ENHANCING URBAN MOBILITY:
AN ASSESSMENT OF PUBLIC TRANSPORT INFRASTRUCTURE IN INDIAN SMART CITIES

A report by

INDIAN INSTITUTE OF TECHNOLOGY BHILAI

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FOREWORD

Urban mobility is more than just the movement of people and goods—it is the lifeblood of our cities, directly influencing economic productivity, environmental sustainability, and quality of life. It is with great pride that I present this report, "Enhancing Urban Mobility: An Assessment Of Public Transport Infrastructure In Indian Cities Under The Smart City Mission." As both a researcher as well as a user of urban transportation systems and infrastructure, I have long recognized that a robust, efficient transport network is critical for driving inclusive development in India's rapidly urbanizing landscape. The Smart City Mission in India endeavours to do just that.

The Smart City Mission in India represents a bold commitment to reimagining urban spaces, and the insights presented in this report provide a critical evidence base for policymakers, urban planners, and all stakeholders invested in sustainable urban development. Employing an ethnographic approach, this study delves deep into the lived experiences of urban residents in five diverse cities—Raipur (Chhattisgarh), Guwahati (Assam), Itanagar (Arunachal Pradesh), Jammu (Jammu & Kashmir), and Aurangabad (Maharashtra)—offering a nuanced understanding of how strategic public transport interventions can transform daily life. Each of these cities differed in their geography and needs and hence presented us with insights about their unique requirements. Our research combines immersive fieldwork with comprehensive stakeholder engagement, revealing the multifaceted benefits of improved mobility: reduced congestion, enhanced accessibility, and significant environmental gains.

At the same time our report covers an analysis of Public Transport Infrastructure for 100 smart cities from which quantitative data was collected. Many of the notable projects included were the introduction of e-buses, construction of smart bus stops and terminals, bicycle sharing system, smart road projects, multilevel car parking, and street lighting to name a few. These improvements not only foster economic opportunities but also promote social equity and safety of all citizens by ensuring that people have access to essential services and opportunities.

Importantly, some of the takeaways from the report include recommendations and policy implications can provide direction for future action. I am confident that the lessons drawn from this study will inspire further innovation and collaboration, paving the way for cities that are not only technologically advanced but also truly responsive to the needs of their citizens.

I would like to congratulate the Smart City Mission for such a timely endeavour and thank them for giving me and my team this opportunity to contribute to the growth of the nation.

Dr Anindita Ghosh,
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20 March 2025

FOREWORD

As one of the Principal Investigators of the SAAR-Sameeksha project from Indian Institute of Technology Bhilai, I take pride in successfully completing this mission on impact assessment of public transport infrastructure development under the Smart Cities Mission. This project has been a significant undertaking for our team, and we are deeply committed to contributing to the advancement of sustainable and inclusive urban development in India. The development of efficient public transport systems is crucial to achieving this goal, and we are proud to have partnered with the Ministry of Housing and Urban Affairs on this important initiative.

Our team has invested considerable effort in conducting a rigorous assessment, utilizing both secondary data analysis from all 100 smart cities and primary assessments conducted in selected cities across diverse geographical regions. This meticulous fieldwork, including site visits, stakeholder interactions, and detailed data collection, has enabled us to thoroughly evaluate the implemented PTI projects and their impact on urban mobility, accessibility, and the overall quality of life. This report not only highlights the successes of the mission but also addresses the challenges encountered, providing valuable insights for future urban planning and development initiatives.

Furthermore, recognizing the importance of disseminating knowledge and fostering further research in this critical area, we are pleased to note that this report will be made available for public access. We believe it will serve as an important reference document for researchers working on urban development and transportation studies. The comprehensive data, detailed case studies, and analytical insights contained within this report can provide a valuable resource for academics, policymakers, and practitioners seeking to understand and improve urban transport systems.

We are confident that the findings and recommendations presented in this report will serve as a valuable resource for the Ministry of Housing and Urban Affairs in shaping policy decisions and promoting best practices in public transport infrastructure development. We believe this collaborative effort will contribute significantly to the realization of India's vision for smart and sustainable cities.

Dr. Jose Immanuel R.
Principal Investigator

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This report represents the culmination of a collaborative effort involving numerous individuals and organizations. First and foremost, we would like to express our sincere gratitude to the Ministry of Housing and Urban Affairs (MoHUA), Government of India, for their support and guidance throughout the SAAR-Sameeksha project. Their commitment to fostering collaboration between academia and government has been instrumental in the success of this assessment. Special thanks to Mr. Dinesh Harode and Mr. Chaitanya Singh for their timely help whenever we reach out to them.

Special thanks are also due to the efficient team at the IIT Bhilai Travel Desk, for their seamless logistical support, which facilitated our extensive fieldwork across multiple cities. Their meticulous planning and execution ensured the smooth conduct of our site visits and data collection activities.

We are immensely grateful to the officials and stakeholders in the smart cities of Aurangabad, Guwahati, Raipur, Jammu, and Itanagar for their cooperation and support during our primary assessments. Their willingness to share insights and provide access to project sites was crucial to the depth and accuracy of our findings. Especially, we would like to thank the following individuals and departments for their valuable support without which our primary assessment would not be possible:

- **Aurangabad smart city:** Mr. Arun Shinde (Additional CEO), Mr. Sanjay Supekar (Chief operation Manager), Ms. Sneha Bakshi (Project manager), Mr. Faiz Ali (Project manager), Mr. Vilas Katkar (Asst. Manager -O&M), and Mr. Pramod Deshmuk (Asst. Manager -O)

- **Guwahati smart city:** Mr.Lakshmanan (CEO), Mr. Chinmoy Prakash Phookan (Joint Secretary Transport Department), Ms. Dipshikha Saikia Administrative Officer), Mr. Nitesh Kumar (Junior Manager-Civil)

- **Itanagar smart city**: Mr. Sonkoli Sonam (EE), Mr. Giluk Belo (AE), Mr. Marpek Riram (AE), Mr. Sonbir Nabam (JE), Mr. Smith Taba (JE), Mr. Bulyu Talu (Office Assistant)

- **Jammu smart city:** Mr. Devansh Yadav (CEO), and Mr. Rakesh Kumar Gupta (Addl CEO)
- **Raipur smart city:** Mr. Shubham Tiwari (Assistant Manager), Mr. Md Imran Khan (Manager), Mr. Saransh Dubey (PMC)

Finally, we would like to acknowledge the residents and commuters of the surveyed smart cities, whose participation in our stakeholder interactions provided invaluable perspectives on the impact of the implemented public transport infrastructure projects. Their feedback and experiences have been essential in shaping the conclusions and recommendations presented in this report.

Dr. Anindita Ghosh & Dr. Jose Immanuel R.

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Executive Summary

Urbanization is a major driver for developing the Indian Economy, contributing to 60% of the Gross Domestic Product (GDP). The urban future of India depends on various challenges and impactful opportunities that require a lot of developmental sustainable planning strategies. The United Nations (UN) predicts that India's population growth up to 2030 will add 164 million people to the urban regions. The government of India has launched numerous missions for urban development, significant among which are-

- **SCM**: Smart Cities Mission
- **AMRUT**: Atal Mission for Rejuvenation of Urban Transmission
- **HFA**: Pradhan Mantri Awas Yojana (Housing For All)
- **HRIDAY**: Heritage City Development and Augmentation Yojana

The Smart Cities Mission, launched by the Government of India in 2015, is a significant initiative aimed at promoting urban development across the country. It promotes sustainable cities aiming at developing core infrastructure for the cities along with improved quality of life for the citizens. Sustainable development is tied to the application and usage of smart technologies under this mission. Major projects executed under this mission fall widely under three ideological developments: Retrofitting, Redevelopment, and Greenfield development. Under *retrofitting projects*, existing urban infrastructures are enhanced by means of technological upgrades and major/minor improvements. Under *redevelopment projects*, city infrastructures are revitalised and existing systems that are older and declining are transformed. City extension/ expansion is done under *greenfield development* projects which are used for creating new and sustainable urban areas.

The *Smart Cities and Academia towards Action and Research* (SAAR)- Sameeksha program was launched by the Ministry of Housing and Urban Affairs (MoHUA), which is a valuable initiative that brings together academic institutions and smart cities to document and analyze urban development efforts. This collaboration shall provide valuable insights into the challenges, successes, and best practices of smart city initiatives. The assessment reports generated through this program shall be a rich source of information containing critical analysis of projects executed under smart city mission, their impact on public well-being and possible directions for future projects. By documenting successful initiatives, SAAR can help identify

and replicate best practices in urban development. By addressing the challenges and finding opportunities, this program can generate valuable knowledge and insights that will help future urban planning and development efforts not only in the country but also elsewhere in the world.

Under the SAAR Sameeksha project, this report focuses on evaluating the progress and impact of public transport infrastructure developed by the smart cities mission in India's 100 smart cities. The report assesses the progress made in implementing PTI projects and evaluates the impact of these initiatives on urban mobility, accessibility, and quality of life. It further presents the challenges faced during the development and implementation stages of such projects and also highlights best practices from among the smart cities which can serve as benchmarks for future projects. The report provides statistical data based on two different pieces of information. Firstly, based on secondary data was collected from all 100 smart cities through a prepared set of questionnaires targeting PTI based projects. Secondly, primary assessment was conducted by the team from IIT Bhilai in selected cities covering various geographical regions of the country. Based on detailed deliberation, Aurangabad, Guwahati, Raipur, Jammu, and Itanagar were chosen for primary assessment. The team did on-site assessments through field visits to project sites, interaction with local stakeholders including residents, commuters, and city officials, to gain diverse perspectives on the implemented PTI projects.

Various projects for the enhancement of public transportation within cities were implemented in smart cities such as air-conditioned buses, smart bus stops and depots, automatic parking facilities, multi-modal transit management systems, footpaths and cycle tracks, etc. Integrated Command and Control Centre (ICCC), a decision-making system for cities to manage operations, respond to emergencies, and mitigate disasters, is found to be a breakthrough. While the projects implemented in these cities through the mission have transformed the landscapes and made them future-ready, a few challenges were also observed. Lack of public awareness about the benefits of various initiatives, difficulty in continuous maintenance and inspection for sustainability are a few noted challenges. Funding constraints also pose a challenge, requiring innovative financing mechanisms and Public-Private Partnerships (PPP) to sustain momentum and ensure project success. Moving forward, prioritizing sustainability, inclusivity, and technological integration will be crucial for advancing smart city goals in these regions and across the broader spectrum of 100 smart cities.

Chapter 1: Introduction

1.1 Smart Cities Mission

India's urban population was 37.7 crore (31% of the overall population) as reported in the 2011 census. This is projected to increase to 60 crore (40% of the projected total) by 2030 and over 80 crore (50%) by 2050. Moreover, as per the 2011 census, urban India contributed 63% to the country's GDP. This is projected to grow over 75% by 2030 and more than 80% by 2050. The growing urban population places a significant burden on civic infrastructure and services like sanitation, water, sewage, housing, electricity, and public transport. To tackle the exponential need for urban expansion and development, India needs several initiatives for the people. One of the initiatives of the Government of India is the Smart City Mission (SCM) which aims to develop the standard of livelihood of the urban people across 100 identified cities of India.

Some key milestones that indicate a growing interest in smart city concepts:

- **Precursors:** Earlier initiatives like the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), launched in 2005, can be seen as laying the groundwork. JNNURM aimed to improve infrastructure and basic services in Indian cities, paving the way for a focus on more comprehensive urban development strategies.

- **Global Context:** The concept of smart cities gained international momentum in the early 2000s. India, looking to keep pace with global trends and address its own urban challenges, likely began exploring smart city approaches around this time. Examining policy documents and discussions related to urban development in the late 2000s and early 2010s reveals early mentions of smart city concepts.

The selection process for Smart Cities in India was based on the principles of competitive and cooperative federalism. This means that cities compete against each other for selection but also cooperate with the central government and state governments to achieve common goals. The selection process involved two stages: **(1)** Shortlisting by States in which States/ Union Territories (UTs) shortlist potential smart cities based on certain criteria, and **(2)** shortlisted cities compete in a "City Challenge" to demonstrate their proposals and vision for becoming smart cities. The City Challenge was conducted in multiple rounds, with a total of 100 cities selected. All the 100 smart cities are geographically presented in Figure 1.1.

Figure 1.1: 100 Smart cities that were selected for the SCM project

The selection for smart cities was done in multiple rounds as presented in Figure 1.2.

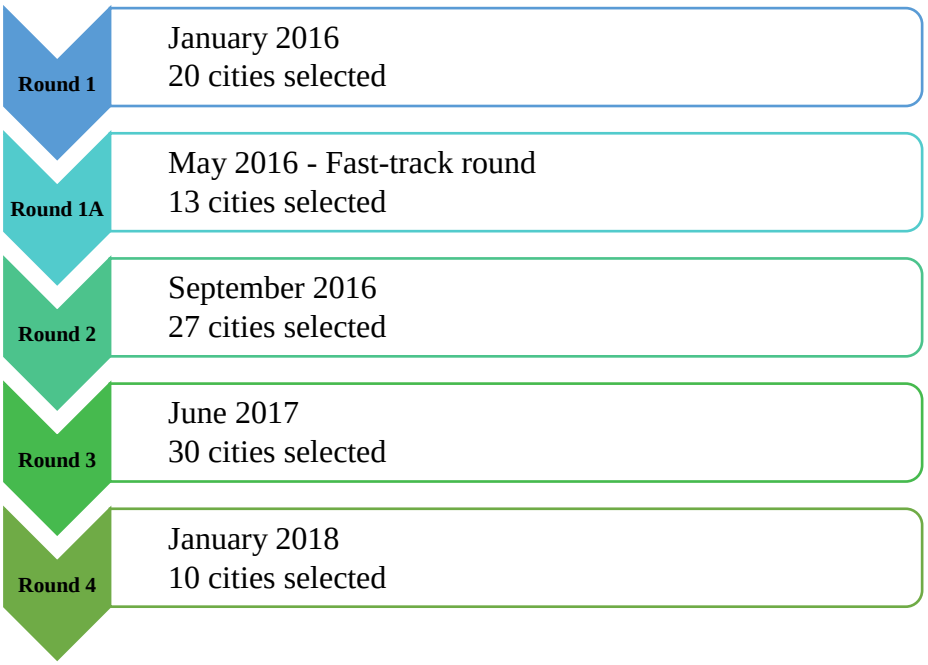


Figure 1.2 Selection timeline of smart cities

In June 2015, Prime Minister Narendra Modi officially launched the SCM insisting on creating modern and eco-friendly cities with a central philosophy of *city for everyone*. Table 1.1 gives the total budget details of the SCM projects.

Table 1. 1 Budget details of the Smart City Projects

Budget	Amount proposed/allocated
Total Investment by 100 Smart Cities	Rs.2,01,981 crore
Area-Based Developmental* (ABD) projects	Rs. 1,63,138 crore
Pan-city initiatives*	Rs. 38,841 crore

***** *To be explained later*

The primary objective of SCM is to develop citizen-friendly and sustainable smart cities across the country. The mission aims to promote cities to provide core infrastructure, a clean and sustainable environment, and a high quality of life through the application of 'smart solutions'. The mission focuses on transforming existing urban areas by improving infrastructure, services, and governance. It encourages the use of technology and innovation to address urban challenges and enhance the quality of life for citizens. It promotes environmentally sustainable practices and reduces the carbon footprint of cities. Through the implementation of smart solutions and citizen-centric approaches, the mission seeks to create a new model of urban development for the country. Various domains of SCM are shown in Figure 1.3.

Figure 1. 3 Various focus areas of projects under SCM

1.2 Special Purpose Vehicle (SPV)

The main agency responsible for implementing the vision in any given smart city is termed as Special Purpose Vehicle (SPV). As a joint venture between the State/UT and the Urban Local Body (ULB), the SPV provides a dedicated entity to oversee and manage the development and implementation of smart city projects. The SPVs are responsible for converting the Smart City Proposal into concrete projects, working with Project Management Consultants (PMCs) to develop Detailed Project Reports (DPRs) and oversee the tendering process. Once the DPRs are approved and tenders are awarded, the SPV will oversee the implementation of the projects, ensuring they are completed on time, within budget, and to the desired quality standards. The SPV acts as a coordinating body between various stakeholders involved in the smart city projects, including the State/UT, ULB, central government agencies, private sector partners, and citizens. The SPV may also facilitate Public-Private partnerships (PPPs) to leverage private sector expertise and investment in the development of smart city projects. The SPV provides a

framework for collaboration, coordination, and accountability, facilitating the development of sustainable and inclusive smart cities across India.

1.3 SAAR Sameeksha project

The Smart Cities and Academia towards Action and Research (SAAR) Sameeksha project is an initiative by the Ministry of Urban and Home Affairs to assess and enhance the infrastructure of smart cities in India. It aims to provide valuable insights into the implementation, impact, and outcomes of these initiatives, facilitating evidence-based policymaking and decision-making. The key objectives of this initiative are:

- ✓ to evaluate the extent to which government schemes and programs are achieving their intended goals and objectives,
- ✓ to identify areas where programs are falling short or require modifications to enhance their effectiveness,
- ✓ to provide policymakers with data and evidence to inform decision-making and improve program design, and
- ✓ to promote accountability and transparency in government by assessing the performance of programs and initiatives.

The SAAR Sameeksha Projects typically employs a mixed-methods approach, combining quantitative and qualitative research techniques. This may include analyzing existing data from government records, surveys, and other sources to assess program outcomes, conducting field visits to program implementation sites to observe firsthand the program's activities and impact, conducting interviews with program beneficiaries, stakeholders, and implementing agencies to gather their perspectives and experiences and analyzing case studies of specific program implementations to gain in-depth insights into their effectiveness. The project shall produce comprehensive reports providing detailed assessments of the programs under review, including their strengths, weaknesses, and recommendations for improvement.

1.4 Public Transport Infrastructure

PTI plays a vital role in the development and sustainability of urban areas. It provides efficient and accessible transportation options for residents, commuters, and tourists, reducing reliance on private vehicles and contributing to a more livable and environment-friendly space. Public

transport can help alleviate traffic congestion and improve air quality. It provides access to jobs, education, healthcare, and other essential services for people of all socioeconomic backgrounds. A well-functioning public transport system can stimulate economic development by attracting businesses and residents. Public transport contributes to a more sustainable and environmentally friendly city by reducing reliance on private vehicles. Advances in technology, such as smart cards, real-time information systems, and electric vehicles, can enhance the efficiency and sustainability of public transport infrastructure. Investing on PTI has become a common goal across most of the smart cities under the SCM. A statistical overview on the projects related to PTI and its quantum comparison with the overall projects is presented in Table 1.2. **Table 1.2: Details of the 100 smart cities (budget, total no. of projects, and specifically no. of public transport projects)**

Table 1. 2 Details of the 100 smart cities (budget, total no. of projects, and specifically no. of public transport projects)

City name	Overall	PTI Projects
	cost in Cr. | project nos.	cost in Cr. | project nos.
Agartala	1988.36 | 66	105.82 | 16
Agra	2133.00 | 38	65.55 | 13
Ahmedabad	2290.00 |32	220 | 16
Amritsar	3430.88 | 35	108.33 | 5
Aurangabad	1562.82 | 36	156 | 9
Bareilly	1922.74 | 66	363.55 | 9
Belagavi	3534.50 |108	93.66 | 61
Bengaluru	1,792.35 | 44	40 | 16
Bhagalpur	1309.30 | 23	308.75 | 2
Bhopal	2719.11 | 70	136.39 | 12
Chandigarh	5979.39 | 32	20 | 13
Chennai	1366.25 | 47	114.96 | 13
Davanagere	1307.18 |114	162.75 | 29
Dehradun	1,347.60 | 22	41.56 | 6
Diu	1442.74 | 36	93.43 | 2
Gandhinagar	1,408.00 | 42	97.81 | 5
Guwahati	2256.00 | 16	332 | 1
Gwalior	2250.00 | 74	98.38 | 12
Jaipur	2340.52 | 149	19.85 | 20
Jammu	3,464.49 | 70	573.78 | 13
Jhansi	1,728.00 | 66	192.96 | 7
K. Dombivali	2027.00 | 14	26.6 | 2
Kanpur	2311.96 | 73	511.11 | 9
Kohima	1661.25 | 32	0.84 | 9
Kota	1387.00 | 70	18.99 |
Lucknow	2053.33 | 76	364.1 | 11
Mangaluru	2000.72 | 67	0.25 | 34
Moradabad	1766.84 | 38	5.89 | 3
Nagpur	1002.00 | 42	61.05 | 4
Namchi	921.56 | 76	11 | 10
Nashik	2193.72 | 26	255.69 | 11
Naya Raipur	1,678.60 | 52	83.59 | 1
NT Kolkata	1532.41 | 195	309.20 | 47
Panaji	1775.12 | 36	49 | 9
Pasighat	1,534.63 | 43	6.99 | 7
Puducherry	1,827.83 | 82	27.21 | 1
Pune	2363.00 | 26	248 | 17
Rajkot	2,623.01 | 49	10 | 9
Rourkela	2571.27 | 64	2.94 | 15
Sagar	1,607.54 | 76	31.62 | 9
Saharanpur	1679 | 106	15.43 | 6
Salem	1908.60 | 102	254.81 | 30
Shillong	1039 | 13	180.39 | 1
Shimla	2,730.27 | 164	57.91 | 79
Shivamogga	1517.39 | 75	61.38 | 22

City name	Overall	PTI Projects
	cost in Cr. | project nos.	cost in Cr. | project nos.
Silvassa	1082.52 | 24	200 | 1
Srinagar	3,634.27 | 125	1200 | 20
Surat	2597.00 |45	233.19 | 9
Thane	5404.00 | 35	260.58 | 6
Thanjavur	1289.52 | 104	31.18 | 12
Thiruvananthpuram	1,538.20 | 68	103 | 11
Thoothukudi	1,327.04 | 75	63.32 | 12
Tiruchirapalli	1,271.04 | 82	8.11 | 19
Tirunelveli	1,217.55 | 82	14.67 | 17

City name	Overall	PTI Projects
	cost in Cr. | project nos.	cost in Cr. | project nos.
Tiruppur	1,190.15 | 28	69.95 | 7
Tumakuru	2227.00 | 177	3.8 | 44
Vadodara	2006.75 | 26	21 | 12
Varanasi	2269.58 | 61	230 | 16
Vellore	1281.12 | 52	53.15 | 12
Visakhapatnam	1601.87 | 59	13.55 | 2
Warangal	2740.00 | 84	201 | 10

** Cities where the data is not available is not included in this table.*

1.5 Impact Assessment of public transport infrastructure

Impact assessment is crucial for evaluating the effectiveness of any public service project to ensure that the envisioned project has delivered the desired outcomes. This report focuses specifically on the impact assessment of SCM projects on PTI in smart cities. Impact assessment was made through field visits, stakeholder interviews, user surveys, etc., (Figure 1.4). Additionally, Impact Assessment used data and metrics to measure the economic, environmental, and social impacts of smart city initiatives.

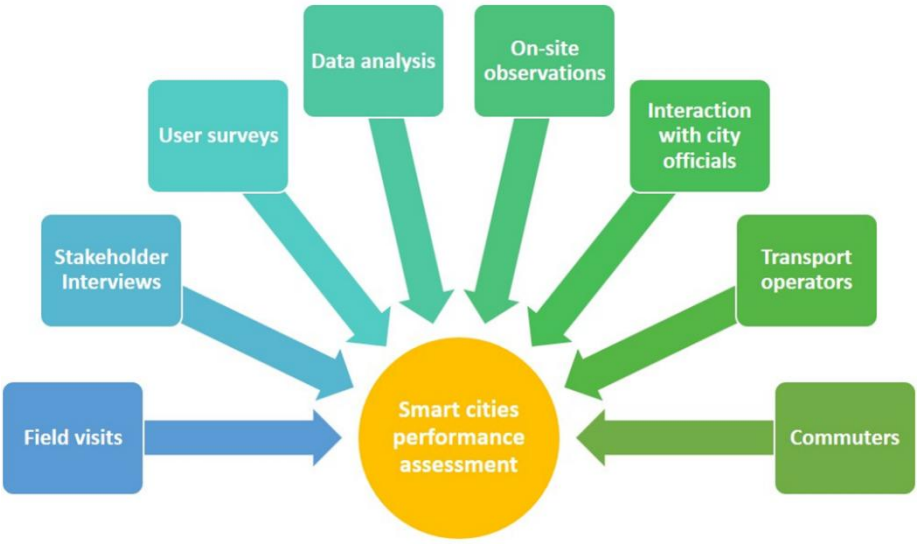


Figure 1. 4 Schematic layout of how impact assessment is carried out in this report

Key Performance Indicators (KPIs) are essential tools for measuring the success and effectiveness of any modern initiatives. In our report also, KPIs were used to pin point the level of success achieved in major projects related to PTI. By tracking and analyzing these metrics, policymakers and stakeholders can identify areas for improvement, optimize resource

allocation, and ensure that smart city investments deliver the desired outcomes. Key KPIs considered for smart city evaluation are:

- Accessibility
- Affordability
- Reliability, and
- User availability.

In this report, a comprehensive review of projects undertaken by smart cities across the country through SCM, that focuses on PTI is presented. The report critically reviews projects that resulted in creation, updation, and/or renovation of city infrastructures that aid in public mobility, and improving their quality of life. In the later part of the report, five cities where major PTI projects were implemented (Figure 1.5) were reviewed in detailing and analysing every major step taken by them towards enhancing the public's mobility within the city.

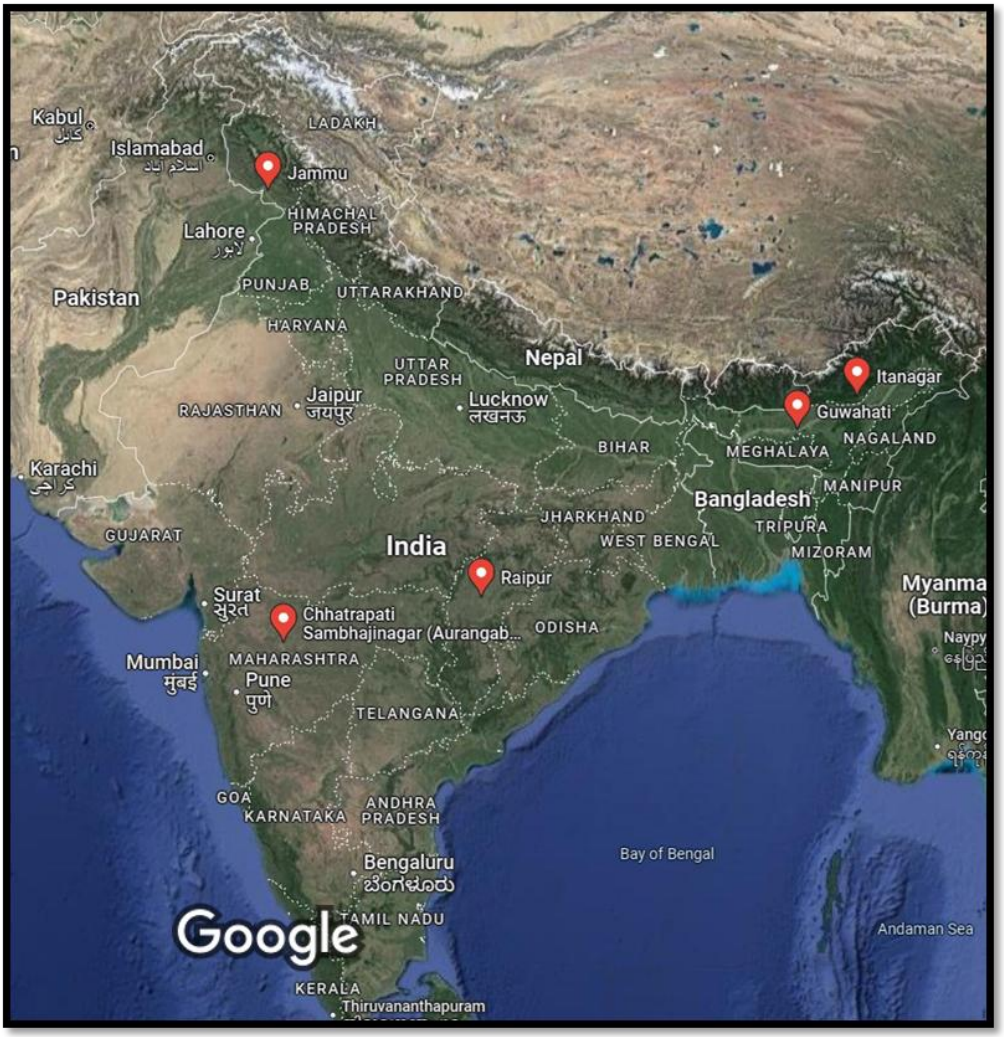


Figure 1. 5 Selected Cities across India for Impact Assessment

Chapter 2: Public transportation infrastructure projects in smart cities and their impact

2.1 Overall Progress of SCM

Smart City Mission (SCM) in India has made significant progress since its launch in 2015. As of December 2023, 47% of projects are at the work order stage in the 20 bottom-ranking cities, indicating that there is still room for improvement in these areas. However, the mission has seen substantial growth in project tendering and completion rates in recent years. As of September 2024, 7252 out of 8042 tendered projects have been completed, utilizing ₹1,45,762 crores out of a total tendered amount of ₹1,64,547 crores, and 790 total ongoing projects with a budget of around ₹18,785 crores (Figure 2.1).

