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LOCAL AIR QUALITY

What has been the impact of SCM in improvement of local air quality in Indian Smart Cities?

Sustainability Impact Assessment Report by

INDIAN INSTITUTE OF TECHNOLOGY HYDERABAD

Smart City

SMART CITIES MISSION
MINISTRY OF HOUSING AND URBAN AFFARIS

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Executive Summary

India is one of the fast-emerging economies of the world witnessing rapid development and industrialization. A direct consequence of this has been increased urbanization and expansion of urban centres (cities) which has in turn led to challenges such as unplanned migration, land-use changes, urban waste generation and natural resource pollution. Air Quality of urban landscapes has therefore become a parameter of increasingly scientific and administrative focus since rapid construction, vehicular emissions and loss of city green cover has led to considerable degradation of ambient air quality in recent years. Air Pollution in India has considerably risen in the past two decades and has become a big risk factor contributing towards the country's disease burden. Additionally, rising air pollution levels also contribute towards climate change.

Taking due cognizance of the situation, the national administration via the Central Pollution Control Board ably supported by State Boards and other private agencies has launched several programs for source identification, improved monitoring, and development of city action plans for improving local air quality. However, since accessibility to clean air is of prime importance to residents living in urban habitats, ***the focus of the present report was to assess the role of the Smart Cities Mission (SCM) in improving Local Air Quality.***

Beginning with a general overview of the relevance of sustainable urbanization and the impact of urbanization on Local Air Quality, the major Aim and Objectives of the study have been detailed. The report then moves on to provide a brief literature review detailing the inter-linkages (impacts and dependencies) between the Sustainable Development Goals and improvement in Air Quality as well as the existing regulations for monitoring air quality and mitigating pollution. Section 3 outlines some key strategies/approaches adopted by cities internationally for tackling the challenges of urban air pollution. Subsequently, Section 4 describes the methodology adopted for ascertaining the impact of SCM in the realm of Improvement of Local Air Quality which is broadly categorised into two major heads that is National Level Impact Assessment and City-visits for Primary Assessment.

Analysis of data received from Smart Cities as part of National Assessment revealed that with respect to Air Quality Improvement, 'Urban Greening and Development of Open Public Spaces' as well as 'Source Apportionment to understand local sources of Air Pollution' were the one focus areas where several smart cities had implemented projects. *This observation was further substantiated through field visits.*

A total of five cities were visited as part of Primary Assessment namely; Indore, Lucknow, Pune, Surat, and Kochi *for understanding the solutions/projects implemented by their respective city Special Purpose Vehicles (SPVs) that have a direct or indirect impact on the local air quality. Technical project details aside the likely socio-economic and environmental impact of the projects being implemented under the SCM*

were also ascertained. ***Overall, review of projects and interactions with SCM officials revealed that in terms of Local Air Quality, most city SPVs are involved in air quality monitoring.***

Besides, projects related to development of parks and open green spaces, road-side tree plantations, enhancement of non-motorised means of transportation (public bike sharing) and, popularization of renewable energy (solar photovoltaics) sources have been implemented by all cities, which tend to have a positive impact on local air quality. However, these impacts need to be better quantified. ***Moreover, the Integrated Command and Control Centres (ICCC) of Lucknow, Pune, and Surat are also implementing smart solutions for traffic management through the ATMS (Adaptive Traffic/Transit Management System) which primarily involves implementing strategies to reduce journey times, traffic congestions as well as improve speed efficiency and access to public transportation. All these would ultimately result in reduction of vehicular emissions which would contribute towards air quality improvement.*** *However, like with the civil development projects the impact of smart solutions for traffic management on local air quality need further empirical evidences.* ***Additionally, Lucknow administration has signed an MoU with A-PAG (Air Pollution Action Group) which is undertaking various actions for air pollution mitigation in the city using Smart City Infrastructure.*** *This serves as a relevant example of how SPVs can initiate collaborative projects for source identification, monitoring, and mitigation of air pollution especially since Local Air Quality Improvement requires pan-city initiatives.* ***Similarly, Indore and Surat have undertaken citizen awareness campaigns for traffic awareness and uptake of public bike sharing respectively which have a positive bearing on air quality through citizen involvement.***

The concluding section of the report provides an overview of the major inferences drawn from the National Assessment and Field Visits which is followed by some recommendations for better integrating the cause of Local Air Quality within Smart Cities future projects. A major requirement for the same is revision of SCM guidelines for recognition of 'Local/Urban Air Quality Improvement' as one of the thematic focus areas of the mission. This would evidently increase projects directly focusing on air pollution mitigation. Besides, boosting PPP (Public Private Partnerships) projects targeting academic-industrial-governance collaborations is also suggested. The report will prove to be an insightful read for policy-makers, administrators, municipal officers, NGOs, academicians, and individuals interested in the Urban Air Quality as it provides a comprehensive overview of city-specific challenges, gaps areas, and strategies with respect to urban air quality.

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FOREWORD

It has been a great privilege for **Indian Institute of Technology Hyderabad (IITH)** to partner with Smart Cities Mission (SCM), Ministry of Housing & Urban Affairs (MoHUA), Government of India, in its unique initiative under SAAR (Smart Cities & Academia towards Action & Research) - Sameeksha Series, aimed at offering an opportunity to the premier institutes of the country to undertake comprehensive, national level independent impact assessment studies. It comprise of 50 national level impact assessment studies by 29 premier institutes of India on various themes. It is focused to bridge the gap between academia and government to document and research new urban initiatives/ models/ projects under SCM, on one hand, and take the learnings to level next on the other.

The **Sustainability Impact Assessment Study on Local Air Quality"** carried out by Dr. Ambika S, Department of Civil Engineering, IITH, delves on **"What has been the impact of SCM in improvement of local air quality in Indian smart cities?".** The study meticulously examines the direct and indirect effects of projects and initiatives on enhancing local air quality practices across 100 Smart Cities. In this study, detailed city-level case studies were undertaken in Indore (Madhya Pradesh), Lucknow (Uttar Pradesh), Pune (Maharashtra), Surat (Gujarat), and Cochin (Kerala). The observations on the impacts were reported in terms of technical, social, environmental and economic impact assessments. Furthermore, the report offers Replicable Best Practices, Recommendations, and Policy Directives aimed at reinforcing local air quality in India, serving as a valuable resource for researchers, technical engineers, city planners, and future smart city endeavors.

Dr. Ambika's team express gratitude to the Mission team at MoHUA for offering well-coordinated data support and on-ground facilitation of site visits to the project team, for documenting the learnings which could be bedrock for future urban development policies. Hope the outcome of these impact assessment studies will go long way in improving living standard of its citizens. We would also take this opportunity to wish good luck to SCM, MoHUA in its future endeavours.

(Prof. B S Murty)

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1. Introduction

1.1 Significance of Sustainable Urban Development:

The level of urbanization is often regarded as a critical parameter for assessing the economic prosperity of a nation as it not only proves to be a yardstick for quantifying the relative access to resources but also helps assess the 'standard of living' based on indicators related to sanitation, education, mobility, and governance. Moreover, mounting anthropogenic pressures has gradually shifted focus towards greater inclusion of ecological and sustainability indicators while measuring city expansion and urbanization. Consequentially, governments world-wide are laying greater emphasis on interventions, frameworks and guidelines that promote 'sustainable urbanization' *(Keith et al. 2023; Takano et al., 2023)*.

1.2 Urbanization and Challenges with Local Air Quality:

While industrialization and expansion of city limits has undoubtedly had a positive impact on the Indian economy, it has also created several challenges. Crucial among them is the gradual deterioration of air quality within urban landscapes. Reduction in green cover within city coupled with expansion of industrial units, unplanned construction and increasing vehicles have all contributed towards urban air pollution. Rise in particulate pollution levels (PM_{10} and $PM_{2.5}$) has been a major concern with air pollution levels in Indian cities being the highest in the world. Exposure to high particulate concentrations for long durations can increase the risk of illnesses such as bronchitis, lung cancer and heart ailments among individuals Moreover, gaseous pollutants (oxides of nitrogen and sulphur) result in the formation of acid rain and suppress plant growth.

1.3 Hypothesis, Aims and Objectives:

Given the mounting scientific evidence on impact of polluted urban air on health of citizens and local environment, it was hypothesized that inclusion of 'Urban Air Quality Improvement' as a major vertical of the Smart Cities Mission (SCM) (a Central Sector Scheme) could have major positive implications on improvement of local air quality. Specific objectives include:

- To assess present efforts for Air Quality Improvement in Smart Cities at the National Stratum.
- To undertake Primary Impact Assessment for Local Air Quality through field visits to selected Smart Cities.
- To comprehend Gap Areas with respect to Local Air Quality and to propose appropriate Recommendations for overcoming them.

1.4 Observed Limitations:

Since 'Air Quality Improvement' does not form one of the thematic focus areas of SCM, projects directly associated to the same remain limited. Therefore, projects likely to improve urban air quality (development of green spaces, renewable energy, improvement of public transportation etc.) were considered for impact assessment study.

2. Literature Review

2.1 Interlinkages between SDGs and Urban Air Quality:

The SCM is directly aligned with one of most significant global frameworks of recent times promoting social, ecological, and economic sustainability that is the United Nations-Sustainable Development Goals (UN-SDGs). Of the 17 Goals, SDG 11 is exclusively dedicated to 'Make cities and human settlements inclusive, safe, resilient and sustainable.' The goal identifies access to basic amenities, effective waste management, clean ambient air, green spaces, and affordable infrastructure as some major essentials to a healthy and sustainable life. As evident the core elements of the SCM also focuses on these aspects which highlights the central administration's effort in propagating the SDGs through political interventions. Besides, several targets of the 17 SDGs bear direct or indirect linkages with 'improvement of local air' which have been further detailed within **Table 1**.

