National Centre for Good Governance- Internship Report

Sustainable development of Smart Cities: Technology Trends, Best Practices, and Innovations

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1. Introduction

Formulation of the theme

Over the last two decades, Internet and Communication Technology (ICT) has become central to the discourse revolving around "smart cities." Around the world, governments are harnessing the benefits of emerging technologies to build more liveable urban environments and efficiently manage the impact of rapid urbanisation, climate change, and demographic imbalance. Initially, much of the discussion around smart cities primarily focused on the technological dimensions due the catalyst role played by the corporate in innovation. However, this narrow discussion point has changed significantly over the years with the well-being of the citizens and sustainable development taking over as a major aspect of smart cities. Sustainable development of smart cities emerged with the development of five major trends. These are- globalisation of environmental problems and sustainable development, urbanisation and urban growth, sustainable urban development, and sustainable cities, information and communication technologies, and smart cities. Various reports highlight the role that technology can play to mitigate the rising sustainability challenges to improve urban and rural living conditions. International organisations such as the United Nations have also recognised the role of Big Data for sustainable development. Although various policies recommend a balanced development of smart and sustainable urban cities, the trend notices a misalignment where smart city assessment downplays the importance of environmental sustainability.

India, an emerging power in the international arena has come to recognise the challenges and opportunities of urbanisation in India. As a result, the Ministry of Housing and Urban Affairs (MoHUA), Government of India (GoI), launched the Smart Cities Mission (SCM) in June 2015. With the launch of this mission, India started paving a new path towards transforming urban development using the power of digital technologies. However, it is important that India comes up with a rigid policy that does not neglect the sustainable development of smart cities. In this view, the current research will try to cull out the significance of technology for sustainable development of smart cities in India by suggesting the best policies and practices from around the world.

Survey of literature

The survey of literature examines the various aspects of sustainable development and smart cities as a stand-alone concept and as an integrated aspect. The literature has reviewed the various discourses surrounding the concepts of sustainable development of smart cities. Further, it has assessed the international scenario concerning the theme under study by

selecting certain smart cities which meet the demands of sustainable development. Finally, the survey of literature has explored India's approach to sustainable development of smart cities.

The Brundtland Commission defines sustainability as "meeting the needs of the present without compromising the ability of the future generations to meet their own needs" (United Nations, 1987). In 2015, as part of the 70th session of the United Nations General Assembly adopted Sustainable Development Goals (SDGs) which provided a shared blueprint of peace and prosperity for people and the planet (UNESCO, 2015) (United Nations, 2015). These objectives recognise different areas that call for action by all the countries. The concept of sustainable development or sustainability became significant with the passage of time and countries tried incorporating this concept in various developmental areas. Smart cities are one of the areas where the objectives of sustainability are highly promoted. The smart city concept emerged with the revolution in the Internet and Communications Technology (ICT). The last decade has witnessed fundamental changes in the living environment of urban areas with different aspects of cities becoming closely intertwined with ICTs (Chuan Tao et al., 2015, p. 2). Digital technologies play a significant role in assisting governments to administer. For instance, governments are using Big data to improve the living conditions of their citizens at a very low cost. Big data analytics is considered as an empowering capability of smart city development as it brings sustainability in smart cities by utilising the analytics outcome for a variety of applications including home security, traffic control, resource allocation, healthcare, education, and environmental protection (Khan et al., 2021, p. 16029).

The ICTs have become a crucial component in solving issues pertaining to urbanisation. Smart cities are thus defined as a city that "infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiencies, conserve energy, improve the quality of air and water, identify problems and fix them quickly, recover rapidly from disasters, collect data to make better decisions, deploy resources effectively, and share data to enable collaboration across entities and domains" (Nam & Pardo, 2011). However, the definition of the term remains ambiguous due to lack of academic consensus over one definition. Smart cities as a term were introduced in the year 2011. Initially, the term focused on the significance of ICT regarding modern infrastructures within the urban areas. The continuous criticism from civil society led to the focus being shifted to governance and human-centrism (Albino et al., 2015, p. 4). A smart sustainable city is a "city that meets the needs of its present inhabitants without compromising the ability for the other people or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations, and where this is supported by ICT" (Hojer & Wangel, 2015, p. 10). This concept should be seen as an aggregate of sustainable development and smart cities.

Sustainable development of smart cities has become a significant topic for diverse stakeholders since digital technologies have become a powerful enabler in stimulating paradigmatic shifts in urban development-related visions, strategies, implementation, and learning. Most smart cities overlook sustainability as a motivating driver of smart cities and tie the smartness approach to innovation, technology, and economic entrepreneurship (Yigitcanlar et al., 2019). However, the development in globalisation of environmental problems and sustainable

development, urbanisation and urban growth, sustainable urban development and sustainable cities, information and communication technologies, and smart cities gave impetus to the concept of smart sustainable cities (Hojer & Wangel, 2015). Countries have come to the realisation that deploying sustainable development practices can address diverse set of problems associated with smart cities, such as pollution and climate change adaptation, human development, natural calamity preparedness, circular economy, biodiversity, and energy consumption (Kutty et al., 2022, p. 2).

Like any other country, India has taken several initiatives to manage the complexity with growing urbanisation. The need to increase efficiency, improve the quality of life, provide a core infrastructure, and clean and sustainable environment prompted the government to apply smart solutions in the Indian cities (India Brand Equity Foundation, 2021). The Smart Cities Mission was launched by the Government of India in 2015 with the mission to drive economic growth and improve quality of life. 200 Indian cities have been selected to be developed as smart cities through a two-stage competition (Smart City, 2021). Dehradun, the capital of the northern state of Uttarakhand has been selected to be developed as a smart city in the phase-2 of the competition. A special purpose vehicle named as Dehradun Smart City Limited (DSCL) has been initiated to develop Dehradun as a smart city (Dehradun Smart City Ltd., 2021). Although the DSCL has taken several innovative steps to incorporate smart solutions for the everyday urban challenges that the city faces, it will be interesting to research whether these steps balance the sustainability aspect of the smart city. The following chapters will elucidate more on the sustainable approach of smart cities in India with Dehradun being the case study of the research.

Research gap

The concept of smart cities has become a wide topic for discussion with countries deploying emerging technologies to combat urban problems more efficiently and effectively. Despite the growing relevance of smart cities, a holistic view to guide practitioners and researchers on this topic is missing. Ergo, an aim of this paper would be to narrow down this gap by providing more nuanced study through incorporating the aspect of sustainable development of smart cities.

The Indian government has launched the Smart City Mission in 2015 to promote core infrastructure, give a decent quality of life to its citizens and a sustainable environment using technology. However, there has been substantially less academic effort to highlight India's approach to sustainable development of smart cities. In this view, the paper will narrow down the gap by studying cases of sustainable development of Indian smart cities.

Objectives of the study

The following would be the objectives of the study:

• To understand the concepts of sustainable development of smart cities;

• To briefly explain the role of emerging technologies in sustainable development of smart cities;

• To study the current status of Dehradun smart city.

Methodology

Deductive approach would be used to conduct this research. To explore the objectives, this research will use qualitative methods extensively. This will allow for an in-depth examination of the concept in question. This will also help in evaluating and analysing the different concepts that the research poses to explain and answer. Further, the research relies on both primary and secondary sources to gather data. In order to get expert insight on various initiatives, discussion and interviews would be carried out. Furthermore, the help of secondary sources such as books, journal articles, research papers, reports published by reputed think tanks, and other online as well as offline sources would be used to substantiate the concepts and phenomenon in question. To ensure that the research is least biased and objective, triangulation method will be deployed.

