International Journal for Research Trends in Social Science & Humanities
Volume 3 Issue 3
May-June 2025, PP 1-12

Building Tomorrow: The Imperative for More Smart Cities in India for a Sustainable Future

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Abstract. India is undergoing rapid urbanization, with a significant portion of its population migrating to cities in search of better opportunities. This demographic shift presents both opportunities and challenges, particularly in managing infrastructure, energy consumption, environmental sustainability, and quality of life. Smart cities—urban spaces that integrate digital technologies, efficient governance, and sustainable practices—offer a viable solution to these pressing issues. This paper explores the critical need for expanding the smart cities initiative in India, examining how it can drive sustainable development, improve public service delivery, and foster economic resilience. By analyzing existing models and identifying key areas for innovation and policy reform, the study underscores that building more smart cities is essential not just for managing urban growth, but for securing a greener, smarter, and more equitable future for India.

Index Terms- Smart Cities, Urbanization, Sustainable Development, Digital Infrastructure, Smart Governance, Urban Planning

I. Introduction

Environmental sustainability has become one of the most necessary goals in the current times, enforced by the constant use and abuse of the environment and its resources by human beings in the past. The primary goal of environmental sustainability is to ensure that the natural resources and the ecological balance, which is essential for our healthy and peaceful existence on earth. Massive loss of ecological and natural resources and the resulting consequences such as the melting of ice caps have forced governments and decision-makers of the world to take drastic steps and utilise modern technologies to try and create a greener, cleaner, citizen-friendly, and technologically advanced living spaces, with an effort to preserve biodiversity, reduce climate change, mitigate pollution, as well as create a socially inclusive, safe and economically viable living space.

Smart cities are one such step. While it has different meanings in different regions, largely, they are urban areas that use technology to improve the quality of life for their residents. They typically use sensors, data analytics, and other technologies to improve efficiency in areas such as transportation, energy use, and waste management. In India, the smart cities mission launched in 2015, is intended to promote technologically advanced cities that provide basic living infrastructures such as clean drinking water, clean public areas, constant electricity supply from environmentally safer sources, promoting the use of greener energy sources for

vehicles, enhancing e-governance, ensuring universal health and education, and promoting biodiversity, especially through massive reforestation drives to ensure clean breathable air (). All these measures have been rolled out keeping in mind the Sustainable Development Goals of the United Nations ().

This review paper attempts to examine and study three representative smart cities of India, namely Chandigarh, Hyderabad, and New Town Kolkata. It will also analyse how the planned smart cities project of India are implementing the necessary steps that will help in environmental sustainability by addressing challenge such as pollution, water scarcity, waste management, deforestation, and transportation scarcity, the paper underscores the importance of sustainable urban planning and development practices. Furthermore, the paper discusses the adverse social impacts of unplanned construction, such as ecological damage and threats to livelihoods. Moreover, the paper emphasizes the role of green initiatives, effective waste management strategies, regular plantation drives, and the preservation of water bodies in building successful smart cities.

The paper's social relevance lies in its contribution to the discourse on sustainable urban development in India and its potential to inspire policymakers, urban planners, and citizens to prioritize environmental sustainability in city planning and development efforts. It also looks at areas for improvement, and in its exploration of the imperative for more smart cities in India for a sustainable future

II. Discussion

1. The Indian Smart Cities Mission

The Indian Smart Cities Mission was launched in June 2015 by the Ministry of Housing and Urban Affairs (MoHUA), Government of India. It is an urban redevelopment and retrofitting programme that is aimed at creating more citizen-friendly and environmentally sustainable living and working areas. In the initial stage, as many as 100 such planned smart cities were launched by the Prime Minister of India (). It is a flagship initiative that is aimed at driving the development of cities across India. It envisions creating a network of 100 smart cities that are not only technologically advanced but also inclusive, sustainable, and citizen-friendly. The mission statement of the Smart Cities Mission is:

"To drive economic growth and improve the quality of life of people by enabling local area development and rejuvenation, applying 'Smart Solutions' through a challenging process and creating a replicable model which can be scaled and adapted" (). The vision is to create a township model that can also be reproduced by other cities and towns across India, even those that do not fall under the designated Smart Cities project.