Table 1: Targets across the 17 SDGs which either influence or can be influenced either directly or indirectly through effective Air Quality Improvement (https://sdgs.un.org/goals)

Goal	Targets	
	Targets directly associated with Local Air Quality	**Targets directly/indirectly influenced by Local Air Quality**
SDG 1	1.5 By 2030, build the resilience of the poor and reduce their exposure to climate-related extreme events	1.3 national social protection systems 1.4 ensure all men and women have equal rights to economic and natural resources
SDG 3	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks
SDG 4		4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development
SDG 7	7.a By 2030, enhance cooperation to facilitate access to clean energy research, including renewable energy, energy efficiency and cleaner fossil-fuel tech	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix 7.3 By 2030, double the global rate of improvement in energy efficiency
SDG 8		8.4 Improve global resource efficiency in consumption and production and decouple economic growth from environmental degradation
SDG 9		9.4 By 2030, upgrade infrastructure and retrofit industries with increased resource-use efficiency and greater adoption of clean technologies
SDG 11	11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems 11.3 By 2030, enhance inclusive and sustainable urbanization 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces
SDG 12	12.4 By 2020, achieve environmentally sound management of chemicals and all wastes throughout their life cycle and significantly reduce their release to air to	12.2 By 2030, achieve the sustainable management and efficient use of natural resources 12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse

Goal	Targets	
	Targets directly associated with Local Air Quality	**Targets directly/indirectly influenced by Local Air Quality**
	minimize their adverse impacts on human health and the environment 12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption	12.6 Encourage companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
SDG 13		13.2 Integrate climate change measures into national policies, strategies and planning
SDG 15		15.2 By 2020, promote the implementation of sustainable management of all types of forests
SDG 17		17.14 Enhance policy coherence for sustainable development 17.17 Encourage and promote effective public, public-private and civil society partnerships

2.2 Administrative Structure for Management of Urban Air Quality:

The Air (Prevention and Control of Pollution) Act operational since 1981 is the leading regulation which mandates the Central and State Pollution Control Boards (CPCB and SPCBs) to take measures for the prevention, control, and abatement of air pollution. Furthermore, taking due cognizance of rising air pollution levels, the CPCB launched the National Air Monitoring Programme (NAMP) for determining the air quality status, trends at the city-scale and ensuring compliance of the air quality standards. The NAMP network consists of 804 operating stations covering 344 cities/towns in 28 states and 6 Union Territories of the country. Four air pollutants that is Sulphur Dioxide (SO_2), Oxides of Nitrogen as NO_2, Respirable Suspended Particulate Matter (RSPM / PM_{10}) and Fine Particulate Matter ($PM_{2.5}$) have been identified for regular monitoring at all the locations (https://cpcb.nic.in/). Furthermore, the Ministry of Environment, Forests and Climate Change (MOEFCC) in partnership with various other ministries and other state level regulatory bodies launched the National Clean Air Programme (NCAP) in 2019 to monitor and improve air quality at city, regional and national level. Presently operational in 131 non-attainment cities (cities recording continuous high levels of PM_{10}, NO_2 and SO_2), the programme is a time bound scheme dedicated to meeting the prescribed annual average ambient air quality standards within all selected cities. City Action Plans (CAPs) developed under the programme would be implemented through co-ordinated action of state governments and city agencies. The funding for the same would be mobilised through convergence of resources from various other operational schemes of Central Government such as Clean India Mission (Urban), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Smart City Mission and Sustainable Alternative to Affordable Transportation(SATAT) as well as from other resources of State/UT Governments and its agencies such as Municipal Corporations, Urban Development authorities and Industrial Development Authorities etc. For monitoring of timely implementation of the NCAP provisions, the PRANA (Portal for Regulation of Air Pollution in Non-Attainment cities) has been set up which supports the physical tracking as well as the financial status of the city air action plans implementation as well as helps in information dissemination to the public.

3. Case Studies for Local Air Quality Improvement-International

Global recognition of the harmful impacts of ambient air pollution on human health has witnessed a steady rise owing to growing scientific evidence. This has consequentially led to increase in global regulations and guidelines related to 'Clean Air' such as WHO Air Quality Guidelines 2021 (WHO, 2021). Besides, several cities are undertaking stringent actions to effectively tackle urban air pollution. Examples of measures undertaken or strategies devised by some cities include; electrification of public bus network and metro system (Colombia, Bogota), development of an air quality database through installation of air sensors to better understand pollution sources (Warsaw, Poland), banning diesel vehicles from public sector and mass transit fleets by 2025 (Seoul, South Korea), undertaking campaigns to educate people about health impacts of indoor cookstoves (Accra, Ghana) and increase per capita green space and overall tree cover (Bangkok, Thailand) (UNEP, 2022). As evident cities are implementing a wide variety of measures for improving air quality and making cities more habitable and sustainable.

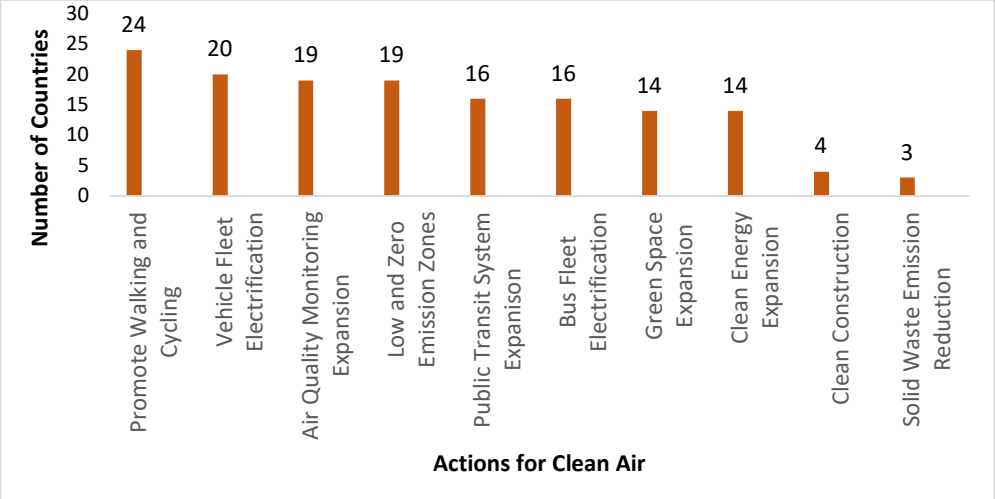

Figure 1: The graph depicts actions that can be undertaken for reducing air pollution and number of cities that have reported implementing them (adapted from López et al., 2023).

Moreover, the World Bank has recently suggested adoption of an 'airshed approach' for tackling the challenge of air pollution in India. An airshed can be defined as a region with a common flow of air which may become uniformly polluted and stagnant. Air quality within an airshed would depend on the pollution sources within it and owing to complex atmospheric dynamics and the movement of primary and secondary pollutant particles, an airshed can extend for several hundred kilometers. Since this would be well beyond city boundaries, India can also consider forming regional action plans for air pollution mitigation (The World Bank, 2023). However, several challenges related to finances, lack of trained personnel and limited computational facilities may be faced as concluded by Khan et al., 2024 following a critical analysis of airshed approaches in developed countries and gaps in developing countries.

4. Methodology

The basic methodology adopted for undertaking the Impact Assessment study for assessing the role of SCM in improving Local Air Quality within Smart Cities has been depicted through the following flowchart:

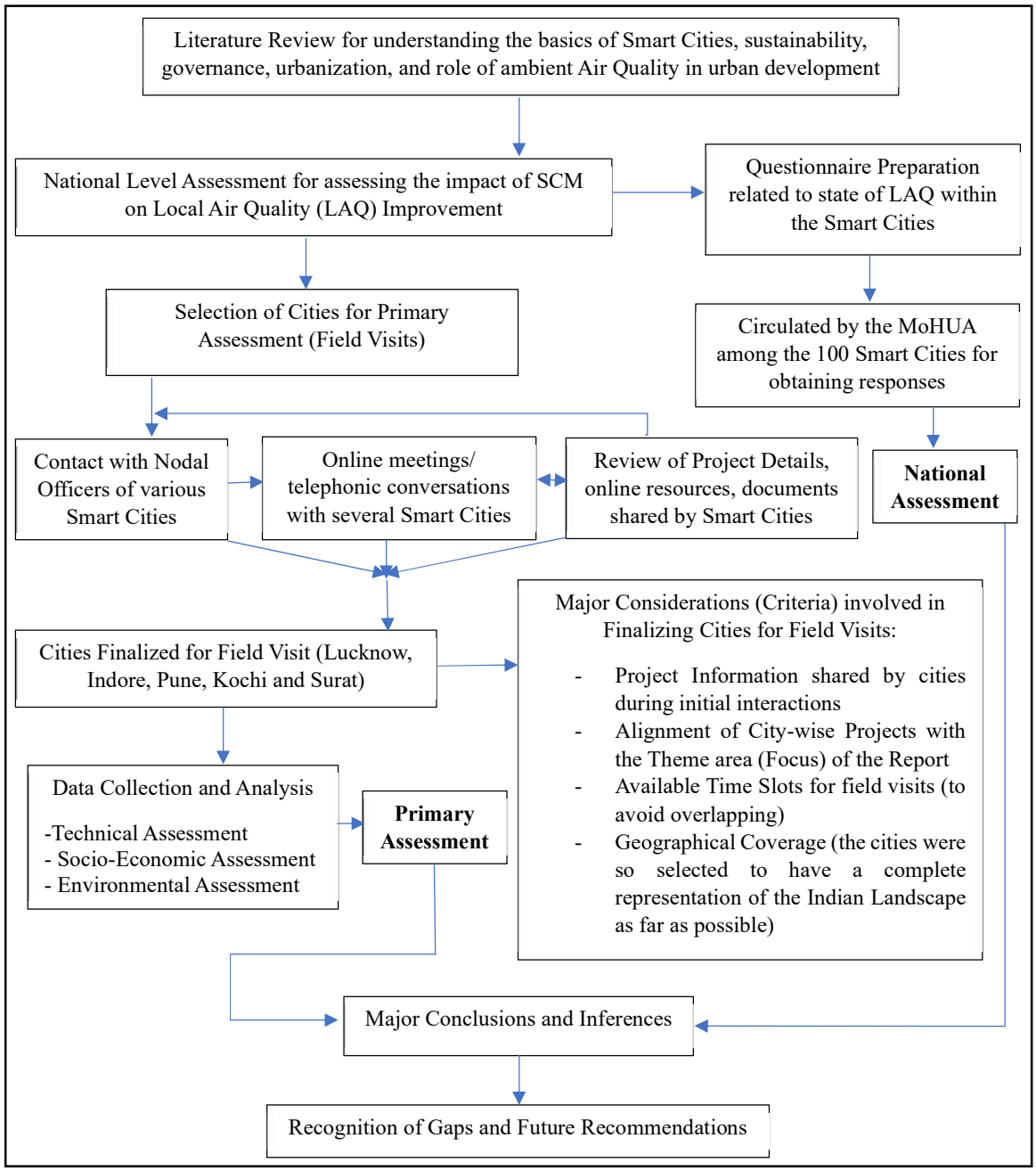

Figure 2: Schematic representation of the Approach adopted for assessing the Impact of SCM in improving Local Air Quality within Smart Cities

5. Impact Assessment Inferences

5.1 National Level Theme-based Impact Assessment:

National Assessment of LAQ Improvement involved circulation of a question bank to the Smart Cities through the MoHUA, results of which have been summarized below:

