EXAMINING THE APPLICABILITY OF EFFECTIVE OPERATIONS FRAMEWORK AND MANAGEMENT IN THE SMART CITY MOVEMENT AND INFRASTRUCTURE DEVELOPMENT

by

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DISSERTATION
Presented to the Swiss School of Business and Management Geneva
In Partial Fulfillment
Of the Requirements
For the Degree

DOCTOR OF BUSINESS ADMINISTRATION

SWISS SCHOOL OF BUSINESS AND MANAGEMENT GENEVA

MARCH, 2026

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DECLARATION

I hereby declare that this dissertation titled **"Examining the Applicability of Effective Operations Framework and Management in the Smart City Movement and Infrastructure Development"** submitted to the **Swiss School of Business and Management Geneva (SSBM)** in partial fulfillment of the requirements for the degree of **Doctor of Business Administration (DBA)** is my original work.

This research has been carried out by me under the supervision and guidance of **Dr. Vasiliki Grougiou**. The work presented in this dissertation has not been submitted, either in whole or in part, to any other university or institution for the award of any degree, diploma, or professional qualification.

I further declare that all sources of information and ideas used in this research have been duly acknowledged and properly cited in accordance with academic standards.

I take full responsibility for the authenticity and integrity of the work presented in this dissertation.

DEDICATION

This dissertation is dedicated to my family, whose love, patience, and encouragement sustained me throughout this long and meaningful journey.

This doctoral research represents the fulfillment of a dream that began many years ago during my higher secondary education, when I first aspired to pursue advanced academic research. Completing this work marks the realization of a lifelong goal.

I dedicate this dissertation with deep affection to my children and grandchildren, whose eagerness and constant encouragement to see this journey completed have been a source of great motivation and joy.

I also dedicate this work to my parents, whose values, guidance, and belief in education laid the foundation for everything I have achieved.

Above all, I dedicate this dissertation in gratitude to the Almighty for granting me the strength, perseverance, and opportunity to complete this important milestone.

ACKNOWLEDGEMENT

First and foremost, I wish to express my deepest appreciation and heartfelt gratitude to my mentor and supervisor **Dr. Vasiliki Grougiou**, whose continuous guidance, insightful comments, and constructive feedback have been invaluable throughout this research journey. Over the past several years, her thoughtful observations, academic rigor, and encouragement have not only strengthened this dissertation but have also significantly shaped my approach to research and professional thinking. I consider myself truly fortunate to have been guided by such an exceptional mentor, coach, and academic leader.

I would also like to express my sincere appreciation to the **Swiss School of Business and Management Geneva (SSBM)** for providing a structured and intellectually stimulating doctoral program. The academic framework, research guidance, and continuous learning opportunities offered by SSBM have been instrumental in enabling me to successfully complete this research.

I am especially grateful for the numerous **doctoral webinars, research workshops, and academic sessions conducted by SSBM**, which provided clarity on research methodology, academic writing, ethics requirements, and dissertation preparation. These sessions played a vital role in strengthening the academic quality of this research and guiding me through the doctoral process in a systematic manner.

I extend my appreciation to the faculty members and academic support team of SSBM for their continuous assistance, encouragement, and administrative support throughout the doctoral program.

I would also like to thank all the industry professionals and participants who generously contributed their time and expertise during the interview process. Their practical insights and professional experience formed a valuable foundation for this research.

ABSTRACT

The high-speed urbanisation process and technological advances have enhanced the speed of smart city developments that aim at enhancing the sustainability of cities, infrastructures, and quality of life by incorporating digital technologies and data-oriented governance. However, without effective operations management frameworks, which would have the capacity to coordinate the movements of the different stakeholders, complicated systems of infrastructure, and informed decision making, the implementation of smart city programmes would be a failure. The objective of the study is to determine the role of operations management structure in efficient infrastructure management, stakeholder coordination, and integration of technology in smart cities. The current study seeks at identifying certain factors of operation, which define the success of smart city projects and overcome the challenges arising in the implementation of such projects. A qualitative research design was selected to emerge with a more profound understanding of the operating practices in the smart city endeavors. The data was obtained through interviews held as semi-structured ones with a total of nineteen individuals who were more directly involved in planning, managing, or implementing smart city programmes. The method through which the data was analysed was the thematic analysis, and therefore, discovered identical themes and trends with respect to governance, technology integration, and operations coordination. The findings of the study indicate that well-functioning operations management systems have the potential to significantly enhance stakeholders' alignment, the management system of infrastructure, and make smart decisions in smart city endeavors. These results highlight some of the most important success areas, which include the integrated data management systems, collaborative governance structures, technological readiness, and a loose policy structure. At the same time, the problem of data interoperability, institutional disaggregation, and technical deficiencies were witnessed as the barriers to effective implementation. The study adds to the knowledge of smart city governance and infrastructure management since it reveals how properly organized operation systems are used as a tool to realize sustainable city development. The results can be used to offer practical information to policymakers, urban planners, and infrastructural managers who would like to make the smart cities projects more efficient, tolerable, and sustainable.

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1.1 Research Background

1.1.1 Smart Cities

Smart cities have been defined by Winkowska et al. (2019) as urban cities that have been developed with the aid of the latest technological tools as well as data-driven tools and processes with the aim of improving the quality of life among citizens who will live in such cities. These cities combine different aspects of living in any city and then attempt to bring innovative and scientific solutions that can aid in addressing them while at the same time, promoting a higher level of efficiency and resource allocation. Nine major attributes of smart cities are discussed below:

Smart Governance

The conceit of smart governance has been promoted as a major attribute in the development of smart cities, for which ensuring proper, continuous, and effective data accessibility is a major aspect, that has been observed by Dembski et al. (2020). Here, it should be noted that data can be of various aspects regarding living normal and regular lives in the cities. After defining the data scope, the next step in focusing is ensuring real-time data is collected and non-historic data, which can affect the efficiency of the project. The third step lies in ensuring such data is readily available to all stakeholders involved in decision-making. The second crucial aspect of smart governance has been established by Noori et al. (2020), who suggested ensuring a participatory form of decision-making regarding various aspects of the city. This process involves two aspects first, involving citizens in initial urban planning regarding the development of cities and infrastructure in such cities. The second aspect is policy formulation regarding different aspects of living, from the daily commute through transportation to waste collection and management. Here, citizens from all sections of society are involved in promoting the level of inclusion and diversity that can lead to making each service accessible to all citizens.

Smart Infrastructure please amend throughout

Infrastructure forms the core of any city, and hence, smart infrastructure development is also a major aspect of a smart city. The study conducted by Sharifi et al., (2020) establishes the first attribute as the adaptability of newly developed or existing infrastructure. Here, adaptability has been defined in two aspects, the availability of proper infrastructure technology that can be used to build adequate infrastructure, and secondly, developing infrastructure that is currently integrated with the latest technology and can be further integrated with future technology. Hence, the adaptability aspect is future-oriented and considers expected future demand and improvements in technology. The second aspect of such smart infrastructure in smart cities has been extensively discussed in the study by Tchotchke and Schieferdecker (2021). This ensures proper resilience of the infrastructure, which should be both resilient against any natural disaster or man-made challenges that may occur in the city and forecasted through predictive analysis. The development of resilience is again considered through both existing and newly developed infrastructure. In the case of existing infrastructure, challenges are more complex in nature, as such infrastructure cannot be demolished; rather, modification needs to be done to ensure it can also meet different expected disasters and challenges.

Smart Mobility - Transportation in any city allows citizens to transport themselves from one place to another, and hence smart cities need to focus on ensuring smart mobility as well. Hence, traffic management is a major attribute of any smart city (Gao et al., 2023). With the aid of real-time data collection and analysis, traffic management is considered to become more efficient. In this regard, the major focus is on route optimizations as well as ensuring efficient usage of both private and public transportation. Reduction of transportation time for both modes and ensuring utilization of seat capacity for public transport must be achieved. This discussion considers a second major aspect of transportation in smart cities, which has been explored by Dzemydienė et al. (2021) as multi-modal integration. A smart city can have different transportation systems ranging from land to air transportation, and hence it needs to be ensured that there is proper connectivity between each form. Citizens must not face inconvenience in accessing any available form of transportation within the city. This also leads us to the second aspect of ensuring the transportation system is so planned that each respective zone in a smart city is connected to the central hub as well as each other for citizens.

Smart Energy - Smart Cities around the world are now starting to focus on the utilization of renewable energy sources to supply power for different operations in the city (Hoang & Nguyen, 2021). Each of these cities is expected to have a separate power grid, and a feasible solution that has been suggested is to use a combination of both non-renewable sources of energy while focusing on renewable energy. The major focus should also be shifted to establishing and installing different energy points throughout the city, which would aid in renewable energy collection. While considering different complex aspects of renewable energy adoption, the basic attributes of energy demand and supply shall also be considered, as per Serban & Lytras (2020). These cities utilize different technological tools to collect data regarding various attributes; hence, it should be adequately utilized to have a real-time idea of expected energy demand and at the same time prepare enough resources to meet peak demand situations. This has been considered important to reduce any chances of a blackout or interrupted power supply, which can negatively impact the convenience of citizens in the city. Thus, an uninterrupted and continuous power supply will be ensured in the smart city.

Smart Economy - Smart cities also aim to have a swift and sustainable growth rate for the local economy. For this aspect, the growth of digital payment attributes shall also be considered, which has been established by Tan (2022). The primary focus has been on digital payments and the growth of virtual business platforms. In this context, digital payments have been established for business payments, transactions among citizens, and payments to the government in the form of taxes, charges, and duties. The government also plays a major role here in promoting cashless transactions and, at the same time, ensuring the privacy and security of citizens. According to the Office of the Government Chief Information Officer (2019), smart cities shall also focus on being considered as launching pads for startups in several economic sectors, primarily in the technology sector. This attribute is often considered comprehensive and multidimensional as it also considers education, the financial system, legal regulations, and the willingness of citizens to engage in developing startups. However, in this regard, the role of the city has been established as providing a conducive and dedicated environment in which such startup founders can innovate, utilize technology to address existing challenges, and at the same time, have financial resources to start operations.

Smart Living - People are expected to live in smart cities and continue their regular lives, in a much more efficient manner, for which smart living is a major aspect (Mayaud et al., 2019). The first aspect of smart living is ensuring a higher level of inclusion and diversity among citizens in the state. Here, inclusivity shall focus on ensuring access to both life and the different services and products that have been made available to all citizens. For inclusion, different communities must be considered either based on gender or economy. Recently, people with disabilities have also been included. The discussion on smart living, according to the study by Quijano-Sánchez et al., (2020) is ensuring healthcare services accessibility and affordability. On a broader level, it implies ensuring each citizen can access doctors, healthcare providers, and medical institutions within the city in an affordable manner without facing major inconvenience. While considering health aspects, the health challenges of different groups of people shall be considered, specifically children, pregnant women, and the geriatric population. It should be noted here that it may not be possible for each smart city to provide enough medical resources for each known disease, but steps can be taken to ensure access.

Smart Environment - While considering the scope of technology, smart cities also focus on ensuring environmental sustainability for their citizens. Qi et al., (2020) have suggested the utilization of machine learning and data collected through various data points, to conduct predictive analysis, and determine the environmental impact. The aspect here is to understand the environmental footprint of different operations conducted by city citizens and then develop solutions and approaches that will lead to the reduction and mitigation of any negative footprint. Thus, the focus here should be on utilizing different scientific tools to promote environmental preservation and reduce emissions. Under the integration of technology tools to aid in environmental protection, the deployment of sensor networks has also been considered an effective solution by scholars such as Zhu et al. (2019). Sensor networks are deployed throughout the city, with a centralized data analysis structure to analyze different data points and, at the same time, enable real-time analysis and address the challenges. This can be adopted to understand different sources of carbon footprints for citizens and then develop a localized strategy accordingly that can be implemented. Here, it should be noted that the major objective is environmental conservation, for which technology is being used as a tool to promote public endeavors.

Smart People - To utilize different aspects that have been discussed above, general citizens of the city shall be able to access such technology, for which attributes such as digital education shall also be considered (Baltac, 2019). Digital education here has been divided into two sections, education for children and education for adult citizens. The primary reason behind such division is to ensure dedicated and systematic plans can be developed for each group. Adult education here signifies upskilling adults living in the city to be able to utilize different digital platforms and participate in city functioning like other citizens. The next aspect that has been discussed in recent years is the study conducted by Levenda et al. (2020), which ensures the engagement of the entire population both as a community and as specific individuals. On the technical aspect, it involves developing digital platforms that can connect and collect the opinions of different members of the population. On the social aspect, this involves increasing the level of willingness among each citizen to actively participate in discussion and decision-making to advance personal interests as an individual and collective interests as a community in the city. Thus, encouraging public participation and ensuring engagement is a major attribute behind smart city development.

Smart Technology - Smart duties build around the concept of technology and data solutions; hence, technology itself shall also be considered a crucial factor. The aspect of 5G technology in recent years has become a major approach (Shahinzadeh et al., 2020). The adoption of 5G internet is being considered due to its possibility of providing a high-speed internet connection that is uninterrupted and continuous in nature. The current focus is on ensuring accessibility to 5G internet services available to be utilized by citizens across the city and thus enjoying uninterrupted connection for the time they stay in the city. Adoption of 5G technology remains incomplete in ensuring the second attribute, established by Amet et al. (2022), which is the interoperability of different systems within the city infrastructure. This requires ensuring different technological tools can relate to each other and work seamlessly and in an integrated manner. While considering the aspects of smart technology, it should also be noted that this attribute is rapidly evolving, and hence the focus should be on the adoption of new tools and services while at the same time having an innovative approach. Together, these attributes combine to function as an efficient smart city for different citizen groups in the city.

A smart city can be defined as urban innovation by harnessing cutting-edge technology and data-driven processes to elevate the quality of life for its inhabitants. Comprising nine key attributes, a smart city entails intelligent governance with accessible real-time data and participatory decision-making, adaptable and resilient infrastructure that integrates future technology, efficient traffic management and seamless transportation connectivity, sustainable energy sources and uninterrupted power supply, a thriving digital economy with digital payments and startup growth, inclusive and healthcare-focused living environments, eco-conscious practices and environmental conservation, empowered and engaged citizens through digital education and participation, and advanced technology adoption with 5G connectivity and interoperability. Collectively, these attributes define a smart city's mission: to create a connected, sustainable, and technologically advanced urban ecosystem that enhances the well-being and convenience of its diverse population. However, the different attributes discussed can be provided only when there exist proper and efficient infrastructure which can address different needs of smart cities which have been covered below:

1.1.2 Infrastructure Development

Infrastructure can be considered the backbone of the development and operation of smart cities. According to the study conducted by Berglund et al. (2020), providing any form of service that aims to improve quality of life requires the development of adequate infrastructure, which highlights the need for developing adequate infrastructure in smart cities. It can, however, also have several challenges in the form of financial and technological limitations that need to be considered. Various types of infrastructure required in smart cities have been discussed below:

Transportation Infrastructure

Smart cities endeavor to cultivate intelligent mobility solutions geared toward addressing the transportation and logistical requirements of diverse citizen demographics (Šurdonja et al., 2020). In recent times, the emphasis has shifted towards the enhancement of public transit systems and the mitigation of road congestion, impacting both private commuters and regular citizens alike. This shift also encompasses the integration of artificial intelligence and novel technological tools to ensure efficient traffic management and real-time navigation assistance, ultimately reducing the likelihood of travel delays. Consequently, the overarching objective revolves around facilitating

swift and uninterrupted movement. An emerging trend in smart cities is the establishment of electric mobility infrastructure within urban areas, as delineated in the study by Ruggieri et al. (2021). From a technical standpoint, this entails the development of fundamental road infrastructure to support electric vehicles, coupled with the provision of charging stations capable of meeting the energy demands of such vehicles. This endeavor aligns with the overarching goals of fostering an environmentally conscious transportation system and curbing associated air pollution. Consequently, the expansion of electric-based mobility and transportation infrastructure stands as a pivotal priority in the smart city paradigm. While previous discussions have centered on various transportation facets, Huo et al. (2021) study underscores the imperative of establishing designated road segments, such as pathways and dedicated cycling lanes, to cater to those citizens who prefer walking or cycling as their mode of transportation. This strategic approach also serves as an effective means of cultivating last-mile connectivity within smart cities, even in regions characterized by limited access to public transportation. Hence, the entire transportation infrastructure is intricately intertwined with the principle of ensuring accessibility.

Energy Infrastructure: Smart cities have recently started to focus on the development of renewable energy sources to meet the power demands faced in the cities (Hoang & Nguyen, 2021). This requires the development of dedicated infrastructure in the form of solar panels, wind turbines, or any other tools required to promote the level of renewable energy generation to meet the demand of people in the city. In this regard, it should be noted that infrastructure that can support the utilization of fossil fuel energy resources while causing minimal pollution and emissions shall also be considered for the time until complete operation of renewable energy is achieved. The next aspect that is also crucial to be considered for development in smart cities as part of energy infrastructure is the development of smart grids, as per the study by Strielkowski et al., (2020). Smart grids are needed to manage electricity flow throughout the city based on expected demand while ensuring each part has access to continuous electricity and there is minimal wastage among distribution lines. Thus, here the focus is on ensuring a stable power supply throughout the city while at the same time being capable of meeting any increase in demand (usually considered with respect to peak demand). To meet such unexpected energy demand, the availability of proper energy storage infrastructure is also required, which has also been given the status of crucial energy infrastructure as per the study by Golpîra & Bahramara (2020). Energy storage infrastructure can be either in the form of batteries or dedicated energy storage systems, which can address volatility

and reduce dependence on external systems in the case of natural disasters. The concept of energy storage is also connected with having a sufficient supply of surplus energy that can be used to meet the needs of the city's population for a predetermined time frame.

Water and Waste Management Infrastructure - Water management is a basic requirement for any city, and dedicated attempts are made to develop adequate water management infrastructure in smart cities (Ramos et al., 2019). The major prospect is ensuring adequate water distribution occurs throughout the city, out of which the focus shall also be on ensuring each citizen can have access to safe water and, at the same time, there is minimal instance of wastage. Such wastage is usually expected to occur through leaks, and hence, water management infrastructure shall be developed to be resilient to the natural environment and not have leakage. Regarding waste management, the primary point is ensuring proper waste collection, which has been explored by Alqahtani et al., (2020). Recent technological advancements in this regard have witnessed the utilization of dedicated waste collection robots and route optimization technology which can ensure waste products are collected throughout the city. The major aim behind such infrastructural development is to ensure a basic level of cleanliness throughout the roads, reduce operational and investment costs associated with waste collection, and ensure swift delivery of all waste products to their respective destination (processing facilities). Therefore, the entire waste collection ecosystem is a crucial part of waste management infrastructure development in smart cities. The second aspect of waste management infrastructure is the development and maintenance of adequate waste processing facilities (Vrabie, 2021). Here, waste segregation, sorting, and treatment procedures are all included together. The two approaches have been utilizing waste to generate energy or transforming it into other products, both while causing a minimal amount of environmental emission. However, both processes are complex in nature and may require different approaches which require the development of distinct and dedicated infrastructure. Such development shall also be complemented by considering the expected waste supply which is expected to increase with growth in population. Hygiene and cleanliness are also required to be considered.

Healthcare and education infrastructure - Healthcare services need to be made accessible to all citizens in smart cities, for which it has been noted by Hassankhani et al., (2021) that the development of telehealth care infrastructure is essential. Such infrastructure is required to reduce

the level of physical visits to clinics and hospitals and at the same time aim to provide 24/7 healthcare services accessibility to different citizens. Telehealth care services can be developed both as either public service or in collaboration with private service providers, however the aim of ensuring medical consultation in an affordable and accessible manner remains the same. Along with healthcare, the wellness of citizens shall also be considered by the city government which also forms a crucial part of the healthcare infrastructure (Laamarti et al., 2021). This aspect can involve the development of recreational infrastructure as well such as parks, gyms, and yoga centers where citizens can go to ensure physical and mental well-being. Along with this, the development of sports facilities both in the form of dedicated infrastructure and large parks for citizens to engage in different sports are also considered part of such infrastructure. In this section, regular maintenance and cleanliness of such infrastructure are also covered. On the other hand, education infrastructure is generally connected with the aim to integrate technology in traditional classrooms and at the same time enable remote learning services (Veselov et al., 2021). The major focus here is to make education both accessible and affordable for all citizens, and here it should be noted that such education service is generally considered to extend from basic elemental and primary education to specialized education imparted at universities. Technology requirements at each level of education can be different and hence dedicated focus is required for each stage by stakeholders which shall also include parents and students.

City planning and governance infrastructure - City planning in a smart city is a major task for which different dedicated technological tools are required, out of which a major aspect is GIS or Geographical Information system (Li et al., 2020). This system is expected to aid in geographical mapping of the entire region, then conduct a spatial analysis, and ensure each geographical detail is covered in an accurate and clean manner. Since these aspects need to be considered while developing a smart city, each part shall be accurately covered, and any scope of error shall be mitigated. In this infrastructure section, the focus shall be on both hardware and software aspects that combine to form GIS. Though smart cities encourage public participation in the governance process, a dedicated government command center is also required to streamline the entire process of governance (Deren et al., 2021). This center, which should be developed as a centralized body and operate in an integrated manner, shall primarily take responsibility for law and maintenance, traffic management, and citizen safety. These responsibilities are accorded to an integrated center

as such require swift action and may also involve situations requiring emergency response which may not be possible with public engagement at the decision-making level. Even for the aspect of public engagement in aspects where such activities are encouraged by the government itself, dedicated infrastructure is needed as analyzed by Simonofski et al., (2021). This aspect of infrastructure requires the development of dedicated digital platforms in which citizens throughout the city can register, engage in discussion, get regular updates, and vote on different aspects of the city. While developing such a platform, three major aspects are required to be considered, firstly ensuring transparency in sharing information and voting, secondly, ensuring safety to all data collected from citizens, and lastly, being inclusive and catering to the needs of various citizens in the city.

Digital infrastructure - Each of the infrastructure sections discussed above requires technological tools as well, for which the basic aspect is the level of internet connectivity (Sharma et al., 2020). The concept of Internet connectivity requires the development of adequate broadband infrastructure that can provide continuous, high-speed, and uninterrupted Internet services to all citizens. In this regard, in the development of Internet connectivity infrastructure, expectations of each group shall be considered like students (who would primarily use the Internet for studies) and citizens (who might use it generally or use it to do their remote work). Hence, ensuring high-speed and uninterrupted internet connectivity is a major requirement. Smart cities also collect extensive data and decisions are made with respect to data collected through different data points for which adequate data centers and cloud infrastructure are required which is also a dedicated part of the digital infrastructure (Jan et al., 2019). A centralized data storage and accessibility facility shall be developed from which management and other relevant stakeholders can collect relevant information to aid in decision-making. Another argument has been to outsource such services to dedicated experts, however having its own centralized feature is considered essential and the city develops and incorporates more citizens. With any technological advancements, cybersecurity also raises the question of cybersecurity which is also a crucial aspect of digital infrastructure developed and operated by smart city officials (Ma, 2021). The city has critical and extensive data regarding different operations as well as the daily lives of citizens which is used for decision-making, hence ensuring proper cybersecurity of such data is also a responsibility of the city for which dedicated cybersecurity aspects need to be developed. Cybersecurity also extends to the security of any and

every digital system that is utilized under any of the infrastructure options discussed above. Hence, digital infrastructure forms the core as well as a shield for entire city operations. To manage such Infrastructure, there is a need for an efficient operation management framework. Prior scholars have established several operation management frameworks with different strategies which will be analyzed in a subsequent section:

1.1.3 Operation Management

Operation management is managing different activities in an organization or any structure in order to ensure the achievement of different firm objectives. Different operation management frameworks and their applications in smart cities will be discussed here:

Six Sigma

The Six Sigma methodology constitutes an operational management strategy with the overarching objective of enhancing existing processes, encapsulating three pivotal objectives: error reduction, elevation of product and service quality, and heightened operational efficiency, while minimizing variance between similar products or services generated by the same process (Yanamandra & Alzoubi, 2022). This pursuit strives for the attainment of near-perfect product or service quality over extended durations, ensuring steadfast process consistency. The initial facet of Six Sigma pertinent to bolstering operational management and decision-making in smart cities is process enhancement, elucidated by Nandakumar et al. (2020). By embracing this dimension, smart city governing bodies gain the ability to pinpoint inefficiencies within their processes, subsequently subjecting these identified areas to in-depth analysis to ascertain root causes and challenges. This analytical scrutiny forms the foundation for the development of tailored strategies to ameliorate inefficiencies at each operational stage. Nonetheless, it is crucial to acknowledge that Six Sigma, being a comprehensive strategy, exhibits limited applicability in selecting smart city facets, though it can find relevance in specific scenarios. Integral to the Six Sigma methodology within operational management is the strategic utilization of data at each juncture of decision-making, as elucidated by Rejikumar et al. (2020). This facet seamlessly integrates with the smart city milieu, offering the means to systematically govern and manage diverse operations. In the multifaceted landscape of smart cities, encompassing resource allocation, optimization, public and private service delivery, and infrastructure maintenance, a multitude of data points come into play. These

data points serve as the cornerstone for leveraging the Six Sigma framework to expedite informed and efficient decision-making processes. Broadly construed, the Six Sigma methodology hinges on the tenet of continuous improvement, as expounded by Ahmed (2019). The imperative of nurturing a culture of perpetual enhancement is central to this approach, a principle eminently adaptable by smart city governance. Smart cities span a gamut of responsibilities, ranging from erecting urban infrastructure to provisioning diverse public services. Cultivating a culture of continuous improvement among stakeholders is a linchpin for mutual benefit and the sustained progression of smart city endeavors. Consequently, the Six Sigma paradigm offers smart city management to harness technological advancements and actively engage in an ongoing journey of improvement and refinement.

Total Quality Management - This operation management approach is a continuous approach that attempts to streamline the entire process and make the system more efficient in nature. Under this process, a continuous and regular evaluation process is conducted under which the primary aspect is to detect any inefficiency or error and then the second step is to take steps to eliminate such errors in both shorter and longer timeframes. Continuance of operation is a major aspect here as the focus is to ensure limited interruption while at the same time improving the process. This process also aims to consider different stakeholders and ensure collaboration and accountability at each stage (Toke & Kalpande, 2020). The TQM approach has largely been considered to focus on customers or end-users and requires a user-centered approach in each step of the underlying process (Pambreni et al., 2019). In a smart city context, end users can be citizens who will live in the city, and hence this approach can be adopted in operation management to identify and subsequently analyses the needs, expectations, and preferences of citizens. This will aid in the development of services that can cater to citizen demands and hence improve the quality of life for such citizens. Thus, TQM would aid in giving more priority to citizen needs and interests while developing smart cities. Along with end users, TQM also required management to involve employees at each level of the process in a more active approach (Ababneh, 2021). Smart city development and maintenance require the recruitment and selection of several employees who are professionals and specialists. This approach can aid city management and governance teams to better utilize professional and scientific skills among employees. Employees, in this approach, are involved in two aspects, firstly in decision-making regarding the areas in which they have expertise

and basic aspects, and secondly identifying areas where improvement is required throughout the city. Further, this approach would also aid management to encourage employee participation which will benefit entire city operations. A technical aspect of TQM strategy adoption in any specific process is establishing adequate benchmarks and comparing the performance of the current process to identify the scope of corrective action (Erdil & Erbıyık, 2019). This aspect can be helpful in the development of smart cities, as it would encourage city governance teams to review smart cities being developed by other countries around the world. The best practices of each smart city can be identified and then utilized in the current city based on city-specific attributes to improve the quality of life for citizens across the city. Adoption of this approach in a comprehensive manner will allow for multidimensional development of smart cities around the world and nurturing an environment of collaboration and innovation.

Lean Management - Lean management methodology aims to improve both the quality and efficiency of the process primarily by trying to reduce any inefficiency or defects witnessed in allocation, optimization, and consumption of three major resources namely time consumption, financial resources, and human resource - efforts. Lean management methodology aims to identify the entire value chain involved in the process and then take steps to engage in continuous improvement of the process to address such resource inefficiency which has been discussed above. Hence, waste elimination either through modification of activities or reduction of non-value-based activities forms the core of the methodology under the lean management process (Ikumapayi et al., 2020). Principles of lean management require giving significant focus on the reduction of any waste generated at any step of the process (Gładysz et al., 2020). Here, it should be noted that on a broader level waste reduction also requires optimization and streamlining of each step in existing process for better efficiency and reduction in waste generation chances. Smart city is based on different operations from infrastructure development to waste management, in which this method can be adopted to identify waste generation points at each stage, and then develop strategies accordingly. This will aid in making the city more environmentally friendly and improve efficiency, benefiting both stakeholders and general biodiversity. The basic concept of adoption of lean management is focused on the aspect of mapping the entire value stream of the process (Shan et al., 2023). The concept of value streaming is important for two aspects firstly identifying in a systematic manner, each step in the process, and secondly, using such detailed structure to identify

any inefficiency and bottleneck with the aim of improving process efficiency. Smart city administration and operation are complex in nature and involve multiple stakeholders, hence the aspect of bottleneck or inefficiency can exist in each step. Utilization of lean methodology would aid in identifying the actual cause behind such inefficiency which can then be utilized to develop corrective strategies. Another concept under lean management that needs to be considered with respect to its adoption in smart cities is the aspect of just-in-time delivery which has been analyzed by Milewski (2022). Delays in providing any public service under smart cities can lead to inconvenience to citizens and other stakeholders involved, which needs to be avoided. On the other hand, having excessive resource inventory can also lead to the blocking of financial resources that might have been utilized for other purposes. The utilization of a just-in-time-delivery system can aid in developing an optimal strategy for resource allocation and also meet the challenge of unexpected rises in demand, which is expected to translate to a better quality of living for citizens.

Agile Management - An Agile project management strategy has been developed to ensure swift working by different stakeholders with proper collaboration among different layers of the team. Here the focus is on addressing inefficiencies while at the same time also meeting different challenges that can arise due to changing requirements in the business environment either through internal or external factors. This process gives more emphasis to feedback collection and takes corrective action to address any negative feedback. Here, the entire lifecycle of the process is considered, and focus is given to ensure completion within the expected lifecycle (Marnada et al., 2022). The primary focus behind the adoption of an agile management strategy is on ensuring iterative development occurs throughout the process (Marović & Bulatović, 2020). An interactive process adoption has been efficient for smart cities, as such would allow dividing the entire project into predefined and specific stages, in which after completion of each stage, feedback can be taken from each stakeholder and be analyzed again based on changing needs and environment under which city ecosystem will operate. Thus, the concept of agile management will allow city management in the initial development phase where the city will become more efficient and able to address the needs of citizens. Hence, an iterative development approach would allow a reduction of future costs. Lean management methodology also aids in recruitment and selection of cross-functional teams which bring together expertise and specialization in different skills (Elsheikh et al., 2022). As noted in prior sections, the smart city aims to develop more advanced and scientific

urban cities which take into consideration several aspects from living to education to healthcare and waste management. This requires the involvement of several professionals who operate in different domains to come together and collaborate to provide innovative solutions. Adoption of an agile management strategy would aid in bringing together such teams, addressing their needs, and developing a collaborative solution that will aid in addressing barriers associated with the city in a more effective manner. Additionally, if technological aspects are considered, agile management has also introduced the strategy of rapid prototyping which has been of benefit for operation management in smart cities (Almeida et al., 2021). The utilization of this concept can be in the form of developing prototypes of smart city solutions and processes in a small phase, testing them with a small number of real stakeholders, and then taking corrective action. If prototyping is found to deliver positive results, then such a solution can be implemented on a larger stage. Hence, with the aid of rapid prototyping, smart cities will be able to implement innovative solutions in a swift manner with limited resource consumption.

In the context of smart cities, four prominent operation management strategies, namely Six Sigma, Total Quality Management (TQM), Lean Management, and Agile Management, offer distinct approaches to address the multifaceted challenges. Six Sigma focuses on process improvement and decision-making through data-driven analysis, allowing smart cities to identify and rectify inefficiencies systematically. TQM prioritizes end-user needs and employee engagement, aligning city development with citizen preferences and fostering professional skill utilization. Lean Management emphasizes waste reduction and optimization across resource allocation, making smart cities more environmentally friendly and efficient in delivering services. Finally, Agile Management enables iterative development, collaboration among cross-functional teams, and rapid prototyping, allowing smart cities to adapt swiftly to evolving requirements and implement innovative solutions. These operation management strategies provide a comprehensive framework for addressing the complex operational and developmental challenges faced by smart cities, ultimately enhancing the quality of life for their citizens while promoting sustainability and efficiency. In the dynamic landscape of smart cities, the need for an effective operations management framework becomes increasingly evident. This imperative arises from a multifaceted set of objectives that encompass the analysis of current operation management strategies and their alignment with the evolving demands of modern urban ecosystems. As smart cities continue to

expand and face ever-evolving challenges, the need for new operational framework becomes eminent. This section covers different frameworks; however, such must be adopted in accordance with different stakeholders. The subsequent section will discuss different stakeholders who can impact decisions in smart cities.

1.1.4 Decision Making in smart cities

Smart cities focus on public engagement and consider the opinions of different stakeholders in the decision-making process. Different stakeholders involved in decision-making and the decision-making process are briefly discussed below:

Stakeholders involved in the decision-making process

Government - The government body is the primary stakeholder which plays a major role in designing, implementing, and regular operations in smart cities (Khan et al., 2020). Government has to establish both smart city goals as well as urban infrastructure goals which form the core framework for strategy development and implementation by other stakeholders. The government is also tasked to play the role of initial collaborator bringing together multiple stakeholders from citizens to specialized officers, with the mutual aim of processing the quality of life in the city. Hence, political opinion and the government system play a major role in decision-making and can influence all other stakeholders in the process.

City architects - The next major role is played by architects who are involved in the actual designing and construction of smart cities based on approved plans (Saborido & Alba., 2020). Different aspects of the city from initial housing infrastructure to the transportation system and other recreational facilities are developed by City architects. Architects while developing required infrastructure must consider both expected requirements by other stakeholders, land use policy and geographical conditions of the land, and aesthetic value as well. Architects selected in smart cities usually have extensive experience regarding different aspects of construction and hence, their viewpoint becomes important for smart city development and operation.

Technology providers - Smart cities operate with the aid of different technological tools, hence technology providers are also major stakeholders in the decision-making process in smart cities

(Neumann et al., 2019). Different software tools, digital platforms, and other important technology tools like sensors are developed by them, and hence their opinion regarding the feasibility of any technological system should also be considered as they develop the product. Since smart cities operate with the aid of different data points, technology providers form the backbone of such technology-based decision-making and hence are required to be involved in every decision-making activity.

Private business organizations - Smart cities, in recent years, have also witnessed the active participation of private entrepreneurs and startup owners as per the study by Söderström et al., (2020), who also form major stakeholders in the process. These entities can either directly invest in different city projects regarding infrastructure or technology or can also engage indirectly by being innovators and pushing the level of economic growth in the region. Hence, their benefit also accrues to citizens directly as well as indirectly, making them important stakeholders whose viewpoints shall be considered when making any decision regarding smart city operations.

Colleges and universities - Colleges and universities are excited to operate as think tanks in smart cities besides also providing education to respective citizens and their children (Cao et al., 2019). Collaboration of other stakeholders with the academic ecosystem is expected to lead to further innovation and development of practical solutions to major problems, while also taking advantage of prior research, and at the same time engaging in new research to address the core problem. Such universities can also act as training institutes which can provide the economy with a skilled and technology-aware workforce who can operate in different sectors of the economy leading to the further development of smart cities.

Citizens - According to Han & Kim (2021), citizens who live in smart cities are also expected to be major stakeholders in the decision-making process adopted by smart city management. Citizens should be informed of all the recent developments in the city, encouraged to engage in decisions, and vote regarding different aspects of the city. Here, it should also be noted that along with citizen engagement, community engagement is essential to ensure a higher level of inclusion and diversity as well. Further, community engagement is also expected to lead to an increase in a sense of ownership and consider the actual needs of citizens in future planning processes.

Decision-making process involving different stakeholders for the operation of smart cities

Problem and Challenge defining: The first step in taking any decision, according to Yazdani et al., (2019) is clear and proper identification of the problem or challenge being faced. From the perspective of a smart city, this could be connected both with the development of a smart city and challenges faced in any of the different operations expected to be conducted by city authorities. In this process, the next aspect is ensuring everyone who will be involved in decision-making knows in a comprehensive manner the problem and challenge which is being faced for which decision has to be taken by the management. Resources and limitations faced shall also be identified at this stage. After the identification of resources, limitations, and problems, the next step is to collect adequate data which is discussed below

Data gathering and collection: After identification of the problem and the challenges that are being faced and need to be addressed, Sarker et al., (2020) have suggested the next step to be the Identification of data points for which data will be collected. Data points established shall aid in decision-making and analyzing the impact of the decision. After the selection of proper data points, proper steps are required to be taken to collect data for a specified time. With respect to smart cities, such data can be demographical, technological, social, and economical in nature. It should be noted that the nature of the data collected depends upon the problem identified. Data alone cannot address the problem, for such it is important to identify stakeholders, as discussed below.

Stakeholder identification: The third systematic step that has been suggested after the collection of proper and relevant data is the Identification of all stakeholders who need to be involved in decision-making (Baumann et al., 2019). With respect to the smart city, such stakeholders will involve all the six groups that have been discussed extensively in the section above, namely government authorities, City architects and designers, technology providers, private business organization heads, professors and researchers from universities and colleges, and citizens themselves. Here, it should be noted that stakeholders are selected from the aspect that they would be impacted by the decision taken to address existing challenges. Each stakeholder can have

different objectives and perceptions regarding the same issue. It is important to ensure a common stage for which goal identification, as covered in the next step, becomes important.

Goal and Criteria establishment: After the collection of relevant data and Identification of all stakeholders who will be impacted by the decision, the next logical step is to establish the goal of the decision-making process (Odu, 2019). The primary goal remains to address the challenge faced by smart cities which has been identified in the first step. However, other goals like ensuring the cost-effectiveness of the entire process adopted, ensuring environmental and social sustainability, and ensuring a better quality of life shall be considered. In this stage, different criteria for decision making are also established, which for the case of a smart city ensures the economic and technological feasibility of the decision taken. With goals, resources, and data, the next step is to generate different options available, as noted below.

Options generation: The above stages are the initial stages, which will help in actual decision-making, which starts at this stage with the Identification of multiple potential solutions and strategies that can address the same problem (Wong-Parodi et al., 2020). In this stage, smart city management shall encourage creativity and innovation among different stakeholders to arrive at potential solutions. In this stage, it becomes important for community participation, as a higher level of diversity and inclusion would lead to the generation of several ideas that can be evaluated in later stages. Hence, at this stage, the Identification of a maximum number of solutions to give problem is a priority. After maximum potential solutions are identified, it becomes crucial to select the optimal option, for which option evaluation is necessary as covered below.

Options evaluation: This stage involves a comprehensive and critical evaluation of the options that have been generated through different stakeholders in the stage above (Kaya et al., 2019). In this stage, the criteria and goals that were established earlier are considered as desired goals and constraints under which the selected strategy shall operate. In this stage, critical analysis needs to be conducted to understand the potential advantages and limitations of each strategy. An objective or subjective evaluation and sorting method can be further adopted in which the expected benefit and limitations of each strategy can be noted for better and easier evaluation. Option evaluation is

done to analyses benefits and limitations and hence shall be evaluated on single criteria in which different priorities are covered as noted below.

Option prioritization: After the establishment of hypothetical benefits and limitations of each option based on realistic assumptions and data collected during the initial stages, an internal process of option ranking and prioritization is generally conducted (Lu et al., 2021). The general rule for the selection of the best option among different strategies is to select the strategy that offers the most favorable benefits with the fewest disadvantages. Hence, the smart city management and administration team, at this point in decision-making, must adopt a more objective route. This will help in determining potential benefits and better communicate the results to the stakeholders for consent. The next step will cover the process adopted to select the optimal option out of the best strategies being considered.

Analysis of impact: After the establishment of the top 3 to 5 options, which can aid in addressing the problem when adopted and also lead to potential positive benefits for the stakeholders, the next step is to analyze the impact of each strategy (Noorzai, 2020). Since a smart city involves several aspects, the impact shall be analyzed with respect to different stakeholders, the general environment in the city, and the well-being of the citizens. While it should be noted that each option cannot have a positive outcome in all three aspects, a strategy should be selected that has a minimal negative impact and then be modified to ensure a positive outcome in each step. Any decision cannot be implemented without proper guidance from consultants, for which stakeholders are informed and consulted in the manner discussed below.

Stakeholder consultation: Another step that must be taken before arriving at a final decision is consultation with different stakeholders who have been identified as be impacted by the decision taken (Van et al., 2020). Stakeholders shall be encouraged to participate in a comprehensive and independent review of the decision and share their feedback and perspectives regarding different aspects of the decision which are being planned to be implemented. City administration shall also ensure that at the same time, such feedback is taken in a positive manner, and feasible changes shall be made as it would lead to better inclusion and community perspective which is an important pillar of the development of any smart city. Prior steps have established the entire process of

developing a plan and bringing different stakeholders together, subsequent step covers final decision adoption and implementation.

Making the final decision: The final step in the entire procedure is taking the final decision, the final strategy that will be adopted to address the problem that had been identified in the initial stage of decision-making (Bomhof-Roordink et al., 2019). In this stage, each of the three aspects, analysis done by the administration, consultation with multiple stakeholders, and potential short-term and long-term impact shall be considered, along with limitations faced in the process. In this stage, it should be ensured that transparency is ensured and that the decision that has a higher level of consent among all stakeholders are adopted to benefit all stakeholders in the long term.

Implementation of the final decision: After the selection of the strategy to be adopted, an implementation plan shall also be developed to ensure better execution of the strategy adopted (Rajesh, 2021). This requires the development of an extensive and systematic plan in which each step is properly identified and the timeframe and resources required should also be established. In this stage, responsibilities shall also be allocated to the personnel who will be involved in execution and proper guidelines should also be established. Another major aspect is the establishment of an execution timeline on which each stage will be covered, which would act as a benchmark and prevent any cost inflation faced due to time delays. Any decision, when implemented requires it to be made smoothly and efficiently, for which proper monitoring is required, as covered below.

Monitoring and Adaptation: After implementation, other steps such as continuous monitoring, feedback collection, taking corrective action, and adaptation with respect to changes in the business environment shall also be considered to ensure better execution (Leicht-Deobald et al., 2022). With respect to smart city development and operation, citizens can act as feedback providers in the process and ensure the timely execution of the strategy. It should be noted that this process is not exhaustive, and several steps may be incorporated to ensure better decision-making while at the same time promoting a higher level of collaboration, inclusion, and community engagement in each step.

1.2 Statement of the Problem

The smart city movement is gradually expanding around the world, as noted by Chatzitheodoridis et al., (2022), and such cities have been noted to integrate urban landscape and technology, for which infrastructure development has been suggested as a major pillar (Sharma et al., 2020). Development of infrastructure and at the same time, management of entire affairs in the city has been considered as a complex task due to different stakeholders involved as well as various challenges in decision making. This requires the adoption of a proper operation management strategy, for which prior organizations around the world have been utilizing strategies such as Six Sigma (Yanamandra & Alzoubi, 2022) and total quality management (Toke & Kalpande, 2020). However, such management frameworks can have significant limitations while being applied in the context of smart cities, due to different stakeholders and its aim to focus extensively on higher quality of life while also ensuring profitability to address future needs. Hence, there exists a major research gap regarding the application of existing operation management frameworks in smart cities, conducting an extensive evaluation, and determining a proper operation management framework that can address the different challenges faced by the management. Another crucial research gap is being able to meet all three aspects of efficiency, sustainability, and social security while developing and conducting regular operations in smart cities. Conducting research on this problem is important as smart cities are gradually expanding around the world, and hence there has been a need to develop an efficient operation management framework that will ensure better convenience and quality of life for citizens, while at the same time meeting the challenges faced by city governments around the world to address the problem. Analysis of the current operation framework is also important as such would allow for modification of existing knowledge to suit the interests of smart city stakeholders. Hence, analysis of the existing framework and development of a new operation management framework is important for which the current research is being conducted. To address the above problem, extensive research will be conducted. Firstly, the need for an operation management framework and different aspects related to data collection and analysis in a smart city context will be analyzed. The role played by different traditional operation management frameworks in ensuring three objectives of sustainability, efficiency, and social security will be reviewed along with both advantages and limitations observed with respect to different stakeholders. Finally, a new operation management framework will be developed which will cover different operational aspects in smart cities from planning to

decision-making and adaptation of the decision which has been taken. Hence, the study will adopt a multidimensional approach to evaluate and develop a new operation management framework to aid smart city movement and infrastructure development, ensuring efficient services for every citizen in the city. Make this statement more succinct.

1.3 Aims and Objectives

The aim of the study is to examine the applicability of effective operations framework and management in smart city movement and infrastructure development. In accordance with the aim, the following objectives will be addressed during the study:

- To identify the challenges faced in smart city movement and infrastructure development in smart cities
- To investigate the needs and different aspects of data collection and management in smart cities from whose perspective
- To explore the role played by the current operation management framework(s) in meeting multidimensional needs (Efficiency, Sustainability, and social security)
- To examine the applicability, advantages, and limitations of different operation management frameworks in decision-making for smart city operations
- To suggest strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities, do you have any objective measures for these? What kind of proxies can be used to measure their appropriateness? These will be the outcome of someone's perceptions (who is going to be? What kind of criteria will be used for his/her selection?).

1.4 Research Questions

To accomplish the above-mentioned objectives of the study, the study will provide the answers to the following research questions:

- What is the need for an effective operations management framework in smart cities?
- What are the needs and different aspects of data collection and management in smart cities? Whose perspective?

- What is the role played by the current operation management framework in meeting multidimensional needs (Efficiency, Sustainability, and social security)? Can you measure them? The objectives tend to be spread (try to make them more focused).
- What is the applicability, advantages, and limitations of different operation management frameworks in decision-making for smart city operations?
- What can be different strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities?

1.5 Significance of the Study

The current study is expected to have major implications in theoretical as well as managerial aspects related to smart cities. The results of this study will address the theoretical research gap regarding the effectiveness of different operation management frameworks in ensuring efficient smart city movement and infrastructure development. Additionally, it will add to the existing literature on operation management framework and its application in smart city decision-making, aiding in the improvement of academic knowledge regarding these aspects. On a practical aspect, this study is expected to play a crucial role in smart city development's next phase by aiding management to make effective decisions in smart city projects which will shift from being tech-oriented to decision-oriented. Hence, this study would help not only city development policymakers, construction teams, and data operations teams, but also the general population who currently or will eventually live in such cities around the world. Smart cities are expected to benefit the entire economy; hence this study is also expected to lead to further economic growth as urbanization continues and demand for smart cities grows around the world. The interview questionnaire as well as the results derived from the study can be utilized by scholars around the world to understand specific concerns, build unique solutions, and further address the inefficiencies in current operation management frameworks regarding smart cities.