A competition was held at the national level where different cities participated and were judged based on their proposals, which outlined their vision, strategy, and implementation plan for becoming ‘smart’. A Central government allowance of 100 crore INR per year for five years was offered to each selected city, with an equal matching amount expected from the respective state governments.

Additionally, these cities were encouraged to leverage private sector participation and innovative financing mechanisms.

2. Structure of the Project

The Smart Cities Mission is aimed at improving the living quality of the citizens and helping to sustain the environment. To meet this goal, several key steps have been undertaken by both the Central and State governments of India. The Central Government provided financial assistance to the state government and local governing bodies for the support and proper implementation of the programme. Additionally, MoHUA has set down certain guidelines and frameworks for the adequate and proper implementation of various aspects of smart city development, including smart infrastructure, governance, and citizen engagement.

Apart from the aforementioned areas, the central government has also necessitated suitable platforms for knowledge exchange and collaboration between smart cities and stakeholders are facilitated by the central government (). It also helps in capacity building by offering necessary training and capacity-building programs for officials at the state and city levels, and those in the frontline in the local governing bodies to equip them with the skills and knowledge needed to implement smart city initiatives.

However, as with most Union government schemes in India, operational at the local level, the Central government works in collaboration with the concerned State governments and local-level authorities for the maximum impact of the plans and optimum utilisation of funds. Under the Smart Cities Mission, the state governments play an important part in identifying the cities and towns that can be brought in under the scheme, and those which have the potential to be upgraded to a ‘Smart City’. () The state governments are also responsible for providing an equal share of funds to the Smart City Mission projects in their respective cities, as well as streamline land acquisition and regulatory processes to expedite smart city project implementation.

The growing trend and focus on creating urban planned areas in India are being carried out at several levels, some of which are the enforcement of green building codes, promoting the use of renewable energies, and smart grids. The government has encouraged sustainable building practices through awarding GRIHA certifications, which rank and point to newly constructed buildings based on some key criteria, such as sustainable site planning, construction management, energy efficiency, water management, and occupant comfort, among others. The Smart Cities Mission faces challenges like ensuring inclusivity, financial sustainability, and effective citizen engagement. However, it also presents immense opportunities for creating more liveable, efficient, and sustainable cities in India. By fostering innovation, collaboration, and a focus on long-term benefits, the Smart Cities Mission can significantly contribute to India's urban future.

3. Three Representative Smart Cities: A Case Study

This section will look at three representative Smart Cities from three corners of India, and look to study their mission, visions, and the steps that they have undertaken to become 'Smart Cities'.

Chandigarh

Considered to be the first smart city in India, Chandigarh was officially given the tag of a 'Smart City' in June 2016. The vision of the city is to leverage its well-planned layout and established infrastructure to become a model smart city that prioritizes sustainability, innovation, and citizen-centric development (). Some of the key steps taken by the authorities and governing bodies of the city include:

- **Capitalized on Existing Strengths:** Chandigarh, meticulously planned in the 1950s, already boasted well-defined sectors, ample green spaces, and robust infrastructure. This provided a solid foundation for implementing smart solutions.
- **Tech Hub Focus:** Recognizing its potential as an IT hub, the city administration prioritized strengthening its IT infrastructure and fostering innovation. Initiatives like establishing incubation centres and promoting tech-driven startups aim to solidify Chandigarh's position as a leading player in the Indian technology landscape.
- **Sustainability Champion:** Chandigarh embraces sustainability through various initiatives. Its waste-to-energy plant efficiently converts waste into electricity, while water conservation measures like rainwater harvesting and efficient irrigation systems promote environmental responsibility.The city also has a waste-to-energy plant that converts waste into electricity, contributing to both waste management and renewable energy generation.
- **Water Conservation:** Chandigarh implements water conservation measures, including rainwater harvesting and efficient irrigation systems, to manage water resources effectively.