Limitations of the study

The research has potential limitations. The literature used to research the concepts will largely be based on works conducted in the English language. Further, due to the evolving nature of certain concepts, the research will also face the problem of lack of literature required for analysis.

Delimitations of the study

The scope of the research is strictly limited to and restricted to August 2023. Further, smart city initiatives of certain cities would be described. Additionally, the research will dominantly focus on Dehradun smart city initiatives.

2. Understanding the concepts of sustainable development and smart cities

Sustainable development has gained wide popularity with countries around the world maximising their effort for a conscious development. The term involves two main components, sustainability, and development (Mitlin, 1992, p. 112). Development is an umbrella term encompassing basic needs and rights, economic growth, political stability among others, whereas, sustainability refers to the conditions necessary for a conscious holistic growth. The 'Report of the World Commission on Environment and Development: Our Common Future' is identified with introducing the word in the international political arena. The Report defines sustainable development as, "development that ensures the needs of the present without compromising the ability of the future generations to meet their own needs" (United Nations, 1987). Although this definition is most cited among scholars, there is no academic consensus when it comes to defining sustainable development. This gives the concept a constructive ambiguity which enables a strategic flexibility in terms of responses. Diverse set of actors with incompatible interests have come to join hands for sustainable development because of this strategic flexibility (Elliott, 2013, p. 19).

In 2015, the members of the United Nations adopted the Sustainable Development Goals (SDG) replacing the Millennium Development Goals (MDG). There are 17 SDGs that stress on five fundamental pillars including planet, people, prosperity, peace, and partnership (International Monetary Fund, n.d.). These 17 SDG are interconnected and are a blueprint to achieve a better and more sustainable future for all. Below is the image depicting the 17 SDG:

Figure 1: 17 Sustainable Development Goals
Source: United Nations https://www.un.org/sustainabledevelopment/blog/2015/12/sustainable-development-goals-kick-off-with-start-of-new-year/

Smart cities

Despite widespread studies worldwide centred around smart urbanism discourse, there is no universal definition for 'smart cities'. A rationale behind this lack of universal definition for such a popular concept could also arise from contextually informed definitions provided by different countries with respect to their policies and practices. The table below highlights the definition of smart city provided by governments of different countries.

Country/international and regional organisations	Definition
Denmark	The Ministry of Transport, Building, and Housing and the Danish Business Authority consider "Smart City" as an evolving concept: "Initially, the concept was only used in a narrow and governmental context especially in relation to environmental, energy and infrastructure issues in terms of how information and communication technologies can improve urban functionality. Subsequently, virtually all other areas of welfare started working with Smart City, for example in business development, innovation, citizen involvement, culture, healthcare and social services, where the use of data and digital platforms helps smart new solutions."
Korea	The Ministry of Land, Infrastructure and Transportation defines a smart city approach as one that "makes use of opportunities from digitalisation, clean energy and technologies, as well as innovative transport technologies, thus providing options for inhabitants to make more environmentally friendly choices and boost sustainable economic growth and enabling cities to improve their service delivery". It also states: "smart cities are a tool for solving urban problems and improving the quality of life by applying ICTs and new technologies to cities."
United Kingdom	The UK Department of Business, Energy and Industrial Strategy says "The concept [of smart city] is not static: there is no absolute definition of a smart city, no end point, but rather a process, or series of steps, by which cities become more "liveable" and resilient and, hence, able to respond quicker to new challenges."
European Union	According to the European Commission, "a smart city is a place where the traditional networks and services are made more efficient with the use of digital and telecommunication

	technologies, for the benefit of its inhabitants and businesses" (European Commission, 2014).
United Nations	A smart city approach, as defined by the United Nations, "makes use of opportunities from digitalisation, clean energy and technologies, as well as innovative transport technologies, thus providing options for inhabitants to make more environmentally friendly choices and boost sustainable economic growth and enabling cities to improve their service delivery" (United Nations, 2016).
OECD	Smart cities are defined by the OECD as "initiatives or approaches that effectively leverage digitalisation to boost citizen well-being and deliver more efficient, sustainable and inclusive urban services and environments as part of a collaborative, multi-stakeholder process" (OECD, 2018).

A robust sustainable smart city will require several fundamental blocks of emerging technologies. The administration must keep a few parameters in mind when building smart cities. These include interoperability, scalability, fast deployment, robustness, eco-friendly and efficiency, and multi-modal access (Javed et al., 2022, pp. 5-6).

Interoperability- The need for seamless collaboration to establish interoperability is crucial to establishing interoperability between systems and devices. This is pivotal for unlocking the true potential of smart cities through the deployment of independent technologies which can minimise the distance to interoperability (Greer, 2021). The IoT plays a significant role in communication between the technologies which further allows the devices to become more compatible with their environment. The feature and capacity of interpretation also increases with data sharing between the devices. Moreover, it also allows for comfortable user experience by making the interaction with devices easier (Javed et al., 2022, p. 5). However, due to lack of common standards it becomes difficult to achieve interoperability among the independent technologies (Koo & Kim, 2021).

Fast deployment- Technology deployment refers to the process of "adding or updating software or hardware for one or more users or systems in an organisation" (Bocchino, 2022). The aim here is to seamlessly integrate the new technology to use immediately post-deployment. Hence, fast deployment of technological devices becomes another crucial aspect of smart cities. The requirement of the recent times demands sustainable but portable technologies since it requires less workforce and comparatively less time in implementation (Javed et al., 2022, p. 6).

Scalability- Scalability is another important feature of emerging technologies. It ensures the versatility of any given technological device in fulfilling consumer requirements. Scalability in technology and its applications refers to making a piece of technology bigger, more expansive, and flexible enough to handle change in behavioural situations (Bridgwater, 2020). This concept denotes, "the ability of a system to accommodate an increasing number of elements or objects, to process growing volumes of work gracefully, and/or to be susceptible to enlargement" (Bondi, 2000, p. 195). Enhanced scalability also ensures less expenditure on different devices and greater consumer satisfaction.

Robustness- Technological robustness is another aspect for implementing a smart city. The term can be understood as the procedure of testing a technology's capability to overcome its limitations and errors (Javed et al., 2022, p.6).

Eco friendly and efficiency- Electricity remains the fundamental source of power for most of the critical technologies. However, with the rise of global warming, there is a conscious effort among various stakeholders to diversify their source of fuel. This has positively affected the way research and technology manufacturing companies work. These companies are trying to orient themselves to a more eco-friendly and efficient manner by taking a collective effort to reduce environmental emissions and defining a products' cost-efficient manufacturing and usage (Javed et al., 2022, p. 6).

Multi-modal access- Multimodal interaction refers to "interaction with the virtual and physical environment through natural modes of communication such as speech, body gestures, handwriting, graphics or gaze" (Bourguet, 2003, p. 717). Recent developments in AI and sensor technologies have revolutionised newer ways of recognition- based interaction by opening up myriad ways of multimodal interaction. Technology can be made more practical and versatile by increasing the channels of communications such as through texts, voice and mails.

Role of emerging technologies in sustainable development of smart cities

The Internet and its allied technologies have empowered citizenry at community and metropolitan level. The IoT devices have revolutionised human-centric interaction (HCI) by making technology more human-centric than computer-centric as in the past. Countries around the world have started incorporating innovative techniques and technologies to better administer the affairs of their cities. To transform the city into a truly sustainable smart city, countries are required to change the design level of the cities by integrating more complementary technologies. Increasing the efficiency of technologies composed of information and communication technologies (ICT) and IoT can make the cities more eco-friendly, agile, and productive (Javed et al., 2022, p. 2). The emergence of the fourth industrial revolution witnessed significant advancements in powerful miniaturised machines that can be deployed for everyday use. The state-of-the-art technologies including AI, IoT, 5G and 6G

networks, robotic systems, Big data, blockchain, electric vehicles among others are vital to the implementation of procedures required to develop holistic and sustainable smart cities.