1.6 Structure of the Dissertation

The entire dissertation will adopt the following structure to address the research problem and research questions established above:

Chapter 1: Introduction: This section has provided a brief background of the major aspects of the study along with research objectives and research questions. The problem statement has also been covered here along with the expected implications of this research.

Chapter 2: Literature Review: This section has covered an extensive review of prior literature on related domains to smart city and operation management in recent years and highlights the research gap to be addressed in this study.

Chapter 3: Research Methodology: Social and technical aspects of research methodology will be covered here. The data collection approach, members from which such data will be collected, and data analysis strategy will also be discussed along with ethical considerations adopted during the study.

Chapter 4: Data analysis and interpretation: Thematic analysis will be conducted in this chapter based on interview transcripts collected above. Major themes and findings from the data analyzed will also be briefly highlighted here in accordance with the strategy established in the previous chapter.

Chapter 5: Results and Discussion: This chapter will have an extensive discussion of different results that have been derived in the prior chapter. This will also be analyzed with respect to prior scholars in the related domain and major inferences from the analysis will be presented here.

Chapter 6: Conclusion and recommendations: Major findings from the entire study will be briefly presented here along with recommendations to stakeholders based on the findings. The limitations faced and future direction will also be stated here along with the expected contribution of this study in both theoretical and practical aspects.

Chapter 2: Literature Review

2.1 Introduction

The desire for a paradigm shifts in cities has been reflected in the growth of the smart city movement in recent years. The main goal of Smart Cities is to stimulate economic growth and enhance people's quality of life by facilitating local area development and utilizing technology, particularly technology that leads to smart results (Yin et al., 2015). A smart city is a developed metropolitan area that uses sensors, voice activation, and a variety of electronic devices to gather data. The information is used to effectively manage resources, assets, and services, which improves operations across the city. However, because every element, including buildings, needs to be created from scratch, a smart city cannot be created in a single day. Operational frameworks and management may therefore be able to influence the direction of this significant smart city movement both now and in the future (Angelidou, 2015).

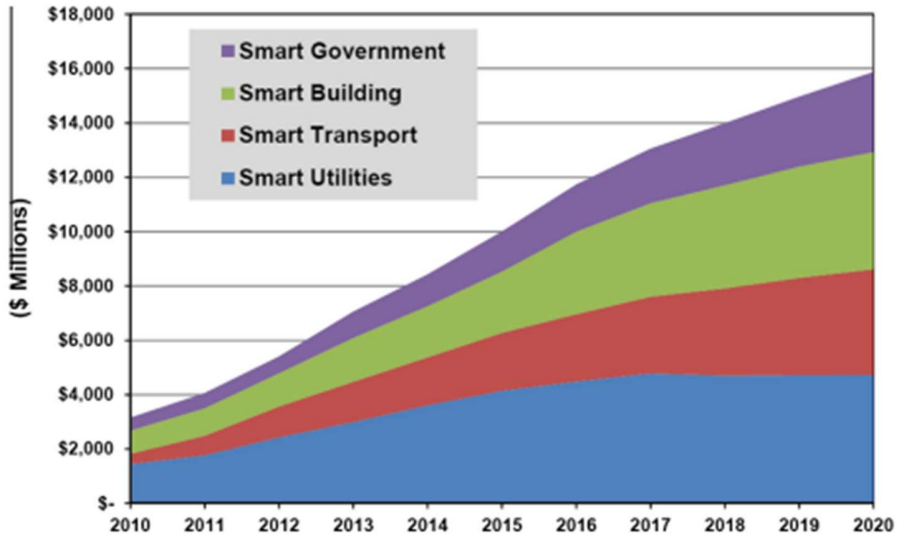

Figure 1. Smart city infrastructure investment by industry, world markets: 2010–2020

(Source: Angelidou, 2015)

It is determined that creating a smart city is considered an emerging strategy to address the problems generated by population growth in urban areas. It is estimated that more than half of the population lives in urban areas, and it is anticipated that over the next few decades, the population

will continue shifting from primarily rural to primarily urban. Cities and megacities have given rise to new problems, encompassing fundamental technical, physical, and material challenges such as waste management, resource shortages, air pollution, human health issues, traffic jams, and inadequate, aging, and declining infrastructures. Another group of issues is not so much technical, physical, or material in nature, but rather social and organizational (Chourabi et al., 2012). From the perspective of operations management, a smart city can be understood as a framework for managing urban planning and operations decisions. Thus, literature provides an understanding related to smart cities around the world, including data management. It will also highlight the advantages and disadvantages of smart cities and the development of infrastructure in smart cities.

2.2 Smart Cities

As per the view of Albino et al. (2015), smart cities can be defined as a fuzzy concept that is used in different ways and remain consistent. There isn't a single definition of a smart city or a template for defining one that works for everyone. The term smart cities were first used in the 1990s. During that time, the focus was on the importance of new ICT concerning modern infrastructures in the cities. Among the first organizations that focused on how cities could be planned to integrate information technologies and become smart, was the California Institute for Smart Communities. In addition to this, it can be referred to as the ability to use sensors, meters, appliances, personal devices, and other comparable sensors to capture and integrate real-time data.

On the other hand, Dameri (2013) stated that a smart city is mainly made through land, citizens, governance, and technology. It is determined that smart cities have broader or larger boundaries from the urban dimension of a single city along with considering the global dimension. Smart cities have measurable and defined goals involving aspects related to environmental sustainability, the participation of citizens, and the creation of intellectual capital. The cities are considered smart as it is intelligent, wired, inclusive, democratic, and digital. The research highlighted the smart city definition as a geographical area that is governed by a clearly defined pool of subjects that can state the rules and policies for the city government and development; it is where high technologies like ICT, logistics, energy production, and so forth work together to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, and intelligent development.

Figure 2. Bottom-up smart city development path

Source: Dameri (2013)

Cavada et al. (2014) stated that smart cities built on the "smart" combination of attributes and activities of self-decisive, independent, and aware citizens, a "smart city" is a city that performs well in these six areas going forward: smart people, smart governance, smart mobility, smart environment, and smart living. The research highlighted the framework of smart cities which has been developed to bring good practices to respond to these issues considered as an integrated way focusing on enabling processes through which innovative technology was used and delivering visions for the future in achieving sustainability. According to research, a smart sustainable city is regarded as an innovative place that makes use of information and communication technologies (ICT) to enhance competitiveness, quality of life, urban operations, and the ability to meet the social, environmental, and economic needs of both the current and the coming generations.

According to Fernandez-Anez's (2016) study, there was no statistical definition of a smart city, which is why over the past few years, scholarly articles have focused extensively on this topic. It has been noted that the idea of "smart cities" has grown since the 1990s in tandem with the liberalization of telecommunications and the expansion of online services. The phrase "smart city" has come to mean a city that uses information technology in recent years. Stakeholders describe the smart city as a knowledge-based system, and the model that is being used is related to triple helix models that are also knowledge-based. Furthermore, sustainability, efficiency, and quality of

life are the three main objectives of smart cities. It has been noted that smart city technologies advancement is important for carrying out business operations in the future.

Sánchez-Corcuera et al. (2019) state that the concept of a "smart city" is a promising approach because there is no agreement on the features or requirements that should be included to define it. The study classified smart cities based on three distinct dimensions: human, institutional, and technological. Another writer by the name of Javidroozi examined smart cities by considering a variety of factors, including technology, process, systems integration, and well-being visions. Like this, Yin et al. defined smart cities using four categories: data processing, domain application, technical infrastructure, and system integration. The study also highlights the obstacles that must be overcome to advance toward the cities of the future, as well as the prospects for smart cities in the future.

The research conducted by Sharma et al. (2020) provides insights into managing waste, considered the most important challenge in developing countries for the past few decades, especially in the context of smart cities. The study identifies barriers associated with smart city waste management to enhance sustainability in the Indian context. The research reveals fifteen Internet of Things Barriers (IoTBs) for smart cities in waste management. IoTBs are determined using the Total Interpretative Structural Modeling (TISM) approach and the Decision-Making Trial and Evaluation Laboratory (DEMATEL). The findings suggest that no single adoption barrier can effectively drive smart city waste management. The present research focuses on incorporating fifteen adoption barriers to aid decision-making in waste management practices for the development of smart cities. The study contributes theoretically by developing a conceptual framework for present IoT barriers in smart city waste management execution in India.

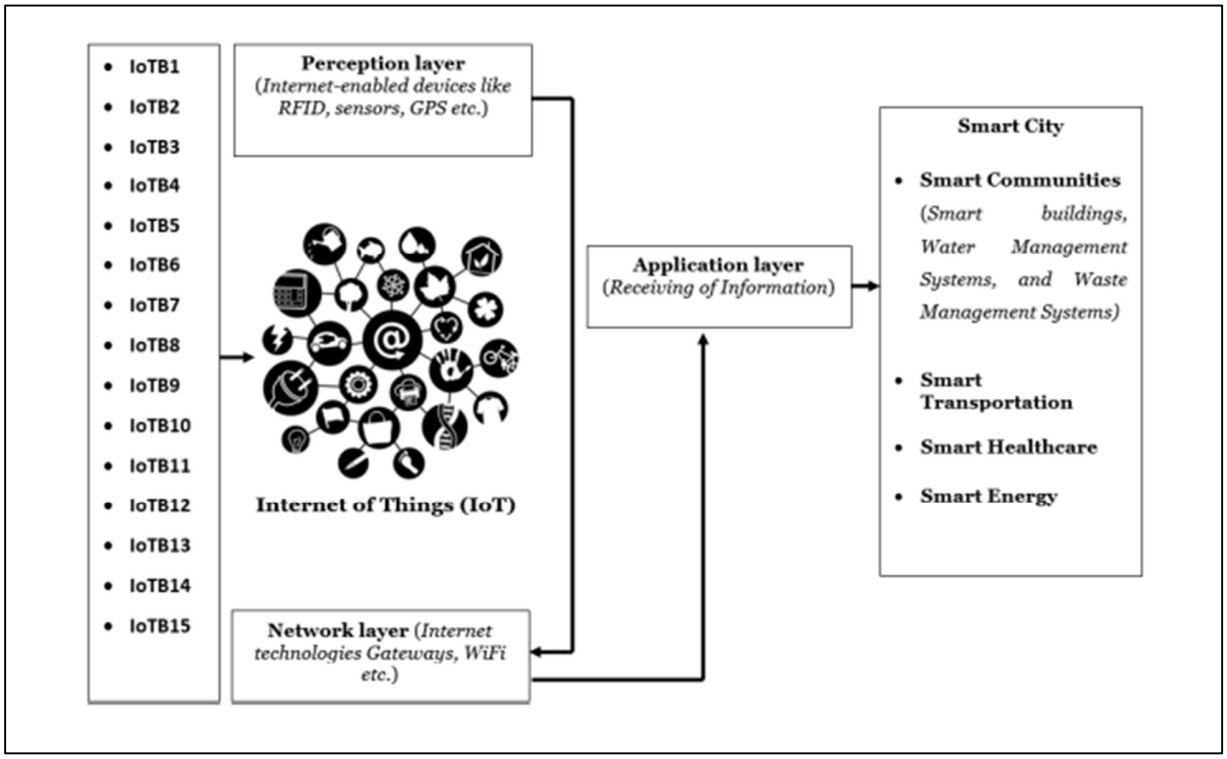

Figure 3. Internet of Things (IoT) adoption barriers of smart cities' waste management: An Indian Context

(Source: Sharma et al., 2020)

Shee et al. (2021) discussed that previous research explored various dimensions of smart cities by involving cyber, digital, networked, real-time lenses, and virtual. Further, the research distinguished the term into different aspects, including sustainable city, intelligent city, and knowledge city. The term 'smart' referred to city-wide ICT infrastructure for exchanging real-time data. Research in these areas emphasizes the emergence of technologies, including advanced analytics, cloud computing, big data, and faster network connectivity. Cities mainly invest in these technologies to enhance economic growth, create a sustainable environment, and increase the quality of life. It is identified that the market size of smart cities grew by more than US$2118 billion between the years 2020 and 2024 due to the declining prices of connected devices. In the year 2013, there were 152 smart city projects from different countries like Europe, the USA, South America, and Asia. It is evaluated that recently, 100 smart city projects in India were initiated to improve business growth with the help of connectivity.

An understanding of smart waste management systems for smart cities that enable Internet of Things technology is provided by Sosunova and Porras (2022). Urbanization, rising incomes, and rising consumption all contribute to an increase in waste output. It has been established that the planning and implementation of waste collection and management systems constitute a significant component of sustainable development. It has been noted that smart waste management, or SWM, entails the gathering and analysis of data from sensors on intelligent trash cans, the planning and optimization of waste truck routes, and the management of waste trucks and urban infrastructure. The research aids in offering a thorough overview of current studies in the areas of methods, programs, and systems for processing solid waste in SWM systems.

The application of various technologies in the creation of smart cities was covered by Ahad et al. in 2020. Cyber-physical systems (CPS) are assessed as a collection of devices, networks, management, calculations, and related physical processes. The IoT and sensory devices formed the backbone of smart cities. The sensors are tiny chips that are affixed to various components and apparatuses of the involved parties. Sensors can detect their surroundings and transmit data to network gateways for additional processing. It has been found that AI makes it easier to process and analyze the data produced by machine-to-machine communication when a smart city is set up. Similarly, advanced translation, sensing, and data transmission were made possible by wireless sensor networks (WSN), which is a crucial component of the framework of the smart city. These are used for decision-making in managing traffic, controlling temperature, and location sensors among different applications in the smart city.

Furthermore, cloud computing technology has contributed to providing cost effective and faster solutions concerning operating platforms, infrastructure and software. It is observed that users did not have to invest huge amounts of money in setting up physical infrastructure instead of availing service from cloud service providers including Amazon, Microsoft and Google etc. (Ahad et al. 2020). In addition to this, CPS helps in encompassing all aspects of processing, networking, storage and computing. It is determined that generic CPS and similarly at the same time also consider domain specific CPS involving examples such as CPS for robotics transportation and healthcare. It is observed that blockchain technology also helps in allowing distribution of data

management and autonomous connectivity between IoT devices. It is discussed that incorporating blockchain in the environment of smart city helps in ensuring, securing, robust, transparent and authenticated flow of data.

Moreover, 5G network helps in providing flexibility and enabling flow of more information for the promotion of participation in the smart city. It also supported enhancing connectivity and along with enabling more data to be collected and analyzed in smart city settings. 5G capable of facilitating communities for enhancing the experience of public and creating smart urban environments involving advanced infrastructure, accessibility, equality and sustainable development (Ahad et al. 2020).

Lai et al. (2020) in a paper discussed smart cities technical standards. It has been identified that smart cities are sustainable as well as intelligent cities. Smart cities require certain technologies including sensor devices and ICT infrastructure. The study provides different definitions of smart cities which is considered as evolving into aspects through which different terminologies are considered due to various scopes and involving region and community as well. In the study, six smart city domains were determined involving smart energy, smart health, smart education, smart mobility, smart governance and smart economy. The research also focuses on involving meaningful comparisons considering execution of smart cities.

2.2.1 Smart Cities around the world

Smart cities in the context of Europe

Knowledge about smart cities in Southeast Europe is provided by Pašalić et al. (2021) through a methodical process of filtering, searching, and categorizing research papers. The study of smart city governance and smart environment has garnered significant interest in smart city research, which the research helps to explore. This aids in offering observations about the entire region of Southeast Europe, where governance was valued and e-government was long considered. The main goal of the research is to provide information about smart cities in Southeast Europe. It also aids in the analysis of the data since research is associated with the addition of new viewpoints and, in a similar vein, aids in urban development.

The study conducted by Engelbert et al. (2019) offers insights into European smart cities, which are useful in assembling the central smart city project and peripheral smart network practices. The study focuses on integrating concepts into the political and economic goals of those who have the means to support those who are intelligent and deserve it. The political economy of European smart cities analyzes citizen participation in the smart city while emphasizing the importance of political and geographic factors. The study places a strong emphasis on incorporating critiques, and it also supports the analysis of urban social practices. Smart city practices center around municipalities vying for recognition, the European Commission advancing its agenda, and specialized discourse surrounding smart cities.

Rothe et al. (2018) stated that in western Europe smart city creation led to two speeds of development, and creating peripheries in the European Union. It is evaluated that when some parts of the EU become periphery then all Europe becomes it. In Europe, Consistent growth of the economy and progress of society is based on knowledge, achieving support, and along with spreading innovative technologies (ICT) and the development of smart and digital cities needs to be balanced by creating favorable conditions for social life and environmentally friendly technologies. In the European integration, economic growth is mainly based on innovations related to technical revolution and the development of smart cities in the areas of Industry 4.0 technology. Smart cities are based on the newest achievements, dedicated citizens, protection, and prosperity by combining the natural environment.

The research carried out by Şerban & Lytras (2020) provides an understanding of use of artificial intelligence for smart renewable energy sector in the region of Europe. In the worldwide, there has been increasing in use of renewable energies which resulted in fulfilling need for the reduction of impact of change in climate and dealing with global warming. It is observed that renewable energy helps in considered as an important aspect and considered as an effective solution for today's economies in the depletion of resources and imperative of protecting of environment. It is determined that AI is supported in managing the production of energy and consumption in the changing business environment. Renewable sources' variability is one of the key issues in this segment with increasing relevance as the RE share in the production of total energy which is growing.

Initiatives in smart cities

As per the view of Haarstad (2016) smart city agenda mainly holds the place of economic service activities at the central stage in strategies for enhancing the economy and making urban energy systems sustainable. Some critics have even suggested that the current popularity of the smart city concept is due to the advertising and lobbying efforts of large companies such as IBM. However, as observations at the Open Days conference illustrate, smartness is being used and mobilized by cities on behalf of a wide range of different strategies. To a significant extent, the smart city label is used to brand urban projects and policy initiatives that individually are not particularly innovative or technologically advanced. Smart cities could be assessed in terms of how they manage to overcome traditional corporate, bureaucratic, and institutional barriers to generate new solutions and ways of thinking about urban sustainability. Also, an assembling approach can enable a more nuanced approach to understanding relations between the social and the technological by unpicking the social dynamics through which smart technologies are used. After all, smart' technologies are only smart if they enable better and more sustainable urban lives.

According to Späth and Knieling (2020), there are initiatives for smart cities in many regions. For example, the SMART life project in Hamburg uses an experimental method to shape the mobility infrastructure. To collaboratively prepare public and private stakeholders for the exploitation of opportunities that may result from technology breakthroughs, it encourages the development of different experiments. Like smart city initiatives in other places, the project of mySMARTlife in the region of Hamburg adopted an experimental approach to shaping the mobility infrastructure. It helps in promoting the multiple experiments development as a means of preparing private as well as public stakeholders for exploiting opportunities that will arise from technological development. It is observed that smart mobility initiatives are mainly placed on considering collaborative experimentation and constitute devaluing views by having an appropriate transportation development.

As the view of AlQaoud et al. (2022) discussed that technological industries mainly rely on artificial intelligence, machine learning, and algorithms to become well-known in the market. It is evaluated that industries are emphasizing climate change for forming a vision of the smart city. In the 2000s challenges related to sustainability and energy scarcity for companies like IBM and

Cisco concerning smart cities. It is observed that Cisco was considering acting as an alleviating climate change and launching the Connected Urban Development (CUD) program to enhance the flow of traffic with the help of new technologies. Many cities take advantage of such projects including Amsterdam, Madrid, Hamburg, and San Francisco. It has also been stated by Cisco that our fundamental belief is today's flow of people, energy, information, media, and services in cities is the traffic of digital products internally. It has been suggested that IBM's program must shift to a smart city in its central systems and optimize the return from limited resources.

Abbas (2017) provides an understanding that over the last two decades, smart cities and smart growth have become more common in some countries It is necessary to consider that cities are the key elements for the future the reason behind is that cities have a huge influence on the economy, environmental and social aspects. Different approaches have been developed based on technology, which supports the creation of smart cities. It is determined that the concept of smart cities is not limited to one definition as it involves different perspectives for different people. It is determined smart cities also involve smart transportation which focuses on the movement of people or goods in the cities from one location to another and around the world. Transportation is mainly linked with a simple idea and along with these focuses on the movement of people or goods around the cities from one location to another in the world. Similarly, a smart economy is concerned with the interface between an intelligent city and the economy. The main objective of the smart economy is to enhance the life of businesses, facilitate and generate business services, and participate in urban development to increase the gross domestic product and create jobs.

The research carried out by Toh et al. (2020) provides knowledge of advancement in roads for developing smart cities. It is identified that in the future smart transportation is related to intelligent roads and signs. While we are entering the era, in which information superhighway helps in meeting the transportation highway. Roads are no longer considered physical entities as they will be empowered by involving info-communications, a capability that was possible decades ago, and along with this involving intelligence by using standardization work which was emphasized on air interfaces and increasing need to look at applications, systems and architectures. It is determined musical roads are produced that produce music or tunes in which cars drive past them. It is also considered as road as a musical instrument. There are some countries in which these types of roads

are constructed such as the USA, Japan, Denmark, South Korea, Taiwan, and Netherlands. The main aim behind constructing musical roads is not for entertainment but also for providing hazard warnings, helping drivers, and road safety.

In the alignment with the above, Baltac (2019) observed that the smart city concept is related with digital technologies. The research emphasizes the role played by IoT devices in smart cities. Different technologies involve such as big data, artificial intelligence, IoT and cloud computing. From these, some of the devices are easily executed in case of IoT mobile devices and along with considering cloud. It is observed that good smart city solution will undertake the real environment of the city and not avoid use of older digital and non-digital technologies. The execution of smart city projects helps in accelerating and decelerating by involving different factors. In the smart city setting, digital technology is an important factor which helps in accelerating activities in an effective manner.

2.3 Smart Cities and Data Management

Matheus et al. (2020) assert that data is being used by governments in all facets of their operations more. In government, data science is the process of taking structured and unstructured data—which can be closed or opened and using it to extract, interpret and present insights. Data visualization in dashboards is a key component of data science. Multidisciplinary research, data models and methods, data computing, pedagogy, tool evaluation, and theory are all components of data science. To analyze data, government data scientists require extensive knowledge of statistics and data analytics. They also need to be knowledgeable about the use of tools and techniques for predictive analysis and result visualization. Governments need to focus on data science because they gather a lot of data in many domains (energy, social security, transportation, and geography, for example) that can be enhanced or combined with information from smart devices, private sector data, and other sources like social media, discussion boards, and other devices. Using quality data is essential to making wise decisions. Data may serve as a catalyst for the development of fresh, creative applications that advance civic ideals like accountability, security, and safety. In data science, utilizing, sharing, and interpreting data are crucial components in closing the communication gap between the public and the government. Data-sharing platforms can be developed.

As per Syed et al. (2021) when considering the flow of decisions regarding the physical and social form of a city, smart cities are frequently conceptualized as constellations of instruments operating at various scales and connected by numerous networks. These instruments provide continuous data about the movements of people and materials. However, the ability of intelligence functions to synthesize and integrate this data to enhance sustainability, equity, efficiency, and quality of life in cities is a prerequisite for cities to be considered intelligent. Although databases contain various spatial data dates back centuries, traffic flows were the first data in cities to be automatically sensed. The concern for gathering census data was just as important to the development of digital computing as the need for scientific computation. Herman Hollerith first introduced the punched card technology for the US Census in 1890, which gave rise to the business that would eventually become IBM. Geographic information systems (GIS) technology has been routinely used to collect and display such data since the late 1990s.

According to Meyer and Schroeder (2023), maps for Navigation were the first visual system to become widely available on the web. This serves as the backdrop for a plethora of diverse initiatives aimed at gathering data from emerging forms of digital access, including GPS in cars and on people, electronic messaging via social media platforms, traces left behind from the purchase of goods and associated supply and demand scenarios, and access to a wide variety of websites. Additionally, the use of satellite remote sensing data is expanding, local scale sensing from LIDAR is increasing, and a range of scanning technologies—from regional to individual level and up to extremely fine scale tagging as in the context of the Internet of Things—are becoming important. Open Street Map, which is maintained by a community of about 20,000 active users who constantly update the map using GPS, is one of the most significant crowdsourcing applications, second only to Wikipedia. New models of scientific discovery are in fact evolving from developments in highly focused crowdsourcing, and these can be applied to the process of determining optimal designs for just and efficient cities.

The goals of a city's numerous infrastructure investments are to promote sustainable growth, improve the standard of living for citizens, and boost the city's competitiveness. Cities are turning into digital copies of the virtual environments in which people live as the world gets more data-

field, and the advancement and use of information and communication technology (ICT) are crucial to this change. Initiatives for smart cities are becoming more feasible as big data and the Internet of Things (IoT) grow. Large volumes of data are stored on cloud computing platforms, which also manage computation, analysis, and decision-making procedures. Automation control is then carried out based on the outcomes of these processes and analyses. Smart cities use cloud computing, big data, and the Internet of Things (IoT) to realize digital city development based on ICT infrastructure.

Big data

Wu et al. (2018) assert that the world is growing increasingly data-driven, with pervasive digital data on every facet of human existence emerging from analyses of patterns in human activity and the digital footprints left by that activity. In smart cities, application analysis and data activation are crucial. Big Data are large datasets, mostly in terms of volume, variety, velocity, and/or variability, that need to be efficiently stored, manipulated, and analyzed using scalable architecture. According to the usage context, several issues could come up during the collection, management, extraction, and analysis of Big Data. Big Data is used by banks all over the world to accomplish sustainable development objectives. The following other uses of big data include:

- to promote accountability and decision-making.
- to manage the allocation of funds; to assess whether funds are going to the appropriate location
- to oversee and evaluate, to spot trends over time.
- to ascertain whether these trends were brought about by a particular intervention.
- to pinpoint additional variables that might have contributed to the result

Growing measurements of environmental and developmental indicators are made possible by Big Data from sensor networks and satellite imagery. Eighty per cent of the world's 6 billion mobile phone users reside in developing nations. Because of its widespread occurrence, researchers have access to a daily-updating network of social sensors. Big Data is a revolution that will alter how people think, work, and live. Big Data has progressively emerged as a technology with a significant impact on the ICT sector, following mobile networks and cloud computing (Big Data for Social Good LUCA Data-Driven Decisions, 2017).

Bianchini et al. (2018) opine that by using cutting-edge methods for handling massive volumes of data, services can be provided with greater efficacy and quality. According to the Internet of Things (IoT) paradigm, data regarding energy consumption on the electrical and methane supply grids, hydric systems, street lighting, and heating are gathered from appropriate sensors and technological equipment of modern cities. These files are kept on exclusive systems that are run by a single energy supplier. Additional data from outside sources (such as weather and pollution data) is combined and arranged in integrated platforms to (a) compile data at the city level, primarily for the benefit of energy providers and the public administration to provide a comprehensive picture of data pertaining to the smart city; (b) provide private citizens with individualized access to relevant data at the level of a single neighborhood, building, or apartment. Social media data is also included, and users can create their own data by posting comments, recommendations, and preferences.

Large amounts of data are being produced by a variety of sources, such as smart cities, Internet of Things (IoT) devices, scientific modeling, and various big data simulations, in addition to user activity. The vast and intricate universe of digital data is made possible by the daily addition of new data to historical repositories. The Fog-to-Cloud (F2C) data management architecture is being developed recently to handle all big data complexities, including various information phases from creation to application from fog to cloud scenario, as well as IoT devices, which are the closest layer to users, and cloud technologies, which are the farthest layer from IoT devices. Furthermore, the fog (distributed) and cloud (centralized) technologies working together can benefit the F2C data management architecture in several ways, such as lowering network traffic and significantly lowering latency times while enhancing security (Sinaeepourfard et al., 2017).

“Zero Emission Neighborhoods” (ZEN) data management architecture, based on a distributed hierarchical F2C data management, has been proposed by Sinaeepourfard et al. (2018) for use in smart city scenarios. The 6Vs big data challenges—Volume, Variety, Velocity, Variability, Veracity, and Value—were in fact employed by the researchers to assess the data management architectures, which included ZEB and ZEN. The evaluation's findings demonstrate that the

suggested ZEN data management architecture can manage the data lifecycle from production to consumption and can effectively handle 6Vs challenges.

2.4 Smart cities and Decision Making

Types of Methods for Making Decisions

As per Tran et al. (2019) there are four categories of decision-making techniques: integrated methods, mathematical programming, artificial intelligence, and multi-criteria techniques. The multi-step process known as multi-criteria decision-making (MCDM) consists of several techniques for organizing and formalizing decision-making procedures. By evaluating options concurrently based on several dimensions, they enable decision-makers to identify the best compromise among a range of options (criteria). Nonetheless, MCDM is regarded as a steady-state technique that yields hotspot snapshots from past data. As a result, this approach does not offer forecasts or future trends, nor does it consider how various metrics, outputs, and parameters will interact over time (Ruhlandt, 2018).

Giang et al. (2017) examined the Mathematical programming (MP) techniques to maximize goals by considering the limitations and different concerns that need to be considered for stakeholders to decide. Numerous optimization techniques have been used in this field, including data envelopment analysis, linear programming, goal programming, and stochastic programming. However, a major drawback of using mathematical programming techniques is that most of them are too complicated for non-expert stakeholders to use effectively

As per Pérez et al. (2017) significant progress has been made in computer techniques to overcome constraints in MP models related to dynamic complexity and nonlinear properties, especially about the application of complex analysis and artificial intelligence (AI) techniques like cellular automata, multi-agent systems, swarm intelligence, genetic algorithms, simulated annealing, Bayesian networks, and reasoning systems. Computer-aided systems that sense their surroundings and behave like humans are the foundation of these techniques. Using highly sophisticated computer programs and information and communications technology-based solutions, these approaches are widely recognized for their ability to address complex and dynamic problems in

urban studies. An additional approach that aims to combine the benefits of the previously mentioned methods is called integrated methods (IM).

Decision-Making Level

Three primary levels of decision-making are involved in smart city and urban project contexts: tactical, operational, and strategic. The analytical framework of multi-level governance is employed to examine the way authorities in smart cities handle intricate matters and the interconnections among stakeholders. Tactics and operations are derived from decisions made at the strategic level of decision-making. The formulation of long-term objectives, the creation of policies, and the formulation of visions or values for the general development of the city are all included in the strategic level processes and activities (Pereira et al., 2017).

To attain the objectives outlined at the strategic level, the tactical level takes medium-term mid-level decisions into consideration. This tire encompasses the formulation of tangible agendas pertaining to green spaces and all stakeholders who consistently manage initiatives, finances, and the formation of alliances and coalitions. Universities and planners are some of these actors. Lastly, the operational level relates to short-term vision experiments and actions that include putting goals into practice and carrying out tangible projects. In smart cities, operational decisions are primarily used to provide operational solutions or to evaluate the outcomes produced by low-level managers (Lacroix et al., 2017).

Stages of the Urban Process

The methods in which stakeholders communicate to share information, collaborate, communicate, or carry out decisions define the term "process" in various contexts related to smart city government. In the field of work, implementation refers to the act of carrying out a plan or decision. Different countries, cultures, and research areas have different names for the different stages of implementing urban processes. The six stages of an urban process, for instance, are as follows: the emergence of the problem, its formulation, its technical formulation, its implementation, and, at the end, its appropriation. This is the French system. Urban ecosystem services are evaluated in the meantime using three stages: concept, development, and implementation. The stakeholders

should be exposed to negotiation at different stages of the process when making complex decisions because they possess varying levels of information and understanding about the issues at hand (Allam et al., 2019).

The study by El-Sayed et al. (2018) breaks down the process of implementing solutions into four stages: conceptualization, model creation, model testing through experiments, and model solution assessment. This general process is described as a real-life process that is developed and matures into a final form that is marketable and that users can fully embrace. Concepts are the initial collaborative products created in the early stages of design in an industrial setting. Improved planning, program development, and interpretation of a project's purpose are made possible by concepts. Models are implemented using general rules to represent a system based on concepts. An experiment is an empirical process used in the scientific method to determine models. Experiments are used by researchers to evaluate established models under trial and real-world settings, with the goal of confirming or refuting them. To consider as many viewpoints as possible and make an informed decision based on a wide range of situational knowledge, it is crucial to obtain an evaluation of solutions from multiple stakeholders, including citizens or users.

Citizens and Other Stakeholders' Participation in Group Decision-Making

The significance of including stakeholders, especially users and citizens, in the creation of cooperative processes for making decisions for smart city projects has been emphasized by a multitude of novel concepts, methods, and strategies. Most decision-making instruments and toolkits were designed and implemented by experts or authors alone, even though group decision-making was involved in about half of the studies. Only one paper (i.e., 28% of the total) examined the participation of multiple stakeholders. Stakeholders were infrequently given the chance to bargain and come to a higher degree of agreement in situations in which they were involved. Sometimes they didn't even compromise to come to an agreement; they just kept debating or negotiated for multiple rounds (Carli et al., 2017).

Making Decisions in Public Administration Based on Evidence

In the context of all-sectors management, evidence-based decision-making can be defined as a dynamic process that involves gathering, analyzing, and applying evidence to support decisions. The evidence must be produced using a strict procedure and be appropriate for the situation in which it is used. The application of evidence-based decision-making in management is still in its infancy; the examples that are currently available come from formal research, mostly in the field of medicine. Evidence-based management is a strategy that uses concepts from external, methodical research to improve the caliber of choices and practices. Practice is the intricate, day-to-day operations of businesses. Disagreement among stakeholders about what constitutes evidence and how to interpret the data is a barrier to the greater use of evidence in policymaking (Newman et al., 2017).

As per Parkhurst (2017) it is possible to conceptualize the creation and application of public administration policy as a two-way process that involves service users and necessitates incremental, evidence-based development. For the purposes of our study, public policy was defined as the government's implementation of a society's norms, values, and beliefs. Adopting evidence-based policy as a strategy makes sense because it would be based on the most accurate data that is pertinent to accomplishing the goals of the policy. Benefits are realized because the evidence-based decision-making process's innate rationality prevents or at least lessens policy failures that stem from the process's ideological underpinnings.

The evidence-based strategy is maintained to make sure that policies address the actual needs of citizens, that problems and issues needing immediate attention are dealt with, and that information sharing between various stakeholders is made possible. There are numerous, direct, and indirect advantages to using evidence when making policy decisions in the field of public administration. Those are the advantages: aid in improving decision-making. Policy planners, legislators, and other stakeholders who are concerned about the distribution of resources among conflicting policy objectives require evidence-based policy. They develop research questions such as how to allocate funds most effectively, which alternatives to use for resources will benefit people more, and how costs and benefits relate to one another (Concilio et al., 2021).

Establishing strong and efficient evidence-based public policy decision-making processes will require the following elements:

superior content based on subject areas; the ability to draw upon professional cohorts' expertise in data analysis, policy evaluation, and monitoring; motivations from a political and organizational standpoint to use analysis and recommendations grounded in evidence; Strong mutual comprehension between those in the demand and supply roles—that is, policy experts, researchers, and decision-makers (Bibri et al., 2021).

The process of acquiring data for real-time traffic, waste collection, and public transportation decision-making systems usually begins with the use of cameras, georeferenced tools, in-car sensors (windshields), and smart devices. The data is then transmitted via the Internet of Things to an aggregation platform, where it is interpreted and used for decision-making by the service provider or by citizens. Usually found in municipal operations centers, city government decision-makers make decisions regarding traffic operations in real time. Information sharing between city agencies, including traffic, separate towns, police, ambulance, the armed forces, and civil defense, is made possible by heavily utilizing ICT, formal protocols, and data mining features (Mills et al., 2022).

According to Babar et al. (2020), the pattern of the Internet of Things-enabled environment links information processing to every action that is encountered. To support improved decision-making, a vast array of physical real-world devices in a pervasive environment will generate copious amounts of data containing a variety of information that require new forms of computation. The Internet will become more reliable, valuable, and varied because of the massive volume of data produced by ubiquitous devices. Large-scale valuable data or information is being generated by advances in ubiquitous computing, and smart cities have a great deal of potential for analytical amenities thanks to the help of Big Data tools and skilled machine learning techniques. Many ideas are discovered for processing and analyzing the data produced by heterogeneous devices to carry out effective decision-making (Weber and Žarko, 2019).

Rajesh et al., (2019) assert that networks in smart cities are susceptible to malware, security breaches, and other cyberattacks due to data computation and ubiquitous intelligence. Several innovative and creative malicious prototypes would undoubtedly be added to IoT data computing by the interconnectivity requirements of common physical devices. Malevolent intruders can produce false information to tamper with the sensed data on authorized devices. Decision-making in a ubiquitous environment may be negatively impacted by intruders. Additionally, by interfering with transmission and sensing a ubiquitous environment, these malevolent entities may launch denial-of-service attacks that lessen the prominence of smart services.

2.5 Smart City- Advantages and Challenges

2.5.1 Advantages

The supply of clean water, energy, and nutritious food for a growing population is hampered by limitations on vital infrastructures and resource availability. Cities are experiencing pressure on public finances to cut spending and implement cost-cutting measures. They are also facing paradigm shifts towards online services, worries about climate change, and economic restructuring aimed at lowering unemployment. As a result, more intelligent approaches are required to handle urban challenges and revitalize urban life, effective infrastructure, and high-quality services for its residents. Enhancing citizen quality of life, environmental efficiency, security, and sustainability through centrally managed and monitored technology infrastructures are the main goals of the development of smart cities (Kumar et al., 2020).

As per Angelakoglou et al. (2019), global resource efficiency and sustainability are predicted to be achieved largely using smart and sustainable cities. We present a comprehensive framework in this study that can be used to identify a database of key performance indicators (KPIs) that can assess new and innovative services and technologies associated with smart city solutions, in addition to standard technologies. The six steps in the framework are as follows: a) Technology/service solutions are grouped into groups called Transition Tracks; b) key stakeholder groups are defined; c) KPI dimensions (or domains) are defined; d) KPI repository is defined per dimension; e) the scope of the evaluation is defined per KPI; and f) threshold definition is defined per KPI. Following the proposed framework's implementation, a repository of 75 KPIs with

matching levels of assessment and stakeholders' groups of interest was created. These KPIs were categorized into six dimensions: technical, environmental, economic, social, ICT, and legal.

Allam et al (2018) stated that examining how popular smart cities are compared to less well-liked alternatives like resilient and sustainable cities is an intriguing topic. The phrase "resilient cities" originated from planners and designers who questioned how to swiftly and effectively recover from urban perturbations, which are frequently connected to climate change. In contrast, the term "sustainable cities" arose from the necessity for cities to address sustainable development. When the terms "smart cities," "sustainable cities," and "resilient cities" are compared, it becomes clear that up until late 2010, "sustainable cities" were more common. After that, the phrase "smart cities" became the most widely used, reaching its peak in 2015. When it came to the popularity of Smart Cities, which peaked in August 2015, Resilient Cities accounted for 3% and Sustainable Cities at 5%.

Chu et al. (2021) claim that Innovation is positively impacted by smart cities. According to agglomeration theory, these cities act as natural knowledge hubs by promoting creation, dissemination, and accumulation of knowledge. Furthermore, cutting-edge in-person communication technology reduces the transaction costs associated with knowledge processing. ICT fosters urban innovation in a good way. Effective smart city policies can boost urban innovation by utilizing city agglomeration and technologies. Furthermore, general improvements in local production function knowledge can be used to improve innovation processes. Additionally, a smart city increases a city's knowledge base and fosters general high-tech innovation, particularly in the areas of ICT and the Internet of Things (loT), which are the primary forces behind green growth.

The following are some ways that innovation helps the environment in turn:

Initially, it was anticipated that green technology will play a major role in assisting with environmental management. Research has demonstrated that SCC can, by using an innovative-driven approach, lessen the environmental damage brought on by the world's fastest rate of urbanization (Contreras and Platania, 2019). Furthermore, because of smart cities' comparative advantage in innovation (Shang et al. 2018), more cutting-edge green technologies are being

integrated into production chains, which will boost output and save environmental costs. Second, the next generation of ICT can help city administration advance to a new level. Innovation makes it possible for smart cities to optimize industrial structure and scale efficiency in the functioning of urban economies in terms of resource allocation. As a result, smart city policies have the potential to significantly improve environmental quality through more effective resource allocation and the promotion of technology, particularly green technology.

The quality of life for residents, the local economy, transportation, traffic management, environment, and citizen-government relations are enhanced by smart cities' use of information and communication technologies. The concept of smart cities has garnered significant attention from researchers across multiple fields, including information systems, due to the relevance of smart cities—also referred to by other related terms like Digital City, Information City, Intelligent City, Knowledge-based City, Ubiquitous City, and Wired City—to all stakeholders as well as the advantages and difficulties associated with their implementation. Global urbanization has a significant impact on socioeconomic and environmental factors. An increasing number of people are drawn to the city's infrastructure in many cultural contexts, choosing the advantages of urbanization over traditional rural lifestyles (Ismagilova, et al., 2019).

By 2050, 6.5 billion people are expected to live in cities, according to UN predictions. Cities are consequently confronted with a multitude of difficulties as the strain on their infrastructure and resources grows daily. The use of information and communication technology (ICT) within an accessible integrated infrastructure is an emerging trend to manage and lessen the impact of these challenges. Smart cities are the term used to describe this idea. Scholars and practitioners are showing a great deal of interest in this topic, which indicates that it is a promising research area. To become "smarter," many cities are concentrating their efforts on using ICT to enhance a variety of aspects of city operation and management, such as the local economy, transportation, traffic control, environment, citizen quality of life, and electronic delivery of public services (Axelsson et al., 2018).

2.5.2 Challenges

Many research challenges arise because of the SCs' inherent multidisciplinary nature. A review of the literature regarding open challenges is completed. Since certain writers concentrate on a particular field, research has split this part into two sections: initially review the literature on various challenges and challenge taxonomies in the Review of Open Challenges section. subsequently, reviews that were limited to challenges within the Domain-specific challenges section. Examples of these include government, traffic, and so on (Sánchez-Corcuera, 2019).

Review of open challenges

1. Organizational and managerial challenges: these include the size of the project, the attitude and behavior of the manager, the diversity of users or the organization, the inconsistency between the organization's goals and projects, the presence of multiple or conflicting goals, the resistance to change, and turf and conflicts.
2. Technological challenges: these include personnel shortages in IT skills (integration skills) and organizational difficulties (lack of departmental and cross-sectoral cooperation, unclear IT management vision, political and cultural issues).
3. Government: cooperation, communication, data sharing, accountability, transparency, leadership and championing, participation and partnership, and integration of services and applications.
4. The context of policy: this includes the difficulties in integrating ICT with institutional and political elements, each of which has its own goals.
5. Individuals and communities: this includes digital divides, information gatekeepers and community involvement, communication, education, quality of life, and accessibility.
The economy comprises various aspects related to economic competitiveness, such as productivity, entrepreneurship, innovation, and so forth.
7. Built infrastructure: this includes IT infrastructure (pricing and availability of software systems and applications; lack of knowledge about interoperability; limitations on internal systems); security and privacy (threats from viruses, worms, and Trojan horses; privacy and personal data); and operational costs (high cost of IT, experts, and consulting firms; cost of setup and maintenance).

8. Natural environment: encompassing all the difficulties associated with the long-term viability of ICT introduction.

Challenges specific to the city's geographic location fall under the following taxonomy categories: living, people, environment, mobility, governance, and economy.

1. European cities' governance structures need to adapt more, and their economies need to become more recession-proof (particularly in the wake of a crisis brought on by the previous emphasis on a single economic sector). The city's transportation system needs to transition to one that is more efficient, inclusive, and sustainable. The author makes the case that to achieve this goal and protect the environment, cities should avoid urban sprawl and instead grow denser and more livable. As a result, there would be less need for cars, which would lower pollution and CO2 emissions. Lastly, the availability of housing, health issues, and the state of the crime rate present three significant challenges in this context.

2. Because of their geographical circumstances and high levels of urbanization, cities in the South and East Mediterranean should concentrate on offering basic services to their residents. In addition, they confront several serious difficulties, including a lack of resources, including food and fresh water; poverty; urban insecurity; unstable governments; and even elevated rates of violence and corruption. These all have an impact on the economy. To make progress toward a better urban future, these issues need to be resolved. Furthermore, compared to European cities, Southern countries have fewer smartphone users and a higher percentage of people who lack basic technology skills, which may cause a delay in the adoption of ICT in cities. As per a study, three main issues faced by SCs are- (1) City traffic, (2) citizen behavior, and (3) city planning are the1. Traffic in cities- There is a challenge in the algorithms to effectively use all the different data sources (e.g., GPS or GIST data). This includes data processing in real-time or traffic behavior and condition analysis.

3. Citizen behavior- A review is conducted on research on mathematical models for human behavior analysis. Furthermore, new methods of analyzing behavior have emerged with the advent of ICT, including the use of GPS and mobile phones.

4. City planning Since there isn't a specific function for doing this, another significant challenge is guiding urban growth and construction using data. Some researchers begin by classifying the various urban areas into residential, industrial, and administrative areas; however, this approach is insufficient for large cities.

Cities are facing these six challenges in their efforts to become an SC: (1) defining the ecosystem position of the city administration; (2) having a team of experts lead the SC growth; (3) developing an internal coordination mechanism (since there was no framework to discuss SC projects); (4) controlling the relationship between IT and business; (5) the requirement for forward-thinking workers who are motivated to work in a SC; and (6) moving from the experimental phase, where SC projects get stuck, to a real implementation.

Pierce and Andersson (2017) suggested a taxonomy for SC challenges, which focuses on municipal decision-making, and analyzes them using both theoretical frameworks and data from interviews. The challenges were categorized as non-technical and included (1) collaboration, (2) financial, (3) governance, (4) awareness, and two technical issues: interoperability and privacy.

1. Collaboration. includes a lackluster effort to collaborate with outside parties.
2. Monetary- includes issues with funding SC initiatives being scarce, requiring substantial upfront investment, having no business plan, and having trouble making money off of SC investments.
3. The administration- difficulties resulting from out-of-date laws and rules that obstruct SC initiatives.
4. Awareness- includes difficulties relating to insufficient expertise and understanding of SC-related technologies
5. Interoperability includes difficulties with integrating SC.
6. Privacy. Accepts the problematic nature of big data
At the same time, citizens have protected privacy.