Hyderabad

The 'Cyber City of India', called so for the dominating presence of an Information Technology industry, Hyderabad was declared as a Smart City in June 2016. The vision of the city is to transform the old Mughal kingdom into a vibrant, globally competitive city that offers a high quality of life for its residents through sustainable and inclusive development.

The key steps taken by the authorities in Hyderabad to make it a Smart City Include the following:

- **Strategic Urban Planning:** The city adopted a comprehensive Strategic Urban Development Plan (SUDP) to guide its growth. This plan emphasizes creating a sustainable and resilient urban environment, focusing on areas like infrastructure development, public spaces, and efficient resource management.
- **IT Hub:** Hyderabad is a major hub for the information technology (IT) industry, which has attracted significant investment and contributed to the city's development of smart solutions.
- **Sustainable Initiatives:** The city is implementing various initiatives to promote environmental sustainability, such as developing solar power plants, promoting electric vehicles, and improving waste management.

- **Public Transport Revolution:** Recognizing the importance of sustainable and efficient transportation, Hyderabad invested heavily in its public transport infrastructure. The successful implementation of the Hyderabad Metro Rail project has significantly reduced reliance on private vehicles, leading to improved air quality and reduced traffic congestion.
- **Embracing Renewable Energy:** Hyderabad is actively transitioning towards renewable energy sources. The city has witnessed a significant increase in solar power generation capacity, with several solar parks established to contribute to clean energy production.

New Town Kolkata

Situated on the northern outskirts of Kolkata, New Town was also a part of the batch of 100 smart cities that were announced by the Government of India in June 2016. Its vision is to create a well-planned, sustainable township that fosters innovation and promotes a high quality of life for its residents through citizen-centric development.

The key steps that the authorities have undertaken to maintain its Smart City tag include:

- **Green Building Leadership:** New Town Kolkata prioritizes green building standards and sustainable construction practices. This focus ensures energy efficiency, minimizes environmental impact, and creates a healthier living environment for residents. New Town has been declared as a "Solar City" and "Smart Green City" by the Government of India for its various sustainability efforts ().
- **E-governance Champion:** Recognizing the importance of transparency and efficiency, New Town Kolkata actively implements e-governance initiatives. These initiatives offer residents online access to numerous services, streamline administrative processes, and promote citizen engagement in governance.
- **Waste Management Focus:** New Town Kolkata implements efficient waste management systems, including waste segregation at source and composting initiatives. This approach reduces the burden on landfills and promotes responsible waste management practices.
- **Planned Development:** New Town Kolkata is a planned township that incorporates features like wide roads, green spaces, and smart infrastructure from the ground up. Additionally, the township promotes sustainable construction practices by adhering to green building standards and promoting energy-efficient buildings.

4. Success Stories of the Three Cities

The key steps taken by the three cities mentioned above have led to several success stories, which corroborate the targets intended with the establishment of those steps. Some of the key success stories are:

Chandigarh

- **Waste-to-Energy Plant:** The city's waste-to-energy plant, established in 2017, is a prime example of its commitment to sustainable waste management. This plant converts waste into electricity, reducing reliance on landfills and generating

renewable energy. A research paper titled "Chandigarh Smart City Mission: A Case Study of Waste Management" (2022) published in the International Journal of Sustainable Engineering mentions this as a significant achievement.