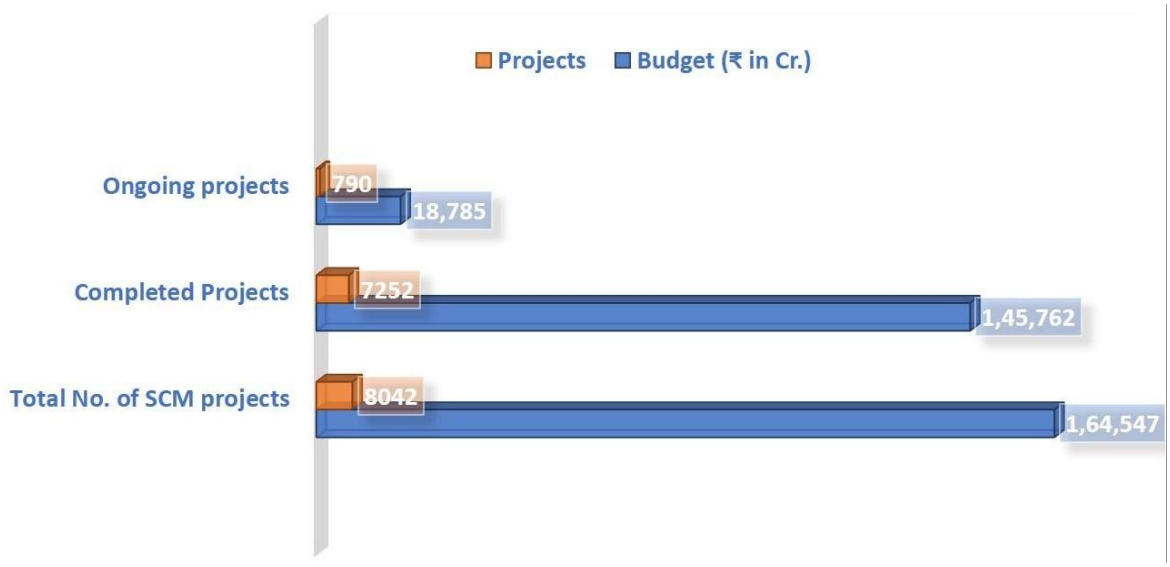


Figure 2.1 SCM projects progress

The mission has attracted significant investments from both the public and private sectors. The mission has led to improvements in various infrastructure sectors, including transportation, water supply, sanitation, and energy (Table 2.1). The mission has improved the quality of life for residents in many cities through better services, amenities, and infrastructure. Some of the initiatives undertaken in various smart cities through SCM that transformed the PTI of the cities are detailed further.

Table 2.1 Status of SCM projects classified into different domains

Sectors	Completed		Work in progress	
	Projects	Cost (₹ Crore)	Projects	Cost (₹ Crore)
Integrated Command and Control Center	100	11,775	-	-
Smart Mobility	1,522	36,084	186	5,378
Smart Energy	662	13,676	32	562
Water, Sanitation, and Hygiene	1,394	45,511	145	4,382
Public-Private Partnership	196	9,197	3	26
Vibrant Public Spaces	1,268	10,012	127	2,299
Economic Infrastructure	810	10,546	127	2,437
Social Infrastructure	815	11,671	75	1,457
Smart Governance	628	15,952	60	1,698
Environment	145	2,277	7	281

The distribution map indicating the execution of major PTI projects in various smart cities. This shall provide a basic understanding on which cities had major focus on improving their city transportation infrastructure.

Smart cities	Bus Terminals	Bus stops	Buses	BSS	Smart Roads	Multi-level parking	ICCC with PTI
Agartala							
Agra							
Ahmedabad							
Aizwal							
Ajmer							
Aligarh							
Amritsar							
Atal Nagar							
Aurangabad							
Bareilly							
Belagavi							
Bengaluru							
Bhagalpur							
Bhopal							

Smart cities	Bus Terminals	Bus stops	Buses	BSS	Smart Roads	Multi-level parking	ICCC with PTI
Bhubaneswar							
Biharsharif							
Bilaspur							
Chandigarh							
Chennai							
Coimbatore							
Dahod							
Davangere							
Dehradun							
Diu							
Erode							
Faridabad							
Gandhinagar							
Gangtok							
Greater Warangal							
Guwahati							
Gwalior							
Imphal							
Indore							
Itanagar							
Jabalpur							
Jaipur							
Jammu							
Jhansi							
Kakinada							
Kalyan-Dombivali							
Kanpur							
Karimnagar							
Karnal							
Kavaratti							
Kochi							
Kohima							

Smart cities	Bus Terminals	Bus stops	Buses	BSS	Smart Roads	Multi-level parking	ICCC with PTI
Kota							
Lucknow							
Ludhiana							
Madurai							
Mangaluru							
Moradabad							
Muzaffarpur							
Nagpur							
Namchi							
Nashik							
New Delhi							
New Town Kolkata							
Panaji							
Pasighat							
Pimpri Chinchwad							
Prayagraj							
Puducherry							
Pune							
Raipur							
Rajkot							
Ranchi							
Rourkela							
Sagar							
Saharanpur							
Salem							
Satna							
Shillong							
Shimla							
Shivamogga							
Silvassa							
Solapur							
Srinagar							

Smart cities	Bus Terminals	Bus stops	Buses	BSS	Smart Roads	Multi-level parking	ICCC with PTI
Surat							
Thane							
Thanjavur							
Thiruvananthapuram							
Thoothukudi							
Thiruchirapalli							
Tirunelvelli							
Tirupati							
Tiruppur							
Tumakuru							
Udaipur							
Ujjain							
Vadodara							
Varanasi							
Vellore							
Visakhapatnam							

2.2 Bus Transportation System

Smart buses play a crucial role in the transportation infrastructure of many smart cities, providing essential connectivity for residents and commuters with digital technology. Some of the notable advanced features in these smart buses are mentioned in Figure 2.2. In the context of smart cities, buses were integrated with advanced technologies to enhance efficiency, sustainability, and passenger experience.

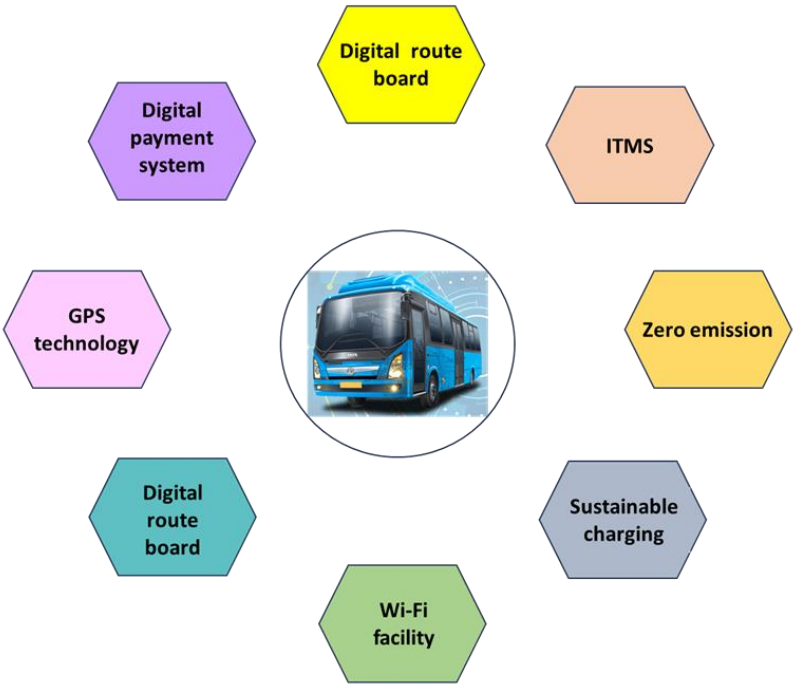


Figure 2. 2 Features of the smart electrical bus

Three types of buses are used in smart cities: Diesel, Compressed Natural Gas (CNG), and Electrical buses. Maximum number of buses were procured in Ahmedabad smart city with a proposed number of 600 buses and current deployment of 100 buses.

Smart bus systems improve the efficiency of public transportation, leading to economic growth and development. Electric buses have zero emissions, less sound pollution (Figure 2.3). Reduced vibration in electric buses give more comfort to riders making them a preferred choice for regular commuters.

Figure 2. 3 Launching of Smart Electrical buses in Srinagar Smart City (Source: tatamotors.com)

GPS technology present in these smart buses allows passengers to track the location of buses in real-time, enabling them to plan their journeys more effectively. Digital route boards help the passenger to take the appropriate bus for the travel. Contactless payment systems streamline the boarding process and reduce the need for physical tickets.

Smart bus systems have incorporated features to improve accessibility for people with disabilities, such as ramps and audio-announcements, providing an inclusive solution for citizens. The total no. of buses launched in smart cities is given in Table 2.2.

Table 2. 2 Number of buses introduced in various cities as part of SCM

State/ UT	Cities	CNG / Diesel Buses	Electric buses
Assam	Guwahati	100	200
Arunachal Pradesh	Pasighat		5
Chandigarh	Chandigarh		80
Dadra and Nagar Haveli	Silvassa		25
Daman and Diu	Diu	11	
Goa	Panaji		1
Gujarat	Gandhinagar		20
Himachal Pradesh	Shimla	28	20
Jammu & Kashmir	Srinagar		100
	Jammu		100
Karnataka	Bengaluru		90
Madhya Pradesh	Gwalior	26	
Maharashtra	Aurangabad	100	
Nagaland	Kohima	4	

In order to improvise on the public transportation based on the huge data coming from various sophisticated infrastructure deployed in these cities, the Ministry of Housing and Urban Affairs

of the Government of India SCM conducted a Transport4All challenge. The smart city teams, citizens, and startups came together to develop solutions to the problems identified that improve public transport to better serve the needs of all citizens. Problems were identified in the areas of infrastructure, financing of public transport, policy changes and technological interventions (Figure 2.4). Problem statements related to technological interventions were compiled and given to startups to address the problems.

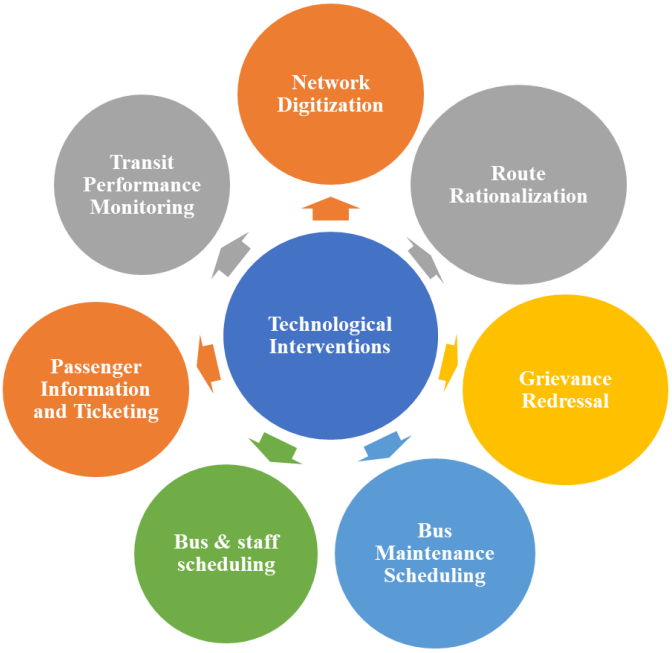


Figure 2.4: Areas of Public transport where technological interventions needed

The challenges started with a participation of 130 smart cities conducting various surveys to identify key problems. Solutions for these problems were received from startups. About 157 ideas were received, which finally narrowed down to 10 startups working on these problems to bring out prototypes. Within a span of about 6 months, few interesting solutions were deployed for pilot trials. Some of the noteworthy solutions are.

- Multimodal passenger information and ticketing system, and bus maintenance scheduling which was tried in Pune.
- Bus and staff scheduling which was implemented in Belagavi
- Transit performance monitoring system which was implemented in Davangere
- Route rationalization introduced in few cities

2.2.1 *Effect of Bus transportation system on resident's QOL*

A well-functioning bus transportation system significantly enhances the quality of life for people in cities. Encouraging bus usage leads to fewer private vehicles on the roads, reducing traffic jams and improving overall traffic flow. Electric Buses, especially, make the city pollution free by not emitting any harmful gases. This contributes to cleaner air and a healthier environment. Reduced traffic noise through electric buses further improves the overall quality of life for city residents. A well-planned bus network across several smart cities connected different parts of the city, providing access to jobs, education, healthcare, and other essential services for all residents. Bus transportation is more affordable than any other public transportation systems such as autorickshaws, etc. making it accessible to people from all socioeconomic backgrounds.

In fact, fewer cars on the road results in decreasing the number of traffic accidents. In some smart cities, dedicated bus lanes have been developed that have improved the safety of bus passengers. Reduced commute times lead to increased productivity for individuals and businesses. Bus transportation is a more sustainable mode of transportation than private car use, contributing to a greener city. In some smart cities, options like bus entry ramps, audio/video announcements, among others, are there for people with disabilities, the elderly, and those who cannot depend on their own vehicle.

In Aurangabad, the city's bus service is mostly valued by the school-going students. Smart bus division implemented a pass system to increase ridership categorized as senior citizens, students, women, etc., There is a 67% discount for students in a student fare. Their plans to add dedicated women's buses and dedicated tourist routes are some new approaches that could be adapted by other cities.

In Guwahati, as reported by ASTC there was a success in revenue achieved after the implementation of these CNG and EV buses. Since it is difficult to predict when and at what time a disabled person might want to avail bus services, Jammu smart city adopted a hydraulic lift for lifting persons in wheelchairs in each electrical bus as opposed to just 25% of the buses as was initially proposed. This model can also be used by other cities to promote equity in access.

2.2.2 *Scope for improvement*

To cater to a growing urban population, the number of electric buses must be increased in all smart cities in a move towards a green and environment-friendly community. Efficient and robust Intelligent Bus Management Systems (IBMS) still have to be developed in all smart cities to get the buses on designated arrival times at bus stops. To extract the full potential of the bus transportation system, an attempt should be made to develop a multi-modal transport system within the city integrating all available public transportation under a single umbrella. Passengers should be able to plan their travel from source to destination with efficient and well-planned multi-modal transport. In Aurangabad, a web portal named "Citizen Portal for ASCDCL" is developed where the passengers can travel as per their plan, which is a small step towards this goal. Whenever technology is involved, ensuring the security of passenger data becomes a critical concern, which still needs to be addressed. By addressing these challenges and leveraging the opportunities presented by smart technologies, cities can transform their bus systems into efficient, sustainable, and passenger-friendly transportation solutions.

In many cities (taking Jammu smart city as an example), buses are operated within the city limits and not operated outside the urban limit. As many smart cities have growing urban population, people are having their residences outside the city limits also. So, there is a need for well-connected and well-planned bus routes in all smart cities outside the city limits for resident's usage in day-to-day life. This will also address concerns of end mile connectivity to some extent.

In most cases, smart cities are planning to add more electric buses to their transportation system. However, the charging infrastructure is predominantly grid dependent. Sustainable charging infrastructure through renewable sources of energy for Electric Buses will help reduce the environmental impact of bus operations.

2.3 Bus stops

Bus stops are essential elements of urban transportation systems, providing convenient and accessible points for passengers to board and disembark from buses. In smart cities, the construction of bus stops is crucial for enhancing the overall efficiency, sustainability, and user experience of public transportation. Some of the bus stops were strategically located to facilitate easy transfers to other modes of transportation, such as metro stations and suburban

stations or cycle paths (say, Chennai Central railway station bus stop). The total no. of bus stops developed under SCM is given in Table 2.3.

Table 2.3 Data on bus stops created under SCM

State	Cities	Bus stops
Andhra pradesh	Visakhapatnam	100
Arunachal pradesh	Pasighat	10
Bihar	Bhagalpur	2
Chandigarh	Chandigarh	240
Chhatisgarh	Bilaspur	12
	Raipur	7
	Atal Nagar	12
Daman and Diu	Diu	1
Goa	Panaji	1
Gujarat	Rajkot	45
Himachal pradesh	Shimla	10
Jammu & Kashmir	Srinagar	370
Karnataka	Belagavi	39
	Shivamogga	40
	Mangaluru	20
	Tumakuru	142
Kerala	Kochi	1
	Thiruvananthapuram	5
Maharashtra	Aurangabad	150
Odisha	Rourkela	23
	Bhubaneswar	18
Tamil Nadu	Salem	10
	Thanjavur	3
	Thoothukudi	8
	Puducherry	9
Uttar pradesh	Lucknow	40
	Kanpur	30
Uttarakhand	Dehradun	66
West bengal	NT Kolkata	31

Several bus stops in smart cities are constructed to be accessible to all passengers, including those with disabilities and some of these provide ramps, tactile paving, and clear signage. Several smart features for bus Stops were developed in smart cities such as solar-powered lighting that uses solar energy to power bus stop lights so that it reduces energy consumption and maintenance costs, USB charging stations for passengers to charge their devices while waiting for buses, free Wi-Fi connectivity at bus stops enhance the passenger experience and provide opportunities for productivity or entertainment, Real-time information display that provide real-time bus arrival information, route maps, and other relevant data, vending machine, and advertising screens.

In Bengaluru smart city, a smart bus stop was constructed and opened in the Elcita area where there is a vending machine for snack items, a Wi-Fi facility, USB charging ports, and a passenger information digital board to check the status of bus arrival time, bus location, frequency, and routes (Figure 2.5).

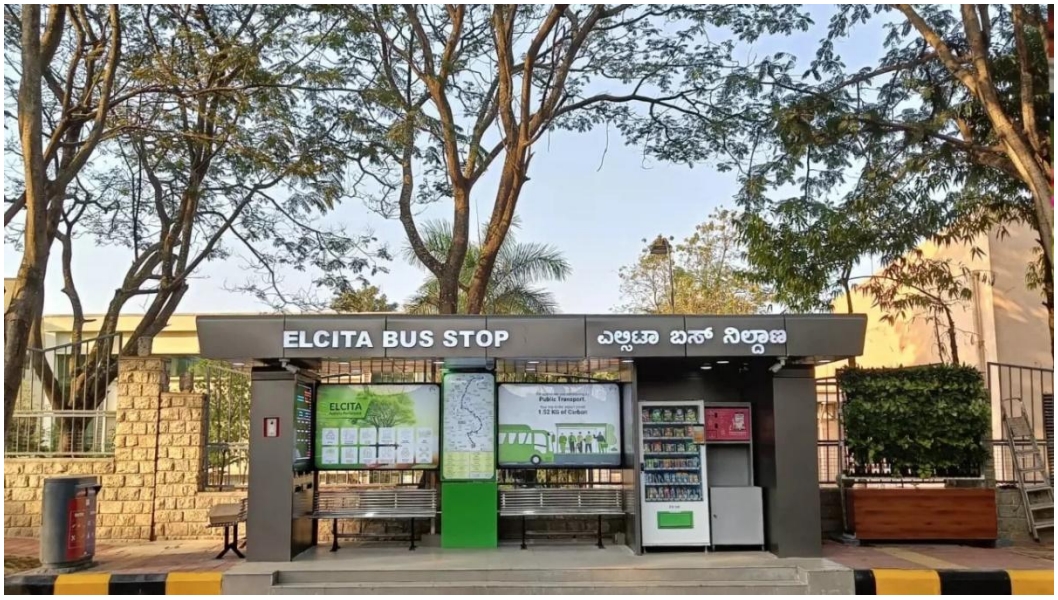


Figure 2. 5 A smart bus stop in Bengaluru city (source: timesnownews.com)

2.3.1 *Effect of bus stops on resident's QOL*

Well-placed bus stops at optimal distances in smart cities minimize walking distance to be covered by bus users to the end point, saving them time and increasing their overall satisfaction. This is essential in encouraging people to use bus transportation. Shelters, seating, and information displays at bus stops offer comfort and convenience, especially during varying weather conditions. Accessibility features like ramps and tactile paving, make public transport an inclusive system thereby improving the quality of life for differently abled people. Efficient bus stops with flushed in stoppage points contributed to smoother traffic flow, reduced congestion and improved overall road safety. Smart bus stops were constructed in some smart cities with well-lit, good maintenance with clear visibility and security measures (CCTV, etc.) to enhance passenger safety.

2.3.2 *Scope of improvement*

With the help of modern technology, GPS based real-time bus arrival timing and typical travel time will provide riders with more confidence in planning their scheduled activities. Having an additional provision for automatic ticket vending systems could be an option that reduces

the time and effort required by riders to get their tickets after entering the bus. This will also help the riders to have a more comfortable ride. The automatic ticket vending machine can also be used to provide tickets for other services. Bus stops could act as an integrating point multi-mode transportation system. For instance, these stops could provide details about other available transportation options, their timings and pricing. These need not be made available via QR codes as they are liable to be made phishing targets. This information should be provided in hardcopy formats on boards at these stops. Importantly, the bus stops can provide advertisement spots at the back of the seating area which are lit at night. These will provide de facto lighting at the bus stops hence reducing crime in these areas while also attracting revenue through these adverts which can be used in the upkeep of the bus stop. One of the major reasons for ill utilization of these bus stops and buses is the heat that passengers have to deal with while waiting for a bus to arrive. Currently, most bus stops provide either a single steel roof or roofs with rods which do not provide adequate shade from the hot summer sun that India has. Shades with more coverage should be planned while designing these bus stops to improve usage.

2.4 Bus terminals

Bus terminals play an important role in the effective operation of bus transportation systems in smart cities. They serve as hubs for bus routes, providing passengers with a comfortable and convenient space to wait for their buses. Bus terminals in smart cities often feature modern amenities such as comfortable seating, waiting areas, and restrooms. Statistical data on the number of bus terminals created across smart cities under SCM is given in Table 2.4.

Table 2. 4 Number of bus terminals built in smart cities under SCM

State	Cities	Bus terminals
Andhra pradesh	Visakhapatnam	100
Arunachal pradesh	Pasighat	1
Bihar	Muzaffarpur	1
Chhatisgarh	Atal Nagar	250
Daman and Diu	Diu	11
Dadra and nagar haveli	Silvassa	25
Goa	Panaji	1
Gujarat	Vadodara	1
Himachal pradesh	Shimla	30
Jammu and Kashmir	Srinagar	200
Karnataka	Davanagere	5
	Belagavi	28
	Tumakuru	60
	Shivamogga	28
Kerala	Kochi	1
Madhya pradesh	Sagar	200
	Gwalior	40

State	Cities	Bus terminals
Maharashtra	Jammu	5
	Kalyan Dombivli	18
	Thane	250
Sikkim	Namchi	1
Tamil Nadu	Tiruppur	88
	Tiruchirappalli	1
	Erode	1524
	Thanjavur	39
	Salem	2
	Vellore	56
	Puducherry	1
Uttar pradesh	Bareilly	25
	Lucknow	1
	Kanpur	110
Uttarakhand	Dehradun	30

Bus terminals in smart cities are equipped with digital displays that provide passengers with real-time information on bus arrivals, departures, and route maps. Terminals are designed in such a way to be accessible to all passengers, including those with disabilities. The terminals are Wi-Fi enabled providing additional comfort to the passengers. Advanced safety and surveillance systems are found to be a part of all these bus terminals.

Delhi Integrated Multi-Modal Transit System (DIMTS) has developed a network of modern bus terminals, including the Sarai Kale Khan Integrated Terminal and the Rajghat Cluster Bus Terminal. DIMTS has also developed a mobile application app for passengers and bus transportation officials to keep track of bus routes, bus location, bus time, etc. Furthermore, DIMTS has created a multi-modal app ‘Pooch-o’ that is used by passengers to transit across different modes of transportation such as buses, metro, e-rickshaws, and taxi to reach their desired location (Figure 2.6). The old bus terminal was renovated and unveiled to the public on 12th January 2025 under the Hubballi-Dharwad Smart City Project.

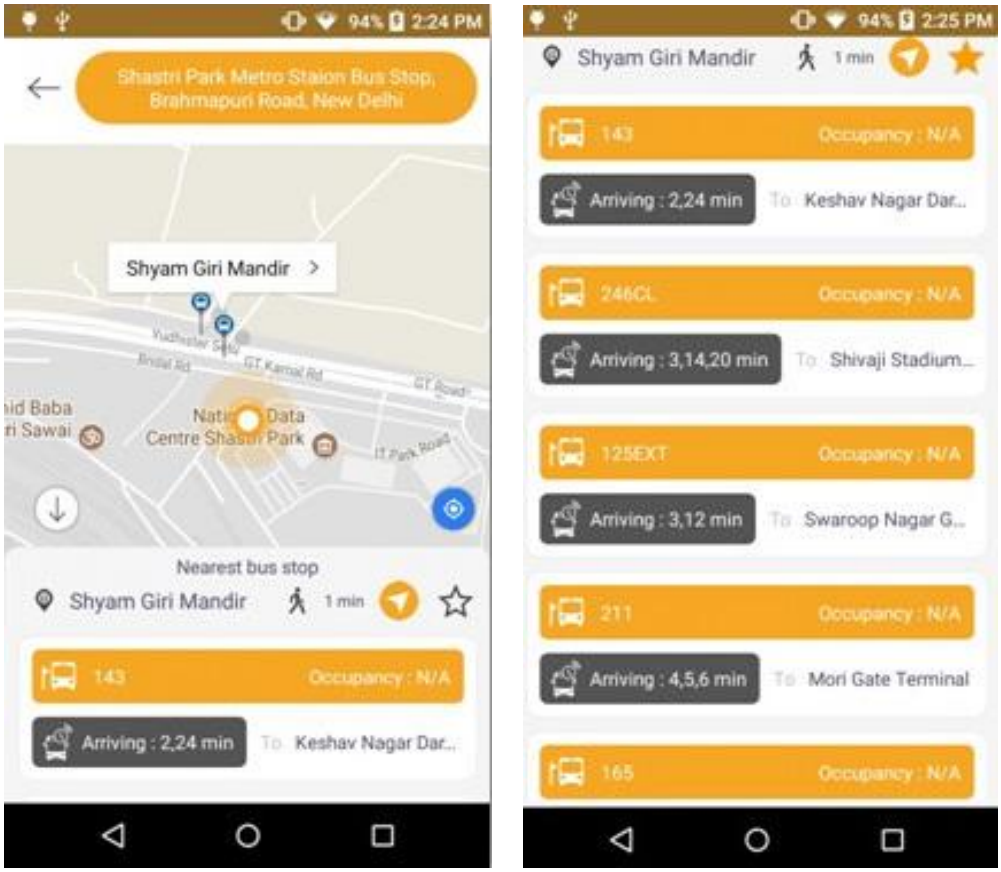


Figure 2. 6 Pooch-o app displaying Route Number, Occupancy, Time, and destination bus stop of the busses arriving at the present bus stop

2.4.1 Effect of Bus terminal projects on resident's QOL

Comfortable and informative bus terminals designed and developed by various smart cities have improved the overall passenger experience, encouraging more people to use public transportation. Modern bus terminals in smart cities were designed aesthetically which are pleasing in appearance hence making them one of the iconic buildings within the city.

2.4.2 Scope of improvement

Bus terminals could be integrated with ITMS. With additional IoT infrastructure data on passenger flow, bus arrival and departure,etc., could be collected that can help to understand the usage of bus transportation and plan effectively for future deployments. AI-powered systems could be brought in to optimize bus schedules, predict demand, and improve operational efficiency.

2.5 Bicycle Sharing System (BSS) in smart cities

Bicycle Sharing Systems (BSS) have emerged as a popular and sustainable mode of transportation in many smart cities across India. In India, the concept of BSS has gained significant traction, particularly in the context of smart city initiatives (Table 2.5). The availability of safe and well-maintained bike lanes is crucial for the success of BSS in smart cities. The density and distribution of docking stations are good enabling accessibility and convenience. Regular maintenance of bicycles and infrastructure is done to ensure the system's reliability. User-friendly mobile apps for registration, booking, and payment for BSS have been adopted by the cities.

Table 2.5 Details on Bicycle sharing systems developed in smart cities

State	Cities	Registered Users	No. of bicycles
Chandigarh	Chandigarh	407111	5000
Chhatisgarh	Bilaspur	200	30
Jammu & Kashmir	Srinagar	46819	1200
	Jammu	35958	800
Jharkhand	Ranchi	126964	600
Karnataka	Belagavi	25000	300
	Davanagere	3075	200
	Tumakuru	10000	150
	Shivamogga	10628	300
Madhya pradesh	Bhopal	218000	500
	Gwalior	30000	500
	Indore	407111	200
Manipur	Imphal	8745	100
Tamil Nadu	Chennai	11814	1115
Uttar pradesh	Jhansi	4962	181
	Moradabad	11811	300
West bengal	New Town Kolkata	91734	500

Real-time tracking was done using GPS installed in bicycles which helps in inventory management and theft prevention. Multiple payment options, including contactless payments, were given for convenience. Along with subscription based usage, pay-as-you-go method was introduced for occasional users. Effective marketing campaigns were given to raise awareness about BSS and its benefits. BSS helps travellers connect to other public transportation hubs such as bus stops, metro stations, suburban train stations, and bus terminals.