Anand and Anand (2017) analyze various challenges in implementing SCs. The water sector does not have enough drinking water and there is no rainwater collection system. In the energy sector, e.g., they provide electricity to all urban areas, and they don't have enough carbohydrates even if they are mostly consumed. In the waste and sewage sector, there is no effective waste collection

system and open defecation problems to which not all houses are connected to sanitation and no citizen participation in waste management and sorting. In the mobility sector, there is an inadequate public transport system that makes citizens rely on private transport, and this is even worse when you consider that roads the infrastructure are not adjusted for congestion. In the area of the built environment there are housing prices increase, as a result of which a disadvantaged part of the population cannot own a home (the consequence is creating informal housing without basic services) and cities have not updated their infrastructure with population growth.

According to Silva et al.'s most recent study, a realistic SC should take into account the following ten factors: (1) connectivity; (2) big data; (3) waste management; (4) performance; (5) sustainability; (6) heterogeneity; (7) cost operation; (8) information security; 9) system failures; and (10) carbon footprints. Deploying and maintaining the city are two major challenges: lower costs increase the likelihood of implementing the concept in the real world, and lower costs again increase the likelihood of sustainability. In addition to these ten key concerns, there are environmental issues like waste management, reducing carbon emissions, and introducing renewable energies, as well as the ability to integrate heterogeneous software and hardware together (interoperability).

Challenges specific to various domains

Farming- The development of new machinery and systems has allowed the agricultural sector to advance recently, but there are still certain challenges in integrating it into the SCs. One of these issues is that cities are taking up fertile land that was once there, so they ought to oversee producing food that could have come from the land. Furthermore, the transportation of imported products from their production locations uses more resources than they do to provide nutrition.

Citizen- the engagement or participation of citizens is essential to achieving the goals of SCs in the best possible way. In this manner, the city can meet their needs by listening to their input and/or involving them as involved members of the community. Simonofski et al. distinguish three ways in which citizens can participate in city life: (1) as ICT users; (2) as co-creators; and (3) as democratic participants. Irvin and Stansbury, for instance, examine the benefits and drawbacks of involving residents in the city's decision-making process in the first case.

Education- The needs of society are constantly being met by education, which is constantly evolving. Zhu et al. predict that as the idea of SCs develops, there will be new difficulties in connecting and expanding the learning services offered by smart education with other contextually aware SC systems. Additionally, they predict that new technologies in smart learning environments will create new difficulties for the fundamentals of education itself, necessitating adaptation and the introduction of ideas like new pedagogical theories, educational technology leadership, teacher learning leadership, educational structures, and educational ideology.

Energy: Reducing energy intensity and achieving energy efficiency are necessary for sustainable growth. Encouraging and involving citizens in this process is a significant challenge. CT integration may not be available to all citizens and may not be energy-sustainable in the SCs' domestic domain. The significance of taking energy consumption into account when implementing ICTs in SCs is emphasized by this. Regulations, which hinder the appropriate use of microgrids, and technical difficulties are the two primary obstacles that Yoldasx et al. identify from the standpoint of smart microgrids. Concerning the latter, they divide the problems into four categories: (1) functioning; (2) parts and compatibility; (3) incorporating renewable energy sources; and (4) safeguarding.

Environment- In regards to the environmental challenges, Colding and Barthel 183 provide an urban-ecology perspective on a number of issues pertaining to SCs: (1) the cyber-security and resilience of the paradigm itself in order to prevent unpleasant surprises and, in particular, to safeguard basic human needs (food, energy, and water security); (2) an analysis of winners and losers within the paradigm, as the SCs may create a technologically marginalized and segregated part of the population; and (3) that humans may become disconnected from nature, as our relationships to physical locations influence our environmental behavior. Therefore, new instruments are required to enable human-nature reconnection.

Government- Gil-Garcı´and Pardo offer a taxonomy for the difficulties faced by government initiatives in the field of e-government, with a focus on information and data, information technology, organizational and managerial, legal and regulatory, and institutional and

environmental barriers. Three obstacles to IoT-based governance are outlined by AlEnezi et al. To safely implement a smart government, three key factors need to be considered: (1) investment in ICT; (2) mindset, or the process of persuading entities to change, as administration systems tend to be rigid; and (3) security and privacy.

Health services- Chen et al. concentrate on wearable sensor challenges in relation to health monitoring. They list the following as the primary problems to be solved: (1) fabrication of bionic smart clothing; (2) big data in health; (3) multimodal body sensor control system design; (4) intra-body area network communication; (5) body human interference; and (6) contextual data interpretation. The difficulties of using homes as smart environments for health monitoring are reviewed by Mshali et al.

The primary concerns that they differentiate are as follows: (1) precision of monitoring; (2) awareness of context; (3) human factors; (4) heterogeneity; (5) availability and reliability; (6) data transmission; (7) security and privacy; (8) intrusiveness; and (9) power consumption

2.6 Infrastructure Development in Smart Cities

Infrastructure in smart cities

The study conducted by Šurdonja et al. (2020) stated that smart cities' main objective is to develop smart mobility solutions to address the issues linked with transportation and logistics needs among various groups of citizens. It is evaluated that the development of smart mobility solutions has shifted to the development of public transportation systems and reduction in road congestion which also affected the private transit as well as regular citizens. The main emphasis is on utilizing new technological tools and artificial intelligence to ensure adequate management of traffic as well as aiding citizens in real-time navigation by reducing the chances of delays that might occur on the road. It helps ensure efficient movement with minimum delays. The present trend that has emerged in smart cities is related to the development of electricity-based mobility infrastructure in the city. On the other side, Ruggieri et al. (2021) stated that the technical aspect requires the development of basic road infrastructure for the promotion of electric vehicles and charging stations which helps cater to the power and energy requirements of such vehicles. In this aspect, both the concept

support ensuring an environment-friendly system and the reduction in the air pollution that needs to be involved. In smart cities, the development of the growth of electronic-based mobility and transportation infrastructure is one of the major priorities. It is determined that the electric car market has grown significantly over the past four years. Involves both Battery Electric Vehicles i.e. cars featuring an electric engine and plug-in hybrid electric vehicles featuring both internal and electric combustion propulsion considering the number of electric cars in the world by 7.5 million of which more than 2.2 million cars were sold in the year 2019.

As per the view of Kasznar et al. (2021) smart cities have gained a lot of attention concerning operating activities and involving social and technological challenges. The infrastructure in smart cities focuses on the development of buildings, roads, and electricity. It is evaluated that most studies focus on traffic management and control, integrating IoT, big data, land use development, and smart grid initiatives. The new infrastructure development aids in involving challenges along with operating and maintaining existing infrastructure worldwide. The research emphasizes the development of infrastructure through smart systems, the adoption of sustainability in current smart infrastructure, and information and communication technology and its role in constructing infrastructure, operation, maintenance, and management. Infrastructure in smart cities highlights the relevance of digital and technological cities, including traffic congestion, long commutes, and lack of parking infrastructure. The dimensions of smart cities comprise institutions, technology, and community.

Alnahari and Ariaratnam (2022) stated that infrastructure in smart cities is considered a concept that has been studied for the past few years. The research focuses on designing future markets and opportunities in the electricity segment by using blockchain technology in smart cities. The study emphasizes infrastructure segments in modern cities including data management, cyber security, smart cities, and improving government systems of management with blockchain, blockchain tracker, and trade of water access rights some of the blockchain applications used. The execution of blockchain technologies in urban data management has a profound impact. It is evaluated that regulatory businesses join forces to ensure a smooth transition as this technology comprises a chain and ceasing and the existing link is missing. It is determined that because of a lack of knowledge and access to technical resources of blockchain-integrated infrastructure projects. The research

focuses on analyzing the risk management schemes that are designed to allocate associated risks and model changes appropriate for use cases. The solutions help in managing obstacles and issues related to it.

The research carried out by Huo et al. (2021) provides knowledge related to the need for the development of a distinct road section in the form of pathways as well as dedicated lanes for cycling which can meet the needs of those citizen groups who might want to walk or cycle for considering the respective destination. This strategy is also supported in consideration of ineffective tools for the development of last-mile connectivity in smart cities even for those regions that have lower levels of connectivity due to public transportation. The entire transportation infrastructure was built around accessibility.

Calvillo et al. (2016) discussed that in smart cities, energy management is considered a complex system. It is determined that smart cities are continuously working towards developing renewable energy sources to meet the power demands faced in the cities. This requires the development of dedicated infrastructure in the form of solar panels, other tools required, and wind turbines to promote renewable energy generation to meet the demand of people in the city. In this regard, it analyzed that infrastructure helps in supporting and utilizing fossil fuel energy resources by causing minimum pollution and emissions considered for the time for completing the operation of renewable energy is achieved. The next aspect is also important to be involved in the development of smart cities as part of energy infrastructure in the development of smart grids. Smart grids are needed to manage electricity flow using the city based on expected demand by ensuring access to continuous electricity and there is minimal wastage among distribution lines. It is evaluated that unexpected energy demand and availability of proper energy storage infrastructure are needed which has been given the status of crucial energy infrastructure.

The research carried out by Pacheco Rocha et al. (2019) discussed that in smart cities healthcare services are necessary and their development in the cities is essential for providing better healthcare facilities to people living in the city. Infrastructure is required for the reduction of physical visits to clinics and hospitals and similarly at the same time providing 24/7 healthcare services accessibility to various citizens. The study's main objective was to determine the

applications supported in the development of infrastructure in smart cities with an impact on healthcare provision. To achieve this objective, systematic literature review was conducted to analyze the solutions provided by the researchers. Potential applications of smart cities with influencing the healthcare provision were analyzed in the study. The importance of infrastructures in the smart city for supporting the provision of healthcare was also discussed.

Water management in smart cities

Mohanty et al. (2016) stated that in the city water management is the basic requirement and dedicated towards attempting to develop adequate management of water in the smart cities. The main reason is related to ensuring the adequate distribution of water in the city of which the focus shall also be support in ensuring each citizen has access to safe water and at the same time there is minimal instance of wastage. The wastage mainly occurs by leaks, and water management infrastructure shall be developed for resilient to the natural environment and not leak. In case of waste management, the primary aspect is ensuring the proper allocation of waste in the cities. The research emphasizes emerging as an application domain of IoT. This helps in utilizing ICT in an urban environment such as a green city, sustainable city, or intelligent city and stand out by considering the various aspects linked with managing strategies associated with waste management. In the modern world, smart cities are becoming an important perspective and along with this constitute providing better facilities for people.

2.7 Operations Framework and Management

Operational frameworks

The study conducted by Pambreni et al. (2019) provides an understanding related to one of the most common operational management frameworks such as total quality management (TQM). The research emphasizes analyzing the impact of total quality management on the performance of the organization. The study primarily focuses on the influence of TQM on small and medium enterprise's performance. It is evaluated that executing TQM will be supported in elevating the quality and improving the performance of the business in the service sector. Total quality is considered an approach for doing business that supports maximizing the organizational competitiveness of the business through continuous improvement of the quality of its products,

services, processes, and people. It is observed that TQM comprises different elements including customer focus, obsession with quality, continual process improvement, unity of purpose, teamwork, education and training, and involvement of employees. Customer focus in the study has gained less influence on the performance of the organization.

Saragih et al. (2020) provides an understanding related to the influence of total quality management, operations capability, and supply chain management practices on the performance of the firm. The main aim of the study is to examine and explain the structural relationship between and among total quality management, operational performance, and supply chain practices. In the study, the short and long-term influence of variables in the model could be determined by involving longitudinal data. There is also a need to analyze the impact of operations capability in the broader aspect including the supply chain. This research will affect the manufacturing organization related to the export activities and benefit by using the research in terms of quality management practices and supply chain impact on the performance of the firm.

As per the view of Lai et al. (2020) smart cities also focus on employing technology and data to enhance efficiencies, sustainability, and economic development and develop the quality of life in urban areas. It is determined that clean technologies help in the promotion of the development of smart cities involving health, energy, and transportation. The concept of a smart city is ambitious and involves refined and standard aspects. It is determined that smart cities are sustainable and intelligent cities. They are also well-known as smart cities and require novel technologies involving sensor devices and robust ICT infrastructure. The research depicted the size domains of the smart city such as smart education, mobility, economy, governance, health, and energy. There is a need for smart city projects to present details on the adoption of global standards and its implications for smart cities. This study helps serve as a guide and along with this constitutes an identifying perspective through which total quality management can be executed in the organization. This helps in considering the aspects of total quality management and along with this emphasizes building perspective through which development in the city can be carried out efficiently.

Sánchez-Corcuera et al. (2019) provide knowledge related to introducing Information and Communication Technologies (ICT) from the last few decades created as the trend of providing daily objects with smartness and further aim to make the lives of humans comfortable. Smart cities as a paradigm support the creation of goals in the city in the future. It is determined that in developing countries, managing water is still an issue that needs to be addressed. Several gaps are making it difficult to implement the programs related to waste management. In the case of India, different gaps were analyzed by considering there is not an organized planned segregation of the waste at the homes and community bin level. Concerning electronic waste in India in the year 2011 and the challenges for tackling to implementing the management of e-waste.

As per the view of Kaswan et al. (2023) the integration of the GLSS-I4.0 approach led to the smart solutions development for manufacturing industries. The approach helps in providing insight related to different aspects of techniques and tools which helps in making a system of service delivery and production of items faster while providing less error. It emphasizes having minimum interruption of humans by creating a healthy working environment, resolving complex decisions, and along with providing automation solutions for considering healthcare facilities. This approach further helps in facilitating healthcare facilities to extend their present capacity by utilizing the utilization of the workforce, reducing the stay in hospital for patients, and increasing value-added time for the healthcare staff. This constitutes the reduction of patients at healthcare facilities and allows hospitals to involve potential capacities.

Management frameworks

Yadav et al. (2021) discussed Six Sigma as another operational management framework that helps in managing quality in the organization. It is determined that modern organizations involve initiatives that help facilitate them in providing a competitive advantage in the international market. It is observed that Green Lean Six Sigma (GLSS) is an inclusive approach that supports enhancing environmental sustainability and leads to improving the financial stability of businesses. For implementing the GLSS strategy it is necessary to involve green, lean, and Six Sigma initiatives. The integration of the GLSS strategy has been proposed based on intangible features such as toolsets, enablers, etc. Efforts made by a team, participation, and dedication of management are considered remarkable aspects for the execution of GLSS in the manufacturing

segment. In addition to this, the study also discussed five aspects related to the GLSS framework for manufacturing businesses in increasing sustainability in the organization. The research facilitates practitioners and managers for executing the GLSS program in the manufacturing business to increase operational excellence and sustainability in the environment.

Qayyum et al. (2021) provide an understanding of the use of Six Sigma in smart cities. It is identified that the endeavors of smart cities are complex and present management challenges. It is observed that smart cities are intelligent and considered to depend on technology at the time of development of smart cities. In this study, the conceptual framework was developed to consider the six sigma in smart cities. In the research, a new method was proposed which helps in combining the methods of six-sigma. DMADICV method comprises six elements including defining, measuring, analyzing, designing, improving, controlling, and verifying. Here, each element is discussed in the study, and a framework was discussed for managing the smart city. The performance of smart cities was tested and integrated with the processes that were discussed in the research. The research also emphasizes factors and processes for all constructs of the DMADIDC method for retrieving and involving different perspectives associated with the conceptual framework developed.

The research undertaken by Khan et al. (2021) provides knowledge of the development of a smart city as an application of digital technologies for providing improved services for residents. In the present market scenario, smart cities are becoming a buzzword and dealing with barriers affecting development. To meet the objective of a smart city, BDA plays a crucial role, and its application further leads to analyzing the applicability towards achieving sustainability in the long term. The research emphasizes the adoption of big data for achieving the development of smart cities. It is observed that barriers in the research are prioritizing and supporting the urban planner for their decision-making associated with the adoption of BDA. The research emphasizes BWM method which helps in accomplishing the goals and carrying out business activities in the long run.

2.8 Operational Management and Smart Cities

As per the view of Li et al. (2016), the research focuses on enabling the development of new operations models concerning smart cities. The research further involves operations management

and the digital economy. Smart cities are continuously developing and involving stakeholder groups for becoming knowledgeable and engaged and they also focus on considering the operations managers within the sector for involving issues and opportunities faced by their people and processes as well as considering tools and frameworks for deploying operational decision making. In the smart city, the execution of operations management is helpful for the researchers and involves emerging operations models. The study focuses on three case studies for determining the transformation of operations models in the smart city context. It is determined that smart cities help provide the environment for ranging innovations between offline and online activities.

Mak (2022) discussed the adoption of new technologies by smart cities for the development of society. The movement is in line with the community of operations management along with focusing on the development of practices and considering different aspects which are important for carrying out business activities in the long run. It is analyzed that operations management is rather than unique aspects as it involves the engineering aspects which further constitute indulging into activities with the help of which problems can be resolved and considering different perspectives associated with managing operations and dealing with the issues in smart cities. This further leads to bringing aspects and along with this constitutes analyzing the activities associated with proposing new ideas and leading into practice. Smart cities are transformed by the adoption of data analytics and further consideration of the aspects for the future terms.

According to Zhuhadar et al. (2017), new technologies were executed in business models and infrastructure which have been developed through globalization and the internet. Innovation is linked with the ability of humans to connect to machines, and the data comes from connections. It is evaluated that urban and regional economies grow by emphasizing the need for smart cities which involve powerful hubs of possibilities and information. In urban areas, cities have greater control over the development focusing on interconnecting the core systems. Smart cities have opportunities for the development of sustainable prosperity. New technologies help in providing greater scope for interconnection, instrumentation, and involving core systems. Cities must be prepared to consider revolution instead of evolution by putting place on the next-generation systems that work entirely in a new way. Smart cities also require shifting in thinking and becoming successful and further supported in bringing out aspects through which development

can be made concerning the smart cities' approaches. The operations management involving smart cities further aims to focus on the development of practices in the future terms.

The research undertaken by Fahimnia et al. (2019) provides knowledge of attributes linked with operations management. It is determined that communication is one of the attributes associated with operations management. In the context of smart cities, communication is important for transferring information. Proper communication is required for managing operations and along with this constitutes the development of practices in the long run. This also supported facilitating and analyzing the aspects through which development can be made. It is important to build aspects and further consider that communication is necessary for carrying out business operations and analyzing the development of the activities in the long term. This is also supported by considering different perspectives through which operations can be managed effectively. Communication is necessary for analyzing the different aspects and along with these focuses on various aspects related to the perspective in the long term.

As per the view of Seidel et al. (2019), leadership is also regarded as an important attribute of operations management. Leadership is necessary for managing operations for the development of smart cities. It includes different perspectives and along with this constitutes in focus on developing perspective and managing activities in the long run. Leadership is treated as an important aspect of facilitating the development of cities by involving various aspects along with analyzing the development and focusing on bringing perspective through which development needs to be done. The research emphasizes leadership theories along with building perspective and developing activities in the future terms. Leadership aspects have been developed and along with this supported in analyzing the perspective necessary for bringing personal attributes and affecting the process and context. This helps in making the comparison between leadership lean and general based on different constructs.

Sánchez-Corcuera et al. (2019) discussed challenges specific to different domains. It is determined that energy efficiency is treated as a challenge as there is a need for motivating and involving citizens in the reduction of energy to achieve energy efficiency. In smart cities, ICT technology was implemented by concerned the unsustainable aspects and focusing on bringing out aspects

linked with the consumption of energy at the time of introducing ICTs in smart cities. Further, it involves the environment, in which challenges are associated with resiliency and cyber-security of the paradigm for avoiding surprises and safeguarding the basic needs of humans. In the governmental area also, challenges are linked with legal and regulatory, information technology, and environmental and institutional. The issues are associated with security and privacy, investment in ICT, mind scaping, or the process of convincing entities, and investment in ICT.

The research carried out by Syed et al. (2021) provides an understanding of related issues while managing operations in the smart city. It is observed that leakage of data is considered a challenge to smart cities. In smart cities, application managers use data to improve their services and offer them better experiences while it is possible that data was provided by a third party. It is important to analyze the data before considering such assignments. Leakage of data takes place at the time of performance of network discovering tasks and providing the information in the network. It is evaluated that data aggregation is an important tool for maintaining privacy and security of leakage of data. Another issue is associated with trustworthiness which constitutes providing secure usage of applications of smart city and encouraging their use which is important that smart city usage be provided for managing their data.

Resilience theory

It is determined that increasing population of urban areas have challenges for the city including urbanization, terrorism, change in climate and increasing risk linked with natural disasters. To deal with these issues the city must have to adapt to dealing with challenges, cities must learn to develop their resilience in facing problems of this era of uncertainty and unpredictability. The resilience approach comprises of two approaches first man and nature has close link and evolve together and have conceived as one social ecology system and secondly responses of these systems towards unpredictable changes. The concept of smart city planning involves resilience elements which can be interpreted for determining new definitions. In the city, complex systems have been considered, and their resilient capacity needs to be developed, the multi-component capacity is the process and interaction which raises the physical limits. It is identified that when city is considered smart it is necessary to be resilient at any time (Arafah and Winarso, 2017).

Resilient smart city framework

According to the framework, smart city provides all necessary infrastructures for making it resilient considered as main criteria of the research. Resilient smart city means conceptualized through technical means of the smart city is smart at the time when it is structured to be resilient as well. It is identified that city is considered as RSC when it depends on ICT centric-infrastructure, intelligent devices and sensors for enhancing human lives at urban level. This is mainly achieved by its elements comprises of ability for maintaining its system and data in-store for recovering and returning quickly to optimal functions which potentially threaten urban livelihood (Khatibi et al., 2021). The starting point of the framework is linked with determining a city from the evaluation of features which makes it smart and ranking in the smart city. Based on the framework, it is evaluated that city is not qualified as smart one then enhancement methods need to execute.

Smart resilient city framework

The main idea behind this framework is establishing resilient city which has potential to be smart as well. The framework involves different aspects considering city is smart as to warn against disruptions and predict the type of disruption. This also focuses on choosing the best method for absorbing the disruption, and taking fast, economic and straightforward plan for recovery and selecting best technic for bouncing back better (Khatibi et al., 2021). This framework is used for measuring the conventional cities that yet non-smart and non-resilient the framework helps in making the city qualifying for being resilient right after the evaluation of smartness, the determined, resilient city which could then be established. The framework might be used for standards for current resilient cities which help in re-evaluating their index of resilience.

2.9 Research Gap

The operations management framework plays an important role in the success of the smart city and the development of infrastructure. There is a gap involving the development of operations and the design of smart cities. The present frameworks derive from traditional management models and concerning applicability to dynamics and considering the technologically driven environment in the smart city which remained unexplored in the previous studies. There is also limited research carried out on operations framework and management and operational management and smart

cities concerning the challenges of operations management. In addition to this, an in-depth examination needs to be carried out based on the operations frameworks in the context of smart cities. Previous studies also lack information related to smart cities around the world, specifically Europe and USA. Depth understanding will be required by emphasizing smart cities concerning the applicability of effective operations framework and management.

2.10 Summary

The above literature review provides knowledge about the smart city movement, addressing the challenges with the help of technology, and supports increasing economic growth and providing quality life to people. There are certain elements of smart cities including mobility, governance, people, and living standards. The literature explores IoT applications along with systems for managing waste and AI's role in the creation of intelligence in urban areas. The research highlights the role of sustainable practices, artificial intelligence, and technology in shaping the environment of urban areas. Different technologies integrated such as IoT, and blockchain for managing data. In the smart city projects, decision making landscape includes four key categories such as mathematical programming, artificial intelligence, integrated methods and multi-criteria techniques. It is observed that multi-criteria decision making helps in allowing simultaneous evaluation of options based on different dimensions yet lacks predictive capabilities. It is evaluated that mathematical programming techniques are powerful and considered as complex for non-expert stakeholders. It is identified that integrated AI, involving genetic algorithms, reasoning systems, increasing decision making in dynamic urban contexts and cellular automata. It is analyzed that decision making is carried out at three different levels strategic, operational and tactical. Strategic decisions help in shaping long-term objectives and policies affecting tactical decisions which supports in addressing medium-term plans.

It is determined that this also evolved in involving challenges faced by cities which provide energy, clear water and nutritious food for growing population which led to emerging to smart cities. The research also emphasizes providing relevance of smart and sustainable urban developments for addressing global resource efficiency, restructuring of economy and environmental concerns. The smart city solutions measured through key performance indicator encompassing as environmental,

technical and economic dimensions. The challenges associated with smart cities are governmental, policy, individual, building infrastructure, economic and natural environment dimensions.

Practical Implications

Effective operations management and framework are important elements in the successful execution of smart city initiatives and the development of infrastructure. In the smart city context, movement helps in integrating advanced technologies for improving the life of people living in urban areas along with well-defined operations for ensuring coordination among different systems. City planners must prioritize data analytics and along with this optimize utilization of resources. City planners must emphasize developing communication networks and data-sharing protocols for facilitating the involvement of smart technologies. They should also involve flexibility and scalability for designing smart city systems for accommodating future growth and advancements in technology. In addition to this, policymakers must prioritize investments in the digital infrastructure, connectivity, data security and enabling smart solutions. They also aim in facilitating partnerships, creating regulatory frameworks and fostering conducive environment for the development of smart cities.

Chapter 3: Research Methodology

3.1 Introduction

Our society is a complex and ever-evolving habitat. With each new advancement, the inner workings become more intricate. This intricate web brings undeniable benefits, but it also throws up unforeseen challenges. Problems that were not encountered before keep popping up, demanding solutions. However, the frustrating part is the fact that just as we grapple with these novel issues, older problems get addressed only to be replaced by a fresh wave of complexities. (Gordon, 2012). This intricate web brings undeniable benefits, but it also throws up unforeseen challenges. It's a constant game of complex cause and effect, where solving one issue seems to trigger the emergence of another. This rapid rise in intricate problems significantly challenges our collective ability to find solutions (Andrews, 2016). This is specifically the case with resolving issues in social sciences. A problem or an issue is usually a dubious case or a challenging trouble that needs to be addressed to be resolved or settled. It is essential to comprehend the suitable facts that are quite important to resolve the issues and problems in society (Taylor et al., 2006). A problem can be made less ambiguous when it is clearly stated and broken down into smaller questions or problems. Scientific research is conducted through research methodology. Two significant principles are essential for a contemporary research study. The researcher's ability to use their imagination freely must be kept under severe testing (Qaisrani, 2016). There must be the existence of free imagination in the researcher's mind to be able to use idealistic thoughts in application thus ending up giving wings to the concepts. There should be tangible outcomes of tests that help draw the imagination, especially in precedence to the situation that exists (Liaquat, 2016a). However, it is through observation that data can be gathered; conclusions can be drawn. Most importantly, the cause and effect need to be analyzed to understand the study and further researchers will get to focus on the smallest aspects (Liaquat, 2016b). All scientific investigations are distinguished by the existence of attentive observations from the researcher.

The transformation of ontological and epistemological concepts into rules and regulations is termed research methodology. The researcher can outline the rules and compose the norms regarding how the research will be conducted (Franks, 2017). It is the rules, regulations, and

standards that provide direction to the research study. There are different types of research methodologies and owing to that there are different types of research approaches that can be utilized for different types of research subjects. Additionally, no one research procedure can be stamped as an ideal one for all types of research issues (Mahawar & Professor, 2023). The researcher must keep in mind that every type of research procedure has its advantages and disadvantages, and the comparison can be reliable. Research methodology helps in researching, examining, evaluating, and analyzing various social processes. The procedures are also used to investigate the natural world, events, and matter; consequently, research methodology particularly talks about data gathering, samples drawn, and then analyzing them to bring out the outcome of scientific research (Groenewold & Lessard-Phillips, 2012). The researcher's effort depends upon the choice of the right set of research procedures and approaches which is utilized in scientific exploration. Henceforth, the research scholar or researcher should choose the best research approach or method. It is the selection of the research approach that determines factors like how the data is gathered, how they are collected using the instruments, and how they are examined and evaluated chronologically (Dibden, 2019). It is through the accessibility of the researcher over different types of research methodologies that an educated choice can be made through a thorough comprehension of the research approach, design, method and strategy followed. The researcher has to equally understand the pros and cons of the research methodologies that are chosen for their study. The goal of the research study is to be able to make significant decisions in solving the research questions (Ismail, 2018). There are different types of research questions such as descriptive questions, relational, analytical questions, and casual questions. Nevertheless, the design of the research questions requires the essential study objective and the context of the subject matter. Experimental procedures heavily rely on quantitative techniques and numerical analysis especially when the researcher's research study subject is science (Canales, 2017).

Most importantly, each research endeavor must have a specific research methodology which the researcher needs to choose before developing the framework for a research study. The framework will determine the collection, organizing, and analysis of the research data chronologically (Koch, 2013). If there is a presence of a clearly defined research technique then, making relevant findings and collecting, getting, and analyzing accurate data becomes easier to obtain. Researchers might have to guarantee that their research work is valid, reliable, accurate, and trustworthy such that the

findings are relevant, significant, and applicable to the research study (*Research Methodology*, 2024). These significant findings can be used to guide critical decisions, which is only possible when the researcher is adhering to an established research methodology. An established research methodology must be used to conduct the research study which ends up in data analysis and finally getting the outcomes (Kourtellidou, 2010). The exact research methodology which is chosen by the researcher outlines the investigation's reliability and validity. Moreover, the researcher defines the problem, and the objective and further fetches the findings based on the data collected throughout the study (Persson, 2010).

Furthermore, the research design and strategy sections will define how the objective of the research will be defined. The research objective will be satisfied by solving the problems and troubles and bringing out the analysis and thus, concluding (Gierlack, 2014). This whole organized procedure helps the researcher to be organized and systematic from the initial moment and further helps to bring out the outcomes that are extremely important for the research endeavors. When it comes to the choice of research methodology it becomes essential to keep in mind, to development of the research questions which are further analyzed to determine and meet the research's objectives (Voortman, 2015). It is the research methodology that carries out every step one by one from choosing the research paradigm, calculating the variables to data analysis, and finally going on to choosing the data that is to be needed, the techniques which would be used to make sure the data is collected through organized manner, and how the data will be analyzed, and finally describing, explaining and interpreting the data (Kalinda, 2007).

3.2 Research Paradigm

When it is about comprehending and studying a phenomenon, the research paradigm turns up and is defined as the conceptual strategy. The concept creates a research strategy by acting as the structure where the concepts and procedures of the study can be incorporated based on the field of research. The fundamental idea includes the objective of the research venture, the research study's questions, the instruments and tools that are employed in the research procedures, and the data analysis techniques followed (Johanek, 2000a). There are two types of research paradigms and they are as follows: -

1. **Positivist Paradigm -** This paradigm is defined as the epistemological concept or doctrine utilized to comprehend social and physical reality (Johanek, 2000b). Moreover, distinct realities must be independent and completely unbiased of any external influences. The observation should also be made in an unbiased manner without causing any influence (Hunt, 1991). The universal acceptance of the outcomes of positive ideology happened in the 20th Century. The ideology became a challenge for comprehension of the truth which is not independent of experimental data but rather supports the scientific claims. Consecutively the study of theology and metaphysics was canceled by the traditional positivist perspectives to add to the academics (Park et al., 2020).

2. **Interpretivist Paradigm -** When it comes to gathering information regarding occurrences, the Interpretivist school of research encourages the comprehension of an individual's beliefs, ideas, motives, and thoughts. It is the concentration of the data and the gathered information and the attention to the context that distinctively the Interpretivist paradigm research sets from the positive ones (Hug, 2016). Furthermore, interpretivism assumes that reality is subjective, has multiple perspectives, and is socially constructed. It also means that the researcher can only understand the participants' reality through their experience of reality. The interpretivism paradigm also does not consider that the social reality is not singular and objective but rather subjective to several social perspectives.

The study will adopt an interpretivist research philosophy as the paradigm emphasizes that reality is understood through subjective interpretations shaped by social contexts and experiences. It seeks to understand how individuals and groups make sense of their world. This paradigm is interested in how people construct meaning within social settings, rather than simply observing external behaviors or quantifying trends. Interpretivist approaches often favor qualitative research methods like interviews, observations, and document analysis to capture rich, detailed perspectives. Smart city development is a complex and rapidly evolving concept. It involves not just technology, but how people interact with it, how it shapes urban life, and the power dynamics at play. This complexity demands an approach prioritizing deeper understanding rather than just data. Smart city projects involve various stakeholders with potentially divergent viewpoints: citizens, governments, planners, tech companies, etc. An interpretivist approach can examine how these stakeholders construct the meaning of effective operations and how these views might conflict or

align. Moreover, implementing a smart city framework is a complex social process. Interpretivism can reveal unforeseen challenges, power imbalances, and how smart solutions are understood by those on the ground. Smart cities are deeply embedded in the unique social, political, and cultural context of each location. An interpretivist approach helps understand why frameworks successful in one city might need adaptations elsewhere.

3.3 Research Design

It refers to the conceptual framework that guides the researcher with instructions to go about their research. It is the research design that enables the researcher to be discrete and attentive in choosing the most compatible research methodology (Gonzales, 2018). Most importantly, it helps to carry on the investigation, ensuring that the entire scientific research process is legitimate, trustworthy, and able to provide valuable insights (Sunderlin, 2010). When scientific explorations are effective, they reduce the biases associated with data gathering, increasing confidence in the integrity of the data gathered through effective instruments and techniques. The objective of a research design is to choose a research procedure with a marginal amount of error (Pane, 2015). In other words, a research design refers to a plan that uses empirical data to carry out research and solve a research problem. There are numerous ways in which a researcher can answer a set of research questions. The aims and priorities of the researcher are important in deciding the apt research design (Garcés-Mascareñas, 2012). Additionally, what outcome a researcher wants to ensue from their research endeavor is also important in determining the research design.

There are different types of research designs, which are as follows:

1. **Experimental Research Design** - This research design is based on an effective set of norms that are utilized in experimental investigations. The set of rules and norms are developed so that the researcher can perform the research with two sets of factors in the most scientific way possible. The primary set of factors is known as constants and the secondary set of factors is known as variables (Miller et al., 2020). The whole research design is computed to determine the distinction between the first set of factors with the second set. When it comes to experimental research design, the researcher's ability to gather data is considered along with the information required. Nevertheless, this research design talks of informed evaluation (Hall, 2011). The experimental research design acts as

the foundation stone of the basis of the factual study. Whenever the researcher wishes to examine how each of the variables interacts with the given situation, event, or occurrence, an experimental research design is chosen. In scientific research, there are key variables: the independent variable and the dependent variable. It's the factor that the researcher deliberately changes or manipulates. This change is often done as the outcome the researcher observes. It is a factor that's expected to be influenced by the adjustments made to the dependent variable. Essentially, the researcher alters the independent variable and then carefully examines how this change affects the dependent variable. This allows them to see if there's a cause-and-effect relationship between the two (Barnes, 2019). The goal of this type of research is to investigate the causal connection involving multiple independent and dependent variables.

2. **Correlational Research Design -** When the research deals with multiple variables in one category, the investigation must be done in various degrees. Nevertheless, correlational research design is utilized to bring out the connections among the multiple variables (Seeram, 2019). Moreover, in this type of research design, no variables or factors are in direct control of the investigators or researchers. It is the intensity or the direction of the relationships that involve any number of variables that are reflected in a correlation (Lau, 2017). A correlational research design can be positive or negative, and it is a completely non-experimental type of quantitative research design. This research design focuses on the research setting and trying to understand the connection between the independent variables and dependent variables (Devi et al., 2023). The relationship between the variables must be measured through statistical methods without any form of influence from the so-called extraneous variables. It is essential to differentiate between categorical data and numerical data, especially in statistical analysis. Moreover, independent and dependent variables cannot be manipulated by the researcher with the assistance of the scientific methodology (Rexhaj et al., 2013). The correlational research design merely focuses on researching and analyzing historical data and observing the events, occurrences, and situations that have happened in the past. Researchers use correlational research design to spot the patterns and trends between two variables.

3. **Exploratory Research Design -** This research design focuses on exploring research questions. This method makes sure that in-depth responses have never been evaluated previously (Burton, 1979). The exploratory research design has its advantages, especially when the researcher gets to dig for additional information in detail during the investigation (Goeman & Solari, 2011). This research method can further examine the perceptions and motives along with deep, open-minded responses that have never been researched before and so bring out unanticipated consequences (Franklin, 2005). This type of research can be verified by other members of the research study, such as the supervisor, and is usually adaptable; also, the research has an overall very low cost for the investigation (Franklin, 2005). Exploratory research designs are many times primary in nature and usually inclined towards a qualitative research approach. In case of a large amount of data, this research can be quantitative. It is also known as the grounded theory approach or interpretative research approach due to its flexibility and open-mindedness in its nature of research (Waters, 2007).

4. **Descriptive Research Design -** This research design talks about descriptive experimentations and investigations that involve individuals, events, and occasions that are observed in their existing reality. The researcher explains the data set of variables without changing any of the factors that exist. It is the only model that considers examining a single factor. This is the method of investigation in which the subject is monitored and investigated without influencing them in any manner. This type of research study aims to accurately represent the subjects without any external forces and further, it characterizes the study subjects discreetly (Morawski, 2016). Most importantly, the researcher can apply the research to a much broader sample just because they are using a descriptive research approach.

5. **Case-Study Research Design -** This research design focuses on empirical research, which depends upon data-gathering techniques and utilizing the research procedure to examine the data gathered in their current occurrence (Gerring, 2004). The current occurrence should be unbiased and in its actual setting without an external influence. The investigator will examine the data collected without causing any involvement with the current

occurrence. These types of design are common in the scientific exploration of social sciences (Breslin & Buchanan, 2008). It is much more qualitative and explores the depth of the data gathered in their current occurrences. Most importantly, the cases are bound by time and activity. The researcher collects detailed information by a variety of data collection methods. The case study research design has five components, specifically, the research questions, the propositions, the units that would be used in the analysis, and lastly the determination to connect the propositions with the data analysis (Ridder, 2012).

6. **Cross-Sectional Research Design -** when it comes to defining the connections between broader components and situations, it is done through cross-sectional research design. This type of research design does not concentrate on the individual cases and their peculiarities, rather it more than ever concentrates on several occurrences and cases (Lebo & Weber, 2015). The generic models are developed from a cross-sectional research design. These generic models should be within certain circumstances that relate to a group of factors with other elements (Rindfleisch et al., 2008).

7. **Comparative Research Design -** When it comes to comparative research design it exclusively distinguishes two specific population groups to reach a particular resolution. The researcher tries to compare the similarities and differences between the two population groups and further pinpoint them (Esser & Vliegenthart, 2017). Furthermore, researchers frequently conduct multinational investigations that contrast two distinguishable population groups. Comparative research helps in bridge the gaps between different communities and cultures. This study further lays the groundwork for cooperation and compromise in the investigation (van der Lippe & van Dijk, 2002).

8. **Longitudinal Research Design -** When it comes to looking at the connected phenomena throughout time, the longitudinal research design defines it in its scientific explorations. The examination of these phenomena highlights alterations over time. The purpose of the longitudinal research design is to permit or enhance the reliability of findings (Cockcroft et al., 2019). These findings from the population are sometimes not feasible to reach in the

cross-sectional research design study. It also helps make assertions based on untenable reasons when looking at a single moment in time (Banati, 2021).

9. **Diagnostic Research Design** - When it comes to diagnostic research design, the endeavor is to find the cause of the problem and to suggest the best solution possible. Moreover, it is frequently utilized in academic research, especially in medical science. It helps in pinpointing the problem regions and the possible areas of improvement. A problem is precisely identified and scrutinized through diagnostic research such that a potential solution can be reached. Most importantly this form of research is utilized to comprehend the root cause of the problem. And further guide the path to solving them (M. Moons & Grobbee, 2002).

The above study will adopt an exploratory design mainly because smart cities are a relatively new concept. While the vision is becoming clearer, cities worldwide are experimenting with different technologies, implementation methods, and governance models. There's limited pre-existing knowledge about the framework of the most effective operations and management tactics specifically tailored for this complex domain. An exploratory design allows for flexibility when concrete, tested practices are few. Smart cities are designed to address local challenges and capitalize on unique local advantages. Strategies that work well in a European city might not translate directly to an Asian or North American city. An exploratory approach helps to uncover the interplay between operations frameworks, management, and the specific needs and resources of different municipalities. It emphasizes understanding how factors like social structure, political climate, and technological literacy shape successful implementation. Moreover, smart cities require collaboration across various domains: urban planning, technology, policy, social sciences, and more.

An exploratory design welcomes contributions from diverse fields of expertise. It encourages gathering perspectives that might not fit into a rigid, pre-defined research structure. This openness helps reveal how different disciplines can inform and improve a city's operational framework. An exploratory approach aims to go beyond merely describing a situation — it strives to uncover the *why* behind successes and failures. By examining a range of smart city initiatives, researchers can

identify the key principles, management approaches, and organizational structures that promote efficiency, sustainability, and better quality of life within the context of smart infrastructure development. Exploratory research prioritizes openness to what emerges during the study. This means unexpected factors or relationships might be revealed. The topic is ideally suited for an exploratory research approach because it deals with a field of study that is still developing, highly dependent on unique contexts, demands contributions from multiple fields, prioritizes finding what works in practice, and values the discovery of novel insights along the way.

3.4 Research Approach or Strategy

Whenever one talks about the research strategy, we consider the framework that is applied to carry out the research study. The whole framework entails laying out the research study and the procedures at the forefront to ensure that the data is collected and correct analysis is done (Goytia, 2013). The research strategy is applied to carry out data analysis, which aims to address the research questions or solve the purpose of testing the hypothesis. When it comes to choosing the right research strategy, the researcher should specifically choose a discretely defined study topic or subject for constructing the investigation such that he/ she can adhere to a properly constructed and thoroughly planned data collection process (Kaufman, 2000). Furthermore, the strategy includes accessing and comprehending the findings and data analysis. A research strategy is necessary to explore, evaluate, examine, analyze, and comprehend the occurrences of the research study (Roelfsema, 2022). There are two types of research strategies: qualitative and quantitative. In most research studies these two research approaches are considered fundamental techniques that are useful and taken for granted by various academics (Meyer & Farrell, 1998). Moreover, the distinction between qualitative and quantitative strategies is based on the choice of researchers for carrying out studies, especially in the subjects of social sciences.

Additionally, these distinctions are valuable for the researchers to carry out the research study in an insightful manner (Ramchand, 2014). There has always been debate about the choice of the right research approach or strategy for scientific exploration, whether to select a qualitative research approach or a quantitative research approach. In the 21st Century, there has been a rise in demand for research studies that choose both approaches — studies in which a mixed research approach is used. The researcher must confirm the research objectives and the type of research

data that would be required to specifically explore the research questions before a research approach is selected (Golder et al., 2007).

There are three types of research strategies or approaches, which are as follows:

1. **Qualitative Research Approach** - This research method specifically considers responses, codes, and themes in the place of numerical data and statistical evaluation. The goal of this research approach is to comprehend a particular facet of the study that considers social existence (Atkinson, 2017). A qualitative research approach considers the responses of the participants and seeks to comprehend the root causes of a particular research topic/ question through their experiences and perspectives (Stickler & Hampel, 2015). As a result, it is the honesty, personality, and intentions of the researcher that is essential when carrying out qualitative research. However, in a quantitative research approach, these aspects are not that important. As a result, the quality and perspective of the raw data collected in qualitative research are extremely crucial (Reeves et al., 2008a). However, qualitative research is rather an inductive process in terms of categorizing the data and determining the correlations between different categories. This type of research is an umbrella term that is used to cover a wide spectrum of various approaches and procedures (Stickler & Hampel, 2015). This spectrum of research varies a great deal in terms of attention, premises concerning the type of information that is available, and the function of the researcher. The goal of qualitative studies is to gain knowledge about the "how" and "why" of a particular phenomenon (Reeves et al., 2008b).

2. **Quantitative Research Approach** - When it comes to the quantitative research approach, the researcher considers numbers and statistics to measure the research topic, especially among a given set of populations. Quantitative approaches always make sure the usage of statistics is in a quantifiable way. The approach helps the researcher to describe an event numerically or statistically to further analyze it for an outcome (Babones, 2016). It also helps the researcher to quantifiably describe the events that assist in identifying the correlations among multiple variables. When it comes to political and social psychology, statistics is the foundation of many scientific investigations. It also enables the investigators to make subtle connections with whatever is happening around them. The quantitative

research approach makes the researcher aware of their surroundings. More precisely, a quantitative investigation is all about using predetermined responses to organized inquiries. The alternative responses are rather dependent on the sizable sample of respondents. As discussed above, the quantitative research approach or strategy includes gathered data, which is a numerical value and can be further analyzed using several statistical tools and numerical calculations. A quantitative investigator gathers data from various sources such as surveys, questionnaires, and more ways (Barroga & Matanguihan, 2022).

3. **Mixed Research Approach -** The mixed research approach considers both quantitative and qualitative research approaches in a single research study or program of inquiry (Kim, 2019). When a mixed research approach is followed, the scholar gathers, collects, and analyzes the data. The scholar further integrates the findings from the data and draws inferences through the application of quantitative and qualitative approaches (Venkatesh et al., 2013). More precisely, the investigators have been searching for an approach that involves both quantitative and qualitative approaches. This creates a concurrent set of techniques that are used in a single study. The capacity of pragmatism can help researchers choose the right methodology and further triumph over other research methodologies (Johnson & Onwuegbuzie, 2004). Additionally, there might be a philosophical underpinning for a mixed-study design. The best part of choosing a mixed approach is that it will provide the investigators with all available options (Lingard et al., 2008).

The study will adopt a qualitative research approach because smart cities are inherently complex systems. They encompass multiple domains like technology, infrastructure, governance, and social systems. A qualitative approach is well-suited for exploring the layered interrelationships within such complex systems, where simple quantifiable data may reveal only some of the picture. The research aims to examine the applicability of operations frameworks. This focuses on understanding the processes, mechanisms, and reasons behind the success or failure of certain frameworks in a smart city context. A qualitative questionnaire is essential for examining the applicability of effective operations frameworks and management in smart city development for in-depth understanding as qualitative research delves into the questions like why and how of the issue. It goes beyond the surface-level data and further allows for a deeper understanding of the

experiences, perceptions, and opinions of various stakeholders who are involved in smart city projects which includes city planners, technology providers, and residents. It also involves the exploration of complex issues such as smart city development is a complex endeavor involving which involves technology, infrastructure, governance, and societal considerations. Qualitative research considers the specific context of each smart city initiative. This is a crucial contextualization that considers and works in one city that may not apply to another due to differences in cultural, political, or economic factors. Qualitative data helps tailor strategies to the unique needs and circumstances of each location.