IBM defines IoT as, "a network of physical devices, vehicles, appliances and other physical objects that are embedded with sensors, software and network connectivity that allows them to collect and share data" (IBM, n.d.). The IoT is the key driver of smart cities, it connects multiple devices and facilitates communication. The industrial IoT integrates smart homes, smart grids, automobiles, wearable devices, automobiles, waste management systems, smart factories, health applications, security, water management, and smart industries (Al-Badi et al., 2020, p. 3). IoT enables improved efficiency, reduces cost and improves profitability, data-driven decision-making and enhances customer experience by creating more personalised and engaging experiences (IBM, n.d.). The potential applications of IoT in an enterprise context are vast and varied ranging from temperature check, air quality, energy consumption, humidity to machine performance. Several technologies come together to make IoT possible. These include sensors and actuators, connectivity technologies, cloud computing, big data analytics, and security and privacy technologies.

Sensors and actuators are the building blocks of IoT devices as they allow the machines to interact with the physical world. Sensors are electronic devices used for measuring physical parameters such as thermistor for temperature, photoresistor for light fluctuation, to detect sound, movements, flames, or any other physical fluctuation in the environment (García et al., 2017, p. 7). Whereas actuators are "mechanical or electro-mechanical devices that provide controlled and sometimes limited movements or positioning that are actuated electrically, manually or by various fluids such as air, hydraulic, etc" (Mouha, 2021, p. 89). Actuators can cause physical changes in the environment, such as turning on a motor or opening or closing a valve. IoT uses several connectivity technologies to receive data. Technologies such as Wi-Fi, Bluetooth, cellular, Zigbee among others.

These data are further stored, processed, and analysed in the cloud. Big data analytics further help in extracting insights and identifying patterns from the vast amount of data that is generated through different IoT devices (IBM, n.d.). Big data projects are changing city landscapes by simplifying complicated data infrastructure efficiently. Big data can solve some of the most challenging issues that a smart city can face. These pressing issues could be related to security of the city, transportation and efficient traffic management, city-planning, sustainability, and future proofing (Chowdhury, 2021).

Artificial Intelligence is the backbone of innovation in modern computing as it enables computers to perform a variety of advanced functions. These functions include the ability to understand and translate spoken and written language, the ability to see, analyse data, and provide better recommendations among others. AI has been defined as, "the field of science concerned with building computers and machines that can reason, learn, and act in such a way

that would normally require human intelligence or that involves data whose scale exceeds what humans can analyse" (Google, n.d.). AI has applications in counting vehicles, object recognition in videos and images, and licence plate reading. AI processes information generated by IoT. For devices to work smoothly, synchronisation is required between IoT, Big data and AI. The image below depicts the relationship between the three:

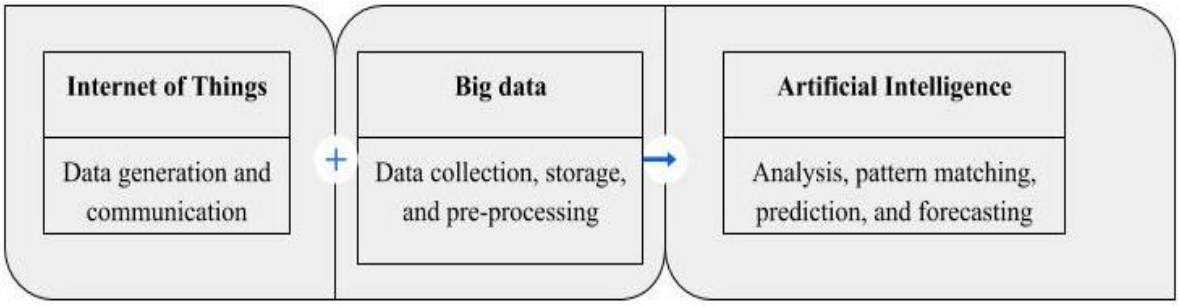


Fig. 2: relationship between emerging technologies in smart cities solutions

Source: Al-Badi, A., Sharma, S. K., Jain, V., & Khan, A. I. (2020, December 11). Investigating Emerging Technologies Role in Smart Cities' Solutions. *International Working Conference on Transfer and Diffusion of IT (TDIT)*, 230-241. https://link.springer.com/chapter/10.1007/978-3-030-64861-9_21#citea

Smart cities require absolute security of data communication since cyber-security threats are an ever-increasing threat. Blockchain solutions can provide a thrustless environment where the stored data is secured from unauthorised third-party data tampering. Smart contracts can further secure data shared between sensors. These smart contracts can only accept or release data if they satisfy a given condition (Jo et al., 2019, p. 771). The healthcare sector is a beneficiary of blockchain technologies. Blockchain is used to create a distributed system for patient health records, manage the outbreak of harmful diseases and transparent supply chains for medicines, help in diagnosing a patient through wearable diagnostic tools, and the use of telemedicine instead of in-person visit. Furthermore, blockchain technologies also assist in better waste management, increased energy savings, efficient mobility, and better education (Joshi, 2023).

Features/Components of smart cities

Smart healthcare- advancement in the healthcare system has seen revolution since early 1990 for agile treatment, delivering and monitoring healthcare services remotely, appropriate early patient serving, delivery, and handling emergency cases swiftly. Further, the challenge of delivering the best services to patients was addressed by employing IoT and evolutionary technologies (Raoof & Durai, 2022). The introduction of these technologies gave rise to the

concept of smart healthcare. It has been defined as, “a healthcare system that enables patients and doctors to communicate with each other and remotely exchange information monitored, collected, and analysed from patients’ daily activities via the IoT” (Annansingh, 2021). Few of the major objectives of smart healthcare include augmenting existing methods for medical research using machine learning and artificial intelligence-based approaches, identifying novel methods for early diagnosis, formulating new and existing health care devices, and creating platforms to use various electronic, mechanical and biosensors to improve remote health care facility (*IITJ-Indian Institute of Technology Jodhpur*, n.d.). Technology companies have helped create more equitable solutions to improve the performance and outcomes of healthcare. Digital transformation has particularly enhanced the healthcare industry.

Intelligent transportation system- intelligent transportation system (ITS) has become an indispensable component of smart cities. Mobility has become a key concern of citizens in a city and ITS can make the city traffic system more efficient, secure, and safer. It provides users with prior information regarding traffic congestion, real-time running information of vehicles, seat availability among others (Choudhary, 2019). ITS include state-of-the-art electronic, wireless, and automated technologies which collectively have the capacity to integrate vehicles, system users, and traffic infrastructures. ITS, which extensively uses IoT, includes vehicle-to-vehicle and vehicle-to-infrastructure technologies. ITS technologies can be applied to varied systems such as car navigation, variable message signs, automatic number plate recognition, security CCTV systems, container management system, and weather information. Additionally, predictive methods are used to compare historical baseline data and produce more accurate information.

Smart grid- smart grids are electricity networks that efficiently manage the supply and demand of electricity in real-time and maintain the stability and reliability of the grid. Smart grids use digital technologies, sensors and software to monitor and manage the transport of electricity (Drtil et al., 2023). Some of the features of smart grid include- real time monitoring, dynamic pricing mechanism, automated outage management and faster restoration, better energy management, in-house displays, web portals and mobile apps, opportunities to reduce and conserve electricity among others (National Smart Grid Mission, 2023).