Table 2: Overview of Cities contribution towards LAQ Improvement through SCM

Questions Asked	Total Cities who Responded	Specific Smart Cities who Responded
Have any studies (source apportionment/ emission related) been undertaken to comprehend the major local factors contributing towards air pollution, with SCM funds?	18	Aurangabad, Belagavi, Bhagalpur, Dehradun, Erode, Pune, Surat, Salem, New Town Kolkata, Pimpri-Chinchwad, Lucknow, Raipur, Sagar, Vadodara, Tumakuru, Ludhiana, Vellore, Bhubaneshwar
Total value of dust suppression systems (like fog canon, water sprinklers) purchased with SCM funds	6	Kakinada, Tirupati, Surat, Davanagere, Sagar, Kochi
Total value of projects undertaken to manage construction and demolition waste with SCM funds	6	Bhagalpur, Indore, Tirupati, Surat, Sagar, Vadodara
Total value of projects undertaken to monitor and regulate vehicular emissions with SCM funds	8	Aizawl, Srinagar, Dehradun, Tirupati, Surat, Mangaluru, Ujjain, Vellore
Total value of projects undertaken to monitor and regulate industrial emissions with SCM funds	2	Tirupati, Lucknow
Total value of projects undertaken to increase green cover/ gardening/ afforestation with SCM funds	29	Aizawl, Aurangabad, Belagavi, Nashik, Srinagar, Bhopal, Bhagalpur, Indore, Tirupati, Silvassa, Surat, Satna, New Town Kolkata, Nagpur, Davangere, Shivamogga, Moradabad, Mangaluru, Raipur, Kota, Sagar, Udaipur, Kochi, Tumakuru, Itanagar, Jaipur, Vellore, Chennai, Muzaffarpur

Furthermore, Jhansi answered in the affirmative to several questions but most of this work has been undertaken through the NCAP program. Similarly, Surat too has invested 40 crores in procurement of dust suppression systems but through utilization of Swachh Bharat Mission (SBM) funds. In terms of urban greening Aurangabad (220 crore) followed by Kota (110 crore), Kochi (46.77 crore), Tumakuru (46.13 crore) and Itanagar have (32.15 crore) made maximum utilization of SCM funds. However, direct efforts/measures (pollution source identification, management of C&D waste, vehicular and industrial emissions) to combat urban air pollution by cities under the SCM remain limited. Several cities however, have undertaken urban greening and green space development projects since 'provision of sustainable environment' forms one of the core elements of Smart Cities. Additionally, telephonic conversations with Mangaluru SCM office revealed that the city has undertaken Integrated Development of the Kadri Park Road in 2 Phases which involved development of concrete roads, shops, food courts, parking spaces seating area and provisions for storm water drainage which is expected to contribute towards reduction in particulate matter concentrations.

5.2 City Visits and Detailed Primary Assessment

5.2.1 Indore:

- Ease Of Living Index 2020: **Score-58.58; Rank- 9** (million+ municipality)
- Municipal Performance Index 2020: **Score- 66.08; Rank- 1** (million+ municipality)
- Swachh Vayu Survekshan 2023 **Rank: 1** (Category 1 cities)
- Field Visit Undertaken on: 8-9th April, 2024

1. Technical Impact Assessment of Smart Solutions for LAQ:

The city has implemented the following initiatives to benefit and improve the local air quality

- **"Clean Air Action Plan"** of the city which proposes innovative Information, Education, and Communication (IEC) campaigns amongst other interventions.
- "**Clean Air Catalyst**" (CAC) is one of a kind program that is being run in Indore for providing technical assistance to Indore Municipal Corporation (IMC), capacity building of citizens and coordination with the stakeholders related to air quality improvements. CAC team comprises of the various agencies such WRI India, EDF, USAID, Vital Strategies etc. The Emission inventory and Source apportionment study of the city are also being done through this program.
- Implementation of the **"*Red Light On—Engine Off*"** campaign to encourage vehicle drivers to turn off ignition when faced with a red traffic signal. "*Red Light On—Engine Off*" is a capacity building activity run by IMC for the awareness among citizen regarding air pollution threats possessed by the vehicular exhaust. The activity has been conducted at multiple squares of the city in a scheduled way through various NGO Volunteers, traffic volunteers etc. with the citizens of the city serving as the target.
- Development of **decentralized green spaces (Ahilya Vans)** throughout the city: a total of 90 Ahilya Vans covering a cumulative area of around 17 hectares have been established so far within the city within which approximately 28916 trees have been planted. Further establishment of 16 Ahilya Vans is being planned under various CSR initiatives. The establishment of Ahilya Vans helped in overcoming the challenge associated with established of green belts which often require large areas of land that are unavailable within city limits. Ahilya Vans solved this problem by undertaking dense forestation in small patches of land within the city.
- Additionally, **the ICCC** is expected to play a major role in monitoring and improvement of local air quality through the modules based on **Intelligent Traffic Management System (ITMS)** and **Indore 311 (Citizen Grievance and Redressal System)** which as indicative from the name is a mobile application accessible to the entire population base of the city easing access to multiple citizen based services and providing a singular platform for registering complaints related to multiple dimensions of public amenities.

ITMS, on the other hand, will integrate traffic, transit, parking, and payment management using ICT elements. It will be integrated with existing and proposed transportation networks/system (BRT, Rail Metro, signals) streamlining traffic and transport management and improving user experience. The Automated Traffic Control Systems (ATCS) having features related to lane monitoring, dynamic messaging boards, web/mobile application for route information and fleet management systems is expected to have a major impact on ambient air quality by route optimization and reduction in fuel emissions.

2. Socio-Economic Impact Assessment of LAQ:

While the city obtained Rank 1 in the 2023 Swachh Vayu Survekshan, it was difficult to ascertain the trend of air quality for the city with respect to particulate and gaseous pollutants since barring the CAAQMS installed at Choti Gwaltoli (which had data available since 2019), the three installed at Residency Area, Regional Park and Maguda Nagar reported data only for 2023 while one installed at Glenmark reported data for 2017 and 2023. Besides, since the ITMS is still in its implementation stages the impact of smart solutions or digital infrastructure on LAQ improvement also cannot be fully ascertained. The city however, has undertaken several campaigns for building citizen awareness regarding the significance of clean ambient air. Besides, given the city's central geographic location, proactive administration, high standards of cleanliness and good performance in various developmental indices (Municipal Performance Index, Ease of Living Index), the city is witnessing increasing infrastructural and industrial expansion. Therefore, devising action plans and strategies that ensure maintenance of clean air quality in the face of rapid development would not benefit citizen health but also serve as an asset in the city's economic development.

3. Environmental Impact Assessment of LAQ:

Clean ambient air with particulate matter concentrations within the CPCB prescribed limits is bound to yield a positive impact on the surrounding city environment. The Ahilya Vans established around the city is a major initiative contributing towards air quality improvement since trees act as natural air filters. Smart Cities-Indore can further contribute in this direction through procurement of monitoring infrastructure that would better quantify air quality in the vicinity of the Ahilya Vans and thereby contribute towards assessing the impact of this project on local environment. Besides, since the city is already ranked one in terms of cleanliness, the administration has already successfully eliminated garbage burning and waste disposal at dumpsites (one of the major point sources of air pollution). Field visit to the city also made it evident that all ongoing construction sites were properly covered to prevent dust from escaping. Besides, since C&D activities are mostly outsourced to private organizations, Indore SPV can play a major role in monitoring ambient environmental conditions (through funding, infrastructure, and skill development) at project sites.

Figure 3: Pictures from the Red Light-On Engine-Off campaign organized to combat air pollution as provided by the Indore Smart city as well as from the visit to one of the several Ahilya Vans established across city to enhance urban green cover.

5.2.2 Lucknow:

- Ease of Living Index 2020: **Score- 55.15; Rank- 26** (million+ municipality)
- Municipal Performance Index 2020: **Score- 44.76; Rank- 33** (million+ municipality)
- Swachh Vayu Survekshan 2023 **Rank: 24** (Category 1 cities)
- Field Visit Undertaken on: 5-6th April, 2024

1. Technical Impact Assessment of Smart Solutions for LAQ:

For mitigating air pollution and improvement of ambient air quality, Lucknow administration has signed an MoU with A-PAG (Air Pollution Action Group) which is implementing the following projects at the city scale using Smart City infrastructure:

- **Dispersed Source Program (DSP)**

DSP focuses on identifying sources that are contributing to Air Pollution as per Source Apportionment Studies (SAS) previously undertaken such as road dust, garbage burning, chronic burning, construction, and demolition activities etc. These sources are identified through a well-defined survey done by surveyors provided by the Lucknow Municipal Corporation (LMC) on daily basis using the **Public Grievance portal (311)** Air pollution Channel, where the raised tickets (complaints) get automatically allotted through ICCC to LMC zonal officials based on their category and jurisdiction area for real time resolution. The DSP program is being managed and monitored by A-PAG PMUs (Project Management Units) with regular review and support from the ULB Director, Municipal Commissioner, Additional Municipal Commissioner and Environment Engineer.

Table 3: Status of Dispersed Source Program (DSP) in terms of the total number of complaints/tickets and their present status. The sub-category refers to the various components under which tickets can be raised. The figures represent the cumulative of the time-period between September, 2022 and April, 2024.

Sub-Category	Assigned	Long Term Project	New / Un-Assigned	Re-Open	Resolved	Submit for Approval	Work in Progress	Grand Total (Total number of complaints)
Barren Land to be Greened			1		2			3
Broken Footpath/ Divider	199	4	5		933	72	14	1227
Burning of Garbage, Plastic, Leaves, Branches etc.	255		19	1	769	49	2	1095
Construction and Demolition Activity Without Safeguards	41		2		253	10		306
Garbage Burning at roadside					1			1
Garbage dumped on public land	2383	2	92	11	6547	463	33	9531
Malba, Bricks, Bori, etc on Dumping Land	2019	15	107	1	6828	1050	148	10168

Sub-Category	Assigned	Long Term Project	New / Un-Assigned	Re-Open	Resolved	Submit for Approval	Work in Progress	Grand Total (Total number of complaints)
Mud/silt sticking on structures on the roadsides/ footpaths/ Dividers	547		31	3	1784	129	9	2503
Overflowing Dustbin	76		4		216	4		300
Pothole	1091	93	20		3248	249	51	4752
Road Dust	2				0			2
Road Dust/ Sand Piled on Roadside	344		111	3	5591	11	4	6064
Unauthorized Parking					9			9
Unpaved road	175	12	1		1015	7	5	1215
Grand Total	**7132**	**126**	**393**	**19**	**27196**	**2044**	**266**	**37176**

Figure 4: Before/After Images depicting various types of issues (A: pothole; B: Unpaved Road; C: Bricks and concrete on public land; D: Garbage dumped on public land) impacting local air quality identified under the DSP initiative of A-PAG and their resolution *(Source: A-PAG)*

- **Monitoring of Recurring / Chronic Air Pollution Issues through Cameras**

A total of 32 PTZ Cameras (installed by Smart City-Lucknow) have been provided to A-PAG and TERI for identification and monitoring of Recurring / Chronic issues leading to air pollution and for their quick and quality resolution. Majority of these installation sites are chronic garbage dumping sites. This essentially leads to the inference that effective solid waste management through improvement in door-to-door collection and segregation efficiency which would ultimately improve waste processing and treatment and lead to long-term reduction in open dumping would have a net positive impact on local air quality.