Protecting bicycles from theft is a significant challenge in smart cities. India being a country located in the temperate zone geographically, is affected by extreme heat surges in the summer months. Hence extreme weather conditions have impacted BSS usage. Several smart cities have constructed separate bicycle tracks to ensure the safety of cyclists and to encourage cycling practices. The BSS system was monitored to evaluate the performance and to find the areas for improvement. Advertisement was given for the environmental benefits of BSS and to encourage sustainable transportation choices among citizens. Chennai Smart City, for instance, launched 'smart bike' BSS in 2019 with 72 live locations (Figure 2.7). (http://cscl.co.in/cycle-sharing#)

Figure 2. 7 Smart bike BSS in Chennai smart city (Source: newindianexpress.com)

2.5.1 Effect of BSS on resident's QOL

Cycling is a great form of exercise that improves cardiovascular health, reduces stress, and boosts overall well-being. BSS in smart cities made cycling more accessible and convenient and encouraged more people to incorporate physical activity into their daily routines. It provides a sustainable alternative to private car and bike use for day to day short distance travel,

thereby helping to reduce traffic congestion. Many riders also found BSS to be a faster transit mode as cycle tracks are free from regular traffic congestion, leading to shorter commute times and an economic travel alternative.

In Jammu smart city, many college students were found using the BSS for transportation. In Raipur smart city, SCM encourages people to make use of the dedicated cycle tracks and help reduce traffic congestion.

2.5.2 Scope of improvement

A common observation across smart cities is the under utilization of BSS. One of the major reasons could be a lack of awareness on the availability of such a facility and another could be non-availability of cycles during the required hours and lesser docking stations to take and drop the cycles. Smart cities should consider increasing the density and strategic placement of docking stations, especially near transit hubs, popular destinations, student areas, and areas with high pedestrian traffic.

Regular advertisement campaigns should be done mentioning the availability of such facilities and key benefits of using BSS over other transit options. One way for such advertisements without any cost to the government could be the announcement systems in the smart poles. These advertisements can be directed at people from different age groups highlighting the times and uses these can provide. Such as, students for easy college and tuition classes commute, senior citizens for maintaining health through evening exercise by cycling and tourists who wish to explore the less explored areas of the city. Integrating the BSS with other public transit apps for efficient travel using multi-modal transportation should be looked into. Since the cycle can be taken into smaller alleyways where buses or other four wheelers cannot enter, this will promote end mile connectivity. BSS system could also have a primary focus on tourists who can visit nearby places of tourist importance through cycles. Maintenance and repair procedures should be more frequent to ensure the availability of reliable bicycles. Smart city people should also attempt to actively engage with the community to gather feedback, address concerns, and promote the use of the BSS.

2.6 Smart road projects

Smart roads have been constructed in smart cities to provide pedestrians with better walkability and connectivity with the other public transportation systems across the city. Smart roads are constructed with well-designed and technology-equipped junctions with smart devices such as

Artificial Intelligence (AI)-enabled cameras, Internet Of Thing (IoT)-sensors, and utility ducts. Smart roads in smart cities were constructed with utility ducts for electrical lines, transmission cables, water supply lines, sewage and drainage lines, etc. These utility ducts are important for developing cities as most of the cities have them above the ground making the roads congested and causing disruptions. Importantly, in Bengaluru and Rajkot, the utility ducts are longer in length due to the construction of longer smart roads for about 28 km and 31.27 km respectively.

Smart roads are also equipped with LED and solar-powered street lighting thereby saving energy. It promotes inclusivity of the elderly and physically challenged population by developing facilities accessible to them. The total length of smart roads constructed in smart cities is given in Table 2.6.

Table 2. 6 Total length of smart roads constructed in smart cities

State	Cities	Road developed (in km)
Andhra Pradesh	Kakinada	8
	Visakhapatnam	30.5
	Tirupati	9
Arunachal Pradesh	Pasighat	21.554
Bihar	Biharsharif	29
	Muzaffarpur	10.92
Chhatisgarh	Bilaspur	10.45
	Atal Nagar	22.23
	Raipur	25.7
Daman and Diu	Diu	17
Dadra and Nagar Haveli	Silvassa	14
Goa	Panaji	10
Gujarat	Gandhinagar	27.5
	Vadodara	24.15
	Dahod	15
	Rajkot	17.72
Haryana	Faridabad	1.67
Jammu & Kashmir	Srinagar	8
	Jammu	6.2
Karnataka	Bengaluru	28
	Davanagere	2.86
	Shivamogga	110
	Mangaluru	33
	Belagavi	49.39
	Tumakuru	14.53
Kerala	Kochi	7.94
	Thiruvananthapuram	9.76
Madhya Pradesh	Bhopal	3.81
	Gwalior	13.5
	Ujjain	5.676
	Indore	12
	Jabalpur	10.66
Maharashtra	Aurangabad	83
	Nashik	36

State	Cities	Road developed (in km)
	Kalyan Dombivli	9.7
	Solapur	1.1
	Pune	40.2
	Pimpri Chinchwad	20
	Nagpur	28
Meghalaya	Shillong	6
Odisha	Rourkela	26
	Bhubaneswar	5.8
Punjab	Amritsar	7.4
Rajasthan	Kota	13
	Jaipur	6.4
Sikkim	Namchi	12
	Gangtok	40
Tamil Nadu	Madurai	3.1
	Thanjavur	30
	Thoothukudi	7.140
	Salem	14.46
	Tiruppur	20.427
	Tiruchirappalli	26
	Vellore	38.57
	Chennai	20
	Erode	21.11
Telangana	Karimnagar	7.26
	Greater Warangal	32
Tripura	Agartala	32
Uttar Pradesh	Agra	7.5
	Bareilly	2.2
	Varanasi	15
	Aligarh	2.1
	Lucknow	20.69
	Saharanpur	3.88
	Moradabad	11.76
	Prayagraj	28
Uttarakhand	Dehradun	16
West Bengal	New Town Kolkata	1.17

2.6.1 Effect of smart roads on resident's QOL

In Itanagar smart city, smart roads are constructed with the installation of street furniture and signages which is a novel approach to create more user-friendly and attractive urban spaces. This initiative not only enhances the daily experience of residents and visitors but also aligns with broader goals of sustainability and urban development.

Smart road additions improved the functionality, aesthetics, and overall experience of public spaces, contributing to a more organized, disciplined, safer and visually appealing city environment.

2.6.2 Scope of improvement

Smart roads are found to rejuvenate the nerves of the cities and hence this initiative should be extended to a larger scale in smart cities. Some smart cities like Itanagar and Guwahati have problems with already developed stormwater drainage systems along the road networks, indicating an improper maintenance post establishment. SCM should incorporate city corporations during the development stage of smart roads project for better maintenance in future.

2.7 Multi-level Car Parking

Several smart cities have executed multi-level automated car parking systems (Figure 2.12) to tackle parking problems in congested urban spaces. This system uses automation technology to load and retrieve cars according to their dimensions. It increases the parking capacity within a smaller area rather than a huge area for the traditional style parking lot. Automated Storage and Retrieval Systems (ASRS) uses conveyors to handle vehicles for parking between parking spaces. Vehicles are stacked/loaded vertically or horizontally to reduce the occupied space. When the car owner requests their vehicle, the automated system retrieves it and delivers it outside the parking area. As a result of this system, vehicle owners not only reduce the time required to survey the area to find an appropriate parking space, but it also reduces traffic congestion. Automated systems ensure security by giving limited access to vehicles and providing smart surveillance to avoid theft. Details on the city-wise parking systems established in presented in Table 2.7.

Table 2. 7 Multi-level car parking systems established in various smart cities

State	Cities	No. of Multi-level Car parking
Andhra Pradesh	Visakhapatnam	1
	Tirupati	1
Arunachal Pradesh	Itanagar	3
Bihar	Bhagalpur	1
Chandigarh	Chandigarh	1
Chhattisgarh	Atal Nagar	5
	Raipur	6
	Bilaspur	3
Daman and Diu	Diu	1
Gujarat	Surat	10
	Ahmedabad	1
Haryana	Faridabad	1
Himachal Pradesh	Shimla	9

State	Cities	No. of Multi-level Car parking
Jammu & Kashmir	Jammu	2
	Srinagar	3
Karnataka	Tumakuru	12
	Mangaluru	10
	Belagavi	2
	Shivamogga	2
Kerala	Kochi	1
	Thiruvananthapuram	2
Madhya Pradesh	Bhopal	4
	Indore	4
	Ujjain	4
	Jabalpur	3
Maharashtra	Kalyan Dombivli	2
	Nagpur	3
Manipur	Imphal	4
Meghalaya	Shillong	2
Nagaland	Kohima	2
Odisha	Rourkela	1
	Bhubaneswar	2
Punjab	Ludhiana	1
	Amritsar	1
Rajasthan	Ajmer	4
	Kota	3
	Jaipur	4
Sikkim	Namchi	3
Tamil Nadu	Erode	4
	Salem	4
	Vellore	1
	Chennai	1
	Tirupur	2
	Tiruchirappalli	2
	Thanjavur	1
	Thoothukudi	1
	Tirunelveli	6
	Coimbatore	1
Telangana	Greater Warangal	20
Tripura	Agartala	1
Uttar Pradesh	Jhansi	1
	Varanasi	4
	Lucknow	3
	Saharanpur	3
	Moradabad	5
	Kanpur	1
	Bareilly	4
West Bengal	New Town Kolkata	2

The Civil Secretariat in Itanagar is upgrading its parking facilities with the introduction of a cutting-edge multi-level automated car parking system (Figure 2.8). Cars are stacked vertically in a series of tiers. This approach allows the parking facility to accommodate a significantly higher number of vehicles compared to conventional parking lots. The convenience and ease of use provided by the automated system will greatly enhance the parking experience for all users, making visits to the Civil Secretariat more pleasant and stress-free. Another project Automated AI-Based Smart Parking System was opened at Tomo Riba Institute of Health & Medical Sciences (TRIHMS) in Itanagar smart city. The facility consists of four towers, each with a capacity to accommodate 18 vehicles, bringing the total capacity to 72 vehicles.

Figure 2.8 Multi-level car parking in Chennai smart city (source: dtnext.in)

2.7.1. Effect of Multi-level Parking on resident's QOL

On-street parking is one of the major problems in Indian cities. Random parking contributes to traffic congestion and safety hazards for pedestrians and cyclists in Indian cities. After the launch of multi-level parking in several smart cities, traffic congestion has reduced. Multi-level parking has reduced the off-street parking of vehicles.

With fewer vehicles competing for on-street parking spaces, traffic flow improves, leading to shorter commute times and reduced fuel consumption. Well-lit and well-maintained parking structures offer a safer environment for drivers and their vehicles compared to on-street parking, reducing the risk of theft, vandalism, and other crimes. Multi-level structures allowed for the efficient use of limited urban land by providing significantly more parking spaces in

smaller land uses. Multi-level structures helped to preserve green spaces and improved the smart city's aesthetics.

2.7.2. Scope for improvement

Since this is new technology for the residents of smart cities, city administration should ensure that the public is aware of this technology and make efficient use of it. As this system requires both hardware and software, maintenance and operation costs need to be considered. In various cities, the parking spaces are isolated or a little way away from the core city area or shopping zone. Therefore, proper signages should be provided for effective usage of parking space.

2.8 Intelligent Command and Control Centre (ICCC)

The Intelligent Command and Control Centre (ICCC) is the decision-making support system for the smart city's operations and management. It acts as a brain for the city's control and plan execution over several fields. ICCC controls various smart city departments such as solid waste management, disaster management, emergency call box system, call centre, bus transport system, e-governance, smart street lighting, ITMS, and public announcement system, etc. (Figure 2.9)

ICCC gets sensor data from various sources and processes the data and analyses the results and helps making real-time decisions and controlling the city's operation. ICCC is connected to various mobile apps such as bus transport system app, multi-modal transport app, resident's app, etc. It sends real-time data collected from various sources to those apps for better usage by the general population and administration. ICCC in various smart cities is used for disaster management such as Covid-19 situations, cyclones, fire, etc.,

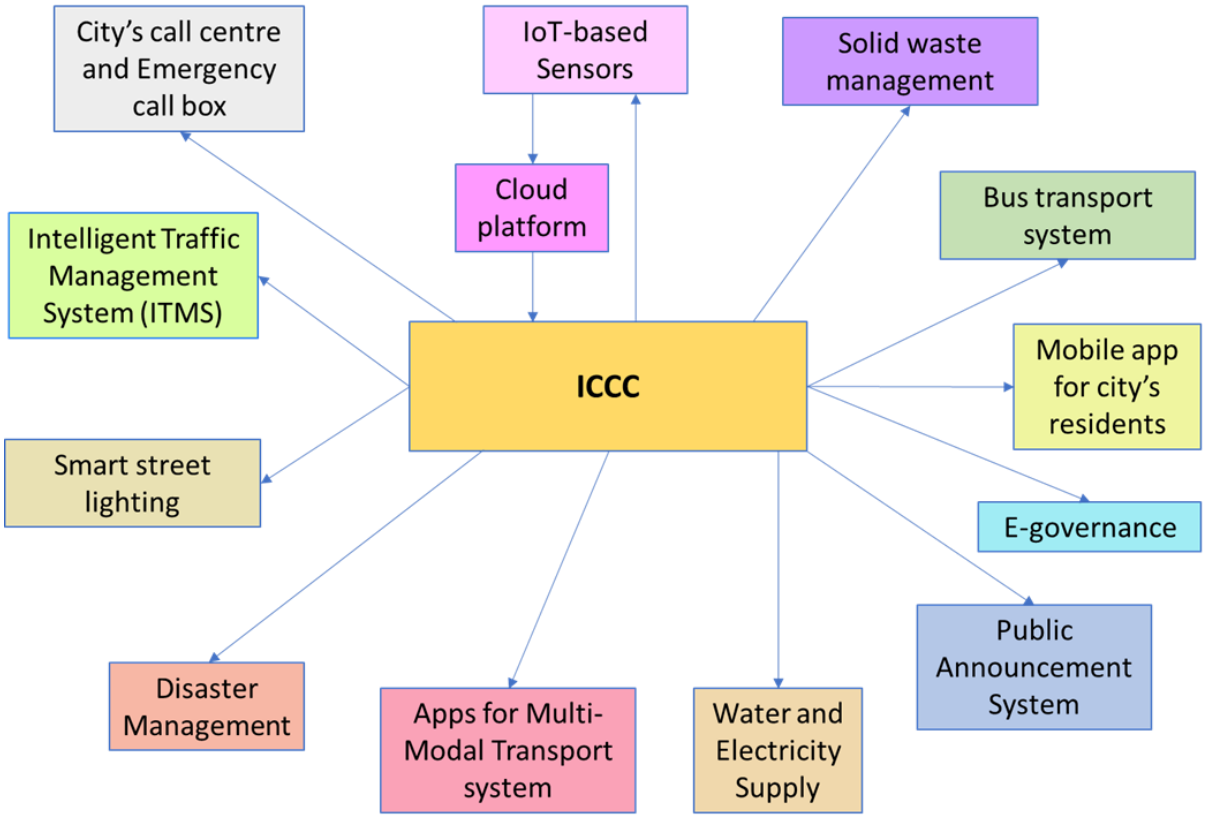


Figure 2. 9 Features of ICCC in smart cities

ICCC in smart cities consists of ITMS which is used to handle traffic congestion, traffic control, and surveillance. ITMS gets data from smart pole sensors such as CCTV cameras, environmental sensors, proximity sensors, speed sensors, etc., to control the city's traffic and reroute the vehicles to reduce congestion. Table 2.9 gives details on features of ICCC in various smart cities that are relevant to PTI. Table 2.10 highlights critical technologies incorporated in various ICCCs that help the city to administer PTI better.

Table 2. 9 ICCC's features relevant to PTI in various smart cities

Smart cities	PTI relevant features of ICCC
Agartala	✓ Monitoring of traffic using Adaptive Traffic Control System (ATCS) ✓ Monitoring of traffic using ITMS
Agra	✓ Monitoring of traffic using ATCS and ITMS
Ahmedabad	✓ Monitoring of Bus Rapid Transit System (BRTS) and Amdavad Municipal Transport Service (AMTC) buses using ITMS (includes Automated Fare Collection System (AFCS) and Command Card Payment System (CCPS))

Smart cities	PTI relevant features of ICCC
	✓ Implementation of an E-challan system using Automatic Number Plate Recognition (ANPR) and Red-Light Violation Detection (RLVD) systems
Ajmer	✓ Effective traffic control using surveillance cameras (400 CCTV cameras deployed in the city)
Aligarh	✓ Automatic incident creation and E-challan generation using ITMS (Using ATCS, ANPR, RLVD, and Stationary Vehicle Detection(SVD)) ✓ Management of traffic using ATCS, Variable Messaging Sign Board, and Public Announcement System and creation of green corridor using Public Announcement system
Amravati	✓ Effective traffic control using surveillance cameras
Aurangabad	✓ Monitoring traffic and enhancing road safety using video analytics (700 Cameras installed all over the city, and Monitoring of suspicious people, vehicles, and objects with regards to protecting life and property and maintaining law and order in the city)
Bareilly	✓ Monitoring of traffic movement using ITMS (Speed violation detectors installed at 6 traffic junctions and 21 traffic junctions controlled by ITMS)
Belagavi	✓ Deployment of smart transport components for effective management of public buses (Tools like Automatic Vehicle Location System (AVLS), Passenger Information System (PIS), public Wi-Fi, and surveillance cameras for tracking information about the movement of public buses in the city) ✓ Deployment of an Adaptive Traffic Management System (ATMS) to reduce traffic-related issues in the city (20 traffic signals controlled by ICCC)
Bengaluru	✓ Monitoring of traffic using ANPR system and Body Worn Cameras (BWC) (Traffic police utilize BWC to record pieces of evidence and for their safety) ✓ Road cutting/Ongoing infrastructure projects (To execute proper road cutting and restoration during road work, pipeline, Optical Fiber Cable (OFC) works, etc.,) ✓ Improve road infrastructure (Redeployment/ Re-routing of buses (feeder and mainline), and Mobilization of Intermediate Public Transport (IPT) for passenger evacuation) ✓ GIS-based OFC (OFC coverage and tracking using Geographic Information System (GIS))
Bhagalpur	✓ Implementation of an e-challan system using RLVD and ANPR systems ✓ Monitoring of green corridors in the city using ITMS (Implemented at 2 traffic junctions)
Bhopal	✓ Monitoring of smart parking systems using IoT sensors ✓ Monitoring of public BSS using ICCC (Gives information about availability of cycle slots and docking stations)

Smart cities	PTI relevant features of ICCC
Bilaspur	✓ Monitoring of traffic using ATCS and ITMS
Chandigarh	✓ Monitoring of traffic using ITMS (RLVD system executed at 40 traffic junctions with 594 InfraRed (IR) cameras and 133 overview cameras, and ANPR system implemented with 80 ANPR cameras and 40 overview cameras at 20 entry-exit locations of the city) ✓ Traffic signal and green corridor management using ATCS
Chennai	✓ Field Smart IoT elements eg. smart poles, flood cameras, sensors, etc., for traffic management ✓ Emergency Call Buttons installed at Traffic Junctions ✓ City-wide Parking Management ✓ Mobile Command & Control Centre ✓ Seamless Integration of ICCC with City Authorities of Corporations, Police, Transport, Traffic, etc.
Dahod	✓ Monitoring of traffic using ITMS (ATCS installed at 13 traffic junctions, RLVD installed at 11 junctions, ANPR and SVD installed at 3 entry-exit points of the city)
Devanagari	✓ Monitoring of municipal vehicles using a vehicle tracking system (Karnataka State Road Transport Corporation (KSRTC) buses - 58, SWM – 136, Fire tender vehicle – 24, Ambulances – 16 are under tracking and 104 Public Information System display boards set up at bus stops of the city)
Dehradun	✓ Monitoring public transport system using Vehicle tracking and Management System (VTMS) (Monitoring the trips of vehicles, Identifying the Estimated Time of Arrival (ETA) of buses for all bus stops) ✓ Managing traffic movement using ATCS (ATCS installed at 49 traffic signals) ✓ Managing green corridors using ATCS
Dharamsala	✓ Monitoring of traffic using ANPR and overview cameras
Diu	✓ Public Bicycle Sharing System (Monitoring of 200 cycles using GPS technology and 20 docking stations)
Erode	✓ Monitoring of smart street lights deployed in the city ✓ Traffic management with real-time monitoring of vehicles
Faridabad	✓ ATCS for monitoring and managing traffic signals (Traffic detectors installed at junctions for controlling the green time of the signals)

Smart cities	PTI relevant features of ICCC
	✓ Integrated Video Management System (IVMS) for crowd detection and analysis (Facial recognition system, Crowd analysis/detection system, and Video surveillance application)
Gandhinagar	✓ Tracking and scheduling of public buses using Automated Vehicle Location System (AVLS) (Live Tracking of Buses, most traveled routes, total trips in last 30 days route wise, trips during peak hour in the morning, trips during peak hour in the evening) ✓ Traffic management using ITMS
Guwahati	✓ Traffic enforcement using a camera-based traffic violation detection system (20 junctions installed with ATCS along with ITMS)
Gwalior	✓ Monitoring of the Public Bike Sharing System using ICCC (Radio Frequency Identification Devices (RFID) tags were attached to the bicycle for tracking, Real-time monitoring of availability of bicycles in docking stations, Real-time information about the bicycle occupancy will be given in various platforms such as web portal, mobile apps, and on-site terminals) ✓ Monitoring of smart city bus service using Global Positioning System (GPS) enabled public buses (Vehicle tracking, bus route monitoring system, passenger count, and bus information boards at bus terminals) ✓ Monitoring of parking using sensor-based systems (Smart parking system using IoT cameras, and vehicle counting system)
Imphal	✓ Reduction in traffic congestion using ATCS (ATCS implemented at 27 junctions) ✓ Road safety and traffic discipline using ITMS (Intelligent Video Management System (VMS) and video analytics)
Indore	✓ Implementation of an Automated Fare Collection System (AFCS) (Summary of transactions, and tracking day-to-day transactions) ✓ Implementation of an AVLS using GPS-enabled buses (Information about Total vehicles, online vehicles, offline vehicles, Live Tracking of Buses, most traveled routes, total trips in the last 30 days route-wise, trips during peak hour in the morning, and trips during peak hour in the evening)
Itanagar	✓ Real-time monitoring and evidence-based planning
Jabalpur	✓ Monitoring of public transport using GPS-enabled city buses (130 city buses were equipped with GPS-based tracking technology, 20 bus transport routes were covered, Vehicle monitoring, ‘Chalo’ a mobile app for residents to live track the buses, route checking, and for booking tickets)

Smart cities	PTI relevant features of ICCC
Jaipur	✓ Monitoring of smart parking systems using IoT sensors (Real-time information about parking availability through mobile applications, advance booking, and cashless mode of payments)
Jalandhar	✓ Monitoring of traffic using ATCS and ITMS (9 traffic junctions installed with ATCS along with ITMS)
Jhansi	✓ Monitoring traffic movement using ITMS (Using RLVD, ATCS, SVD, and ANPR)
Kalyan-Dombivali	✓ Monitoring traffic using ITMS (RLVD and ANPR systems installed at various junctions, automatic e-challan generation, surveillance camera for monitoring traffic congestion, green corridor movement, video message display boards, and public announcement systems)
Kanpur	✓ Monitoring of traffic using ITMS (ATCS developed at 50 junctions, intersection controller monitored and controlled by the central controller, RLVD, and SVD)
Karimnagar	✓ Enhanced traffic management by integrating ATCS with ICCC for real-time monitoring (RLVD, ANPR, vehicle detection, and E-challan system)
Karnal	✓ Implementation of ITMS for ensuring hassle-free mobility in the city (RLVD, ANPR, E-challan, CCTV camera surveillance, Installation of Public Announcement System, Emergency Call Box, VMD, and their integration with ICCC)
Kavaratti	✓ ICCC is being utilized for tracking ships sailing in the sea
Kohima	✓ Enhancing traffic management using ICCC (Live CCTV surveillance footage) ✓ ATMS (5 systems developed at 2 traffic junctions)
Kota	✓ Monitoring of traffic using ANPR cameras (ITMS using ANPR live data feed at ICCC, SVD, Automatic challan issue for traffic violation and vehicle tracking)
Ludhiana	✓ Effective traffic surveillance deploying ANPR and RLVD systems (ANPR and RLVD systems deployed at 159 locations, efficient traffic and route management, vehicle and its route tracking, and E-challan generation)
Mangaluru	✓ Integrated Transport Management System for monitoring of public buses (GPS-enabled buses, Mobile apps for citizens to plan their trips, to get bus route details and ETA, and variable display facility using Unified Messaging System (UMS) available in ICCC, and passenger information board installed at e-smart bus shelters)
Moradabad	✓ Identification of theft vehicles using ANPR system (Predetermined lists such as wanted, blacklist, stolen, and suspicious license plates created to find the theft vehicles)

Smart cities	PTI relevant features of ICCC
	✓ Parking violation (to find vehicles parking at no parking zone and finding vehicles parked at more than a time limit)
Muzaffarpur	✓ Monitoring of traffic using ATCS and ITMS (ATCS installed at 12 junctions and ATCS along with ITMS installed at 3 junctions)
Nagpur	✓ Implementation of E-challan system using ITMS (509 ANPR cameras and 154 RLVD cameras installed at 63 junctions)
Namchi	✓ Monitoring traffic using Automated Traffic Management System (Traffic poles installed at 10 junctions around the city)
Nashik	✓ Monitoring traffic in the city using an Intelligent Traffic Management System (ATCS system installed at 40 junctions, traffic synchronization, and geo-visualization, green corridor movement, real-time monitoring of traffic signals, traffic management software integrated with ICCC, and traffic data from field sensors, crowdsourced data, traffic cameras, and fleet operators)
Atal Nagar	✓ Monitoring of traffic movement using ITMS (ANPR system deployed at 8 entry-exit points of the city, and speed detection camera installed at 10 locations across the city)
New Delhi	✓ Monitoring parking slots availability and revenue collection using Information and Communication Technology (ICT) interventions (smart parking sensors for monitoring the parking and revenue generation)
Panaji	✓ Deployment of paid smart parking facilities using sensors in the city (200 parking sensors and 2 display units were installed) ✓ Deployment of ITMS for efficient mobility services in the city (Traffic signals installed at 10 locations in the city)
Pasighat	✓ Monitoring traffic using ATCS and RLVD (ATCS and RLVD systems installed at 4 locations in the city)
Patna	✓ Monitoring of traffic using ATCS and ITMS including RLVD, ANPR, and SVD (ATCS along with RLVD installed at 40 junctions, ANPR system installed at 25 locations, and SVD at 10 locations of the city)
Pimpri-Chinchwad	✓ Traffic management using VMS, video analytics, ANPR, RLVD, face recognition system, storage of the video feed
Raipur	✓ Implementation of ATCS for increase in average traffic speed of city (ATCS installed at 50 junctions, monitoring the traffic congestion, green corridor movement, and increasing the average travel speed of vehicles in the city)

Smart cities	PTI relevant features of ICCC
	✓ Use of RLVD and SVD technologies to reduce traffic violations (Traffic control system installed at 45 locations of the city, wrong way detection, no helmet detection, and triple riding detection) ✓ Use of ANPR system to capture stolen vehicles (ANPR system installed at strategic locations, GIS location, image, time, and data of the hot listed vehicles are recorded for evidence)
Rajkot	✓ On time arrival announcement of city buses through public announcement system
Ranchi	✓ Monitoring traffic using ATCS (ATCS installed at 40 junctions, traffic signal controller, Vehicle Detection Camera, Countdown timer, Traffic Light Aspects (Red, Green, Amber), VMS, and Pedestrian lamp heads (Stop, Walk))
Rourkela	✓ Monitoring of traffic using ATCS and Traffic Violation Detection System (TVDS) (ATCS installed at 2 junctions, finding volume of the traffic by AI analytics, and pelican signals for pedestrian crossing)
Sagar	✓ Monitoring of traffic using ITMS (ATCS, RLVD, ANPR, E-challan generation, 43 RLVD systems, 138 ANPR systems, 2 Pan Tilt Zoom cameras, 12 surveillance cameras, 12 ECB, 12 traffic enforcement system installed at various locations of the city)
Saharanpur	✓ Implementation of a traffic enforcement system (ATCS system to manage traffic signal timing in real time and traffic signal controller were deployed at 17 junctions, and E-challan generation)
Salem	✓ Real time monitoring of traffic violence and to penalize violators with recorded evidence
Satna	✓ Intelligent transport system to effectively manage traffic and roads and to support police department to maintain law and order
Shivamogga	✓ Monitoring the traffic movement using ANPR system(ANPR system installed at 9 major entry-exit of the city, Traffic management with traffic count/volume, classification, speed and other traffic information, system input certain license plate according to hot listing categories like wanted , stolen, and suspicious. ✓ Monitoring traffic violations using speed sensors (sensors were installed at 9 entry locations in the city and generate E challan system) ✓ Monitoring traffic violation using E-challan data (RLVD system installed at 14 junctions) ✓ Monitoring traffic using ATCS (check ETA, Traffic volume, count, classification and average speed) ✓ Monitoring public buses using Vehicle Tracking and Management System (Route Deviation, Bus Breakdown details, Late Arrival, Late Departure, Cancelled trip status, Non operated schedules and nonfunctional Vehicle Tracking Unit (VTU devices), mobile app created to give details such as bus route, bus schedule, bus fare, ETA to passengers)