Smart waste management- smart waste management focuses on solving solid waste management problems by using intelligent monitoring systems, sensors, and mobile applications. Sensors can inform the waste management services about the fill level of bins or containers and timely update them about the same. Sensors can also alert the authorities in charge of waste management in case of any undesirable incident. Whereas, mobile applications can be used to keep in track the drivers working on the field. In this way, the internet and its allied technologies can provide the authorities with data intelligence and real-time insights. This can have several benefits including, elimination of missed pickups, reduction in the collection and unnecessary fuel consumption cost, reduction in the emission of CO2, and waste generation geo-specific data analysis (Evreka, n.d.).

Smart governance- IGI Global defines smart governance as the “use of technology and innovation to facilitate and support enhanced decision-making and planning within governing bodies” (Esses, 2022). It is very often associated with improving democratic processes, administration, and delivering services with the use of emerging technologies. It is one of the fundamentals of smart cities. As digital technologies are becoming an integrating force in the governing processes, there seems to be a rise in smart governance. And among the many technologies, social media sites have become the foremost platforms for conducting governance using technologies.

3. India's approach to sustainable development of smart cities

Evolution- Pan India Schemes

India has undergone a spatial transformation as it developed. This can be better substantiated with the trend in the urbanisation curve. In the initial stage, most of the Indian population resided in rural areas and were dependent on primary sector occupation. According to the data shared by Macrotrends, the percentage of total population residing in rural areas of India in 1960 was 82.08 %, whereas in urban areas it was just 17.92 % (Macrotrends, 2023). This was followed by an accelerated stage which witnessed structural transformation of the Indian economy that led to the population shift towards urban areas. In the year 2005, the percentage of total population residing in rural areas decreased to 70.77 % whereas in urban areas it increased to 29.24 % (Macrotrends, 2023). The pace at which India is recording the transition of its population to urban areas, it is estimated that by 2035 the percentage of total population residing in urban areas will increase to 43.2% (PTI, 2022). Scholars attribute this trend to growth in population and emergence of new towns, expansion in urban agglomerations and municipal limits.

There has been a concerted effort to standardise urban policy in India since the early 1970s. Several national level infrastructure development schemes have been implemented to accentuate the standard of urban lifestyle in India. However, the formulation and implementation of these policies were ineffective for many decades. For instance, in 1988 a policy report titled National Commission of Urbanisation was introduced to provide recommendations to the centre and the state government to carry out a balanced and sustainable development of urban centres. Both the centre and the state governments neglected the suggestions to follow up the implementation (Kundu et al., 2019).

Huge funds were allocated for the first time to cities for urban development with the launch of Jawaharlal Nehru National Urban Renewal Mission in 2005. An investment of more than INR 1,00,000 crores during 2005 to 2012 was envisaged for the mission. The rationale behind the mission was to uplift infrastructure and service availability in cities and towns that was restricted by indifferent implementation of the Constitution (74th) Amendment Act, 1992. There was also a need to make cities work more effectively and equitably for which it was essential to create regulatory frameworks, provide support and incentives to aid urban reforms at city and state level, and integrate the poor with the service delivery system (Comptroller and Auditor General of India, 2012). However, the government funds allocated were largely biased against non-mission cities and towns. Further, the mission was criticised for not considering separate cost benefit analysis for metropolitan cities and small towns.

There were certain operational issues linked to the JNNURM process. The Eleventh Planning Commission mentions how the "Projects hitherto being implemented by city level agencies have been very small in size compared to those being taken up under JNNURM. The overall institutional capacity and more specifically the project implementation capacity is clearly

inadequate to deal with such large projects. This calls for immediate lateral expansion of human resources with appropriate skills, backed up by good project management systems. There is also a shortfall in the contracting capacity in the private sector. Large/organised sector players in the infrastructure industry have not yet seriously looked at municipal infrastructure because of uncertainty in the enabling environment. The project sizes have been small, with overdependence on the government funding. Poor credibility of implementing agencies is also one of the concerned areas" (Planning Commission of India, 2012, p. 399). Other issues pertaining to continuous engagement with all the cities, capacity building efforts to absorb the investment and need for an independent agency to evaluate the programme timely with appropriate remedial measures.

In 2011 Rajiv Gandhi Awas Yojana was launched with the aim to upgrade slums and provide basic infrastructure and social amenities in the selected slums. The "Slum Free India" encouraged states/union territories to bring all existing slums under a formal system while also redressing the failures of the formal system that lie behind the creation of slums (Ministry of Housing & Urban Poverty Alleviation, 2011). However, negligible progress was achieved and soon with the change in Central government in 2015 the mission was renamed as 'Housing for All'. The mission was to be implemented from the year 2015 to 2022 to provide 'central assistance to implementing agencies through States and UTs for providing houses to all eligible families/beneficiaries by 2022' (Ministry of Housing & Urban Poverty Alleviation, 2015). The mission is further extended till 2024.

In 2015, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was also launched to provide basic infrastructure such as water supply, storm water drainage, sewerage and septage management, non-motorised urban transport, and green spaces and parks to the selected 500 cities. Till date, 134 lakh water tap connections and 102 lakh sewer connections have been provided through AMRUT & in convergence with other schemes against targeted 139 lakh water connections and 145 lakh sewer connections respectively (PIB, 2022). The mission was further subsumed as AMRUT 2.0 to promote a circular economy of water.

Smart City Mission

According to the Census of 2011, cities accommodate 31% of India's current population and contribute to 63% of its GDP. It is estimated that the total percentage of population dwelling in cities would rise to 40% and their contribution would increase by up to 75% by 2030 (National Portal of India, 2016). Hence, there arouse a need to equip cities with comprehensive infrastructural development. The central government's Smart City Mission introduced in 2015 under the Ministry of Housing and Urban Affairs, is a step in this direction. The mission is not just a dream but a way to increase the liveability index in the cities by uplifting the standards of necessities using technologies. The Mission does not define the term 'smart city' for a simple reason that the conceptualisation varies from city to city.

The objective of the mission is to provide core infrastructure to the citizens with the application of ‘smart’ solutions. The mission statement emphasises on the need for sustainable and inclusive development. The core infrastructure elements in a smart city would include: (i) adequate water supply, (ii) assured electricity supply, (iii) sanitation, including solid waste management, (iv) efficient urban mobility and public transport, (v) affordable housing, especially for the poor, (vi) robust IT connectivity and digitalisation, (vii) good governance, especially e-Governance and citizen participation, (viii) sustainable environment, (ix) safety and security of citizens, particularly women, children and the elderly, and (x) health and education (Ministry of Urban Development, 2015).

The Mission covers 100 cities and initially the duration to complete the projects was FY 2015-16 to FY 2019-20. However, the Mission is extended till FY 2024 after evaluations conducted by the Ministry of Urban Development (The Hindu Bureau, 2023). The Mission is a centrally sponsored scheme and the central government will provide financial support of up to Rs. 100 crore per year to the assigned cities. Further, the State/ULB will also contribute an equal amount for the projects. The Mission will have convergence with other schemes for comprehensive development. These schemes are Atal Mission for Rejuvenation and Transformation (AMRUT), Swachh Bharat Mission, National Heritage City Development and Augmentation Yojana (HRIDAY), Digital India, Housing for All, programmes connected to social infrastructure such as Education, Health, and Culture (Ministry of Urban Development, 2015).