It involves the identification of challenges and opportunities as qualitative questionnaires can reveal unforeseen challenges and opportunities which are related to the implementation of operational frameworks and management practices. Most importantly flexibility and adaptability involve qualitative research to be flexible as it allows adjustments in the research design based on several emerging insights. This adaptability is particularly crucial in the rapidly evolving field of smart city development, where new technologies, and significant approaches which are constantly emerging. Qualitative questionnaires can go on to generate rich data in the form of different narratives, observations, and quotes. This data provides a complex understanding of the issues at hand and can be used to develop more effective policies and practices. Qualitative questionnaires further involve stakeholders in the research process, stakeholders in the research process giving them a steady voice and making them feel heard. This engagement can foster a sense of ownership and collaboration, which are essential for the successful implementation of smart city projects. Overall, qualitative research is invaluable for understanding the complex and varied nature of smart city development. It further provides a rich and diverse understanding of the challenges with opportunities involved and helps to inform effective strategies for operational frameworks and management practices.

Qualitative research enables deep exploration of these *how* and *why* questions through methods like interviews and observations (Jamshed, 2014). Effective operations in smart cities involve diverse stakeholders: policymakers, technology providers, urban planners, and citizens. Qualitative methods, like interviews and focus groups, can gather the different perspectives and experiences of these stakeholders. This provides a holistic understanding of the challenges and

opportunities involved in operationalizing smart city frameworks. The success of an operations framework likely depends on the specific context of a smart city — its unique culture, political landscape, and existing infrastructure. Qualitative research, through case studies and observations, allows researchers to delve into these contextual factors that influence the effectiveness of a framework. Smart cities are a relatively new concept with constantly evolving technologies and management practices. Qualitative research provides flexibility in uncovering unexpected themes, patterns, and insights that may not be apparent through predetermined quantitative measures (Jamshed, 2014). These insights can be crucial for refining the existing frameworks or developing new ones tailored to the dynamic nature of smart cities. While quantitative data might offer insights into performance metrics of smart city operations, its qualitative research can offer a rich understanding of the processes, experiences, and contextual factors critical for truly effective management and operations within smart cities.

3.5 Reasoning Approaches

The way we use the knowledge we already must reach new conclusions, figure out what might happen next, or explain why things work the way they do is known as the reasoning approach. There are different ways to go about this reasoning process, and three common approaches are called deductive, inductive, and abductive. With deductive reasoning, we start with a general rule or principle that we know is true (H. R. & Aithal, 2022). Then, we apply that rule to a specific situation to figure out what must also be true in the situation to figure out what must also be true in that situation. It's like working from the top down — a big idea to a specific conclusion. Inductive reasoning is a bit like working in reverse. Here, we gather specific observations or pieces of evidence, and we try to spot patterns in them. From those patterns, we attempt to develop a broader rule or theory. Finally, abductive reasoning is a bit more focused on finding the best explanation.

1. **Inductive Reasoning** - It is a way of thinking that draws broader conclusions from a collection of observations, experiences, or facts. Rather than relying on a fixed set of rules, it uses patterns found within existing knowledge or past examples to make judgments about a situation (Shin, 2019). A key strength of inductive reasoning is its ability to generate possibilities — some of these may ultimately be untrue, but the process offers a range of

potential outcomes. This type of reasoning is essential because it allows us to start forming ideas and perceptions, even if they need further refinement. Inductive methods begin with a specific observation or idea and encourage us to investigate if it holds under wider circumstances. As we gather more observations, we start to build a clearer picture of the validity of our initial conclusion.

2. **Deductive Reasoning -** It starts with a hypothesis or general statement that is assumed to be true. From this starting point, it follows a path of logical steps to reach a specific conclusion. It's about taking that initial assumption and figuring out what else must logically be true if the starting point holds (Shin, 2019).

The present study will consider an inductive reasoning approach because smart cities are a relatively new and evolving concept. An inductive approach allows research to start with observations and real-world cases to build understanding. The topic aims to examine the *applicability* of operations and management frameworks. This implies looking at multiple smart city implementations, identifying patterns in what works well, and what doesn't, and then drawing broader conclusions about effective practices. The goal isn't necessarily to test a pre-existing theory about smart city operations. Instead, the inductive approach allows the researcher to observe case studies and potentially generate new theories or refine existing ones based on those observations. Moreover, smart cities involve complex interactions between technology, infrastructure, governance, and human behavior. Inductive reasoning is well-suited for handling complex systems where a multitude of factors might be at play. An inductive approach allows for flexibility in exploring a less rigidly defined field like smart cities. The researcher can start with specific observations and case studies, identify patterns and trends, and eventually build more generalized insights into effective operations and management for this unique context.

3.6 Population and Data Collection

The population selected for the research is known as the research population or the target population. The researcher has drawn data from a large population sample. Further insights are added to the collected data, which is then evaluated and analyzed. This collection of data involves individuals, incidents, events, or occasions that the scholar is interested in. However, the identified

subjects (the groups or events from which data is drawn) are selected based on select criteria which are identified using definitions and characteristics. The research population or target population, drawn from a large population, is used as the sample for data collection. This data is later utilized and analyzed for research. The study aims to comprehend the qualities and features of the target population and helps to define the population under scrutiny (Gill, 2007).

Data collection is done by every member of the target population. It is also vital to understand the circumstances in which data is collected from the target population. A small part of the target population is used as the sample population for the study. (Bauer, 2014).

The primary target populations are urban planners, city administrators, government officials, policymakers, researchers, and academics. The secondary target populations are consultants, NGOs, citizen groups, and the public.

The present study will make use of a primary data collection approach wherein data will be collected through a qualitative questionnaire instrument developed from standard scales. The reason behind considering the rationale which involves capturing perceptions and experiences, as standardized scales for comparability help in evaluating specific frameworks and addressing a nascent field. Effective operations within smart cities aren't just about technical metrics. Success depends on how well the frameworks are understood, adopted, and perceived by those involved – planners, administrators, technology providers, and even citizens. A qualitative questionnaire allows for gathering insights into the experiences, opinions, and attitudes of these key stakeholders. While qualitative data focuses on rich descriptions, using standard scales offers some benefits. These scales can help the researcher compare responses across different participants, identify patterns in perceptions, and potentially add a layer of quantitative analysis to the data. The topic focuses on the *applicability* of operations frameworks. Questionnaires can be tailored to target specific aspects of these frameworks, allowing respondents to rate their effectiveness, ease of implementation, and challenges encountered. This structured feedback provides more targeted insights than purely open-ended qualitative methods. Since smart cities are still relatively evolving, there might be limited pre-existing data sets on the effectiveness of specific operations frameworks

and their real-world implementation. Primary data collection fills this gap, allowing the researcher to gather fresh information tailored to their research questions.

3.7 Sampling

Sampling is the procedure through which small samples are collected from the target population for further research study. The sample units are drawn to understand their characteristics and features through a predetermined selection procedure. Sample points are the principal components of the sampling method (Shively, 2011). These describe the factors that determine the features and characteristic traits of the target population. In this case, the samples are the four-party models. Scientific exploration is dependent on the efficiency of drawing samples from the target population. In most cases, studying the entire target population can be exhaustive, time-consuming, and expensive (Nakkeeran, 2016). There is a potential issue with conventional sampling methods in research. They might overemphasize a specific group: those who are wealthy, well-educated, living in industrialized nations, and part of a democratic system. This can lead to conclusions that don't accurately reflect the experiences of the broader population. In such cases, samples are drawn from the population to get a generic idea about the whole population. Sometimes, the investigation becomes difficult in the case of the whole population, and the sampling procedure is taken into consideration (Abramzon, 2014). There are several insights that the scholar gains from testing and studying the samples. However, not all insights turn out to be specific; some of them can be over-generalized since they can be or must be avoided (Turner, 2019).

In such cases, these individuals are further over-sampled. To avoid such cases, the researcher or the whole community can avoid over-sampling by adopting a realistic strategy, which is done using suitable enticements (Elfil & Negida, 2017). The investigator should have clearly defined decisions that help in determining the sampling methodologies and help in documenting the impacts of the sampling methods on the validity of the research study (Sedgwick, 2015b).

There are two types of sampling methods which are described below:

1. **Probability Sampling** - When the researcher can calculate the probability of a single person selected from the selected population, it is called probability sampling. A single

person is selected for the research study, and the study is considered for further mathematical and statistical precision and analysis (Elliott & Valliant, 2017).

2. **Non-probability Sampling** - When the researcher cannot estimate and calculate the probability of a particular individual from the given research population, it is called non-probability sampling. The individuals who are selected for non-probability sampling usually give less accurate results and low precision in terms of comprehending the characteristics of the research population. As a result, these samples are inaccurate representations of the research or target population (Elliott & Valliant, 2017).

Using probability sampling, there are five types of sampling methods, which are mentioned below:

1. **Simple Random Sampling** - Simple random sampling is also known as SRS, when each participant has an equal probability of being chosen from the population for the research study. Each type of participant has the same type of characteristics and features when drawn from the same population type. Nowadays, researchers use computer programs to generate random samples from different sets. Since each participant has the same probability of being selected, the biases and the influences of the researcher do not come into play. The true potential of random sampling can be challenging because the researcher needs the identity of every single participant in the sample drawn (Noor et al., 2022).

2. **Stratified Sampling** - When a given distinct population is divided into different strata or groups, it is called stratified sampling. The word “stratified sampling” is a variation of random sampling. This method focuses on making the samples a much more discrete representation of the research population (Elfil & Negida, 2017). One single study may incorporate several samples to be randomly drawn from each stratum. Each stratum is the representative sample of the target population. Usually, stratification can be done based on age, gender, income, and profession.

3. **Systematic Random Sampling** - This sampling is all about creating subgroups from the main research population. However, this research population can be a reference list from which the researcher can choose the participants to be studied more accurately. Systematic random sampling is a much more organized sampling method than random sampling.

Moreover, bias can be easily eliminated from systematic random sampling. (Elfil & Negida, 2017).

4. **Cluster Sampling** – This sampling focuses on the division of the research population into several samples called clusters. It is the clusters that correlate to different geographical areas. The researcher chooses the clusters for a particular study. Additionally, each participant in a cluster takes part in the study. Cluster sampling is not like stratified sampling. Some of the clusters are not defined or represented in the final sample. However, the researcher used any participant from each stratum in a stratified sampling method (Sedgwick, 2014).

5. **Multistage Sampling** - This is a mixture of different sampling methods at different stages of the same study. This type of study is specifically popular with larger populations. In case of a large population size, where it is not possible to involve each participant in the study, the researcher uses cluster sampling to divide the population into groups. The groups are then divided into strata, and each stratum is used to draw random samples (Sedgwick, 2015a).

Under non-probability sampling, there are four types of sampling methods, which are mentioned below:

a. **Convenience Sampling** - This type of sampling method involves choosing random people for testing subjects. The samples are not under the control of the researcher. Sampling is done at the convenience of the researcher drawing sample units. Usually, these types of sampling are cost-effective and time efficient as the researcher can choose samples from anywhere as relatively as possible (Galloway, 2005).

b. **Purposive Sampling** - Purposive Sampling is a popular technique within qualitative research, as it helps researchers identify and select cases that offer rich and relevant insights into the phenomenon they are studying. This approach aligns better with the goals of implementation research and reflects recent shifts in quantitative methods. Therefore, a review focusing on the principles and practices of purposive sampling in implementation research is valuable. Such a review should offer an overview of the different types of

purposive sampling in implementation research (Campbell et al., 2020). Such a review should offer an overview of the different types of purposive sampling strategies, guiding when to use a single strategy versus a multistage approach, with an emphasis on their applications in state implementation research.

c. **Quota Sampling** – In quota sampling, the researcher chooses the samples from a group that has predefined traits. This procedure helps the researcher to collect specific samples that are distinguishable demographically (Futri et al., 2022).

d. **Judgmental Sampling -** When the chosen samples from specific groups or subjects are solely at the discretion of the researcher, it is called judgmental sampling. In this type of sampling, the researcher picks the individuals whom they find particularly positive for their research study. In judgmental sampling, the researcher asks questions to the participants and then chooses them from a population based on their perspective answers (Reddy, 2017).

e. **Snowball Sampling -** This type of sampling procedure is used by the researcher when data gathering becomes extremely difficult. It is difficult to gather this sample group based on the survey method. For this sampling to be done, the researcher must ask a set of questions to the test subjects. The test subjects will be contacted and nominated to take part in the study. Significantly, snowball sampling is effective in gathering sampling subjects, but the factors determining the test groups are difficult to control (Browne, 2005).

The present study is going to consider non-probability sampling and further will consider Purposive Sampling. This is likely the most common approach for this topic. The researcher would handpick participants based on their specific roles, expertise, and involvement in smart city initiatives. The researcher will consider focusing on individuals with deep knowledge of smart city operations, technology, or policy. The researcher selects participants representing common roles in smart city development, ensuring a diverse range of stakeholder perspectives.

3.8 Data Gathering/Creation, instruments, and Techniques

The study collected primary and secondary data to collect insights into the area of research. Data gathering allows the investigation to be addressed specifically during the key phases of scientific exploration. The collection of data is the method of getting information from the area of study which is the aim of the research study. A target population is selected from which data is collected, and further samples are drawn for further study. Different types of data collection techniques correspond to different types of data (Heaton, 2008). Further, the study utilized the survey method to carry out the collection of data. The survey method is defined as the method of primary data collection based on communication with a representative sample of individuals. The survey method is the method that is used to collect samples to be utilized to collect quantitative data (Kabwe, 2018). The data can be analyzed statistically because it allows for the accumulation of data from a large set of respondents. It provides a standard set of questions and responses which is much more objective.

The study will use primary data collection wherein a qualitative interview instrument will be employed to acquire data from 15 members. In the case of primary data, the data instrument to be used is a Structured and Pretested Questionnaire that will gather the necessary and important as well as relevant data from the respondents. Nevertheless, secondary data was to be collected using journals, theses, blogs, articles, books, websites, conferences, and various types of proceedings. In the primary data collection, the scholar will use a Qualitative Questionnaire which is a universal tool for evaluating beliefs and points of view.

3.9 Data Analysis tools and techniques

Data analysis is the process of cleaning, processing, and raw data such that it can be used for extracting the relevant information, which is actionable and useful for scholars. This data helps the scholars in making informed decisions in their research study. The process of data analysis provides useful insights into data that are frequently displayed in the form of charts, graphs, graphics, and tables, which lessen the perceived risk associated with decision-making (Ali & Bhaskar, 2016). It is the type of data that the scholars are dealing with that helps them choose the perspective data analysis method. There should be different data analysis methods depending on

whether it is quantitative data or qualitative data (Monte-Mór, 2020). The three types of significant programs that are used to analyze quantitative data are SPSS, Access, and Excel. SPSS is the short form for Statistical Package for Social Sciences. These programs let academics compute quantitative data more efficiently through the utilization of these programs. SPSS is used for various types of statistical data analysis, especially for collecting, evaluating, visualizing, and modeling the data that is extracted and examined. SPSS, being the tool from IBM, was the first software introduced in 1968. The primary purpose of this software is to analyze data using statistical evaluation. This program always uses the data effectively for processing the data, charting them, and finally directly marketing them. The IBM SPSS has a simply instructed language program, which is like English and helps the researcher to navigate the flow.

The data analysis will consider the process of manual thematic analysis. Thematic analysis is a method used to analyze qualitative data. It involves carefully reading materials like transcripts from interviews or focus groups to find recurring patterns of meaning. These patterns then form the basis of broader themes within the data. Unlike purely objective analysis, thematic analysis recognizes that the researcher's experiences and interpretations play an important role in identifying these patterns. It's a process that requires active reflection and allows the researcher to bring their insights into shaping the understanding of the data. Thematic analysis is a well-suited methodology for exploring interview transcripts in qualitative research. Its strength lies in identifying recurring patterns and themes within the data, offering valuable insights into the participants' experiences and perspectives. By carefully examining the transcripts, researchers can uncover underlying meanings and connections, contributing to a deeper understanding of the research topic. Moreover, the qualitative nature of this approach, incorporating qualitative tools would be inappropriate and unnecessary. The qualitative nature of this approach incorporates the quantitative tools that would be inappropriate and unnecessary. Quantitative methods rely on numerical data and statistical analysis, which are not applicable when dealing with the rich and complex data obtained from interviews. Thematic analysis focuses on the qualitative aspects, emphasizing the interpretation and contextualization of the data. Therefore, when taken into consideration, it is essential to adhere to the chosen methodology and avoid any attempts to integrate quantitative tools into the analysis. By doing so, researchers can maintain the integrity and rigor of their qualitative research, ensuring that the findings accurately reflect the qualitative nature of the data and contribute meaningfully to the broader body of knowledge.

3.10 Ethical Considerations

It is the motto of every researcher to maintain ethics and uphold the rules and norms throughout the research study. The standards are met by the researcher by maintaining ethics in qualified research (Organization, 2020). The norms, ethics, and rules are adhered to by the researcher throughout the research study which must be conducted following a rigid system. Usually, ethics and norms instruct and govern the researcher to earn the platform for carrying out qualified research studies. Moreover, the ethical code and the conduction of quality research are tightly intermingled (Organization, 2020); they are conjunct to carry out a successful research study.

Before sending the questionnaires, the permission of participants will be taken and ensured regarding the confidentiality of their responses and personal data. The data and information collected from selected participants will only apply for academic purposes and not for any personal application. The age group of the respondents will be 20 to 60, which leads to including from younger users to the older. Experiences from every age group are going to be collected. Therefore, this research tends to have a large significance by analyzing the data acquired from the selected population.

Chapter 4: Results and Discussion

4.1 Introduction

The primary aim of the study is to examine the applicability of effective operations framework and management in smart city movement and infrastructure development. To accomplish this research aim, the study conducted a qualitative study based on semi-structured interviews (n=19) and the data collected was analyzed using thematic analysis. By employing thematic analysis on the collected data, patterns and trends that stakeholders have towards and with their smart city projects have been determined; thus, improving the understanding on how operational frameworks and management structures can be fashioned to enhance the expressions of smart cities. This chapter of the results and discussion is subdivided into two main sections. The results and discussion section address the five main objectives. Firstly, it analyses the need for an effective operations management framework in smart cities. This is followed by identifying factors affecting data collection and management in smart cities. Further, the study explores the role played by the current operations management framework in meeting multidimensional needs (Efficiency, Sustainability, and social security). This is followed by the examination of the applicability, advantages, and limitations of different operations management frameworks in decision-making for smart city operations and extending them based on the current scenario. Finally, the study suggests strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities.

Further, here the study findings obtained are compared with those of the previous research scholars. The next segment of conclusions provides a glimpse of the entire chapter and shows the major research findings.

Smart cities are metropolitan regions designed to improve the quality of life for their residents by utilizing the most recent technological advancements in conjunction with data-driven strategies and procedures. For data management, several tools are combined, such as blockchain and the Internet of Things. The method of decision-making for smart city projects involves the application of multifaceted techniques, unified techniques, mathematical programming, and artificial

intelligence. It has been observed that making decisions based on a number of factors is not predictive, even though it makes it easier to evaluate options collectively depending on several factors. Smart cities are predicated on the use of Internet of Things apps and other technologies to encourage the effective execution of municipal infrastructure, improve responsiveness and dependability, lower costs, and drive creativity in the urban setting. The subject of smart cities has seen the emergence of multiple uses across the communication, facilities, and service sectors. In order to improve coordination, decision-making, and responsiveness in smart city planning, it is important to establish effective coordination procedures, data-driven choices, and involvement of stakeholders. Many participants specifically suggested establishing a single platform for data integration, promoting cross-functional collaboration, and utilizing data analytics for making informed decisions. They also underlined how important it is to have ongoing community input to ensure that the planning process meets public expectations.

4.2 Demographics of the Participants

Although indicative percentages are occasionally used to describe patterns across interviews, these are based on a small qualitative sample (n = 19) and are intended only to convey relative emphasis.

Table 1: Demographics of the Participants

Participants	Age	Gender	Educational Qualification	Current Occupation	Years of Professional Experience	Sector of Employment	Sector/Project Type
Participant 1	61 and above	Male	Postgraduate	President / City Management	More than 20 years	Private Sector	Smart City Projects
Participant 2	41-50	Male	Graduate	Electrical Power management professional	More than 20 years	Private Sector	Infrastructure Projects
Participant 3	51-60	Male	Graduate	Consultant	More than 20 years	Private Sector	Infrastructure Projects

Participant 4	61 and above	Male	High School or Equivalent	Retired bank employee	More than 20 years	Public Sector	Rural entrepreneurs
Participant 5	31-40	Male	Postgraduate	IT professional	11-15 years	Private Sector	Technology Integration Projects
Participant 6	41-50	Male	Postgraduate	Civil Engineer	More than 20 years	Private Sector	Urban Development Projects
Participant 7	61 and above	Male	Postgraduate	Consultant	More than 20 years	Private Sector	Coaching and Audits
Participant 8	51-60	Male	Doctorate or Equivalent	Researcher/Academic	More than 20 years	Academia	currently guiding UG and PG projects
Participant 9	51-60	Male	Postgraduate	Civil Engineer	More than 20 years	Private Sector	Infrastructure Projects
Participant 10	61 and above	Male	Postgraduate	Facility Manager	More than 20 years	all of the above	Cross-sector experience
Participant 11	41-50	Male	Postgraduate	Biotechnologist	More than 20 years	Private Sector	Technology Integration Projects
Participant 12	51-60	Male	Postgraduate	IT professional	More than 20 years	Private Sector	Technology Integration Projects
Participant 13	51-60	Male	Postgraduate	Consultant	More than 20 years	Private Sector	Urban Development Projects
Participant 14	51-60	Male	Postgraduate	Consultant	More than 20 years	Private Sector	All the Above projects

Participant 15	41-50	Male	Postgraduate	Facilities Management	More than 20 years	Private Sector	Urban Development Projects
Participant 16	41-50	Male	Postgraduate	Service	More than 20 years	Private Sector	Environmental Projects
Participant 17	41-50	Male	Postgraduate	Urban Planner	More than 20 years	Private Sector	Urban Development Projects
Participant 18	61 and above	Male	Postgraduate	Multiple Roles	More than 20 years	Public Sector	Urban Development Projects
Participant 19	31-40	Female	Postgraduate	IT professional	15-20 years	Public Sector	Technology Integration Projects

The demographic analysis of the participants reveals a highly experienced and predominantly male group, with a strong representation from the private sector. The age distribution shows that most participants fall within the 41-50 (31.6%) and 51-60 (31.6%) age brackets, while 26.3% are aged 61 and above, and only 10.5% are in the 31-40 category.

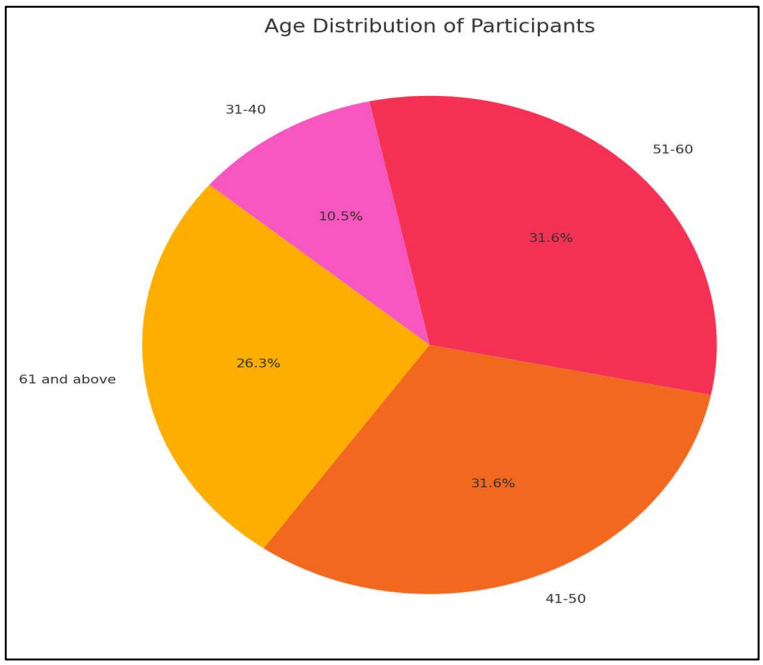

Figure 4: Age Distribution of Participants

Gender representation is significantly skewed, with 94.7% of participants being male and only one female participant (5.3%).

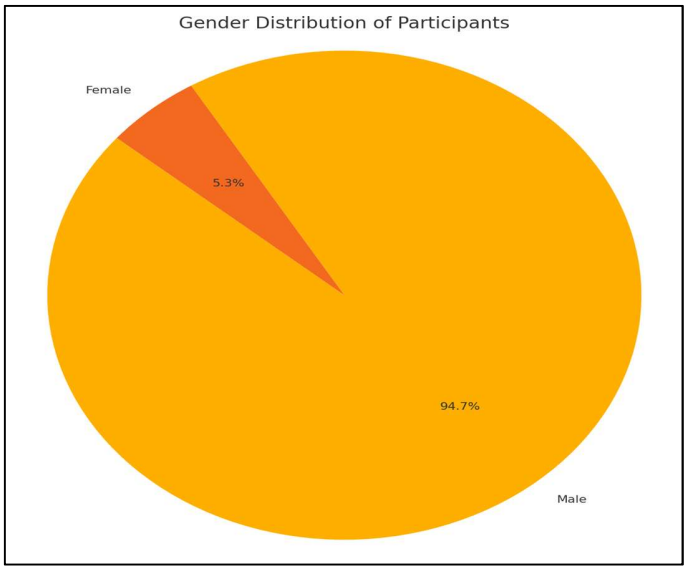

Figure 5: Gender Distribution of Participants

In terms of educational qualifications, most participants (68.4%) hold postgraduate degrees, while only 10.5% have a graduate-level education. There is also one participant with a doctorate (5.3%) and one with only a high school or equivalent qualification (5.3%). This indicates a highly educated sample, with advanced academic backgrounds being the norm.

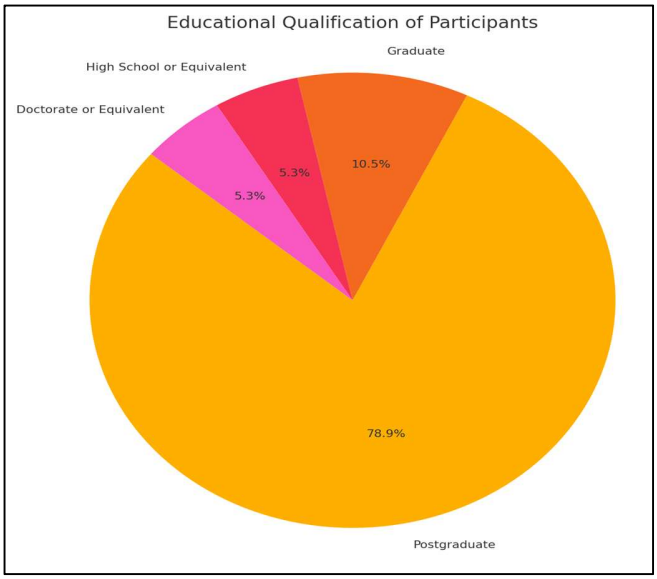

Figure 6: Educational Qualification of Participants

Regarding professional experience, nearly 90% of the participants have over 20 years of experience in their respective fields, highlighting an exceptionally seasoned group.

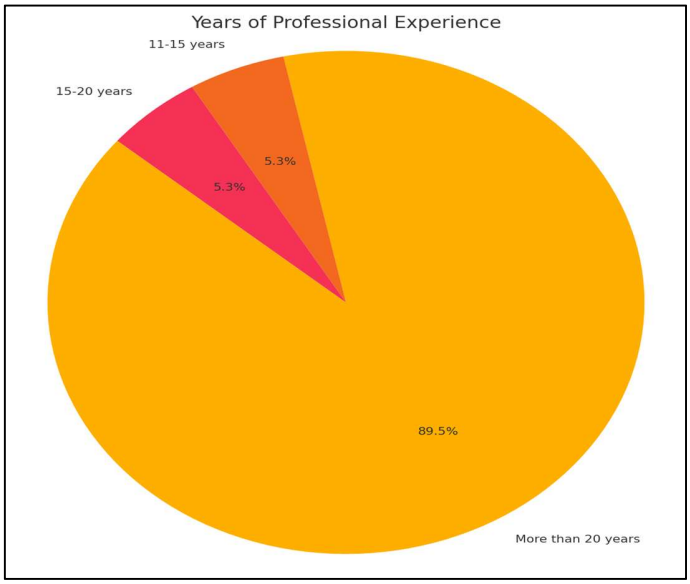

Figure 7: Years of Professional Experience of Participants

Sector-wise, the private sector dominates, employing 73.7% of the participants, whereas 15.8% work in the public sector, 5.3% in academia, and one participant engages across all sectors. The nature of projects participants is involved in reflects a strong focus on urban development (26.3%) and technology integration (21.1%), followed by infrastructure projects (15.8%). Other areas of specialization include environmental projects, smart city projects, rural entrepreneurship, coaching and audits, and academic research.

Descriptive Comparison of Participants' Demographics

The demographic features of the people involved show that the sample consists of middle-aged and older professionals in large numbers. The highest age groups are 4150 years and 5160 years that constitute 31.6% and 31.6% of the respondents respectively, the highest age group (61 and above) comes next with 26.3 percent, and the lowest age group (3140) is 10.5 percent. The sample is predominantly male dominated with 94.7 percent male respondents and one female respondent. The group is well educated with most graduates having postgraduate level, there are very few with just school or doctorate level education. In terms of their professions, the respondents will be a wide mix of professions, the largest being consultants and IT professionals, but also civil engineers and specialists of different professions. The sample is highly experienced as almost 90% of the participants have more than 20 years of professional experience. Most respondents have work experience in the private sphere, with minor percentages in the public sphere and academia. Owing to its specialization in projects, urban development, technological integration, and infrastructure projects are the dominant ones, which implies that it is more oriented towards urban development, modernization, and digital transformation.

4.3 Results

Objective 1: To analyze the need for an effective operations management framework in smart cities

- **Elements crucial for developing an effective operations management framework in smart cities**

Most participants stressed the significance of strong governance, technological integration, and financial sustainability in creating an efficient operations management system for smart cities. This

is observed from the assertion given by Participant 1 who stated “Critical for Operations Management Framework -

1. Financial Sustainability - pacing capex with tight cashflow management, smooth and tight management of Utilities/services and receivables, good mix of revenues
2. Choosing Appropriate Technology, spend on technologies that improve quality, reliability, and speed of services and utility delivery, smooth cross-functional information flow, and reduce manpower
3. Proper design of SLAs and operations management processes & KRAs
4. Managing projects tightly within budget and timelines and putting them to use.”

According to interpretation of the comments, 40 per cent of the respondents brought up financial sustainability, making it one of the most often emphasized factors. Furthermore, according to 35% of participants, technological integration is crucial, especially when it comes to connectivity and digital execution strategies. About 30% of respondents said that leadership and governance were essential to the efficient operation of smart cities. Along with the necessity of cutting-edge technology like ubiquitous wireless connectivity and safe data management, several respondents emphasized components like managing finances, cost-benefit evaluation, and public-private collaborations. This is observed from the response given by Participant 2 who revealed, “Pervasive connectivity, the first essential element for smart cities

The first building block of any smart city application is reliable, pervasive wireless connectivity. Evolving low-power wide area network (LPWAN) technologies are well suited to smart city applications. Although many wireless technologies (LTE CatM, NB-IoT, LoRa, and the like) are contributing to the fabric of connected cities, the advent of 5G is expected to be a watershed event that propels smart city technology into the mainstream and accelerates new deployments”

The necessity of robust authentication and trust procedures in data sharing is highlighted by the noteworthy fact that approximately 5 of 19 respondents specifically named data security, transparency, and integrity as major concerns. The growth of human resources, data exchange, and citizen participation were also cited by several respondents as important considerations. While some participants doubted the necessity for "smart city" initiatives even though they were linked

to quantifiable performance results, others concentrated on problems like utility shifting, handling water supplies, and the requirement for thorough manuals for maintaining infrastructure. About 3 of 19 participants highlighted practical implementation problems relating to infrastructure, such as utility relocation and water supply issues.

A few respondents also emphasized the importance of compliance, safety precautions, and long-term planning for operational sustainability. This is observed from the response given by Participant 15 who revealed that,

1. Financial Management- Resource Allocation, Cost-benefit analysis, and Public-Private partnership.
2. Sustainability and Resilience- Impact on Environment, Disaster management, Withstand disruptions.
3. Governance and Leadership- Collaborative approach of Government-Private Sector-Citizens, Strong Leadership and Clear Vision.
4. Data Management and Analytics- Collection, Quality, and Security of the Data.
5. Citizen's engagement and Participation- Feedback mechanisms and Digital literacy.
6. Performance Measurement- KPI and monitoring.
7. Development of Human Resources.

According to the statistics, while fundamental concepts like governance and financial sustainability predominate in discussions, operational difficulties and risk-reduction tactics are also important issues that together influence the success of smart city frameworks altogether.

Furthermore participant 6 revealed that "It identifies six important aspects for developing smart cities: (1) information network and broadband, (2) digitization of planning management, (3) smart infrastructure, (4) convenience of public services, (5) modernizing industrial development, and (6) sophisticated social governance." On the other hand, Participant 9 highlighted the aspect of infrastructure and asserted that "Following are the elements where it's getting difficult.

1) Shifting of the water supply line and its adjoining connection. As already initial water supply lines are laid and there are adjoining connections given. Now it's getting very

difficult to identify land and lay new lines as well and we must restore initial and new connections also without disturbing society's routine. In short, Utility shifting i.e. Water supply, Electrical connection, Telephone line, etc. relocation is one of the challenges."

Below is the pie chart displaying the crucial elements for developing an effective operations management framework in smart cities. Each segment corresponds to a major theme, sized according to the number of specific sub-elements associated with it.

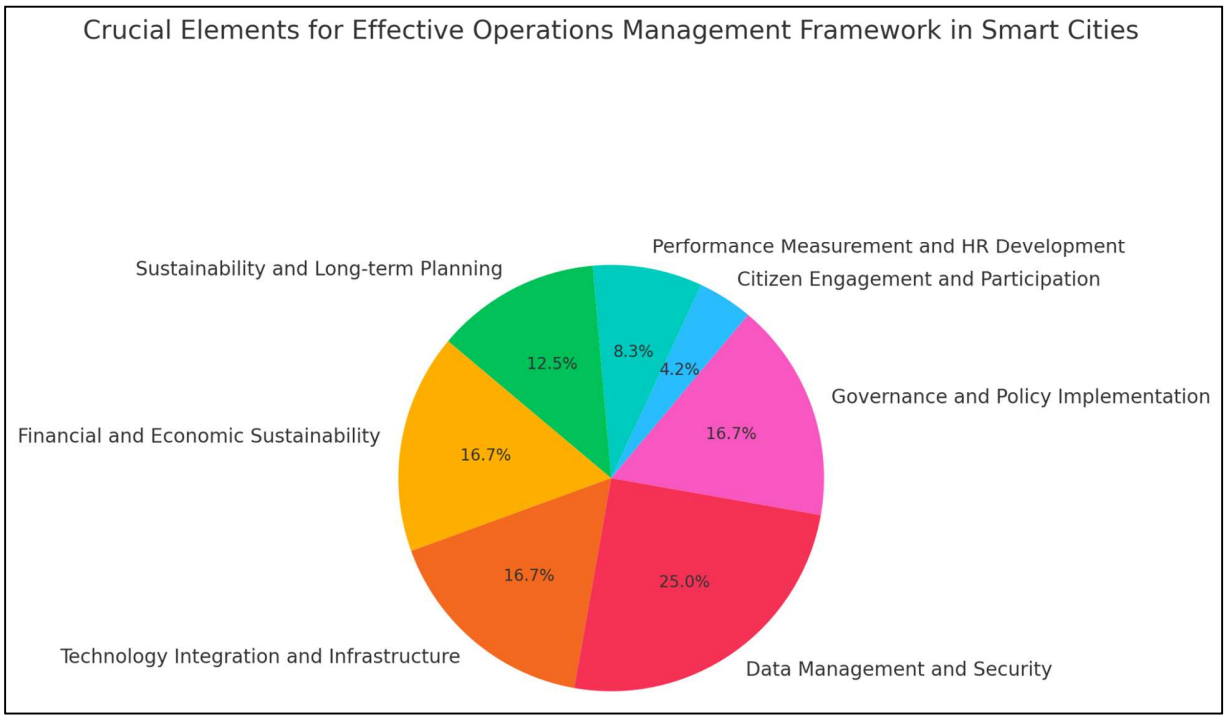

Figure 8: Crucial Elements for Developing an Effective Operations Management Framework in Smart Cities

The graph depicts that most of the respondents, that is, 5 of 19 participants believe that data management and security is a crucial element, followed by 3 of 19 participants who believe Governance and Policy implementation, Financial and Economic sustainability, and technology integration and infrastructure play a crucial role.

- **The current operations management framework in addressing the efficiency needs of smart cities**

Although the current framework for operations management in smart cities is only partially functional, it needs to be significantly improved to meet efficiency requirements. Although some cities have used ICT, public interaction platforms, and data-driven decision-making to improve operational efficiency, problems like limited funding, outdated infrastructure, and disjointed departmental coordination impede advancement. This can be observed from Participant 1's response, who stated "Partially. Some areas need to change, like unitizing data to drive cross-functional smooth coworking and efficiency. E. g. If the IoT system in the sewage pumping station has an outage at night, customer-facing / communication should automatically inform large users to hold sewage at their end and stop pumping to the network and parallel system to let the transport department arrange sewage tanker just in case there is an overflow." While Participant 10 revealed, "Unfortunately, I have seen more incongruency between what is possible and what is done." Based on the responses, 4 of the 19 respondents explicitly stated that the framework is ineffective, while only 2 of the 19 participants found it to be good or effective. A significant 3 of the 19 participants expressed uncertainty or had no idea, indicating a lack of awareness or engagement with the framework's effectiveness. Additionally, 5 out of 19 respondents highlighted key weaknesses such as poor anticipation, incongruence between plans and actions, and outdated public works and upkeep systems, emphasizing systemic inefficiencies. Continuous advancements are also required in fields like waste management, public safety, and transportation. Optimizing resources requires proactive maintenance, better public works management, and enhanced data analysis. This is evident from the response, given by Participant 15 who stated "The current OM framework is quite effective but there is always scope for improvement like Engagement with Citizens, Integration of Data, Skill development for better Human Resources, Improvements in Transportation, Public Safety and Waste Management and Performance Management"

Furthermore, 7 of the 19 respondents referenced the necessity for better data integration, automation, and cross-functional coordination, showing a strong demand for digital transformation in smart city operations. Examples like Singapore's Smart Nation initiative demonstrate potential, but many cities struggle with integrating new technologies and managing the gap between plans and actual execution.

Identically, Participant 14 highlighted that the current operations management framework in addressing the efficiency needs of smart cities is effective as revealed from the response, “The operations management framework needs continuous improvements in different elements incorporating different strategies needed for maintenance or reducing timelines. GIS system can accommodate original and revision in the operations management framework to review the need for such changes, the method statements for maintenance need to be modified accordingly.
For example, there are manually operated valves in pumping systems, and they pose problems in operation and maintenance in terms of reaching the spot conveying the valves at leveled ground and fixing them back. If they are replaced with power-operated valves, maintenance will be very easy to identify the actual valve and can be repaired faster.”

Below is the pie chart representing how different factors contribute to the effectiveness of the current operations management framework in smart cities. It highlights that Coordination & Planning has the most mentioned concerns, while Financial Constraints is less frequently addressed.

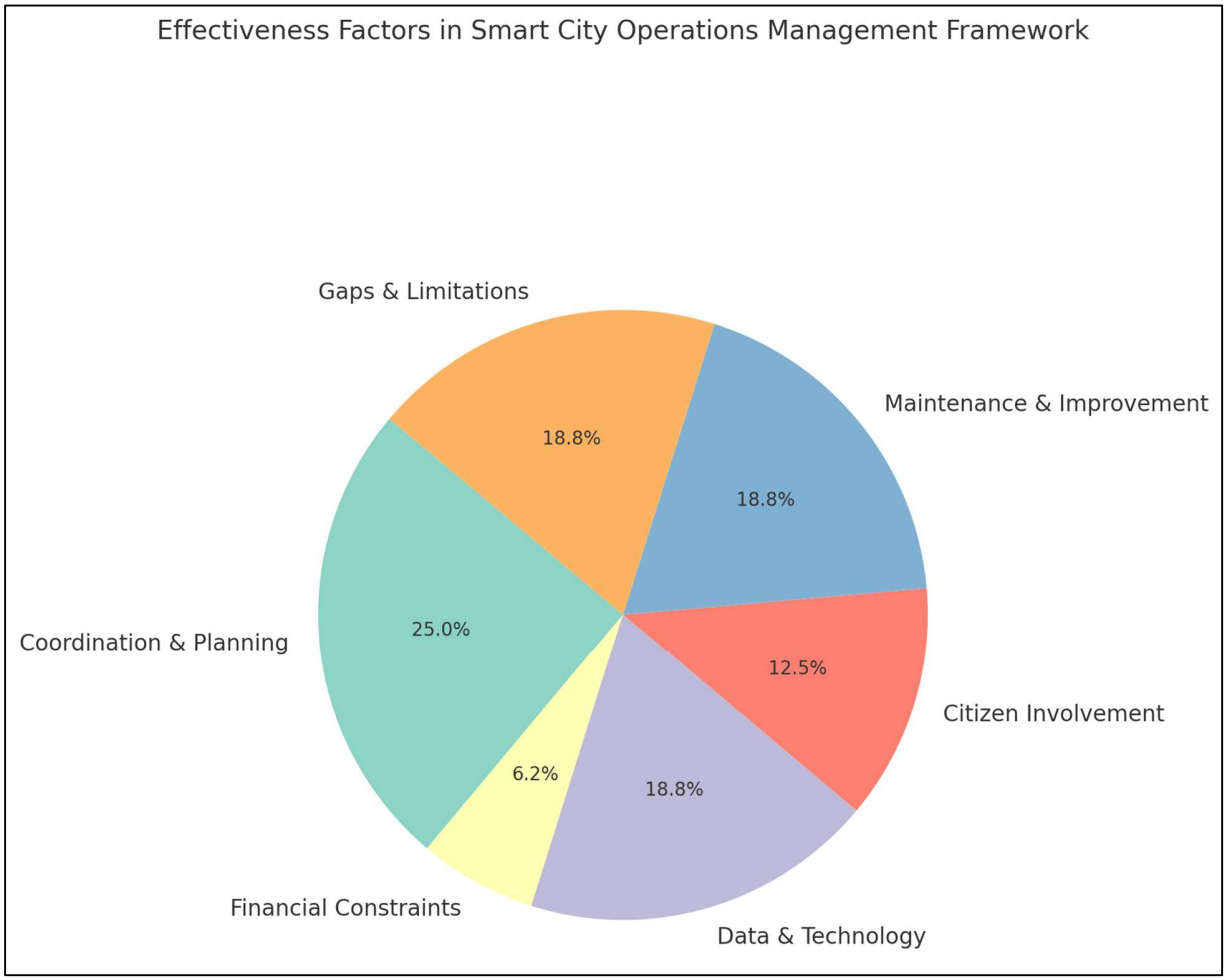

Figure 9: Effectiveness in Current Operations Management Framework

Concerning the Effectiveness in Current Operations Management Framework, 25 per cent suggested coordination and planning is necessary, while 4 of the 19 study participants revealed that gaps and limitation and maintenance and improvement.

Objective 2: To identify factors affecting data collection and management in smart cities

- **Types of data are most crucial for effective management of smart cities**

Real-time data on energy consumption, traffic, and air quality are the most important statistics for smart city management since they allow city officials to make informed decisions. Environmental information, infrastructural specifics, and sensor data from Internet of Things devices that track

public services and conditions are equally significant. This is evident from the statement given by Participant 1 who revealed,

1. Utility facilities and Network - STP, WTP, Power, Waste management facility, usage, outage, SCADA, billing, cost
2. Traffic data, Security and safety cameras, CCC
3 Assets conditions - Public places, Waste collection, street lighting, roads condition

3. Waste collection and processing.

From the responses, 9 of the 19 respondents highlighted real-time data as the most critical, emphasizing its role in immediate decision-making and adaptive urban management. Additionally, 6 of the 19 respondents stressed the importance of infrastructure and asset conditions, underlining the necessity of maintaining public utilities, roads, and buildings. Information on population, transportation, and government regulations is vital for urban planning, while historical and operational data help predict future needs and manage resources. This is evident from the statement given by Participant 3 who revealed "Historical Operations data, data analytics tools, skilled manpower resources" and Participant 4 who stated, "Government rules and regulations, local problems, and labor issues." Notably, 5 of the 19 respondents mentioned the significance of environmental and stormwater data, reflecting growing concerns over sustainability and climate resilience. Citizen feedback, maintenance data, and performance metrics further support optimization efforts, ensuring cities can anticipate challenges, maintain sustainability, and improve the quality of life for residents. Moreover, 39% of responses pointed to the need for comprehensive and clean data integration, suggesting that data accuracy and accessibility remain key challenges in smart city management.

- **The most effective methods for data collection in smart cities**

The respondents found that citizen feedback platforms that collect data through mobile apps and surveys, as well as the use of IoT sensors for real-time monitoring of infrastructure like water, power, and traffic systems, are the most efficient ways to collect data in smart cities. This is evident from the response of Participant 2 who revealed "Many data collection methods include IoT devices, surveillance cameras, mobile devices, social media platforms, open data platforms, and wearable devices. IoT devices, embedded in various objects, continuously collect and transmit

data. Additionally, Participant 6 also asserted, “IoT sensors are essential parts of smart city infrastructure, enabling real-time monitoring of the urban environment. Whether checking air quality, noise levels, energy consumption within buildings, water levels, or even the presence of wildlife, they collect data that powers smart cities.” Evaluation of the responses indicates that IoT sensors were mentioned in approximately 12 of the 19 study participants, making them the most frequently cited method, followed by citizen feedback mechanisms at 7 out of 19 respondents. Geospatial Mapping (GIS) and open data platforms are commonly used for spatial and public data analysis, while surveys and crowdsourcing are effective for gathering insights from local populations. The aspect of GIS is evident from the response of Participant 14 who affirmed, “The integrated GIS system is used for keeping all the data for infrastructure, utilities, and all plants, residential and commercial facilities, etc. The design and drawings can be put in the system with the as-built data with changes done in the original drawings also must find a place.