- **Hotspot Survey and Hyper Local Sources Survey**

Smart city Lucknow through ICCC is monitoring data being generated by a total of 35 environmental sensors installed at various locations across the city of which SCM-Lucknow has installed 5 sensors. An additional six sensors have been installed by the UPPCB (Uttar Pradesh Pollution Control Board) and CPCB. The remaining (24 sensors) have been installed by the LMC (via E&E solutions, private vendor). Both air pollution parameters and hydro-meteorological parameters are monitored by the sensors. Alerts (through mobile application/SMS/e-mails) are raised to concerned authority when the AQI (Air Quality Index) exceeds the prescribed norm at a particular location following which appropriate strategies are deployed to bring down the pollutant levels. Data is being captured at an hourly basis. Additionally, the A-PAG PMU also undertakes periodic surveys with all activities being periodically reported to the LMC for incorporation within the NCAP reporting.

Figure 5: Environmental Sensor as seen during field visit to Lucknow (top panel) and the dashboard prepared by ICCC-Lucknow for Environmental Monitoring (bottom panel)

2. Socio-Economic Impact Assessment of LAQ:

Field visit to the Lucknow ICCC office revealed that the ITMS (comprising of ATCS [Adaptive Traffic Control System], TSS [Traffic Surveillance System] and TES [Traffic Enforcement System]) was fully functional within the city. The A-PAG team is working with ITMS, LMC and Traffic Police department to devise solutions for effectively handling the Traffic decongestion hot spots leveraging ITMS. Effective implementation of these strategies would not only reduce ambient pollution levels but also ease public movement. Besides, ICCC Lucknow has a dedicated module on Environmental Monitoring which is engaged in compiling and analysing data received from various environmental sensors to provide daily and monthly AQI reports at the zonal level. Air monitoring aside, high AQI levels are also being displayed on the VMS (Variable Message Systems) installed at various locations of the city for public information dissemination. Clubbing such initiatives with information/measures on how individual actions can reduce ambient pollution levels as well as necessary safety measures to be adopted during incidences of high particulate concentrations would not only help reduce air pollution levels but also increase citizen awareness and involvement in LAQ improvement.

3. Environmental Impact Assessment of LAQ:

ICCC and ITMS aside, Smart Cities Lucknow has also undertaken projects related to 'Beautification of Park Greens and establishment of Open Gyms' (cost 0.23 crores), 'installation of solar roof top Photovoltaics on 7 government buildings and solar pumps in 5 schools' (cost 2.21 crores) and 'development and renovation of various parks in Lucknow' (cost 0.64 and 0.8 crores). While development/enhancement of urban green spaces within city limits undoubtedly improves local environment it also contributes towards improving air quality. Better quantification of the impact of green spaces on air quality is however needed. Similarly, transition towards renewable energy sources reduces emissions (a major detrimental consequence of conventional energy sources) and thereby improves air quality and surrounding environmental conditions. Furthermore, A-PAG is working with LMC to devise a mechanism to identify, track and monitor the C&D waste across Lucknow for its collection at secondary points and then disposal at C&D processing plant with Smart City Lucknow likely to provide a technological base for its effective implementation. Improved management of C&D waste would yield a positive impact not only on the waste related metrices of the city but also benefit air and environment indicators.

5.2.3 Pune:

- Ease of Living Index 2020: **Score- 66.27; Rank- 2** (million+ municipality)
- Municipal Performance Index 2020: **Score- 58.79; Rank- 5** (million+ municipality)
- Swachh Vayu Survekshan 2023 Rank: 29 (Category 1 cities)
- Field Visit Undertaken on: 10th April, 2024

1. Technical Impact Assessment of Smart Solutions for LAQ:

Most of the projects undertaken by Pune Smart City Development Corporation Limited (PSCDCL), although not directly related to mitigation of air pollution or improvement of LAQ, can yield a positive impact on LAQ. A brief overview of some relevant projects is as follows:

- **ICCC-Smart Elements:** established in 2019 as part of Network of Smart Elements across the Pune city, the components under ICCC particularly relevant to LAQ include Environmental Sensors (air quality monitoring) and VMDs (display of information/awareness related to ambient air quality). Pune City presently comprise of 50 environmental sensors and 161 VMDs installed at various locations for air quality monitoring and information dissemination respectively.
- **Adaptive Traffic Management Systems (ATMS):** Covering a total of 125 junctions across the city, the ATMS envisages to provide smart traffic management solutions to improve the traffic burden on roads by reducing journey time and improving traffic enforcement and traffic related information dissemination.

Table 4: Impact Status of Adaptive Traffic Management System Implementation

Corridor Name	Corridor Length (KM)	Avg. Speed Before ATMS (KPH)	Avg. Speed Post ATMS (KPH)	% Improvement in Speed	% Improvement in Time
Karve to Khandoji Baba -	3.7	20.75	26.19	26.22%	-20.77%
Khandoji Baba to Karve	3.7	22.93	24.38	6.32%	-5.94%
Alka chowk to swargate	2.1	20.11	19.21	-4.47%	4.68%
Swargate to Alka Takees	2.1	20.77	18.72	-9.86%	10.94%
Swargate to Ravidarshan	9.8	27.05	26.92	-0.49%	0.50%
Ravdarshan to swargate	9.8	23.64	24.98	5.66%	-5.36%
Swargate to Katraj Naka	6.1	20.18	23.36	15.78%	-13.63%
Katraj Naka to Swargate	6.1	24.43	25.19	3.12%	-3.03%
Saras Baug to Navsya maruti chowk	2.4	23.65	27.9	17.96%	-15.22%
Navsya Maruti to Saras Baug	2.4	22.62	23.5	3.89%	-3.74%
Alka Chowk to Dandekar Bridge chowk	1.3	22.12	24.02	8.61%	-7.93%
Dandekar Bridge Chowk to Alka Chowk	1.3	22.73	22.8	0.29%	-0.29%
Paud Phata to Lohiya jain IT park-2	4.3	22.42	23.92	6.68%	-6.26%
Lohiya jain IT park-2 to Paud phata	4.3	24.14	26.25	8.73%	-8.03%
AISSMS to Swarget	3.1	19.13	19.41	1.48%	-1.46%
Modern College to Khandoji Baba chowk	1.5	24.91	26.71	7.23%	-6.74%
Khandoji baba to Dyaneshwar paduka Chowk	1.5	21.85	26.88	23.04%	-18.72%
Shivaji Housing society to Athvae Junction	2.7	24.7	26.46	7.13%	-6.65%
Athvae Junction to Shivaji Housing society	2.7	18.67	26.55	42.21%	-29.68%
Shastri Nagar to Keshanand Pata	10.5	20.83	26.71	28.23%	-22.02%
Keshanand Pata to Shastri Nagar	10.5	26.75	28.51	6.56%	-6.16%

As evident implementation of ATMS has resulted in improvement of speed efficiency and reduction of travel journeys in 11 corridors of Pune city. While this gives evidence of the effectiveness of ATMS in improving traffic management, it also contributes towards air quality improvement through fuel reduction which needs to be better quantified.

- **Community Farming:** Located in a prime residential area and focusing on space provision to improve community engagement in activities related to organic farming, the project has designated spaces to accommodate gardening workshops, group sessions and even provides for a vermicomposting area. The project can prove to be an important example of how green spaces and in-situ waste management can co-exist as well as how community engagement in urban farming related activities can improve local air quality.

Figure 6: Images from the Community Farming Project as provided by PSCDCL

- **Environment Park:** The objective behind the park was to provide a space for workshops, public gathering and for installation and demonstration of environment friendly energy generation and reuse of scrap material to create awareness about renewable energy generation and waste recycling. The project commenced in 2019 and spans an area of 1165.34 square kilometres.

Figure 7: Images from the Environment Park as provided by the PSCDCL

- **Tree Plantation in ABD Area:** tree plantation can have direct positive impacts by helping combat air pollution, improving local air quality and reducing urban heat island effect. It can also contribute towards urban biodiversity conservation and stormwater management. As part of the project 12000 saplings were planted in the Aundh, Baner

and Balewadi areas of Pune. Additionally, they also improve the aesthetic appeal of urban areas and improve psychological well-being of residents.

Figure 8: Images for tree plantation in ABD area of Pune as provided by PSCDCL

2. Socio-Economic Impact Assessment of LAQ:

Pune like Lucknow has installed environmental sensors for air quality monitoring and VMDs for information dissemination as part of ICCC. Robust air quality reporting, use of digital technology for trend analysis and future projections from recorded data and utilization of developed insights for awareness building and educating people about the impact of polluted air on health and well-being of individuals can further increase the social relevance of LAQ related projects. PSCDCL has also initiated several projects related to enhancement of citizen engagement and participation. These include the PB+ (Participatory Budget Plus) which is an intervention which aims to digitize the existing Participatory Budgeting mechanism in Pune. The main component of this project is to empower citizens with an input platform for project suggestions with a corresponding database for the Pune Municipal Corporation. The second project is the Digi Pune (PMC CARE 3.0) which aims to act as a two-way communication between the city administration and other stakeholders. Both these projects can potentially include components related to air quality index, monitoring of air pollution and simple measures that can be undertaken at the local scale to help reduce ambient air pollution levels.

3. Environmental Impact Assessment of LAQ:

Since Pune is one of the fast-emerging cities of India, a high population density coupled with a high proportion of floating population along-with expanding city limits, traffic congestions and high volume of ongoing C&D activities are some of the major challenges impacting the LAQ. While the ITMS is functional within the city, its various sub-components could be further trained to assess the impact of reduction in travel times and improvement in speed (attained through ATMS) on reduction in fuel emissions. This would directly help ascertain the environmental impact of smart solutions implemented for traffic management on LAQ improvement. Likewise, improved empirical evidences of the impact (before vs after) of development of urban green spaces on LAQ can improve future funding for such projects which would not only improve the air quality but also improve city aesthetics, create recreational spaces, and likely have a positive impact on citizen's quality of life as well.

5.2.4 Surat:

- Ease Of Living Index 2020: **Score- 61.73; Rank- 5** (million+ municipality)
- Municipal Performance Index 2020: **Score- 60.82; Rank-2** (million+ municipality)
- Swachh Vayu Survekshan 2023 **Rank: 13** (Category 1 cities)
- Field Visit Undertaken on: 12th April, 2024

1. Technical Impact Assessment of Smart Solutions for LAQ:

- **Environmental Sensors:** As part of primary environmental/ air quality monitoring Surat has installed several sensors across the city. Of these, one is a CAAQMS (Science Centre, Surat) while the remaining have been installed by GPCB (Gujarat Pollution Control Board) and are all manual monitoring stations (total 10 in number).
- **Development of Open and Vibrant Public Spaces:** Surat Smart City Development Limited (SSCDL) has been involved in the development of several open spaces detailed below:

Table 5: Details of 'Open and Vibrant Spaces' projects implemented by Surat Smart City

Location	Project Cost	Major Initiatives Undertaken	Area Redeveloped
Improvement in the ABD area	85.99 crores	Installation of signboards (path-finding), advertisement poles, dedicated cycling tracks, road-side plantations	(18.28 kms), Aai Mata Road, Limbayat
Canal Pathway development	51.88 crores	Covering of the open canal to improve aesthetics, promotion of public activities, public engagement	(3 kms), Anuvrat Dwar to Jamnaba Park
VIP Model Road	31.76 crores	Development of sculptures from scrap, installation of dustbins, road-side plantations	(4.85 kms), Vesu
Airport-Iconic Road	14 crores	Installation of digital signboards, city branding, road-side plantations	(2.10 kms), Surat Airport to ONGC Bridge

Figure 9: Vibrant Open Space development by SSCDL (A). improvement in ABD area, (B). VIP model road, (C). Airport Iconic Road and (D). Canal Pathway (Source: Smart City-Surat)

- **Intelligent Transit Management System:** Implemented at a total project cost of 61.67 crores, the ITMS is controlled via the ICCC (SMAC centre). It comprises of several components such as ITMS software module, enterprise management system, helpdesk

solutions as well as ITMS fitments (Passenger Information Systems, GPS trackers) on BRT buses and SMC vehicles.