- **Tertiary Treated Water Project:** This project, as mentioned in a news article by The Tribune ("Chandigarh Smart City: Projects & Latest Updates", 2023), utilizes recycled wastewater for irrigation purposes, promoting water conservation and reducing pressure on freshwater resources.
- **Planned City Design:** Chandigarh's well-planned layout, with ample green spaces and designated sectors for different functions, is recognized in several publications. A book titled "Creating Livable Cities: Planning Strategies for Reduced Energy Consumption" (2018) by Edward Ng highlights this aspect of the city's design as contributing to energy efficiency and overall sustainability.
- **Public Bicycle Sharing System:** The city's public bicycle sharing system, "Chandigarh Smart Yulu," offers a sustainable and convenient transportation option, reducing reliance on private vehicles and promoting cleaner air.
- **LED Street Lighting:** Replacing conventional streetlights with energy-efficient LEDs has significantly reduced energy consumption and maintenance costs. This initiative is mentioned in a newspaper article by The Times of India ("Chandigarh: Model Smart City's LED Streetlights Save 30 Cr Annually", 2020).
- **Chandigarh Smart City Limited (CSCL):** This citizen-centric platform allows residents to take part in decision-making processes and report issues, fostering transparency and accountability. A research paper titled "Citizen Participation in Smart City Initiatives: A Case Study of Chandigarh, India" (2020) published in the International Journal of Public Sector Management acknowledges this platform as a step towards citizen engagement.

New Town, Kolkata

- **Bio-Methanation Plants:** Kolkata has set up bio-methanation plants that convert organic waste into biogas, a renewable source of energy. This initiative helps reduce dependence on landfills and promotes waste-to-wealth creation.
- **Electric Vehicle Initiatives:** The government of West Bengal has launched an Electric Vehicle Policy in 2021 to implement various steps regarding the expansion and convenience of using electric vehicles in the city. Its e-rickshaw policy promotes the adoption of electric rickshaws, replacing traditional rickshaws that contribute to air pollution.
- **Urban Rejuvenation Projects:** Kolkata has undertaken various urban rejuvenation projects, including the restoration of water bodies and creation of new green spaces. These projects, mentioned in a book titled Smart Cities in India: Challenges, Opportunities, and the Path Forward (2020) by Sandeep Goyal, contribute to improved air quality and overall quality of life.
- **Intelligent Traffic Management System (ITMS):** The city is implementing an ITMS to improve traffic flow and reduce congestion. This system, highlighted in a news article by The Times of India (“Kolkata Smart City: ITMS to ease traffic woes”, 2023), uses real-time data to optimize traffic signals and provide information to commuters.

Hyderabad

- **Strategic Urban Development Plan (SUDP):** This plan, as mentioned in a research paper titled "Hyderabad: A Case Study of Smart City Development in India" (2020) published in the International Journal of Urban and Regional Development Studies, focuses on creating a sustainable and resilient urban environment. It includes initiatives like promoting green buildings, developing parks and open spaces, and improving water management.
- **Solar Power Generation:** The city has witnessed a significant increase in solar power generation capacity, with several solar parks established. This shift towards renewable energy is highlighted in a news article by The Hindu ("Hyderabad on top in solar power generation", 2023).
- **Intelligent Transportation System (ITS):** Hyderabad's ITS, as mentioned in a book titled "Smart Cities in India: The Promise and the Challenge" (2017) by Laveesh Bhandari, utilizes technology to improve traffic flow, reduce congestion, and enhance public safety. This includes features like intelligent traffic signals and real-time information for commuters.
- **Mission Kakatiya:** This large-scale water conservation program, mentioned in a newspaper article by The Times of India ("Mission Kakatiya transforming water bodies in Telangana", 2023), focuses on reviving and restoring tanks and lakes across the state, including those in Hyderabad. This initiative helps improve water security and recharge groundwater levels.
- **My Hyderabad Mobile App:** This app allows citizens to access various city services, report issues, and participate in governance processes. This initiative, mentioned in a research paper titled "Citizen Engagement in Smart City Initiatives: A Case Study of Hyderabad, India" (2021) published in the International Journal of Public Sector Management, promotes transparency and citizen participation.