We can get all coordinates for carriageways along with the services utilities laid down in median, or dedicated ducts, joints in utilities, appurtenances on conveyance systems, crossings, depth at which utilities are laid, utilities laid one below other at different depths, integration of various utility and carriageway integration. It has helped in making statements compatible with the actual positions on the projects and can save tremendous time and reduce as far as possible damages to the utilities while excavation.” Approximately 30% of respondents highlighted the importance of GIS mapping, demonstrating its growing relevance in urban planning. Smart meters for energy and water usage, environmental monitoring stations for tracking air and water quality, and mobile devices for footfall data collection further enhance the ability to monitor and manage urban systems. Analytical methods such as descriptive statistics, correlation analysis, and machine learning were referenced by 2 of the 19 study participants, suggesting an emerging trend towards advanced data analytics in smart city governance. These methods, complemented by public-private partnerships and the integration of diverse data sources, enable cities to collect comprehensive data for informed decision-making.

Also, Participant 8 asserted that Real-time data, Growth data, Sensor data, Geospatial data, Citizen data, Transportation data, Economic data, public safety data and performance metrics. Below is the pie chart showing the distribution of effective data collection methods in smart cities,

categorized by themes. As shown, the majority fall under IoT/Sensor-Based and Citizen Engagement methods (that is 7 out of 19 respondents) while mapping and public data platforms make up smaller portions.

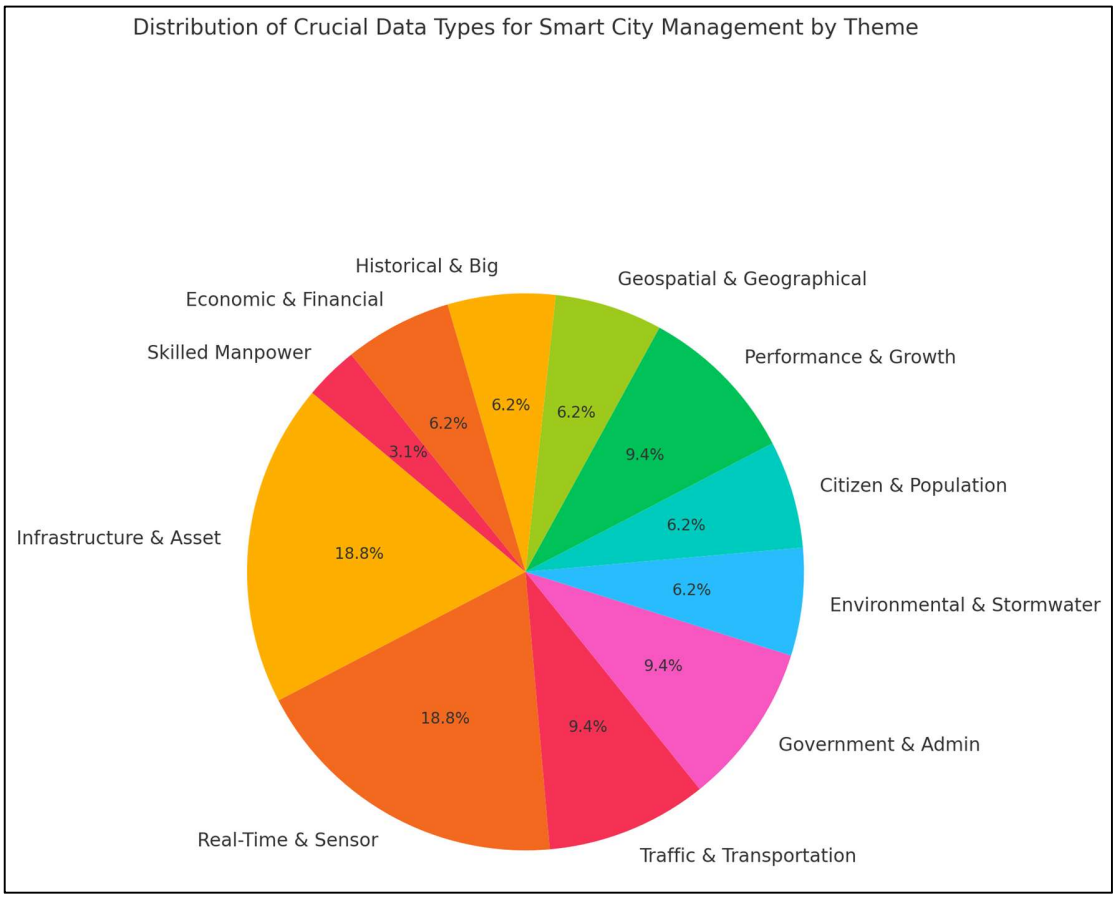

Figure 10: Effective Methods for Collection of Data in Smart Cities

Distribution of Crucial Data Types for Smart City Management depicts that 3 out of 19 respondents Real-time and sensor, 3 out of 19 respondents Infrastructure and Asset and 1 of the 19 study participants Traffic and Transportation and Performance and Growth. This pie chart shows the distribution of crucial data types needed for smart city management, categorized by themes. The largest portions are Infrastructure & Asset and Real-Time & Sensor data (that 3 out of 19 study participants), indicating their high importance, while areas like Skilled Manpower and Economic & Financial data are the least emphasized.

Objective 3: To explore the role played by the current operations management framework in meeting multidimensional needs (Efficiency, Sustainability, and Social Security)

- **The current operations management framework in addressing the efficiency needs of smart cities**

Smart cities' current operations management frameworks optimize resources, integrate IoT technology, and improve public safety, waste management, and transportation systems, all of which support sustainability and social security. 4 out of 19 study respondents concentrated on sustainability issues including waste and energy management, while 6 out of 19 study respondents specifically addressed IoT-enabled technologies and their contribution to increased efficiency. As Participant 8 stated, "Smart grids and smart buildings optimize energy consumption, reducing waste and emissions." While some respondents highlighted the positive impact of energy efficiency and best practices, others pointed out challenges such as outdated technologies, budget constraints, and lack of sustainability. Approximately 5 out of 19 study participants indicated concerns regarding the limitations of existing frameworks, with Participant 3 stating, "Existing frameworks are not foolproof as the relatively older installations are not up to the mark with the latest technologies available." Budget constraints were also a recurring issue, with another participant emphasizing, "Organizations are struggling to manage their budgets" (Participant 3). Social sustainability, including equity and collaborative planning, is also seen as critical for smart city success. Around 3 out of 19 study participants specifically addressed social sustainability, with Participant 6 highlighting that "Smart city policy agendas must include the social dimension of sustainability" and listing key factors such as inclusion, equity, and infrastructure. Furthermore, public safety and emergency response were acknowledged as crucial, with Participant 9 noting, "As there are several junctions provided in cities, government has placed signals, VUP, and Underpasses to avoid congestion; this has helped safeguard the general public from possible accidents." Framework standardization and ICT integration are suggested as necessary improvements to overcome current limitations and ensure a more holistic approach to sustainability and resilience in smart cities. Despite the benefits, 2 out of 19 study participants argued that current frameworks do not contribute significantly to sustainability, as expressed by Participant 13: "Should contribute to sustainability but do not at present." This indicates that while frameworks offer potential, they require further refinement for widespread effectiveness.

By addressing these challenges, particularly through better integration of technology, increased budget allocations, and comprehensive framework standardization, smart cities can enhance their sustainability and social security outcomes.

Below is the pie chart showing the distribution of themes related to how operations management frameworks contribute to the sustainability and social security of smart cities. Each slice represents the number of sub-themes under each major theme, reflecting the emphasis placed in discussions or findings.

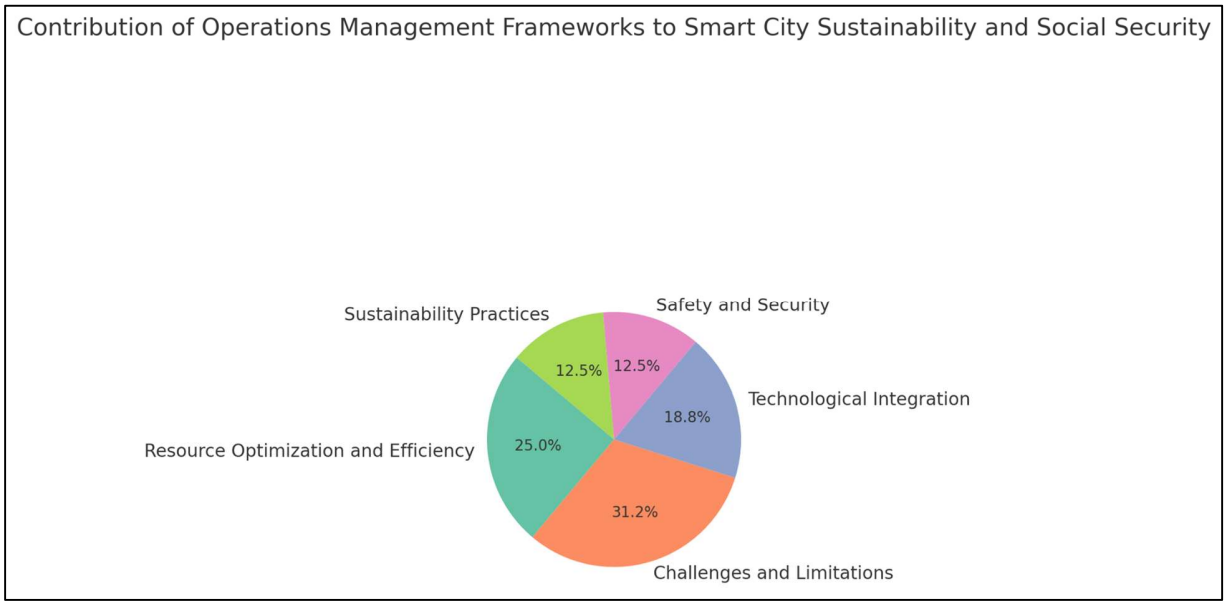

Figure 11: How Operations Management Frameworks Contribute to Sustainability and Social Security

This pie chart illustrates the contribution of operations management frameworks to smart city sustainability and social security. Challenges and Limitations (5 out of 19 participants) and Resource Optimization and Efficiency (4 out of 19 participants) are the most significant areas of focus, while Sustainability Practices and Safety and Security have been highlighted by 2 out of 19 study participants.

Objective 4: To examine the applicability of different operations management frameworks in decision-making for smart city operations

- **The key benefits of different operations management frameworks in facilitating decision-making for smart city operations**

When making decisions about the operations of smart cities, different operations management systems provide different advantages. Among the main benefits are increased departmental efficiency, resource optimizations, and improved citizen communication. The Intelligent Community Framework (ICF) and the Smart City Framework (SCF), for instance, use data analytics to make data-driven, well-informed decisions, increasing departmental effectiveness and lowering the amount of work required to maintain seamless city services. This is depicted in the response given by Participant 6 who asserted, "More effective, data-driven decision-making. Enhanced citizen and government engagement. Safer communities. Reduced environmental footprint. Improved transportation. Increased digital equity. New economic development opportunities. Efficient public utilities." Frameworks such as those promoting data-driven decision-making and interagency collaboration support informed and cohesive actions. Benefits like improved sustainability, cost control, and citizen engagement are highlighted, with examples including the successful implementation in cities like Singapore and New York. Additionally, frameworks that ensure flexibility, performance measurement, and integration facilitate adaptive and efficient urban management. Moreover, frameworks such as Lean Management and Six Sigma drive resource optimization and cost control, while Agile Urban Planning (AUP) and the Adaptive City Framework (ACF) enhance flexibility and adaptability, allowing cities to respond dynamically to emerging challenges. Overall, these frameworks contribute to more effective, data-informed, and responsive smart city operations. These findings are evident from the statement, "Benefits of different operations are that at least we know tentative data and on which line we are proceeding and Perdon can make at least some decisions about what exactly or tentatively he can do the best to guard himself and guide others to follow."

Below is the pie chart illustrating the key benefits of various operations management frameworks in smart city decision-making. Each theme is represented equally, showing a balanced emphasis on efficiency, sustainability, data use, collaboration, productivity, and strategic growth.

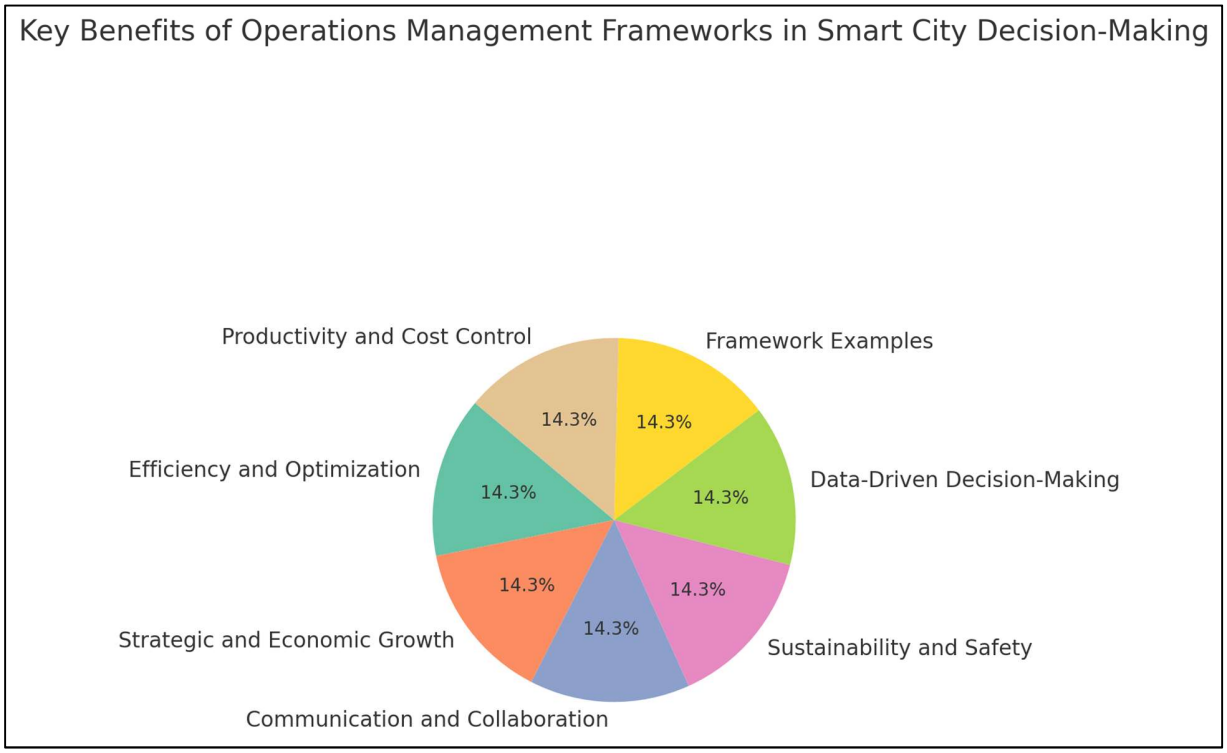

Figure 12: Key Benefits of Operations Management Frameworks

Key Benefits of Operations Management Frameworks in Smart City Decision-Making involves and equal percentage given to all benefits like Data-driven decision making, sustainability and safety, communication and collaboration, strategic and economic growth, efficiency and optimization, productivity and cost control and framework examples.

- **The main limitations and challenges associated with applying various operations management frameworks**

The primary obstacles and difficulties in implementing different operations governance structures in smart city operations involve problems with infrastructure and technology integration, such as obsolete systems and the requirement for significant modifications. The necessity to modernize legacy infrastructure is highlighted by the fact that 35 per cent of participants identified technology integration as a major hurdle, according to the findings. The enormous volume of data being collected raises serious privacy and security issues that need for strong security solutions. As Participant 2 noted, "The backbone of a smart city is data," while Participant 6 reinforced this by stating, "Data Privacy and Security remains a top concern." Funding and investment challenges

arise from the high costs of implementing smart technologies and convincing stakeholders of their long-term benefits. Approximately 4 out of 19 study participants highlighted financial constraints, with Participant 1 emphasizing “Cost of Smart City systems and RoI model" as a critical issue. Public acceptance is also a hurdle, as citizens often have concerns about privacy and job displacement. Participant 2 stated, "Overcoming these concerns requires effective communication and education about the benefits of smart cities." Additionally, governance and policy issues can complicate the implementation process, and factors like bureaucratic delays, corruption, and the need for skilled manpower further exacerbate these challenges. Participant 4 directly pointed to "Bureaucracy delays," while Participant 7 identified "Corruption" as a major obstacle. The rapidly evolving technology landscape and the complexity of managing diverse dimensions in smart city planning also contribute to the difficulties in applying these frameworks effectively. Participant 18 captured this challenge well: "Everyone is defining what a smart city is differently, and independently determining what constitutes success."

Below is the pie chart showing the primary limitations and challenges in applying operations management frameworks within smart city operations. Each theme reflects the number of related sub-themes, indicating how frequently these challenges emerge in discourse.

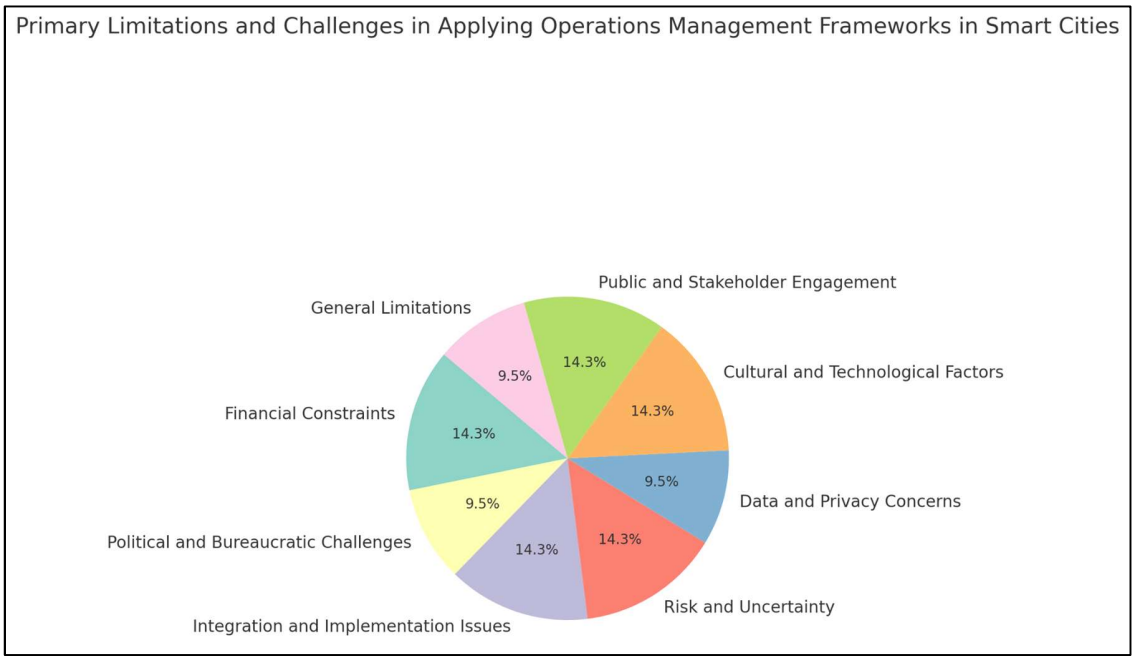

Figure 13: Primary Limitations and Challenges in Applying Operations Management Frameworks

Primary Limitations and Challenges in Applying Operations Management Frameworks in Smart City reveals that 2 out of 19 respondents highlighted Public and Stakeholder engagement, cultural and technological factors, risk and uncertainty, integration and implementation issues and financial constraints. The study further revealed that 1 of 19 participants had data and privacy concerns, 1 out of 19 had political and bureaucratic challenges, and 9.5 per cent had general limitations.

Objective 5: To suggest strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities

- **The key challenges you face regarding smart city movement and infrastructure development**

Most of the participants highlighted money, legacy systems integration, governance, and coordination amongst many stakeholders as the main obstacles to smart city development and mobility. Financial restrictions were cited by 11 out of 19 respondents as a major worry, with controlling cashflows, getting long-term finance, and ensuring financial viability being of particular importance. Participant 1 stated, "Finding long-term funding to match long-term infrastructure capital spend and direct/indirect returns" as a key challenge.

Additionally, 8 of 19 respondents mentioned the difficulties of integrating new technologies with existing infrastructure, data security and privacy concerns, and the lack of interoperability and standardization. Participant 6 noted, "Cities must upgrade their infrastructure to support IoT devices, high-speed internet, and data centers," reflecting concerns about modernization. Governance, including the need for better collaboration between public and private sectors and resistance from various stakeholders, was also frequently mentioned (42%). Participant 9 stated, "Local bodies don’t cooperate. Even government officers don’t support easily and accept the concepts," illustrating the bureaucratic hurdles.

A minority of respondents raised concerns specific to the local context, such as land acquisition (4 of 19 participants), inadequate urban planning (5 of 19 participants), and infrastructure scalability

(4 of 19 participants), while others noted issues like environmental impact, energy scarcity, and political and regulatory risks. Participant 14 highlighted, "The existing infrastructure of all the cities is stressed beyond yield point as migration to urban cities has been progressing at a very rapid pace," emphasizing the urgent need for better planning. These findings underscore the multifaceted nature of smart city challenges, requiring strategic investment, policy adjustments, and stakeholder engagement to ensure sustainable urban development.

Below is the pie chart illustrating the distribution of key challenges in the smart city movement and infrastructure development. Each segment represents a thematic category, sized according to the number of related sub-themes and issues mentioned.

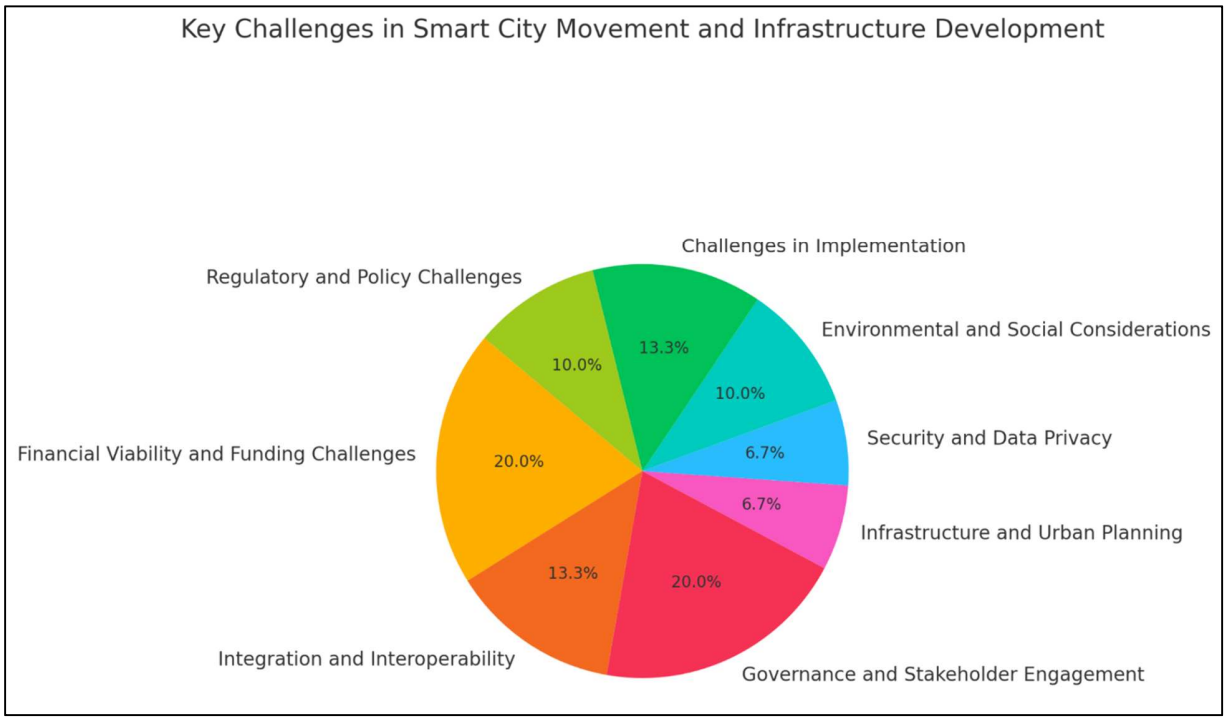

Figure 14: Key Challenges in Smart City Movement and Infrastructure Development

This pie chart highlights the key challenges in smart city movement and infrastructure development. The top concerns are Financial Viability and Funding Challenges and Governance and Stakeholder Engagement (each 20%), followed by Integration and Interoperability and

Implementation Issues (each 13.3%). Lesser-emphasized issues include Security and Data Privacy and Urban Planning, both at 6.7%.

Technical difficulties, including a shortage of qualified personnel, inexperienced vendors, and complicated data management problems, were cited by most respondents as primary barriers to administering smart city initiatives. 6 out of 19 study participants pointed out shortcomings in technical skills, and 5 out of 19 study participants expressed worries about privacy, security, and data management, according to the study findings. Concerns about privacy and security were also often brought up, along with issues with the expense of solutions and the adaptation of Western models to local settings. For instance, Participant 1 stated, "There is a tendency to cut and paste what works in Western countries," reflecting concerns about contextual adaptability. Issues of governance, stakeholder engagement, and funding further compounded the difficulties, with some respondents highlighting problems in public acceptance and scalability of solutions. Approximately 4 out of 19 study participants pointed to governance and funding challenges, with Participant 16 noting, "Collaboration, lack of skilled professionals, sustainability, funding, governance, energy management, waste management, social inclusivity" as key barriers. A minority of participants noted specific logistical issues, including economic considerations for project sustainability, maintenance concerns, and traffic management. Participant 14 warned, "Economic considerations without giving complete thought to the availability of spares, cost of maintenance, etc., can create major setbacks." Additionally, a few respondents emphasized the importance of clear project goals, effective digital execution, and collaboration, while others lacked direct experience in smart city management.

Below is the pie chart showing the distribution of challenges encountered in operations management of smart city projects. Each segment reflects the number of issues grouped under each thematic challenge.

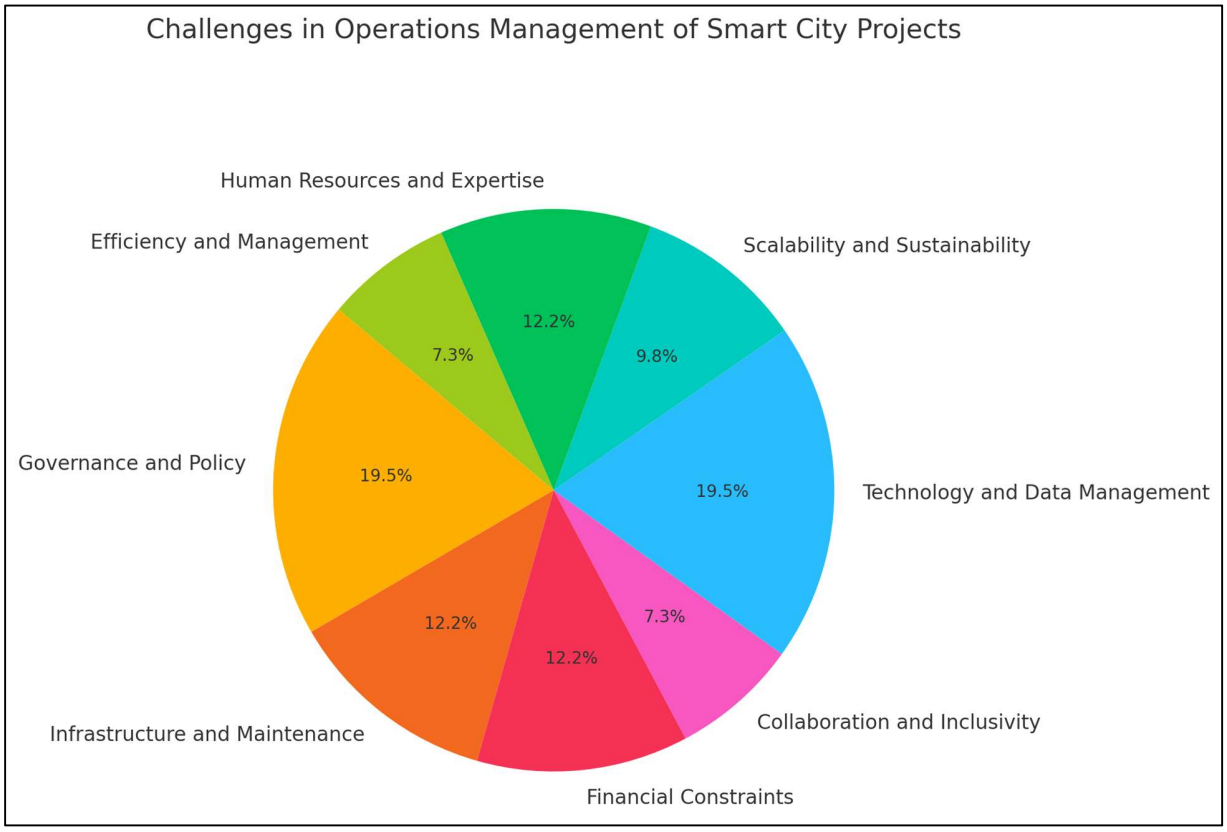

Figure 15: Challenges in Operations Management of Smart Cities

This pie chart outlines the challenges in operations management of smart city projects. The most significant issues are Technology and Data Management and Governance and Policy (each 19.5%), while Collaboration and Inclusivity and Efficiency and Management are the least represented (7.3%). Other moderate challenges include Financial Constraints**,** Infrastructure**, and** Human Resources**,** all around 12.2%.

- **Strategies for improving coordination, decision-making, and adaptation in smart city planning**

8 out of 19 study participants stated that data-driven decision-making and policy frameworks are crucial, while 11 out of 19 study participants stressed coordination tactics such cross-functional collaboration and stakeholder involvement. Additionally, scalability and long-term planning were mentioned by 30% of respondents as adaptation techniques. Participant 1 stressed,

1. Ensure that you can define the problems and priorities as a city/ business

2. Spend time to develop internal expertise and people who have confidence in technology use.
3. Ensure management does not get carried away by solution providers and do proper cost-benefit analysis.
4. All operations department heads should get ready to be open to collaborate and develop a cross-functional SLA and not optimize only for their department
5. Integrate all customer-facing systems into the smart city solution so that there is smooth and mutually beneficial working of the system.," reinforcing the need for integrated coordination. Respondent 12 stated, "Technology integration across various systems and technologies is a must. Generate big data to fish out the problem and find a solution," underscoring the significance of data-driven approaches. Moreover, 20% of responses focused on structural and implementation challenges, such as land acquisition and utility shifting, as Participant 9 noted, "The first and foremost thing that the Government should do is clear the Land acquisition issue.
Plan the permanent plans for a further 50 years.
Design the utility shifting accordingly.
Implement one by one as per the finalized concept.
Give local bodies responsibility for the implementation of such work and the time frame for completion.

Involve all such bodies during decision-making and make sure they are held responsible for getting work executed within the time frame." These findings suggest that while there is a strong consensus on broad strategic improvements, specific challenges like clean data accessibility and scalability require targeted interventions.

Below is the pie chart showing the distribution of suggested strategies by theme. Each slice represents how many sub-strategies fall under each theme, helping to visualize focus areas for better planning, coordination, and adaptation in smart cities.

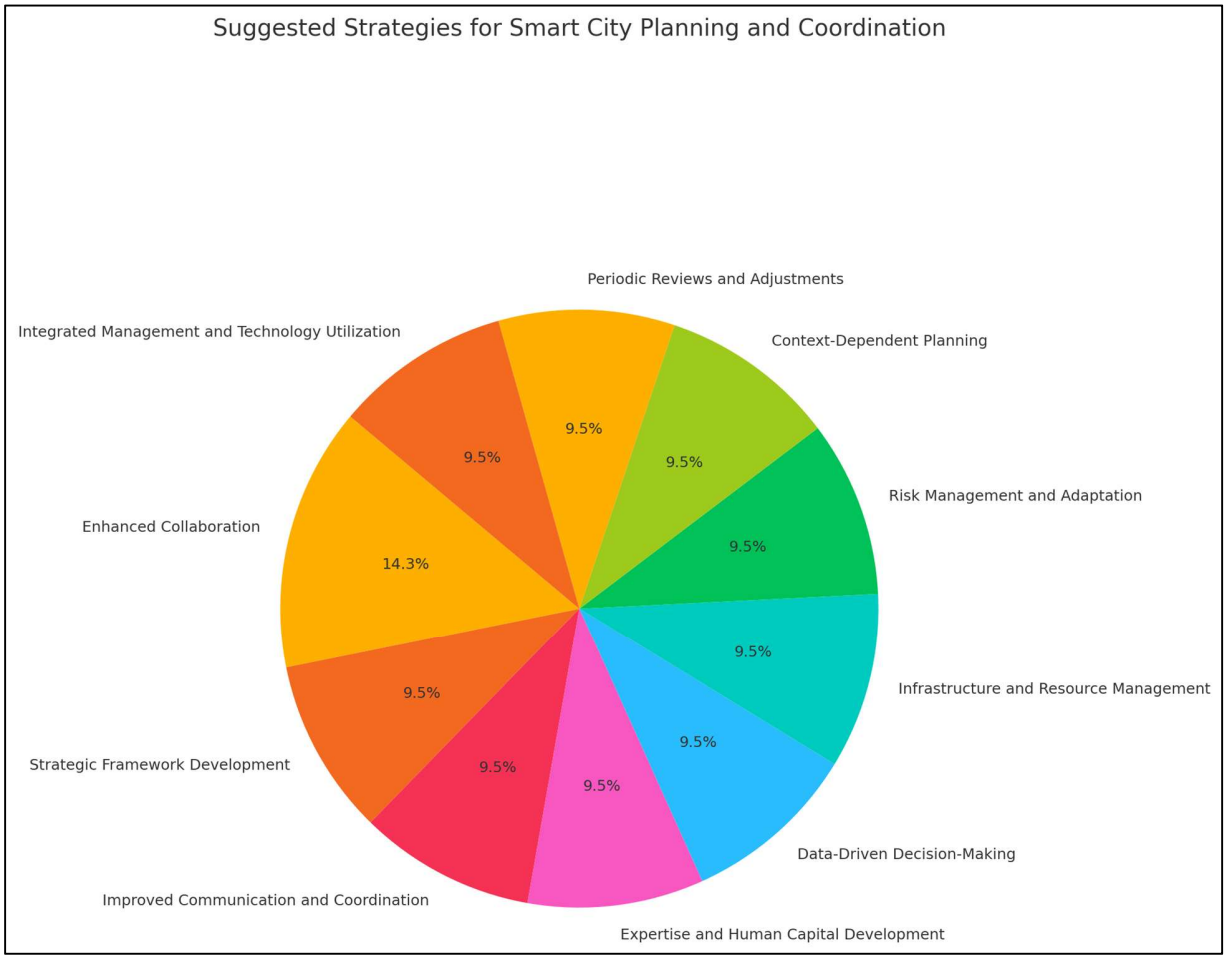

Figure 16: distribution of suggested strategies by theme

This pie chart presents suggested strategies for smart city planning and coordination, with Enhanced Collaboration receiving the highest emphasis at 14.3%. All other strategies, including Data-Driven Decision-Making, Risk Management, Strategic Framework Development, and Context-Dependent Planning, are evenly distributed at 9.5%, highlighting a well-rounded strategic approach.

4.4 Discussions

Through neighborhood development and the use of technology, especially technology that produces smart outcomes, smart cities aim to improve people's standard of life and spur economic development (Yin et al., 2015). A smart city is an urban region that has been constructed which employs a range of electronic gadgets, voice activation, and monitors to collect data. The

community's activities are improved when assets, resources, and services are managed efficiently owing to the data. The smart city concept is progressively spreading throughout the world. These cities are known to connect technology and urban landscape, with the construction of infrastructure being proposed as an important foundation for this integration. Due to the numerous parties engaged and difficulties in making decisions, developing infrastructure while simultaneously managing all city issues has been viewed as a difficult undertaking. This necessitates the implementation of an appropriate operations management plan, which is why previous businesses worldwide have been using techniques like total quality management and Six Sigma. This chapter of results and discussion aims to address the research objectives along with supporting and contrasting the findings obtained with those of the previous research studies.

Effective operations management framework in smart cities.

Objective 1 was addressed using two broad themes. The first theme highlighted the elements that are crucial for developing an effective operations management framework in smart cities, while the second theme taken into consideration is the effectiveness of the current operations management framework in addressing the efficiency needs of smart cities

While analyzing the need for an effective operations management framework in smart cities, it was found that strong governance, technological integration, and the significance of economic viability are all essential components of creating an efficient operations administration structure for smart cities. In addition to the requirement for cutting-edge technology like ubiquitous wireless internet access and safe storage of information, other crucial components include financial management, evaluation of costs and benefits, and public-private collaborations. Human resource development, collaboration on data, and citizen involvement are other important components. The responses indicate that financial sustainability was mentioned by 40% of the respondents, making it one of the most frequently highlighted elements. Additionally, 35% of participants stressed the importance of technology integration, particularly in terms of connectivity and digital execution plans. Governance and leadership were identified by approximately 30% of respondents as crucial for ensuring the smooth functioning of smart cities. Identically, Mak (2022) asserted how smart cities are embracing new technologies to advance society. Along with emphasizing practice growth and taking into account many factors that are crucial for conducting company activities over the long term, the trend is consistent with the operations management framework. According to the

researchers, operations management is not particularly unique because it incorporates engineering elements, which also include engaging in activities that aid in problem-solving and considering various viewpoints related to operations management and smart city issues (Mak, 2022). Moreover, the present research study found that the "smart city" programs were necessary unless they were linked to quantifiable performance objectives, citing specific issues such as utility relocation, water supply administration, and the requirement for thorough manuals for infrastructure maintenance. A similar finding was also observed in the literature review wherein Li et al. (2016) asserted that smart cities are constantly evolving and incorporating various stakeholders to become informed and involved. They also prioritize considering the sector's operations managers to involve the possibilities and difficulties that their people and procedures encounter, as well as frameworks and instruments for implementing operational decision-making. Investigators find that the use of operations management in smart cities, which incorporates new operations scenarios, is beneficial (Li et al., 2016). Moreover, the present study also highlighted the importance of long-term preparation, safety precautions, and adherence to viable operations.

Another prominent result of the study was that the efficiency requirements of smart cities are considered in the existing operations management system. Efficiency requirements are the standard that ensures the optimal usage of resources like IoT integration for real-traffic management. The study suggested that although the present structure for operations management in smart cities is only partially operational, it requires to be significantly improved to meet efficiency requirements. Certain cities have used ICT, public interaction channels, and data-driven decision-making to improve operational effectiveness, nevertheless, problems like limited funding, outdated infrastructure, and disjointed departmental coordination impede advancement. Continuous advancements are also required in fields like managing waste, ensuring the safety of the public, and maintaining mobility. To maximize resources, proactive upkeep, better infrastructure management, and enhanced evaluation of information are essential. Though many cities struggle to integrate new technology and manage the disparity between goals and real execution, instances such as Singapore's Smart Nation program show promise. In this context, Notably, 25% of respondents specifically mentioned data security, accountability, and integrity as key concerns, underscoring the need for strong authentication and trust mechanisms in data sharing. Similarly, Sánchez-Corcuera et al. (2019) also asserted that when ICTs were first

introduced in smart cities, people focused on highlighting concerns related to energy usage and addressing the unsustainable features of the technology. Additionally, it incorporated the environment, where issues are related to cyber-security and the resilience of the framework for preventing surprises and protecting human necessities. Technology-related problems, legal and regulatory issues, and institutional and environmental issues are all associated with difficulties in the governmental sector. The concerns are related to ICT investment (ICT investment involves funding technologies like broadband infrastructure and secure data systems), mind scaping, or the procedure of persuading entities, safety and confidentiality, and ICT investment. Additionally, when managing operations in a smart city, the research conducted by Syed et al. (2021) offers insight into associated challenges. According to observations, data leaks are a problem for smart cities. When network discovery tasks are being performed and information is being provided to the network, data leaks occur. An additional concern pertains to reliability, which includes ensuring the safe use of smart city apps and promoting their adoption. Smart city utilization must be made available for data management.

The research results demonstrate that to ensure an effective operations management framework in smart cities, it is important to integrate the aspects of governance, technological advancements, and stakeholder collaboration. The present study findings align with those of Mak (2022) and Li et al. (2016) who discussed the significance of governance and technology incorporation within the smart cities project. Nevertheless, the present study comprehensively builds on their research by recognizing the gaps pertaining to the existing paradigms like restricted departmental corporation and lack of resource optimization, thus providing strategies that overcome these limitations.

Factors affecting data collection and management in smart cities

Here, the themes concerning “data that are most crucial for effective management of smart cities” and “methods most effective for data collection in smart cities” have been critically analyzed.
Real-time information on traffic, air quality, and energy consumption is essential for smart city governance because it empowers city officials to make informed decisions. Infrastructure information, sensor data from IoT devices that track public facilities and situations, and data regarding the environment are all equally significant. According to Albino et al. (2015), Smart

cities are a vague term that can be applied in a variety of contexts and is not always the same. It can be defined as the capacity to collect and synthesize real-time data using detectors, meters, equipment, personal gadgets, and other similar sensors.

Urban planning requires knowledge of the population, transit, and government laws, functional and historical data aid in resource management and future demand forecasting. To ensure that cities can foresee problems, uphold sustainability, and enhance the standard of life for citizens, optimization initiatives are further supported by maintenance data, performance indicators, and citizen input. Identically, as observed in the literature review, Javidroozi et al. (2023) investigated smart cities by considering several aspects, such as well-being ideas, technology, processes, and systems convergence. While Yin et al. (2015) characterized smart cities through four elements including the processing of information, domain usage, technical support, and system coordination. The report also discusses the potential for smart cities in the future and the challenges that need to be addressed to move closer to the municipalities of the future.

According to the respondents, citizen feedback websites that collect data via mobile apps and questionnaires, along with the application of IoT sensors for real-time surveillance of infrastructure like water, power, and traffic systems, are the most efficient ways to collect data in smart towns. While questionnaires and crowdsourcing work well for obtaining information from local people, open data platforms and geographic information systems (GIS) are frequently utilized for spatial and public assessment. The capacity to monitor and control urban infrastructure is further improved by mobile devices for gathering data on foot traffic, environmental tracking systems for measuring the quality of the air and water, and smart meters for the consumption of water and energy. These techniques allow cities to gather thorough data for well-informed decision-making processes, especially when combined with collaboration between the public and private sectors and the incorporation of different sources of information. Notably, 28% of respondents mentioned the significance of environmental and stormwater data, reflecting growing concerns over sustainability and climate resilience. Citizen feedback, maintenance data, and performance metrics further support optimization efforts, ensuring cities can anticipate challenges, maintain sustainability, and improve the quality of life for residents. Along similar lines, Syed et al. (2021) emphasized that the first data in cities to be automatically sensed were traffic flows, even though

databases with different spatial data go back hundreds of years. The requirement for scientific computation was as crucial to the development of digital computers as the issue of collecting census data. In 1890, Herman Hollerith developed the punched card procedure for the US Census, which led to the establishment of the company that would later become IBM. Throughout the late 1990s, the technology known as geographic information systems (GIS) has been widely employed to gather and present this kind of data.

Conclusively, the factors affecting data collection and management in smart cities are IoT devices, GIS platforms, and citizen feedback contribute to comprehensive data collection and addressing operational challenges in real-time. The present study supports the research findings of Albina et al. (2015) and Yin et al. (2015) concerning the importance of IoT devices regarding real-time data gathering. Nevertheless, it contradicts the previous researchers' beliefs by emphasizing the limitations of privacy issues, ineffective infrastructure, thus providing a gist of the strategies to incorporate citizen feedback and GIS system to improve data governance.

The role played by the current operations management framework in meeting multidimensional needs (Efficiency, Sustainability, and social security).

The role played by the current operations management framework in meeting multidimensional needs has been analyzed using two themes that are "The current operations management framework in addressing the efficiency needs of smart cities" and "Operations management frameworks contribute to sustainability and social security in smart cities".

The current operations management system takes into consideration the efficiency requirements of smart cities. This refers to the tools, frameworks, and stakeholders managing smart city activities. Even though the current operations management framework in smart cities is only partially functional, it needs to be greatly enhanced to satisfy efficiency standards. Even though some cities have improved operational effectiveness through ICT, public interaction channels, and data-driven decision-making, issues including inadequate financing, antiquated infrastructure, and fragmented departmental coordination stand in the way of progress. Additionally, industries like waste management, public safety, and transportation maintenance need constant improvements. Proactive maintenance, improved infrastructure management, and improved information

assessment are crucial for optimizing resources. From the responses, 35% of participants explicitly mentioned IoT-enabled technologies and their role in improving efficiency, while 25% focused on sustainability aspects such as waste and energy management. According to Lai et al. (2020), smart cities also emphasize the use of technology and information to improve economic development, long-term sustainability, and efficiency while also improving urban regions' standard of life. Clean innovations have been shown to support the growth of smart cities that integrate transportation, energy consumption, and healthcare. In addition to being determined, the idea of a smart city incorporates sophisticated and standardized elements. It has been established that smart cities are adaptive and resilient. They are recognized as smart cities and necessitate the use of cutting-edge technologies like sensor devices and strong ICT infrastructure. The key categories of smart cities, including smart schooling, transportation, economy, administration, health, and energy, were illustrated. Smart city initiatives must also provide information about the adoption of international norms and how they affect smart cities (Lai et al., 2020).

By maximizing resources, incorporating IoT technology, and improving public safety, waste management, and transport networks, the current operations management models in smart cities support social security and long-term viability. Some responders emphasized the benefits of energy-saving technologies and standard procedures, while others drew attention to drawbacks such as antiquated technology, financial limitations, and lack of sustainability. The development of smart cities is also seen to depend on social sustainability, which includes equity and cooperative planning. To get past present constraints and guarantee a more comprehensive approach to resilience and sustainable development in smart neighborhoods, it is recommended that framework standardization and ICT integration be implemented. Approximately 30% of responses indicated concerns regarding the limitations of existing frameworks.

Summarizing, the role played by the current operations management framework in meeting multidimensional needs suggests that ICT and public interaction tools improve efficiency, sustainability, and social security, directly addressing this objective. These study findings are in line with those of Lai et al. (2020) who extensively undermined the impact of ICT in improving operational efficiency and sustainability. Nevertheless, our study further extends their research by

emphasizing the domains that require improvements like improved infrastructure management. Proactive maintenance, thus accomplishing the multidimensional requirements.

The applicability, advantages, and limitations of different operations management frameworks in decision-making for smart city operations and extend them based on the current scenario.

