWRpZXMucGR m

17 https://cpcb.nic.in/displaypdf.php?id=c291cmNlYXBwb3J0aW9ubWVudHN0dWRpZXMucGRm

18 Catalogue: Indian Emission Inventory Reports, January 2022, The Energy And Resources Institute and Environmental Defense Fund, https://www.teriin.org/sites/default/files/files/Indian-Emission-Inventory-Report.pdf

19 https://www.teriin.org/sites/default/files/files/Indian-Emission-Inventory-Report.pdf

20 https://wwfin.awsassets.panda.org/downloads/air_pollution_in_gurugram_souces_impact___soluti ons_wwf_fnl.pdf

Diesel generator sets: Haryana government authorities estimate that, at present, more than 14,000 diesel generator sets are running in Gurugram (2019). Besides shopping malls, markets and offices, thousands of residential apartments run on diesel generators. A study by the Centre for Science and Environment (CSE) in 2018 reported that the use of diesel generator sets increases the level of PM2.5 and PM10 in Gurugram by 30 per cent.

4.8 The 2018 report on Gurugram by ARAI and TERI states that the contribution of the transport sector to PM2.5 and PM10 pollution is in the range of 16-27% and 14-23%, respectively, while that of the industry sector is 13-30% and 13-26%, respectively. However, the contribution of dust to PM2.5 and PM10 pollution is higher, and it is in the range of 20-49% and 23-52%, respectively. The remaining contribution comes from residential and other sources. This clearly indicates the need to have a multi-sectoral approach to address air pollution in Gurugram.

4.9 The a vailable information[21] shows that Gurugram generates over 1,000 tonnes per day (TPD) of solid waste – of this, about 600- 700 TPD goes to the Bhandwari landfill located on the Gurugram-Faridabad Road, which was established as a landfill-cum-waste treatment facility under the JNNURM scheme in 2010-11. An estimate available from the International Council for Local Environmental Initiatives (ICLEI) shows that Gurugram generates about 700 TPD of construction and demolition waste and 1.5 TPD of biomedical waste; the city also produces 70,000 tonnes of e-waste annually. The MCG estimates show that the per capita waste generation in Gurugram is about 320 gm/day, which includes residential, commercial and institutional waste. According to the data of the MCG, the per capita increment in waste generation has been estimated to be 1.33 per cent per annum.

4.10 The said report prepared by the GMDA in 2023 shows the Fuel Type Wise Personal Vehicle Distribution (vehicles plying on the roads of Gurugram), which is: 73% of vehicles run on petrol; 23 % of vehicles run on diesel; 4% of vehicles run on CNG, 1% of vehicles run on e lectric.

Currently, there are 3881 Diesel Generator sets running in Gurugram city as per the data provided by the Haryana State Pollution Control Board. If we see the status of DG sets in Gurugram City, the north region of Gurugram has 1659 DG sets, with an average capacity of 1034 kVA, whereas south Gurugram has more DG sets than the north region (2222), but its average capacity is lower than that that of the north region (885 kVA).

The total registered goods vehicles in Gurugram city are as follows : diesel vehicles–3154; petrol vehicles–102,353; and CNG vehicles– 16005. In addition to this, the total registered passenger vehicles in Gurugram are as follows : g asoline v ehicles– 673,747; and electricity–1508. The number of cars: gasoline– 21821, diesel– 15,196, electricity– 5905 and CNG–17,545. The number of buses on diesel is 2264. The number of three- wheelers: gasoline- based– 21821; diesel– 15196; electricity– 5904; and CNG–17545. However, these numbers are just an indicator of the vehicles registered in the city. In reality, there are more vehicles passing through the city, both towards Delhi as well as Jaipur and Mumbai.

4.11 'Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources' report, prepared by ARAI and TERI; Report No. ARAI/16-17/DHI-SA-NCR/Final Report: The source app o rtionment studies[22] conducted by ARAI and TERI based on 2016-17 data deals with the Delhi NCR region, including Gurugram, though there was no monitoring station in Gurugram in the study. Source-wise multi-pollutants inventories of air pollutants have been prepared for the year 2016, at a high resolution of 4x4 km2. Along with PM, inventories of sulphur dioxide (SO2), oxides of nitrogen (NOx), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs) have also been prepared to account for the secondary particulates formation.

21 https://gmda.gov.in/download.html?fid=GMDA_74bfd02b-417e-46c8-86a5-768352ef0521&code=opinion&key=attachment&identifier=1694845701116

22 Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources' report prepared by ARAI and TERI, Report No. ARAI/16-17/DHI-SA-NCR/Final Report

The study estimates the sectoral contribution in PM10 concentrations by dispersion modelling and receptor modelling in Delhi NCR as under:

Sr. No	Sector	% Contribution estimated by dispersion modelling		% Contribution estimated by receptor modelling	
		Summer	Winter	Summer	Winter
1	vehicle	14	23	19	16
2	road dust	52	30	32	23
3	biomass	13	14	19	20
4	industries	13	26	24	26
5	others	8	7	6	15

The sectoral shares in PM10 and PM2.5 concentrations were estimated in this study based on both dispersion and s receptor modelling techniques. There are stark variations across different towns due to the varying monitoring schedules (and corresponding modelling results) in the NCR t owns. For PM2.5, the contribution of combustion- based sources, such as vehicles, industries and biomass is higher, while dust (road, construction, and ex-NCR) contributes dominantly with respect to PM10 concentrations. Summers show higher dust contributions from international boundaries (mainly of natural origin) due to higher wind speeds.

Though the data and its interpretation is based on the 2016 data, and that too on a larger scale for the NCR region, these percentage concentrations give a fair idea of the relevance of each type of source and the need to devise suitable actions for mitigation.

4.12 The first source apportionment and emission inventory studies were carried out in 2006-7 under the 6 - city study coordinated by CPCB. Much of the scientific and technical work in standardising and streamlining various processes such as monitoring, measurements, emission inventory, air quality modelling and action plan were formulated under these studies. However, subsequently, in recent years the nature of air pollution sources has evolved significantly due to India's high urbanisation growth and associated urban construction and infrastructural growth. This has created a need for an updated emission inventory by identification of these sources along with their emission load, which depends on various factors on ground crucial for prioritis ing actions to mitigate air pollution. Further, several sources are not considered big emitters. For instance, emissions from restaurants and bakeries are significantly less than the emission load from the transport sector. However, cumulatively, these sources (including but not limited to construction and demolition waste, paved road dust, crematoria, bakeries and restaurants, diesel gen-sets) add up to a significant number. These sources are usually only accounted for the total emission inventory studies, but there is a need for a more substantial push to develop individual EI reports for such less- studied sectors.

4.13 Emission inventories have several variables that affect or limit the reliability of the emission estimates, including their spatial, temporal and compositional resolution and accuracy. However, emission inventory is an `on-going' process and every iteration brings more certainty. Presently, there are no guidelines for frequency of updation of emission inventory in India, though some of the developed countries have specific guidelines to update the emission inventory every 3-5 years. The uncertainties in emission inventory may impact policy measures and pollution control/ mitigation strategies to achieve the targets goals of action plans.

4.14 The Haryana Pollution Control Board has now reportedly initiated a city- specific source apportionment studies including source inventory; this would be useful for identification of major sources and their effective control if actions are prioritised based on source apportionment studies.

5. CURRENT STRATEGIES AND ACTIONS BEING TAKEN

Many Indian cities and urban areas are experiencing significant levels of air-pollution, mainly the particulates. R esearch also indicates that more than half of PM2.5 particulate emissions in India are formed in `secondary` way in the upper atmosphere, when different types of gases and pollutants (such as ammonia) from one or more areas mix with other pollutants like sulphur dioxide and nitrogen oxides from other places. Agriculture, industry, power plants, households and transport, all contribute significantly to the formation of secondary particulates. Thus, the air pollution challenge in India is, therefore, a multi- sectoral and multi-jurisdictional problem. The cities need to look beyond their immediate jurisdiction for effective air pollution control strategies and apply an innovative set of tools for air quality management.

5.1 Several steps are being taken to respond to the problem of air pollution, and there has been a strong emphasis on expanding renewable energy, promoting electric vehicles and supplying LPG cooking fuel to millions of households. There has also been emphasis on providing infrastructure in and around the city, including flyovers and effective traffic signalling systems to reduce traffic congestion. Bypasses for the highways are cutting through the cities to divert heavy traffic away from the cities. Public transport is also being emphasised through programmes like JNNRUM, Smart cities, and provision of mass rapid transport, i.e., metro services, which has supported reduction in vehicle use.