Fig. 3: 100 Smart Cities

Source: Maps of India, https://www.mapsofindia.com/government-of-india/smart-cities-project.html

The selection of the cities was concluded on an equitable criterion, where equal weightage was given to urban population of the State/UT and towns in the State/UT. The mission strategy is divided into two broad categories, that is, Area Based Development (ABD) and Pan-City Initiative. The Area based-development comprises retrofitting, redevelopment, and greenfield

developments. Whereas, in the Pan-city Smart solutions would be applied throughout the city. The retrofitting model introduces planning in an existing built-up area. More intensive infrastructure service levels and mass use of smart applications will be deployed in retrofitted smart cities. In the redevelopment model, an existing built-up environment will be replaced by a layout with enhanced infrastructure. The greenfield development model will introduce major smart solutions in a vacant area with the use of innovative planning, plan financing and plan implementation tools with provision for affordable housing. Whereas, a pan-city model envisages application of selected smart solutions to the existing city-wide infrastructure (Ministry of Urban Development, 2015).

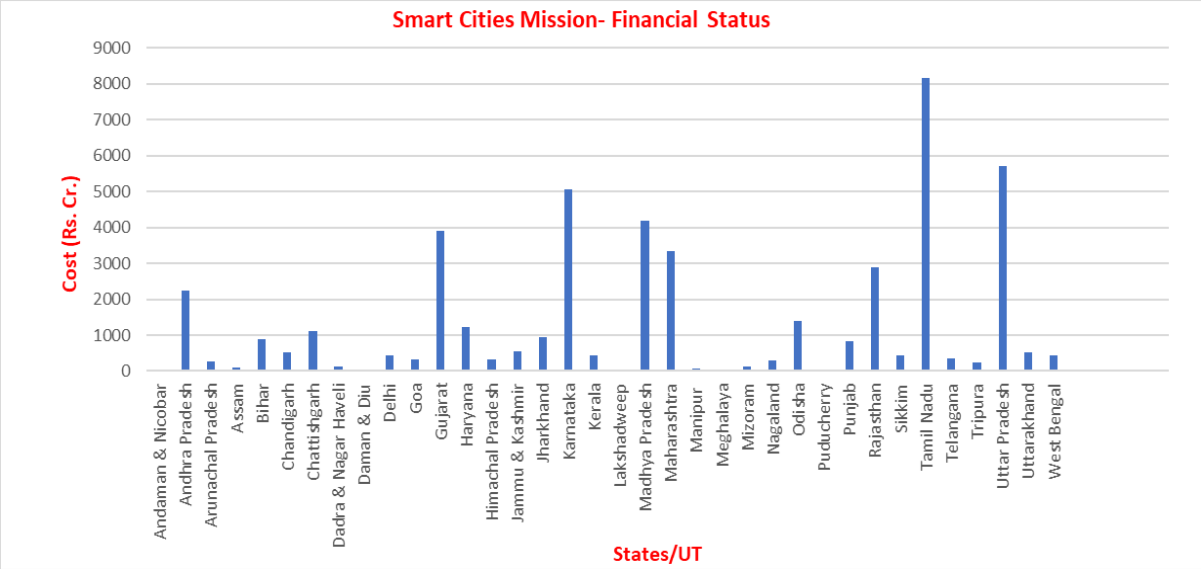
To tackle the challenges of urban management, the government introduced Special Purpose Vehicle (SPV) as a strategic intervention. The primary responsibilities of SPVs are to plan, appraise, approve, release funds, and implement, manage, operate, monitor, and evaluate projects. The projects are implemented through public-private partnerships, joint ventures, subsidiaries, turnkey contracts among others. The members of the SPV are appointed from each hierarchy of the governance system of India (Maurya & Biswas, 2019, pp. 145-146). The Smart City Proposal was introduced by the SPVs for the challenge. These proposals by SPVs of different cities included at least one pan-city solution and either retrofitting, redevelopment or greenfield models. Further, the proposal contained a detailed financial plan for the complete lifecycle of the proposal. An interesting point to note here is that the Proposals have been citizen driven from the very beginning. The authorities have been taking consultation from citizens, including Taxpayers Associations, Senior Citizens and Slum Dwellers Associations, and Residents Welfare Association.

Current status: Physical and financial

The Covid-19 pandemic created a widespread disruption in economies around the world. It also affected the projects undertaken by the Smart City Mission. However, Smart Cities showed better resilience during the pandemic. In a reply to The Indian Express by the Right to Information it was revealed that out of 100 Smart Cities a dozen Smart Cities undertook projects worth Rs 70.40 crore to address the critical situation. The RTI also revealed that as of May 2023, a total of 4,382 projects costing Rs 46,374.24 crore were completed by the 100 cities selected under the Mission (Nath, 2023). A World Economic Forum report in partnership with Deloitte highlights how some of the Smart Cities such as Surat, Bengaluru, and Pimpri Chinchwad leveraged technology to coordinate between different agencies to monitor and plan their COVID-19 emergency response. Many of the smart cities effectively used their Integrated Command and Control Centre (ICCC) to analyse city-specific data, coordinate activities within various agencies and connect with citizens (World Economic Forum et al., 2020). However, the mission was extended in 2021 till June 2023 due to the delay caused by COVID-19. There were delays in implementation of the projects in some of the cities due to the late formation of SPVs.

The Mission was extended for the second time by a year till June 2024 for the completion of the pending work. A total of 7,804 projects worth Rs 1,81,322 crore have been sanctioned and 72% of the projects worth Rs 1,07,000 crore were completed till April 30, 2023. As part of the Mission, Integrated Command and Control Centres have been introduced in all the 100 cities to improve service delivery through data-centric solutions. 53 Smart Cities have taken up 232 infrastructure development projects worth Rs 15,006. Further, 1104 smart mobility projects worth Rs 22,785 crore have been completed while 526 projects are about to get completed. Similarly, Rs 5861 crore have been used to develop 984 public spaces in cities and 343 more such spaces are going to be developed (Chitlangia, 2023).

The Smart Cities Mission released a document on 7th July 2023 indicating the list of completed projects in different States/Ut with the cost accrued by each State/UT. Among the states, Tamil Nadu, Uttar Pradesh, Karnataka, Madhya Pradesh, and Gujarat have done exceedingly well in completing the projects. Whereas, North-eastern states of Meghalaya, Manipur, Assam, Mizoram, and Tripura have had the least progress. The graph below represents the costs accrued by different states and Union Territories for the Smart City Mission.



Graph 1: Smart Cities Mission- Financial status of Indian States/UT
Source:https://smartcities.gov.in/sites/default/files/2023-08/List%20of%20Completed_Projects_SCM_7July2023_0.pdf

Some of the recently completed and upcoming projects under the SCMs of top-most cities are highlighted below:

1. Indore- A Memorandum of Understanding was signed between the co-Founder of the Pataa Navigations and Indore Smart City Development Limited (ISCDL), making Indore the first Indian Smart city to have a fully implemented digital addressing system (CNBCTV18, 2022). The city now has over 5 lakh digital addresses, easing the problems arising out of unstructured addressing systems (IndianWeb2 Desk, 2023).

Recently, the ISDCL has been awarded a tender for the installation of a 60-megawatt capacity solar power plant worth Rs 420 crore with the aim to meet the city's electricity demands (Hall, 2023).