- **Public Bike Sharing System:** It is a high-quality bicycle based public transport system in which bicycles, stored in a closely spaced network of stations, are made available for short-term shared use. The basic process involves installing multiple bicycle stations at several different key locations. A user checks-out the bicycle from one location, rides to his or her destination, and drops the bicycle to another location. The operators coordinate the redistribution of bicycles and ensure availability of cycles at locations with the highest demand at any given time. The partial pilot project was started in ABD (phase-I) with 25 docking stations with 418 docks and total of 265 fleets of bicycles. In the second phase the was implemented on Surat Dumas Road with 18 docking stations with 204 docks and a total of 135 fleets of bicycles. Phases III and IV of the project had 22 docking stations with 393 docks and total 254 fleets of bicycles and 55 docking stations with 837docks and total 613 fleets of bicycles respectively. Around 1,72,186 users have registered for cycle sharing project and weekly ridership stands at approximately 6000. Additionally, several awareness campaigns to promote non-motorized transport among citizens was also undertaken.

Figure 10: Map showing the location of the 120 docking stations for the PBS system as well as a docking station with bicycles and people using the PBS system *(Source: Smart City-Surat)*

2. Socio-Economic Impact Assessment of LAQ:

The ITMS is playing a major role in traffic management within the city by providing several services. The ITMS software module along with its fitments on the BRT buses, BRT stations and SMC vehicles not only enhances consumer (citizen satisfaction) in terms of public transportation through a robust information display system but also ensures smooth traffic movement through real-time monitoring, data analysis and alert generation in case of violations. Both these factors

contribute towards local air quality improvement by encouraging uptake of public transportation and reducing fuel consumption respectively. Data provided by the Surat Smart City indicates that approximately 2.5 lacs commuters are daily using the public transport services. Likewise, the public bike sharing system is a clean mode of transportation, improves last mile connectivity and can potentially have a positive impact on health of residents in the long-term.

Figure 11: Recreational activities underway at the Canal Pathway Development Project *(Source: Smart City-Surat)*

3. Environmental Impact Assessment of LAQ:

As with the previous case studies, SSCDL also has undertaken several projects related to development of open and vibrant public spaces. While these projects may not directly be linked to mitigation of air pollution, road-side plantations and road-development usually undertaken as part of such projects bear a direct positive impact on LAQ by preventing dust resuspension and reducing particulate concentrations in air. Besides, recreational activities encouraged as part of these projects (the Canal Pathway Development Project) improve nature-human connectedness by motivating people to spend more time outdoors. Clubbing such recreational activities with educating people about necessity of breathing clean air, sources of ambient air pollution and measures through which air pollution can be mitigated could further enhance the relevance of such developmental projects with respect to LAQ improvement and well-being of residents. Besides, issues such as road digging and road sweeping being identified, monitored, and resolved by ICCC as part of Swachhta Monitoring while ensuring city cleanliness also benefits the LAQ.

5.2.5 Cochin:

- Ease of Living Index 2020: **Score- 51.41; Rank- 39** (less than million+ municipality)
- Municipal Performance Index 2020: **Score- 46.85; Rank- 12** (less than million+ municipality)
- Swachh Vayu Survekshan 2023 Rank: *(Rankings assess only NCAP cities)*
- Field Visit Undertaken on: 19-20th April, 2024

5.2.5.1 Technical Impact Assessment of Smart Solutions for LAQ:

Cochin was the only city visited as part of the primary assessment that did not fall under the NCAP which directly indicated the healthy air quality of the city since all parameters being monitored as part of NCAP (RSPM, NO_2 and SO_2) fall within the CPCB prescribed guidelines. While the city is the fastest growing metropolitan region within the state of Kerela with expanding city limits, ongoing construction activities and vehicle population, the city's geography seemingly plays a major role in regulating urban air quality. Additionally, the Cochin Smart Mission Limited (CSML) has also completed several projects which are either directly or indirectly contributing towards improving the urban air quality of the city.

- **Open Spaces and Park Project:** Redeveloping green spaces has been a major initiative of CSML which has direct linkages with improvement in local air by ensuring green pockets throughout the city. Kochi Smart City Proposal (SCP) identifies the rejuvenation the public spaces in the city as strategic intervention for enhancing quality of life. Besides, with objective to increase of green cover by around 5% and reduce carbon footprint, this project emphasizes the need for development of green neighborhoods. The project not only enhances aesthetic and visual character of smart city area, improves tourist footfall (which directly benefits local economy) as well as give evidence of the city's rich culture and heritage values. Around 18 medium and small open spaces are planned to be enhanced as part of the project. The project has been implemented in various phases.
- **Open space DH to Mangalavanam:** The project targeted revitalizing all open/ public spaces, along the western water edge of Ernakulum mainland. As a result, an integrated continuous open space corridor was built between Durbar Hall and Tata Canal along-with upgradation and integration of all the open spaces between Rajendra Maidan and Tata Canal into a corridor. The 2.4 km long reconstructed walkway has 120 granite seats. 201 new LED lights, playgrounds for children and a gym. CCTV cameras have been installed to ensure the safety of people coming to the Marine Drive Walkway. Dustbins have been installed to prevent littering of public spaces. Plants and flowers have been planted as part of beautification.

Figure 12: Before and After Images of the Marine Drive walkway *(Source: CSML)*

Figure 13: Before and After Images of the Vasco Square *(Source: CSML)*

Figure 14: Before and After Images of the Nehru Park *(Source: CSML)*

Figure 15: Before and After Images of the Ro Ro Jetty (Fort Kochi area) *(Source: CSML)*

Figure 16: Before and After Images of the Mattancherry Park *(Source: CSML)*

- **Public Bike Sharing System (PBS):** The project aimed to popularize non-motorised transportation among the citizens of Kochi and was launched in 2019 in a PPP model with CSML and KMRL (Kerela Metro Rail Limited) being the major stakeholders. Around 1000 cycles were procured as part of the project. The project was relaunched in 2021 to improve last-mile connectivity within the city and presently citizens can access around 900 cycles from 46 docking stations including 21 metro stations around the city.

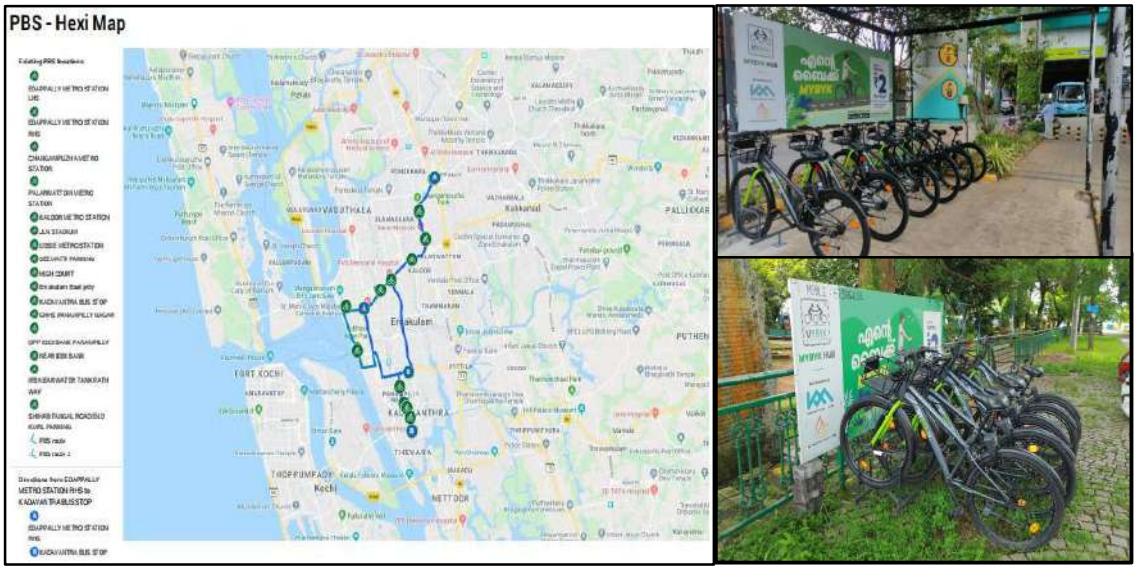

Figure 17: Map showing the location of the 46 docking stations developed under the PBS system and bicycles parked in some of the docking stations (Source: CSML)

- **Roof top solar projects in 28 government buildings:** Roof-top solar plants have been installed in 28 government buildings within the Kochi Corporation limits by CSML (Bharat Heavy Electricals Limited (BHEL) serving as the contractor). These grids connected solar plants having a total capacity of 1Mega Watt (individual capacities ranging between 20-70 kilowatt power) generate around 1.46 million units of green energy annually. The advantages of the project include savings in the electricity bill of the Government establishments by about 10.2 million rupees per year as well as reduction of carbon foot print by almost 1000 tones which is almost equivalent to planting 5400 trees.

2. Socio-Economic Impact Assessment of LAQ:

Cochin's Smart City Proposal (SCP) recognises that development of open green spaces besides improving quality of life also improves tourist footfall thereby benefitting city economy. This evidently reflects that maintenance of the city's green spaces in addition to social recreation would also boost tourism. Interaction with CSML officials also revealed that development of the 'open space corridor' has had positive implications on the local economy also with several local vendors benefitting from increase in tourism and local visitor movement.

Similarly, the PBS initiative as observed previously in the case of Surat city (section 5.2.4.1) is a good example of how promotion of non-motorised modes of transportation can not only improve ambient air conditions but also contribute towards citizen health and well-being. CSML can further undertake citizen awareness campaigns to popularize the uptake of the PBS.

Figure 18: Roof top solar panels on Government Buildings *(Source: CSML)*

3. Environmental Impact Assessment of LAQ:

The roof-top solar panel project serves as an excellent example of how Cochin is generating renewable energy and contributing to the state's vision of achieving 2500 Mega Watt solar capacity by 2030. Besides, uptake and promotion of renewable energy has direct positive consequences on the ambient air quality as it helps in emission reduction from utilisation of conventional sources of energy. Other advantages of the project include reduction in ambient noise pollution levels since solar power generation does not produce noise, removal of harmful by-products produced through use of conventional fuels and economic savings through reduced usage of electricity generated from coal burning. Additionally, the role of IC4 (Integrated Command, Control and Communication Centre) can be further upscaled to identify and timely mitigate point sources of air pollution (localized burning incidents, traffic congestions, open garbage burning etc.) within the city through regular monitoring and surveillance.