5.2 In the last two decades, initiatives were also taken to improve India's automobile fleet from Bharat-2/3 to Bharat-VI, thus leapfrogging technology improvement. Effective steps were also taken towards cleaner fuel, which included providing benzene- free fuel, lead- free petrol and also low-sulphur fuel. This is also supported by stringent standards for emissions from the industries and also development of an industrial area- specific action plan, called C omprehensive E nvironmental P ollution I ndex (CEPI), for the critically polluted industrial areas.

5.3 Some scholars argue that India's response to the multidimensional problem of air pollution has not been adequate in terms of achieving the desired results. It is also argued that some of the major drawbacks of earlier efforts were non-provision of financial support for the implementation of action plans, non-involvement of community and also lack of evidence-based actions. It is necessary that all the stakeholders are appropriately identified and their views are taken into account for evolving an action plan and its implementation. There have been various sectoral actions in industries including automobile, construction, energy,etc.; however, there is a need to bring synergy among all these sectoral actions for maximising the benefits of air pollution abatement. It is also now well recognised that the air pollution control strategies have a co-benefit of climate mitigation in terms of GHG reductions. As India has set ambitious targets for GHG reductions, the air quality improvement initiatives can be developed in sync with the climate goals so that there is synergy between the actions and their effective and timely i mplementation.

5.4 The current strategies for air pollution control and abatement can be summarised as under:

- Regulatory framework for air emission sources, ambient air quality and best practices for air pollution control Emphasis on science-based approach with better air monitoring network including, continuous air analysers, data analysis through AQI, source apportionment studies, emission inventory and developing action plans.
- Public participation and involvement: Air quality data disclosure, AQI, separate portal to disclose all data, reports and information
- Central finance under NCAP for city-based action plans
- Involvement of city governments and academic institutions including National Knowledge Network (NKN) and local institute of repute for local capacity building

- Emphasis on public transport through public transport buses and provision of metros
- Emphasis on clean fuel, lead/benzene- free petrol, low- sulphur diesel, ban on pet coke without adequate air pollution control
- Promotion of e-vehicles and renewable energy, energy efficiency programs like PET
- Infrastructure development like city flyovers, ring roads, by-passes for highways passing through cities
- New and emerging strategies like circular economy for waste management to develop alternative solutions, particularly for landfills and biomass burning.

5.5 However, there is still a long way to go to tackle the urban air pollution problem. There are inevitable sources of air pollution in the city and, therefore, it is necessary that they are identified and tracked adequately. As Peter Drucker said : "If you cannot measure it, you cannot manage it."

6. NATIONAL CLEAN AIR PROGRAMME

6.1 The National Clean Air Programme or NCAP is a government programme launched by the Union Ministry of Environment, Forests and Climate Change in 2019. The goal of NCAP is to meet the prescribed annual average ambient air quality standards at all locations in the country in a stipulated time-frame. NCAP targets to achieve reduction in Particulate Matter (PM10) levels up to 40% or match the national standards (60 microgram/cubic metre) by 2025-26 in the targeted 132 cities of 24 States, taking 2017 as the base year for comparison of concentration.The programme[23] aims:

- To prevent, control and abate air pollution through convergence of other missions, schemes and programmes
- Capacity building for SPCBs/ PCCs/ Local Bodies
- Enhance green transport infrastructure for public transport
- Adoption of cleaner / renewable fuels
- Policies, programmes, and strengthening mechanism for control of industrial pollution
- Better compliance with municipal solid waste management and C&D waste management rules
- Promote research and development for prevention, control and abatement of air pollution
- Augment public awareness and outreach programmes for enhancing public participation
- To expand the national air quality monitoring network
- To build capacity for air pollution management

6.2 NCAP recognises that the clean air action plan requires multi-layered initiatives and the role of central, state and local governments in overall planning, implementation and evaluation of the action plan. There are several policy initiatives taken at the central level, which forms the core of the NCAP. They are as under:

- Notification of national ambient air quality standards and sector-specific emission and effluent standards for industries
- Setting up of monitoring network for assessment of ambient air quality
- Introduction of cleaner gaseous fuels like CNG, LPG, etc.
- Ethanol blending in liquid fuels
- Launching of National Air Quality Index (AQI)

23 https://prana.cpcb.gov.in/assets/pdf/NCAPWorkshop/Day-1/FinancialSession3/1.Key_Features_of_Operational_Gui delines_XVFC_MPCCF_23Nov21.pdf

- Universalisation of BS-IV for vehicles by 2017
- Leapfrogging from BS-IV to bs-VI standards for vehicles by 1st April, 2020
- Banning of burning of biomass
- Promotion of public transport network
- Pollution under control certificate
- Issuance of directions under Air (Prevention and Control of Pollution) Act, 1981
- Installation of on-line continuous (24x7) monitoring devices for17 highly polluting industrial sectors
- Vehicle scrapping policy
- Emphasis on renewable energy and e-vehicles
- Ban on bursting of sound emitting crackers between 10 PM to 6 AM
- Notification of Graded Response Action Plan for Delhi and NCR, identifying source-wise actions for various levels of air pollution, etc.

6.3 The NCAP works on an approach of:

- Collaborative, Multi-scale and Cross-Sectoral Coordination between relevant Central Ministries, State Government and local bodies
- Focus on No-Regret Measures, Participatory and Disciplined approach

6.4 The NCAP also aims to have a feasible plan for the prevention, management and control of air pollution. At the national level, the implementation of the programme will be done by an apex committee at the Environment Ministry level. At the state level, committees at the Chief Secretary level will oversee the implementation of the scheme.The NCAP is a joint collaboration between:

- Ministry of Road Transport and Highways
- Ministry of New and Renewable Energy
- Ministry of Petroleum and Natural Gas
- Ministry of Heavy Industry
- Ministry of Health
- Ministry of Housing and Urban Affairs
- Ministry of Agriculture
- Central Pollution Control Board
- NITI Aayog
- The programme also ropes in academia, philanthropic foundations, civil society, etc.

6.5 NCAP has triggered several initiatives across the country and the important achievement of the NCAP was creating a large-scale awareness and also technical capacity in the country in air quality inventory, source apportionment, modelling and control measures. Some of the important initiatives under NCAP are listed below:

- Augmentation of the National Air Quality Monitoring Network
- Air Quality Management Plan for the cities chosen
- Indoor Air Pollution Monitoring & Management
- National Emission Inventory – this is an inventory of the quantity of pollutants discharged into the air
- Network of Technical Institutions
- Technology Assessment Cell
- International cooperation including the sharing of best practices with respect to abatement of air pollution

6.6 The Government of India has provided a grant of INR 4,400 Cr for the improvement of a ir q uality in 42 Million-Plus Cities in FY 2020-21, and a grant of INR 12,139 Cr for augmenting the measures to improve air quality in 42 Million-Plus Cities for a period starting from 2021-22 to 2025-26. However, the release of these funds is linked to the performance of the local city government, evaluated on a prescribed format. The relative weightage for assessment of city performance on air quality is based on four parameters:

1. Strengthening of pollution monitoring mechanism
2. Source-wise Cause Analysis for Air pollution
3. Progress on Action P lans and Compliance of Statutory guidelines
4. Quantification and evaluation of Air Quality Improvements
5. Reduction in Air Pollution level (Particulate matter)
6. Frequency of Exceedance in AQI levels

7. GRADED RESPONSE ACTION PLAN (GRAP)

The directive of the Hon'ble Supreme Court in 2016 had led to the notification of the Graded Response Action Plan (GRAP) for graded and emergency response in January 2017. This was linked to the National Air Quality Index that was notified by the MoEFCC in 2015 for daily relay of information to the public and to inform emergency measures. Several measures have been graded according to the severity of daily air quality; these include temporary closure of industries, brick kilns and stone crushers; stopping of trucks and construction, and others.

7.1 For the last few years, Delhi NCR has been facing the challenge of severe air pollution in winters, and, therefore, the emergency actions have been designed to abate extreme pollution during smog episodes, when pollution is trapped due to atmospheric inversion and the prevailing cold and calm winds during winters. These measures help prevent ingress of additional pollution when the natural ventilation index is low and pollution cannot disperse. These are drastic but temporary measures, and can cause socio-economic hardships. These measures need to be reviewed and evaluated for their effectiveness from time to time according to the exigency based on scientific data and understanding. It is also evident that temporary closure orders on industry, construction, etc., and other restraint measures have the potential to catalyse more systemic changes, as polluters want to avoid temporary disruptions. It is important to underscore that only more sustained and systemic solutions can reduce the requirement for emergency action.