This objective was addressed using two broad themes that are "the key benefits of different operations management frameworks in facilitating decision-making for smart city operations" and "the main limitations and challenges associated with applying various operations management frameworks in the context of smart city operations".

Decision-making in smart city governance might benefit from a variety of operational administration systems. Enhancing departmental effectiveness, resource optimization, and citizen engagement are some of the main benefits. Frameworks that encourage interagency cooperation and data-driven decision-making, for example, facilitate well-informed and coordinated action. With instances of successful implementation in places like Singapore and New York, advantages including enhanced sustainability, cost management, and citizen participation are emphasized. Furthermore, frameworks that guarantee adaptability, integration, and performance evaluation make adaptable and effective urban administration possible. All things considered, these frameworks support smart city operations that are more efficient, data-driven, and proactive. 35% of participants cited technological integration as a major barrier, highlighting the need for modernizing legacy infrastructure. As observed in the literature review according to Tran et al. (2019), there are four distinct kinds of decision-making strategies: multi-criteria approaches, numerical programming, integrated approaches, and AI. Several methods for structuring and formalizing decision-making processes make up a complex procedure referred to as multi-criteria decision-making (MCDM). Decision-makers can find the optimum agreement among a variety of possibilities (criteria) by analyzing options simultaneously based on multiple dimensions. However, MCDM is considered a steady-state method that uses historical data to provide hotspot snapshots. Consequently, this method does not provide projections or future patterns, nor does it consider the ways in which different measures, outputs, and characteristics might interact over the years (Ruhlandt, 2018). Identically, Babar et al. (2020) claim that the design of the Internet of

Things-enabled environment connects information processing to all actions. A wide range of physical, real-world devices in a ubiquitous setting will produce enormous volumes of data with a variety of information that call for new computational methods to facilitate better decision-making. Since ubiquitous gadgets generate vast amounts of data, the Internet is going to grow more dependable, valuable, and diverse. Big Data tools and advanced machine learning techniques have a lot of applications for analytical services in smart cities, and improvements in ubiquitous computing are producing large amounts of important knowledge or data. Numerous concepts are found for handling and evaluating the data generated by heterogeneous devices to make efficient decisions (Weber and Žarko, 2019).

Another obstacle is public acceptance since people frequently worry about job loss and privacy. The procedure for implementation can also be complicated by governance and policy concerns, which are made worse by things like bureaucratic hold-ups, fraud, and the demand for qualified personnel. Effective application of these concepts is made more challenging by the quickly changing technological landscape and the difficulty of coordinating the many facets of smart city design. This study result is supported by the findings of Rajesh et al. (2019) who revealed that data computing and omnipresent intelligence make networks in smart cities vulnerable to malware, security lapses, and various other cyberattacks. The interconnection demands of ordinary physical equipment would surely introduce several inventive and imaginative malevolent designs to IoT data computing. Malicious intruders can fabricate information to alter the sensed data on authorized devices. In ubiquitous surroundings, intrusions may have a detrimental effect on decision-making. Furthermore, these malicious entities may perform denial-of-service operations that diminish the importance of smart services by interrupting transmission and sensing a pervasive environment.

While examining the applicability, advantages, and limitations of different operations management frameworks in decision-making for smart city operations, the study discussed decision-making strategies, including MCDM and AI-based models, while identifying limitations like adaptability and cybersecurity risks. These study findings are like those of Tran et al. (2019) and Ruhlandt (2018) who depicted the importance of MCDM and AI paradigms in the process of decision-making. The study further advances this study by depicting the challenges like cybersecurity

challenges and proposes anan adaptive paradigm to pinpoint the evolving aspects of demand of smart city operations.

The strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities.

Concerning the strategies related to better coordination of planning, decision-making, and adaptation in smart cities. Three broad themes were analyses viz a viz “the key challenges you face regarding smart city movement and infrastructure development”, “the challenges encountered in managing smart city projects” and the strategies to improve coordination, decision-making, and adaptation in smart city planning”.

Many participants listed money, legacy systems integration, governance, and collaboration among stakeholders as the main obstacles to smart city activity and building infrastructure. Several respondents brought up concerns about finding long-term funding, managing cash flows, and the financial sustainability of smart city initiatives. Furthermore, others noted the problems of integrating emerging innovations with current infrastructure, confidentiality and security of data issues, and a shortage of compatibility and standards. Governance was also brought up a lot, along with the need for improved cooperation between the public and commercial sectors and opposition from different groups. 63% of respondents highlighted financial constraints as a major concern, particularly balancing cashflows, securing long-term funding, and ensuring financial viability. Similar study findings were observed by Sánchez-Corcuera (2019) who revealed that organizational and managerial challenges include the project's size, the manager's demeanor and attitude, the organization's or its users' diversity, the inconsistency between projects and the organization's goals, the existence of multiple or conflicting goals, resistance to change, and turf and conflicts. Moreover, organizational constraints (lack of departmental and cross-sectoral cooperation, unclear IT management strategy, political and cultural issues), as well as technological hurdles such as a lack of IT staff with integration capabilities. Moreover, Sánchez-Corcuera (2019) emphasized concerns pertaining to government that include collaboration, communication, data exchange, accountability, transparency, leadership and advocacy, involvement and collaboration, and service and application integration. Finally, policy concerns include how hard it is to combine ICT with institutional and political components, each of which

has its own objectives. According to Fahimnia et al. (2019), there are qualities associated with operations management. A few of the qualities linked to managing operations are found to be communication. Transferring knowledge in the framework of smart cities depends on collaboration. In addition to being necessary for managing processes, efficient interaction also contributes to the long-term growth of practices. This also backed the facilitation and analysis of the factors that can lead to development. Building features and because communication is essential for conducting business operations and assessing the long-term trajectory of the activities are both vital. Considering various viewpoints that allow for efficient operations management further supports this. In addition to focusing on numerous issues related to the viewpoint over the long term, communication is essential for analyzing the many components.

Most of the participants cited technical difficulties as primary barriers to administering smart city projects, including a shortage of qualified personnel, inexperienced vendors, and complicated data management problems. Considerations about security and confidentiality, as well as difficulties integrating Western ideas into regional settings and the expense of remedies, were also commonly brought up. The challenges were exacerbated by difficulties in governance, financing, and participation of stakeholders; several respondents pointed out issues with remedy scalability and popular acceptance. Several respondents (47%) mentioned the difficulties of integrating new technologies with existing infrastructure, data security and privacy concerns, and the lack of interoperability and standardization. Similarly, it was found that Pierce and Andersson (2017) proposed a taxonomy for SC problems that centers on municipal decision-making. The obstacles were classified as non-technical and comprised of two technological issues, interoperability and privacy, as well as (i) teamwork, (ii) financial, (iii) governance, and (iv) awareness. A meagre attempt to work with other people is part of the collaboration. Additionally, financial concerns include the lack of funding for SC efforts, the need for a large initial investment, the absence of a business plan, and difficulties generating revenue from SC investments. The administration presents challenges brought on by outdated laws and regulations that hinder SC activities. Additional awareness encompasses challenges associated with inadequate knowledge and comprehension of SC-related technology. Integration challenges with SC are part of interoperability. Additionally, privacy acknowledges that big data might be dangerous while also protecting citizens' privacy. Additionally, Smart cities have drawn a lot of interest in relation to operational tasks and incorporating social and technological concerns (Kasznar et al., 2021). The

construction of roadways, structures, and energy is the primary goal of smart city infrastructure. It is assessed that most research focused on traffic regulation and administration, combining big data, IoT, land use growth, and smart grid projects. The operations and upkeep of current facilities around the world are made easier by the construction of new technology. Information and communication technology and its significance in infrastructure construction, functioning, upkeep, and administration are highlighted in the research, as is the acceptance of sustainability in existing smart infrastructures and the advancement of infrastructure through automated processes. Smart city infrastructure, such as long drives, traffic jams, and inadequate parking facilities, emphasizes the importance of electronic and technological towns. The three components of smart cities are community, technological advances, and organizations (Kasznar et al., 2021).

Many those interviewed stressed the significance of setting up efficient coordination mechanisms, data-driven decision-making, and stakeholder involvement in response to the question about methods for enhancing coordination, decision-making, and adaptation in smart city planning. A lot of respondents recommended creating a single platform for data integration, encouraging cross-functional cooperation, and using data analytics to make well-informed decisions. To guarantee that the procedure for planning satisfies the demands of the public, they also emphasized the necessity of continuous community involvement. However, a small percentage of those surveyed concentrated on more specialized issues and technological facets, such as making sure that performance evaluation information is clean and handling the intricacy of incorporating systems. To successfully execute smart city initiatives, they also emphasized the significance of tackling long-term planning concerns including utility moving and acquiring land. Consequently, certain individuals offered specific proposals addressing operational issues and technical factors, even while the majority center on broad strategic changes. Inference asserted that minority of respondents raised concerns specific to the local context, such as land acquisition (26%), inadequate urban planning (31%), and infrastructure scalability (22%), while others noted issues like environmental impact, energy scarcity, and political and regulatory risks. Concerning this, as observed in the literature review, Silva et al. found that a feasible Smart city should consider several variables like connectivity; big data; disposal of waste; effectiveness; long-term viability; variability; cost functioning; security of information; system mistakes; and carbon emissions into account. These major concerns are accompanied by environmental issues such as waste

management, carbon emission reduction, and the introduction of renewable energy sources, as well as the capability of integrating diverse hardware and software (compatibility).

While suggesting strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities, the study proposed creating unified data platforms and promoting stakeholder collaboration to enhance coordination and adaptability. 60% of participants emphasized coordination strategies, such as cross-functional collaboration and stakeholder engagement, while 45% underscored the importance of data-driven decision-making and policy frameworks. Additionally, 30% of respondents highlighted adaptation strategies, including scalability and long-term planning. Moreover, 20% of responses focused on structural and implementation challenges, such as land acquisition and utility shifting. The research findings are further supported by Sánchez-Corcuera (2019) and Pierce and Andersson (2017) who depicted the significance of stakeholder cooperation and data incorporation. On the contrary, it also suggests that the introduction of unified platforms and tailored strategies help in addressing the operative and governance issues, depicting a roadway for smart city adoption.

4.5 Conclusions

Smart cities are urban areas created with the use of the newest technology together with data-driven techniques and processes to enhance the standard of life for the people who will reside there. These municipalities integrate all facets of urban life and then endeavor to provide creative and technological remedies that can help address problems while encouraging improved productivity and allocation of resources.

Several technologies, including blockchain and the Internet of Things, are integrated for data management. Mathematical programming, AI, integrated methodologies, and multi-criteria techniques, are used in the decision-making process of smart city initiatives. It has been noted that while decision-making using multiple criteria facilitates a combined assessment of possibilities based on various parameters, it is not predictive. For consumers who are not experts, methods of mathematical programming are deemed difficult and effective. It has been determined that integrated AI, which includes cellular automata, reasoning structures, and genetic algorithms, increases decision-making in changing urban situations. Three distinct levels of decision-making,

strategic, operational, and tactical, are examined. Long-term goals and policies are shaped by strategic decisions, which also influence tactical actions which promote medium-term objectives. To promote the efficient execution of municipal infrastructure, enhance reactivity and dependability, reduce costs, and foster innovation in the urban environment, smart cities are based on the adoption of applications for the Internet of Things and other innovations. Numerous applications spanning communication, facilities and service sectors have emerged in the field of smart cities. Smart neighborhood lighting, smart trash management, advanced infrastructure tracking, smart water administration, and smart energy conservation are a few instances of uses in smart neighborhoods.

The significance of setting up efficient coordination processes, data-driven decision-making, and participation by stakeholders as ways to enhance coordination, decision-making, and adaptability in smart city planning. A lot of the participants recommended creating a platform for data integration, encouraging cross-functional cooperation, and using data analytics to make well-informed decisions. To guarantee that the procedure for planning satisfies the demands of the public, they additionally emphasized the necessity of continuous community involvement. However, a small percentage of participants concentrated on more specialized issues and technical facets, such as making sure that performance evaluation data is clean and handling the intricacy of integrating systems. To successfully execute smart city initiatives, they also emphasized the significance of tackling strategic concerns including utility moving and acquiring land. Therefore, some participants offered specific proposals targeting operational issues and technical factors, even while the majority center on broad strategic changes.

While addressing Objective 1 which is “Analyzing the need for an Effective Operations Management Framework in Smart Cities” it was found that according to OM, a smart city is a management structure that allows for the coordination between strategic and managerial choices at an urban level, which is farther away than the conventional supply chain boundary. It also reflects multifaceted requirements, such as effectiveness, sustainability, and welfare, and it is flexible enough to accommodate vast amounts of data and breakthroughs. For operations management in smart cities, technological adoption and advances, good governance, collaboration among stakeholders, and financial viability are extremely important. Additionally, data storage

collaborations between public and commercial entities, IoT technologies, and efficient infrastructure are critical. Efficiency needs are somewhat addressed by present applications, but there are still major gaps, including poor departmental collaboration, antiquated infrastructure, and a lack of funds. Nonetheless, issues including data security, ICT spending, and regulatory limitations continue to exist. The results highlight how crucial it is to have a comprehensive, flexible framework that puts governance, technology, and sustainability first to maximize efficiency in smart cities.

While analyzing the second objective that states “Identifying Factors Affecting Data Collection and Management in Smart Cities” it was found that for smart city governance, real-time data on energy consumption, transportation, and air quality is crucial since it enables decision-making by local authorities. Sensor information gathered by IoT devices that monitor public spaces and conditions, infrastructure data, and environmental data are all equally important. Urban planning necessitates an understanding of government regulations, transportation, and population; operational and historical information support the administration of resources and demand forecasts. Environmental monitoring equipment for assessing the state of the air and water, smart meters that gauge electricity and water use, and mobile phones for collecting data on foot traffic all contribute to the ability to monitor and manage the infrastructure of cities.

The third objective analyses “Exploring the Role of the Current Operations Management Framework in Meeting Multidimensional Needs”. According to the report, the current framework uses data-driven decision-making, public interaction systems, and ICT to partially satisfy efficiency requirements. But obstacles like insufficient funds, antiquated infrastructure, and disjointed departmental collaboration stand in the way of advancement. Public safety, transportation upkeep, and waste management are just a few of the areas that need constant development. To maximize resources and boost operational effectiveness, proactive upkeep and improved infrastructure management are essential. The present framework makes contributions to social security as well as environmental sustainability through energy-saving technology, IoT integration, and resource optimization. Nevertheless, sustainability initiatives are hampered by problems including a lack of funding and outdated technology. Sustainable smart cities require social sustainability, which includes equity and cooperative planning.

While addressing the fourth objective which is “To examine the applicability, advantages, and limitations of different operations management frameworks in decision-making for smart city operations and extend them based on the current scenario.”, it was found that various operations management systems may be useful for decision-making in the governance of smart cities. Among the primary advantages are increased citizen participation, resource optimization, and departmental efficiency. For instance, frameworks that promote data-driven decision-making and interagency collaboration make it easier to take well-informed and coordinated steps. Additionally, flexible and efficient urban management is made feasible by mechanisms that ensure integration, flexibility, and performance evaluation. All things considered, these frameworks facilitate more proactive, data-driven, and effective smart city processes. Public acceptability is a barrier because people are often concerned about privacy and losing their jobs. Concerns about governance and policy, which are exacerbated by issues like fraud, bureaucratic delays, and the need for skilled workers, can significantly hinder the implementation process. The rapidly evolving technical environment and the complexity of coordinating the various aspects of smart city design make it more difficult to apply these ideas effectively. The research talked about decision-making techniques like MCDM and artificial intelligence-based models while analyzing the applicability, benefits, and drawbacks of various operations management structures in smart city governance decision-making. It also pointed out drawbacks like cybersecurity threats and adaptability.

The fifth objective aims “To suggest strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities.” While suggesting strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities, the study proposed creating unified data platforms and promoting stakeholder collaboration to enhance coordination and adaptability.

4.5.1 Practical and Theoretical Implications

The implications of the experiences and views of participants in this qualitative research that are discussed below are meant to inform managerial reflection and practice in similar smart city and infrastructure situations. The current work has theoretical and practical implications for the development of smart cities. In terms of practical aspects, the study provides a framework for

increasing integrative governance, technology advancements, and stakeholder involvement to improve smart city operations. By enhancing coordination, decision-making, and the sustainability of urban planning, the study provides tactical solutions that assist technology providers, urban developers, and policymakers in carrying out certain interventions. Apart from theoretical frameworks, the study closes research gaps in existing paradigms, especially for the application of operations management and multifaceted decision-making procedures. The field of academia is improved by this. The results assist build the foundation for previously published literature by enhancing the integration of AI, IoT, and sustainable practices to solve challenges like resource optimization, data protection, and long-term infrastructure planning.

Although the results provide useful information about operations management in smart city projects, it is important to consider that the study was based on a qualitative design and the sample size used is rather small, and the findings can be applied only to similar situations but not to generalization.

Integrated operational models for smart cities are lacking, according to the current study. Although the importance of operational paradigms for smart cities was confirmed by the studies of Li et al. (2016) and Mak (2022), these studies were unable to create an integrated paradigm that incorporates technology, governance, financial sustainability, and governance. However, this study extends prior work by incorporating all of these elements, resulting in collaboration and data-driven decision-making. This research study blends the principles of technology, governance, financial sustainability, and governance to provide a comprehensive smart city paradigm. Previous studies have discussed governance and technology separately.

Furthermore, prior studies such as those by Albina et al. (2015) and Yin et al. (2015) emphasized the significance of IoT-driven data collecting, but they did not examine the part that public participation plays in the decision-making processes. Furthermore, while creating policies for smart cities, the importance of public input and participatory government is frequently overlooked. However, the current study looks at how stakeholder interaction, collaboration, real-time citizen feedback, and public obligations affect policymaking.

Furthermore, Pierce and Anderson (2017) recognized the inefficiencies associated with smart cities, but they did not offer any suggestions for enhancing coordination and planning. Nonetheless, the current study evaluates the main inefficiencies in the functioning of smart cities, such as problems with governance, inefficiencies in bureaucracy, and scattered data management. To reduce operational bottlenecks and improve productivity, it also suggests industry-specific partnerships, the usage of AI, and standardized data-sharing platforms. Prior research studies did not evaluate the cyber security threats; instead, they concentrated on the advantages of data-specific decision-making. For example, Lai et al. (2020) evaluated smart city management in relation to ICT, but they did not evaluate cyber security hazards or data privacy concerns. For example, Lai et al. (2020) evaluated smart city management in relation to ICT, but they did not evaluate cyber security hazards or data privacy concerns. However, the current study examined the cyber security threats related to open data platforms, real-time analytics, and IoT devices.

Implication of Governance Structure.

The results suggest that smart cities need cross-sector systems of administration as opposed to the departmental systems of administration. Particularly, the municipal governments are to be transformed into global governance institutions where the rights to decisions of utilities, transport and ICT and public services are well identified.

Implication of Data Trust Mechanism and Data Governance.

The research found that to ensure the success of smart city projects, it is crucial that the projects install clear data governance designs and do not just implement data technologies. This is linked with establishing data ownership, access control, authentication, and cybersecurity roles of the general and non-government actors.

Implication of Planning of Coordination and Integration Mechanisms.

These results show that smart cities cannot be successful regarding specific technologies, but work coordinated mechanisms that are operationalized. It is made up of shared digital platforms, interoperable GIS-based infrastructure repositories and combined customer-facing infrastructure. The research recommends the application of cross-functional coordination procedures in the cities, where the information about the operations would automatically lead to the response in several

departments (e.g. utilities, transport, emergency service) and it would take less time and limit the inconvenience of the services.

Implications on Capability-Building and Human Resources.
These findings demonstrate that the operations of a smart city should be premised on the unceasing development of abilities and not make an investment in technology once. The local governments must invest in the digital literacy or data analytics abilities of the operational managers combined with system thinking or in-house digital literacy.

Implications of financing and investment Models.
The results suggest that the conventional methods of budget making in the public sector do not suit smart city projects. Rather, cities are to have hybrid funding schemes that align the long-term investments in infrastructure to the long-term returns. These are the public-private involves, the outcome-based investment and the plans of staged investment against the measured reference to the performance indicators.

4.5.2 Chapter's contribution to the research

The present chapter has significantly accomplished the research objectives by assessing the applications of operations management paradigms, deciphering the challenges and emphasizing the strategies for developing smart cities. By comparing the research findings with those of previous literature, the chapter provides insights regarding the gaps in the literature and also presents insights for improving the operational paradigms. Furthermore, the chapter also provides practical and theoretical implications that provide the study significance by highlighting the procedures for operational efficiency, smart city development resilience and sustainability.

4.5.3 Limitations of the Research Study

Although the study comprehensively builds on the applicability of effective operations framework and management in the smart city movement and infrastructure development, it still has several limitations. Firstly, this research adopted a qualitative design based on semi-structured interviews, analyses through thematic analysis; therefore, interpretation may be influenced by researcher subjectivity. Since the data collected is analyzed using thematic analysis, it is crucial to highlight

that the data may be subjected to researchers' bias. There exists a subjective interpretation inherent in qualitative thematic analysis. Future research could incorporate mixed methods, integrating qualitative insights with quantitative validation through large-scale surveys. Additionally, the study is particularly focused in the context of urban settings, which impacts the generalizability of the study as the findings and the recommendations obtained may not necessarily be applicable to distinct geographical, political and economic scenarios. Thus, future studies must be conducted in a way that considers quantitative data and is also conducted to compare distinct areas concerning smart city movement and infrastructure development.

4.5.4 Future Research Areas

There exist several areas wherein future research scholars can conduct comprehensive studies. Future scholars can assess the influence of advanced technologies like blockchain, AI and quantum computing regarding smart city operations. Also, scholars can conduct longitudinal studies to monitor the evolution of smart city paradigms and their pragmatic implications. Moreover, future studies can explore the interaction between community, private and public sectors for operational decision-making. Future studies must be conducted that compare various socioeconomic and cultural circumstances to evaluate how adaptable smart city concepts are. Also creating uniform standards to assess the efficacy and long-term viability of smart city initiatives around the world. Qualitative thematic analysis inherently involves subjective interpretation. Future studies might use a combination of approaches, combining quantitative validation from extensive surveys with qualitative observations.

4.5.5 Recommendations

Based on the study findings, the following recommendations have been proposed

- ➔ The effective development of a smart city depends on the strong involvement of its stakeholders. This is the development of combined communication and data-sharing systems to improve cooperation among government, corporate, and community players. Encouragement of private partnerships and stakeholder seminars will help to build confidence and cooperative decision-making procedures.

- ➔ Urban problems rely on the rapid advancement of modern technology like BDA, IoTand AI. Strategic use of these technologies will help to improve public safety operations, resource allocation, and real-time traffic management.
- ➔ Smart city implementation depends on human capital investments being carried out effectively. Technical and managerial abilities in project management approach, data analytics, and cybersecurity should be underlined in specialized training courses for lawmakers, operations managers, and city planners.
- ➔ Using defined models and rules that also take interoperability into account is necessary to deal with big problems like data privacy, hacking, and interoperability. So that data exchange and implementation go smoothly, these models need to be based on global best practices and be adaptable enough to work in different places.
- ➔ For smart urban growth to work, it needs to focus on being environmentally friendly. To have less of an effect on the environment, this means using green technology, sustainable infrastructure, trash reduction systems that work well, renewable energy sources, and the cycle economy.
- ➔ Digital tools, polls, and real-time feedback systems that encourage public involvement will make sure that smart city projects meet the needs and demands of the people. Getting people involved in making decisions helps them feel more responsible and empowered.
- ➔ Developing strong financial plans and investigating many revenue sources helps one to attain long-term financial stability. In this regard, investigating ways to help to build facilities and improve technology by means of government, commercial, and international financing sources.
- ➔ Pilot tests looking at how pragmatic and successful the suggested operational techniques are conducted at many sites These tests seek to guarantee that the procedure stays scientific and ongoing by means of data-driven insights on how to enhance policies prior to their wider use.
- ➔ Building smart cities with an eye on resilience helps them to meet a variety of difficulties, including natural catastrophes, cyber-attacks, and unanticipated losses: Important actions that show this dedication include building strong ICT systems, developing efficient emergency plans, and providing buildings adept of withstanding harm.

- ➔ Smart city initiatives give security and privacy priority, but they also depend on good data governance to guarantee that data is gathered, kept, and used safely. People have rights to trust this method to protect their privacy, guarantee data security, and follow relevant laws.
- ➔ Traditional procedures and services are disrupted and digitally transformed by the smart city. Approaches for managing smart cities need to incorporate an innovative network of entrepreneurs and value producers. They have to develop, maintain, and make money from new company models, procedures, and services. For "smart" businesses to be supported, they need to update their current management procedures and technology. Lastly, an entirely novel set of measures must be used to assess the city's progress.
- ➔ To create, and run, while keeping the smart city, an entirely novel array of partnerships, regulations, funding sources, and models for engagement are needed. To enter and remain in the "smart city competition," cities need to acquire an additional set of "smart" competencies.
- ➔ Information is a vital component of the smart city. Open information campaigns, data markets, analytics offerings, and monetization rules are just a few of the approaches that the smart city must support. Organizations that promote the exchange of information and confidentiality standards that safeguard the types and methods of data collection are equally crucial.
- ➔ In a smart city, individuals, things, and technology are all interlinked. It is essential to be able to link all three with ease, monitor and confirm who and what is interconnected and exchanged and safeguard users and data. Establishing a smooth layer of reliable connectivity is one of smart cities' top concerns.
- ➔ When many individuals hear the term "smart cities," they immediately envision technologies. A new class of value creators and urban/user partners must be supported by the smart city technology framework, which must grow outside the typical municipal customers.
- ➔ To achieve a set of results, the smart city is an intricate network of individuals, processes, laws, technological advances, and other facilitators. The municipality is not the sole proprietor of the smart city. There are other value producers participating as well, occasionally working alone and other times collaborating. Smart cities that are profitable

and environmentally friendly involve their stakeholders throughout the ecological system through a programmed strategy.

Chapter 5: Conclusion and Recommendations

5.1 Major Findings

Finding 1: Smart city initiative failed mainly due to operational and governance fragmentation instead of technological immaturity.

The first objective of the study is to identify the challenges faced in the smart city movement and infrastructure development in smart cities. It is analyzed that the smart city movement faced issues associated with organizational and managerial issues, such as the size of the project, diversity of users or the organization, behavior of the manager, and inconsistency between the organization's projects and goals, and turf and conflicts. There are also technological issues linked with the shortage of IT skills and organizational difficulties. There are also infrastructural issues, such as a lack of knowledge linked to interoperability, pricing, and availability of software systems and applications, operational costs, and security and privacy.

Further, there are challenges related to the city's geographic location, as well as the European cities' governance structured need to adapt more, and their economies need to become more recession-proof. The city's transportation system needs to transition to one that is inclusive, sustainable, and efficient. Due to geographical situations and a higher level of urbanization, cities in the South and East Mediterranean need to concentrate on offering services to their residents. They faced issues such as a lack of resources, involving food and fresh water, poverty, urban insecurity, unstable governments, and even elevated rates of violence and corruption. It is evaluated that smart cities faced issues related to city traffic, citizen behavior, and city planning.

Additionally, smart city's facing issues, including defining the ecosystem position of the city administration, having a team of experts lead the SC growth, developing an internal coordination mechanism (since there was no framework to discuss SC projects); controlling the relationship between IT and business; the requirement for forward-thinking workers who are motivated to work

in a SC; and moving from the experimental phase, where SC projects get stuck, to a real implementation. Moreover, challenges associated with specific domains, such as farming, in which one of the main issues is that cities are taking up fertile land of farmers, so they ought to oversee producing food that comes from the land. The transportation of imported products from their production locations uses more resources than they do to provide nutrition.

Considering that education issues are associated with connecting and expanding the learning services offered by smart education with other contextually aware SC systems. It is observed that new technologies in smart learning environments create difficulties for the fundamentals of education itself, necessitating adaptation and the introduction of ideas such as teacher learning leadership, educational structures, and educational ideology. Considering energy as one of the domains, reducing energy intensity and achieving energy efficiency are important for sustainable growth. Motivating and engaging citizens in this process is a serious challenge. CT integration cannot be accessible to all citizens and may not be energy-sustainable in the field of SCs.

Environmental challenges associated with cybersecurity and resilience of the paradigm itself to prevent unpleasant surprises and safeguard basic human needs. The issues identified are linked to IoT-based governance, as investment in ICT, mindsets, or the process of persuading entities to change, as administration systems tend to be rigid, and security and privacy. In the health context, sensor-related issues occur at the time of monitoring. The primary issues differentiating include precision of monitoring, awareness of context, human factors, heterogeneity, availability and reliability, data transmission, security and privacy, intrusiveness, and power consumption.

Finding 2: - The abundance of data is not accompanied by decision value without combining lifecycle-oriented data management structures.

Furthermore, the second objective is to investigate the needs and different aspects of data collection and management in smart cities from the perspective. It is determined that data is being used by the government in all aspects of its operations more. In the case of government, data science is considered a process of taking unstructured and structured data, which can be closed or opened, using it to extract, interpret, and present insights. Government data scientists need a wide knowledge of statistics and data analytics to analyze data. They must also be informed about the

application of tools and methods of predictive analysis and the display of results. Governments should pay attention to the field of data science since they are receiving numerous data in numerous areas (energy, social security, transportation, and geography, to name just a few) which can be improved or integrated with the information of smart devices, data of the private sector, and other sources, such as social media, discussion boards, and other devices.

Some of the technologies that were involved included big data, artificial intelligence, IoT, and cloud computing. Among them, some of the devices are readily implemented in the event of IoT mobile devices and with cloud consideration. It is noted that a good smart city solution will embrace the actual environment of the city and not avoid the exploitation of older digital and non-digital technologies. Implementation of smart city projects assists in decelerating and accelerating by engaging various aspects. Digital technology is also a significant consideration in the smart city environment, and it aids in the acceleration of activities in an efficient way.

Information can be used as a springboard for the innovation of new, imaginative uses to bring civic principles of responsibility, security, and safety. Data science entails the use, dissemination, and interpretation of data as important elements in bridging the communication gap between the government and the people. Sharing data platforms may be created. Smart cities are often thought of as constellations of instruments functioning at different sizes and connected by several networks, which facilitate the flow of decisions about a city's physical and social structure. People and material movements are continuously recorded by these devices. However, for cities to be deemed intelligent, intelligence functions must be able to synthesize and integrate this data to improve sustainability, equality, efficiency, and quality of life. Traffic flows were the first data in cities to be automatically sensed, although databases holding a variety of spatial data date back centuries.

The world is getting more data-driven because everywhere there is the growing sprouting of digital information about every aspect of human life, and studies of the trends of human behavior and digital traces of human behavior. Applications and data activation analysis are useful in smart cities. Big Data is large volumes, types, and/or changeable information, speed, and/or information, which should be effectively stored, processed, and analyzed at a scalable architecture. Big Data

from sensor networks and satellite imaging enables increasing measurements of environmental and developmental variables. Of the 6 billion mobile phone users worldwide, 80% live in developing countries. Researchers have access to a daily-updating network of social sensors due to its widespread occurrence. Big Data is a revolution that will change people's lives, careers, and ways of thinking. After cloud computing and mobile networks, big data has gradually become a technology that has a big impact on the ICT industry.

The external data (including weather and pollution data) are integrated and presented in integrated platforms to gather data on the city level, where it is mostly beneficial to energy providers and the public administration to create a complete image of the data related to the smart city, and provide the individual citizens with a personalized access to the useful information at the scale of a single neighborhood, building, or apartment. Social media data is also added, and users have an opportunity to create their own data, post comments, recommendations, and preferences. In addition to human activity, a multitude of sources, including smart cities, Internet of Things (IoT) devices, scientific modeling, and different big data simulations, are producing vast amounts of data. The continual addition of new data to historical collections makes the huge and complex world of digital data conceivable. Recently, the Fog-to-Cloud (F2C) data management architecture has been developed to handle the complexities of big data, including IoT devices, which are the closest layer to users, cloud technologies, which are the furthest layer from IoT devices, and various information phases from creation to application, spanning the fog-to-cloud scenario. Additionally, the combination of cloud (centralized) and fog (distributed) technologies can improve security while reducing network traffic and latency times, among other benefits for the F2C data management architecture.

On the other side, big data is mainly used to promote accountability and decision-making, managing the allocation of funds, assessing whether funds are going to the appropriate location, overseeing, and evaluating to spot trends over time, ascertaining whether these trends were brought about by a particular intervention, and pinpointing additional variables that might have contributed to the results zero emission neighborhoods data management architecture based on a distributed hierarchical F2C data management. 6Vs big data challenges such as Volume, Variety, Velocity, Variability, Veracity, and Value. Assessing the data management architectures, which included

ZEB and ZEN. The findings indicated that the ZEN data management architecture can manage the data lifecycle from production to consumption and can effectively handle 6Vs challenges.

Finding 3: Conventional operations models (TQM, Six Sigma, GLSS) are useful and inadequate unless they are adjusted to the multi-agencies and services continuity settings.

The third objective is to explore the role played by the current operation management framework(s) in meeting multidimensional needs (Efficiency, Sustainability, and social security). It is evaluated that one of the most common operational management frameworks includes TQM. The research emphasizes analyzing the influence of TQM on the performance of the organization. The study focuses on the effect of TQM on small and medium enterprises' performance. It is observed that executing TQM helps elevate the quality and enhance the performance of the business in the service segment. This approach comprises different elements involving customer focus, obsession with quality, continual process improvement, unity of purpose, teamwork, education and training, and involvement of employees. Customer focus has gained less influence on the performance of the organization.

The effect of TQM operations capability and supply chain management practices on the firm's performance. The research aims to determine and explain the structural relationship between and among TQM, operational performance, and supply chain practices. Using longitudinal data, the model's variables' short- and long-term effects could be ascertained. Analyzing how operational capability affects the supply chain and other broader aspects is also necessary. The manufacturing company involved in export operations will be impacted by this study, which will also enhance the company's performance in terms of supply chain impact and quality management techniques. Smart cities also emphasize employing technology and data to increase sustainability, efficiencies, and economic development, and to improve the quality of life in urban areas.

It is determined that clean technologies help in the promotion of the development of smart cities, involving health, energy, and transportation. The concept of a smart city is ambitious and involves refined and standardized aspects. It is determined that smart cities are sustainable and intelligent cities. They are also well-known as smart cities and require novel technologies involving sensor devices and robust ICT infrastructure. The research depicted the size domains of the smart city, such as smart education, mobility, economy, governance, health, and energy. There is a need for

smart city projects to present details on the adoption of global standards and its implications for smart cities. This study helps serve as a guide and, along with this, constitutes an identifying perspective through which total quality management can be executed in the organization. This helps in considering the aspects of total quality management, and along with this emphasizes building perspective through which development in the city can be carried out efficiently.

It is observed that in developing countries, managing water is still an issue that needs to be addressed. The adoption of an operational framework supports providing insight related to different aspects of techniques and tools, which supports making a system of service delivery and production of items faster while providing fewer errors. It places strong emphasis on minimizing human disruption by establishing a healthy workplace, handling difficult choices, and offering automation solutions for taking healthcare facilities into consideration. By making use of the workforce, shortening hospital stays for patients, and boosting value-added time for medical personnel, this strategy also helps healthcare institutions expand their current capacity. This results in fewer patients at medical facilities and enables hospitals to use their full capacity.

Apart from this, six sigma is another operational management framework that supports managing quality in the organization. It is established that contemporary organizations entail activities that assist them in offering a competitive edge in the global market. As it is noted, the Green Lean Six Sigma (GLSS) is a comprehensive strategy that can help to increase the level of environmental sustainability and contribute to the financial stability of companies as well. Green, lean, and Six Sigma initiatives must be introduced in the implementation of the GLSS strategy. The adoption of the GLSS strategy has been put forward through the intangible characteristics that include toolsets, enablers, etc. The efforts of a team, involvement, and management commitment have been viewed as impressive features in the implementation of GLSS in the manufacturing segment. Along with this, the study also touched upon five dimensions associated with the GLSS construction of manufacturing businesses in growing sustainability within the organization. The study enables practitioners and managers to implement the GLSS program in the manufacturing business to promote operational excellence and sustainability in the environment.

In smart cities, the use of six sigma creates complexity and presents management challenges. It is determined that smart cities are intelligent and considered to depend on technology at the time of their development of smart cities. A new method has been proposed that supports combining the methods of Six Sigma. The performance of smart cities was tested and integrated with the processes that were discussed in the research. The research also focuses on factors for all constructs of the DMADIDC method for retrieving and involving various perspectives associated with the conceptual framework developed. The evolution of a smart city is one of the ways digital technologies are used to serve residents better. The contemporary market environment is turning into smart cities, which are becoming a buzzword, and addressing the obstacles impacting development.

It is determined that smart city objectives were achieved as BDA played an important role, and its application leads to analyzing the applicability towards achieving sustainability in the long run. The study focuses on how big data can be adopted to attain the development of smart cities. It is noted that the research barriers give precedence and favor the urban planner to make choices related to the adoption of BDA. The study focuses on the BWM technique that assists in achieving objectives and conducting business in the long term.

Finding 4: The efficacies of decision-making frameworks lie at certain levels of governance and fail in urban adaptation, being dynamic and long-term.

The fourth objective is to examine the applicability, advantages, and limitations of different operation management frameworks in decision-making for smart city operations. It is observed that the supply of clean water, energy, and nutritious food for a growing population is affected by limitations on vital infrastructures and the availability of resources. Cities are experiencing pressure on public finances to cut spending and execute cost-cutting measures. Paradigm shifts towards online services, worries about climate change, and restructuring of the economy aimed at lowering unemployment. Intelligent approaches are required to handle urban issues and to revitalize urban life, effective infrastructure, and high-quality services for residents. Enhancing citizen quality of life, environmental efficiency, security, and sustainability through centrally managed and monitored technology infrastructure is the main goal of the development of smart cities.

It is determined that sustainability and global resource efficiency are predicted to be achieved largely with the help of the use of smart and sustainable cities. A comprehensive framework used to determine a database of key performance indicators can assess new and innovative services and technologies linked with smart city solutions, in addition to standard technologies. The six steps in the framework, such as technology solutions, are grouped into groups known as transition tracks. Key stakeholder groups are defined, KPI dimensions are defined, the KPI repository is defined as a dimension, the scope of the evaluation is defined per KPI, and the threshold definition is defined per KPI. Smart cities are compared to less well-liked alternatives like resilient and sustainable cities. Resilient cities originated from designers and planners questioning the need to swiftly and effectively recover from urban perturbations, which are frequently connected to climate change.

Innovation is positively affected by smart cities. Cities act as a natural knowledge hub by promoting the creation, dissemination, and accumulation of knowledge. Moreover, cutting-edge in-person communication technology reduces the transaction costs associated with knowledge processing. ICT enhances urban innovation in a good way. Smart city policies boost urban innovation by utilizing city agglomeration and technologies. Improvements in local production function knowledge can be used to enhance the innovation processes. A smart city increases a city's knowledge base and enhances its general high-tech innovation, mainly in the areas of ICT and IoT, which are the primary forces behind green growth. Green technology played a major role in assisting with environmental management. Using an innovative-driven approach, lessen the environmental damage brought on by the world's fastest rate of urbanization. Smart cities have comparative advantages in innovation, and more cutting-edge green technologies are being integrated into production chains, boosting output and saving environmental costs. ICT support city administration advance to a new level. Innovation makes it possible for smart cities to optimize industrial structure and scale efficiency in the functioning of urban economies in terms of resource allocation. Smart city policies have the potential to significantly enhance environmental quality through more effective resource allocation and the promotion of technology, mainly green technology.

On the other hand, challenges are linked with organizational and managerial challenges, including the size of the project, the attitude and behavior of the manager, the diversity of users or the organization, the inconsistency between the organization's goals and projects, the presence of multiple or conflicting goals, the resistance to change, and turf and conflicts. Issues are associated with a shortage of IT skills and organizational difficulties. Challenges are also related to data sharing, accountability, transparency, leadership and championing, participation and partnership, and integration of services and applications. This involves infrastructure and applications' lack of knowledge about interoperability, limitations on internal systems security, and privacy and operational costs.

Issues are also linked with geographical circumstances and higher levels of urbanization, such as cities in the South and East Mediterranean, which concentrate on offering basic services to their residents. Additionally, many serious difficulties, including a lack of resources, including food and fresh water, poverty, urban insecurity, unstable governments, and even elevated rates of violence and corruption. Progress toward a better urban future, these issues need to be resolved. Issues related to city traffic, citizen behavior, and city planning. Traffic in cities is challenging for the algorithms to effectively use all the different types of data sources. Further, challenges are linked with their efforts to become an SC, defining the ecosystem position of the city administration, having a team of experts lead the SC growth, and developing an internal coordination mechanism, controlling the relationship between IT and business, and the requirement for forward-thinking workers who are motivated to work in an SC and moving from the experimental phase, where SC projects get stuck, to a real implementation.

There are also monetary issues, such as funding SC initiatives being scarce, requiring substantial upfront investment, having no business plan, and having trouble making money off of SC investments. The administration difficulties resulted from out-of-date laws and rules that obstruct SC initiatives. Awareness is associated with difficulties relating to insufficient expertise and understanding of related technologies. Interoperability involves difficulties with integrating SC. Privacy support accepts the problematic nature of big data. Citizens have protected privacy. Further, challenges have been implemented considering that the water sector does not have drinking water, and there is no rainwater collection system. In the energy segment, electricity is

provided to all urban areas and does not have enough carbohydrates, even if they are mostly consumed.

The waste and sewage industry lacks an efficient system of waste collection, and open defecation issues, to which not every house is connected to sanitation, and no citizen is involved in waste disposal and sorting. The mobility sector also has a poor public transport system, which leaves citizens with no other alternative but to move around using private transport, and this is not even good when you factor in that the roads and infrastructure are not designed to accommodate a lot of traffic. The housing prices are increasing in the domain of the built environment, due to which a disadvantaged segment of the population is unable to have a home (the result is the establishment of informal housing without any basic facilities), and the cities have not expanded their infrastructure correspondingly with the increase in population.

Finding 5: Operational preparedness and evidence-based decision cycles are the key to smart city success and not a single strategic vision.

The last objective is to suggest strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities do you have any objective measures for these? What kind of proxies can be used to measure their appropriateness? These will be the outcome of someone's perceptions (who is going to be? What kind of criteria will be used for his/her selection?). It is determined that there are different categories of decision-making techniques, including integrated methods, mathematical programming, artificial intelligence, and multi-criteria techniques. A variety of methods for structuring and formalizing decision-making processes make up the multi-step process known as multi-criteria decision-making (MCDM). They allow decision-makers to find the optimum compromise between a variety of possibilities (criteria) by simultaneously analyzing options based on many dimensions. However, MCDM is thought of as a steady-state method that uses historical data to provide hotspot snapshots. Because of this, this method does not provide projections or future trends, nor does it consider the long-term interactions between different measures, outputs, and parameters.

By considering the constraints and various issues that must be taken into consideration for stakeholders to make a choice, mathematical programming (MP) techniques maximize goals. This

field has employed a variety of optimization approaches, such as stochastic programming, linear programming, goal programming, and data envelopment analysis. However, most mathematical programming techniques are too complex for non-expert stakeholders to use effectively, which is a significant disadvantage. In the context of smart cities and urban projects, there are three main levels of decision-making: tactical, operational, and strategic. The way authorities in smart cities address complex issues and the relationships between stakeholders are examined using the multi-level governance analytical framework. Decisions taken at the strategic level of decision-making are the basis for tactics and operations. The strategic level procedures and activities involve the formation of long-term goals, policies, and visions or values for the overall growth of the city.
The tactical level considers medium-term mid-level decisions to achieve the goals specified at the strategic level. This layer includes all stakeholders who regularly oversee projects, finances, and coalition and alliance development, as well as the creation of concrete agendas related to green spaces. Among these actors are planners and universities. Finally, the operational level deals with short-term vision experiments and activities, such as implementing objectives and completing concrete projects. Operational decisions in smart cities are mostly used to assess the results generated by lower-level managers or to offer operational remedies. Numerous innovative ideas, techniques, and tactics have highlighted the importance of including stakeholders, particularly users and citizens, in the development of collaborative decision-making processes for smart city projects. Although group decision-making was used in around half of the research, most decision-making tools and toolkits were created and applied by experts or authors alone.

Evidence-based decision-making is a dynamic process that includes obtaining, evaluating, and using evidence to support decisions in the context of all-sector management. The evidence must be appropriate for the context in which it is utilized and prepared in accordance with a rigorous process. The use of evidence-based decision-making in management is still very new; the examples that are currently accessible are primarily from formal research in the medical profession. Evidence-based management is a tactic that raises the standard of decisions and procedures by utilizing ideas from outside, systematic research. The complex daily activities of enterprises are called practice. The increased use of evidence in policymaking is hampered by stakeholder disagreement over what evidence is and how to interpret the data.

The evidence-based approach is upheld to ensure that the policies meet the real needs of the citizens, issues and problems that require immediate response are addressed, and information exchange among the different stakeholders is facilitated. The benefits of using evidence in policy making in public administration are too many, direct and indirect. Such are the benefits: support in enhancing decision-making. Evidence-based policy is needed by policy planners and policy makers, as well as other stakeholders, who are interested in the allocation of resources among competing policy priorities. They come up with research questions like how to use the funds in the most effective way, which options to use in case the resources are going to be more beneficial to people, and how the costs and benefits interrelate with each other.

The trend in the environment with the Internet connects information processing to all the actions that are encountered. A pervasive environment will call on the creation of numerous physical, real-world devices that will generate large quantities of data at a wide range of information that will need new modes of computation to assist in making better decisions. This enormous amount of information generated by ubiquitous devices will make the Internet a more dependable, useful, and diverse place. The innovation in ubiquitous computing is producing large-scale valuable data or information, and the potential of smart cities in terms of analytical amenities is enormous, with the assistance of Big Data tools and effective machine learning methods. Several concepts have been identified to process and analyze data generated by heterogeneous devices, enabling effective decision-making.