Smart cities	PTI relevant features of ICCC
	✓ Implementation of public bus information system using ICT intervention (Public bus information system displayed at 40 bus shelters) ✓ Implementation of smart parking solution (13 conservancies are chosen for off street, 10 major streets for on-street parking, android based ticket vending machine, mobile app and web based user interface for finding parking availability)
Silvassa	✓ Real time traffic flow calculations and controlling using ATCS with ICCC ✓ E-challan system using ITMS incorporated with ICCC
Srinagar	✓ Managing traffic by using real time information from ATCS installed at junctions
Surat	✓ Bus transport management using ICCC (Driver enrolment, vehicle and driver allocation of buses, route violation, detour and short routing, schedule deviation, speed violation, stopage and non-stoppage violation, ETA, speed of vehicle, schedules and trip information, vehicle utilization, employee status, trip and schedule adherence status, critical alerts, upcoming schedules for buses, public information system displays, vehicle statistics, and operational violations)
Thane	✓ Monitoring the street hawkers in the city (Street hawkers are found using CCTV cameras with video analytics feature) ✓ Monitoring public transport using GPS enabled public buses (Buses with GPS technology for online monitoring, Information about total buses on the road, buses under repairs, status of bus on each route, routes under operation, and bus timings were found in real time, Mobile app for residents to check the information about bus route and frequency)
Thiruvananthapuram	✓ Monitoring of E-autos using GPS (15 electrical autos procured, and real time monitoring of e-autos using GPS technology)
Tumakuru	✓ Monitoring of traffic using ITMS (ANPR system developed at several junctions) ✓ Monitoring of traffic using ATCS (traffic signal controller system, and vehicle detector system)
Udaipur	✓ Real time monitoring of traffic using ICCC ✓ Reduction in traffic violations using real time data from surveillance and security systems
Vadodara	✓ Identification of theft vehicles using ANPR system ✓ Monitoring of green corridors in city using ITMS ✓ Implementation of automated emergency vehicle corridors using GPS and adaptive traffic signals (auto-activated green corridor (Traffic signals are configured with geo-fence)

Smart cities	PTI relevant features of ICCC
	✓ Monitoring of operation of city buses using ITMS (Route Management, Driver Assignment, Planning and Optimizing, Depot Management, Schedule Adherence Dispatch, and Management Information System (MIS) and reports
Varanasi	✓ Monitoring of traffic using ITMS (RLVD, ATCS, and ANPR systems installed at 21 junctions in the city, SVD systems installed at 4 locations, Variable Messaging System installed at 13 locations, Public address system installed at 55 locations, and E-challan generation)
Visakhapatnam	✓ Monitoring traffic violations using ANPR system and RLVD system

Table 2.10 Technologies relevant to PTI used in ICCCs of various cities

Cities	ATCS	ITMS	ANPR	RLVD	SVD	PIS	Green corridor	E-challan	Vehicle tracking	ECB	FRS
Agartala	■	■									
Agra	■	■									
Ahmedabad			■	■				■			
Ajmer	■		■	■	■	■	■				
Bareilly		■									
Belagavi	■					■			■		
Bengaluru		■	■								
Bhagalpur		■	■	■			■				
Bilaspur	■	■									
Chandigarh		■	■	■			■				
Chennai		■								■	
Dahod	■	■	■	■	■						
Davanagere									■		
Dehradun	■						■		■		
Dharamsala			■								
Erode		■									
Faridabad	■										■
Gandhinagar		■							■		
Guwahati	■	■									
Gwalior									■		
Imphal	■	■									
Indore									■		
Jabalpur									■		
Jhansi	■	■	■	■	■						
Kalyan-dombivali		■	■	■		■	■	■			
Kanpur	■	■	■		■						
Karimnagar	■		■	■				■	■		

Karnal		■	■	■		■		■		■	
Kota	■	■	■					■	■		
Ludhiana			■	■				■	■		
Mangaluru						■			■		
Muzaffarpur	■	■									
Nagpur		■	■	■				■			
Namchi		■									
Nashik	■	■									
Atal Nagar		■	■								
Panaji		■									
Pasighat	■			■							
Patna	■	■	■	■	■						
Pimpri-Chinchwad			■	■							■
Raipur	■		■	■	■						
Ranchi	■										
Sagar	■		■	■				■		■	
Saharanpur	■							■			
Satna		■									
Shivamogga	■		■	■		■			■		
Silvassa	■	■									
Sri Nagar	■										
Surat						■					
Thane									■		
Thiruvananthapuram									■		
Tumakuru	■	■	■						■		
Vadodara		■	■				■				
Varanasi	■	■	■	■	■	■		■			
Visakhapatnam			■	■							

2.8.1. *Effect of ICCC on resident's QOL*

ICCCs provide real-time monitoring of various city operations, including traffic, surveillance, and emergency services. This enables quicker response times to incidents like accidents, crimes, and natural disasters. By integrating data from various sources, ICCCs facilitate better coordination among different city agencies, leading to more effective emergency response and disaster management. Surveillance cameras and other monitoring systems integrated into the ICCC help deter crime and improve public safety. ICCCs enable city officials to monitor and manage city services more efficiently, especially in traffic management.

2.8.2. *Scope of Improvement*

ICCC generates a large amount of data every day. With the help of AI, the data could be used to build more robust ITMS systems. This can help optimizing traffic flow and minimizing delays. This translates to less time spent in traffic, leading to reduced stress levels in driving. With real-time traffic information and optimized signal timings, residents can better predict their travel times, allowing them to plan their schedules more effectively and reducing anxiety. By optimizing traffic flow and identifying potential hazards, ITMS can help reduce the number and severity of traffic accidents, making roads safer for all users.

In Aurangabad, the ICCC is ineffective in terms of traffic rules and regulations due to the lack of awareness among the citizens and a weak challan collection system. SMS is received by violators for challans but these SMS are left unexecuted for long. The major problem faced by the ICCC facility is less manpower.

In Guwahati, there are a total of 66 junctions under ICCC out of which 64 are operational and some in partial operation due to optical cable damage. The overspeeding cameras are installed in between the junctions. Currently, 3 over-speeding cameras are installed in between junctions and 10 are planned to be installed. The main reason for the trouble in the installed equipment is improper construction, thunder effect, and ground ethernet cable damage due to very heavy rainfall.

In Jammu Smart City, CCTV cameras have been installed at a few large chowks. These help in monitoring traffic violations and auto-generated challans. However these challans, like in other cities with integrated traffic control systems, require to be manually verified. Herein, more personnel are required to be employed to manually check these challans. Currently, in most cities, the number of challans far exceeds the capacity of manual verifiers.

2.9 Other prominent projects related to PTI

LED streetlights: Installation of LED streetlights in over 100 smart cities is a significant step towards improving energy efficiency, reducing carbon emissions, and enhancing urban infrastructure. LED lights consume significantly less energy compared to traditional incandescent or fluorescent lights and also have a longer life. This leads to substantial energy savings for municipalities and reduces their operational expenditure. Reduced energy consumption translates to lower greenhouse gas emissions, helping mitigate climate change. LED lights provide better lighting quality, with a higher colour rendering index (CRI) and more consistent light distribution. This enhances visibility, safety, and security in urban areas. Few smart cities had attempted to have a mass transformation of their roads lighting through these LED projects. For instance, in Guwahati, where spine roads act as the backbone of the road network, around 85 km of them are lit with about 6400 LED lights.

Smart poles: Another transformative initiative in the domain of PTI is installation of smart poles in smart cities. These smart poles are equipped with intelligent sensors such as environment sensors, AI-powered CCTV cameras, routers for Wi-Fi connectivity, smart LED street lights, solar-powered billboards, pedestrians' crossing call buttons, emergency call buttons/panic buttons, etc. For example, New Delhi Municipal Corporation (NDMC) which has constructed 55 smart poles in Connaught Place of New Delhi and several smart poles installed at Sarojini Nagar, Bengali Market, Netaji Nagar, BK Dutt Colony, Bengali Market, and Gole Market (Figure 2.10).

Figure 2.10 One of the smart poles installed in New Delhi (source: smartcity.ndmc.gov.in)

Emergency call buttons (ECBs): Emergency call buttons installed in several smart poles at traffic junctions or roads sideways have come as a quick SoS tool for the residents (Figure 2.11). One can contact the Integrated Command and Control Centre (ICCC) by pressing the button to report any form of emergencies accidents, crime, medical emergency, natural disasters, etc. Large number of Emergency call boxes were installed in smart cities such as New Town Kolkata (421 boxes), Pune (136 boxes), and Dehra Dun (107 boxes).

However, there is lack of awareness about this facility among the general public and hence it is proposed that information about its availability and functions can be broadcasted using the announcement systems in the smart poles itself.

Figure 2. 11 Emergency call box installed at Gandhinagar smart city (source: gandhinagarmunicipal.com)

Streets for people: Streets for people is a street transformation project under smart cities with a prime focus on enhancing pedestrian's city experience. Three types of street transformations were done in smart cities: (1) transit streets that run with the commercial roads that pedestrians use as walkways/footpaths, (2) neighbourhood streets which are used by pedestrians as everyday walkways with commercial restaurants, shops, services, etc., (3) Market streets which are commercial streets where shops in between both the edges of the streets are present for people to purchase from (Figure 2.12).

Various walkways and footpaths are also developed in many Smart Cities to create pedestrian-friendly zones. Walkways and footpaths are used for pedestrian mobility with enhanced safety, contributing to a more sustainable urban environment. These walkways were made accessible to physically challenged persons through ramps, tactile paving, etc.

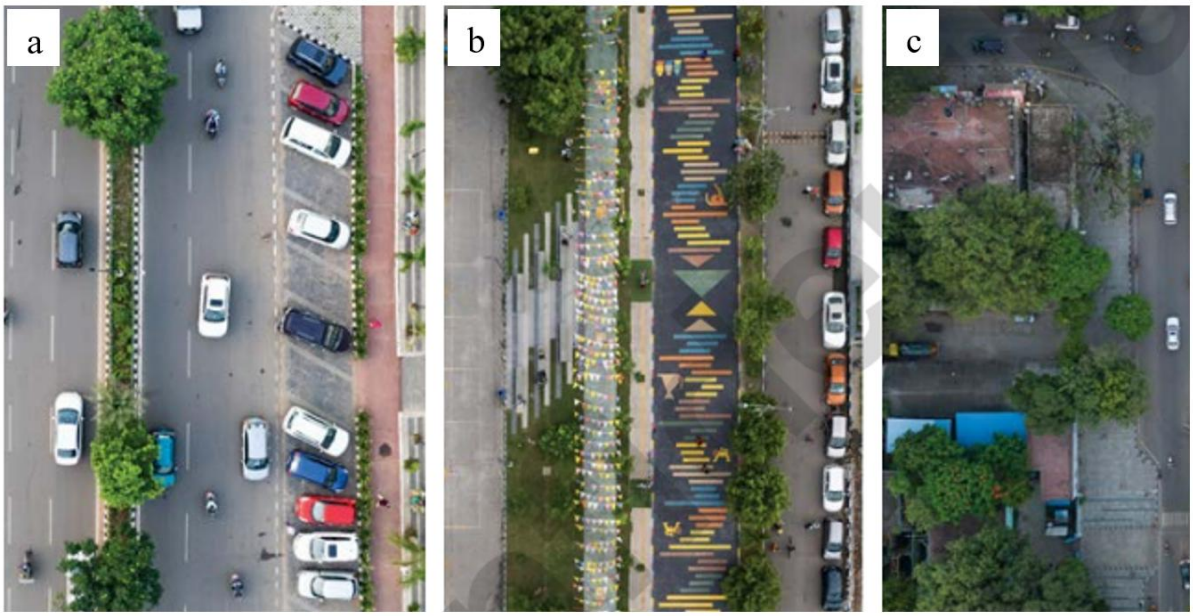


Figure 2.12 Three street transformations in Streets for People Initiative (a) Transit streets (b) Neighborhood streets (C) Market streets (Reference:)

The Chennai Smart City Ltd. in association with Greater Chennai Corporation has launched 'Pedestrian plaza' which is a walkway and footpath to provide social space for T. Nagar area people. Residents of T. Nagar and pedestrians who come to T. Nagar utilize the space for shopping, eating, walking and lounging purposes (Figure 2.13).

Figure 2.13 Pedestrian Plaza in T. Nagar area at Chennai smart city (Source: cscl.co.in)

Some of them are connected with bus stops, metro stations, suburban stations, and bicycle tracks, promoting an effective multi-modal transportation option to residents. Some of the smart cities have also attempted to use solar-powered lighting to power streetlights. Walkways and footpaths have provided people with social interaction and community engagement.

Statistical details on the walkways and footpaths developed in smart cities are given in Table 2.7.

Table 2. 7 Details on walkways and footpaths developed by SCM in various cities

States	Cities	Walkways developed (in km)
Andhra Pradesh	Kakinada	6.8
	Tirupati	18
Arunachal Pradesh	Pasighat	23
	Itanagar	6.2
Bihar	Bhagalpur	40
Chhattisgarh	Atal Nagar	15
	Bilaspur	20
	Raipur	43.3
Daman and Diu	Diu	17
Dadra & Nagar Haveli	Silvassa	1.5
Goa	Panaji	27.5
Gujarat	Rajkot	40
	Gandhinagar	20.3
Himachal Pradesh	Shimla	23
Jammu & Kashmir	Srinagar	16
	Jammu	65.9
Karnataka	Shivamogga	38.8
	Mangaluru	60
	Davanagere	0.150
	Belagavi	7.55
	Tumakuru	17.5
Kerala	Kochi	76.56
Madhya Pradesh	Bhopal	3.8
	Indore	11
	Jabalpur	50
	Sagar	0.320
	Ujjain	11.4
Maharashtra	Nashik	28
	Kalyan Dombivli	7.6
	Pune	30.28
	Pimpri Chinchwad	35.3
Manipur	Imphal	3.5
Mizoram	Aizawl	1.4
Nagaland	Kohima	4.5
Odisha	Bhubaneswar	11.6
Punjab	Amritsar	22
	Ludhiana	2.2
Rajasthan	Kota	26
	Jaipur	4.95
Sikkim	Namchi	1.9
Tamil Nadu	Coimbatore	34.5
	Vellore	0.5
	Tirunelveli	1.8
	Erode	1.342
	Salem	9.2
	Thanjavur	62
	Tiruchirappalli	18
	Chennai	20
Telangana	Greater Warangal	38

States	Cities	Walkways developed (in km)
Uttar Pradesh	Jhansi	10
	Varanasi	15
	Aligarh	20.5
	Lucknow	2.07
	Kanpur	17.4
	Saharanpur	47.5

2.9.1 Effect of these works on QOL of citizens

The widespread adoption of LED streetlights have provided brighter and more consistent illumination, lighting the cities at night. Improved visibility for pedestrians, cyclists, and motorists led to reduced risk of accidents. This transformation has given more confidence for city residents to comfortably move around the city at night. Well-lit public spaces encouraged outdoor activities and social interaction.

For example, in Guwahati, an initiative, Project Jyoti, aimed to illuminate both houses and streets, benefiting residents in various ways. Households paid a nominal fee of 20-25 rupees per month for street lights in Project Jyoti.

2.10 Smart poles

Smart poles enhanced public safety and security. The ability to monitor public spaces in real-time allows rapid response to emergencies and deters criminal activity. weaker sections including children, women and senior citizens could benefit immensely using ECB to report any crime/emergencies. This has the potential to positively impact resident's quality of life by creating a safer and more comfortable environment. However, this is currently underutilized due to the public's unawareness regarding these features. The integration of Wi-Fi hotspots, charging stations, and digital information displays enhance the convenience and connectivity for residents and visitors. The integration of energy-efficient technologies, such as solar panels and LED lighting, in smart poles contributed to a more sustainable urban environment.

Tactile pavement in smart streets for people projects have transformed smart cities to be more inclusive. It empowers specially abled people to move around the city with more confidence and safety (Figure 2.14).

Figure 2. 14 Tactile pavement on the footpaths at Pune smart city (source: kartavyasadhana.in)

Signages for specially-abled people such as audio poles, direction poles with visual contrast displays, and audio beacons have added more convenience. Signages for the specially-abled were developed in smart cities such as Atal Nagar Nava Raipur, Diu, Nashik, Srinagar, Indore, Kakinada, Madurai, Jhansi, Varanasi, Davanagere, Lucknow, Ranchi, Saharanpur, Shivamogga, Mangaluru, Bilaspur, Raipur, Tiruppur, Gandhinagar, Kanpur, Greater Warangal, Vellore, and Tirunelveli.

2.10.1 Scope of improvement

While a large number of LED street pole installations have illuminated the city greatly, its operational maintenance has become a challenging task to the local administration. Its effective integration with the ITMS system is not yet brought into effect in most cities, which calls for regular manual inspections. Moreover, due to limited manpower, many cities were not able to repair faulty lights on time.

The digital signages placed in a few smart poles are a good source of revenue. It could also be used more effectively in broadcasting government schemes and public awareness videos on various matters.

ECB is a very well thought option introduced in various cities. However, we have observed very less usage of these ECBs. There is very less public awareness about the ECB box installed with the smart pole. Public awareness campaigns could be an option to educate people about the benefits of ECB and the importance of using it during emergencies.

Specifically for pedestrian walkways, citizens have raised concerns over maintenance. Regular maintenance including removal of debris, overgrown vegetation, and uneven surfaces should be undertaken more frequently. Incorporating more rest areas with benches and seating for pedestrians to take a break and installation of drinking fountains or water refill stations would give a more refreshing experience for pedestrians.

While tactile pavement coverage across the city is a major and essential step towards an inclusive progress, its presence and usage could be publicized through PA systems and through campaigns where visually challenged persons gather.

Chapter 3: A Case Study on Aurangabad Smart City

3.1. Introduction to Aurangabad Smart City

Aurangabad - "The Tourism capital of Maharashtra", is a historical city in Maharashtra (Figure 3.1). It is the administrative headquarters of Aurangabad district and is the largest city in the Marathwada region. Located on hilly terrain in the Deccan region, Aurangabad is the fourth-most populous urban area in Maharashtra with a population of 1,175,116. Despite its embrace of modernity, Aurangabad retains its connection with past glory, heritage, and traditions. The city also has a vibrant industrial economy, with industrial clusters in Waluj and Chikalthana. In 2019, the Aurangabad Industrial City (AURIC) became the first greenfield industrial smart city in India under the country's flagship Smart Cities Mission.

Figure 3. 1 Aurangabad city map (Source: aurangabad.gov.in)

Aurangabad thus has the rare distinction of a city presenting a perfect confluence of historical heritage, modern industry, and educational eminence. Aurangabad Smart City Development Corporation Ltd. (ASCDCL) smart city project was established to further this image of Aurangabad, by introducing interventions that can improve the ease of living in the city. The Aurangabad Smart City project aimed to incorporate best practices in technology, city planning, and infrastructural development to improve the standard of living in the city of

Aurangabad. Selected as one of the smart cities by the Government of India, Aurangabad is poised to provide world-class services through well-designed and citizen-centric programs. Smart city project details of Aurangabad city are given in Table 3.1.

Table 3. 1 Smart city project details of Aurangabad

Item	Detail
Total area	138.50 sq/km
Total population	1,175,116
Households	236,659
Area for Greenfield development	233 sq/km
Budget	1198.30 crores
PAN city development budget	364.52 crores
O & M and Contingency budget	0.08 crores
Fund from Central Government	500 crores
Fund from State Government	500 crores
Convergence	184.60 crores
Private investments/PPP	101 crores
Other sources	277.30 crores
No. of smart city projects	35
No. of public transport infrastructure projects	9
Budget for public transport infrastructures	353.23
Boost to local identity	3.51 crores
Improved walkability theme	0.18 crore
Development of Bus depot	27.86 crore

The projects proposed in the Area-based development of the Aurangabad smart city are electricity supply, solar energy, solid waste management, rainwater harvesting, smart metering, IT connectivity, and digitalization, pedestrian walkways and footpaths, BSS, ITMS, streets for people, smart parking, LED street lighting, green spaces, and safety of children, women, and senior citizens. In redevelopment and green-field, construction of green buildings should be energy efficient, and if houses are built and provided to the citizens at least 15% should be in the ‘affordable housing' category (Table 3.2). Aurangabad smart city projects were planned and executed by Aurangabad Smart City Development Corporation Limited (ASCDCL). ASCDCL is an SPV formed to implement SCM in September 2016 after Aurangabad was selected as a smart city in round 2. ASCDCL is formed and controlled by the Government of Maharashtra and Aurangabad Municipal Corporation.

Table 3. 2 List of projects proposed for Aurangabad smart city

Projects	Cost (Rs. in Crore)
I Area Based Development (ABD)	
1. Infrastructure Development	
Water Supply System	58.60
Sewerage System	53.70
Road Network incl. Cycle track	136.30
Solid Waste Management	21.50
Power	99.50
Telecom and ICT infrastructure	45.30
Open Space and Garden	30.80
CCTV surveillance	6.30
Solar Power	11.20
2. Affordable Housing Development	
EWS Housing	90.20
LIG Housing	72.20
MIG Housing	198.50
3. Social Infrastructure Development	
Fire & Disaster Management	4.70
Police Station	3.90
Government Health Facilities	31.30
Govt. School	99.00
II. Pan city	
1. Smart & Safe Integrated Urban Mobility	
Smart Street Lighting & Surveillance	168.90
Smart Mobility	110.20
Smart Solutions for Solid Waste Mgmt.	26.30
Command Center & ICT infrastructure	25.00

3.2. PTI of Aurangabad smart city

Aurangabad has rightly identified that to become a people-loving smart city, its primary focus is on building a sound PTI. Its focus on PTI projects is evident from the ratio of PTI projects to the overall projects executed by ASCDSL in Figure 3.2.

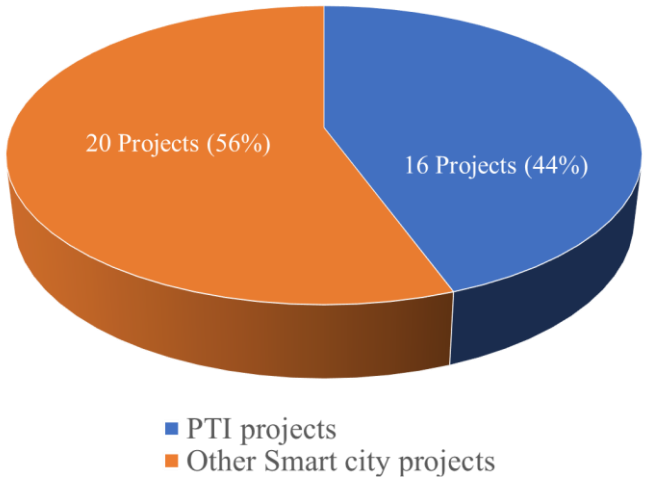


Figure 3.2 Pie chart comparing the Total No. of PTI projects with the Total No. of other Smart city projects

Technology-enabled public transportation in Aurangabad consists of the ASCDSL Smart bus division, Maharashtra State Road Transport Corporation (MSRTC) city bus division, bus shelters, and e-ticketing. The major focus of PTI projects by ASCDSL is represented in Figure. 3.3.

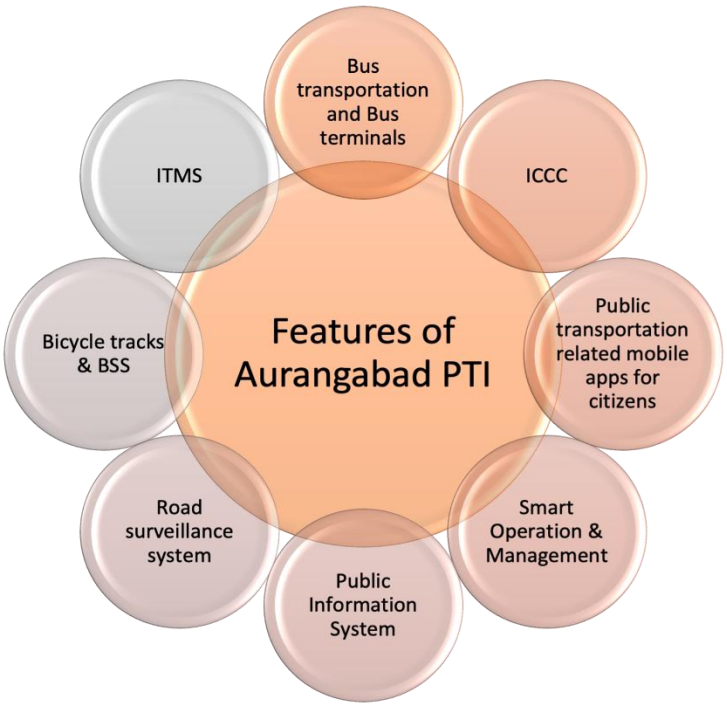


Figure 3.3 Significant features of Aurangabad PTI projects

Daily commuters are using early 25000 auto-rickshaws which have services within the city. To solve the traffic congestion problem in the city, 6 flyovers were developed on major traffic junctions on Jalna Road (NH-211) which is the important transit road of Aurangabad. The Safe and Smart Integrated Urban Mobility Framework concerning Aurangabad PTI gave significant changes such as real-time monitoring using a single Command and Control centre, management of traffic congestion, mobility services, bus transportation interface through mobile Apps and Aurangabad smart city bus portal, usage of the ITMS, and the introduction of bicycle tracks and BSS, Streets for people, safe city initiative and surveillance system with the police control centre, public information system at the bus stops, and smart operations and management. All PTI projects and their current status are listed in Table 3.3.

Table 3. 3 Public Transportation Projects in Aurangabad and their current status (as on July2024)

Projects completed	Projects in progress
● Smart Bus ● Smart mobility ● Construction of Bus Stop Sign Poles ● Bicycle Tracks ● Development of Shiv Srishti under Kranti chowk flyover ● Streets for People ● Smart traffic signals ● Delineators for Traffic Management and Road Safety ● Concreate approach road to safari park ● Bitumen approach road to safari park ● Development of Bicycle track – MGM to central Naka ● Development of bicycle track – khijri gate to TV centre	● Bus Depot ● Smart Roads Package 1 ● Smart Roads Package 2 ● Smart Roads Package 3

3.3. Smart bus system

Public transportation was the key area selected from the survey conducted with the people of Aurangabad city to select areas for SCM. ASCDCL along with MSRTDC started the smart city bus division in January 2019 (Figure 3.4).

Figure 3.4 Picture from the launch of the smart bus at Aurangabad smart city (source: aurangabadsmartcity.in)

The smart bus runs along 27 routes with 100 Buses. Smart bus details were accessed using the Vehicle Tracking System (VTS) and mobile applications by the commuters (Figure 3.4). Smart city buses are equipped with CCTV cameras, digital bus route display boards, onboard vehicle diagnostics, VTS, etc., Bus transit mobile app used to check bus routes, arrival time, ETA, bus location, schedule, and digital payment. Bus route optimization to improve ridership based on

data analytics. Several smart bus stops were constructed with bus information digital display boards. Smart buses were equipped with GPS for vehicle tracking. Key statistical details on the project are detailed in Table 3.4.

Table 3. 4 Details of the Aurangabad Smart Bus System

Item	Detail
Total no. of Buses	100
Total number of routes	31
Length of the route	Minimum 6.6 Kms and Maximum 22.6 Km
Average	13.9 km
No schedules (No buses on the road)	90 Nos
Total no of trips throughout the day	1405 (taking into consideration – single trip)
Buses operational	from Early Morning 3:11 am till 00:30 am
Span of operations	21.19 Hrs
Min Frequency of the Bus	17 Mins
Max Frequency of the Bus	1 Hr 24 Mins

3.3.1 Impact assessment of smart bus system

During the initial commencement of the smart city project in Aurangabad, at first 20 buses were running in the city, which were increased to 35 buses and then again to 85 buses. Currently, 99 diesel buses are running in the city in a 20 km radius around the municipal council in various routes. 135 more electric buses are planned to be procured. The newly procured buses are equipped with a VTS, real-time bus location using GPS, CCTV cameras, public announcement speakers, panic buttons, and digital ticketing machines used for ticketing and generating bills. Currently temporary depot on rent with MHRTC is in use for the buses. There are two departments, maintenance and operation. The maintenance department manages scheduling, cancelling of trips, and the breakdown of buses having manpower. The inventory is always maintained for repairing the buses. Currently, 28 persons are working in the maintenance section on a contract which is renewed every 11 months. The operations department looks after the operation of buses. The safety, security, and audit of buses are done by the Central Institute of Road Transport (CIRT). log books/waybill allocation were managed digitally to reduce human errors and better planning using algorithm. A digital handheld

ticketing machine (Figure 3.5) is used to digitally log the route details such as conductor details, bus details, passenger details, and bus fare details.

Figure 3.5 Digital ticketing system allotment with bus and conductor details

The new bus depot under the smart city project is a state-of-the-art infrastructure with modern amenities (Figure 3.6). The depot is under construction on 7 acres of land with work nearing completion. The new depot will have separate bus parking sections each for diesel, CNG, and electric buses fully equipped with charging stations. CNG gas refill stations have separate provisions for electric and diesel buses, there will be a separate battery room. Totally three washing ramps are built in the bus depot. There is a water recycling plant just near the three washing ramps. The cash and issue room were constructed on the 2nd floor of the bus depot building. Waiting areas were constructed for the public with washrooms and toilets. There will be a pay-and-park provision in this new bus depot, which will also contribute to generating revenue that can be used for effective maintenance of the infrastructure.