7.2 CAQM revised Graded Response Action Plan (GRAP) FOR NCR in August 2022. The GRAP for the NCR has now been classified under 4 different stages of adverse air quality in Delhi, viz., Stage – I 'Poor' (AQI 201 – 300), Stage – II 'Very Poor (AQI 301-400), Stage – III 'Severe' (AQI 401-450) and Stage – IV 'Severe +' (AQI >450) respectively. Actions under Stages II, III and IV of the GRAP shall be invoked at least three days in advance of the AQI reaching the projected levels of that stage, based on the dynamic model and weather/ meteorological forecast to be provided to the Commission by IMD / IITM on a day-to-day basis.

Restrictive actions undertaken as per previous stages shall be continued in addition to the air pollution stage under which the restrictive actions are envisaged to be taken. For example, restrictive actions under the Stage III category, whenever invoked, shall be taken in addition to those under Stage I and II respectively and so on. The Sub-Committee on GRAP constituted by the Commission shall meet frequently to plan for advance action and issue necessary orders for invoking various provisions of the GRAP, based on the prevalent air quality and the AQI forecast to be provided by IMD from time to time. The Sub-Committee shall also review the actions taken by various agencies responsible for the effective implementation of the GRAP.

7.3 Key Actions under GRAP

Key restrictions / regulations of activities during the revised GRAP are as under:

Stage II - 'Very Poor' AQI category (AQI 301-400)

- Banning diesel generator sets, except for emergent and essential services
- Ban on coal / firewood including tandoors in hotels / restaurants / open eateries

Stage III - 'Severe' AQI category (AQI 401-450)

- Ban on C&D activities in NCR, except emergent and essential projects (like railways, metros, airports, ISBTs, national security/ defence-related / projects of national importance) and non-polluting / non-dust generating activities such as plumbing work, interior decoration, electrical work and carpentry-related work
- Regulate operations of industries in NCR, which are not running on PNG / cleaner fuels / biomass fuels to a maximum five days per week (staggering 'off days' for different sets of industries in the entire week)
- Shutting down of brick kilns, hot mix plants, stone crushers not operating on clean fuels like PNG and biomass-based fuels
- Ban on mining and associated activities in NCR
- State governments in NCR/GNCTD may impose restrictions on BS III petrol and BS IV diesel LMVs (4-wheeled vehicles)

Stage IV - 'Severe+' AQI category (AQI > 450)

- Stop entry of truck traffic into Delhi, except trucks carrying essential commodities / providing essential services and CNG / electric trucks
- Ban on plying of Delhi registered diesel-run Medium Goods Vehicles (MGVs) and Heavy Goods Vehicles (HGVs) in Delhi except those carrying essential commodities / providing essential services
- Ban on plying of 4-wheeler diesel LMVs in NCT of Delhi and districts of NCR bordering Delhi, except for BS-VI vehicles and vehicles used for essential emergency services
- Ban on industries in NCR, which are running on fuels other than PNG/cleaner fuels, electricity and biomass, except industries like milk and dairy units, industrial units involved in manufacturing of life-saving medical equipment / devices, drugs and medicines
- Ban on C&D activities in linear public projects such as highways, roads, flyovers, overbridges, power transmission and pipelines
- State governments to decide on allowing 50 per cent staff strength to work from home (WFH) in public, municipal and private offices
- State governments may consider additional emergency measures like closure of schools/ colleges/ educational institutions, plying of vehicles on odd-even basis, etc.

7.4 It is pertinent to know that the GRAP works only as an emergency measure. As such, the plan does not include action by various stakeholders to be taken throughout the year to tackle industrial, vehicular and combustion emissions. The plan is incremental in nature — therefore, when the air quality moves from 'Poor' to 'Very Poor', the measures listed under both sections have to be followed. The Graded Response Action Plan should be seen as an evolving plan and as more experience is gained in its implementation, it should be suitably calibrated. It is necessary that the actions be monitored and evaluated to appraise their effectiveness and suitably update the GRAP with more effective actions in future. There is no data publicly available on any scientific study or evaluation of effectiveness of GRAP or the individual actions contained therein.

8. ALIGNMENT OF GURUGRAM ACTION PLAN WITH NATIONAL CLEAN AIR PROGRAMME

Gurugram, as discussed earlier, does not have a city-specific air quality action plan, but is covered under air quality action plan[24] of Delhi NCR area under the statutory prescription. Gurugram city is also required to comply WITH the policy[25] on air pollution abatement notified by the Commission on Air Quality Management for Delhi NCR area. The NCR action plan covers a larger area comprising Delhi and parts of Haryana, Rajasthan and Uttar Pradesh. However, challenges still exist, and it is proven that the air emissions from faraway sources, like farm residue burning in Punjab, is affecting the air quality in the NCR area. This has initiated a debate on much wider airshed management with respect to the Indo-Gangetic plain acting as an airshed. So far, the efforts in Delhi have highlighted the need for airshed consideration rather than city-specific action plans.

8.1 The NCAP is a national level air quality improvement action plan and provides a broad framework for cities to make a tailor-made action plan to meet the local requirements based on local conditions. Since India is a large country with different socio-economic, climatic and meteorological conditions, the NCAP expects the city governments to play a proactive role in the design of the action plan based on a common framework. This enables the city governments to use their local knowledge about the sources of pollution, implementability of various pollution control measures, local public participation and awareness, etc. to ensure that the action plan is public- oriented, result-oriented and effective.

8.2 There are several technological interventions which are possible for a variety of sources in order to control, abate and mitigate air pollution. However, a city-specific action plan needs to carefully choose the strategies for selection of such technologies based on city-specific considerations. It is therefore necessary to understand these city/ areas-based action plans for the following aspects:

- *Regulatory Status of city air action plan*
- *Any legal/ judicial orders for such CAAP*
- *Development process for such city-based action plans to address its technical, financial, legal, and implementation feasibility concern; include use of baseline data, and suitable ground-level data; stakeholder engagement*
- *Target-based, time-bound, scalable and with suitable financial and institutional resources*
- *Components on technological interventions for air pollution mitigation, IEC activities, and take into account the short and long-term health benefits of the proposed measures*
- *Can the CAAP/ regulatory or policy mechanism be integrated into the existing system of AQM (if any)?*
- *Priority actions, sector-specific measures, performance-linked evaluation criterion*
- *Airshed approach, transboundary impacts consideration*

8.3 Current air quality management practices/action plans (AQMP) are useful at the city level but inadequate to address sudden rises in pollution at an urban hotspot or non-attainment area. Each such non-attainment area is unique in terms of spatial and temporal patterns of emission sources. Therefore, one of the essential requirements is the site specificity of an AQMP, which makes it capable of effectively dealing with the complexity of atmospheric changes, topographical constraints and pollution sources at a local scale. The importance of the role of relevant local government departments needs to be emphasised for air quality management at a local scale. Effectiveness of particular measures should be evaluated not only based on scientific and economic parameters but also on public and political acceptability.

24 https://caqm.nic.in/WriteReadData/LINKS/GRAP%20Schedulebc030504-9c75-4773-8c69-9942a9175aab.pdf

25 https://caqm.nic.in/WriteReadData/LINKS/Policy%20to%20curb%20air%20poluution%20in%20NCR_8bc1ddf1-b34 a-4506-b29f-34390650e053.pdf

8.4 The major emphasis on the NCAP is science-driven action supported with measurements and monitoring. Gurugram did not have adequate air quality monitoring stations, and trends of air quality were not available for the city. GSPCB has informed that the city has now initiated 4 continuous air quality measurement stations to give online real time data that is also available on CPCB website for public review. HSPCB also informed that the city has started two important studies, i.e., source inventory and source apportionment, which would give a sound scientific basis for specific interventions that can be carried out. It is a well-accepted fact that a significant portion of air pollution in the city originates outside the city limits, and such scientific studies will help the city administration and HSPCB to pursue the matter with central government and CAQM for suitable interventions.