Table 2. Objectives, Key conclusion and Implication

Objective	Key conclusion	Implication
To identify the challenges faced in the smart city movement and infrastructure development in smart cities.	Operational fragmentation is the dominant failure factor	Operations must precede scaling
To investigate the needs and different aspects of data collection and management in	Lifecycle data architectures are important	Data governance is core infrastructure

smart cities from the perspective		
To explore the role played by the current operation management framework(s) in meeting multidimensional needs (Efficiency, Sustainability, and social security).	Frameworks require contextual adaptation	Hybrid operations models required
To examine the applicability, advantages, and limitations of different operation management frameworks in decision-making for smart city operations	Single method did not support decision levels	Layered decision systems required
To suggest strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities do you have any objective measures for these? What kind of proxies can be used to measure their appropriateness? These will be the outcome of someone's perceptions (who is going to be? What kind of criteria will be used for his/her selection?).	Measurable operations enable resilience	KPIs must be operational, not aspirational

5.2 Recommendations

The projects developed in smart cities will fail (or not be successful), not due to the ineffectiveness of technologies, but because the operations are considered an add-on. Cities buy platforms and sensors, initiate pilots, declare dashboards, but fail to sustain value because of the lack of clarity in accountability, part-way ownership of services, fragmented data management that is not efficient, ineffective maintenance, and strained performance management. Smart city investment is a long-term undertaking of the right operations structure, and it transforms investments into services and balances the stakeholders, introducing unending improvement. These recommendations have been categorized as follows to assist the concerned leadership of the city, program managers, and owners of these types of infrastructures in actualizing the dreams of smart cities, enabling their quantification.

Build a clear operating model before scaling tech: - Smart cities initiatives failed mainly because they adopted solutions without agreeing on day-to-day operations in the city. They should adopted operating models including proper governance, service delivery, data operations, and technology operations to streamline the city's development. Creation of the service catalogue includes prioritizing services such as traffic, water, waste, and safety in the city. Adopt a minimum viable operations strategy: do not go citywide until you have demonstrated operations in 1 -2 zones with quantifiable results.

Treat smart city services as 24/7 operational products: - The smart infrastructure cannot be placed and left alone. It needs to be monitored, responded to, and maintained and optimized continuously. Smart cities should emphasize building a city service operations center by creating a central dashboard for service health, monitoring, and predictive maintenance. Departments are analyzing response time, resolution time, and field repair windows. Cities should focus on standardizing operational workflows such as planned maintenance scheduling, change management, and reviews of post incident and corrective actions.

Building talent and change management plan: - Most cities do not even understand the needs in capabilities: data engineers, cybersecurity, OT experts, product managers, field technicians, and service managers. Cities should emphasize creating skill mapping in OT operations, networking,

cybersecurity, data engineering, analytics, service management, and urban planning. Cities should emphasize using mixed capability strategies, such as internal training on some of the rotations and certifications, outsourcing capabilities of the areas where the level of risk is quite high and creating local talent networks through training partners. Investing in change management includes redesigning processes, setting up adoption KPIs, engaging frontline staff, and using feedback loops.

Enhancing procurement and vendor management for long-term operations: - Cities should focus on using performance-based contracts with operational KPIs. Developing strong provisions such as source documentation, operational manuals, and architecture diagrams. Implementing a vendor scorecard to deliver quality, compliance, security posture, and control cost. Avoiding fragmented procurement by standardizing domains such as common IoT device standards, sharing cybersecurity requirements, and adopting a unified approach.

Build an Integrated Operations Center with Tiered Support: - Smart cities require a central operational nerve center, but not necessarily a single giant so-called command center, which tries to do it all. The combination of incident coordination and performance, as well as department retention as domain owners, has proven to be a tiered and integrated model. Development of an integrated City Operations Center (COC) helps monitoring infrastructure, IoT, and citizen reports, and creates situational awareness during emergencies. Implementing the support model and standardizing incident categories and prioritizing levels across departments, avoiding firefighting.

Adopting a standard operations framework and localizing it: - Structures such as ITIL (service management), ISO 55000 (asset management), and ISO 27001 (security) offer established designs, but they need to be changed to fit the city. Using an IT service management approach for digital platforms such as ticketing, monitoring, and change control. Usage of asset management discipline for physical infrastructure, considering the asset registry, maintenance schedules, and replacement planning. Creating a localized smart city operations playbook combination including service management processes, field operations processes, data governance, and citizen engagement processes.

Creating integrated governance with clear decision rights: - Smart city initiatives take up interdepartmental, inter-utility, vendor, and regulator roles. Absence of good governance will lead

to duplicated systems, no accountability, and procrastination in making decisions. The city should be run in a manner that is not overly fast and transparent. Cities should emphasize setting up a Smart City Program Management Office (PMO) with authority to coordinate standards, timelines, and budgets. Defining RACI matrix for different domains such as cybersecurity, platform operations, procurement, field operations, citizen, and finance. Developing a multi-agency committee by a senior executive with the power to resolve conflicts and unblock decisions.

Build operational readiness into infrastructure projects: - Infrastructure projects often consider operations as a handover activity. The design of the operations in smart cities must be performed early because sensors, platforms, and field groups create continuous working processes, which demand staffing, training, and maintenance budgets. Cities require an operational readiness & transition plan for every smart infrastructure project. Developing asset management practices using ISO-aligned approaches, such as condition monitoring, preventive maintenance schedules, and a vendor support model.

Building a sustainable funding model for operations and maintenance: - Many smart-city projects are now being rolled out with state-funded grants or even special budgets, which do not take into consideration the long-term maintenance. Cities need financial models of OPEX and renewals. Creating a total cost of ownership model for the initiative, considering devices, connectivity, cloud costs, and maintenance staffing. Treating data platforms and cybersecurity as an important infrastructure, not discretionary IT.

Strengthening citizen engagement and trust through transparency: - The success of smart cities requires adoption. Individuals must observe actual changes and believe that their information is utilized properly. Cities should publish service dashboards for metrics and use multi-channel service access, along with ensuring digital inclusion and maintaining transparency on the usage of data.

Building reference architecture and enforcing it: - Cities should emphasize defining standard building blocks, such as the integration layer, data platform, security, and monitoring. Mandating

architectural review before the department buys new systems. Keeping a no-duplicate platform rule unless there is a strong reason.

Building strong incident command for multi-agency events: - Cities should focus on emergencies, such as defining an incident command structure with pre-agreed roles. Running regular drills combining police, utilities, hospitals, and transport. Standardizing communication channels and escalation procedures.

Building a regulatory and compliance management layer: - Cities should maintain a compliance mapping for privacy laws, surveillance rules, and retain data, along with infrastructure safety requirements. Further, creating audit-ready documentation, including SOPs, system logs, and changing history.

Executing identity and access management across the ecosystem: - Cities should adopt centralized SSO for vendors and staff. Adoption of role-based access control (RBAC) and time-bounding access for contractors. In addition to this, maintain audit logs for sensitive systems.

Prioritizing equity and inclusion operationally: - Cities should focus on the design of service delivery, avoiding digital exclusion. This further focuses on multiple access channels, local language support, and accessing UI/UX. Measuring adoption and service levels through neighborhood.

Priority 1: Developing a smart city operations model and PMO (derived from findings 1 and 5): - The creation of a Smart City Operations Model and PMO will be central to the planning, coordinating, and monitoring of smart city projects. It guarantees alignment of cross-departments, standardization, performance and risk tracking, optimization of resource utilization and enhanced sustainable operational effectiveness within integrated urban services.

Priority 2: Implement Integrated Operations Center with tiered support (Derived from 3rd and 4th finding): Introduce even stronger degrees of tiered support (L1-L3) in Launch Integrated Operations Center to provide the ability to monitor in a central manner, identify incidence much faster, and escalate in a linear manner. The model enhances the coordination of the cross activities

team, minimization of the resolution time, responsibility and proactive operation of the standard workflow and real-time visibility.

Priority 3: Institutionalize performance-based vendor and data governance (Derived from 2nd and 5th findings): To institutionalize performance-based vendor and data governance would entail establishing unmistakable KPIs, SLAs, and data quality thresholds, which are connected to the process of vendor evaluation and renewal. Periodic audits, reporting and frameworks of corrective actions, lead to sustained performance, data integrity and alignment with organizational goals.

5.3 Limitations

There are various limitations in this study that can impact the extent to which the study can be generalized to various applications in the smart city setting. First, smart city initiatives in different nations differ greatly in terms of country, form of governance, financing, and legacy infrastructure, and thus an operational framework that succeeds in one city cannot be easily migrated into another city. Second, the research might be based on secondary data (policy documents, project reports, vendor claims), which might be incomplete, selectively reported, or inconsistent among initiatives. Third, operational effectiveness is a measure that is difficult to assess due to the impact of numerous external influences, such as service quality, citizen satisfaction, resilience, and cost efficiency, which are affected by political cycles, regulatory shifts, population growth, and economic shocks. Fourth, the scope can fail to represent informal settlements and low-resource settings where limitations are not as blurred as in a planned city area. Lastly, the conclusions may become time-bound due to rapidly changing technologies (IoT, AI, data platforms), which do not allow making long-term generalizations.

5.4 Contribution to the study

The research is relevant because it provides a connection between the theory of Operations management and the current reality of smart city initiatives, as well as large-scale infrastructure development, where the advice is likely to be divided among technology, policy, and project delivery spheres. It explains how a good operations framework could be implemented throughout the smart city lifecycle, planning and procurement, implementation, service delivery, and

continuous improvement. The research provides a systematic means of determining preparedness, governance, and capability disparities, which demonstrates the effect of issues such as standardization of processes, performance measurement, risk management, and inter-agency coordination on the results in terms of reliability of services, cost control, and citizen satisfaction. It also adds a management-oriented perspective, as it clarifies how leadership choices, distributing resources, and changing management influence the process of technology adoption and long-term sustainability, instead of considering smart city projects as digital-only projects. Incorporating operational measures and accountability measures, the study provides a practical foundation of benchmarking and comparison of efforts in different contexts. Overall, it assists policymakers, city managers, and project teams with practical information to enhance discipline in their delivery and minimize the rates of implementation failures, and to harmonies smart city investments with measurable operational and social benefits.

5.5 Future Research

Future research into the successful operations structures in the smart city trend should transcend conceptual frameworks and experiment on what works in different contexts of governance and infrastructure. First, the study can develop and test operational maturity models of cities that would be able to tie the capabilities to integrate services, respond to incidents, control assets, and support citizens with quantifiable outputs, including uptime, safety, economical operation, and user satisfaction. Second, scientists should also examine management procedures that could support the sustainability of activities in the long-term that include cross-agency coordination, vendor governance, data-sharing deals, workforce upskilling, and continuity of piloting funds. Third, the need to compare the work based on the typologies of cities (large vs mid-sized, high-income vs resource-constrained) should be very high to comprehend what practices can be best adapted and which ones will have to be changed. Further work should include the interaction with physical infrastructure (transport, water, energy) during disruptions of the digital infrastructure (IoT platforms, data hubs, command centers), which will be measured in the resilience metrics and stress tests with the help of simulations. Finally, the ethical and political issues of the operations (especially privacy-by-design, accountability of the algorithms, and equity impacts) can be studied to discover that the operational efficiency does not contribute to the increase of exclusion.

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APPENDIX

Thematic Analysis
On

Examining the applicability of effective operations framework and management in the smart city movement and infrastructure development

The social topicality of the third millennium is the so-called smart cities, which are based on the provision of Smart technology to improve the performance of urban systems, management, and residents' quality of life. Currently, cities globally seek to learn how other cities have integrated frameworks and management structures to design and implement intelligent sustainable cities. However, these efforts are often faced with some challenges given the fact that cities consist of interacting systems of social, technology, economic and environmental systems. Thus, the study of the applicability of effective operation framework and management in smart city infrastructure development is very important to ensure that the initiatives are successful.

The objective of the research is to analyze the readiness and feasibility of the discussed frameworks in focusing on smart city projects, looking at the related governance, technology, and infrastructural field relatively. Thus, the research focuses on detailing how operations frameworks are implemented across various municipal level and its result unveils the best practices for this implementation and discovers potential obstacles for efficient operations. However, smart cities require multisectoral cooperation, which means that different viewpoints must be considered and those of city planners, technology vendors, government agencies, and citizens.

Due to the emergent nature of smart city development, there is a deficiency in existent research that examines the ideal operation models and management aimed at smart cities. This research therefore, adopts an exploratory research design enabling the research to adapt as it undertakes investigation on the specificities of smart city development. Quantitative survey questions, sampling from stakeholders of different types of frameworks for action, will collect further information about the usefulness of different types of frameworks and the conditions under which each is optimal. By means of this analysis, the study advances the theoretical and empirical knowledge on how smart cities can grow into feasible functional Urban Systems.

Familiarizing with the Data

The familiarization process is meant to help the reader get acquainted with the research topic and goals. On that note, this research aims at examining Danish experience with a view to establishing how operations frameworks and management systems can be applicable in developing smart cities. The study will seek to understand how cities can adapt and adopt these frameworks to improve urban structures, administration and wellbeing of the inhabitants.

The purpose of the research is therefore to evaluate the preparedness and sustainability of these current operations frameworks and management systems in regards to smart city projects. Such frameworks consist of governance elements, technology, and infrastructure assets. Knowledge of their efficiency and flexibility will enable cities to better design and orchestrate a sustainable smart city.

The focus areas are: the parts played by municipal management in the implementation of smart city projects (Governance), the manner in which smart technology is implemented into the overall management of cities (Technology), and the structural and architectural needs of smart cities (Infrastructure).

Proper planning of the smart cities is important therefore involves players such as urban planners, and technology industries, governments and citizens. Every stakeholder holds different perceptions and demands which may create issues with creating integrated solutions. Most cities are composed of coupled socio-technical-economic environmental systems that are interconnected and dynamic. Such a distribution of IT consumption across sectors brings in the challenge of impossibility of having a standard framework for smart city development.

There is relatively little empirical literature dedicated to defining the best practiced models of Smart City management. Since the issue is emerging, the study embraces an exploratory research design to collect data and information using quantitative questionnaires on various framework models from stakeholders' sampling.

The source of the data for the study will involve the administration of surveys to stakeholders involved in smart city projects, including municipal authorities, vendors, developers of smart city infrastructure, and individuals or users of the intelligent cities. The survey aims to gather insights on: the applications of various operations frameworks, when these frameworks are most effective, and the challenges arising in the development of smart city operations and management systems.

One of the main trends distinguishing all the analyzed data is flexibility within smart city paradigms. The fact that cities are very different means that the useless frameworks that help in one city do not need fixings in another. It is thus of paramount importance for the chain's operational management that specific contextual factors that underpin success be identified.

Another big trend is a call to increase effective governing institutions and their coordination. The establishment of smart cities entails integration of various stakeholders in order to achieve a single vision of the city.

The next step includes operationalizing or coding of the survey data rely on the highlighted themes above. By employing thematic analysis on the collected data, patterns and trends that stakeholders have towards and with their smart city projects will be determined thus; improving the understanding on how operational frameworks and management structures can be fashioned to enhance the expressions of smart cities.

Initial theme and sub-theme development:

1. What are the key challenges you face regarding smart city movement and infrastructure development?			
Theme 1: Financial Viability and Funding Challenges Sub-theme 1.1: Balancing Cashflow **Balancing Cashflow**	**Theme 2: Integration and Interoperability** Sub-theme 2.1: Integration of Legacy Systems	**Theme 3: Governance and Stakeholder Engagement** Sub-theme 3.1: Governance Challenges	**Theme 4: Infrastructure and Urban Planning** Sub-theme 4.1: Infrastructure Scalability

Private sector capacity Sub-theme 1.2: Long-term Funding Funding Sub-theme 1.3: Financial Viability Cost Risk Management **Theme 5: Security and Data Privacy** Sub-theme 5.1: Data Security Data Security Security	Integration Technology Quality Sub-theme 2.2: Standardization Standardization **Theme 6: Environmental and Social Considerations** Sub-theme 6.1: Environmental Impact Environmental Impact Sub-theme 6.2: Social and Economic Factors Facilities for Public Social and Economic	Governance Coordination and Decision making Sub-theme 3.2: Stakeholder Resistance Stakeholder Resistance Not Accepting Change Sub-theme 3.3: Public Awareness Public Awareness **Theme 7: Challenges in Implementation** Sub-theme 7.1: Technology Quality Technology Quality Sub-theme 7.2: Obsolescence Obsolescence Sub-theme 7.3: Coordination and Decision-Making Coordination and Decision making	Infrastructure Scalability Sub-theme 4.2: Urban Planning Urban Planning **Theme 8: Regulatory and Policy Challenges** Sub-theme 8.1: Governance Challenges Regulatory Challenges Sub-theme 8.2: Government Focus on Temporary Solutions Lack of Vision Government Focus on Temporary Solutions
2. In your opinion, what elements are crucial for developing an effective operations management framework in smart cities?			

Theme 1: Financial and Economic Sustainability Sub-theme 1.1: Financial Planning and Compliance **Financial Sustainability** **Maintaining compliance** Sub-theme 1.2: Risk Management and Contingency Planning **Backup plan & action** **Focus on Temporary Solutions** **Theme 5: Citizen Engagement and Participation** Sub-theme 5.1: Citizen Engagement **Citizen Engagement**	**Theme 2: Technology Integration and Infrastructure** Sub-theme 2.1: Smart Technology Implementation **Appropriate Technology** **Risk Forecasting** Sub-theme 2.2: Infrastructure Development **Infrastructure** **Monitoring, Safety & Control** **Theme 6: Performance Measurement and Human Resources Development** Sub-theme 6.1: Human Resources Development **Performance Measurement** **Human Resources Development**	**Theme 3: Data Management and Security** Sub-theme 3.1: Data Governance and Privacy **Data Sharing** **Digital Security** Sub-theme 3.2: Data Integrity and Accessibility **Availability** **Integrity** **Confidentiality** **Accountability** **Theme 7: Sustainability and Long-term Planning** Sub-theme 7.1: Sustainability **Sustainability** **Risk Forecasting** **Backup plan & action**	**Theme 4: Governance and Policy Implementation** Sub-theme 4.1: Policy Frameworks and Compliance **Governance and Leadership** **Accountability** Sub-theme 4.2: Stakeholder Engagement and Accountability **Stakeholder Engagement** **Government Policies & Strategies**
3. What are the challenges you have encountered in the operations management of smart city projects?			

Theme 1: Governance and Policy Sub-theme 1.1: Regulatory Compliance and Legislative Hurdles **Legislation** **Public Support** **Regulations** **Governance** Sub-theme 1.2: Stakeholder Engagement and Resistance **Definition Clarity** **Stakeholder Engagement** **Local Support** **Public Acceptance** **Theme 5: Infrastructure and Maintenance** Sub-theme 5.1: Infrastructure **Land Acquisition** **Maintenance** **Infrastructure** Sub-theme 5.2: Maintenance **Traffic Management**	**Theme 2: Financial Constraints** Sub-theme 2.1: Budgetary Limitations and Funding Issues **Cost** **Funding** **Cost-Benefit** Sub-theme 2.2: Economic Considerations and Cost Management **Economic Improvement** **Economic Consideration** **Theme 6: Collaboration and Inclusivity** Sub-theme 6.1: Collaboration **Stakeholder Engagement** **Collaboration** **Inclusivity**	**Theme 3: Technology and Data Management** Sub-theme 3.1: Data Security and Privacy Concerns **Privacy** **Security** **Data Usage** **Integration** Sub-theme 3.2: Technological Complexity and Integration **Data Management** **Cybersecurity** **Technical Complexity** **Digital Execution** **Theme 7: Scalability and Sustainability** Sub-theme 7.1: Sustainability **Scalability** **Success Measurement** **Evaluation** **Sustainability**	**Theme 4: Human Resources and Expertise** Sub-theme 4.1: Vendor Management and Outsourcing **Vendor Maturity** **In-house Expertise** Sub-theme 4.2: Talent Acquisition and Skill Development **Skilled Resources** **Exposure** **Skilled Professionals** **Theme 8: Efficiency and Management** Sub-theme 1.2: Management **Efficiency** **Management** **Implementation**

Energy & Waste Management			
4. In your opinion, what is the most crucial type of data that needs to be collected for effective management of smart cities?			
Theme 1: Infrastructure and Asset Data Sub-theme 1.1: Utility and Asset Management Data **Utility data** **Asset conditions** Sub-theme 1.1: Management Data **Infrastructure data** **Maintenance data** **GIS data** **Building data** **Theme 5: Environmental and Stormwater Data** Sub-theme 5.1: Environmental and Stormwater Data **Environmental data** **Stormwater data** **Theme 9: Historical and Big Data**	**Theme 2: Real-Time and Sensor Data** Sub-theme 2.1: Real-Time Monitoring and Sensor Data **Real-time data** **Sensor data** Sub-theme 2.2: Public Safety and Operational Data **Public safety data** **Operational data** **IoT data** **Theme 6: Citizen and Population Data** Sub-theme 6.1: Citizen and Population Data **Citizen data** **Population data** **Theme 10: Economic and Financial Data**	**Theme 3: Traffic and Transportation Data** Sub-theme 3.1: Traffic Flow and Transportation Data **Traffic data** **Transportation data** Sub-theme 3.2: Vehicle Data **Vehicle data** **Theme 7: Performance and Growth Metrics** Sub-theme 7.1: Performance and Growth Metric **Growth data** **Performance metrics** **Performance data** **Theme 11: Skilled Manpower** Sub-theme 11.1: Skilled Manpower	**Theme 4: Government and Administrative Data** Sub-theme 4.1: Government data **Government data** Sub-theme 4.2: Administration data **Strategic plan data** **Administrative data** **Theme 8: Geospatial and Geographical Data** Sub-theme 3.1: Geographical Data **Geospatial data** **GIS data**

Sub-theme 5.1: Historical and Big Data **Historical data** **Big data**	Sub-theme 6.1: Economic and Financial Data **Economic data** **Comprehensive data**	**Skilled manpower**	
5. What are the most effective methods for collection of data in Smart cities?			
Theme 1: IoT and Sensor-Based Data Collection Sub-theme 1.1: IoT Sensor Networks **IoT Sensors** Sub-theme 1.2: Real-Time Data Integration **Real-Time Data** **Environmental Monitoring** **Smart Meters**	**Theme 2: Citizen and Public Engagement** Sub-theme 2.1: Citizen and Public Engagement **Citizen Feedback** **Surveys** **Crowdsourcing** **Mobile Devices**	**Theme 3: Geospatial and Mapping Techniques** Sub-theme 3.1: Mapping Techniques **GIS Mapping**	**Theme 4: Open and Public Data Platforms** Sub-theme 4.1: Public Data Platforms **Public Data Platforms**
6. How effective is the current operations management framework in addressing the efficiency needs of smart cities?			
Theme 1: Coordination and Planning Sub-theme 1.1: Cross-Functional Coordination	**Theme 2: Financial and Budgetary Constraints** Sub-theme 2.1: Budget Constraints **Budget Constraints**	**Theme 3: Data Utilization and Technology** Sub-theme 3.1: Data-Driven Decision-Making	**Theme 4: Citizen and Public Involvement** Sub-theme 4.1: Citizen Engagement **Citizen Engagement**

Cross-Functional Coordination Sub-theme 1.2: Comprehensive Planning **Comprehensive Planning** Sub-theme 1.3: Incongruence Between Plans and Actions **Incongruence Between Plans and Actions** Sub-theme 1.4: Lack of Common Framework **Lack of Common Framework** **Theme 5: Maintenance and Continuous Improvement** Sub-theme 5.1: Continuous Improvements **Continuous Improvements** Sub-theme 5.2: Transportation and Safety	**Theme 6: Gaps and Limitations** Sub-theme 6.1: Manual Processes **Manual Processes** Sub-theme 6.2: Negative **No idea** **Poor anticipation**	**Data-Driven Decision-Making** Sub-theme 3.2: ICT Implementation **ICT Implementation** Sub-theme 3.3: Data Management and Analysis **Data Management and Analysis**	Sub-theme 4.2: Public Works and Upkeep **Public Works and Upkeep**

Transportation and Safety Sub-theme 5.3: Proactive Maintenance **Proactive Maintenance**			
7. In what manner do the existing operations management frameworks contribute to the sustainability and social security of smart cities?			
Theme 1: Resource Optimization and Efficiency Sub-theme 1.1: System Efficiency **System Efficiency** Sub-theme 1.2: Energy Efficiency **Energy Efficiency** Sub-theme 1.3: Waste Management **Waste Management** Sub-theme 1.4: Resource Optimization **Resource Optimization**	**Theme 2: Technological Integration** Sub-theme 2.1: IoT Integration **IoT Integration** Sub-theme 2.2: ERP Solutions **ERP Solutions** Sub-theme 2.3: ICT Integration **ICT Integration**	**Theme 3: Safety and Security** Sub-theme 3.1: Public Safety **Public Safety** Sub-theme 3.2: Traffic Management **Traffic Management**	**Theme 4: Sustainability Practices** Sub-theme 4.1: Social Sustainability **Social Sustainability** Sub-theme 4.2: Best Practices **Best Practices**

Theme 5: Challenges and Limitations Sub-theme 5.1: Budget Constraints **Budget Constraints** Sub-theme 5.2: General Approval **General Approval** Sub-theme 5.3: No Opinion **No Opinion** Sub-theme 5.4: Lack of Sustainability **Lack of Sustainability** Sub-theme 5.5: Limited Contribution **Limited Contribution**			
8. What are the key benefits of different operations management frameworks in facilitating decision-making for smart city operations?			
Theme 1: Efficiency and Optimization Sub-theme 1.1: Efficiency **Efficiency**	**Theme 2: Communication and Collaboration** Sub-theme 2.1: Communication	**Theme 3: Data-Driven Decision-Making** Sub-theme 3.1: Data-Driven Decisions	**Theme 4: Productivity and Cost Control** Sub-theme 4.1: Productivity

Sub-theme 1.2: Optimization **Optimization** Sub-theme 1.3: Resource Optimization **Resource Optimization** **Theme 5: Strategic and Economic Growth** Sub-theme 5.1: Economic Growth **Economic Growth** Sub-theme 5.2: Flexibility **Flexibility** Sub-theme 5.3: Strategic Goals **Strategic Goals**	**Communication** Sub-theme 2.2: Citizen Engagement **Citizen Engagement** Sub-theme 2.3: Collaboration **Collaboration** **Theme 6: Sustainability and Safety** Sub-theme 6.1: Sustainability **Sustainability** Sub-theme 6.2: Safety **Safety** Sub-theme 6.3: Environmental Sustainability **Environmental Sustainability**	**Data-Driven Decisions** Sub-theme 3.2: Informed Decisions **Informed Decisions** Sub-theme 3.3: Continuity **Continuity** **Theme 7: Framework Examples** Sub-theme 7.1: Business Process **Business Process** Sub-theme 7.2: Lean Management **Lean Management** Sub-theme 7.3: Digital Equity **Digital Equity**	**Productivity** Sub-theme 4.2: Cost Control **Cost Control** Sub-theme 4.3: Cost-Benefit **Cost-Benefit**
9. What are the primary limitations and challenges associated with applying various operations management frameworks in the context of smart city operations?			
Theme 1: Financial Constraints Sub-theme 1.1: Cost Constraints	**Theme 2: Integration and Implementation Issues**	**Theme 3: Data and Privacy Concerns** Sub-theme 3.1: Data Privacy	**Theme 4: Public and Stakeholder Engagement**

Cost Constraints Sub-theme 1.2: Funding Challenges **Funding Challenges** Sub-theme 1.3: Maintenance Cost **Maintenance Cost** **Theme 5: Political and Bureaucratic Challenges** Sub-theme 5.1: Bureaucracy **Bureaucracy** Sub-theme 5.2: Corruption **Corruption**	Sub-theme 2.1: Integration Issues **Integration Issues** Sub-theme 2.2: Complexity **Complexity** Sub-theme 2.3: Governance Hurdles **Governance Hurdles** **Theme 6: Risk and Uncertainty** Sub-theme 6.1: Hazard Identification **Hazard Identification** Sub-theme 6.2: Uncertainty **Uncertainty** Sub-theme 6.3: Risk Management **Risk Management**	**Data Privacy** Sub-theme 3.2: Data Quality **Data Quality** **Theme 7: Cultural and Technological Factors** Sub-theme 7.1: Outcome Clarity **Outcome Clarity** Sub-theme 7.2: Technology Evolution **Technology Evolution** Sub-theme 7.3: Cultural Factors **Cultural Factors**	Sub-theme 4.1: Public Acceptance **Public Acceptance** Sub-theme 4.2: Skilled Manpower **Skilled Manpower** Sub-theme 4.3: Communication Gaps **Communication Gaps** **Theme 8: General Limitations** Sub-theme 8.1: Frameworks **Frameworks** Sub-theme 8.2: NA **NA**
10. What are the key strategies you would like to suggest for better coordination of planning, decision-making, and adaptation in smart cities?			
Theme 1: Enhanced Collaboration	**Theme 2: Strategic Framework Development**	**Theme 3: Improved Communication and Coordination**	**Theme 4: Expertise and Human Capital Development**

Sub-theme 1.1: Cross-Functional Collaboration **Cross-Functional Collaboration** Sub-theme 1.2: Public-Private Partnerships **Public-Private Partnerships** Sub-theme 1.3: Community Engagement **Community Engagement** **Theme 5: Data-Driven Decision-Making** Sub-theme 5.1: Data Utilization **Data Utilisation** Sub-theme 5.2: Performance Management **Performance Management** **Theme 9: Periodic Reviews and Adjustments**	Sub-theme 2.1: Policy Frameworks **Policy Frameworks** Sub-theme 2.2: Long-Term Planning **Long-Term Planning** **Theme 6: Infrastructure and Resource Management** Sub-theme 6.1: Infrastructure Planning **Infrastructure Planning** Sub-theme 6.2: Resource Constraints **Resource Constraints** **Theme 10: Integrated Management and Technology Utilization** Sub-theme 10.1: Tech Integration **Tech Integration**	Sub-theme 3.1: Communication **Communication** Sub-theme 3.2: Coordination **Coordination** **Theme 7: Risk Management and Adaptation** Sub-theme 7.1: Adaptation **Adaptation** Sub-theme 7.2: Risk Management **Risk Management**	Sub-theme 4.1: Expertise Development **Expertise Development** Sub-theme 4.2: Talent Selection **Talent Selection** **Theme 8: Context-Dependent Planning** Sub-theme 8.1: Strategic Planning **Strategic Planning** Sub-theme 8.2: Scope Clarity **Scope Clarity**

Sub-theme 9.1: Progress Communication **Progress Communication** Sub-theme 9.2: Periodic Checks **Periodic Checks**	Sub-theme 10.2: Integrated Management **Integrated Management**		

Discussion of Themes

1. What are the key challenges you face regarding smart city movement and infrastructure development?

Theme 1: Financial Viability and Funding Challenges

The financial constraints faced by smart city projects, such as balancing cash flow, private sector capacity, and the ability to secure long-term funding, are pivotal in determining the success or failure of infrastructure development. Without financial viability and proper risk management, the sustainability of smart cities is jeopardized, undermining their long-term goals.

Funding emerged as a crucial challenge, with patterns showing that cities struggle with both short-term cash flow management and securing sustainable long-term funding. This pattern suggests that without financial stability, cities may face interruptions in project progression, undermining long-term goals. The implications are clear: addressing this financial instability is critical to ensure consistent project development, especially as funding needs grow with the expansion of smart technologies.

Theme 2: Integration and Interoperability

Integration of legacy systems and the establishment of standardization across various technological platforms are essential to ensure smooth and efficient smart city operations. Poor integration or lack of standardization hampers overall system performance, leading to delays and inefficiencies in infrastructure development.

A recurring trend was the difficulty in integrating legacy systems and ensuring standardization across technological platforms. Many respondents cited that inconsistent standards lead to delays and operational inefficiencies, impacting the overall system performance. This suggests

that developing universal standards for interoperability could be foundational to overcoming integration issues, crucial for operational continuity and achieving system-wide efficiency in smart cities.

Theme 3: Governance and Stakeholder Engagement

Governance challenges, including stakeholder resistance and the lack of public awareness, often slow down the decision-making process, impacting the effective execution of smart city initiatives. Active engagement with stakeholders and public participation is crucial to foster acceptance and smooth governance transitions.

Patterns in responses highlight stakeholder resistance and governance issues as significant barriers. This trend indicates that the lack of structured engagement mechanisms often slows down decision-making processes, resulting in project delays. The implication here is the need for proactive stakeholder engagement strategies to align various interests and foster public acceptance, which is essential for smooth governance and a cooperative project environment.

Theme 4: Infrastructure and Urban Planning

Issues related to infrastructure scalability and urban planning highlight the complexities involved in managing rapidly growing urban populations while developing smart city infrastructure. Inadequate urban planning can lead to infrastructure bottlenecks, reducing the effectiveness of smart city solutions.

There is a clear concern over data security, with participants noting vulnerabilities due to multiple data integration points. This recurring theme suggests that, without robust data privacy measures, public trust could be compromised. Implementing stringent security protocols is therefore essential for safeguarding both city systems and citizen data.

Theme 5: Security and Data Privacy

Concerns over data security and privacy are significant in smart city infrastructure, where the integration of multiple data points increases vulnerabilities. Ensuring robust security measures is critical for building trust among citizens and safeguarding the integrity of the city's systems.

Theme 6: Environmental and Social Considerations

The environmental impact and the social and economic factors must be carefully considered to create smart cities that are not only technologically advanced but also sustainable and inclusive. Failure to address these considerations can lead to long-term environmental degradation and social inequality.

Theme 7: Challenges in Implementation

Technological obsolescence, coordination issues, and decision-making delays present major hurdles in the implementation phase of smart city projects. These challenges, if not managed effectively, can derail the progress of smart infrastructure development, leading to cost overruns and reduced project viability.

Theme 8: Regulatory and Policy Challenges

The absence of clear regulatory frameworks and a tendency of governments to focus on temporary solutions rather than long-term visions for smart cities hinder sustainable development. A lack of robust policies can result in fragmented efforts, delaying progress and reducing the overall impact of smart city initiatives.

2. In your opinion, what elements are crucial for developing an effective operations management framework in smart cities?

Theme 1: Financial and Economic Sustainability

Effective financial planning, maintaining compliance, and implementing risk management strategies are crucial to ensure the long-term viability of operations in smart cities. Without a solid financial base and contingency plans, smart city frameworks risk becoming unsustainable in the face of unforeseen challenges.

The emphasis on financial sustainability and compliance indicates a collective awareness of the need for risk management and contingency planning. By ensuring economic stability, cities can avoid disruptions in essential services. The implication is that without robust financial planning, smart city projects may struggle to withstand economic fluctuations, compromising long-term viability.

Theme 2: Technology Integration and Infrastructure

The successful implementation of smart technologies and infrastructure development is essential for ensuring efficient operations, with careful attention to risk forecasting, safety, and monitoring. Integrating appropriate technologies ensures smooth operations, while poor integration can disrupt essential city services and limit future scalability.

Respondents consistently highlighted technology integration as essential for efficient operations. This pattern suggests that careful selection and integration of smart technologies can prevent future scalability issues and optimize service delivery. The findings imply that cities must prioritize adaptable technology frameworks to support seamless future upgrades, essential for the longevity of smart city infrastructure.

Theme 3: Data Management and Security

Robust data governance frameworks, ensuring data privacy, integrity, and accessibility, are vital to maintaining secure and accountable operations. Without stringent data security measures, smart city systems become vulnerable to breaches, potentially compromising sensitive citizen information and disrupting operational efficiency.

Data governance emerged as a top priority, emphasizing privacy, integrity, and accessibility. Respondents expressed concerns over data breaches, underscoring the importance of secure and accountable data practices. This suggests that efficient data management frameworks are necessary to build trust and ensure the resilience of smart city operations.

Theme 4: Governance and Policy Implementation

Clear policy frameworks, strong leadership, and stakeholder engagement are central to ensuring effective governance and accountability in smart city operations. Governance failures or weak policy enforcement can lead to operational inefficiencies and limit the long-term success of the city's management framework.

Theme 5: Citizen Engagement and Participation

Active citizen engagement is crucial for developing inclusive and responsive smart city operations, as it fosters public trust and ensures that services align with the community's needs. Without meaningful participation, smart city initiatives may face resistance or fail to meet the expectations of the population.

Theme 6: Performance Measurement and Human Resources Development

Regular performance measurement and the continuous development of human resources are essential for maintaining high operational standards in smart cities. Human capital plays a pivotal role in managing and improving the efficiency of smart city operations, and neglecting this area can lead to skill gaps and reduced performance.

Theme 7: Sustainability and Long-term Planning

Sustainability and risk forecasting must be prioritized to ensure that smart cities remain resilient and adaptable over time. Focusing on long-term planning helps prevent the over-reliance on temporary solutions, safeguarding the city's operations against future uncertainties and resource constraints.

3. **What are the challenges you have encountered in the operations management of smart city projects?**

Theme 1: Governance and Policy

Regulatory compliance, legislative hurdles, and stakeholder resistance are major governance challenges that hinder the smooth implementation of smart city operations. Clear regulations and public support are crucial to ensuring that policies are well-aligned with operational goals and that stakeholder engagement fosters local support, without which progress is stalled.

Participants noted issues with regulatory compliance and legislative hurdles, which often lead to project delays. This pattern indicates that clearer regulations and public support are required to synchronize policies with operational goals. The implication is that better-aligned governance frameworks would streamline project execution, reducing the impact of bureaucratic red tape on city operations.

Theme 2: Financial Constraints

Budgetary limitations and challenges in securing funding make it difficult to balance costs and the economic benefits of smart city initiatives. Proper financial management is critical to overcoming these constraints, as insufficient funding can lead to project delays and compromises in the quality of infrastructure.

Budget limitations and funding issues were recurring concerns, pointing to the difficulty in balancing costs with economic benefits. This challenge suggests that without sufficient funding, project quality may suffer, affecting the overall reliability of smart city infrastructure. Addressing these constraints is thus essential for maintaining high-quality, sustainable infrastructure over time.

Theme 3: Technology and Data Management

Concerns over data security, privacy, and the complexity of integrating advanced technologies present significant hurdles in managing smart city operations. If these technological challenges are not adequately addressed, the city's operational efficiency and trust in digital solutions could be compromised, leading to vulnerabilities in data management and cybersecurity.

The complexity of integrating advanced technologies and managing data was a common theme, with multiple respondents citing security concerns. This indicates that unresolved technological issues can hinder operational efficiency, and therefore prioritizing cybersecurity and data integrity measures is vital for resilient city management.

Theme 4: Human Resources and Expertise

Challenges related to vendor management, talent acquisition, and the development of skilled professionals impede the effective execution of smart city projects. A lack of in-house expertise and reliance on underdeveloped vendor capabilities can result in mismanagement and delays, making human resource development essential for operational success.

Theme 5: Infrastructure and Maintenance

Land acquisition, traffic management, and energy and waste management pose significant challenges in maintaining the infrastructure needed for smart city operations. Effective maintenance and infrastructure planning are essential for long-term sustainability, as failures in these areas can lead to inefficiencies and increased operational costs.

Theme 6: Collaboration and Inclusivity

The lack of collaboration and inclusivity among stakeholders creates obstacles in ensuring that smart city projects meet diverse community needs. Effective stakeholder engagement and collaboration are vital for fostering inclusivity, without which projects may face resistance and fail to gain the necessary local support.

Theme 7: Scalability and Sustainability

Challenges in measuring success and ensuring the scalability of smart city initiatives affect their long-term sustainability. Ensuring that smart city projects are scalable and sustainable is essential for their continued success, as limitations in these areas can prevent growth and lead to inefficiencies over time.

Theme 8: Efficiency and Management

Inefficient management and implementation processes lead to operational delays and increased costs in smart city projects. Ensuring management efficiency is crucial to the timely execution of these projects, as poor management practices can derail even well-funded and well-planned initiatives.

4. **In your opinion, what is the most crucial type of data that needs to be collected for effective management of smart cities?**

Theme 1: Infrastructure and Asset Data
Utility and asset data are essential for managing smart city infrastructure effectively. Proper management of these assets ensures long-term sustainability and efficient service delivery. A trend in responses emphasized the importance of utility and asset data for managing smart city infrastructure. This pattern underscores the necessity of accurate asset management to ensure efficient service delivery and sustainability. The implication is that cities need detailed infrastructure data to plan and maintain services effectively, which is critical for long-term operational stability.

Theme 2: Real-Time and Sensor Data
Real-time and sensor data provide immediate insights into city operations. This data is critical for responsive management and ensuring public safety in real time. The importance of real-

time data for monitoring city operations was a significant trend, indicating that immediate data access enables responsive management. This suggests that cities must invest in IoT and sensor technology to ensure real-time decision-making, enhancing both public safety and operational efficiency.

Theme 3: Traffic and Transportation Data
Traffic and transportation data help optimize urban mobility. Effective collection of this data reduces congestion and improves transportation efficiency.

Theme 4: Government and Administrative Data
Government and administrative data are necessary for strategic decision-making. Accurate data allows for better governance and streamlined administrative processes.

Theme 5: Environmental and Stormwater Data
Environmental and stormwater data are key for monitoring and managing city ecosystems. This data is crucial for mitigating environmental risks and ensuring sustainable development.

Theme 6: Citizen and Population Data
Citizen and population data guide policies for urban planning and resource allocation. Understanding population dynamics helps ensure that smart city services meet the needs of all residents.

Theme 7: Performance and Growth Metrics
Performance and growth metrics provide insights into the success of city initiatives. This data is important for evaluating progress and adjusting strategies accordingly.

Theme 8: Geospatial and Geographical Data
Geospatial and GIS data offer critical insights into city planning and development. This data supports effective land use and infrastructure expansion.

Theme 9: Historical and Big Data
Historical and big data enable trend analysis and long-term planning. These insights are essential for predicting future needs and improving city services.

Theme 10: Economic and Financial Data
Economic and financial data are crucial for budgeting and resource management. This data helps ensure the financial sustainability of smart city projects.

Theme 11: Skilled Manpower
Data on skilled manpower is essential for workforce planning. Having a skilled workforce is critical for maintaining and advancing smart city technologies.

5. **What are the most effective methods for collection of data in Smart cities?**

Theme 1: IoT and Sensor-Based Data Collection

IoT sensors provide continuous, real-time data for efficient city management. This is crucial for monitoring and automating essential services like energy use and traffic flow. Respondents highlighted IoT as a leading method, especially for real-time monitoring of infrastructure. This indicates a collective view that real-time data is central to managing essential services like traffic flow and energy usage. The implication is that by expanding IoT capabilities, cities can optimize service delivery and quickly address emerging issues.

Theme 2: Citizen and Public Engagement

Engaging citizens through surveys and mobile devices enables direct data collection. Public participation ensures that data reflects community needs and enhances service delivery. Collecting feedback through mobile apps and surveys was commonly cited, reflecting a trend toward more interactive public engagement. This finding implies that encouraging citizen participation provides cities with valuable insights into community needs, helping align services with public expectations.

Theme 3: Geospatial and Mapping Techniques

GIS mapping offers precise geographical data for urban planning. This method is vital for optimizing land use and infrastructure development.

Theme 4: Open and Public Data Platforms

Public data platforms enable transparent data sharing for collaborative problem-solving. These platforms foster innovation and improve the scalability of smart city solutions.

6. **How effective is the current operations management framework in addressing the efficiency needs of smart cities?**

Theme 1: Coordination and Planning

Cross-functional coordination improves interdepartmental efficiency, which is essential for seamless operations. Comprehensive planning aligns long-term goals with immediate needs, but incongruence between plans and actions can hinder progress.

Multiple participants, including **Satish Kamat** and **Scot Wrighton**, noted a lack of coordination among departments and the need for improved cross-functional collaboration. **Kamat** pointed out that certain systems, such as IoT in sewage management, require coordinated responses to prevent issues like overflows. **Wrighton** emphasized that without a common framework, cities struggle with comparing and benchmarking operations effectively.

These patterns indicate that interdepartmental coordination is essential for efficient service delivery. By addressing these gaps, smart city frameworks can reduce redundancy and ensure smooth functionality, aligning with the study's objective to identify areas for improving operational efficiency.

Theme 2: Financial and Budgetary Constraints

Budget constraints limit the scope of improvements, affecting resource allocation for critical operations in smart cities. **Prasanna Kumar Potdar** and **Vinay Vishwanath Mangrulkar** discussed challenges with outdated systems and the need for proactive technology upgrades. Potdar highlighted that older installations are incompatible with new technologies, while Mangrulkar suggested integrating GIS to enhance maintenance planning.

These insights suggest that prioritizing technology integration and upgrading outdated systems could significantly improve smart city management. Enhanced data utilization aligns with optimizing operational effectiveness, as targeted in the study.

Theme 3: Data Utilization and Technology

Data-driven decision-making optimizes efficiency, but ICT implementation is uneven, leading to gaps in data management and analysis.

Theme 4: Citizen and Public Involvement

Citizen engagement boosts operational responsiveness, ensuring that public works and upkeep are maintained according to real-time needs.

Theme 5: Maintenance and Continuous Improvement

Continuous improvement processes enhance service delivery, with proactive maintenance ensuring long-term efficiency, particularly in transportation and safety.

Theme 6: Negative

Lack of anticipation for future needs leads to reactive, rather than proactive, solutions. These limitations highlight inefficiencies that hinder the overall effectiveness of smart city operations management frameworks.

7. **In what manner do the existing operations management frameworks contribute to the sustainability and social security of smart cities?**

Theme 1: Resource Optimization and Efficiency

System Efficiency: Efficient systems contribute to the sustainability of smart cities by optimizing resource use.

Energy Efficiency: Energy efficiency enhances environmental sustainability.

Waste Management: Effective waste management reduces environmental impact.

Resource Optimization: Resource optimization ensures long-term sustainability.

Respondents like **Vikas Yadav** and **R Ponnudurai** emphasized resource management, with **Yadav** pointing out that frameworks optimize waste management, energy efficiency, and clean transportation. **Ponnudurai** elaborated on frameworks for smart waste management, optimized energy use, and water conservation as critical to sustainability.

This recurring focus on resource optimization suggests that sustainability in smart cities is closely tied to operational efficiency. Implementing these frameworks not only conserves resources but also supports long-term environmental goals, critical to the study's objectives of achieving sustainability through operations management.

Theme 2: Technological Integration

IoT Integration: IoT integration improves system efficiency and social security.

ERP Solutions: ERP solutions streamline resource allocation.

ICT Integration: ICT integration enhances data management and sustainability efforts.

Jayachandran and **CRS Vijayakumar** highlighted that public safety systems, such as surveillance and emergency response, contribute directly to social security. Jayachandran mentioned frameworks for healthcare, public safety, and emergency response, while Vijayakumar pointed out gaps in achieving sustainable social security.

These findings indicate that by enhancing public safety and emergency response frameworks, smart cities can provide a secure environment for residents, supporting the study's goal of fostering social resilience.

Theme 3: Safety and Security

Public Safety: Public safety measures contribute directly to social security.