6. Study Outcome and Conclusions

The study attempts to undertake a sustainability impact assessment of smart cities in India with respect to improvement in local air quality based on survey responses from and field visit to smart cities. Overall, it was concluded that several SCM medicated projects (such as development of green spaces, improvement in traffic management, enhancement of solar energy and installation of environmental sensors) are contributing towards the cause of local air quality improvement. However, future projects can be further streamlined to improve SCM's contribution in urban air pollution mitigation.

6.1.1 Major Observations from National Assessment:

A major observation following analysis of responses received from all Smart Cities was that project implementation and data availability related to 'LAQ Improvement' was still limited. Besides, enhancement of urban green spaces was the most common focus area through which SCM was contributing towards LAQ Improvement. Therefore, to further increase the relevance of urban greening projects it is recommended that selection of trees for plantation should be based on local environmental conditions and their ability to purify air (phytoremediation potential, dust absorption capacity etc.). This would further improve the significance of urban green projects. City SPVs can also undertake training and skill development programs for improved analysis, interpretation and utilisation of data being generated through environmental sensors and traffic management modules for mitigation of air pollution.

6.1.2 Major Observations from Field Visits:

Primary assessment (field visits) undertaken as part of the present impact assessment study further revealed that of the five cities surveyed, Lucknow was the only city whose SPV via ICCC, was contributing towards mitigation of air pollution related episodes by providing digital infrastructure to A-PAG. The other cities SPVs were mostly contributing through development of green spaces, promotion of non-motorised transport systems, enhancement of renewable energy uptake and through environmental monitoring (monitoring of common ambient air pollutants). Indore, furthermore has undertaken awareness building campaigns among citizens related to fuel saving and emission reduction while waiting at crossings. Therefore, a major conclusion from the primary assessment was that several projects being implemented under the SCM by various cities contribute towards 'air quality improvement', however, their impact needs to be better quantified. Furthermore, utilization of SCM funds for 'air pollution mitigation' can be further improved.

6.2 Recommendations and Policy Directives:

Field visits as part of Primary Assessment revealed since smart cities involvement in air quality improvement is mostly through indirect projects, any specific innovative project/smart solution that can be highlighted as a 'best practice' with potential to be replicated by other cities remains unavailable. A major reason behind this is that **'improvement of local air quality'** has not been

included as a direct vertical within the focus areas of Smart Cities in the SCM guidelines. Therefore, some key recommendations and future directions include:

First, an amendment to the guidelines resulting in inclusion of this aspect would significantly influence SPVs in proposing projects and opening tenders directly related to abatement of air pollution and improvement of local air quality.

Second, air quality improvement like solid waste management is a pan-city initiative with most of the SPVs limiting their civil and developmental works to the ABD areas while pan-city projects are mostly related to city surveillance and easing access of public services using digital infrastructure (ICCC). Therefore, it is suggested that greater weightage be given to proposals submitted by cities in future that incorporate pan-city developmental projects and focus on LAQ improvement.

Third, while air monitoring especially in the non-attainment cities has improved owing to implementation of the NCAP, analysis of the data being generated in order to gauge major trends related to air pollutants with respect to diurnal and seasonal temperature changes, meteorological variations and geographic differences, identification of minor and major sources of air pollution at the local scale as well as impact of indirect projects (city greening, promotion of public transportation and non-motorized transportation, increase of renewable energy uptake and traffic decongestion efforts through ITMS) on local air quality is still lacking. This serves as another potential area where city SPVs can contribute by building data analysis centres dedicated to analysis of voluminous data being generated via the ICCC and training personnel for the same.

Fourth, city SPVs can facilitate academic-industry-administrative collaborations (PPP projects) with focus on air quality improvement and air pollution mitigation with academic institutions providing the much needed scientific background through gap analysis and causes of air pollution at the city-scale, industrial stakeholders providing the technical infrastructure and the city administration (municipal corporations) providing funding, manpower and physical space for project implementation. Furthermore, academic institutions can also help with analysis of data generated through project implementation.

Lastly, making citizens aware of their rights and responsibilities as far as access to clean air is concerned can prove to be a key determinant in improving urban air quality. Air unlike water, electricity and housing is perceived as a free resource therefore provisions related to maintenance of ambient air quality standards are often ignored when it comes to development of new or renovation of existing residential and commercial units. Smart Cities SPVs can therefore plan and implement extensive awareness campaigns for attaining a behavioural change among city residents and making them aware of their right to clean air. Once citizens can perceive the impact of clean air on health and life longevity and start demanding presence of clean air in their vicinity, upcoming residential and commercial projects would be bound to monitor and report emissions associated with their projects in a more robust manner.

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Annexure I

Details of Projects related to Local Air Quality Improvement:

1. "Clean Air Action Plan", of the city which proposes innovative Information, Education, and Communication (IEC) campaigns amongst other interventions.
    - "Clean Air Catalyst" is one of a kind program that is being run in Indore providing technical assistance to Indore municipal corporation, capacity building of citizens and coordination with the stakeholders related to air quality improvements.
    - CAC team comprises of the various agencies such WRI India, EDF, USAID, Vital Strategies etc.
    - The Emission inventory and Source apportionment study of the city are also being done through this program.

2. Implementation of the "*Red Light On—Engine Off*" campaign to encourage vehicle drivers to turn off ignition when faced with a red traffic signal.

- "*Red Light On—Engine Off*" is a capacity building activity run by IMC for the awareness among citizen regarding air pollution threats possessed by the vehicular exhaust.
- The activity is done at multiple squares of the city in a scheduled way through various NGO Volunteers, traffic volunteers etc.
- Target Audience are the citizens of the city.
- Photographs are attached.

3. Details related to smart roads, improvement in mobility infrastructure (footpaths and cycle tracks) as well as development of decentralized green spaces (Ahilya Vans) throughout the city.

Ahilya Vans: -

- There is a total of 90 Ahilya Vans established so far.
- The area covered by the Ahilya van is around 17 hectares.
- Around 28916 number of trees are being planted.
- Around 16 ahilya van are being established from CSR initiative.

Annexure II

Overview of A-PAG's work provided via email

As per our MoU (Air Pollution Action group) with ULB Directorate & MoEFCC in Uttar Pradesh, We are working for Mitigation of Air Pollution and Improvement of AQI in NACs,

In Lucknow to address the **local air pollution sources, for its Mitigation and Improvement** of AQI - following projects are being implemented leveraging Smart city Infrastructure,

Dispersed Source Program (DSP)

- DSP focuses on identifying sources that are contributing to Air quality as per Source Apportionment Study (SAS) like Dust, Road Dust, Garbage burning, Chronic burning, Construction & Demolition activities etc.
- These Sources are identified through a well-defined survey done by Surveyors provided by Nagar Nigam Lucknow on daily basis using **Public Grievance portal (311)** Air pollution Channel, where the raised tickets get automatically allotted through smart city (ICCC) to Nagar Nigam zonal officials of that geography as per their category for real time resolution and monitoring.
- This DSP program is managed & monitored by A-PAG PMU, regular review and support by ULB Director Sir, Municipal Commissioner sir, Additional Municipal Commissioner sir and Environment Engineer Sir ensures the resolution of tickets and engagement of officials for the same.
- PFA, Status of DSP , Category wise Status. **(Data shared is cumulative data of DSP - Sept 2022 - April 2024).**

Monitoring of Recurring / chronic sites through Cameras

- **32 PTZ Cameras** were provided by **A-PAG and TERI** for monitoring of Recurring / Chronic issues for quick and quality resolution.
- Cameras were Installed by Smart city Lucknow in the identified locations and are functional , PFA the details of the sites.

Hotspot Survey and Hyper Local Sources Survey

- Smart city Lucknow has integrated **06 CAAQMS** data and **05 Environment Monitoring System Installed by Smart city Lucknow** (EMS) and **24 EMS (E & E solutions**, where AQI data is being regularly monitored, areas where there is high AQI (hotspot and hyperlocal source survey are being conducted to identify the sources and resolve them).
- These surveys are conducted and monitored by A-PAG PMU for effective identification and resolution of issues.
- These activities are also reported by Nagar Nigam Lucknow periodically as part of **PRANA, NCAP reporting.**

Other Projects in pipe line for Implementation -

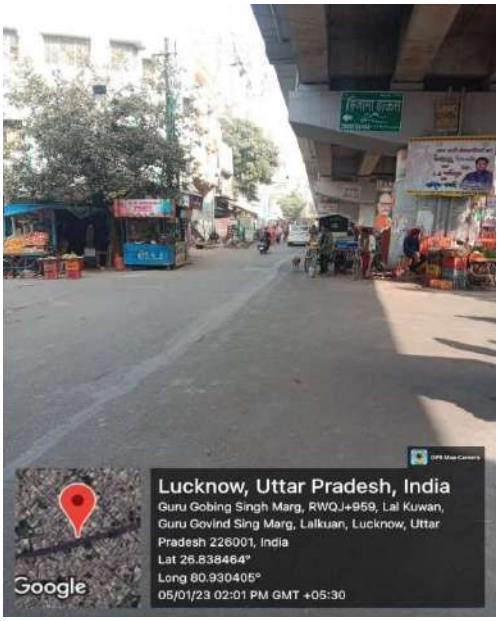
- **Traffic Decongestion** - A-PAG team is working with **ITMS (Integrated Traffic management system)** in Smart city , Nagar Nigam and traffic police to devise solutions for effectively handling the Traffic decongestion hot spots leveraging ITMS.

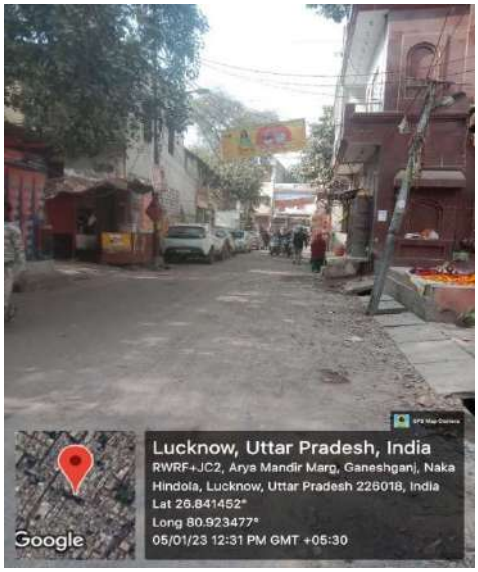
- **C&D waste management -** A-PAG team is working with Nigam Nigam Lucknow to devise a mechanism to **identify, track and monitor** the C&D waste across Lucknow for its collection at Secondary points and then disposal at C&D processing plant, Smart city Lucknow will provide a technological base for its effective implementation.