8.5 The city action plan would also focus on hotspots in the city for effective air quality improvements. Urban hotspot is the location in the city where air pollution level already fails or likely or is likely to fail to meet the National Ambient Air Quality Standards (NAAQS) due to high source activities or adverse meteorological conditions or both. Usually, the central business districts, busy traffic intersections and heavily trafficked, congested roadways convert into urban hotspots. Due to the heterogeneous and unplanned growth of cities in developing countries, the movement of vehicles is non-uniform throughout the city, which results in high spatial variations in pollutant emissions leading to formation of urban hotspots. In addition, topographical and meteorological variations in urban areas lead to complex spatial and temporal variations in pollutant concentrations. De-congestion of traffic, road dust cleaning and avoiding solid waste burning could be immediate low-hanging fruits in action plan implementation.

8.6 The city government therefore needs to develop their capacity to collect more scientific information on various sources of air pollution, identification of hotspots, local meteorology and the interventions to be implemented in case of adverse air quality. The NAMP framework suggests various measures including mechanical road cleaning, anti-smog guns for water mist spray, water cannons, etc.; however, the selection of technology options, their placement, operation and impact evaluation need to be carried out by the city government.

8.7 Recent research suggests that air quality management strategies, including regional environmental coordination and collaboration, restrictive vehicle emission standards and promotion of public transport should be strictly implemented for improvement of urban air quality. It also reported that source apportionment based on high time resolution of trace elements can be a powerful tool for local air quality management. The key components of an air quality action plan are setting the air quality objectives, monitoring, emission inventory, prediction and forecasting tools, control strategies and public participation.

8.8 The role of urban planning in air pollution mitigation has not been extensively covered in the city air mitigation action plan so far. The impacts of urban air pollution can be mitigated by constructive city planning. The complete separation of industry and habitation, originally envisaged as an environmental improvement and a reasonable solution in a society with heavily polluting industries, is now outdated and only leads to increased commuting traffic and congestion. Attempts to reduce urban driving by various types of economic incentives (green taxes, road pricing, km taxes), parking restrictions and pedestrian streets have had some success, but they have often been opposed by trade. It must also be considered that driving restrictions in cities may increase recent years' growth of big shopping centres, hotels and office buildings outside the cities, where they offer free parking space and other facilities, such as child creche, thus often resulting in an increase in total traffic. One such reference[26] is USEPA report on `A Guide for Reducing Air Pollution through Urban Planning-1973'. There is also some literature available from OECD on this important subject.

26 USEPA report on `A Guide for Reducing Air Pollution through Urban Planning-1973'

8.9 The goal now is integrated land use, which minimises transport and thus total urban emissions. Open spaces and parks can be used to improve environmental quality, especially in residential areas. In existing cities, the possibilities of restructuring are limited, but construction of ring-roads, which lead part of the traffic around the city-centre, is one of the options. Another major challenge in cities where large construction works are ongoing due to economic growth is the presence of high-rise buildings, which may affect natural wind patterns, and also the heat island effect due to massive construction and concretisation activities in the cities. However, unfortunately, there is no discussion on these major issues related to urban planning in the context of the environment.

8.10 Some of the major considerations in urban planning pertaining to air pollution impacts can be transportation, mobility, green construction, green belt and green cover, reduction of urban fragmentation and spatial policies leading to decrease in population density.

8.11 The major alignment of Gurugram air action plan with the NCAP must be related to matching the time-bound results expected in NCAP. Presently, the Gurugram air action plan does not anticipate a clear target of air pollution reduction, except a broad objective of meeting the NAAQS. However, NCAP recognises that achieving the NAAQS is a complex objective and, while it can be the final objective, the initial targets should be set at reducing emission load in a time-bound manner. It also recognises the fact that not all the pollution in the city is generated within the city and, therefore, the city can effectively contribute by reducing the air pollution generated within the city. The major challenge before the Gurugram action plan is that it is mandated by the CAQM law and compliance with the directions of CAQM is mandatory. On the other hand, the NCAP is a policy document backed by the technical and financial support of the central government, making it more attractive for city governments to derive technical expertise and financial aid. The NCAP also has a provision of performance- linked release of grant, and the evaluation of performance is done by a third party objectively and in a prescribed format. This transparent method also improves the public confidence in the system

8.12 Another significant part of NCAP is its reliance on science-based interventions. NCAP mandates emission inventory and source apportionment, which forms the basis of the design of city-specific action plans, and then the emission inventory forms the basis of performance evaluation of action plan as well. The source apportionment provides a broad idea of the contribution of city-based sources to the city air quality, while specifically identifying the impact of external sources on the city air quality. Such identification helps the State and National agencies to plan their intervention.

8.13 NCAP also places focus on industrial emission control through regulations. The regulation of industrial pollution in India broadly fits into three categories. *First*, and most common, is that the regulator or the government establishes absolute standards for the production of pollutants that need to be adhered to, failing which penalties may be levied. *Second*, the regulator may explicitly mandate the use of specific technologies, production processes, or fuels. This may include a requirement to install pollution abatement equipment,e.g. switching to natural gas as a combustion fuel. *Third*, the government may ration or even entirely ban certain types of polluting economic activity. India's existing command-and-control regulation leaves much to be desired, both in terms of reducing pollution and reducing costs. This leads to the question of how the effectiveness of the regulatory framework may be improved. Although incremental improvements may be achieved through several mechanisms, three promising avenues are important for substantive and material improvement, which can be taken up in a city-specific action plan. These include:

- Improving the reliability and transparency of data
- Accounting for the incentives of those affected by regulation
- Encouraging a culture of piloting and testing regulatory innovation

8.14 In summary, it can be noted that the Gurugram action plan, which is an offshoot of air quality action plan for NCR and complies with the policy on air pollution notified by CAQM and the directions issued by CAQM from time to time, is a more expressive version of air quality improvement action plan with statutory value and compliance objective. NCAP, on the other hand, is more focused on facilitating compliance and technological interventions, scientific evaluation of the problem of air pollution, targets of emission reduction, public consultation and, most importantly, financial support that is linked to performance. The Gurugram city has already initiated work on improved air quality monitoring, source apportionment studies and source inventory studies. The city now needs to adopt the emission reduction targets as per NAMP, and plan interventions on short and long-term basis for policy actions, innovative technology adoption, interdepartmental coordination and public participation.

9. TECHNOLOGICAL INTERVENTIONS

Technological interventions are an integral part of any air quality improvement action plan to: i. correctly identify the problem of air pollution through advanced monitoring and measurement techniques to know the source and composition of pollution; ii. support effective prediction modelling to get early warning and information about the scale of problem for effective response, iii. identify hotspots and also facilitate quantification of source-wise pollution data to design suitable control systems; iv. foster effective public disclosure and awareness through tools like AQI and digital mapping of pollution details; iv. develop policies and actions based on available technologies. There are several technologies that have been introduced through NCAP and various other actions of EPCA and CAQM. Broadly, the technology domains in air quality action plans are:

- Air quality measurements, monitoring and prediction
- Air pollution control and abatement at source
- Air pollution mitigation at receptor level
- Air quality management through coordination amongst the stakeholders
- Air quality data analysis and interpretation for health impacts and pollution control

9.1 Technologies in NCAP: NCAP recognises the need for multidimensional efforts for air quality improvement, as there are numerous sources of pollution characterised by their activity levels, the meteorological parameters and their impact on dispersion, the sources that are located outside the city limits and the overall impact of air pollution. The important anchor for the NCAP is source inventorisation for various pollutants and its periodical assessment to assess the impacts of the mitigation measures implemented. NCAP relies heavily on the air quality measurements and source inventorisation; it is based on source apportionment studies and prioritises the interventions. The major sectors generally covered under NCAP are traffic, industries, road dust re-suspension, construction/demolition, solid waste management, DG sets and small industries in the city.

9.2 Emerging technologies: The most prominently emerging area of air pollution control technology is related to air quality measurements, monitoring and prediction. The new areas of satellite-based measurements, sensor-based monitoring and use of Artificial intelligence and Machine language (AI-ML) through air quality data[27] provide opportunities for accurate pollutant measurement supported by prediction analysis, which can help expedite effective field-level interventions. The large number of CAQMS and sensor-based monitoring in Gurugram area provides a unique opportunity to use advances in big data analysis for predictive analysis. Similar advances are also reported in vehicle emission monitoring through satellite and linking all PUC to a common data base for effective monitoring of vehicle emission tracking. India has already digitalised vehicle registration data and, therefore, it is very easy to track non-compliance in vehicles. This is also important to track the performance of trucks handling the construction material in the city.