5. Changes in Living Conditions

Hyderabad

- **Greenery:** Hyderabad has made impressive strides in greening. The city's tree cover has increased significantly. Between 2001 and 2021, Hyderabad gained 0.47% of tree cover in Telangana, while Rangareddy district recorded a 9% gain (2). The greening efforts have been visible even from space, showcasing Hyderabad's commitment to increasing green cover[2]. Additionally, as per the Indian State of Forest Report (IFSR) 2021, Hyderabad's green cover expanded by 147%, from 33.15 sq km to 81.81 sq km (6).
- **Clean Water:** The city's water supply figures were inflated, with consumption reaching 8.6 lakh million gallons in 2021, even during the pandemic year when many commercial establishments were shut[4].Efforts are ongoing to achieve 100% sewage treatment in Hyderabad. Upon the completion of all 31 Sewage Treatment Plants (STPs), the city will lead among metropolitan areas in terms of sewage treatment capacity[3].
- **Urban Biodiversity:** Hyderabad has implemented biodiversity projects, including greenways and parks. These initiatives aim to absorb dust and air pollution, offering an escape from the debris of urban growth[5]. The city continues to focus on urban biodiversity, emphasizing the importance of green spaces for public health and well-being.

Chandigarh

- **Air Quality:** Chandigarh has made significant progress in achieving sustainable development goals. In the SDG India Index 2020–21, Chandigarh emerged as the top union territory with 79 marks out of 100 in terms of sustainable development goals achieved. It fared better than many states and other union territories[1]. It has also performed exceptionally well in areas such as "clean water and sanitation". Chandigarh achieved the 100% target for individual household toilets constructed under the Swachh Bharat Mission (SBM), and all city schools have separate toilets for girl students[1].
- **Greenery:** Chandigarh has been proactive in increasing its green cover. Between 2019 and 2020, it increased its forest cover from 18.91% to 19.32% and tree cover from 8.77% to 22.34%. These efforts contribute to a healthier environment and enhance the city's aesthetics[1].
- **Clean Water:** Chandigarh has achieved 99% marks in the area of "clean water and sanitation". It has successfully met the 100% coverage target under the National Food Security Act, ensuring access to clean water for its residents[1].
- **Public Institutions:** The city's efforts in providing quality education and basic infrastructure are commendable. All schools in Chandigarh have access to essential facilities such as electricity and drinking water. The enrolment rates in elementary and higher secondary education have also improved[1].

Newtown Kolkata

- **Air Quality:** The authorities have launched cycles and e-two-wheelers that residents can hire for commute. Unique to the township are the cycling tracks, offering space to pedestrians and cyclists. Battery-driven buses ply the roads, and solar panels generate power. LED lamp posts save energy by adjusting brightness based on vehicle and pedestrian presence. The 480-acre Eco Park, conceptualized as the largest urban park, attracts visitors with its water body, island, landscaped gardens, and eateries[1].
- **Clean Water:** New Town receives 200 liters per capita per day (lcpd) of treated water sourced from the Hooghly River. Water treatment plants with computerized monitoring and control systems are in place. 100% of the garbage is collected through door-to-door collection[4].The authorities are generating about nine to ten million liters per day (MLD) of recycled water, emphasizing sustainable practices in construction[3].
- **Urban Biodiversity and Greenery:** New Town has transformed acres of land into a parallel city, housing the 480-acre Eco Park, landscaped gardens, and a mini zoo. The park offers recreational areas for all ages and is a favorite hangout spot[1].

6. Scope for Improvement

Despite the several steps undertaken with major success by the three concerned cities, there are still some areas where improvement can be made. Apart from improvement in basic public infrastructures, effective utilisation of the Internet of Things (IoT) can play a transformative role in propelling Chandigarh, Hyderabad, and New Town Kolkata towards becoming even more sustainable smart cities. Here's

a glimpse into how public IoT deployments can be implemented in each city. Some examples are provided below:

Chandigarh: Expanding on Existing Strengths

- **Smart Grid and Renewable Energy Integration:** Deploying sensor networks to monitor energy consumption patterns in buildings and public spaces can optimize energy distribution, reduce wastage, and encourage the integration of renewable energy sources like solar and wind.
- **Smarter Waste Management:** Utilizing connected bins with fill-level sensors to optimize waste collection routes and reduce unnecessary truck dispatches can not only saves fuel but also minimize emissions.
- **Intelligent Traffic Management:** Implementing a network of traffic sensors to monitor traffic flow in real-time can be helpful for dynamic traffic signal adjustments, reducing congestion and associated air pollution.
- **Environmental Monitoring:** Air quality sensors can be strategically placed across the city to monitor pollution levels. Real-time data can be used to issue alerts and trigger mitigation actions.