Figure 3.6 The site of the bus depot getting ready to house the buses, as inspected during our visit

The bus service in the city named Majhi Smart Bus, starts at 05:00 am and operates till 11:30 pm. There are a total of 35 routes defined in the city. All the buses in total cover an average of 24000 km with a total of 1100 trips per day. The average total number of passengers is 30000 per day. The peak hour of the city bus service is from 10 am to 7 pm and the peak operating days of the week are from Monday to Friday. 70% of the city's bus operation is in the Waluj area.

3.3.2 Effect of smart bus system on resident's QOL

The city's bus service is mostly valued by the school-going students. Smart bus division implemented a pass system to increase ridership categorized as senior citizens, students, women, etc., There is a 67% discount for students in a student fare. There are also plans to add procuring and running dedicated women's buses in the city and also plans for having dedicated tourist buses. While previously having an app for city bus services "Aurangabad Smart Bus ITS", a new advanced app called "Mazi Smart Bus" dedicated to the smart city bus service was developed for use with all the necessary features including ticket booking, no. of stops, route checking, schedule checking, live bus location, incomplete trips, cancelled trips and all other information available. The app will be also used for office management with all the data available on the app digitally.

The portal named "Citizen Portal for ASCDCL" was launched by the ASCDCL smart bus division and it is used for commuters to check live routes and bus services, to check ETA and to give feedback and complaints. It has a journey planner where users can enter the source and destination to find the bus routes for travelling. The live routes tab is used by commuters to live-track the buses to their destination.

The implementation of city bus services resulted in a reduction of traffic issues and rickshaws primarily the main cause of traffic also got a reduction in number. When the smart bus was introduced, it reduced the fare of rickshaws and other modes of travel. Earlier the local travelling charge for rickshaws was three times higher than what it is now. Currently, there is nearly a 50% difference in the rickshaw fare and the city bus fare for the same distance.

3.3.3 Scope of improvement

There is a requirement of 60 people for maintenance but currently, the bus division has only 28 people. Currently, the bus service and major maintenance are done through outsourcing which is very costly. Since Aurangabad is a very big and one of the busiest cities, also being a tourist attraction, as per the department there is a requirement of 500 buses in the city for a smooth functioning covering all the areas efficiently. Currently, the frequency of buses is very low.

3.4 Bus shelters and Bus stop sign poles

Several bus shelters (Figures 3.7 & 3.8) and bus stop sign poles are constructed all over the city. During Phase 1, 372 bus stop sign poles were constructed and during Phase 2, 123 bus stop sign poles were constructed. There are 150 bus shelters constructed in the PPP model around the city with a budget of 5 crore. ₹ 2700 per month rent is paid to the government by each PPP model bus shelter which is 15 crores of total rent received by the government in 10 years.

Figure 3.7 A picturesque view of the bus stop constructed at Aurangabad Smart City

Figure 3.8 Bus stop sign pole at Aurangabad smart city with bus timings and bus route details

3.5 ICCC of Aurangabad smart city

An ICCC is functioning in the Aurangabad smart city for the police department, traffic police department, and municipal corporation. The ICCC has its control room in the Aurangabad smart city office (Figure 3.9).

Figure 3. 9 A view of ICCC control room at the Aurangabad smart city office

ICCC have a total of 750 cameras of which 600 are fixed Field of View (FoV) cameras and 100 are Ultra High Definition (UHD) PTZ (Pan, Tilt, and Zoom) cameras. Among these 250 are recognizing cameras and 122 are ANPR cameras for finding red light jumps, wrong parking, safe road crossings, junction redesigning, car movement in restricted zones, and suspect searches. Video analytics was used for finding traffic violations. 450 public announcement speakers were installed across 450 junctions around the city connected through an optical fiber. In the current scenario, 50% of the city is effectively covered and surveilled through these cameras.

If any traffic rule is violated the surveillance cameras immediately capture images of the violating vehicle and that is viewed on the system in ICCC, where the operators from the traffic police department do an initial manual check if anything is wrongly detected and make changes accordingly which is then sent to National Informatics Centre (NIC) for Regional Transport Office (RTO) data fill-up and reverted to the ICCC, after then a e-challan is issued on the vehicle registration (Figure 3.10). Currently, helmet challan is not done as proper awareness advertisement and information about the ICCC is yet to be spread among the citizen of the city. The ICCC in the police headquarters currently has a total of 21 manpower, working in 3 shifts in 24 hours. In addition to the ICCC, surveillance drones are also given to the police department from the smart city project for night patrolling and controlling rallies.

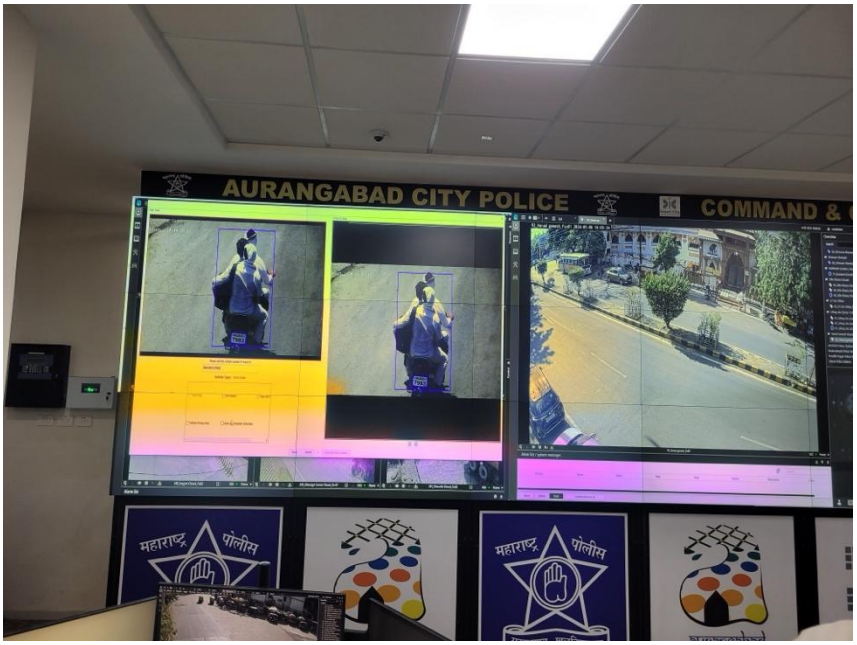


Figure 3.10 A use case of detecting traffic violation at the ICCC of Aurangabad smart city

3.6 Smart traffic poles

LED traffic poles with aesthetic lighting are installed in various critical junctions, to indicate signals more visibly from a long distance, and to view in drastic weather conditions. The entire pole is fixed with LED lights that are connected to the traffic signal. Therefore, the LED lights glow with respect to the traffic signal turning Red, Yellow, and Green (Figure 3.11).

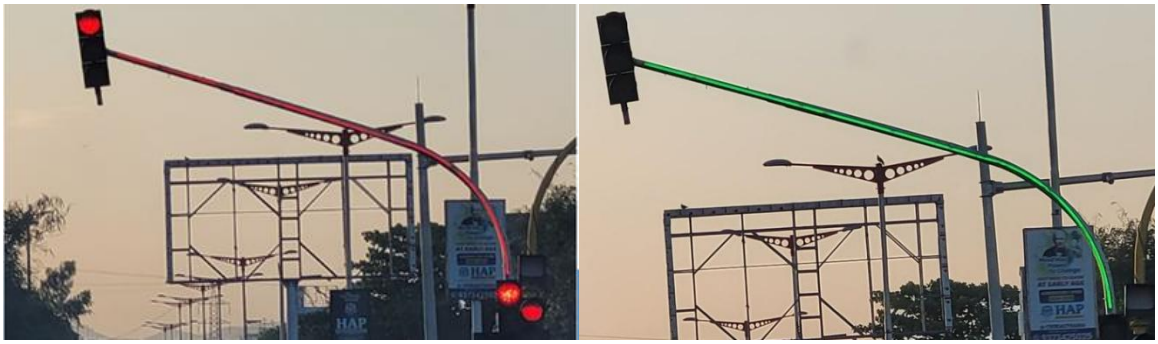


Figure 3.11 LED traffic poles installed at traffic junctions in the Aurangabad smart city

3.7 Smart poles

Smart poles consist of smart LED lights, Wi-Fi, environmental sensors, surveillance cameras, PIS, and ECB (Figure 3.12). Several smart poles were installed at Aurangabad smart city. Smart poles were used for intelligent street lighting where the intensity of the street light changes with respect to the vehicle movement on the road. Environmental sensors were used

to check pollution levels by sensing the air quality in the city and the noise pollution. Surveillance cameras are used for security purposes. PIS is used for announcing any emergency during a national calamity. ECB were used for residents to contact ICCC for reporting any emergencies on the road such as road accidents and problems due to adverse weather conditions.

Figure 3.12 Smart poles installed at a junction in Aurangabad

3.8 Streets for People

Smart walkways and footpaths were constructed and made with several smart features. Under the street for people, Bicycle tracks were made for 90 km of road constructed with a footpath along with safety railings (Figure 3.13). Wholesome streets for public gatherings and socializing were also constructed.

Figure 3.13 Bicycle tracks at Aurangabad smart city

3.9 Summary

To summarize the assessment, Key Performance Indicators (KPIs) are presented in Table 3.5. Keeping in mind, the objective of this report, which is to study the impact of PTI projects on improvement in the public's well-being, parameters such as Accessibility, Affordability, Frequency, Reliability, and User satisfaction were identified as KPIs. These indicators are not generalized as few indicators may be applicable only for specific projects, for example, frequency and affordability are specific to bus transportation projects only, while accessibility is applicable to all projects.

Table 3. 5 Assessment of smart city projects in Aurangabad city

Key Performance Indicators (KPIs)	5 Star Rating
Accessibility	★★★★★
Affordability	★★★★★
Frequency	★★★
Reliability	★★★
User Satisfaction	★★★★

Chapter 4: A Case Study on Guwahati Smart City

4.1. Introduction to Guwahati Smart City

Guwahati is the capital city of Assam and one of the important cities of the Northeastern part of India for transportation, trade and commerce, and its strategic location is connected to other cities. It has an aesthetic landscape of hilly regions and a wide Brahmaputra river (Figure 4.1). It is geographically located between the southern bank of the Brahmaputra River and the foothills of the Shillong Plateau. Guwahati has a rich history dating back centuries with significant trading centres and is the capital of various ancient kingdoms. It consists of various ethnic groups, including Assamese, Bengali, and Nepali and has religious diversity.

Figure 4.1 Map of Guwahati city (source: google maps)

Guwahati experiences a tropical climate with hot summers and mild winters. The city receives heavy rainfall during the monsoon season (June-September). Guwahati is a major center for the tea industry in India, with numerous tea gardens in the surrounding areas. The city's historical and cultural attractions, as well as its natural beauty, contribute to its growing tourism industry. Guwahati has been actively pursuing smart city initiatives to improve the quality of life for its residents and enhance its overall development. These initiatives leverage technology to address various urban challenges and create a more sustainable and efficient city. Guwahati was included in the SCM during the first round of selection. The inclusion in the SCM made Guwahati a technologically equipped smart city and it aims to leverage its potential as a pivotal urban center in the Northeastern region.

Guwahati has incorporated an SPV which is a Guwahati Smart City Limited (GSCL) to plan, design, and execute the smart city projects in Guwahati. GSCL is a company incorporated and established on 11th May 2016 under the Indian Companies Act 2013 with equal shareholding from the central government and the government of Assam. A statistical summary of GSCL is presented in Table 4.1.

Table 4. 1 Smart city project details of the Guwahati city

Description	Data
Area	219.06 Sq.km
Population	9,57,352
Total No. of Households	2,29,718
Area under ABD	2.82 Sq.km
Area for Retrofit	696 Sq.km
Budget for ABD	₹ 1,634 Crores
Budget for PAN city development	₹ 622 crores
Overall budget	₹ 2256 crores
Fund from Central Government	₹ 500 crores
Fund from the State Government	₹ 500 crores
Convergence	₹ 778 crores
Private Investments/PPP	₹ 468 crores
Total No. of Smart City projects	18
Total No. of Public transport projects	8

Area-Based Development (ABD) focuses on specific areas within the city for redevelopment and infrastructure improvements. Pan-City solutions address city-wide challenges, such as waste management, transportation, and public safety. Smart infrastructure includes implementing smart technologies like intelligent transportation systems (Figure 4.2 & Figure 4.3), smart grids, and smart waste management solutions. Citizen Engagement was done to involve citizens in the planning and implementation of smart city projects. Category-wise list of projects are presented in Table 4.2.

Table 4.2 List of projects under Guwahati smart city

Categories of Smart City Projects	Projects
Smart Transportation	➢ Intelligent Traffic Management Systems

Categories of Smart City Projects	Projects
	➢ Bus Rapid Transit (BRT) System ➢ Cycle-sharing and Car-sharing initiatives
Smart Energy	➢ Smart Grids for Efficient Electricity Distribution ➢ Energy-efficient street lighting ➢ Renewable energy projects
Smart Waste Management	➢ Waste segregation and recycling facilities ➢ Smart waste bins with sensors
Smart Water Management	➢ Water conservation and leak detection systems ➢ Improved water supply infrastructure
Smart Governance	➢ E-governance platforms for citizen services ➢ Open data initiatives ➢ Citizen engagement apps
ABD	➢ Development of Borsola Beel (Lake) ➢ Mora Bharalu River ➢ Bharalu River ➢ Deepor Beel (Lake/Wetland) ➢ Brahmaputra Riverfront Development
PAN City Development	➢ ICT- Smart Poles & OFC ➢ ICT- System Integrator ➢ ICT- City Operation Centre Building ➢ ICT- Improvement of Roads/Footpath/Traffic Junctions (Package 1)

Categories of Smart City Projects	Projects
	➢ ICT- Improvement of Roads/Footpath/Traffic Junctions (Package 2)
	➢ ICT- Airport Road
Other Projects	➢ Gandhi Mandap - Guwahati Prime Hill Site Redevelopment
	➢ GIS Mapping
	➢ ATW (Any Time Water)
	➢ Roof Top Solar Mission (Govt. Building)
	➢ Smart Bio-Toilet
	➢ Installation of Water ATMs
	➢ Installation of LED Street Lights in selected Spine Roads
	➢ Installation of LED Street Light under "Project Jyoti -Phase 1"
	➢ Gandhi Mandap Light and Sound Show
	➢ Development of Ashwaklanta Devalaya Premises
	➢ Development of Umananda Devalaya Premises
	➢ Installation of Illumination and Technology (Laser) based show at Shankardev Kalakshetra
	➢ Streetscape for Beautification at Sankardev Kalakshetra
	➢ Procurement of Drain De-Silting Super Sucker Machines with Dump Storage (10nos)
	➢ Implementation of Street Light Poles under Project Jyoti Phase II scheme on design build operate basis with operation and maintenance
	➢ Installation of High Mast Light Pole at Shankardev Kalakshetra
	➢ Brahmaputra River Front Development (Phase 2)

Categories of Smart City Projects	Projects
Other Projects (Proposed as Per SCP RFP) – II	➢ Bus Stop Wholly developed by the Private organizer (100%) on BOT Model ➢ Smart Road- PWD (World Bank Funded)

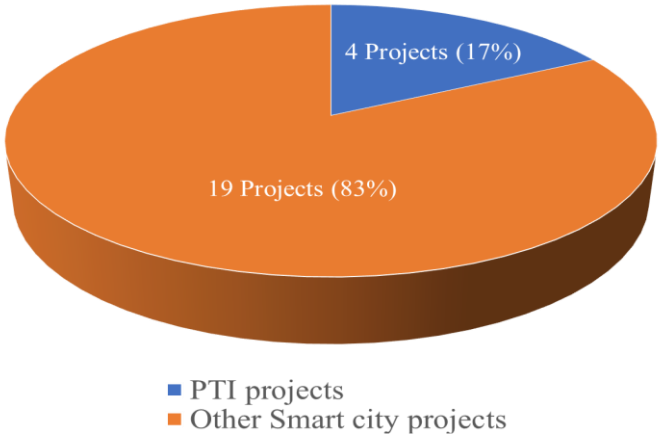


Figure 4.2 Pie chart comparing the Total No. of PTI projects with the Total No. of other Smart city projects

The Guwahati Smart City Mission has undertaken several public transport infrastructure projects to improve urban mobility and enhance the overall quality of life for its residents. Some key initiatives include Intelligent Traffic Management Systems, Bus Rapid Transit (BRT) Systems, Cycle-sharing and Car-sharing initiatives and Light Emitting Diode (LED) street lighting along the spine roads (Figure 4.3).

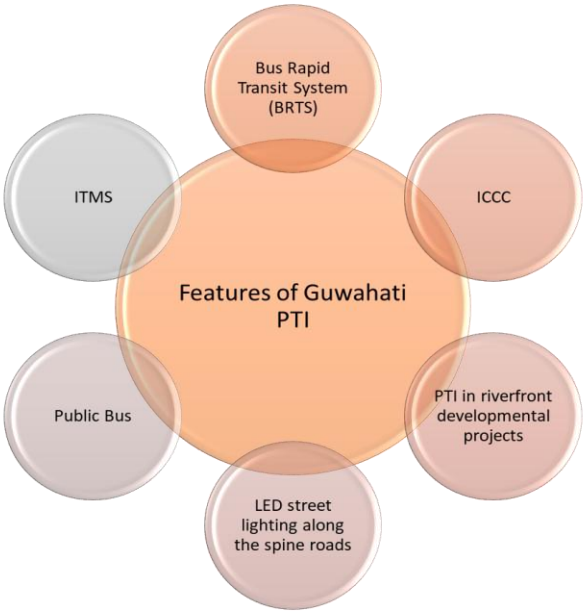


Figure 4.3 Significant features of Aurangabad PTI projects

4.2 PTI in Riverfront development projects

Guwahati consists of several riverfronts because of the Brahmaputra River branches that flow through the city. Borsola Beel is a lake with an area of 25 acres in the central part of the city from the Bharalu water system. This lake became very polluted because of solid waste dumping and poor sewage networks. The development of Borsola Beel Lake is one of the smart city projects. It consists of cleaning the lake, and developmental activities around the lake for PTI. Several bridges across Beel Lake were constructed such as one parking bridge, two girder bridges, and one arch bridge for public transportation. Several roads were constructed as part of infrastructural works. The seven sister's walkway was constructed for public usage.

Several development activities were done in Morabharalu River as part of riverfront development projects. Several Reinforced Cement Concrete (RCC) bridges were constructed for pedestrian and vehicle movement replacing the old wooden bridges. One walkway was constructed on the riverfront of Morabharalu river with a play area, toilets, and water dispensers as part of landscaping developments. The new bridge was constructed at Jonali with pedestrian and vehicle pathways.

4.3. LED Street Lighting Project along the Spine Roads

Spine Roads are the main roads of Guwahati city, acting as the backbone of the road network. Guwahati has implemented a comprehensive LED street lighting project to enhance public safety and energy efficiency. It focused on spine roads, the city's main arteries, covering a total of 137 kilometres with 103 roads. This project aims to illuminate the spine roads in Guwahati. Approximately 85 km of spine roads are already lit with 6400 LED lights. The remaining 165 km of spine roads are to be illuminated in phases. LED streetlights were equipped with a Centralized Control and Monitoring System (CCMS) for remote on/off and dimming functions. Precise fault identification was enabled through GIS integration with Google Maps. High-power LED lights (90 watts or more) were installed, reducing energy consumption significantly. Presently the coverage of street lights within Guwahati is not uniform. There exist many dark spots due to the absence of street lights. This project intends to cover such dark spots along the spine roads. A map of the City indicating the Spine Roads in the project is shown in Figure 4.4.

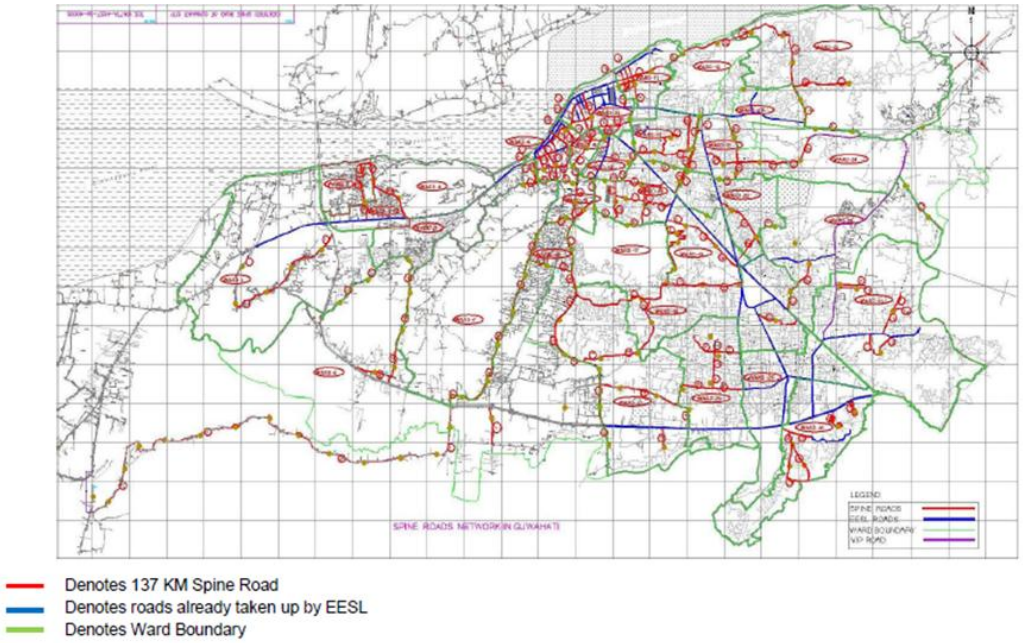


Figure 4.4 Map of the City indicating the Spine Roads

4.3.1 Effect of smart street lighting project on resident's QOL

A separate initiative, Project Jyoti, aimed to illuminate both houses and streets, benefiting residents in various ways. Households paid a nominal fee of 20-25 rupees per month for street lights in Project Jyoti. The project addressed dark spots, enhancing public safety. Before the project, street lighting coverage was uneven. LED lights offer significant energy savings compared to traditional lighting as well, reducing the operational burden on the city administration.

4.4 Public Bus Transportation

Proposal for 200 Air-Conditioned electric buses and 100 CNG buses along with the development of 5 charging infrastructures that can charge the buses in one hour span dedicated to the electric buses was made for Guwahati City under the smart city mission. One charging station is developed in the Rupnagar area which can accommodate 32 buses. The fuel filling station is developed in the ASTC near the Pan Bazar area of Guwahati. 100 Electric buses were launched by the Hon'ble Chief Minister of Assam, Dr. Himanta Biswa Sarma on 1 January 2024 (Figure 4.5). ASTC executed and maintained public bus services. As reported by ASTC there was a success in revenue achieved after the implementation of these CNG and EV buses. There is a parking zone constructed under the smart city mission which can accommodate 50 cars.

Figure 4.5 Electrical Buses Launched in Guwahati Smart City

4.5 ICCC in Guwahati smart city

An ICCC was developed as the heart of the ITMS project, enabling the Guwahati City police department to real-time monitor various facets including management of traffic, safety, and security in the city. The ICCC is equipped with all the facilities comprising an Enterprise Management System, Video Management System, Viewing Display, Helpdesk facilities, for immediate access and execution of major functions of the data and communication network (Figure 4.6). A total of 15 personnel are in the ICCC out of which two are from the police department. The other 13 persons are handling the monitoring and help desk. One person from the operator team handles the police station calls and helpdesk. The ICCC is operational for 24 hours in 3 shifts, 1st shift from 6 am-2 pm, 2nd shift from 2 pm-10 pm, and 3rd shift from 10 pm-6 am. The challan system starts from 6-7 am till 10 pm. Challans are not generated at night and signals are also turned off at night. Every day the operator team checks the cameras, sensors, and signals at all the junctions, and the maintenance team is sent. The maintenance team comprises 7 personnel, 5 technicians, and 2 managers. The maintenance team is in continuous connection with the operation team and all the camera and sensor troubles are solved within a day. On average, around 300 challans are generated for violations. Every day at 10 pm all the challan report is sent to the DC office and police headquarters.

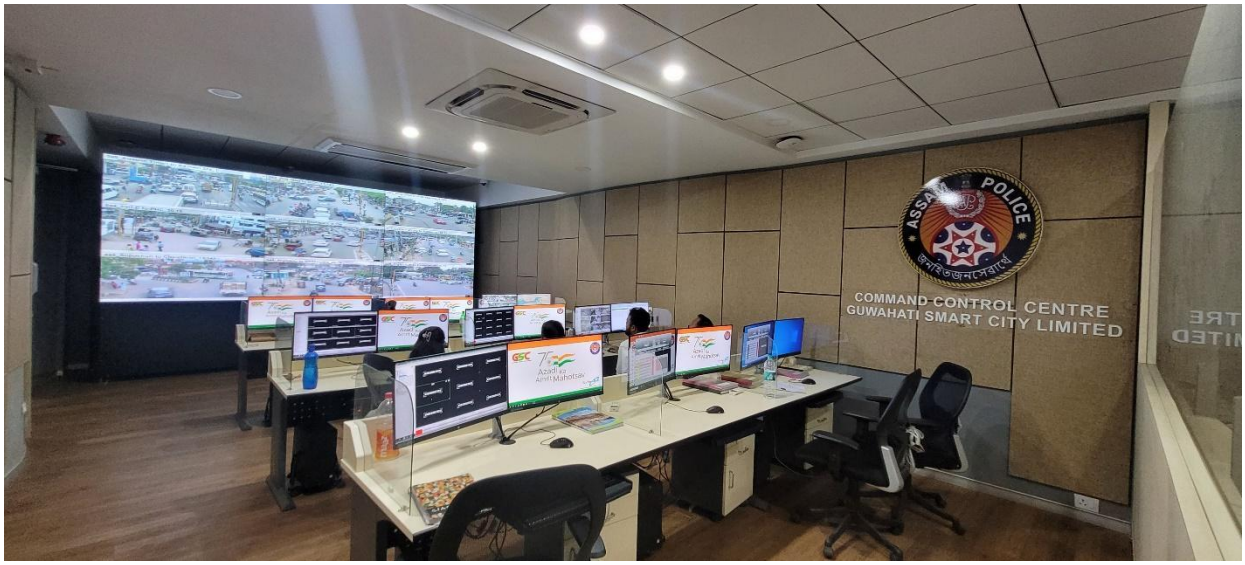


Figure 4.6 ICCC at Guwahati Smart City Office

An ITMS was introduced for the Guwahati smart city (Figure 4.7) considering the traffic and safety-related issues in the city like severe traffic jams, increase in the number of road accidents, traffic rule violations, and overspeeding being a hotspot in the northeastern region of India. This ITMS is comprised of ATCS, ANPR, RLVD, SVD, Automatic Traffic Counting and Classification (ATCC), Traffic Enforcement System - e-Challan System, and Command & Control Center with help desk. Integrated ATCS with ICCC facilitates real-time monitoring of traffic across the city. Integrated CCTV cameras installed in the city traffic junctions with ICCC have helped authorities in effective city surveillance.

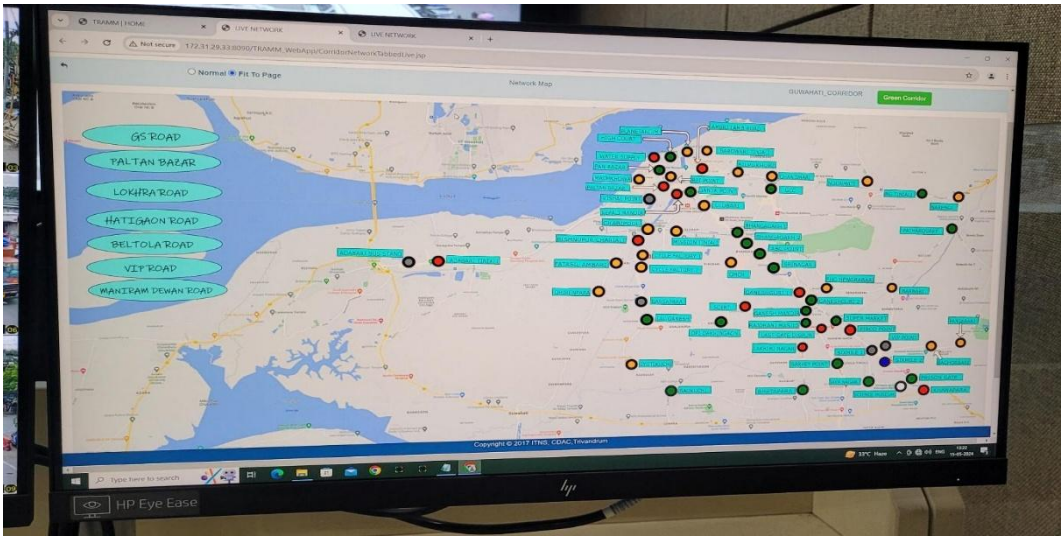


Figure 4.7 Live network showing traffic signal control at various junctions using ITMS

The Guwahati city administration aimed to ensure that the city has an effective traffic management system to monitor traffic congestion and hence improve travel time reliability.