27 https://omdena.com/projects/analyzing-air-quality-in-gurugram-using-machine-learning/

9.3 NCR area has already taken several initiatives on industrial pollution control, including ensuring clean fuel supply to industries, banning pet coke and furnace oil, installation of Continuous Emission Monitoring Systems (CEMS) and linking them to HSPCB servers, besides connecting the small industries. In fact, the NCR area is a pioneer of all air quality-related initiatives in India since the problem of air pollution was identified early and has been under judicial scrutiny and mandamus for a long time.

9.4 Several initiatives for traffic-related emission control, including supply of clean fuel, promotion of public transport systems, e-mobility, intelligent traffic management systems, road improvement including flyover and bypasses have been taken in the NCR area. This was supported by India's leapfrogging from BS-IV to BS-VI,which has been successfully rolled out with equivalent BS-VI auto fuel supply. Currently, the efforts for improving the ethanol blending from 10% to 20% in the auto fuel are ongoing.

9.5 This study included a review of NCAP, CAQM Policy and Gurugram DEP, which have comprehensive provisions for various air quality initiative interventions. They include policy initiatives like cleaning fuels, improving air emission norms, vehicle technology upgradation, online monitoring, etc. The broader consideration while preparing these action plans indicate the comprehensiveness of actions and initiatives. The EPCA comprehensive action plan and CAQM policy and directions are the statutory mandates given to various authorities and are mandatory through force of law. On the other hand, NCAP is a more facilitative action plan that provides the local authorities with technical guidance and financial support based on performance.

9.6 Various technology innovations and practices have been discussed and presented in Report-1 of the study in detail. Based on those discussions and the review of various action plans being implemented in Gurugram, a summary of various technological interventions needed to make a comprehensive action plan is presented below. It is observed that though the action plans are comprehensive, there is an urgent need to substantiate these action plans with:

- Financial support for local authorities to implement the action plan and substantiate efforts in the long term
- Capacity building of local authorities on various aspects of air action plan
- Improved coordination of various authorities and agencies for effective implementation of action plan
- Public awareness and participation in the formulation, implementation and evaluation of action plan

Based on the technological innovations and practices presented in Report 1 and the review of air quality action plan for Gurugram, a suggestive intervention of technologies on sectoral basis has been worked out and presented in Table-1 below.

Table-1 Broad Compilation of Various Technological Interventions Required for Urban Air Quality Improvement Program in Gurugram

Action	Broad Aspects that can be covered
Measurements and Monitoring	
Source inventory and Apportionment	• Air Pollution source inventory as per CPCB protocol; the work has already started in Gurugram • Source apportionment studies as per CPCB protocol
Use of low-cost sensors	• Hotspot identification and effective interventions would require real-time air quality data for city administration. This can be done through low cost sensors with good reliability and frequency of data. • Presently, there is a debate in CPCB on whether to adopt the sensors for ambient air quality; notably, they can be used for hotspot analysis and also assessing the efficacy of local level control measures, as they are mobile. • Evaluation of site-specific interventions (road clearing and construction projects, etc.) and also hotspots like solid waste dumping grounds/ landfills • These sensors can be developed to define the airsheds and further used to assess the trends of air quality in the airshed.
Satellite-based monitoring	• Satellite remote sensing is increasingly being used for air quality monitoring due to good temporal resolution of various satellite sensors, coverage of large areas and capability to monitor many pollutants simultaneously. • India with its own satellite network can effectively use this method for air quality monitoring over large areas (airsheds) and also use the information for tracking and prediction modelling. • City government shall tie up with local technological institutes to explore satellite based measurements for city application.
Prediction Modelling and dissemination of information	• The air quality prediction modelling is an important tool for air quality management. Although this is going to be developed at the state and central level, the information needs to be transmitted to city officials for local level controls and enforcements. • The information needs to be shared with health officials, schools and CSOs with wider publicity in case of adverse conditions expected.
Advance pollutant characterisation capacity for EC/ OC and other trace elements	• EC/OC analysis helps to measure the black carbon concentrations, and effective steps can be taken to reduce this important climate-related pollutant. This is in line with the national goal of GHG reductions. • The precursor measurements provide assessment of secondary particulate formation.

Data analysis and Prediction	• Adopting airshed approach based on measurements and monitoring • Capacity building of local agencies and local technical institutes in air quality prediction modelling for identification of hotspots • Use of CEMS data from industry to assess the impact on local air quality • Use of AI-ML application in air quality data analysis for air quality predictions
Industrial Sector	
Switching to cleaner fuels (Natural Gas)	• Promotion of use of cleaner fuels such as natural gas to curb air pollution • Ban the use of fuels with high sulphur content, such as heavy furnace oil, tyre oil, pet coke, etc., and move towards cleaner fuels like PNG. • Promote biomass to replace coal where gas is still not available. • Cities like Delhi-NCR have already implemented this initiative. • CAQM has already issued directions for supply of CNG to industrial areas with assured supply in sufficient quantities.
Flue Gas Desulphurisation and Denitration technologies in industries	• Precursors to secondary particulate formation like SOx and NOx emitted from industrial combustion contribute to air pollution. It is necessary to explore desulphurisation units for medium size boilers. • India already has NOX and SO2 emission standards.
Common Heat and Power Units for cluster of industries replacing smaller boilers	• India promotes small scale industries, and has a significant number of small coal fired boilers (<10 T). • Smaller boilers have relaxed emission standards. These decetralised sources of pollution need effective control. • In industrial areas, dispersed coal-fired boilers can be phased out through centralised construction of Combined Heat and Power units (CHP). There are examples of such CHPs in Gujarat and also sugar industries in Maharashtra adopting captive power plants instead of multiple boilers. • Promote CHPs as common environmental infrastructure • Restrict installation of small coal-fired boilers (E.g. below 10 tph) as the installation of higher capacity units leads to higher efficiency.
Upgradation of brick kiln manufacturing technology	• Brick kilns are recognised as one of the largest stationary sources of black carbon. • Among the brick kilns, zigzag kilns have higher efficiency and lower emissions as compared to Fixed Chimney Bull Trench Kiln (FCBTK) and down-draught kiln. • India has notified standards and needs to enforce it. The challenge is the cost and scale of the kiln. • Need a financial model for the transition, which also has a significant GHG reduction

Solid Waste Management	
Source Segregation and collection of waste.	• Burning of waste/garbage in the open at public places and landfills causes air pollution. Thus, it is important that at both household and commercial levels, segregation of waste at source is done so that the waste can be recycled and reused. • Solid Waste Rules 2016 stipulate entire SW management in detail, including segregation, treatment and processing, which needs to be complied with. • Other government programmes like Swachh Bharat Mission have significant funding and technology support for solid waste management, which can be explored by cities.
Centralised and Decentralised Composting Plants	• SW Rules 2016 has several enabling provisions for promoting in-situ solid waste management. Many corporations have made SW management on site compulsory for certain types and scale of construction. • Buildings with Environmental clearance are also mandated to have their own SW management. • New technologies for efficient biomethanation and composting, which have entered the market, can be used. • Some corporations are incentivising the in-site decentralised SW management by offering subsidies on property tax, etc. • Several composting technologies like vermicomposting, aerated stack-pile composting, and in-vessel are currently available, but windrow method is suited to producing large volumes of compost. • In India, as per MSW Rules 2016, it is mandatory for fertiliser companies to use city compost as raw material. Hence, tie-ups to be done with the national fertiliser companies for long-term sale of compost.
Biomethanation plants	• Biomethanation allows the capture of biogas, which can be used for cooking or for electricity generation; it also produces liquid fertiliser. • Requires segregation of biodegradable waste, can be useful for vegetable markets, canteens, etc. It also has GHG reduction potential.
Waste to Energy (W2E) Plants/ Incinerators	• Useful for large volumes of solid waste, becoming a choice for mega-cities as it requires less land. • Associated problems of air pollution and acceptance of local people, but there are several plants around the world with adequate pollution control systems. • Recovery of energy embedded in waste, but the resource is lost. • Cost intensive, public perception and statutory controls are challenges for this technology.