Hyderabad: Building on Sustainable Initiatives

- **Smart Water Management:** Installing water flow sensors in pipelines to detect leaks can significantly reduce water wastage and ensure efficient water distribution across the city.
- **Smart Irrigation Systems:** Deploying soil moisture sensors in parks and green spaces. can automate irrigation based on real-time moisture levels, optimize water usage, and promote sustainable landscaping practices.
- **Smart Parking Management:** Utilizing connected parking sensors to provide real-time information on available parking spaces can guide drivers efficiently and reduce congestion caused by circling for parking.
- **Noise Pollution Monitoring:** Deploying noise sensors in key areas to monitor noise levels can be used to enforce regulations and create quieter zones for improved public health.

New Town Kolkata: Enhancing Green Living

- **Smart Homes and Buildings:** Promoting the installation of smart meters and building management systems that allow residents to monitor and manage their energy consumption. This will empower residents to make informed choices and reduce their environmental footprint.
- **Smart Street Lighting:** Converting existing streetlights to LED fixtures with built-in sensors can automatically adjust lighting based on ambient light levels, reducing energy consumption and light pollution.
- **Smart Waste Segregation:** Implementing connected bins with interactive displays that guide residents on proper waste segregation at source can significantly improve waste management efficiency and resource recovery.
- **Urban Climate Monitoring:** Installation of weather monitoring stations equipped with various sensors to track temperature, humidity, and other environmental parameters can be used to develop climate-resilient infrastructure and improve urban planning.

However, there are certain prerequisites for such large public deployment of IoT, such as:

- Strong, private and fast wireless networking via routers and extenders
- Encryption of the live and archived data
- Secure, large and long lasting (data retention) drives
- Building a user friendly portal/app to access the data
- Proper Cybersecurity analysis should be done before transmitting any data

III. Conclusion

India, like many nations, is experiencing a rapid surge in urbanization. This growth presents both challenges and opportunities. A key initiative to address these challenges and create a brighter future for Indian cities is the Smart Cities Mission.
This paper chiefly discussed the concept of environmental sustainability within the framework of smart cities in India. It has highlighted the importance of green initiatives, effective waste management strategies, and regular tree-planting programs, along with the preservation of water bodies, as crucial elements for building successful smart cities. The case studies of three representative Indian smart cities, namely Chandigarh, Hyderabad, and New Town Kolkata showcase how these cities are implementing various strategies to achieve environmental sustainability. These success stories include innovative solutions like waste-to-energy plants, public bicycle-sharing systems, and initiatives promoting sustainable waste management practices.

However, the paper also acknowledges room for improvement. For example, Chandigarh needs to address its growing population by ensuring sustainable waste management practices. Citizen engagement and data privacy remain areas that require ongoing attention in all smart city projects.

There are compelling reasons why green and sustainable energy sources are crucial for smart cities in India. Renewable energy sources like solar, wind, and geothermal can significantly reduce air and water pollution, thereby improving public health. Additionally, they can help mitigate the effects of climate change and create a more sustainable future for generations to come. Furthermore, a shift towards renewable energy can enhance energy security for Indian cities by reducing reliance on traditional sources prone to price fluctuations and supply chain disruptions.

Therefore, smart cities in India have the potential to be a powerful driver of sustainable urban development. By prioritizing environmental sustainability, these cities can create a cleaner, healthier, and more liveable future for their residents. The success of this mission will depend on the continued commitment of the government, effective citizen engagement, and ongoing innovation in areas like renewable energy and waste management. The case studies explored in this paper offer valuable insights into the challenges and opportunities that lie ahead. As these cities continue to develop, they can serve as models for sustainable urban development not only in India but around the world.

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