This was envisaged to be done by integrating an ATCS and ITMS platform with ICCC for live traffic data feed (Figure 4.8). Automatic challan generation through ANPR for Red Light Violation, No Helmet Detection, Triple Riding Detection, No Seat Belt Detection, Driver Call Detection, and Speed Violation. Enhancement of Safety and Security through Traffic Surveillance with 24*7 video surveillance at 94 junctions and ATCS at 94 traffic junctions. 20 Junctions have been completed in phase 1 with ATCS along with ITMS across the city. ICCC enabled all traffic junctions to work independently as well as in coordination with one another to manage the city traffic. ICCC facilitated the Continuous distribution of green light time equitability for all traffic movements. It helped in improved travel time reliability by progressively moving vehicles through green lights and allowing the emergency vehicle to travel without any halt by configuring "Green Corridor".

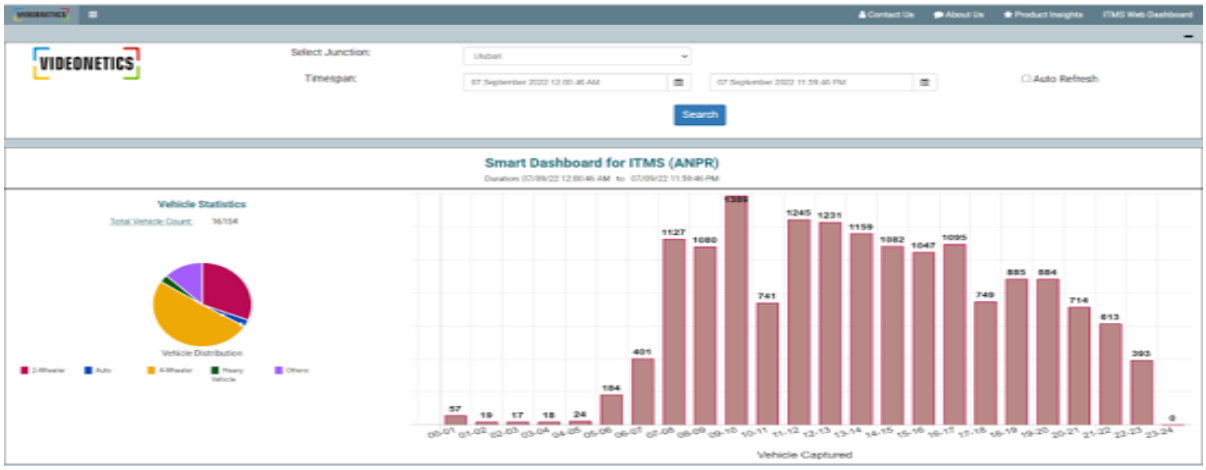


Figure 4.8 Smart dashboard for ITMS showing data of vehicles captured for traffic violations in Guwahati smart city

4.5.1 Effect of ICCC on Resident's QOL

The implementation of the ITMS in Guwahati has delivered substantial benefits to both the city administration and its citizens, enhancing the efficiency of urban management. Integration of online systems within the ITMS promotes collaboration across various city departments. This unified approach ensures compliance with standard operating procedures, fostering transparency and accountability in Guwahati city administration. The ITMS facilitates better city planning and development by providing valuable data and insights. The enhanced traffic management and safety measures contribute to local economic development. The system generates a lot of data which can be properly utilized through AI tools to significantly enhance

the urban transport network, ensuring that it becomes more efficient, safe, and reliable for daily commuters and residents alike.

4.6 Summary

In summary, Guwahati smart city is getting transformed with a more advanced public transportation system. New road networks with improved technological features are expected to reduce the bulging traffic congestions. Public bus transportation introduced in Guwahati is seen as a savior for regular city commuters as well as tourists. With more buses introduced and lesser travel cost as compared with other transportation options, it has definitely improved the quality of life in Guwahati. With our team having limited access to do a detailed analysis, the overall assessment chart is presented in Table 4.3.

Table 4.3 Assessment of smart city projects in Guwahati city

Key Performance Indicators (KPIs)	5 Star Rating
Accessibility	★★★★
Affordability	★★★★★
Frequency	★★★★
Reliability	★★★
User Satisfaction	★★★

Chapter 5: A Case Study on Itanagar Smart City

5.1. Introduction to Itanagar Smart City

Itanagar is the capital of Arunachal Pradesh which is the 24th State of the Indian Union from 20th April 1978 (Figure 5.1). Itanagar is popularly called the town of bricks and is named after Ita Fort (Fort of Bricks) which was built during 14-15 A.D. Itanagar is situated at the foothills of the Banderdewa Hills, surrounded by the Pachin and Papu Nallah rivers. It comes under the administration of Papum Pare district. The original settlement of Itanagar was at Naharlagun. The present-day Itanagar was initially known as New Itanagar. Over time, New Itanagar became the main city, while Naharlagun emerged as a satellite township, leading to the twin capital towns of Itanagar and Naharlagun.

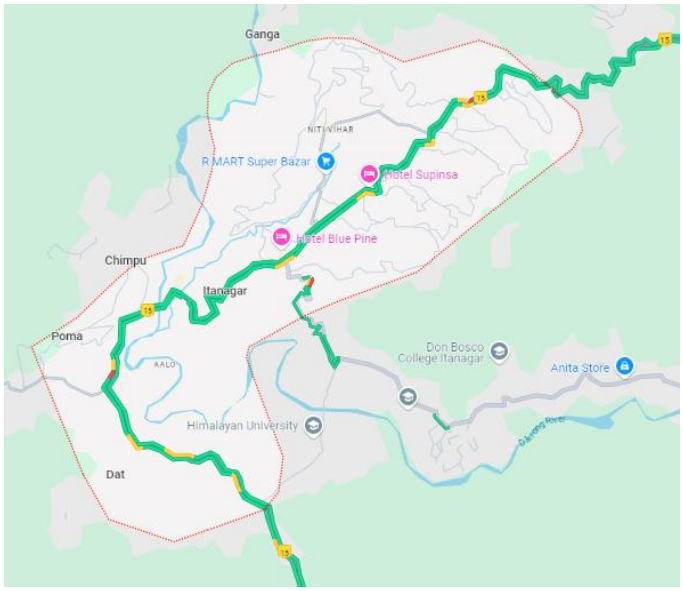


Figure 5.1 Itanagar map (source: Google maps)

Itanagar showcases the diverse tribal culture of Arunachal Pradesh through its museums and festivals. The city is surrounded by lush forests, mountains, and rivers, offering opportunities for trekking, wildlife spotting, and nature exploration. Some popular tourist spots in Itanagar include the Jawaharlal Nehru State Museum, Ganga Lake, Gompa Temple, and Itanagar Zoological Park. Itanagar was selected in the fourth round of the Smart City Mission and the project details are presented in Table 5.1. List of projects executed by Itanagar under SCM is presented in Table 5.2. They are classified into two categories: those that are completed and those that are ongoing.

Table 5.1 Project details of Itanagar smart city

Description	Data
Population	59,490
Area-Based Development (ABD)	1.1 Sq. Km
Total Budget for ABD	₹ 1,041.64 crores
Retrofitting	₹ 787.58 crores
Redevelopment	₹ 254.06 crores
PAN city development budget	₹300.92 crores
Overall budget for Itanagar Smart City	₹1,342.56 crores
Central government	₹500 crore
State government	₹500 crores
Convergence	₹292.24 crore
Private investment and PPP	₹43.8 crore
Other sources	₹6.52 crore
Total No. of Smart city projects	33 (Completed – 21, Under progress – 12)
Total No. of Public Transportation projects	13 (Completed - 5, Under development - 8)

Table 5. 2 Project details under Itanagar smart city

Completed	In Progress
1. Stormwater Drain in ICR	1. Multi-level automated car parking at the civil secretariat.
2. Drinking water Supply at TRIHMS	2. Street Furniture and signages in ICR
3. Bio-remediation of three dumping sites in ICR	3. Development of a Car parking facility at ICR
4. Smart Classrooms: 5 Schools with 28 Smart Classrooms	4. Place Making at Clock Tower, Ganga
5. River Rejuvenation at Yagamso	5. Development of Eco-Tourism Park at Hollongi
6. Retrofitting of Ita Fort, State Museum, Library Building etc.	6. Face-lifting of the Ganga market with Smart Vending facilities
7. Improvement of Capital Roads under CD-A and CDB	7. Development and retrofitting in Indira Gandhi (IG)PARK
8. Improvement of mobility and drainage service in ICR	8. C/o Bus Queue Shelter under Itanagar Smart City Phase-I
9. ICCC	9. Artisan -Cum-Handicraft Exhibition Centre, Itanagar

Completed	In Progress
10. Thin white topping concrete overlay on existing damaged flexible pavement for sustainable performance of roads in the area-based development locations of Smart City	10. Development of Multipurpose Vendor Market at Naharlagun
11. Dynamic Architectural illumination of Arunachal Pradesh Civil Secretariat Complex at Itanagar	11. Smart Gate at Banderdewa and Hollongi
12. Redevelopment of Niti Vihar Park, Itanagar as Gandhi Udhyan SH- Supply Installation of Park beautification items	12. Retrofitting of State Guest House-II at Itanagar
13. Infrastructure Development of IG Park, Itanagar, sub-head- Installation of stainless-steel benches	
14. Supply, installation, commissioning, integration, and testing of surveillance system, wireless networking, testing, and seamless integration with existing ICCC network with maintenance	
15. Development of Green Spaces	
16. Recreational Space under Itanagar & Naharlagun	
17. Redevelopment of Niti Vihar Park as Gandhi UdyanCivil Work	
18. Redevelopment of Polo Park, Naharlagun	
19. Development of Pedestrian sidewalks in Itanagar	
20. Development of AI-based fully automated smart Parking System at TRIHMS	
21. Development of smart toilets in ICR under Smart City Itanagar including Govt. Schools, colleges, public places, festival grounds, etc.	

Itanagar smart city concentrated on urban development with significant public transportation. Totally 13 public transportation projects are in the smart city mission of Itanagar City out of 33 total projects (Figure 5.2). PTI in Itanagar smart city focused on projects such as a smart parking system, bus shelter construction, cycle tracks, cycle4change, pedestrian walkways, street furniture and signages, smart gates, and ICCC (Figure 5.3).

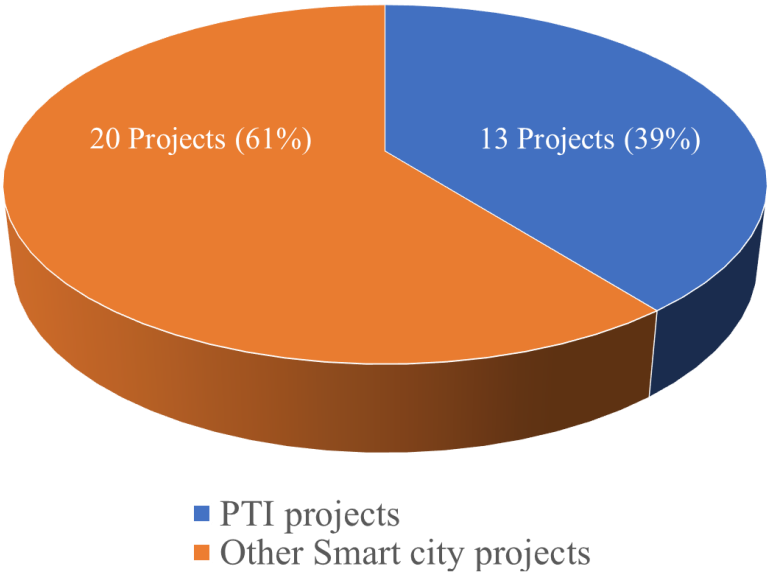


Figure 5.2 Pie chart comparing the Total No. of PTI projects with the Total No. of other Smart city projects

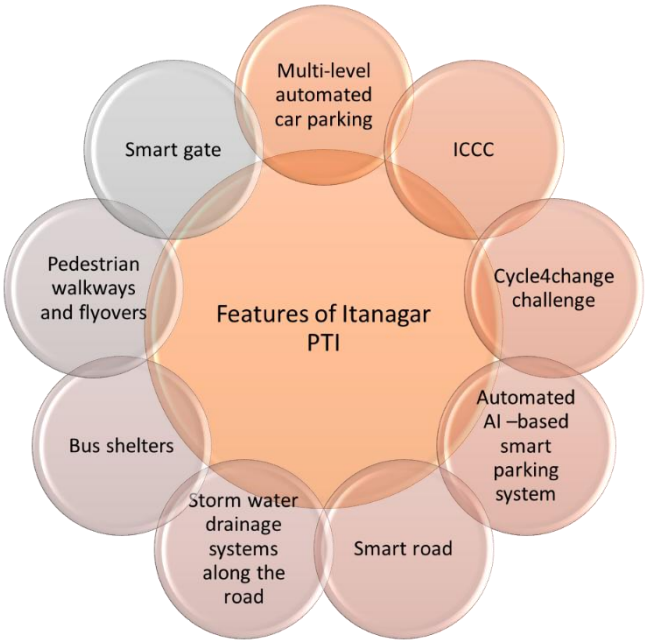


Figure 5.3 Features of PTI projects of Itanagar smart city

5.2. Multi-level automated car parking at the civil secretariat

The Civil Secretariat in Itanagar is upgrading its parking facilities with the introduction of a cutting-edge multi-level automated car parking system (Figure 5.4). This innovative project is designed to address the ever-growing demand for parking spaces in the bustling administrative centre, providing a modern solution that optimises space, enhances convenience, and promotes

sustainability. Itanagar, like many growing urban centres, also having a hilly terrain faces a significant challenge with parking space availability. As the city continues to expand and the number of vehicles increases, finding adequate parking has become a daily struggle for residents, government employees, and visitors, leading to congestion and inefficiency. This pressing issue has necessitated the development of an innovative and efficient parking solution.

Figure 5.4 Multi-level parking building in the civil secretariat at Itanagar smart city

Cars are stacked vertically in a series of tiers. This approach allows the parking facility to accommodate a significantly higher number of vehicles compared to conventional parking lots where citizens keep circling a parking lot in search of an empty spot. In a city where land is a precious commodity, this efficient use of space is invaluable. With the automated system, drivers simply drive their vehicles to a designated entry point. From there, sophisticated machinery takes over. Elevators, conveyors, and turntables work in harmony to transport the car to an available slot within the structure. This fully automated process eliminates the need for human intervention, ensuring a smooth and hassle-free parking experience.

Additionally, the restricted access to the parking structure enhances security, protecting vehicles from theft and vandalism. This convenience is particularly beneficial during peak hours, reducing the time spent waiting for a parking space or retrieving a vehicle. The facility also includes a passenger lift, ensuring easy access to all floors. The total capacity of this parking infrastructure is 108 cars.

- **Above Ground Levels (4 floors):** Each floor is designed to accommodate 12 sedan cars, resulting in a total capacity of 48 sedans.

- **Level 1 Below Ground:** This level can accommodate 12 sedan cars.

- **Levels 2 to 4 Below Ground:** These three floors are specifically designed for Sport Utility Vehicles (SUVs)

- **Additional Amenities**: The top floor of the parking structure is designed to enhance the overall experience for users. It includes a cafeteria, a gym, and toilet facilities, providing a space for relaxation and fitness for both government employees and visitors.

5.2.1 Effect of multi-level car parking on resident's QOL

Introduction of advanced parking solutions is expected to have a transformative impact on the Civil Secretariat and its surrounding areas. By streamlining the parking process, the system will alleviate traffic congestion around the Civil Secretariat, contributing to smoother traffic flow in the area. The convenience and ease of use provided by this automated system will greatly enhance the parking experience for all users, making visits to the Civil Secretariat more pleasant and stress-free.

Multi-level automated parking system aligns with the principles of sustainable urban development. By minimizing the need for expensive surface parking areas, the system contributes to the preservation of green spaces within the city. Furthermore, the reduction in idle time and the efficient handling of vehicles help decrease carbon emissions, supporting the city's environmental goals.

5.3. Automated AI-Based Smart Parking System at Tomo Riba Institute of Health & Medical Sciences (TRIHMS)

The capital city of Naharlagun witnessed the inauguration of a revolutionary fully automated AI-based smart parking system on Sunday, March 10, 2024, at the Tomo Riba Institute of Health & Medical Sciences (TRIHMS). This state-of-the-art project, the first of its kind in India, represents a significant leap forward in addressing the parking challenges faced by Itanagar, especially at TRIHMS as an inception (Figure 5.5).

Figure 5.5 Inauguration of AI-based smart parking system at TRIHMS

The AI-based smart parking system, developed using advanced Korean technology, is designed to maximize efficiency and space utilization. The facility consists of four towers, each with a capacity to accommodate 18 vehicles, bringing the total capacity to 72 vehicles (Figure 5.6). This innovative solution is poised to mitigate the parking distress prevalent in the area. The ground-breaking project, constructed by Itanagar Smart City Development Corporation Ltd at an estimated cost of 27 crore, sets a new benchmark in the country. Similar projects have previously been implemented in Indonesia, Bangladesh, and Sri Lanka. The system's infrastructure consists of prefabricated equipment, allowing it to be constructed in minimal space while maintaining robust performance.

Figure 5.6 AI-based Multi-level parking prototype model

- **Tower Design:** The parking system comprises four towers, each enclosed within a building structure. Each tower is capable of accommodating 18 cars, with a total load capacity of 500 tons per tray. The total height of each tower is 14 meters.

- **Proximity Sensors:** The system is equipped with 18 proximity sensors strategically placed to ensure the smooth movement of the car parking carriage trays. These sensors help guide the vehicles into position and prevent any potential collisions.

- **Automated Parking Process:** Drivers simply need to bring their cars to the entrance of any of the parking gates, which will open automatically. The parking chamber, equipped with sensors on all sides, will guide the driver to park the vehicle accurately.

- **Automated Retrieval:** Once the vehicle is parked, the automated system takes over, safely parking the car. When the driver returns, the system retrieves the car and brings it back to the parking door, ensuring a seamless and efficient experience.

- **Capacity:** Cars, with each floor accommodating 16 SUVs, resulting in a total capacity of 48 SUVs.

Itanagar Smart City Development Corporation Ltd had an agreement with TRIHMS to manage the collection of parking fees and operating expenses for 5 years. During the liability period, the company will also take responsibility for the maintenance and upkeep of the parking facility.

5.3.1 Effect of AI-automated car parking on residents' QOL

This AI-based smart parking system is a transformative addition to the infrastructure at TRIHMS. By leveraging cutting-edge technology, the project addresses the pressing need for parking solutions in Itanagar. Its successful implementation demonstrates a commitment to innovation and sets a precedent for future developments in smart city infrastructure across India. With a limited availability of space, this parking tower has significantly reduced the parking congestion within the premises and reduced the street parking outside the premises, thus improving the traffic flow in this core city zone.

5.4. Smart Road in Itanagar City

Smart road in Itanagar city has a pedestrian footpath and utility duct along NH-415 for 5.8 km and along TT Marg road for about 2.5 km. Three junctions such as Bank Tinali, Secretariat and July Basti junction were equipped with Intelligent Transit Systems (ITS) under the smart road project. Itanagar city is in the process of enhancing its urban landscape with the introduction of modern street furniture and signage. Smart roads equipped with Solar LED street lights,

signage boards, and VMS along the NH 415 for about 5.8 km. The smart road was constructed with solar-powered glow-in-the-dark trails for about 2.5 km along TT Marg road. These glow-in-the-dark trails give aesthetic value and give clear nighttime visibility. These additions improved the functionality, aesthetics, and overall experience of public spaces, contributing to a more organized, disciplined, safer and visually appealing city environment.

5.4.1 Effect of smart roads on resident's QOL

The installation of street furniture and signage in Itanagar City is a strategic initiative to create a more user-friendly and attractive urban space. These elements are designed to cater to the needs of a diverse population, including pedestrians, cyclists, and motorists. By improving the infrastructure and aesthetics of public areas, this project enhanced the overall quality of life for residents and visitors alike.

5.5. Storm-water drainage systems at Itanagar City to avoid traffic congestion and disruption

Urban flooding has become an increasingly severe issue in recent years, causing significant socio-environmental hazards such as traffic congestion and disruptions to urban life. Notable instances of flooding had devastating impacts, both economically and in terms of loss of life. Addressing this growing threat of urban flooding necessitates a well-organized approach to storm-water management with proper planning, design, construction, and maintenance of urban storm-water drainage systems, focusing on how to mitigate flooding effectively. Since Itanagar is a very rainy region throughout the year and it gets heavy and extreme rainfall during the monsoon; accurate rainfall data is essential for effective stormwater management. Historical rainfall patterns should be analyzed to predict the volume of stormwater that the system must accommodate. Itanagar's existing stormwater drainage system comprises a mix of open drains and rudimentary pipelines. These systems have struggled to handle the increasing volume of runoff due to rapid urbanization and inconsistent maintenance. The city has experienced several instances of urban flooding, particularly during the monsoon season. Inadequate drainage capacity, poor maintenance, and blocked drains have exacerbated these problems. The current drainage infrastructure is insufficient to manage peak stormwater volumes, leading to frequent waterlogging and flood risk and heavy water flow over the national highway throughout the city. This Smart City Project has modernized Itanagar's stormwater drainage infrastructure by replacing outdated systems with more efficient ones.

This includes installing new RCC (Reinforced Cement Concrete) box drains and improving existing pipelines.

5.5.1 Box Drains

RCC box drains are specially designed to manage large volumes of stormwater in areas with heavy vehicular traffic. These drains are constructed to withstand significant loads and are capable of directing substantial amounts of water to designated disposal points. For optimal performance, box drains should be installed at intervals of 15 to 30 meters along streets. The drains need to be placed 200 to 300 mm below ground level and at a suitable gradient to ensure efficient flow. Access holes should be spaced every 30 meters to facilitate routine cleaning and maintenance, which are essential for preventing blockages and ensuring the system's effectiveness.

5.5.2 Kerb Inlets

Kerb inlets are vertical openings built into the road kerb, often equipped with diagonal notches or ridges that help guide stormwater into the drain. These inlets are particularly suited for areas with heavy traffic, where effective storm-water management is crucial. The notches or ridges in kerb inlets are designed to direct water flow and prevent surface water accumulation, which can cause dangerous conditions for both pedestrians and vehicles. By managing surface water efficiently, these inlets help reduce traffic hazards and improve overall safety on roadways.

The project is being implemented in phases, with priority given to areas most prone to flooding and those with the highest urban functionality, traffic congestion and critical areas. This phased approach ensures that improvements are made where they are most needed, optimizing resource allocation.

5.5.4 Problems in Stormwater Drainage System

The stormwater drainage system in Itanagar City faces several challenges. The new drainage system is often insufficient to handle heavy rainfall, leading to waterlogging and flooding in various parts of the city. Lack of regular maintenance and cleaning of drains results in blockages, reducing their capacity and exacerbating flooding issues. Rapid growth of the city has also put a strain on the drainage infrastructure, which was not designed to handle the increased volume of stormwater. Illegal encroachments on drains and water bodies further hinder the flow of stormwater, contributing to flooding.

5.6. Bus shelter construction under Itanagar Smart City Phase-I

As part of the Itanagar Smart City Phase-I initiative, the construction of bus shelters is a pivotal project aimed at improving public transportation infrastructure. These shelters are designed to enhance the commuter experience, protect from weather elements, and promote the use of public transportation (Figure 5.7). The shelter has provision for advertisement display and the revenue generated through them shall help in maintaining the facility.

Figure 5.7 Bus shelter under construction during the inspection by the IIT Bhilai team

5.7. Development of Pedestrian Sidewalks in Itanagar

The development of pedestrian sidewalks in Itanagar is a key initiative under the city's Smart City Project (Figure 5.8). This project aims to create a safer, more accessible, and pedestrian-friendly urban environment. By improving sidewalks, the city hopes to encourage walking, reduce traffic congestion, and enhance the overall quality of life for its residents. The rapid development of Itanagar has highlighted a critical need for improved pedestrian infrastructure. The lack of adequate pedestrian walks and zebra crossings has led to numerous road accidents, posing a serious safety concern for the city's residents.

Figure 5.8 One of the pedestrian sidewalks with safety railings

5.7.1 Shortcoming with the pedestrian sidewalks

Pedestrian walkways provide safe and convenient paths for pedestrians. Modern sidewalks constructed by the smart city team have been received very well by the residents. More such pedestrian walkways are needed throughout the city, providing a network of sidewalks for the citizens. The scarcity of proper pedestrian walks and zebra crossings has significantly contributed to numerous road accidents. Pedestrians often have no choice but to walk on the roads, mingling with vehicular traffic, which drastically increases the risk of accidents and also reduces the efficiency of motorized vehicles' traffic.

Some existing footpaths could be revamped to give them new life. The railings that separate them from the roads are battered and rusted, with many already having collapsed. These deteriorated railings have turned previously designated footpaths into parking spaces, rendering them useless for pedestrians.

There are four pedestrian flyovers in the region, three in Itanagar and one in Naharlagun, located near major hospitals and schools. Despite their intended purpose to facilitate safe road crossings, these flyovers are rarely used by citizens due to poor maintenance and lack of awareness about their benefits.

Addressing these challenges through comprehensive improvements and expansions in pedestrian pathways, enhancing safety features, and maintaining existing infrastructure is essential for creating a safer, more accessible, and pedestrian-friendly city. These efforts will

not only protect the residents but also foster sustainable urban development and a higher quality of life in Itanagar.

5.8. Smart Gate at Banderdewa and Hollongi

The implementation of Smart Gates at Banderdewa and Hollongi marks a significant step in enhancing security, monitoring, and traffic management in Itanagar. These strategic entry points to the city are crucial for maintaining order and safety, and the introduction of advanced technology through Smart Gates will bring substantial improvements. This initiative not only addresses current challenges but also sets the stage for a smarter, safer, and more efficient urban environment in Itanagar. The smart gate, which is expected to be opened soon, shall enable smooth entry and exit of tourists among others to and from the capital city of Arunachal Pradesh.

5.9. Cycles4Change Challenge

The Cycles4Change Challenge is a significant initiative launched by the Ministry of Housing and Urban Affairs to promote cycling as a mode of transportation in Indian cities on 25th June 2020. Itanagar was selected for this Cycles4Change challenge (Figure 5.9). Developed dedicated cycling infrastructure, including cycle lanes and paths. Organized cycling events, campaigns, and workshops to encourage people to cycle. Implemented measures to make cycling more accessible, such as bike-sharing schemes and secure parking facilities.

Figure 5.9 Cycles4Change ride in action at Itanagar smart city

5.10 ICCC

ICCC was developed at the Itanagar smart city office. Some of the ICCC systems that were designed and developed for Itanagar City are

- Real-time monitoring and evidence-based planning: Real-time city-wide capturing of events across the city

- Enables centralized and integrated ICT solutions: Detection of unusual activities by using smart field devices and taking prompt action

- Single point aggregation of information for monitoring: Prioritizing and coordinating actions and pro-actively deploying assets to address and potentially prevent multiple, complex incidents

Figure 5.10 ICCC room visited by Honorable CM Shri Pema Khandu at Itanagar smart city

5.10. Summary

While large-scale public transportation infrastructures such as buses were not brought in through the smart city mission in Itanagar, minor additions including state-of-art parking facilities, walkways, etc. have significantly changed the resident's lifestyle in the city The overall assessment based on KPIs is presented in Table 5.3.

Table 5.3 Assessment of smart city projects in Itanagar city

Key Performance Indicators (KPIs)	5 Star Rating
Accessibility	★★★★★
Affordability	–
Frequency	–
Reliability	–
User Satisfaction	★★★★

Chapter 6: A Case Study on Jammu Smart City

6.1. Introduction to Jammu Smart City

Jammu, a historic city (Figure 6.1) and the winter capital of the Union Territory of Jammu and Kashmir is undergoing a transformative phase as part of India's smart city initiative. Selected in the third round of the smart city, its strategic location makes it a significant hub for administration, tourism, and regional development, warranting modernization and improved infrastructure in the state of Jammu & Kashmir.

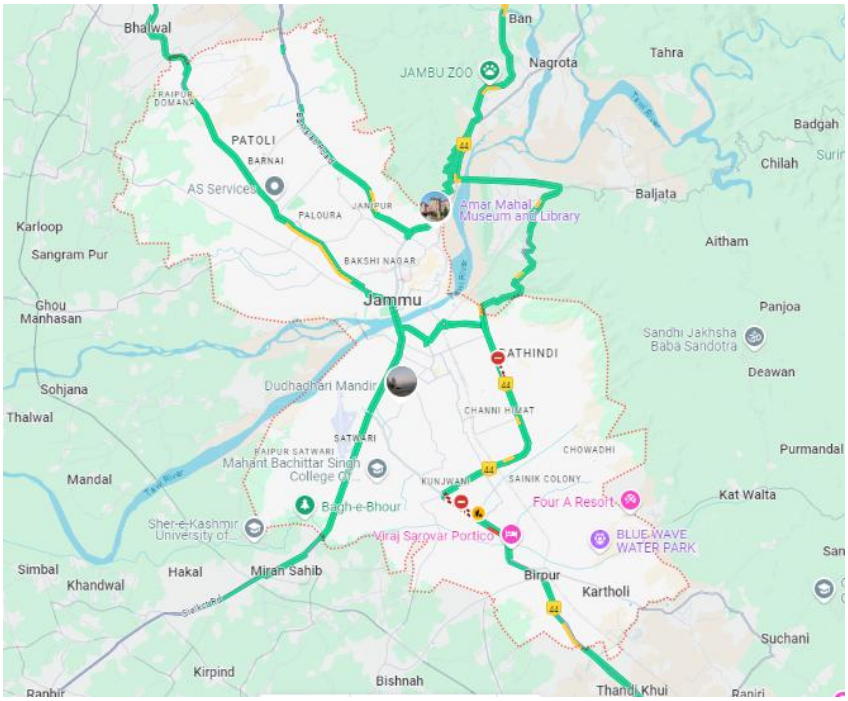


Figure 6. 1 Jammu city map

The smart city projects for Jammu are comprehensive development efforts designed to enhance urban infrastructure, promote sustainability, and improve the quality of life for its residents. The comprehensive financial backing demonstrates a strong commitment to transforming Jammu into a state-of-the-art smart city, focusing on sustainable growth, improved infrastructure, and enhanced urban management. Table 6.1 lists prominent details about Jammu's smart city.