Reused Derived Fuel (RDF) Plants/ biomining of existing dumpsites	• RDF consists largely of combustible components of such waste, as non-recyclable plastics (not including PVC), paper cardboard, labels, and other corrugated materials. • Biomining of existing dumps can also generate RDF. • RDF can be used in a variety of ways to produce electricity. It can be used alongside traditional sources of fuel in coal power plants. • India now encourages RDF for industrial use, particularly in cement and thermal power plants. • The challenge is consistency of calorific value and presence of refractory material
Pavement of roads/ Road Maintenance	• Unpaved roads are the primary reason for road • dust and needs to be managed. • Paving the roads carpet to carpet is essential. • Maintain pothole free roads for free flow of traffic to reduce emissions and dust. • Local bodies need to chalk out plans to improve conditions of all roads.
Mechanised road cleaning	• High speed mechanised road sweeping machines should be deployed. Some key points for this practice include: • Focus on removing the smallest particles and not just large debris • New models of sweepers come with sensors and data collection on quantity of dust, route, etc., which can be used for planning further abatement. • CAQM has decided that the city administration shall have mechanical sweeping and sprinkling machines @ one mechanical road sweeping machine for every 40 km; identified roads to be cleaned / sprinkled every day. • It is necessary to evaluate the performance of such machines for effectiveness. • There are various technologies that are emerging in this space, smaller versions with more effective corner suction, solar energy/e-vehicles, etc. for use on interior and less wide roads
Periodic watering of roads	• Feasibility needs to be studied in terms of the ratio of air pollution to water pollution. • Some selected roads can be tested for effectiveness. • Treated STP water should be used for sprinkling • The wastewater generated after the road washing shall be periodically checked for pollutant contents

Increasing moisture content of the road surface through deliquescent salts	• The moisture content of dirt roads can be increased either through sprinkling water or by application of deliquescent salts that attract water. Deliquescent salts like calcium chloride and magnesium chloride are some of the options. • However, their environmental impact needs to be studied, as they are a kind of dust palliative.
Binding dust particles together through use of chemicals Increasing green cover of traffic corridor and public places	• Use of chemicals that bind fine particles together or onto larger particles can help in reducing dust pollution. These chemicals fall into several groups, such as petroleum-based, organic non-petroleum, electrochemical stabilisers and synthetic polymers. • Need to study environmental impacts of such chemicals before use • Petroleum-based binders include emulsified asphalts, cutback asphalt and Bunker C. • Organic Non-petroleum Dust Suppressants include lignosulfonates and resins. • Electrochemical Stabilisers include sulphonated petroleum, ionic stabilisers and bentonite. • Synthetic Polymer Products include polyvinyl acrylics and acetates. • Green cover and plantation can reduce dust emissions and re-suspension of dust. • Greening of open spaces can reduce fugitive emissions. • Hanging gardens at public places improve aesthetics and reduce dust pollution also.
Introduce water fountains at major traffic intersection	• Act as scrubber, wherever feasible, with the use of tertiary treated water. • Waste and sludge disposal need to be accounted for.
Domestic Sector	
Use of cleaner fuels in domestic and commercial areas	• Cooking simple stoves fuelled by kerosene, biomass (wood, animal dung and crop waste) and coal in household and commercial areas (hotels, eateries, etc.) needs to be replaced with cleaner fuels like LPG, electricity, PNG, etc. • Current scheme of Ujjawala is an example. • Urban small-scale eateries and hotels shall use cleaner fuel, i.e., PNG
Restriction on use of firecrackers	• Restricted use of firecrackers during episodic events like Diwali, weddings celebrations, etc. Also, eco-friendly green crackers should be preferred. • Directions have already been issued by CAQM on this aspect.
Use of DG Sets	• The DG set use shall be restricted as per CAQM guidelines. • Revised standards for DG sets

Promotion of Renewable Energy	• Promoting solar lightning in housing societies and commercial complexes to reduce dependence on fossil fuel-based power with co-benefit of GHG reductions
Promotion of E-vehicles	• Central/states are promoting the e-vehicles with certain subsidies; city government can also provide innovative support to e-vehicles, like subsidised or free parking • Development of common e-charging facilities
Transport Sector	
Switch over to cleaner fuels	• Use of cleaner fuels like LPG/CNG, particularly for heavy-duty diesel buses and trucks or two-stroke three-wheelers, which are considered as the most polluting sources • Support to Electric Vehicles along with generation of equivalent renewable energy • Ensure fuel availability and distribution networks; refuelling infrastructure; and costs • Support to three-wheelers opting for electric (earlier, capital subsidy was given in many cities for converting to CNG)
Improve fuel quality	• India has adopted BS VI norms (Equivalent to Euro 6) since April 2020. • Ethanol blending is already being practised, up to 10% now, and the target is to increase the ethanol blending further up to 20% soon.
Install vapour recovery systems in fuel refuelling outlets to reduce benzene emissions	• Petrol refuelling stations are a major source of volatile organics emission, which are harmful for human health • Vapour recovery device is an instrument to capture displaced vapours that emerge from inside a vehicle's fuel tank when petrol or diesel is dispensed into it. • CPCB has already issued directions for setting up the vapour recovery device at fuel stations.
Check Fuel Adulteration	• Strict enforcement mechanisms to prevent adulteration of petrol and diesel with kerosene; city administration to enforce this by carrying out random checks at fuel outlets. • Public awareness and education
Installation of Diesel Particulate Filter (DPF)	• A diesel particulate filter (DPF) is a device designed to remove diesel particulate matter or soot from the exhaust gas of a diesel engine. • DPF can remove up to 99% of particles coming from the engine, including ultrafine particles. • DPFs have been made mandatory in European countries since 2011. • Need a national policy

Phase out policy for older vehicles	• India has notified vehicle scrapping policy in 2022, with support to vehicle owners to facilitate the scrapping of old vehicles. • City government needs to encourage local people to implement the policy • Old scrap vehicles stacked in the city shall be identified and disposed of as per policy. City government needs to have a policy framework for compliance, which will reduce congestion and risks of other diseases, like dengue, etc.
Intelligent Traffic Management System	• Intelligent Transportation Systems (ITS) has emerged as an important element for both improving air quality and economy with the main objective of optimising road traffic by managing the capacity of the roads, improving driver safety, reducing energy consumption and improving the quality of the environment. • Real-time information can influence drivers to take alternative routes around congested areas, alleviating air pollution hotspots.
Promote use of public Transport .	• Use of public transport, such as Metro, Bus Rapid Transit (BRT) and Mass Rapid Transit (MRT), is an effective way to reduce air pollution. • Integration of various transport modes by single ticketing will encourage people to use the services. • Public display of bus/ train timing and use of app for ticketing etc • Increase electric mobility by e-public transport • Promote app based office commuting public transport to reduce cars on road.
Link Pollution Under Control (PUC) certificate with insurance	• Making PUC mandatory before renewing insurance for vehicles can put a check and improve compliance of vehicle emissions. This has been enforced by a Supreme court judgement now.
Construction of highways to reduce traffic congestion	• Building of alternative routes/bypass roads can reduce congestion and improve air quality. • Delhi NCR already has a working plan for such diversion of traffic.
Parking Policies	• Parking policy with suitable parking fees is required. • Public transport vehicles, e-vehicles and non-motorised modes of transport should be given preference in parking space allocation.
Construction & Demolition Activities	
Preparation of environmental management plan	• A site-specific environmental management plan should be prepared and shared with authorities before the start of construction & demolition activities. Copy should be available at site also. • It should include design elements, operating practices, selected technologies, products, and equipment that will be applied to prevent or control emissions from all sources and also include management of solid and liquid waste.