Annexure III

Before and After Photos Lucknow:

BEFORE (Unpaved road)	AFTER(Resolved)
	

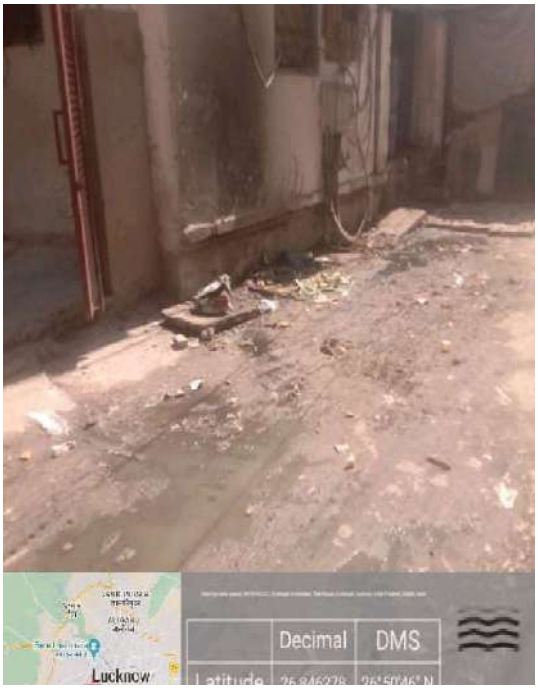
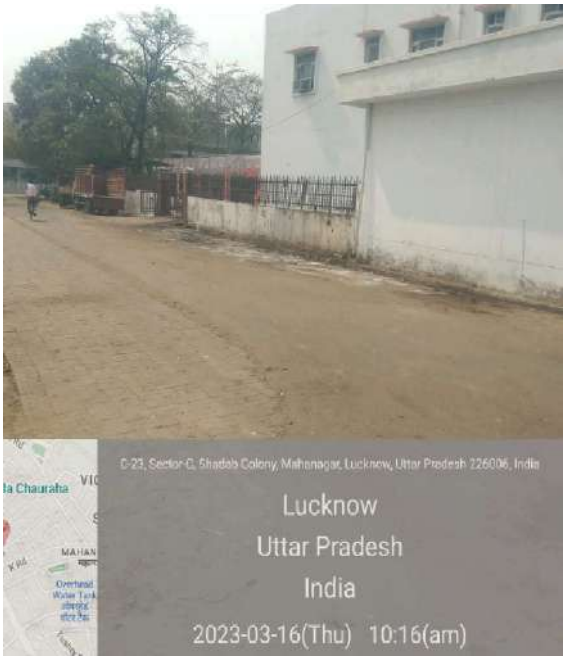
BEFORE (Pothole)	AFTER(Resolved)
	

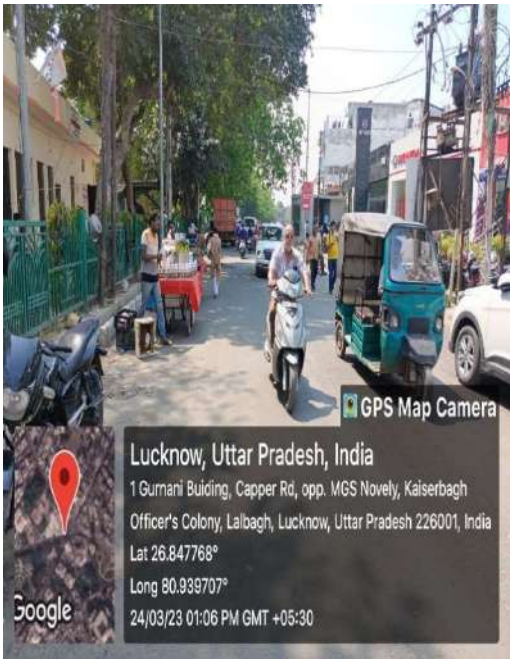
BEFORE (Pothole)	AFTER(Resolved)
	

BEFORE (Pothole)	AFTER(Resolved)
	

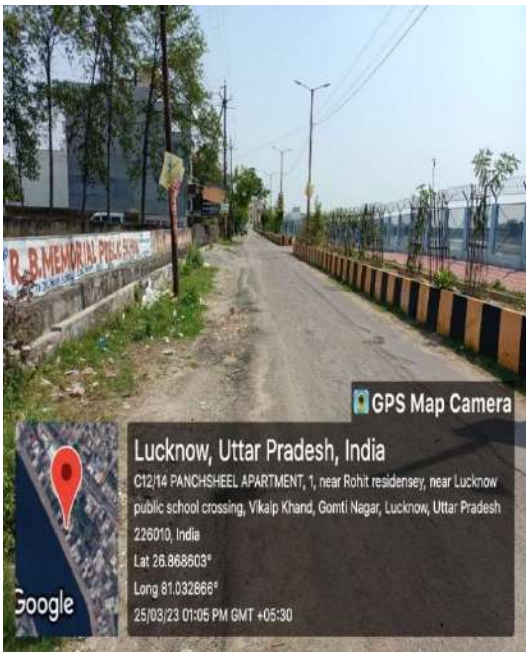
BEFORE (Malba, Bricks, Bori etc on public land)	**AFTER(Resolved)**
	

BEFORE (Malba, Bricks, Bori etc on public land)	**AFTER(Resolved)**
	

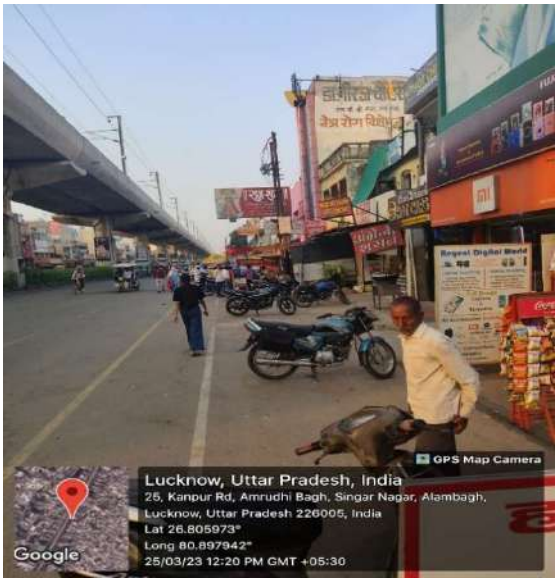
BEFORE (Malba, Bricks, Bori etc on public land)	AFTER(Resolved)
	
BEFORE (Garbage dumped on public land)	**AFTER(Resolved)**
	

BEFORE (Malba, Bricks, Bori etc on public land)	AFTER(Resolved)
	

BEFORE	AFTER(Resolved)
	

BEFORE (Garbage dumped on public land)	AFTER(Resolved)
	

BEFORE (Malba, Bricks, Bori etc on public land)	AFTER(Resolved)
	

BEFORE (Malba, Bricks, Bori, etc dumped on public land)	AFTER(Resolved)
	

Annexure IV

DSP Status- Sept 2022 – April 2024, Lucknow

Sub-Category	Assigned	Long Term Project	New / Un-Assigned	Re-Open	Resolved	Submit for Approval	Work in Progress	Grand Total
Barren Land to be Greened			1		2			3
Broken Footpath/ Divider	199	4	5		933	72	14	1227
Burning of Garbage, Plastic, Leaves, Branches etc.	255		19	1	769	49	2	1095
Construction and Demolition Activity Without Safeguards	41		2		253	10		306
Garbage Burning at roadside					1			1
Garbage dumped on public land	2383	2	92	11	6547	463	33	9531
Malba, Bricks, Bori, etc on Dumping Land	2019	15	107	1	6828	1050	148	10168
Mud/silt sticking on structures on the roadsides/footpaths/Dividers	547		31	3	1784	129	9	2503
Overflowing Dustbin	76		4		216	4		300
Pothole	1091	93	20		3248	249	51	4752
Road Dust	2				0			2
Road Dust/Sand Piled on Roadside	344		111	3	5591	11	4	6064
Unauthorized Parking					9			9
Unpaved road	175	12	1		1015	7	5	1215
Grand Total	**7132**	**126**	**393**	**19**	**27196**	**2044**	**266**	**37176**

Annexure V

Camera Installation Sites

Locations Identified	Site Specification
Corner of Road, Near Mahesh Mattar, Garhi Kanaura, Talkatora	Industrial
Public Garden, Garhi Kanaura, Talkatora (Water tank)	Industrial
Khinni wala maidan, Talkatora (Near CAAQMS)	Industrial
Vivekanandapuri Hydel Colony, Nirala Nagar, Lucknow, 226020	Dumping area
MRF Site, Purania, Lucknow	Dumping area
ICCC, Lalbagh	Dumping area/Burning site
Near Engineering College Chauraha, Near Domino's pizza, Sector B, Jankipuram, Lucknow 226021	Dumping area
Sector-F, Jankipuram, Lucknow, 226021	Dumping area
Naya Khera, jankipuram Extention, Lucknow, 226031 (Near CDRI)	Dumping/Burning
Transfer Station, Engineering Chauraha	Dumping area
Gwari, Vikas Khnad, Lucknow, 226010	Dumping area
Gauri Goan, Model Shop, Vikram Khand, Lucknow, 226010	Dumping area
Near Lekhraj Metro Station,	Chronic Burning site
Sanjay Gandhi Puram, Lucknow, 226010	Dumping area
Front of Mahesh Mattar Namkeen Factory, at corner of Road, Nadarganj	Industrial
Near Syan Farm House, at corner, Amausi Station Road, Nadarganj	Industrial
Badli Kheda Bagh No, Near Rameshwari Public School, Sindhunagar, Lucknow	Dumping area
Near PN International Unit 2, Gagauli, Nadarganj	Industrial
Transfer Station Nagar, Krishna Nagar	Dumping
Ghaila ghat	Chronic Burning site
M.C Saxena College Mode, Dubbga Dumping Site, Lucknow, 226003	Dumping site
Dump Site, Thakurganj	Dumping site
H-Park, Mahanagar	Dumping site
Dump Site, Khudra	Dumping site
Bansmandi Chauraha	Dumping site
Opposite BBD University, Near Primary School, Faizabad road, Lucknow	Chronic Burning site
Polytechnc Flyover, Lucknow, 226016	Dumping/Chronic burning site
Indira Nagar road, S-22, Lucknow, 226016	Chronic Burning site
W389+24C, Chihat	Industrial
Dhawa, W359+RX5, UPSIDC industrial Area, Dhawa, Chinhat	Industrial
Eldeco Udyan II, Mohanlalganj, Lucknow, 226014	Dumping areaa
R & R Center, Lucknow	Dumping/ Burning site

Annexure VI

Cochin-Projects Overview

Open space DH to Mangalavanam

Aiming at revitalizing all the open/ public spaces, along the western water edge of Ernakulum mainland, by improving the accessibility, introducing various activities and linking the same with each other to create an active corridor for recreational facilities, CSML proposes an integrated continuous open space corridor between Durbar Hall on south of the corridor up till Tata Canal, to the north of the corridor. The project is conceived to upgrade and integrate all the open spaces between Rajendra Maidan and Tata Canal into an open space corridor as public space. The proposed project shall ensure to provide a variety of attractions and recreational activities for all walks of people and thereby transform the area into one of the most visited areas of the city.