Table 6. 1 Details on Jammu smart city

Description	Details
Area	240 Sq.km
Population	5,02,197
Total budget	₹3,464.49 crore
Area-based development (ABD)	₹2,774.11 crore
PAN component	₹690.38 crore
Contingencies	₹173.22 crore
Central Government	₹492.00 crore
State Government	₹492.29 crore
Convergence of funds	₹1,650.18 crore
Private investments and Public-Private partnerships (PPP)	₹1,003.00 crore

The Jammu Smart City Limited (JSCL) and Jammu Municipal Corporation (JMC) have initiated several PTI projects (Figure 6.2) for Jammu City to improve urban mobility and reduce traffic congestion around the city (Table 6.2). There was construction of a ring road around Jammu City to manage traffic problems and to increase connectivity across other districts of Jammu and Kashmir under Bharatmala Pariyojna Phase-I. It consists of the construction of 8 flyovers, 16 underpasses, 4 viaducts, 31 minor bridges, 8 major bridges, 255 culverts, Intersections, and Service roads.

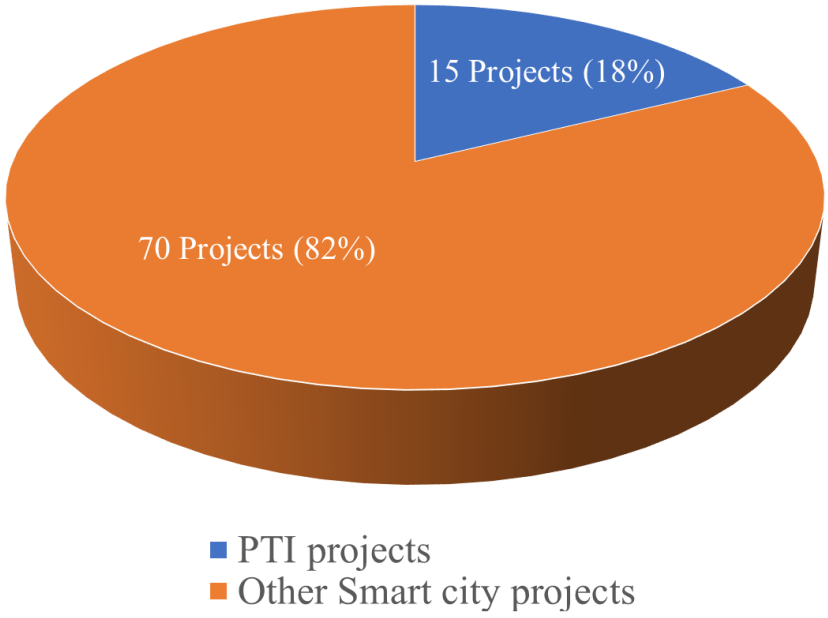


Figure 6.2 Pie chart comparing the Total No. of PTI projects with the Total No. of other Smart city projects

Table 6. 2 Details on PTI projects in Jammu Smart City

Completed	In Progress
1. Signages and Wayfinding	1. Complete Street Development - Canal Road - Talab Tilo
2. Multilevel Parking at Bus Stand	2. 23 Junction Improvement (Phase 2)
3. eAutos (EV Passenger 3-Wheelers)	3. Construction of Water Fountains / Curtains
4. Improvement of the Road from KC Chowk to Dogra Chowk	4. Tawi River Front (Construction of Promenades & other Utilities) and Real Estate Development - TRF (Phase-2)
5. Complete Street Development NW-3: Apsara Road "High Street" Gol Market area along with adjoining roads	
6. Complete Street Development NW-4: Trikuta Nagar (Tawi Canal Road) from Gorkha Nagar to Railway Station, along with Blue-Green project of Tawi Canal	
7. Jammu Smart Public Bicycle Sharing System	
8. Blue Green Project - Ranbir Canal BSF Paloura to Pawan Ice Cream Intersection	
9. Refuse Compactor	

Completed	In Progress
10. Smart City Policing (Equipment for District Police lines) 11. Smart Schools and Modernization of School Infrastructure	

PTI projects in Jammu City concentrate on multilevel parking, road infrastructure improvements, smart streets, BSS, riverfront redevelopments with walkways and footpaths, signages and wayfinding, e rickshaws, etc., (Figure 6.3)

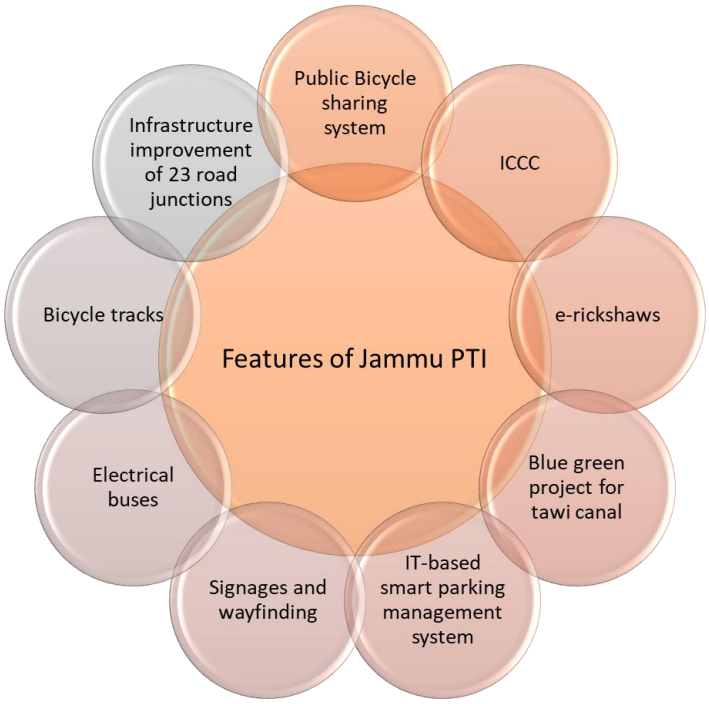


Figure 6.3 Features of PTI projects of Itanagar smart city

6.2 Public Bicycle Sharing System

The Project Cost of the Public Bicycle Sharing System is around ₹6.50 Cr. with nearly 820 bicycles procured and installed in nearly 100 docking stands covering Jammu city. Among that 80 are Pedal assist electric bikes and 720 are unisex bicycles. The public can use it by scanning a QR code and paying online. The payment packages include monthly, weekly, and pay-per-use schemes. Most college students are using this for transportation. App-based and GPS-enabled locking and tracking system was installed for smart usage (Figure 6.4).

Figure 6.4 Bicycle with the digital lock at Jammu smart city

Aadhaar & JSCL Apps were linked for user registration. Users can check out from any stand/check in at any stand. The booking process is simple with one click registration. Executing agency of BSS is JMC (Figure 6.5).

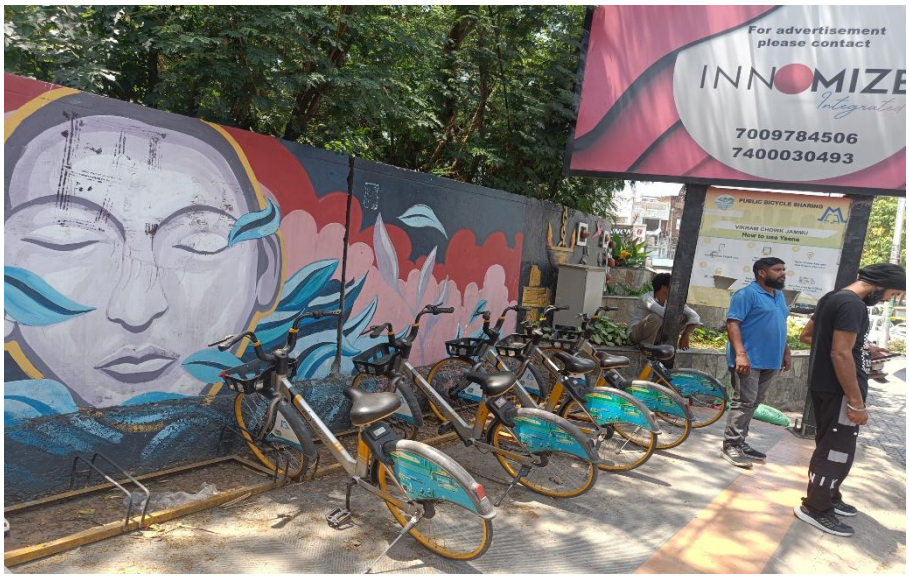


Figure 6.5 Bicycles kept at a docking station for public sharing

6.2.1 Problems in BSS

The cost per use comes down to 50 paise per 30 minutes as well. However, even though this is economical, it has not led to widespread adoption. Upon investigation, it was found that since the weather in Jammu is hot and sunny people prefer to not use bicycles and opt for other means of transportation.

6.3 Infrastructure Improvement of 23 Road Junctions

The project cost is around ₹ 32.00 Cr. Geometric improvements were done for road junctions in Jammu smart city. Dedicated places were developed for Pick-up/ Drop-off locations on the roads. Street furniture was kept at junctions. The tree line was designed aesthetically and kept along the road line (Figure 6.6).

Figure 6.6 Street furniture and tree line on the road at Jammu Smart City

A bus stand is constructed around those junctions. Traffic signals were constructed strategically. Catch pits were constructed on the road sideways for rainwater drainage.

6.4 e-Rickshaws

The implementation of subsidies for the purchase of e-rickshaws under the smart city mission seems to be a positive step towards promoting sustainable transportation and creating job opportunities. Here are some key points from the information provided:

Types of e-rickshaws:

I. L3 e-rickshaw: These have a lower speed (25 km/hr) and may struggle on slopes, making them more suitable for flat areas or shorter distances.
II. L5 e-rickshaw: These have a higher speed (beyond 25 km/hr), making them suitable for longer distances and potentially more efficient for commercial use.

The subsidies have led to the sale of approximately 700 e-rickshaws, indicating a significant increase in adoption. The e-rickshaw industry has created job opportunities for many individuals, contributing to the local economy. The JSC is working on creating dedicated routes for e-rickshaws to minimize traffic congestion and ensure their smooth operation. Currently, e-rickshaws are not allowed on high-speed roads so that they dont slow down the traffic.

This project won the 'Award of Excellence in Urban Transport' at the 17th Urban Mobility India Conference and Expo held in Gujarat on 27th October 2024. The award was given by the Union Minister for MOHUA Manohar Lal Khattar, in the 'City with Most Innovative Financing Mechanism' category.

6.4.1 Scope of improvement

Investing in infrastructure, such as charging stations and dedicated lanes, can further promote the use of e-rickshaws and improve their efficiency. Providing additional incentives for businesses to adopt e-rickshaws can help reduce pollution in urban areas. However, it also needs to be noted that e-rickshaws cannot and shouldn't be allowed on all roads as they are slower than the other moving traffic and can often cause traffic congestion. Moreover, e-rickshaws are open from both sides without complete protection of passengers from both sides and are lightweight. Hence implementing safety regulations and safe driving training programs for e-rickshaw drivers can ensure the safety of both drivers and pedestrians.

6.4.2 Effect of e-rickshaws project on Resident's QOL

- **Improves end-mile connectivity**, which is a major issue in the city of Jammu where public transportation systems are not yet well developed. The roads of the city are narrow, and hence inaccessible by the heavily used private bus operators. Small minibuses which can go into small roads, well known as matadors, are also run by private operators who do not maintain their matadors making the journey in these troublesome for the users. These small narrow places can be easily covered by e-rickshaws, thus providing end-mile connectivity to the populace instead of having to always rely on matadors run by private companies which do not always run on time schedules.

- **The financial health of the auto drivers:** The Project was implemented during the non-tourist season and hence feedback from tourists was not possible. However, an investigation of drivers who have received the JSM subsidies revealed that they are happy and content with the scheme. They mentioned that their daily earnings from transporting customers were sufficient to sustain them and their families. It was adequate to take care of their children's education as well.

- **Financial health of commuters:** The rates of rickshaw rides are not yet regulated by the state, but are being managed to keep them at reasonable levels by increasing the supply of e-ricks on the road, which helps keep the transport rates competitive.

6.5 Blue-Green Project for Tawi Canal

The project cost is around ₹ 18.18 Cr. The project is about the construction of walkways with paver tiles on both sides of the canal (Figure 6.7).

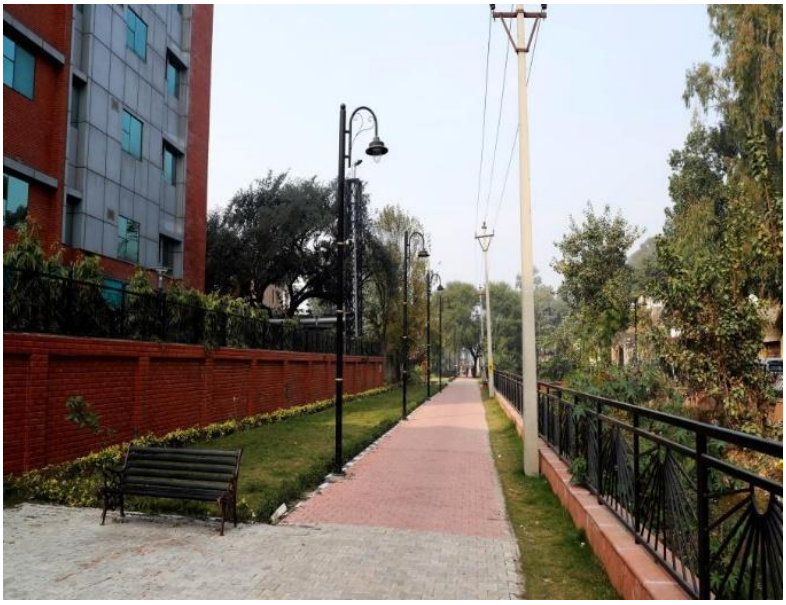


Figure 6.7 Walkway in Tawi Canal at Jammu Smart City

The canal of the RCC parapet was built with red sandstone cladding and railing on both sides of the Tawi River Canal. Green spaces and plantation work were developed along the canal at various locations. Construction was done for double-storied parking with a 40-vehicle parking capacity. Decorative street lighting was done on both sides of the canal. The construction of public toilets and renovation of the park at Gorkha Nagar was completed for public use. Renovation work was done for the existing damaged canal lining. Pedestrian bridges were built to connect the left and right sides of the Canal bank.

6.6 Smart Traffic Police Booth

The project Cost of the Smart Traffic Police Booth is around ₹ 0.63 Cr. JSCL is the executing agency of this project. Smart Traffic Booths were installed at 25 locations around Jammu city. The traffic booths are pre-fabricated using 50 mm thick Poly Urethane Foam (PUF) panelling walls and prefabricated single-unit toilets (Figure 6.8).

Figure 6.8 Smart Traffic Police Booth installed at Jammu Smart city

Single-unit prefabricated toilets are also provided at locations where there is no public or community toilet in the near vicinity. Thermal insulation in the wall panels and roof panels was done to maintain a pleasant temperature inside the booths.

6.7 IT-based Smart Parking Management System

The project cost is around ₹ 9.0 Cr. A parking app was created for users where it will go live at 10 Locations. This app is used by users to check parking slot availability, guidance, access, payment, occupancy, traffic, and updates. This parking system is used to reduce traffic congestion and improve parking efficiency by real-time monitoring and management (Figure 6.9).

Figure 6.9 Smart parking system at Jammu smart city

6.8 Signages and Wayfinding

Efficient signage and wayfinding are needed for any urban area for any visitor new to the city. Strategically placed signage and wayfinding all over Jammu city helped the visitors to discover new places and navigate efficiently without any delay. Signages were kept at key traffic junctions of the Jammu city for effective navigation (Figure 6.10). The project cost is around ₹10.38 Cr. JSCL is the executing agency. The project was completed and handed over to JMC.

Figure 6.10 Large signage across a major highway in Jammu

In addition to this, advertisement panels and dashboard displays were installed at various intersections of Jammu Smart City and street lights were installed at 10 locations under SCM. The project cost is around ₹3.48 Crore. JMC was the executing agency. The project started in December 2021 and completed in June 2022.

6.9 Electric buses

100 e-buses have been employed in Jammu, of which 75 run on routes within the city and 25 on intercity (Figure 6.11). Each of these buses is equipped with a hydraulic lift for lifting persons in wheelchairs. They are quality-checked and can withstand heavy loads. For easier transportation, the "Chalo app" was launched in January 2024, which provides those using it with the time schedules of the buses and routes.

Figure 6.11 AC electrical bus in Jammu smart city

6.9.1 Scope of improvement

The buses currently operate only in the brownfield areas, which are the municipal areas as mandated by the JSCL. The green field areas which are on the outskirts of the city are not yet covered in the bus's circuits and are not in the JSCL's mandate. Buses should also be launched in greenfield areas.

6.9.2 Effect of bus transportation on resident's QOL

1. **Safety features that can lead to psychological safety:** The buses are also equipped with CCTV cameras inside, dash cams on the outside, panic buttons, and GPS systems. Importantly the bus won't move until the doors are closed which is an important safety feature. The presence of CCTV cameras will dissuade pickpockets inside the buses. These will lead passengers to feel psychological safety as long as there is awareness about these features. A suggestion towards this is that these features be flashed on the LED screens inside the bus, to educate the passengers about these safety features to promote psychological safety.

2. Reliability of timing and air conditioning leading to psychological satisfaction: The buses always start on time from the starting point. Accounting for traffic congestions, these buses reach their designated stops at near the correct timings leading to greater satisfaction with reaching destinations on time. This also reduces the dependence on private bus operators who move from the stop only when the bus is full leading to delays in reaching respective destinations by commuters. Furthermore, since the Jammu climate is very hot during summers

which starts as early as March and lasts till June, the air-conditioned buses are preferred by the commuters.

3. **Increasing employment:** Employment of these buses has also provided jobs to many as bus drivers and ticket collectors, indirectly affecting their purchase power and contributing to economic upliftment.

6.10 Multi-level Parking

A 3-level parking lot has been constructed in the old city of Jammu. This area is more hilly as compared to the rest of the city and therefore there is a dearth of vehicle parking. This has taken the load off of the roads considerably.

Figure 6.12 Three level parking in Jammu's Old City

6.10.1 Scope of improvement

A lot more work is required to be done in the old city which has narrow cobbled roads such that only one vehicle can move in one direction at a time. The roads have been mostly covered by the JSCL with cobbled stones to increase their durability. However, whether such roads are good for vehicles is still questionable. More focused research needs to take place on the effect of these cobbled roads on pedestrian knees specifically and vehicle life.

Due to lack of space in the old city, the JSCL is searching for more places where vehicle parkings can be created. This will significantly reduce the burden on the existing roads and create safer spaces for pedestrians.

APSARA Road walking plaza

A major market place in Jammu, known as the Apsara Road was cleared of hawkers and vendors on the road, the road was widened and cobbled stones were used to reconstruct it to make it more durable. Vehicles (other than two-wheelers) are no longer allowed to enter this area, making the space less congested and safer for pedestrians. Hence a walking plaza was constructed here with wide footpaths as well. These footpaths have markings for the visually impaired. At the crossroads, the road has been leveled to make it easier even for physically disabled persons to cross from one end to the next. Open drains have been covered.

6.11 ICCC

ICCC with Data Center, ITMS, and eBill Pay for Civic Services including Bandwidth and Cloud platform were constructed with a budget of around ₹ 143.76 Cr. (Figure 6.12). It is used for real-time monitoring and control of all departments of JMC and the integration of various services rendered by JMC through apps and data centres to the residents of Jammu City. ICCC is used for effective traffic management, safety and crowd surveillance. ICCC is used for maintaining web portals and apps for sharing information about various e-governance and public transportation. JSCL is the executing agency.

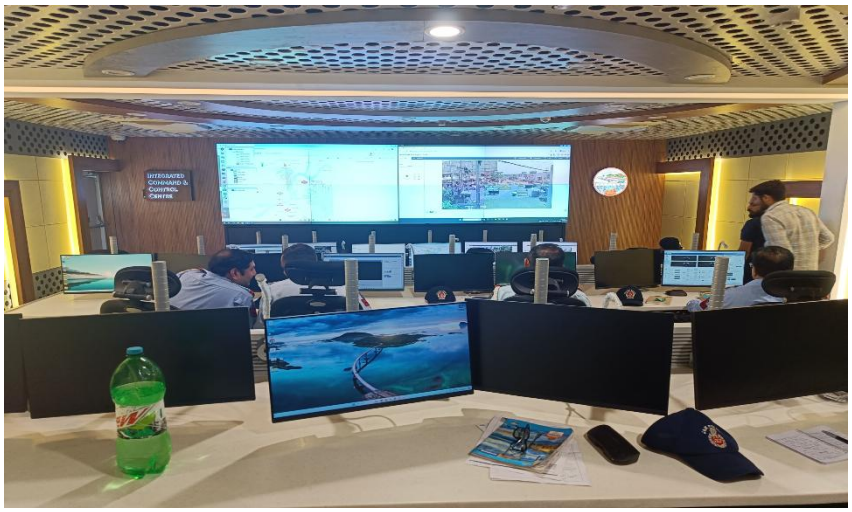


Figure 6.13 ICCC data centre room at Jammu smart city

6.11.1 Problems in ICCC

CCTV cameras have been installed at a few large chowks. These help in monitoring traffic violations and auto-generated challans. However these challenges, like in other cities with integrated traffic control systems, require to be manually verified. Jammu being an old city has

less space for the construction of such offices hence currently it can accommodate about 20-25 workers. No specific problems in manually generating challans were reported by any of the employees.

6.12 Other Transportation Projects

- The Jewel Chowk's height was reduced to promote visibility of the city skyline.

- "Bolats" were erected on the Dogra-KC Chowk.

- An enormous garbage dumping ground was removed from near the Jammu Aknoor road, which is also near the canal. This has reduced considerable bad smell in the air and likely reduced the risk of disease to nearly resident colonies.

- 80 kiosks are to be made for vendors near the parks which are situated near roads (mostly the Jammu-Akhnoor road). These are expected to provide more employment opportunities. These parks have been constructed in the last 18 months and do seem to contribute to the beauty of the roads and the city.

- Embankments along the roads in hilly areas have been constructed in some places to prevent the hillside soil from falling onto the road. These have also been painted to beautify the city.

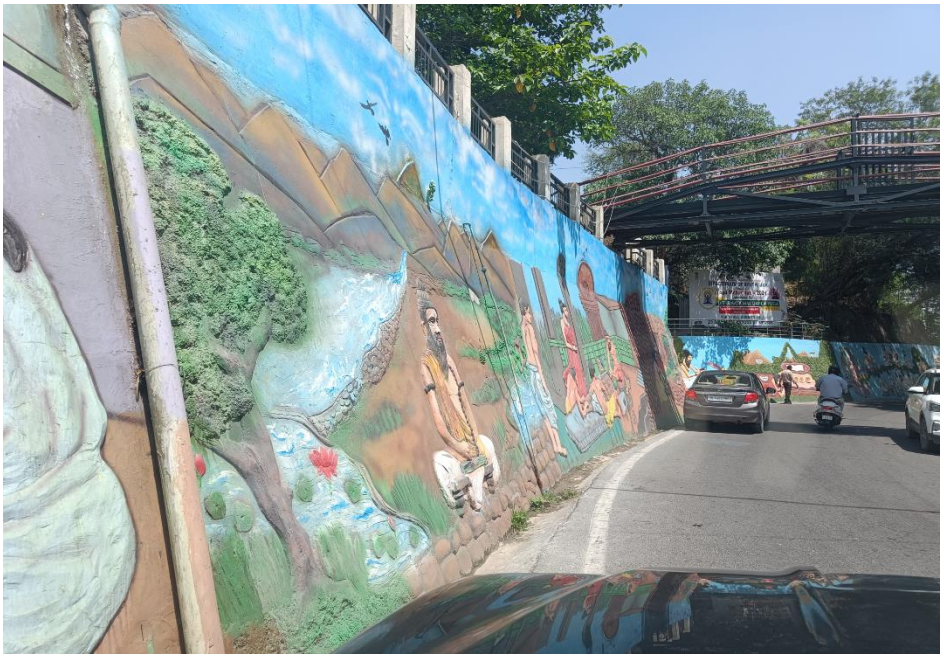


Figure 6.14 Embankments along a hilly road near a hospital

- Vertical gardens were constructed at multiple locations, such as in front of a major hospital, and on the pillars supporting flyovers (Figure 6.13). The project budget is around ₹ 3.80 Crore. These do add to the beautification of the city. However, the maintenance of these is poor due to extreme heat in the summer weather.

Figure 6.15 Vertical gardens installed under Jammu smart city flyovers

- Parking markings using road paints have been made on relatively wider roads so that improperly parked cars and auto rickshaws do not cause traffic congestion.

- Four cycle tracks were constructed around the city. The project cost is around is ₹2.07 Cr. JSCL was the executing agency. The project started in January 2022 and was completed in March 2024 (Figure 6.14).

Figure 6.16 Cycle track constructed in Jammu Smart City

- Peerkoh Walkways (Figure 6.15) were constructed around the Jammu smart city. The project cost is around ₹3.87Cr. It was started in January 2021. Executing Agency is the JMC.

Figure 6.17 Peerkoh walkways in Jammu smart city

- City Chowk Parking was constructed and the parking capacity is around 352 Cars & 168 Bikes (Figure 6.16). The project cost is around ₹ 62.00 Crore.

Figure 6.18 City Chowk Parking

- Ramp-based multi-car parking was constructed at the General bus stand. Parking capacity is around 80 Buses and 1312 Cars (Figure 6.17). The project cost is around ₹201.66 Crore. The executing agency is the Jammu Development Authority (JDA).


Figure 6.19 Ramp-based multi-car parking at General bus stand

6.13 Problems in the PTI projects of Jammu city

- The smart city mission covers only the municipal areas and therefore adequate road construction and street lights on the outskirts of the city fall outside the jurisdiction of the JMC. However, these need to be given priority as well to ensure smooth and safe transportation facilities, especially concerning women's safety.

- The introduction of the electric buses has seen resistance from the local transporters as this reduces the commuters' dependence on them thus causing the flow of profits away from their business.

- The metro line that was to be constructed has not yet been made. Also, a new road was to be constructed between the railway station and Janipur road to Greater Kailash which had to be dropped along with a greenery project along the same line. Construction of a parking space under a flyover also had to be dropped due to NHAI norms.

6.14 Possible suggestions for improvement

Bus timing plaques can be put at the bus stops. More seating spaces that are covered by the sun can be created to promote usage of bus stops which will reduce the overflow of the waiting passengers onto the streets, increasing the drivable space.

Figure 6.20 Bus stop with water harvesting roof

Currently, it was observed that even though bus stops have been constructed, they are constructed in a manner that does not provide adequate shade for commuters from the excessive heat and sun. There is also a lack of seating spaces at these bus stops. Hence very few people use these bus stops. This may perhaps be because previously successful models from other countries were being followed. As can be seen from the images attached, the bus stops were created to collect rainwater. While it is successful in this endeavour, given the nature of heat and the temperate climate of our country, combining this design of water collection with providing shade should be attempted.

The canals near the roads require proper maintenance such that regular cleaning of these is done. People can be employed to clean these which will also increase employment of the local people. Currently, these canals are covered in garbage in many places. On many roads, the electrical wirings are extremely tangled and at some places almost touch the ground. These can be detangled and laid down to prevent mishaps and injuries.

6.15 Ongoing projects

1. The roads in the old city are narrow but have a heavy footfall of both pedestrians and large vehicles as this area is highly populated. Currently, work is underway to make the roads more durable by using cobbled stone to reconstruct them. Parking spaces have been identified and these are under construction.

2. The construction of the riverfront project is underway. These will have walkways, parks, and bicycle tracks. The plan for this project is shown in the image below.