Use of water and dust suppressants at construction sites	• Water and dust suppressants can be applied to mitigate fugitive dust from site preparation, storage piles, materials handling, and transfer. Water is the most common of the two as it is cheap. • The chemical suppressants, though more expensive than water, are very effective. The two most frequently used dust suppressants are calcium chloride and magnesium chloride, which are hygroscopic (moisture attracting) materials that draw moisture from the air to provide extended dust suppression. It is important that these suppressants are utilised keeping in mind any environmental consequences their usage can have. • CAQM has mandated all projects to adopt effective dust control measures, including wind breakers, dust screens, water sprinkling, dust suppressing and soil stabilisation measures, etc., and deployment of adequate numbers of anti smog guns, in proportion to the area of the construction sites, as under: a) At least 1 for a total construction area between 5,000-10.000 sqm b) At least 2 for a total construction area between 10,001-15,000 sqm c) At least 3 for a total construction area between 15,001-20,000 sqm d) At least 4 for a total construction area >20,000 sqm.
Efficient management of construction materials	• Material handling should be responsive to wind speed and directions, distance from boundary, and also have covering or enclosures (three sided bunkers or silos), wind screens or fences, etc. • For small-scale construction, tarpaulins can also be used as a temporary covering, but they should be properly anchored to prevent the wind from removing them. • Construction material inventory should be minimum, as per the requirements. There should not be any storage along the road or outside the construction area.
Transfer and handling of construction materials	• The trucks shall be covered. • Minimum drop heights to be maintained during the transfer of materials onto vehicles and conveyor belts. When feasible, the transfer points should be enclosed from the top and the sides. • Washing of wheels and underbodies of trucks to ensure the removal of material from truck underbodies and tires prior to leaving the site • Regularly remove dirt track out/carryout from paved streets at the access point(s) • The accumulated dirt or similar debris deposited on paved roads should be removed and cleaned at the end of each day. • Use of foam or water spray system on material transfer systems. Deployment of closed tankers/trucks with enclosures for transfer of transportation of material to a construction site. • Limiting the speed of vehicles transferring construction materials can also mitigate fugitive dust emissions. • Monitoring the air quality at construction sites

Demolition/destruction techniques	• City government to develop good practice guidelines for construction and demolition works in the city • Compliance of C&D Waste rules 2016 • Buildings, to the extent possible, should be deconstructed rather than demolished so that materials can be reused (Circular Economy). • Blasting must be avoided wherever possible. • Use of enclosures to cover chutes dropping demolished materials. • Fogging system for fugitive dust areas to increase moisture in dust, thereby settling it. • Avoid prolonged storage of debris on site and its exposure to wind.
Green Construction	• Use of precast structures and ready mix concrete to avoid material handling at site. • Use of green walls and cool roofs for energy conservation • Use of fly ash bricks • Green construction products; responsible steel, green cement and environment-friendly paint and other material
Air monitoring at construction and demolition sites	• Suitable air quality monitoring systems shall be installed at construction and demolition sites, and operations shall be stopped/controlled based on air quality data. • Some cities like Mumbai have already issued directions in this regard.
City Authorities GMC, GMDA, HSPSB	
Execution of action plan, coordination with all stakeholders, monitoring and evaluation	• Provision of sufficient road cleaning mechanism, including mechanical road sweeping machines • Intelligent traffic management systems and road infrastructure to reduce congestion and air emissions • Provision of sufficient number of anti-smog guns and water sprinklers in the city • Support and encourage e-mobility and public transport • Air quality measurements and monitoring at required number of stations for identification of hotspots • Source inventory and source apportionment • Compliance of waste management rules; solid waste, e-waste and plastic • Public awareness and information dissemination Field-level verification and inspections on construction and demolition projects • Periodic review of traffic congestion in the city and taking suitable corrective measures

10. STAKEHOLDERS CONSULTATION

The scale, complexity, and urgency of the problem necessitates a strong, coherent, and coordinated response from all concerned stakeholders to address the air pollution issues. To strengthen institutional capacities on implementation and research for air quality management, multidisciplinary collaborative governance involving existing regulatory institutions, especially in public health and livelihoods must be encouraged. This can be initiated by simply ensuring representation at the decision-making table.

10.1 Stakeholders Identification: The key stakeholders and their roles and responsibilities are as under:

Sr. No	Stakeholder	Role and Responsibility
1	HSPCB	Overall responsible for air quality management, identification of sources, control and regulation of source emissions, standards for emissions, measurement and monitoring, enforcement and compliance, legal actions, air quality data disclosures
2	Gurugram Municipal Corporation	Overall ownership of the action plan, including implementation and coordination of the implementation of action plan. Traffic systems and planning, solid waste management, construction and demolition waste management, construction activities enforcement, road cleaning, plantation, etc. Promotion of E-vehicles, sufficient charging stations, clean fuel Hotspot identification; grievance redressal
3	District Administration	Fuel supply, overall coordination of government authorities, solid waste management compliance
4	Road Transport Office	Vehicle registration, Pollution under Control Certification, old and scrapped vehicles, traffic management
5	Health Authorities	Records of the cases of diseases related to air pollution, awareness
6	Academic Institutes	Air quality research, monitoring, performance evaluation of control measures, development of control techniques for site-specific conditions
7	NGO/ CSO	Awareness, information dissemination, public concerns
8	Construction Industry	Construction and demolition waste, green and sustainable construction practices, material handling, good construction practices
9	Industry	Air pollution control to meet standards, material handling emission control
10	Air quality professionals including environmental labs, control equipment suppliers, maintenance facilities, etc.	Interact with GMC and HSPCB for effective implementation of the action plan.

10.2 Expert Group Consultation: An expert group consultation from the three participating countries was held on 25th May, 2023, where experts from the three countries (Bangladesh, India and Thailand) and also from outside participated. The main objectives of the consultation were:

- Collect good case studies of innovative technologies and their applications to control air pollution in cities across the Asia-Pacific region
- Understand enabling strategies and opportunities for scaling up and adoption of technologies for city air pollution control in terms of innovative methods of implementation, efficiency, effectiveness, affordability and accessibility
- Solicit recommendations for cross-border technology collaboration and regional cooperation to accelerate adoption of air pollution control technologies in cities

The discussions in this consultation highlighted the need to deal with the issue of urban air pollution and all aspects of air quality in a comprehensive manner, including measurements, monitoring, inventory, source apportionment, stakeholders coordination, dust control measures, transport-related pollution, solid waste management, construction activities, etc. Some of the new initiatives like e-mobility, hydrogen as fuel, air quality predictions linked to regulating the air pollution source activity, etc. were also discussed. The expert consultation also highlighted that there are several initiatives being carried out at the city level, though there is a need to strengthen the financial support for implementing various action plan points and enable better coordination and capacity building of the local agencies and stakeholders.

10.3 Stakeholder consultation: A stakeholders consultation was organised by GMDA on 19th October at Gurugram, where the current study was presented to the stakeholders. During the interactions, following points emerged for suitable consideration while finalising the report:

- The action plan needs to be holistic and consider a long-term regional approach with multi-sectoral strategy for the NCR and adjoining areas.
- There is no single solution, and multi-pronged measures would be required for various sectors to tackle air pollution.
- The action plan should not just be used as a response to seasonally deteriorated air quality, but it should aim to improve the air quality throughout the year.
- Reduce emissions from sources year round as well as reduced reliance on emergency measures, such as the Graded Response Action Plan, are needed. The data on source-wise emissions needs to be verifiable and quantifiable.
- Participation of people in action plan design, implementation and evaluation, i.e. the entire air quality improvement exercise is needed.
- The action plan for the city should not be restricted to city limits; rather, it should be part of an airshed with specific focus on rural and peri-urban areas.
- The efficacy and adequacy of various actions need to be evaluated through modelling-based cost-benefit analysis to drive interventions.
- Publish periodic reports on progress made against interim targets; assess why regulatory and enforcement measures succeeded or failed.
- Develop sectoral action plans and solicit expert and public comments.

10.4 Inputs from technical expert consultation and stakeholders consultations have been duly considered while finalising the suggestions.

11. FINANCIAL ASPECTS

One key constraint or limiting factor for the air quality action plan has been the lack of financial support to the various actions proposed. Many of the actions, like development of road infrastructure, mechanical road sweeping machines, solid waste management, intelligent traffic system, etc., require heavy capital investment. Also the industrial interventions, such as provision of piped gas, technology for sources such as stubble burning, etc.,are also capital-intensive. Similarly, all the actions need recurring expenditure for its sustained operation. One of the essential features of the action plan is that the actions are to be implemented on a continuous basis and need to be evaluated regularly and intensified as per requirement. This necessitates that the action plan is supported with sufficient capital and recurring finances.

11.1 India has been implementing several central and state programmes, social and infrastructural, which has had a direct positive impact on air emission reduction. One of the examples is the Swachha Bharat programme[28] that provides substantial financial and technical support for sanitation, hygiene and, most importantly, scientific solid waste management. As unscientific disposal of solid waste through burning and landfill fire contribute significantly to air pollution, the programme support can reduce air emissions. The program also provides road cleaning equipment and supports better infrastructure. Another example is the Smart City Programme, which provides for holistic improvement in the city, leading to better quality of urban life. Another example is the Ujjwala Scheme,[29] where urban and rural poor are provided with free gas connections to reduce the use of wood and coal etc. for domestic purposes. The Central Government has also taken up developing by-pass roads in and around Delhi to divert the traffic away from city centres. Similar schemes and projects are available for supply of piped natural gas to urban and industrial areas; provision of mass and rapid transport systems like metro; support to public transport augmentation; and renewable energy initiatives.