The 2.4 km long reconstructed walkway has 120 granite seats. 201 new LED lights enhanced the night views of the Marine Drive walkway. Playgrounds for children and a gym in the common area have been constructed as part of the project. CCTV cameras are being installed as part of the Intelligent City Surveillance System project to ensure the safety of people coming to the Marine Drive Walkway. Dustbins have been installed to prevent littering of public spaces. CSML has also planned to install more dustbins realizing the need in the area. Plants and flowers have been planted as part of beautification. The project cost is Rs.9.52cr

Roof top solar projects in 28 government buildings

Roof top solar plants are installed in 28 government buildings within the Kochi Corporation limits by Cochin Smart Mission Limited. These grids connected solar plants with total capacity of 1Mega Watt will be generating 1.46 million units of green energy in a year. Apart from savings in electricity bill of the Govt. establishments by about 10.2 million rupees per year, the solar plants will assist in reduction of carbon foot print by 1000 tones. This is equivalent to planting 5400 trees. 1Mega Watt (1000kW) roof top solar power project installed by Cochin Smart Mission Ltd is also an excellent example of how a city can generate renewable energy and contribute to the state's vision of achieving 2500Mega Watt solar capacity by 2030. The project cost is Rs.5.80 cr.

Development of Open Spaces, Playgrounds and Museum of Freedom Struggle in West Kochi

Major interventions of the Parks & Playground project include surface paving, landscaping and providing street furniture (such as benches, stone pergola, & post top light), fixing of play equipment, gym equipment, solar panel system, solar tree & repairing/constructing storm water drainage trenches etc. in 4 parks in West Kochi. The project also envisages conceptualisation, design and development of a Museum of Freedom Struggle in the old Fort Kochi Jail premises. The project cost is Rs.4.07cr. The project includes Pattalam ground, T M Muhammad Park, Karipplaam ground,

Distribution of household bins and street litter bins

The project is intended to maintain the efficiency of segregation originating from households & public places by one-time distribution of a pair of green bins for wet waste and blue bin for dry waste of 15 litres capacity each to every household. Approx. 40, 000 bins have been supplied and 37, 000 disturbed to the residents. The project cost is Rs.0.61cr

Public Bike Sharing

To promote non-motorized transport in Kochi City CSML and KMRL together had launched the Public Bicycle Share System in the year 2019 as a PPP model which included 1000 cycles as part of the project. In order to support public in commuting in current conditions the PBS project has been reinitiated jointly by KMRL and CSML to address the problem of first and last-mile connectivity faced by the citizens. In the year 2021 Cochin Smart Mission Limited and Kochi Metro Rail Limited re launched the PBS system in the Kochi. The citizens can now access 900 cycles from 46 docking stations including 21 metro stations around the city. The project cost is Rs.1.21 cr.

Smart Bus shelter

The Cochin Smart Mission Limited (CSML), as part of its efforts to make the city's roads smart, is all set to build smart bus shelters to aid commuters in the city. As part of the first phase, two bus shelters have been constructed at Abraham Madamakkal (AM). The total cost of the shelters is Rs 0.19 cr. The new bus shelters are greener, cleaner, and smarter and the solar-powered bus shelter also have facilities such as an SOS alert switch, charging points, waste bins and CCTV surveillance for enhanced safety.

Implementation of Smart LED Lights

Cochin Smart Mission Limited (CSML) intends to replace existing conventional lights on streetlights and lighting Masts with intelligent LED streetlights with light poles having smart controls. Substantial energy saving can be achieved by replacing the conventional lighting with LED lighting. LED modules have very long life running as high as 50,000 hours, hence by installing LED based lights there is a good scope of reducing maintenance cost. The project cost is of Rs 23.93 Crore. Under this project, CSML has installed 3000 LED lights in the ABD area which helps to reduce the electricity usage and charges to the Kochi Municipal Corporation.

Development of parks and open spaces package: 2

Under this project CSML is developing Pared ground, Ro Ro Jetty, Subhash Park, and open space at Church road and river road. The major components are landscaping, sculptures, ornamental light, Play equipment and heritage architecture will be provided as per the site requirement. The project cost is Rs. 8.80cr.

Development of parks and open spaces package: 4

Under this project CSML is developing Rajendra Maidan, Marine Drive balance work, High Court Junction development, Vanchi Square are the open spaces. The major components are landscaping, sculptures, ornamental light, Play equipment and new toilet block will be provided as per the site requirement. The project cost is Rs. 4.90 cr.

Development of P J Antony Cultural Centre and Ground.

Under this project CSML is widening the entrance gate, providing rest room facilities, gym equipments, drains, children's play area, new walkways, football and net ball ground. The project cost is Rs. 5. 90 cr.

Supply Operation & Maintenance of Truck mounted Sweeping machine

Cochin Smart Mission Limited has launched a pair of truck-mounted sweeping machines, with an amount of ₹10.98 crore Smart Cities Mission funds to clean roads. The machines that can clean up to 8 km in an hour and each of the 6,000-litre capacity machines can store 1,800 litres of water that can be sprinkled on roads to prevent the emanation of dust when the cleaning process is on. The machines come with a five-year operation and maintenance contract. They can be tracked using GPS and also have a pair of CCTVs. The machines would initially be deployed to cover 35 km of roads in the Kochi Municipal Area under the first phase of the project, mostly during night hours

Pan City Smart LED

In a move to brighten up city roads and reduce energy consumption, Cochin Smart Mission Ltd (CSML) is installing 40,400 LED streetlights by June 2024. The project, implemented at a cost of Rs 40 crore in the corporation limits, will help the local body lower its electricity bill to a large extent and provide well-lit streets.

On a pilot basis, CSML has installed LED lights at five locations: Vyttila area, Cochin Shipyard Road, MG Road, Venduruthy bridge, and South over bridge. A total of 2,000 smart meters will be installed as part of the project, and the lights can be monitored at the Integrated Command, Control and Communication Centre (IC-4). They can be operated remotely. As a result of real-time monitoring, IC-4 can identify the malfunctioning lights and replaced within 48 hours. The new LED lights will come up on 2,263 local roads, 102 major roads, 223 minor roads, three state highways, and three national highways. A total of 773km of road will be illuminated under the project. These lights will reduce the monthly electricity bill to Rs 29 lakh, from the previous Rs 1 crore. Apart from that, the corporation can save Rs 2.5 crore in maintenance expenses over the first five years. Based on that calculation, the corporation will be able to save Rs 11.5 crore a year. This will help reduce the financial burden on the corporation. The agreement was signed in November 2023, and the project must be completed within seven months.

Annexure VII

CSML PROJECTS

Open Space and park project

Kochi Smart City Proposal (SCP) identifies the rejuvenation the public spaces in the city as strategic intervention for enhancing quality of life. Besides, with objective to increase of green cover by around 5% and reduce carbon footprint, the project emphasises the need for development of green neighbourhoods. The proposal enhances aesthetic and visual character of smart city area, tourist appeal as well as its rich culture and heritage values. Similarly, the project works on integrating Green-blue network. Around 18 medium and small open spaces are planned to be enhanced as a part of the project.

Rajendra Maidan

https://maps.app.goo.gl/xwHJqitHpcUZK9a66

Marine Drive Walkway

https://maps.app.goo.gl/J1Q1LH1mq7LQKKnM6

Subash Park

https://maps.app.goo.gl/MgUG3mpBHLkSxibD8

DH Ground

https://maps.app.goo.gl/pQZVjHLf1NTs41kR6

PJ Antony Cultural Ground

https://maps.app.goo.gl/DkotTouLiSii7D5d7

Vasco Square Development

Near Fort Kochi beach

Open Spaces Near St.Francis Church https://maps.app.goo.gl/WwEfjv3mzJxyJn7B7

Nehru Park

https://maps.app.goo.gl/9Ju4DpVZC9dsF56R8

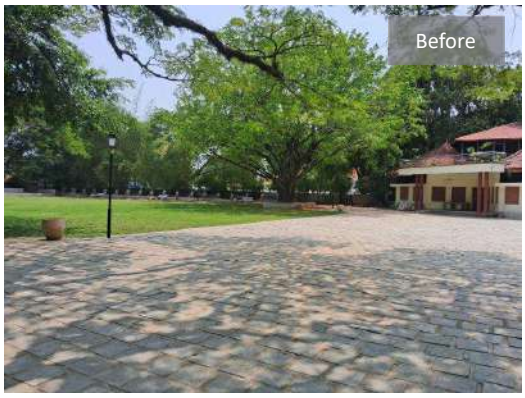
Area near Revenue office

https://maps.app.goo.gl/9iHRFVk7YosczBCt8

Parade ground

Mattanchery Park

Pallathu Raman Ground



RoRo Jetty, Fort Kochi

Annexure VIII

INTEGRATED DEVELOPMENT OF KADRI PARK ROAD Mangaluru

The development proposal is to provide additional facilities of user amenities, beautification, organized parking and shopping and eateries to the users in this strategic road between the two parks and add value to the already existing popular parks. It is seen that there are few private properties on this road and the NH which runs parallel to this road provides a convenient alternative route for users of this road. All these factors have influenced the proposal.

PHASE - 1 :-

The **PHASE 1** i.e. Integrated Development of Kadri Park Road in Kadri, Mangaluru (Phase 1) has the estimated amount of Rs.12,00,00,000/-. This includes infrastructure works like:-

1. Concrete road – 860 Rmt
2. Construction of shops – 38 No's
3. Food courts – 5 No's
4. Plaza areas
5. Parking for bus, four wheelers, two wheelers and cycles,
6. Storm water drain,
7. Shaded seating area etc.

The approach road to the circuit house is also developed under this Phase as it is a prime junction with various Dignitaries and Government officials visiting Circuit House for official work and this also serves as a major link between city and the National Highway 66.

This phase also includes special provisional items like:-

1. precast benches,
2. spheres,
3. food court seating,
4. tensile roofs for shade in plazas,
5. dustbins,
6. Facility signage's etc.

Parking:

Type	West Plaza (Nos.)	East Plaza(Nos.)	Total(Nos.)
Cycle parking	35	00	**35**
Two-wheeler	75	100	**175**
Four-wheeler	19	112	**131**
Bus parking	04	05	**09**

PHASE - 2:-

Works of landscaping (softscaping and hardscape),works of providing irrigation system, Electrical works of electrical HT yard, Panel Boards, meters for shops and wiring, Street lighting and plaza lighting form the scope of **PHASE-2** for an estimated amount of Rs. 4,50,00,000/-.

Annexure IX

Additional files from Pune, Surat, Kochi and Mangaluru received as from city teams for purpose of the study:

Pune

1. Pune Smart City IT Projects (pdf file).
2. Placemaking Projects by PSCDCL (Pune Smart City Development Corporation Limited) (ppt file).

Surat

1. Vibrant Public Places (pdf file)
2. Additional Information ICCC (pdf file)
3. Public Bike Sharing (PBS) System (pdf file)
4. Smart Traffic Management System (pdf file)
5. Environmental Sensors (pdf file)

Cochin

1. Project Details

Mangalore

1. ICCC write-up