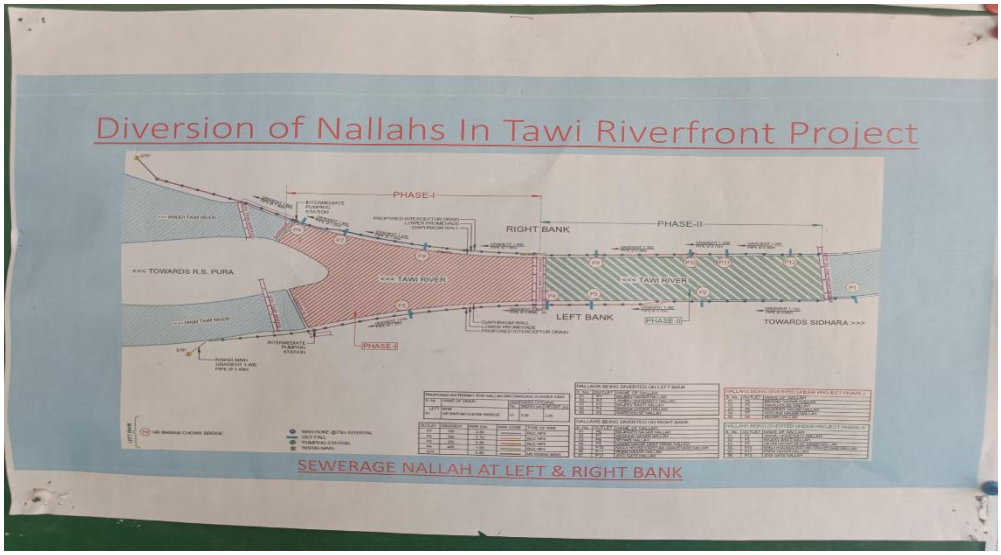


Figure 6.21 Plan for the Tawi riverfront project

6.16 Summary

Jammu smart city has made its focus towards improving the quality of life for its residents by through enhanced public transportation system. Subsidizing e-rickshaws, adding buses to the public transport pool, bicycle system as a healthy alternative are some of the key projects taken up by Jammu that are worth a mention. The overall assessment based on KPIs is presented in Table 6.3.

Table 6. 3 Assessment of smart city projects in Jammu city

Key Performance Indicators (KPIs)	5 Star Rating
Accessibility	★★★★★
Affordability	★★★★★
Frequency	★★★★
Reliability	★★★★
User Satisfaction	★★★★

Chapter 7: A Case Study on Raipur Smart City

7.1. Introduction to Raipur Smart City

Raipur, the capital of Chhattisgarh, is a significantly growing urban center in Central India, known for its rich culture, history, and steel markets (Figure 7.1). As a major trade hub, Raipur holds the significance of India's largest steel market. The city is undergoing a significant transformation as part of the SCM and that has enhanced the city's infrastructure, services, and overall quality of life. Major improvements were made in road networks, flyovers, and underpasses to reduce traffic congestion, in public transportation systems, such as buses to improve connectivity, and footpaths and cycle lanes to promote non-motorized transport.

Figure 7. 1 Raipur City map (source: raipur.gov.in)

More Raipur City Central (MRCC) is a significant urban renewal project aimed at transforming the heart of Raipur. This 777-acre area, encompassing the city's Central Business District (CBD), has undergone a comprehensive retrofit and redevelopment. The project has revitalised the central area of Raipur by improving infrastructure, enhancing public spaces, and promoting sustainable development. It has created a more livable city center by providing better housing, transportation, and recreational facilities. It has boosted the local economy by attracting investments and creating jobs. Table 7.1 lists the statistical significance of the Raipur smart city project.

Table 7. 1 Smart city project details of Raipur city

Description	Details
Raipur city area	226 Sq. Km
Population	1,047,389
Households	215,227
Total budget	₹ 3,940 crores
Area-Based Development (ABD)	9.75 Sq. km
Infrastructure upgrades, urban mobility solutions, and smart governance	₹ 3,655.10 crores
Pan-City development	₹ 284.90 crores
Retrofit projects area	777 acres
Budget of retrofit projects	₹ 3,454.19 crores
Redevelopment projects	1,633 acres
Budget of Redevelopment projects	₹ 200.91 crores
Central Government	₹ 482.50 crores
State Government	₹ 482.50 crores
Convergence	₹ 900 crores
Private investment and Public-Private Partnerships (PPP)	₹ 2,075 crores
Total No. of Smart City Projects	313
Total No. of public transportation projects	37

Raipur's smart city initiative has placed significant emphasis on improving its transportation infrastructure, particularly in addressing traffic congestion. The implementation of an ITMS is a key component of this strategy. Major transportation projects were completed such as cycle track, smart road works, multilevel parking, bus shed construction, ITMS development, traffic signages, etc., Table 7.2 lists major PTI projects executed in Raipur smart city and their current status.

Table 7. 2 List of Public Transportation Projects in Raipur smart city and their status

Completed	In Progress
1. Development of Cycle Track, Non Motorised Track corridor at Gaurav Path, A C	1. Redevelopment of Shastri Market Phase - I (Under Raipur Smart City Limited)
2. Wet Mix Macadam (WMM) work at Baijnath Para Maulana Abdul Rauf Ward (46), Chhotapara	2. Design, Supply, Installation, Testing and Commissioning of 3MLD Compact Sewage Treatment Plant for Treatment of Influent to Maharajbandh Talab using Conventional Technology including Operation and Maintenance of 5 Years
3. Smart Road Construction Work in ABD area Zone 04	3. Improvement of Junctions and Roads on Peripheral Road Budhatalab
4. Smart Road Construction Work in ABD area Zone 07	4. Upgradation of Lakhenagar Chowk to Budheshwar Chowk road to Smart city
5. Construction of BT Road in Inner Pathway of Naraiyya Talab	5. Underground Cabling works at various roads in Raipur (Phase 2)
6. Development of Multi Level Parking in EAC Colony	
7. Smart Parking at Pandri Cloth Market	
8. Bitumen Work in Swami Vivekanand Sadar Bazar Ward	
9. BT Road Construction and Road/Pavement Marking at Ward 46	
10. Road Construction Work at Maulana Abdul Rauf Ward Chhotapara Ward No. 46	
11. Road Development in Zone 2 of RMC	
12. WMM Work at Maulana Abdul Rauf Ward (46) Chhotapara	
13. Road Marking Work at Swami Vivekanand Sadar Bazar Ward 45 and Gaurav Path	
14. BT & Road Marking Work at Zone 04	
15. BT Road Works at Maulana Abdul Rauf Ward 46 Chhotapara	
16. Shed Construction at Jail Road	
17. Junction Improvement & Road Widening at Khamardih	
18. Road Marking Under Empanelled Contractor	
19. Traffic Signages, Road markings, and divider Repair work for improved traffic movement	

20. Traffic Illumination System 21. Smart Road Development work near Maharajbandh Talab phase II 22. ITMS Shifting of poles at Tatibandh Chowk 23. Malviya road smart road 24. Façade lighting pole and other parking facility MLCP E.A.C colony 25. Construction of drain from kabir chowk to picaddily hotel	

The PTI projects (Figure 7.2) aim to create more efficient and accessible transportation systems in Raipur city, improving the quality of life for residents and reducing environmental impact. The features of PTI projects of Raipur city are shown in Figure 7.3.

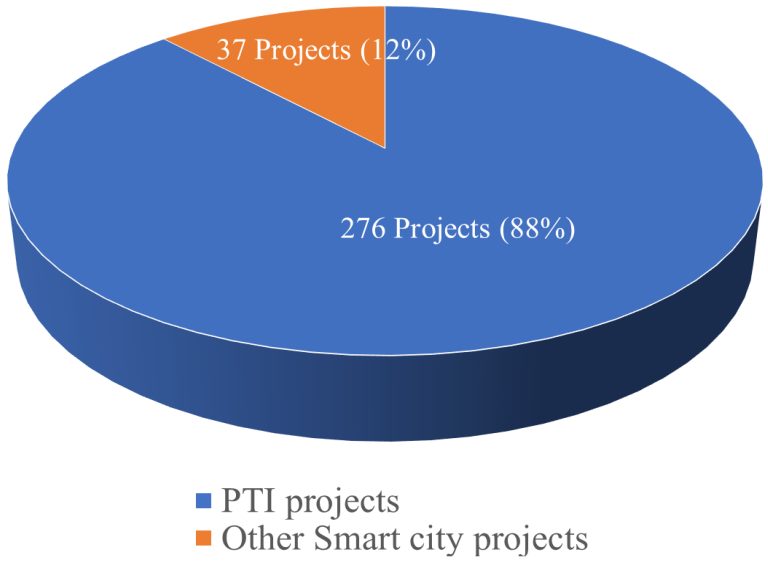


Figure 7.2 Pie chart comparing the Total No. of PTI projects with the Total No. of other Smart city projects

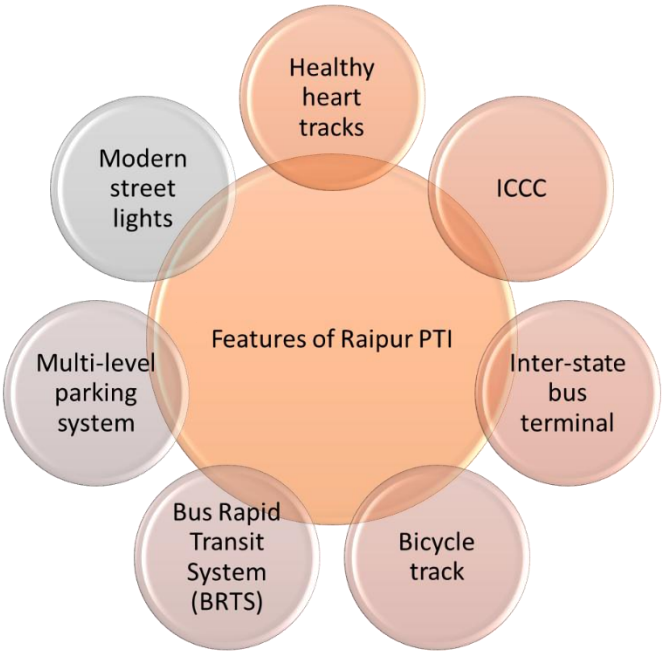


Figure 7.3 Features of PTI projects of Jammu smart city

7.2 Healthy Heart Tracks

The 500 m Healthy Heart track was constructed with a budget of ₹1.42 Cr. which is a commendable initiative to promote public health and wellness. By providing a dedicated space for physical activity, the track encourages residents to incorporate exercise into their daily routines (Figure 7.4).

Figure 7.4 Healthy Heart Tracks constructed in Raipur smart city

The key facilities were provided, such as seating arrangements, landscaping, shelters, parking, and electricity, that enhanced the overall user experience.

7.2.1 Effect of healthy heart tracks on resident's QOL

Modern amenities created a comfortable and convenient environment for people of all ages to engage in physical activity. This initiative aligns with the broader goals of the SCM, which aims to create sustainable and livable cities. By promoting active lifestyles and improving public health, the Healthy Heart track aims to contribute to the overall well-being of Raipur's residents.

7.3 Inter-State Bus Terminal

The development of the new inter-state bus terminal in Ravanbhanta, Raipur, is a significant step towards improving the city's transportation infrastructure and passenger experience (Figure 7.5). The terminal is equipped with all modern amenities, including comfortable waiting areas, food courts, and retail outlets. The design of the terminal is optimized for smooth bus operations, reducing congestion and improving passenger flow. The terminal has state-of-the-art technical facilities for bus maintenance and repair. The terminal offers a range of amenities for passengers, including clean restrooms, drinking water, and seating areas.

Figure 7.5 Inter-State Bus Terminal at Raipur Smart City

7.3.1 Effect of Inter-state bus terminal on resident's QOL

The project ensured the rehabilitation of shopkeepers from the old bus stand, providing them with new spaces in the new terminal. A total of 60 shops have been built in these premises where the shopkeepers rehabilitated from the current bus stand in Pandri and special bollards were installed to mark the limited area allotted to the shopkeepers.

7.4 Bicycle Track

Raipur's smart city initiative to promote cycling through the development of a 2.5 km long cycle track in between SRP square and the collectorate garden (Figure 7.6) is a commendable step towards sustainable urban mobility. If Raipur SCM expands its cycling infrastructure it will encourage people for greater adoption in cycling as a mode of transportation.

Figure 7.6 Bicycle track in Raipur smart city

7.4.1 Effect of bicycle track on resident's QOL

By encouraging cycling, the city aims to reduce carbon emissions, improve air quality, and promote a healthier lifestyle for its residents. By investing in cycling infrastructure and promoting cycling culture, the city encourages people to choose cycling as a mode of transportation, reducing traffic congestion and improving public health.

However, lack of network of these tracks has limited its usage to only morning time cycling rather than making cycling an alternate mode of transportation. Specifically in Raipur, cyclists cycle on the VIP road in the morning. However since this road becomes filled with fast running vehicles in the day, its utility as a cycling track remains underutilized.

7.5 ICCC

The ICCC has significantly enhanced Raipur's ability to manage its urban environment, leading to improved service delivery, faster response to incidents, and more efficient use of resources (Figure 7.7). Under the ITMS project, 549 surveillance cameras were installed at various traffic signals in Raipur. Of these, 96 are rotating cameras, while the rest are fixed-box cameras. These cameras are equipped with advanced analytics to perform several functions: reading vehicle number plates, calculating vehicle speed, detecting wrong-way driving, identifying triple riding, and monitoring helmet usage and red light violations. Six traffic signals have been

upgraded to smart junctions, incorporating cameras and other smart elements such as emergency call boxes, smart lights, environmental sensors, billboards, and signals (Figure 7.8).

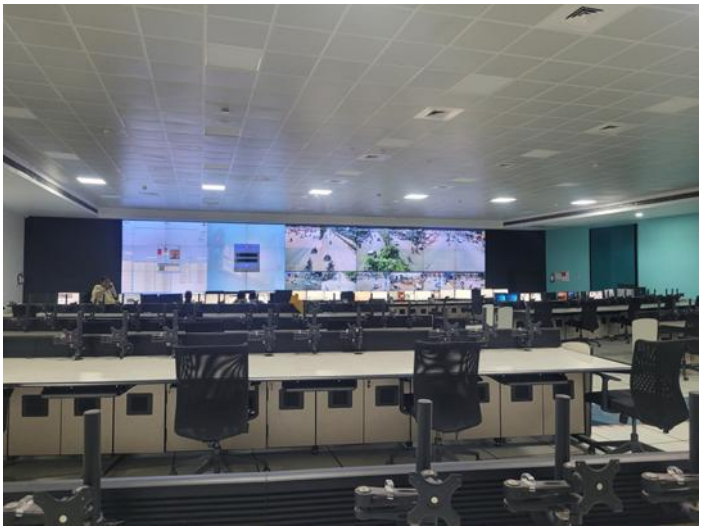


Figure 7.7 ICCC in Raipur smart city

The system also facilitates electronic challans. Currently, the system generates approximately 1.2 lakh e-challans per day, but only 0.1% of these are collected. According to staff, there is a need for more improvement and guidance, as the installations are not fully utilized or generating significant revenue as expected. According to data from the command center, the ITMS project has contributed to a reduction of over 3,000 road crimes and a reported 25% reduction in travel time from the airport to the city.

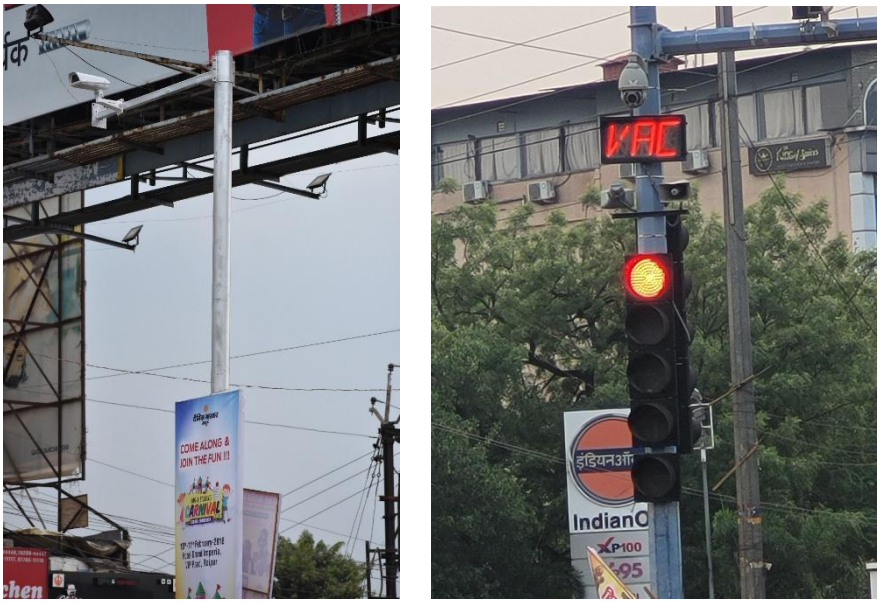


Figure 7.8 CCTV cameras installed at various traffic signals of Raipur smart city

In ICCC, 580 advanced systems have been installed. 20 smart poles equipped with environmental sensors were installed to measure particulate matter in the air, assessing air

pollution levels. These sensors can also alert if there is any unusual air pressure. The ICCC has significantly transformed Raipur's urban management by centralizing operations, improving efficiency, and enhancing responsiveness to both routine and emergencies. Live monitoring of city operations enables departments to give quick responses in emergencies to citizens. The ICCC dashboard helps police for real-time monitoring of traffic violence and penalize violators with recorded evidence. Integration of ICCC with the city surveillance system facilitates monitoring of unlawful activities in the city.

ECB were installed at 20 locations in Raipur (Figure 7.9). A simple interface allows users to quickly initiate a call to emergency services. Users can communicate with emergency services directly through the call box. It offers real-time monitoring of emergency calls and dispatching of appropriate resources. The call box's location is automatically transmitted to the emergency response center using GPS. By strategically placing emergency call boxes in public spaces and ensuring their proper maintenance, cities can significantly enhance public safety

Figure 7.9 ECB installed at Raipur smart city

ATCS were installed at 50 selected junctions (in coordination with Raipur Traffic Police) in the city. ATCS systems use various sensors like loop detectors, cameras, and radar to collect real-time traffic data, including vehicle speed, volume, and queue length. The collected data is analyzed by sophisticated algorithms to identify traffic congestion points and optimize signal timings. ATCS adjusts the timing of traffic signals in real time to improve traffic flow and reduce congestion. This includes adjusting the duration of green and red lights, as well as coordinating signals at multiple intersections. Traffic control centers at the police office at ICCC monitor the performance of the ATCS system and make necessary adjustments.

Traffic enforcement systems (RNVD and SVD) were installed at nearly 45 strategic traffic junctions in Raipur city. Cameras are strategically placed at intersections to capture images of vehicles violating traffic rules. The system automatically detects violations, such as red light jumping or speeding. The system identifies the vehicle's registration number using ANPR technology. E-challans are generated automatically and sent to the vehicle owner. The system provides real-time monitoring of traffic violations, allowing authorities to take immediate action. The traffic challan generation process and violence evidence collection have become transparent and simple. The total Challans generated by Raipur Traffic Police to date is 80890. The total amount collected from generated Challans by Raipur Traffic Police is ₹ 2,31,68,700.

Another noteworthy initiative is the creation of Green Corridors for healthcare, facilitating swift transportation for emergency services and critical medical needs like organ transplants. This initiative ensures seamless traffic management along designated routes to minimize delays for emergency vehicles. These developments align with the goals of creating a commuter-friendly city and enhancing public transportation as part of the smart mobility framework.

7.6 Bus Rapid Transit System (BRTS)

The Bus Rapid Transit System (BRTS), introduced in Raipur, is designed to provide fast, efficient, and reliable public transport. Covering 32 KM of the city's major routes, the BRTS ensures that residents have access to affordable and efficient travel options, reducing reliance on private vehicles and alleviating road congestion. Raipur's Smart City has developed modern bus shelters and transport hubs to ensure last-mile connectivity and improve passenger convenience.

7.7 Multilevel Parking System

Jai-Stambh Chowk Multilevel Parking: The first multilevel parking system at Jai-Stambh Chowk is designed to accommodate 200-300 four-wheelers and 250 two-wheelers. Managed by the Nagar Nigam, this facility operates on a paid parking basis. The design includes a dedicated floor for the ICCC. On the third floor of the parking structure, you'll find the environmental sensor report room and the traffic cameras control room, both of which are integral to monitoring and managing traffic and environmental data.

Pandri Kapda Market Multi Level Parking: The second multilevel parking system is located at Pandri Kapda Market and features a distinctive spiral design. This design not only

enhances vehicle flow and speed but also provides a more convenient parking experience. With a capacity of 500 vehicles, it is a significant addition to the area. Additionally, this parking facility features a charging station for electric vehicles, which supports both fast and normal charging equipped with all types of connectors for both two-wheelers and four-wheelers. Users can operate the charging stations through a dedicated app, enabling online payment priced at ₹18 per unit and direct connection of the charger to their vehicle while parked. This setup provides a significant advantage by offering a seamless, user-friendly experience that simplifies the charging process and enhances the convenience of electric vehicle owners. The city has introduced non-street parking areas, such as those in Pandri and Telibanda, to reduce traffic congestion and improve parking availability. The Mahakshimi market is currently constructing a parking facility, which will further solve parking issues in the area.

Problems in Gol Bazar Multi Level Parking:

Despite its advantages, the facility faces several challenges. Maintenance issues are a significant concerns. Each floor is equipped with washrooms for user convenience, however all of them are locked and seemed not to be functional during our visit. There is a huge water logging problem on the ground floor, which is attributed to improper maintenance attention. A notable problem is that the lift is not working, which affects accessibility and the overall user experience. This highlights the need for timely maintenance and infrastructure improvements to ensure the parking facility's efficient operation, long-term functionality and user satisfaction.

7.8 Other related projects

A pink toilet has been installed in the Shastri market, promoting hygiene and accessibility. Square-shaped beautification projects have been implemented in areas with heavy traffic, such as the Pahadi Maina statue. As part of Raipur’s urban development efforts, electrical lighting and aesthetic enhancements have been implemented on both sides of major roads. This initiative improves visibility and ensures safety for pedestrians and drivers, particularly at night. In addition to enhancing road safety, the installation of modern streetlights and beautification efforts like landscaping and decorative elements, contribute to a more attractive and organized urban environment enhancing the overall ambience of the city. Raipur’s broader smart city initiative has created more efficient and appealing infrastructure for residents and visitors. This beautification work also aligns with the city's ongoing projects, such as the Budha

Talab project, which showcases similar attention to public spaces, blending infrastructure improvements with environmental and recreational enhancements.

7.9 Scope of improvement

As of now, Raipur does not have proper city bus services in operation. While the city has been making strides in modernizing its infrastructure and transportation systems, introduction of electric buses is a need of the hour to bring down the ever increasing city traffic. The non-existence of a transport department at the state level is a demerit, which has become a bottleneck for the team to implement a bus system within the city.

7.10 Summary

Raipur smart city is a dense and busy city the state capital of Chhattisgarh. The effort put in by the smart city team to change the landscape of the city without affecting the daily routine of the citizens is highly commendable. While the city in its core area is already packed with dense residences and narrow roads, the team has put their effort into enhancing the PTI considering the future expansion and projected population density. The overall assessment based on KPIs is presented in Table 7.3.

Table 7. 3 Assessment of smart city projects Raipur city

Key Performance Indicators (KPIs)	5 Star Rating
Accessibility	★★★★
Affordability	–
Frequency	–
Reliability	–
User Satisfaction	★★★

Chapter 8: Conclusions – Recommendations and policy directives

8.1 Summary

The assessment of public transport projects in smart cities reveals a mixed bag of successes and challenges. While significant strides have been made in developing and implementing modern public transport infrastructure such as bus transportation systems, BSS, smart roads etc., challenges remain in terms of ensuring their efficiency, accessibility, and reliability.

Many cities have successfully implemented innovative public transport solutions. These projects have improved connectivity, reduced traffic congestion, and enhanced the quality of life for residents. Challenges remain in areas such as ensuring the financial sustainability of public transport systems, smooth operation and regular maintenance, ICCC management, sufficient manpower, public awareness about the smart technologies implemented, and integrating different modes of transport seamlessly.

8.2 Recommendations for Future and Policy Directives

Impact assessment was made through field visits, stakeholder interviews, user surveys, etc., Based on the on-site assessment in smart cities such as Aurangabad, Itanagar, Guwahati, Jammu, and Raipur, stakeholders interviews, user surveys, Transport4All Challenge, News, and smart city documents, following recommendations and policy directives were given for the improvement of public transport infrastructure in smart cities across India.

8.1.1 Recommendations for Smart Cities

- SCM may plan to invest in and expand BRT systems in all major cities, which is found to be a major success in various cities where they have been implemented.
- To make smart cities truly sustainable, small and light windmills can be installed on the road dividers where traffic moves at a high pace (Figure 8.1). This will be an additional source of generating electricity in a renewable fashion without the use of fossil fuels or requiring too much in infrastructural costs. A representational image is provided below.

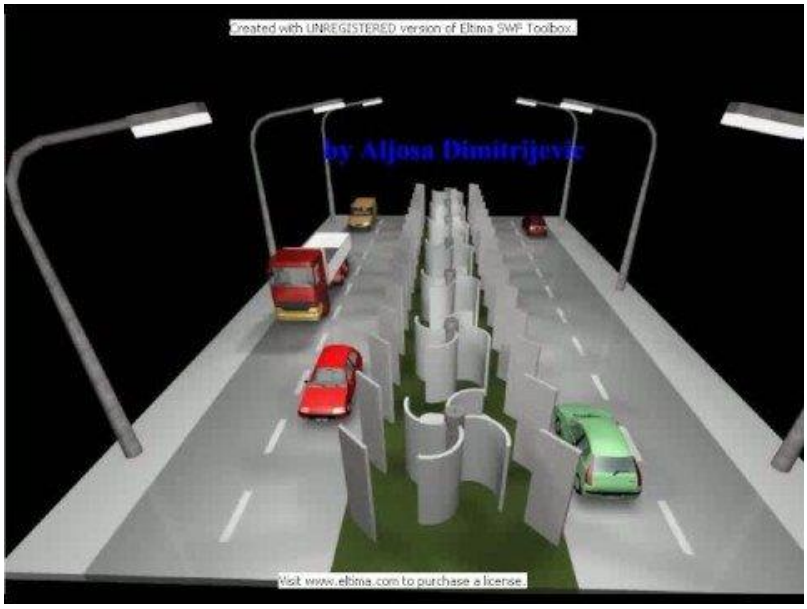


Figure 8.1 Representational design of windmills on road dividers that generate electricity when vehicles pass by at high speeds

- Encourage the adoption of electric buses while ensuring more solar-based charging infrastructure to make the option truly green.
- More utilization of real-time data collected (using ML) to optimize bus routes, schedules, and service levels.
- SCM should implement multi-modal transportation by integrating bus services with other modes of public transport, such as metro, rail, and cycle-sharing.
- Involving the community in the planning and development of bus services shall ensure that they meet the needs of residents. For example, conducting public surveys to understand greater requirements for bus routes rather than just relying on population metrics. Identifying areas that have a greater need for end-mile connectivity would aid the endeavour.
- Having dedicated women-only buses and plying special night services will enhance the safety for women empowering them to choose a career of their choice irrespective of the time schedule.
- Dedicated tourist routes could be planned as a potential revenue generation option for the city.
- Encourage walking as a preferred mode of transportation through an improved network of walkways within cities. This must be complemented with ensuring adequate and well

maintained street lighting and provision for small shops at regular intervals so as to reduce chances of theft and being mobbed while walking on the roads.

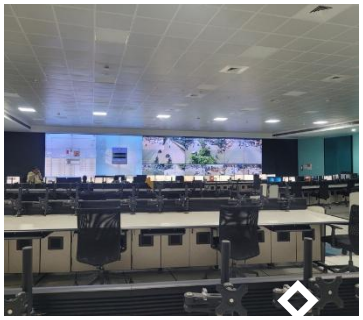
- Strong legal regulations such as heavy fines can be enforced so as to discourage parking on sidewalks which create restrictions on pedestrian mobility on sidewalks. This will ensure pedestrian safety and decongestion of the area.
- For BSS, strategic locations for docking stations should be identified within the city with high demand for BSS and proper multimodal connections are available including pedestrian walkways.
- A research and development section could be created in all smart cities for using advanced AI and machine learning algorithms for more sophisticated traffic management.
- More multi-level parking facilities should be brought within cities, especially in hotspots of the cities where the city traffic piles up. By encouraging PPP models and revenue generation models to finance and develop more multi-level parking facilities, financial burden on the city administration will also be reduced.
- Integrate smart parking technologies, such as real-time occupancy information and automated parking guidance systems, to improve parking efficiency and reduce search times.
- Manpower shortage is almost a common problem across smart cities. Cities should plan to deploy more manpower to get the maximum potential of these state of art ICCC facilities.

8.1.2 Policy suggestions for SCM

- With more buses getting introduced in the cities, minimum service standards for urban bus services should be framed as a policy that includes baseline frequency, punctuality, accessibility, etc. to build nation-wide confidence on city bus transportation system.
- To prevent the larger possibility of buses flooding the main city roads leading to traffic problems, development of dedicated bus lanes should be prioritized that can not only remove the traffic hazard coming from the buses but also improve the bus speed and reliability.
- Development and implementation of comprehensive pedestrian master plans should be done at city level, to avoid piece-wise development of walkways.

- Enforce traffic laws and regulations that prioritize pedestrian safety, such as jaywalking fines and stricter penalties for drivers who endanger pedestrians.
- Development of public parking facilities within private buildings could be incentivized to add more parking space within the city's traffic areas. A possible way to incorporate this could be adding it to the private company's CSR activities. Since the number of parked vehicles can be counted, the impact of providing the parking service can also be quantitatively deduced, hence fulfilling the CSR criterias as well.
- Stray parking should be highly penalized and parking in designated places should be incentivized with coupons, discounts, etc. to promote usage of parking spaces.
- Importantly, there is a requirement of extensive study and research on end user and stakeholder satisfaction and the effect of the changes brought in by smart city initiative on quality of life. Currently since many projects are still underway and hence another survey will be needed in 1 or 2 years to understand their impacts.

Gallery



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