11.2 Urban health and sanitation is the prime responsibility of the city government, and, therefore, the city government needs to raise the required funds for implementation of clean air action plans. Many of the actions envisaged in the action plan are an integral part of the city government functions, like traffic planning, solid waste management, road cleaning etc. However, there are several opportunities for involving the private sector, either in the CSR mode or the PPP mode, to carry out several actions in the CAP. Gurugram, being a hub of several large corporations, is uniquely poised to tap the CSR funds for various actions like greening the traffic islands, water fountains, air pollution control equipment at hotspots, awareness activities, etc. Similarly, the private sector can be roped in PPP mode for several actions like road cleaning, solid waste management etc.

11.3 'Polluter pays' principle has been widely practised in India, with several proactive judgements of NGT and the Hon'ble Supreme Court. CAQM has also issued directions for levying environmental compensation to the polluters for non-compliant activities. Delhi NCR has been imposing fines and also charging environmental compensation cess[30] since 2015. Though the exact amount of these funds is not available, these funds can be very well utilised[31] for various actions envisaged in the action plan.

11.4 The government is also encouraging startups and innovators to work in the public space and provide an opportunity for innovations and startups. This can make a difference across the proposed actions, including air quality measurements, modelling, control technologies, traffic management, etc. It is required that the city government encourage startups to find effective solutions in various components of the action plan.

28 https://sbmurban.org

29 https://www.pmuy.gov.in/about.html

30 https://www.hindustantimes.com/cities/delhi-news/129838-crore-collected-as-green-cess-from-vehicles-entering-delhi-101646424984985.html#

31 http://www.indiaenvironmentportal.org.in/files/file/EC-fund-guideline-CPCB-order-NGT.pdf

11.5 There are several opportunities for funding major investments, like public transport augmentation, solid waste management, e-public transport, road diversions and bypasses through various DFIs like JICA, ADB, WB and others, through private funds at subsidised rates. The proposals under air quality improvement action plans generally have a co-benefit of GHG reduction, which is one of the priorities of the Government of India.

12. CONCLUSIONS AND RECOMMENDATIONS

The ambient air quality in most of the Indian cities and, more particularly, in northern India is a cause of grave concern, and the government authorities have responded to it by creating a statutory structure and graded action plans that deal with a much wider area (though not exactly an airshed) on sectoral basis with many technological interventions. The increasing population of cities and economic growth, leading to development of infrastructure, along with an improved lifestyle and rising income, have contributed to air pollution in these areas.

This study has identified technological interventions and some policy recommendations that are best suited for the city of Gurugram in order to strengthen the present action plan by first studying the various technological solutions for its applicability, affordability, relevance, replicability and effectiveness in the context of Gurugram. It is recognised that many of the actions have already been taken through regulatory measures, but there is a need to create synergy among several actions through stakeholders coordination to achieve the desired results. It is also well recognis ed that the air quality problem is very complex, and there is a need to deal with this issue on an airshed basis, rather than a city- centric approach. There is a strong political and social desire to improve the air quality, with necessary regulatory and financial support; therefore, the use of appropriate technologies and policy interventions would be helpful in achieving the desired air quality in the city. The recommendations of the study are summarised below:

1. There is a need for source inventory and source apportionment studies to identify the major sources and source- wise contribution to ambient air quality for effective interventions in the city.
2. Improved monitoring for identification of hotspots within city limits would enable the local authorities to take immediate and effective actions. Use of LCS and remote sensing could be potential options, though operation of LCS could be comparatively easy.
3. Promotion of innovations and startups in the field of air pollution control and mitigation through policy interventions, mainly for areas of green construction, air pollution hotspot identification, and circular economy in urban environments.
4. Technological interventions provide an opportunity to mitigate air pollution mainly at the receptor level, though significant efforts are required for control of air pollution at the source.
5. Transport, industry, construction, road dust and solid waste management have been reported to be the main contributors to city air pollution. They shall be given priority when implementing city action plans. Point sources like gensets, bakeries and tandoors are also important.
6. Though there are several technologies for abatement, mitigation and control of air pollution, their performance to achieve ambient air quality has not been tested sufficiently; hence, there is need to include performance evaluation of such technology intervention.
7. The area of influence of air pollution control technologies is an area of research and evaluation. Considering the capacity of urban local bodies, the environmental regulators, including SPCB and CPCB, need to play a critical role for technology appraisal and validation for uniform and consistent adoption in city action plans.
8. There is an urgent need to develop infrastructure and capacity at the level of urban local bodies and SPCB to deal with technical and scientific aspects of air pollution, including technology adoption, evaluation and operation for effective implementation of city action plans.

9. Airshed approach needs to be adopted for holistic air quality management as significant contribution has been reported from sources located outside the city limits.
10. More studies are required to assess the adverse impacts of air pollution on human health, and more particularly on poor and marginalised communities, women and children, and aged persons.
11. More studies are required to assess the adverse impacts of air pollution on flora and fauna (including urban and rural areas and agriculture).
12. Effective cost-benefit analysis of air pollution mitigation action plan and preparation of a detailed comprehensive action plan would attract investments in this sector, as already evident in various countries including China and Philippines.
13. Adoption of new principles and governance tools, such as circular economy, carbon and green credits and innovations, needs to be integrated into city action plans.
14. Economic instruments like green credits need to be explored for adoption of new technology and practices, such as conversion of transport fleet to electrical/CNG, bakeries, tandoors, small boilers, etc. There are opportunities to get institutional funding if such a project is planned.
15. The city action plan needs to be supplemented through various city-specific policies like parking policy, scrapping policy, mobility action plan, development plan, among others.
16. There is a need to develop a city-specific action plan for Gurugram based on source inventory and source apportionment studies, which is dynamic but aims to achieve the desired air quality in a time-bound manner using the various technologies discussed in this report.
17. There is a need to increase meaningful public participation in city action plans through continuous engagement throughout its life cycle; also, city-specific portals must give all relevant information on city air quality action plans and include a grievance redressal mechanism.

REFERENCES

1. EPCA: Report No. 71: Comprehensive Action Plan for air pollution control with the objective to meet ambient air quality standards in the National Capital Territory of Delhi and National Capital Region, including states of Haryana, Rajasthan and Uttar Pradesh: April 2017
2. Policy to Curb Air Pollution in the National Capital Region July, 2022 published by Commission on Air Quality Management for NCR and Adjoining Areas 2022
3. District Environmental Plan prepared by HSPCB, HUDA, GMDA, GMC and HSIIDC
4. A brief Issue Paper prepared by NRDC with CEE in 2020 titled `Clearing the Air: A Review Of 10 City Plans To Fight Air Pollution In India'
5. Ganguly, Tanushree, Kurinj L. Selvaraj, Sarath K. Guttikunda. 2020. "National Clean Air Programme (NCAP) for Indian cities: Review and outlook of clean air action plans." Atmospheric Environment: X, Vol 8 . https://doi.org/10.1016/j.aeaoa.2020.100096
6. USEPA report on `A Guide for Reducing Air Pollution through Urban Planning-1973':
7. Climate Action Plan For Net Zero Gurugram By 2050 by GMDA https://gmda.gov.in/download.html?fid=GMDA_74bfd02b-417e-46c8-86a5-768352ef0521&code=opinion&key=attachment&identifier=1694845701116
8. Policy to Curb Air Pollution in the National Capital Region by Commission for Air Quality Management in NCR https://caqm.nic.in/WriteReadData/LINKS/Policy%20to%20curb%20air%20poluution%20in%20NCR_8bc1ddf1-b34a-4506-b29f-34390650e053.pdf
9. Commission for Air Quality Management in NCR: Various orders and directions including Graded Response action plan (GRAP) and its implementations https://caqm.nic.in
10. National Clean Air Program (NCAP) India: https://moef.gov.in/wp-content/uploads/2019/05/NCAP_Report.pdf
11. Prana portal of MoEFCC India containing all relevant technical guidelines for monitoring, measurements, control and abatement https://prana.cpcb.gov.in/#/resources
12. City Action Plans of the Non-attainment cities under NCAP India: https://cpcb.nic.in/approved-city-action-plans/