2. Surat- As of May 2023, Surat Smart City has completed 78 projects worth Rs 2,567 crore (ANI, 2023). The PM Awas Yojana and other city housing projects have made commendable efforts to reduce the population of slum dwellers. Slum dwellers stood 25% of the total population of the city; however, it has come down by 6% in 2023 (Press Trust of India, 2023). Additionally, the construction of Asia's biggest biodiversity park is underway in Surat. The park aims to rejuvenate the existing wasteland of Kankara Creek and transform it into a usable public space (National Institute of Urban Affairs, 2022).
3. Coimbatore- Coimbatore Smart City projects are near its completion with 43 out of the 54 projects being completed and the rest pacing up for completion (ANI, 2023). Projects that balance beautification, cultural aspects, aesthetics, and functionality of Tamil Nadu such as the 25 ft tall statue of Thiruvalluvar, 11-metre-tall Media Tree, restoring lakes, and model roads have been appreciated by the Ministry of Urban and Housing Affairs (TNN, 2023).
4. Agra- Agra has been among one of the Smart cities to complete its projects on time. Smart Health Centres have been pivotal under the Smart Cities Mission. As of October 2022, 4 out of 8 Smart Health Centres have been completed and have been opened for public use (Amit Dixit, 2022).
5. Bhubaneswar- The Bhubaneswar Smart City Limited has completed 29 projects as of 2023 and is aiming for 9 other ongoing projects (OB Bureau, 2023). The BSCL recently upgraded the Wi-Fi facility by providing higher speed and better download limit to its citizens (The New Indian Express, 2023).

The Ministry of Housing and Urban Affairs have initiated several programmes to enhance the impact of the Mission. The National Urban Digital Mission, launched on 23 February 2021 was introduced for enhancing digital infrastructure. Under this, initiatives like India Urban Data Exchange, Smart Cities Open Data Portal, and Smart Code have been created to ensure data availability and skill building. An India Smart Cities Awards Contest has been organised every year since 2018 to award the best performing cities. Further, internships have also been offered under The Urban Learning Internship Programme (TULIP) for experiential learning to graduates. The National Urban Learning Platform (NULP) enrols knowledge creators, to promote capacity-building (Aijaz, 2021).

Smart City Mission- A case study of Dehradun

Dehradun is situated in the north-west corner of Uttarakhand state. Nested in the mountain ranges of Himalaya, the district became the capital of Uttarakhand in 2000 and serves as the headquarters of many institutes of national importance. The total area of the district is 3088 sq. kms and it is 2100 ft above the sea level. The district has 7 tehsils, 6 blocks and 767 villages. The population of the city is 16,96,694 (Government of Uttarakhand, 2023). The population of the district has grown multi fold since it was declared as the capital of the newly formed state of Uttarakhand. This increased the pressure on the infrastructure and surrounding land and immediately called for a proactive plan to govern the growing urban area in a sustainable way.

The Smart City Mission came as a relief to the city dwellers of Dehradun, for its objective is to improve the quality of life of city dwellers by addressing key challenges with the use of technology. Moreover, transforming Dehradun into a Smart City would only supplement its strategic location. Dehradun has good connectivity to New Delhi, it is a popular tourist destination, it has proximity to Hindu holy cities of Haridwar and Rishikesh, and it is also an educational hub. The Smart City Proposal introduced by Dehradun had a citizen centric approach. To reach out to the people of Dehradun for their suggestions and advice, various mediums were utilised including press conferences, door-to-door survey, workshops, websites, blogs, advisory committee meetings, industry experts' meetings, campaigns, online opinion poll, public meetings, and general queries (Smart City, 2016). Further, the Proposal was dovetailed with the UN Sustainable Development Goals to link the vision with sustainable development.

The SPV to implement the projects in Dehradun came to be known as the Dehradun Smart City Limited (DSCL). The SPV consists of a high-powered steering committee which includes the Board of Directors, Advisory Body, CEO and Project Management Consultant. DSCL will receive funds from the Government of India and State Government of Uttarakhand for the completion of the projects. The total projects undertaken by the DSCL are 22, out of which 14 projects have been completed and 8 projects are under development. The budget that has been released till date is INR 789 crore out of the total budget of INR 990 crore. Out of the budget that has been released, the total expenditure done till date is INR 627.46 crore.

Initiatives by the DSCL

Currently 18 out of the total 22 projects have been completed. Out of these 18 projects, 11 projects use smart solutions to meet the city's demands. The table below provides a brief overview of the completed projects.

Table 1: Projects completed by the DSCL

Project name	**Cost (Rs. cr)**
Digitisation of Collectorate and CDO office	0.56
Smart Waste Vehicle for Nagar Nigam and Jal Sansthan	21.28
Monumental Flag	0.09
Facade works at Paltan Bazaar	4.79
Water Supply Augmentation	26.92
Creche Building in Secretariat	1.02
Bandwidth for DICCC	32.00
Parade Ground rejuvenation	21.92
Citizen Outreach Programme	1.00
Doon Integrated Command and Control Centre	289.92
Modern Library Complex	5.75
Smart Schools	5.92
Sewerage line project along smart roads	22.15
Smart water metres	9.48
Smart water management	25.07
Paltan bazar pedestrianisation MLCP	13.81
Electric buses	33.30
Smart toilets	1.81

Source: https://smartcities.gov.in/sites/default/files/2023-08/List%20of%20Completed_Projects_SCM_7July2023_0.pdf

This research will only focus on technology intensive projects by reviewing the current status and challenges associated to them. The data is collected from ITDA, DSCL, DTP, and Government of Uttarakhand.

1. **Doon Integrated Command and Control Centre (DICCC)**

Doon Integrated Command Control Centre aims to enable ICT-based handling of various civic operations and facilitates the city administrator in the monitoring of all municipal departments for efficient service delivery. The Centre is spread across 3200 sq. feet of floor area. It consists of a war room, a discussion room, and a conference room. There is provision for 30 operators. The beneficiaries of this are ITDA, traffic police, City police and Nagar Nigam.

The functions of the DICCC are as under-

- The ICCC helps in real-time monitoring of solid waste collection services efficiently,
- It facilitates real-time monitoring and analysis of surveillance data from CCTV cameras to improve safety measures in the city
- The ICCC aids in the effective management of traffic in the city
- The ICCC has been instrumental in making the public transport more efficient
- The ICCC has helped with monitoring the vital environmental parameters in order to ensure effective public health measures.
- The Emergency Call Box response system has also helped citizens immensely
- The ICCC helps in cross-departmental coordination and effective management of services

Use cases

1. Monitoring public transport system using Vehicle Tracking and Management System (VTMS)

Overview- The city administration aimed to install GPS devices in public buses to track the E-Buses for facilitating monitoring of bus location, identify the ETA for each bus stops falling within the route, and ensure trip adherence.

Implementation details- All the 10 vehicles are fitted with GPS live feed for tracking the location of Bus can be viewed in DICCC through TMS Application & ICCC Dashboard. Some key activities facilitated at ICCC using the application are as follows:

- Monitor each trip of Vehicles
- Trip Not Started: In case any vehicles do not start the trip as per schedule, inform the concerned Authority to make an alternative arrangement
- Identify the ETA for all Bus Stops
- Ensure Trip adherence
- Prepare to produce MIS reports to Officers

Outcomes achieved-

- Increased accuracy of ETA information for buses: Citizens can schedule their travel from the nearest bus stop based on ETA as the accuracy of the information has increased.

- Reduced waiting time: It is not required for citizens to wait for a long time at any bus stop.
- Real-time vehicle monitoring: Real-time updates of bus arrival on any stop has improved the efficiency of the public bus system.

2. Electric buses

Dehradun has witnessed an exponential increase in motorisation which has subsequently impacted the air quality, noise pollution, congestion, accidents, encroachments, and deterioration of health. As a solution for this gridlock, a regular fleet of environment friendly transportation system was advised. Under the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, the Uttarakhand government deployed a fleet of 30 E-Buses. The E-buses will cover a total distance of 277 km, along 16 routes with 134 stops and pick-up points at regular frequency of 5-10 minutes.

An In-built ITS (Intelligent Transport System) application has also been developed by Dehradun Smart City Limited (DSCL) for smooth movement of the fleet buses along with their proper monitoring as in the form of services of Trip scheduling, Alert System, GPS Tracking, Estimated Time of Arrival (ETA) Service among others. As per the functionality and usability of Intelligent Transport System (ITS) team is Scheduling Trips along with Service Configuration, Vehicle Tracking for all categories namely Running, Idle, Under Maintenance, Vehicle Trip Status, ETA along with Vehicle and Trip Dashboard.

Fig 4: ITS

Source: ITDA

Citizen Centric Public Transportation system have many Operational, Community and Utility benefits. Reports can be accessed for better route allocation, last mile connectivity, Alert Management, Economic benefits as well. Significant reduction in emission of Green House Gases along with other health benefits for citizen, especially children and patients with Asthma and heart related ailments.

Statistics:
- Revenue Generated (₹) =37064670(Approx 4 Crore till date)
- Total Passenger Travelled = 1730614 (Approx 18 Lakh till date)
- Total Distance covered = 4 lakh Km.
- Total Trip = 19178
- Total reduction in PM 2.5= 50-60 tonnes per year

3. Solid Waste Management

Municipal Solid Waste (MSW) management is a challenging task for cities. Increase in the population of Dehradun city has affected the disposal and management of MSW. This waste is a combination of commercial waste, industrial waste, food waste, sweeping waste, construction waste, sanitation waste and it may also contain toxic chemicals. As per Environmental Information System data, 40% of the total MSW is not collected and lied littered in the city.

Various surveys were conducted in 2018 with several stakeholders to help identify the gaps and solutions for the ongoing crisis of solid waste management. Two major concerns which were addressed way back in 2019 were Proper and effective collection of the generated Garbage and finding and allocating optimal route which results in most efficient use of labour and equipment. Smart Bins is an economical solution saving time and money by using smart waste collection bins and systems equipped with fill level sensors and integrated with command centre. As smart transport vehicles go only to the filled containers or bins. It reduces infrastructure, operating and maintenance costs.

Analysis and close monitoring are carried out through SWM application currently hosted in Integrated Control and Command Centre (DICCC) at ITDA. Garbage Weight, GPS tracking of vehicles deployed for Door-to-Door collection, Attendance marking of field and supervisor staff through workforce Application, Bin Sensor status – are running in parallel through SWM application.

Outcomes

- Citizen friendly Grievance redressal system for prompt action to be taken by concerned department.

- Staff attendance and Location can be exactly known through workforce application.
- QR Code enabled door to door primary garbage collection ensuring full transparency and exact statistical monitoring.
- Reports related to all Alerts and Complaints, Bin Status, Vehicle Trips, Total Vehicles on fields can be fetched for analytics which can be very helpful in making required administrative decisions for carrying out required operations in a more effective manner.

Table 2: Bin Sensors log report

SN	Month	Bin Sensors Log Report
1	15th March	1749
2	30th April	
3	May-22	295
4	Jun-22	937
5	Jul-22	557
6	Aug-22	780
7	Sep-22	475
8	Oct-22	1362
9	Nov-22	2440
10	Dec-22	382
11	Jan-23	219

Source: ITDA

Table 3: Zone wise household collection

SN	Month	Zone wise Household collection (In Num)
1	Apr-22	2
2	May-22	953
3	Jun-22	634
4	Jul-22	1230
5	Aug-22	745
6	Sep-22	342
7	Oct-22	318
8	Nov-22	53
9	Dec-22	2

Source: ITDA

Table 4: Total garbage weight- door-to-door

SN	Month	Total Garbage Weight [In Kg] [Door to Door Zone wise]
1	Apr-22	38.75
2	May-22	32865
3	Jun-22	21552.75
4	Jul-22	20865
5	Aug-22	25505.25
6	Sep-22	10822.5
7	Oct-22	10501.25
8	Nov-22	1672.5
9	Dec-22	62

Source: ITDA

4. Citizen Outreach Programme

Citizen engagement in Dehradun is to be promoted through virtual interaction, dialogue and discussion and is therefore centre to the urban development.

This can be done by reporting on the cleanliness of roads, parks, and public toilets, encouraging the public to use more public transport and to use apps to report incidents of corruption and malpractice. Encouraging general public to act as citizen police, taking on the responsibility of making the city safer, is a way towards a more aware doon

For instance, the Doon-1 app helps to promote cities as engines of economic growth through improvement in the quality of urban life by facilitating creation of quality urban infrastructure, with assured service levels and efficient governance and for creating economically vibrant, inclusive, efficient, and sustainable.

Table 5: Complaints lodged for SWM IN 2022

No. of SWM Complaints in 2022		
S No.	Month	No. of Calls
1	April	22
2	May	34
3	June	43
4	July	65
5	August	49
6	September	53
7	October	51
8	November	18
9	December	13
Total		348
No. of SWM Complaints in 2023		
S No.	Month	No. of Calls
1	January	55

2	February	8
3	March	7
Total		70

Source: ITDA

5. Smart schools

The importance of smart classes has increased in this age of technology. In the three smart schools developed under the smart city project, the students will get the latest facilities. Along with smart labs and virtual classes, various new technologies are being used for education in these smart schools. three smart schools under the Dehradun smart city project were inaugurated at the Government Inter college, Rajpur Road. The smart schools inaugurated by the CM include the GIC Rajpur Road, GIC Khudbuda and pre secondary school at Khudbuda. The schools provide with virtual classes, digital content, school management system, learning management system, library management system, CCTV surveillance, and biometric attendance.

6. Modern Doon Library

The Modern Doon Library has been built at the Lansdowne Chowk near Parade Ground. This is a joint initiative and the SCM contributed to around INR 5.75 cr while the CSR funds allocated for the same where INR 7.50 cr. The library is built in an area of 3000 sq. Mt, and has seating arrangements for 500-600 readers. The library has been equipped with high technology and facilities such as e-reading, books, newspapers, and magazines of diverse subjects are available for the readers. The low membership charges of the library make it convenient for the readers to take full advantage of the facilities. The annual membership charge of the library of the library is INR 300, while INR. 1000 is deposited in the security room. Whereas, the life membership is just INR 2000. The library is also a research centre. The library will soon inaugurate a museum where the artefacts, showcasing Uttarakhand's culture and heritage are donated by various patrons.

Features:

- Offline books- 14,000 with 2500 titles, including text books, book banks, and reference books
- E-journals- 6000+ and subscribed to 5 E-Databases
- E learning CD/DVDs- 1000+

7. Water ATM

The rationale to encourage this project was the problems arising from the availability of water at high costs in Dehradun. To make easy availability of portable water at reasonable cost to citizens at public places, slum areas, parks, and schools the DSCL installed water ATMs. This is directly advantageous to the public and particularly the marginalised and economically weaker section. The project was completed in 2019 and 24 Water ATMs have been installed so far.

Features:

- Automated treated water dispensing unit at public places
- Low cost of water
  - 300 ml- INR 1
  - 300 ml with glass- INR 2
  - 1 Lt. without container- INR 3
  - 5 Lt. without container- INR 14
- Facility to display water quality and online dissemination of such reports
- Coin/RFID card-based system
- Total revenue collection till March 2023- INR 8,98,548

8. Smart Toilets

The lack of the presence of public toilets in Dehradun encouraged open defecation and littering. The DSCL, thus undertook the initiative to build seven Smart Toilets. The project was completed in 2019. The toilets have been built at public spaces. The locations for these Smart toilets are- Parade Ground-1 & 2, ISBT, Old Tehsil Compound, Niranjanpur Sabji Mandi, Doon hospital, and near Collectorate office.

Features

- Total new toilets 07 nos.
- The complex has 3 sets of toilets viz. Gents', Ladies' & Handicapped.
- The gents' toilet has 4 WC, 7 Urinal and 3 Nos wash basins.
- The ladies' unit 4 WC and one child care room and 4 nos wash basins.
- The total area of smart toilet complex is 665 Sq Ft.
- Automated features for cleaning and collection of Payments for usage.
- User Charges - INR 5 per usage of WC and Urinals are Free

9. Smart water metre

The consumption of water needs to be monitored with integrity and accuracy for water loss management. Accurate measurement of water consumption at domestic and non-domestic water connections became the need of the hour in Dehradun city. Under the Smart Water Meter project, all 5,901 nos. domestic and non-domestic water connections in selected DMA (District Metered Area) in ABD area of Dehradun Smart City has provided with smart metering. This technique offers the benefits of mobile data collection system.

This has various functions including, regulation of water consumption, enforcing water discipline, implementing volumetric tariff, smart billing, and making consumers pay for what they consume. The grouping of data is done with the help of GPS positioning as well as the off-field methods. The IP68 water meter can be submerged up to 3 meters. The AMR is easily readable in submerged conditions which are otherwise tough to read by manual or conventional methods of meter reading.

10. Smart water management- ESCO supervisory Control and Data Acquisition (SCADA)

The ESCO model was adopted and implemented to increase pumping accuracy in Dehradun city for water supply. This model uses less energy consumption during the pumping process. An estimated of INR 35 cr of energy will be saved over 10 years.

Features-

- Flow monitoring
- Ground water level and draw down monitoring
- Long term maintenance
- Analysis through SCADA software
- Level based operation- saves water
- Real-time monitoring through GPRS 4G communication
- Pressure monitoring
- Mobile monitoring through android app
- Smart water management

Table 6: SCADA

Item	Quantities as per BOQ	Supplied Oty (Nos.)	Installed Qts (Nos.)
Flow meter	286	293	290

Valves	296	520	479
Actuator	296	520	479
Depth sensor (only 63 available locations)	63	63	63
Observation bore well (63 available locations)	63	63	63
Actuator panel	504	504	504
Hard wire timer circuit	287	484	484
Ultrasonic level transmitter	72	72	72
Pressure transmitter	217	217	217
Chlorine analyser	278	278	278
Chlorine dozer	206	206	206
RTU panel installed for automation	206	206	206
Energy efficient pumps (Non BOQ item for ESCO)	206	206	206

Source: DSCL

Challenges with Dehradun Smart City

The Dehradun Smart City faces some potential challenges that is hindering the smooth functioning of the projects.

1. The smooth functioning of smart cities relies on the utilisation of internet connectivity to its full potential. Smart solutions used in smart cities depends on technologies such as IoT which requires robust connectivity to further provide services. Thus, quality and reliability of connectivity becomes critical to the smart city. This will transform the smart cities into vibrant socio-economic hubs that helps businesses thrive and easy to govern. However, the DSCL projects face challenges due to poor internet connections. The internet vendors are in Dehradun smart city are BSNL and UPCL. The city surveillance report by the Dehradun traffic Police of April 2023 revealed that out of 96

cameras installed at various junctions, 28 were inactive due to BSNL issue, 9 were inactive because UPCL had issue, 5 cameras were inactive because of UPCL high voltage, and 1 camera was inactive because of UPCL cable was damaged.

2. The Dehradun Smart City follows retrofitting strategy. There lie latent challenges with retrofitting strategy. The challenge lied in aligning new solutions to the existing master plan of the city. Delay in the rapid implementation or construction of these projects can adversely impact the residents of Dehradun smart city. For instance, the 8.1 km long Smart Road project which includes utility ducts, sewer work, drain work, water supply works, and road improvement works is still incomplete. The INR 191 cr project has crossed its deadline, that is, June 2023. In order to complete the project on time, all the roads were dug up at once. This has left the residents baffled. These constructions often abrupt internet and electricity connectivity creating further problems for the residents.
3. Proper management of the Dehradun smart city needs coordination among various stakeholders. Although the implementation body is DSCL, the projects need convergence from various stakeholders including public and private sectors. However, there is lack of coordination and unity among the stakeholders. For instance, when the residents wanted to register complaint about the dug-up road in Dalanwala, instead of registering the complaint, they were made to approach different departments for the solution to the problem.
4. For the residents to understand and avail the benefits of the initiatives, there has to be good communication strategy between the stakeholders and the public. However, this is not the case. For instance, there were cases of residents burning the underground garbage fill because of their unawareness about the sensors installed in them. Since sensors are expensive devices, such incidents have attached costs to it. This incident could have been avoided if better communication strategy were deployed by the authorities.
5. Since the smart solutions makes the most of the smart cities, it is important to equip all the teams handling the projects with enough technical experts. For instance, no technical team was appointed to the Dehradun Traffic Police from the DICCC. This is a major concern when dealing with devices such as RLVD, ATCS, and Radars. Further, it is important that all the devices work efficiently since smart city relies heavily on these. For instance, the City Surveillance Report by the Dehradun Traffic Police (April 2023) mentions that the ANPR system skipped tracking some cars, indicating that it is incompatible to track cars.

Recommendations

Challenges such as lack of coordination among stakeholders, untimely allocation of funds, and lack of technical experts can be dealt by having an integrated approach to the implementation of smart city projects. This integrated approach will need to have the Dehradun Municipal Corporation and Dehradun Smart City Ltd. working together as a single entity. Municipal Corporations have a long history and expertise of managing cities. There needs to be an

authority that needs to check the working of the SPV, in this case, the Dehradun Municipal Corporation should be the concerning body.

The city needs more technical support in the form of manpower and funds to manage the projects. Lack of technical experts have created hurdles in the effective functioning of the Dehradun smart city. Further, the city needs a rugged cyber security system to deal with mishaps. A city data policy is another recommendation for Dehradun Smart City. Although there are many national policies for management of data, city governments' proximity to their constituents enables them to efficiently understand, utilise and monitor the usage of data at the city level and put it to use for better service delivery.

Conclusions

As cities grow, there is a conscious understanding among the authorities to keep it up with the global trends. In this context, smart city is a phenomenon that is technologically modern urban area deploying diverse ICT solutions to improve the operations across the cities. Cities globally are adopting technologies to effectively fasten governance models. The concept of sustainability has positively contributed to the development of smart cities. Smart sustainable city balances its priorities between technology and sustainability.

The Indian Smart City Mission launched in 2015 is a direction to sustainable growth of cities by employing technology as a means. Although the Mission does not define the term smart city, it focuses on the core infrastructural development criteria to inform the citizens about the concept. Dehradun is one among the 100 smart cities to be chosen under the Mission. The Dehradun Smart City Ltd receives funds from the Government of India and the Government of Uttarakhand to implement its projects. Under the DSCL, the projects that have been implemented vary in nature, aiming to provide the city with a holistic growth. However, the projects face some potential challenges which is required to be overcome in order to avail the benefits to the citizens. The implementation and execution of certain projects needs to be inspected for its prompt completion.

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