Traffic Management: Effective traffic management reduces accidents and enhances security.

Theme 4: Sustainability Practices

Social Sustainability: Promoting social sustainability ensures the well-being of city residents.

Best Practices: Implementing best practices fosters a culture of long-term sustainability.

Theme 5: Challenges and Limitations

Budget Constraints: Budget constraints limit the effectiveness of sustainability initiatives.

Public approval is essential for the success of sustainability measures.

No Opinion: Lack of stakeholder input can hinder sustainability efforts.

Lack of Sustainability: Insufficient focus on sustainability impacts long-term city viability.

Limited Contribution: Current frameworks may have a limited role in promoting sustainability.

8. **What are the key benefits of different operations management frameworks in facilitating decision-making for smart city operations?**

Theme 1: Efficiency and Optimization

Efficiency: Efficiency frameworks streamline operations and speed up decision-making.

Optimization: Optimization ensures the best allocation of resources for effective smart city management.

Resource Optimization: Resource optimization enhances sustainability and long-term planning.

Scot Wrighton and **Vidya Ramesh** highlighted that frameworks promoting efficiency allow for faster, data-driven decision-making. Wrighton stressed that smart city initiatives should focus on measurable outcomes, while Ramesh pointed out that optimizing resources leads to better management and citizen welfare. The focus on efficiency in decision-making indicates that adopting outcome-based frameworks could make city operations more strategic. This aligns with the study's aim of identifying frameworks that enhance decision-making and resource allocation for sustainable urban management.

Theme 2: Communication and Collaboration

Communication: Effective communication between stakeholders improves the clarity of decisions.

Citizen Engagement: Engaging citizens ensures decision-making is aligned with public needs.

Collaboration: Collaborative frameworks enhance interdepartmental decision-making.

Ganpati Kumbhar and **R Ponnudurai** advocated for frameworks that use real-time data. Kumbhar highlighted the role of data for efficient city operation, while Ponnudurai discussed leveraging data for informed decisions and better collaboration among departments. These insights suggest that data-driven frameworks enable timely and accurate decision-making, essential for adapting to dynamic urban needs. Aligning with the study's objectives, these frameworks are pivotal for enabling responsive city management.

Theme 3: Data-Driven Decision-Making

Data-Driven Decisions: Data-driven frameworks support precise and timely decision-making.

Informed Decisions: Informed decisions reduce risks in smart city management.

Continuity: Ensuring continuity in data usage maintains consistent decision-making.

Theme 4: Productivity and Cost Control

Productivity: Productivity frameworks increase operational output and decision efficiency.

Cost Control: Cost control frameworks help manage budgets and resource allocation.

Cost-Benefit: These frameworks optimize spending for smart city projects.

Theme 5: Strategic and Economic Growth

Economic Growth: Frameworks focused on economic growth boost city prosperity and smart infrastructure.

Flexibility: Flexibility in frameworks allows quick adaptation to evolving city needs.

Strategic Goals: Alignment with strategic goals enhances the city's long-term planning and sustainability.

Theme 6: Sustainability and Safety

Sustainability: Sustainability-focused frameworks ensure long-term environmental and economic health.

Safety: Safety frameworks prioritize public security in decision-making.

Environmental Sustainability: Environmental sustainability frameworks protect urban ecosystems.

Theme 7: Framework Examples

Business Process: Business process frameworks standardize decision-making procedures.

Lean Management: Lean management frameworks minimize waste and improve efficiency.

Digital Equity: Digital equity frameworks ensure fair access to smart city services.

9. **What are the primary limitations and challenges associated with applying various operations management frameworks in the context of smart city operations?**

Theme 1: Financial Constraints

Cost Constraints: High costs limit the scalability of operations management frameworks in smart cities.

Funding Challenges: Lack of stable funding hampers long-term infrastructure development.

Maintenance Cost: Ongoing maintenance costs create financial strain on smart city operations.

Financial limitations were frequently cited, with **Prasanna Kumar Potdar** and **Vikas Yadav** noting issues with budget allocation and long-term funding. Potdar described how budget constraints hinder large-scale smart city installations, while Yadav mentioned cost-benefit analysis as a critical area where funding falls short. Financial challenges point to a need for structured funding mechanisms to sustain smart city projects. Addressing budget limitations is key to avoiding project delays and ensuring operational continuity, supporting the study's objective to highlight resource allocation issues.

Theme 2: Integration and Implementation Issues

Integration Issues: Difficulty in integrating various systems reduces operational efficiency.

Complexity: Complex frameworks lead to delays in decision-making and implementation.

Governance Hurdles: Ineffective governance structures complicate framework application.

John Ringness and **Satish Kamat** highlighted issues with integrating older frameworks and aligning stakeholder priorities. Ringness cited ERP limitations in current frameworks, while Kamat emphasized the need for unified governance across departments. The focus on governance and integration challenges suggests that resolving these issues could streamline operations and enhance project efficacy, which is crucial to meeting the study's goal of identifying barriers to efficient framework application.

Theme 3: Data and Privacy Concerns

Data Privacy: Concerns over data privacy hinder full utilization of smart city technologies.

Data Quality: Poor data quality results in unreliable decision-making processes.

Theme 4: Public and Stakeholder Engagement

Public Acceptance: Low public acceptance creates resistance to new frameworks.

Skilled Manpower: A shortage of skilled professionals limits the effective implementation of frameworks.

Communication Gaps: Communication breakdowns between stakeholders delay project execution.

Theme 5: Political and Bureaucratic Challenges

Bureaucracy: Bureaucratic red tape slows the application of operations frameworks.

Corruption: Corruption undermines transparent and efficient framework implementation.

Theme 6: Risk and Uncertainty

Hazard Identification: Inadequate hazard identification exposes cities to unforeseen risks.

Uncertainty: High uncertainty complicates strategic planning and operations.

Risk Management: Inefficient risk management frameworks increase vulnerability to crises.

Theme 7: Cultural and Technological Factors

Outcome Clarity: Ambiguity in outcomes affects framework acceptance and success.

Technology Evolution: Rapid technological advancements make existing frameworks obsolete.

Cultural Factors: Cultural resistance to change poses a barrier to adopting new frameworks.

Theme 8: General Limitations

Frameworks: Outdated or rigid frameworks fail to adapt to the dynamic needs of smart cities.

NA: Some frameworks lack clear guidelines, resulting in operational inefficiencies.

10. **What are the key strategies you would like to suggest for better coordination of planning, decision-making, and adaptation in smart cities?**

Theme 1: Enhanced Collaboration

Cross-Functional Collaboration: Encouraging cross-functional teams enhances the integration of diverse perspectives in planning and decision-making.

Public-Private Partnerships: Establishing public-private partnerships fosters resource sharing and innovation for urban development.

Community Engagement: Actively involving the community ensures that plans reflect local needs and priorities.

Scot Wrighton and **Vidya Ramesh** recommended fostering collaboration between public and private sectors and ensuring clear policy frameworks. Wrighton advocated for cross-functional teams to ensure diverse perspectives, while Ramesh emphasized community engagement to align services with public needs. Encouraging collaboration between stakeholders can improve both resource sharing and project alignment, which is essential for smart cities. This aligns with the study's goal to outline strategies that enhance coordination across city departments.

Theme 2: Strategic Framework Development

Policy Frameworks: Developing comprehensive policy frameworks guides coordinated efforts and sets clear objectives for smart city initiatives.

Long-Term Planning: Emphasizing long-term planning prepares cities for future challenges and sustainable growth.

Rajesh P and **CRS Vijayakumar** stressed the need for data-utilization and adapting strategies to local contexts. Rajesh mentioned big data for operational insights, while Vijayakumar suggested tailoring strategies to meet community-specific needs. These insights suggest that data-driven frameworks should be adapted based on the unique needs of each city. This aligns with the study's goal of developing customized approaches to planning and decision-making for effective urban management.

Theme 3: Improved Communication and Coordination

Communication: Strengthening communication channels among stakeholders promotes transparency and informed decision-making.

Coordination: Enhancing coordination mechanisms ensures that all parties work towards common goals effectively.

Theme 4: Expertise and Human Capital Development

Expertise Development: Investing in expertise development equips teams with the necessary skills to navigate complex urban challenges.

Talent Selection: Strategic talent selection enhances the capabilities of smart city initiatives by bringing in diverse skills.

Theme 5: Data-Driven Decision-Making

Data Utilization: Leveraging data analytics supports informed decision-making and improves operational efficiency.

Performance Management: Implementing robust performance management systems helps track progress and adapt strategies as needed.

Theme 6: Infrastructure and Resource Management

Infrastructure Planning: Strategic infrastructure planning ensures that physical assets meet current and future demands of smart cities.

Resource Constraints: Addressing resource constraints through efficient management is crucial for sustaining urban development initiatives.

Theme 7: Risk Management and Adaptation

Adaptation: Developing adaptive strategies enables cities to respond proactively to emerging challenges and uncertainties.

Risk Management: Implementing comprehensive risk management frameworks protects urban systems from potential disruptions.

Theme 8: Context-Dependent Planning

Strategic Planning: Tailoring strategic planning to local contexts enhances the relevance and effectiveness of urban initiatives.

Scope Clarity: Ensuring clarity of scope in planning processes helps to align efforts and resources toward specific objectives.

Theme 9: Periodic Reviews and Adjustments

Progress Communication: Regular communication of progress fosters accountability and encourages stakeholder engagement in the planning process.

Periodic Checks: Conducting periodic checks allows for timely adjustments to strategies based on evolving circumstances.

Theme 10: Integrated Management and Technology Utilization

Tech Integration: Integrating technology into management processes improves efficiency and facilitates real-time data access for better decision-making.

Integrated Management: Adopting integrated management approaches promotes a holistic view of urban operations and fosters coordinated actions across various sectors.

Refinement of Themes

1. Key Challenges in Smart City Movement and Infrastructure Development

- **Financial and Economic Challenges**: Combines "Balancing Cashflow," "Long-term Funding," and "Financial Viability." This captures all finance-related obstacles under one comprehensive theme.
- **Integration and Technology Challenges**: Merges "Integration of Legacy Systems," "Standardization," and "Technology Quality," highlighting the need for systems compatibility and technological adaptability.
- **Governance and Stakeholder Issues**: Encompasses "Governance Challenges," "Stakeholder Resistance," and "Public Awareness," focusing on coordination, decision-making, and citizen involvement.
- **Environmental and Social Considerations**: Groups "Environmental Impact" and "Social and Economic Factors" to highlight sustainability and community well-being.
- **Implementation and Regulatory Barriers**: Combines "Challenges in Implementation," "Regulatory Challenges," and "Government Focus on Temporary Solutions," addressing obstacles in policy and implementation strategy.

2. Elements Crucial for Developing an Effective Operations Management Framework in Smart Cities

- **Financial and Risk Management**: Merges "Financial Planning and Compliance" with "Risk Management and Contingency Planning," reflecting the need for stable funding and risk control.
- **Citizen and Stakeholder Engagement**: Combines "Citizen Engagement" with "Stakeholder Engagement and Accountability," emphasizing the importance of inclusive participation and accountability.
- **Technology and Infrastructure Development**: Groups "Smart Technology Implementation," "Infrastructure Development," and "Performance Measurement," underscoring the role of technology in efficient city infrastructure.
- **Data Management and Security**: Includes "Data Governance and Privacy" and "Data Integrity and Accessibility," focusing on safeguarding information and ensuring data reliability.

- **Sustainability and Governance**: Merges "Sustainability," "Policy Frameworks and Compliance," and "Long-term Planning," highlighting the need for sustainable policies and governance.

3. Challenges in the Operations Management of Smart City Projects

- **Governance and Regulatory Compliance**: Combines "Regulatory Compliance," "Stakeholder Engagement," and "Policy Challenges," addressing the governance structures and regulatory challenges.
- **Infrastructure and Maintenance**: Merges "Infrastructure" and "Maintenance" under a single theme that focuses on ongoing upkeep and facility management.
- **Financial Constraints and Cost Management**: Groups "Budgetary Limitations" and "Economic Considerations," emphasizing cost control and financial sustainability.
- **Technology and Data Security**: Includes "Data Security and Privacy Concerns" and "Technological Complexity and Integration," highlighting technological vulnerabilities and the need for data security.
- **Human Resources and Skill Development**: Combines "Vendor Management" and "Talent Acquisition," addressing skill gaps and workforce capabilities.

4. Most Crucial Data for Effective Smart City Management

- **Infrastructure and Asset Management Data**: Combines "Utility and Asset Data" with "Management Data," addressing essential data for infrastructure operations.
- **Environmental and Public Safety Data**: Merges "Environmental and Stormwater Data" with "Public Safety and Operational Data," focusing on monitoring environmental and safety factors.
- **Citizen and Population Data**: Keeps "Citizen and Population Data" as a standalone theme, given its focus on understanding population needs and demographics.
- **Performance, Economic, and Growth Metrics**: Combines "Economic and Financial Data," "Performance Metrics," and "Growth Metrics," focusing on economic indicators and success measurement.
- **Real-Time and Geospatial Data**: Merges "Real-Time and Sensor Data" and "Geospatial and Geographical Data," covering location-based and real-time monitoring data.

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5. Most Effective Methods for Data Collection in Smart Cities

- **IoT and Real-Time Monitoring**: Combines "IoT Sensor Networks" and "Real-Time Data Integration," emphasizing the role of sensors and immediate data collection.
- **Citizen and Community Engagement**: Merges "Citizen Feedback," "Surveys," and "Crowdsourcing," highlighting methods to gather community-sourced data.
- **Geospatial Mapping and GIS Techniques**: Groups all mapping-related techniques, focusing on spatial data for planning.
- **Open and Public Data Platforms**: Stands as a distinct theme for collaborative data collection and accessibility.

6. Effectiveness of the Current Operations Management Framework in Addressing Efficiency Needs

- **Coordination and Planning Gaps**: Combines "Cross-Functional Coordination," "Comprehensive Planning," and "Incongruence Between Plans and Actions," addressing inter-departmental alignment.
- **Maintenance and Continuous Improvement**: Merges "Continuous Improvements," "Proactive Maintenance," and "Public Works and Upkeep," focusing on ongoing development and quality maintenance.
- **Financial Constraints and Budgeting**: Combines "Budget Constraints" and "Cost Management," addressing fiscal challenges.
- **Data Utilization and ICT Implementation**: Combines "Data-Driven Decision-Making" and "ICT Implementation," underscoring the need for effective technology use in data analytics.
- **Citizen Involvement**: Retains "Citizen Engagement" as a standalone theme for improving community involvement in city management.

7. Contribution of Existing Operations Management Frameworks to Sustainability and Social Security

- **Resource Optimization and Efficiency**: Combines "System Efficiency," "Energy Efficiency," and "Resource Optimization," focusing on optimizing resources for sustainability.
- **Technological and IoT Integration**: Merges "IoT Integration" and "ERP Solutions," focusing on technology's role in achieving sustainability.
- **Social Security and Safety**: Combines "Public Safety" and "Traffic Management," highlighting security's role in social resilience.
- **Environmental and Sustainability Practices**: Groups "Social Sustainability" and "Best Practices," focusing on practices for long-term sustainability.

8. Key Benefits of Different Operations Management Frameworks in Facilitating Decision-Making

- **Efficiency and Resource Optimization**: Combines "Efficiency," "Optimization," and "Resource Optimization," addressing resource allocation for effective decision-making.
- **Strategic and Economic Growth**: Merges "Economic Growth" and "Strategic Goals," focusing on frameworks that align with long-term strategic objectives.
- **Data-Driven Decision-Making**: Groups "Data-Driven Decisions" and "Informed Decisions," highlighting evidence-based decision-making.
- **Collaboration and Communication**: Combines "Citizen Engagement," "Collaboration," and "Communication," stressing coordinated stakeholder interaction.

9. Limitations and Challenges of Applying Operations Management Frameworks in Smart City Operations

- **Financial and Funding Constraints**: Combines "Cost Constraints" and "Funding Challenges," addressing financial limitations.
- **Governance and Bureaucratic Hurdles**: Merges "Bureaucracy" and "Governance Hurdles," emphasizing administrative barriers.
- **Integration and Technological Complexity**: Groups "Integration Issues," "Complexity," and "Technology Evolution," addressing challenges with technology application.
- **Cultural and Public Engagement Barriers**: Merges "Public Acceptance" and "Cultural Factors," highlighting societal acceptance issues.
- **Risk and Uncertainty**: Combines "Hazard Identification" and "Risk Management," focusing on managing risks in smart city operations.

10. Key Strategies for Improving Coordination, Decision-Making, and Adaptation in Smart Cities

- **Collaboration and Engagement**: Combines "Cross-Functional Collaboration," "Community Engagement," and "Public-Private Partnerships," emphasizing partnership.
- **Data-Driven and Performance-Based Strategies**: Groups "Data Utilization" and "Performance Management," focusing on data's role in adaptive strategies.
- **Strategic and Long-Term Planning**: Combines "Policy Frameworks" and "Long-Term Planning," underscoring future-oriented strategies.
- **Infrastructure and Resource Management**: Merges "Infrastructure Planning" and "Resource Constraints," highlighting essential resource allocation.

- **Risk Management and Adaptability**: Groups "Risk Management" and "Adaptation," addressing strategies to mitigate risks and enhance flexibility.

Detailed Initial Codes

Objective 1: To analyze the need for an effective operations management framework in smart cities

2. In your opinion, what elements are crucial for developing an effective operations management framework in smart cities? Please elaborate on each element.

Respondents	Responses	Initial Codes
Satish Kamat	Critical for Operations Management framework - 1. **Financial Sustainability - pacing capex with tight cashflow management, smooth and tight management of Utilities/services and receivables, Good mix of revenues** 2. **Choosing Appropriate Technology, spend on technologies that improve quality, reliability, and speed of services and utility delivery, smooth cross-functional information flow, and reduce manpower** 3. Proper design of SLAs and operations management processes & KRAs 4. Managing projects tightly within budget and timelines and putting them to use.	**Financial Sustainability** **Appropriate Technology** **Data Sharing** **Security** **Sustainability** **Governance and Leadership** **Infrastructure** **Citizen Engagement** **Performance Measurement** **Human Resources Development** **Not Applicable** **Digital Security** **Availability** **Integrity** **Confidentiality** **Accountability** **Monitoring, Safety & Control** **Maintaining compliance** **Risk Forecasting** **Backup plan & action** **Focus on Temporary Solutions** **Government Policies & Strategies**
Ganpati Kumbhar	1. **Pervasive connectivity, the first essential element for smart cities** **The first building block of any smart city application is reliable, pervasive wireless connectivity. Evolving low-power wide area network (LPWAN) technologies are well suited to smart city applications. Although many wireless technologies (LTE CatM, NB-IoT, LoRa, and the like) are contributing to the fabric of connected cities, the advent of 5G is expected to be a watershed event that propels smart city technology into the mainstream and accelerates new deployments** 2. **Unlock the vault to open data**	

	Historically, governments, enterprises, and individuals alike have held their data close to themselves, sharing as little as possible with others. Privacy concerns and fear of security breaches have far outweighed the perceived value of sharing information. However, a key enabler of sustainable smart cities is that all participants in the complex ecosystem share information so that informed decisions can be made in real-time. Multiple sectors need to cooperate to achieve better, sustainable outcomes through the analysis of contextual real-time information, which is shared among sector-specific information and operational technology (OT) systems. For instance, imagine a major urban area is gearing up for a mega event like the Olympics or the World Cup finals. As the city prepares to transport, feed, house, and supply power to hundreds of thousands of visitors, municipal intelligent transport systems must be sharing data with Uber and Airbnb platforms to get people from point A to point B without seizing up the city's infrastructure. In Dubai, one of the world's most ambitious and comprehensive data initiatives is already underway to improve the quality of city living. **3. Smart cities only work if we can trust them. Open data gathered from different sources needs to be shared but only with authorized and approved platforms and individuals. Strong authentication and trusted ID management solutions are the third essential element needed at all levels of the ecosystem to enable trust that smart cities are safe cities.** 4. **Secure open data across the smart city ecosystem** **The smart city ecosystem is inherently complex, which can be mitigated through strong authentication and ID management solutions that enable a secure digital handshake between**	

	different parties in the ecosystem that either allows or denies access. Governments, enterprises, citizens, software providers, device manufacturers, energy providers and the networks they operate on all come into play and every link in the chain must be held accountable to this same set of core security objectives, which include four core goals: 1. **Availability: Ensuring timely and reliable access to and use of information is an essential component of the smart city.** 2. **Integrity: Smart cities depend on reliable and accurate data. To prevent fraud and other harmful attacks, measures must be taken to ensure that data is accurate and free from manipulation.** 3. **Confidentiality: Smart cities generate huge volumes of data that must be collected, stored, and analyzed. Some of this data will include sensitive details about citizens themselves. Steps must be taken to prevent unauthorized disclosure of sensitive information.** 4. **Accountability: Accountability is the idea that users of a system should be responsible for the actions they perform. This means that user interactions with sensitive systems should be logged and associated with a specific user. These logs should be difficult to forge and have strong integrity protection.**	
Prasanna Kumar Potdar	**Monitoring & control**, **process and data analytics**, Integration	
Venugopal M	**Unwavering dedicated team. Good water supply, good roads with connectivity to main road links, uninterrupted power supply, schools, and hospitals.**	
Prasanna Ramesh	**Safety & control** **Maintaining compliance** **Risk Forecasting**	

	Backup plan & action	
Jayachandran	It identifies six important aspects for developing smart cities: (1) **information network and broadband,** (2) **digitization of planning management,** (3) **smart infrastructure,** (4) **convenience of public services,** (5) **modernizing industrial development,** and (6) **sophisticated social governance.**	
CRS Vijayakumar	**Need to focus on long-term solutions. Should be proactive**	
R Ponnudurai	**The design period of town planning should be at least 50 years. The water supply and sanitation infrastructure should be designed at least for 50 years. We can take a model of Pondicherry for the infrastructure along with the recent AI tools.**	
Shri Anil Digambar Barge	Following are the elements where it's getting difficult. 1) **Shifting of the water supply line and its adjoining connection. As already initial water supply lines are laid and also there are adjoining connections given. Now it's getting very difficult to identify land and lay new lines as well and we have to restore initial and new connections also without disturbing society routine.** **In short, Utility shifting i.e. Water supply, Electrical connection, Telephone line, etc relocation is one of the challenges.**	
John Ringness	**An effective digital execution plan - this facilitates a pathway to a digital neuro network connecting all elements of the AECO ecosystems.**	
Dinesh Krishnan	**Security management**	
Rajesh P	**NA**	

Aneesh Kadyan	**Centralized management, agile workforce, flexibility of contracts, real-time monitoring**	
Vinay Vishwanath Mangrulkar	The operation management framework consists of 1) making routine, preventive, and breakdown maintenance manual: - different facilities have different necessities for operation management. We need to develop a comprehensive manual for each type of element like (a) **carriageway maintenance (b) stormwater drainage maintenance during monsoon (c) water and waste treatment plant, appurtenances, and special maintenance for pumping and gravity lines (d) power utility maintenance system like transmission systems, HT and LT lines, transformers, panels, etc** (e) **IT infrastructure maintenance, etc (f) residential apartments, commercial spaces maintenance, (g) Lakes and reservoir maintenance, etc.** Each of the elements can be elaborated in detail based on best practices adopted by the industry SOPs created to have uniformity for the same and a statistical maintenance plan be created for each activity in every element.	
Vikas Yadav	1. **Financial Management- Resource Allocation, Cost-benefit analysis, and Public-Private partnership.** **2. Sustainability and Resilience- Impact on Environment, Disaster management, Withstand disruptions.** 3. **Governance and Leadership- Collaborative approach of Government-Private Sector-Citizens, Strong Leadership and Clear Vision.** 4. **Data Management and Analytics- Collection, Quality, and Security of the Data.** **5. Citizens engagement and Participation- Feedback mechanisms and Digital literacy.**	

	6. Performance Measurement- KPI and monitoring. **7. Development of Human Resources.**	
Nilesh Shetkar	(1) **information network and broadband,** (2) **digitization of planning management,** (3) **smart infrastructure**, (4) **convenience of public services,** (5) **modernizing industrial development,** and (6) **sophisticated social governance.**	
Anubandh Hambarde	**I never managed a city let alone a smart city.**	
Scot Wrighton	**I reject the notion that Smart City initiatives should be advanced simply because they have the label of "Smart City" attached to them. Smart City initiatives should be advanced and pursued if, and only if, they help the organization achieve specific performance outcomes included in the entity's strategic plan, and do so more effectively and more efficiently than other (less tech/smart) strategies. Smart City ideas should not be advanced for their own sake. So the crucial elements are the detailed and measurable performance outcomes achieved, and the cost-benefit/ROI analysis connected directly to these measures. Without this framework, organizations are just adding gadgets.**	
Vidya Ramesh	The core infrastructure elements in a Smart City would include - **adequate water supply, assured electricity supply, sanitation, including solid waste management, efficient urban mobility and public transport, affordable housing, especially for the poor, robust IT connectivity and digitalization, good governance.**	

The majority of participants emphasized the importance of financial sustainability, technology integration, and strong governance in developing an effective operations management framework

for smart cities. Elements like financial management, cost-benefit analysis, and public-private partnerships were highlighted by many respondents, along with the need for advanced technology such as pervasive wireless connectivity and secure data management. Several respondents also mentioned citizen engagement, data sharing, and human resources development as critical factors. A minority of participants focused on more specific challenges like utility relocation, water supply management, and the need for comprehensive manuals for infrastructure maintenance, while others questioned the necessity of "smart city" initiatives unless they were tied to measurable performance outcomes. Additionally, a few respondents stressed long-term planning, safety measures, and compliance as vital for sustainable operations.

Ganpati Kumbhar emphasized, "Reliable connectivity is the foundation for all smart city applications," while **Vidya Ramesh** added, "Public engagement is essential for a responsive framework." These quotes underscore the importance of both technological infrastructure and public interaction in operations management. Kumbhar, a technology professional, stresses technical aspects, while Ramesh's focus on engagement reflects her community outreach experience. Their backgrounds add diverse insights into the framework elements needed.

6. How effective is the current operations management framework in addressing the efficiency needs of smart cities? Please provide examples or experiences.

Respondents	Responses	Initial Codes
Satish Kamat	Partially. **Some areas need to change, like, unilizing data to drive cross-functional smooth coworking and efficiency.** E. g. If the IoT system in the sewage pumping station has an outage at night, customer-facing / communication should automatically inform large users to hold sewage at their end and stop pumping to the network and parallel system to let the transport department arrange sewage tanker just in case there is an overflow.	**Cross-Functional Coordination** **Budget Constraints** **Comprehensive Planning** **Data-Driven Decision-Making** **Citizen Engagement** **Manual Processes** **Incongruence Between Plans and Actions** **Public Works and Upkeep** **Continuous Improvements** **Transportation and Safety** **ICT Implementation** **Proactive Maintenance** **Lack of Common Framework** **Data Management and Analysis** **No idea** **Poor anticipation**
Ganpati Kumbhar	-	
Prasanna Kumar Potdar	**Most of the large organizations are not able to implement the infrastructure required for the smart cities due to a lack of focus and budgets.**	
Venugopal M	**Good**	
Prasanna Ramesh	**No idea**	

Jayachandran	**The framework for smart cities involves a comprehensive plan that integrates technology, data, and communication** to optimize city operations. It includes infrastructure for mobility, energy, healthcare, and public services to create a connected and sustainable urban environment.	**Good**
CRS Vijayakumar	**Poor anticipation**	
R Ponnudurai	The current operations management framework in smart cities has shown varying levels of effectiveness in addressing efficiency needs. Some strengths and weaknesses include: Strengths: 1. *__Data-driven decision-making*: Many smart cities have implemented data analytics platforms, enabling data-driven decisions and improving operational efficiency.__ 2. *Streamlined processes*: Smart cities have automated and optimized processes, reducing manual errors and increasing productivity. 3. *__Citizen engagement*: Smart cities have implemented citizen engagement platforms, improving service delivery and responsiveness.__ Weaknesses: 1. *Silos and fragmentation*: Departments and agencies often work in silos, hindering coordination and efficiency. 2. *Legacy infrastructure*: Aging infrastructure can hinder smart city initiatives and create integration challenges. 3. *Cybersecurity risks*: Smart cities face increased cybersecurity risks due to the interconnectedness of systems. Examples: 1. *Singapore's Smart Nation initiative*: Demonstrates effective operations management through integrated data analytics and a robust cybersecurity	

	framework. 2. *New York City's NYC 311 system*: Shows effective citizen engagement and service delivery, but faces challenges in integrating with other city agencies. 3. *Barcelona's Smart Lighting system*: Exhibits efficient energy management, but requires continued investment to maintain and upgrade infrastructure. Experiences: 1. *Integration challenges*: Smart cities often struggle to integrate new technologies with legacy infrastructure. 2. *Change management*: Implementing smart city initiatives requires significant organizational change management. 3. *Cybersecurity threats*: Smart cities must continually address evolving cybersecurity risks.P2 To improve efficiency, smart cities should focus on P2 1. *Interagency collaboration* 2. *Investing in digital infrastructure* 3. *Developing robust cybersecurity frameworks* 4. *Fostering a culture of innovation and continuous improvement* By addressing these areas, smart cities can enhance their operations management frameworks and better meet efficiency needs.	
Shri Anil Digambar Barge	Very well we can say there are several flaws in current operations as they are not completely mechanized but anyhow **we try to mitigate the problems with available data.** One of the most suitable examples is flooding during the monsoon as there is the availability of HFL marking on ground. But at the same time, we don't know the intensity of rain and what the quantum of flow will be as there is no accurate forecast data available with us.	

John Ringness	**Unfortunately, I have seen more incongruency between what is possible and what is done.**	
Dinesh Krishnan	**No idea.**	
Rajesh P	**NA**	
Aneesh Kadyan	**Not effective - cleaning, public works, and upkeep all are below par. It's not organized and Depth don't have up-to-date knowledge.**	
Vinay Vishwanath Mangrulkar	**The operation management framework needs continuous improvements in different elements** incorporating different strategies needed for maintenance or reducing timelines. GIS system can accommodate original and revision in the operation management framework to review the need for such changes, the method statements for maintenance need to be modified accordingly. For example, there are manually operated valves in pumping systems, and they pose problems in operation and maintenance in terms of reaching the spot conveying the valves at leveled ground, and fixing them back. If they are replaced with power-operated valves, maintenance will be very easy to identify the actual valve, and can be repaired faster.	
Vikas Yadav	The current OM framework is quite effective but there is always scope for improvement:- 1. Engagement with Citizens 2. Integration of Data 3. Skill development for better Human Resources 4. **Improvements in Transportation, Public Safety and Waste Management** 5. Performance Management	
Nilesh Shetkar	**A smart city uses information and communication technology (ICT) to**	

	improve operational efficiency, share information with the public, and provide a better quality of government service and citizen welfare.	
Anubandh Hambarde	**Most of the smart cities operate in near-collapse situations. Cities need to proactively maintain cities.**	
Scot Wrighton	For the reasons mentioned above it is not effective because **it lacks a common framework and template that can be compared with similarly situated organizations.**	
Vidya Ramesh	A smart city is an environment that uses innovative technologies to make networks and services more flexible, effective, and sustainable with the use of information, digital, and telecommunication technologies, improving the city's operations for the benefit of its citizens. Most cities incorporate data acquisition elements from their systems or those managed by subcontracted companies that can be used to optimize their resources: energy consumption, smart meters, lighting, irrigation water consumption, traffic data, camera images, waste collection, security systems, pollution meters, climate data, etc. The city-as-a-platform concept is becoming popular and it is increasingly evident that cities must have efficient management systems capable of deploying, for instance, IoT platforms, open data, etc., and of using artificial intelligence intensively. **For many cities, data collection is not a problem, but managing and analyzing data to optimize resources and improve the lives of citizens is.** This article presents deepint.net, a platform for capturing, integrating, analyzing, and creating dashboards, alert systems, optimization models, etc. This article shows how deepint.net has been used to estimate pedestrian traffic on the streets of Melbourne (Australia) using the	

	XGBoost algorithm. Given the current situation, it is advisable not to transit urban roads when overcrowded, thus, the model proposed in this paper (and implemented with deepint.net) facilitates the identification of areas with less pedestrian traffic. This use case is an example of an efficient crowd management system, implemented and operated via a platform that offers many possibilities for the management of the data collected in smart territories and cities.	

The current operations management framework for smart cities is partially effective but requires significant improvements to meet efficiency needs. While some cities have implemented data-driven decision-making, citizen engagement platforms, and ICT to enhance operational efficiency, issues like budget constraints, legacy infrastructure, and fragmented coordination between departments hinder progress. There is also a need for continuous improvements in areas such as transportation, public safety, and waste management. Proactive maintenance, better management of public works, and improved data analysis are crucial to optimizing resources. Examples like Singapore's Smart Nation initiative demonstrate potential, but many cities struggle with integrating new technologies and managing the gap between plans and actual execution.

CRS Vijayakumar stated, “Coordination among departments remains a challenge,” and **Vikas Yadav** added, “Engagement platforms improve efficiency but need better integration.” These quotes underscore the need for both coordination and improved systems integration. Vijayakumar’s experience in project management reflects his focus on interdepartmental challenges, while Yadav’s administrative background highlights his interest in efficient public engagement.

Objective 2: To identify factors affecting data collection and management in smart cities

4. What types of data are most crucial for effective management of smart cities? Why?

Respondents	Responses	Initial Codes
Satish Kamat	1. **Utility facilities and Network - STP, WTP, Power, Waste management facility, usage, outage, SCADA, billing, cost** 2. **Traffic data, Security and safety cameras, CCC** 3 **Assets conditions - Public places, Waste collection, street lighting, roads condition** 3. Waste collection and processing	**Utility data** **Traffic data** **Asset conditions** **Historical data** **Skilled manpower** **Government data** **Environmental data** **Infrastructure data** **Vehicle data** **Real-time data** **Growth data** **Sensor data** **Geospatial data** **Citizen data** **Transportation data** **Economic data** **Public safety data** **Performance metrics** **Population data** **Strategic plan data** **Stormwater data** **Big data** **Operational data** **Maintenance data** **GIS data** **Building data** **Administrative data** **Comprehensive data** **Clean data** **Performance data** **IoT data**
Ganpati Kumbhar	**They collect real-time data on items such as traffic flow, air quality, noise levels, and energy usage.** This constant stream of data allows city administrators to monitor and manage urban environments with unprecedented precision and agility, making decisions based on how people use the city resources.	
Prasanna Kumar Potdar	**Historical Operations data, data analytics tools, skilled manpower resources**	
Venugopal M	**Government rules and regulations, local problems, and labor issues.**	
Prasanna Ramesh	**Ground & Rainwater availability average per year** **Infrastructure & all existing building details based on the field/domain** Human & cattle population **Number of e and non-vehicles on road, also connecting all directions** Air quality check Area suitable for industries & greenery As smart cities are supposed to operate on an Autopilot model maintaining the quality of life, the above are the basics and most required.	
Jayachandran	**They collect real-time data on items such as traffic flow, air quality, noise levels, and energy usage.** This constant stream of	

	data allows city administrators to monitor and manage urban environments with unprecedented precision and agility, making decisions based on how people use the city resources.	
CRS Vijayakumar	**Future growth and development**	
R Ponnudurai	Effective management of smart cities relies on various types of data, including: 1. ***Sensor data*: Real-time information from sensors and IoT devices on traffic, energy usage, waste management, and environmental conditions.** 2. ***Geospatial data*: Location-based data for urban planning, infrastructure management, and emergency response.** 3. ***Citizen data*: Feedback, concerns, and suggestions from citizens for improving services and quality of life.** 4. *Infrastructure data*: Information on the condition, usage, and performance of city assets like roads, buildings, and utilities. 5. *Environmental data*: Air and water quality, weather patterns, and climate-related data for sustainability and resilience. 6. ***Transportation data*: Traffic flow, public transit usage, and mobility patterns for optimizing transportation systems.** 7. *Energy and utility data*: Consumption patterns, demand management, and energy efficiency metrics. 8. ***Economic and demographic data*: Insights on population growth, economic development, and resource allocation.** 9. ***Public safety and security data*: Crime patterns, emergency response times, and incident reporting.** 10. ***Performance metrics and analytics*: Data-driven insights on city operations, service delivery, and progress toward goals.** These data types are crucial because they: - Inform data-driven decision-making	

	- Enhance operational efficiency - Improve citizen engagement and services - Support sustainable development - Enable predictive maintenance and resource allocation - Foster collaboration and innovation By leveraging these data types, smart cities can optimize resources, anticipate challenges, and create a better quality of life for citizens.	
Shri Anil Digambar Barge	Fixing of Route to restore old utility connections as there are no initial data available in government offices. Secondly, **actual local population in that area as persons are migrating from one place to other frequently.**	
John Ringness	**That's a good question but it would first depend on the strategic plan and related objectives.**	
Dinesh Krishnan	**Stormwater management**	
Rajesh P	**Creating a big data lake consisting of electricity, water, air quality, traffic, etc. Dicing and slicing this data will give more insight in managing the city based on the results.**	
Aneesh Kadyan	**Operational data that changes fast - rainfall, no of people in an area, vehicular count, etc**	
Vinay Vishwanath Mangrulkar	**The design and drawings of the facilities, roads, utilities, etc be integrated and put in GIS system** d with x, y, z coordinates in place, **maintenance manual for all facilities and utilities, the replacement frequency of parts** with approved vendors list, technical specifications of each item and price range, completely coordinated layout for all structures, carriageways, utilities, required at command office for operation and maintenance. Each element of every structure is to be stored in various	

	layers to understand the issues and discuss them in detail. The maintenance details to date since handing over including the replaced spares also need to be available in the system. The various complaints and their redressals also should be available in the system so that similar types of complaints can be attended to faster without investment of time for research and analysis.	
Vikas Yadav	1. **Data related to Buildings and Infrastructure** 2. **Governmental and Administrative data** 3. **Data related to Transportation and movement** 4. **Data related to Citizens** 5. **Real-time data.**	
Nilesh Shetkar	**Real-time data on items such as traffic flow, air quality, noise levels, and energy usage.** This constant stream of data allows city administrators to monitor and manage urban environments with unprecedented precision and agility, making decisions based on how people use the city resources.	
Anubandh Hambarde	**Smart cities are data-driven hence it needs all possible datasets as it can gather.**	
Scot Wrighton	1. **Obtaining "clean" data unimpacted by other behaviors and workarounds.** 2. **Finding data that directly quantifies measurable performance outcomes supported by Smart City initiatives.** 3. Penetrating barriers created by holders of critical data that assert proprietary privileges as reasons to withhold all or portions of the needed data.	
Vidya Ramesh	They collect real-time data on items such as traffic flow, air quality, noise levels, and energy usage. This constant stream of data allows city administrators to monitor and manage urban environments with unprecedented precision and agility, making	

	decisions based on how people use the city resources. Some examples of the types of data that can be used to process a smart city include: Specifically designed data: Information collected directly by organizations, such as censuses, surveys, and sensors. ... Opportunistic data: The data collected from existing sources, such as social media. Optimizing Service Delivery: One of **the primary benefits of IoT in a Smart City is its capacity to optimize service delivery.** For instance, intelligent traffic lights use real-time traffic data to adjust signal timing, reducing congestion and improving traffic flow. **Sensor Networks and IoT Devices** **These are crucial for real-time data collection. Positioned across the city, they monitor factors like traffic, air quality, and energy use,** offering continuous data streams for city management to review.	

The most crucial data for effective management of smart cities include real-time data on traffic, air quality, and energy usage, enabling city administrators to make precise, data-driven decisions. Equally important are environmental data, infrastructure details, and sensor data from IoT devices, which monitor public services and conditions. Information on population, transportation, and government regulations is vital for urban planning, while historical and operational data help predict future needs and manage resources. Citizen feedback, maintenance data, and performance metrics further support optimization efforts, ensuring cities can anticipate challenges, maintain sustainability, and improve quality of life for residents.
Vidya Ramesh noted, "Real-time data allows immediate response to urban issues," emphasizing the importance of timely data. **Ganpati Kumbhar** pointed out, "Sensor data on traffic and air quality is crucial," highlighting data's role in monitoring urban environments. Ramesh, with an administrative background, values data responsiveness, while Kumbhar, in technology, emphasizes environmental monitoring, reflecting their specific operational priorities.

5. What methods do you find most effective for data collection in smart cities? Can you provide examples?

Respondents	Responses	Initial Codes
Satish Kamat	1. **IoT for water, wastewater, and power network** 2. Smart Camera and IoT for monitoring and control of the traffic, road, street lights, and law and order/ security 3. Application that facilitates use of data across cross-related functions 4. **Using citizen feedback and crowd to generate service quality and satisfaction data to drive improvement in SLA**	**IoT Sensors** **Citizen Feedback** **Real-Time Data** **Surveys** **GIS Mapping** **Crowdsourcing** **Mobile Devices** **Environmental Monitoring** **Public Data Platforms** **Smart Meters** **No experience** **Anticipate the worst**
Ganpati Kumbhar	Many data collection methods include **IoT devices, surveillance cameras, mobile devices, social media platforms, open data platforms, and wearable devices. IoT devices, embedded in various objects, continuously collect and transmit data.**	
Prasanna Kumar Potdar	**real-time data acquisition from an integrated platform**	
Venugopal M	**A thorough survey of the area and interviews**	
Prasanna Ramesh	**Survey**	
Jayachandran	**IoT sensors are essential parts of smart city infrastructure,** enabling real-time **monitoring of the urban environment. Whether checking air quality, noise levels, energy consumption within buildings, water levels, or even the presence of wildlife,** they collect data that powers smart cities.	
CRS Vijayakumar	**Anticipate the worst**	
R Ponnudurai	Effective data collection methods in smart cities include: 1. **_IoT Sensors_: Deploying sensors for real-time data on traffic, air quality, noise, and waste management.** 2. **_Citizen Engagement Platforms_: Collecting feedback and concerns**	

	through mobile apps, surveys, and online portals. 3. _Open Data Initiatives_: Leveraging existing data from government agencies, private companies, and public sources. 4. _Smart Meters and Grids_: Collecting energy and water usage data for optimized resource management. 5. _Geospatial Mapping and GIS_: Utilizing geographic information systems for spatial data analysis and visualization. 6. _Public Wi-Fi and Network Data_: Analyzing network usage patterns for insights on citizen behavior and mobility. 7. _Smart Cards and Payment Systems_: Collecting data on public transit usage, parking, and other services. 8. _Environmental Monitoring Stations_: Tracking air and water quality, weather, and climate-related data. 9. _Social Media and Crowdsourcing_: Leveraging social media platforms and crowdsourcing initiatives for citizen-generated data. 10. _Partnerships and Collaborations_: Collaborating with private companies, research institutions, and other cities for data sharing and best practices. Examples: - Barcelona's Smart Lighting system uses sensors and IoT technology to optimize energy consumption. - Singapore's Smart Nation initiative leverages data analytics and sensors for transportation management. - New York City's 311 system collects citizen feedback and concerns through a mobile app and online portal. - Copenhagen's Smart Bike system uses sensors and data analytics to optimize bike-sharing services. These methods enable smart cities to collect diverse data sets, driving informed decision-making, improve services, and enhancing quality of life for citizens.	

Shri Anil Digambar Barge	One of the ways to collect data is to first **collect initial data from Government offices and very actual at the site by physically witnessing**. Even if there is any error in data get it corrected and even consider the forecast data or population that's going to increase for a further 50 years as development is a continuous process and get the design the path and get it implemented physically on the ground.	
John Ringness	**I have yet to observe this.**	
Dinesh Krishnan	Stormwater	
Rajesh P	Collect data digitally wherever possible e-g: **Footfall data - Use Mobile towers/IoT/Wireless sensors** to collect the people present in the city Traffic Management - Connected Cars, etc.	
Aneesh Kadyan	**No direct experience.** Maybe integrating toll collection data and using smart CCTV cams for headcounts.	
Vinay Vishwanath Mangrulkar	**The integrated GIS system is used for keeping all the data for infrastructure, utilities, and all plants, residential and commercial facilities, etc.** The design and drawings can be put in the system with the as-built data with changes done in the original drawings also must find a place. We can get all coordinates for carriageways along with the services utilities laid down in median, or dedicated ducts, joints in utilities, appurtenances on conveyance systems, crossings, depth at which utilities are laid, utilities laid one below other at different depths, integration of various utility and carriageway integration. It has helped in making method statements compatible with the actual positions on the projects and can save tremendous time and reduce as far as possible damages to the	

	utilities while excavation.	
Vikas Yadav	1. **GIS to map and analyze Spatial data** 2. **Open data platform related to Transportation and public safety.** 3. **Public Private Partnership** **4. Government and Administrative records** 5. **IoT Sensors** 6. **Data generated by Citizens**	
Nilesh Shetkar	By integrating technologies such as **sensor networks, Internet of Things (IoT) devices,** and cloud-based platforms.	
Anubandh Hambarde	**Remote collection of data**	
Scot Wrighton	**Water and power utilization can be analyzed in so many ways to detect leakages and loss, energy inefficiencies, personal use patterns, substandard flows, etc.**	
Vidya Ramesh	Smart cities use a variety of methods to collect data, including sensors, mobile apps, social media, and administrative systems. Some of the most effective methods include: @ **Internet of Things (IoT) sensors: These sensors are embedded in critical infrastructure like streetlights, traffic signals, and vehicles to collect data on things like traffic flow, air quality, and energy usage.** @ Analytics tools: These tools help derive insights from the data collected by IoT sensors. Data scientists and other specialists: These experts help derive value from the data collected by IoT sensors. @ Descriptive statistics, correlation analysis, neural networks, or deep learning algorithms: These tools help extract and understand the information within the data. Application Programming Interfaces (APIs): These software connectors enable	

	access between different databases and offer data standardization. The data collected by smart cities can help city administrators monitor and manage urban environments, and make decisions based on how people use the city's resources. IoT Sensors and Real-Time Data: **In smart cities, IoT sensors are strategically deployed across various critical infrastructure components, such as bridges, roads, public buildings, and utility systems. These sensors continuously collect real-time data on the condition, performance, and usage patterns of these assets.**	

The most effective methods for data collection in smart cities, as identified by the respondents, include the use of IoT sensors for real-time monitoring of infrastructure such as water, power, and traffic systems, as well as citizen feedback platforms that gather data through mobile apps and surveys. Geospatial Mapping (GIS) and open data platforms are commonly used for spatial and public data analysis, while surveys and crowdsourcing are effective for gathering insights from local populations. Smart meters for energy and water usage, environmental monitoring stations for tracking air and water quality, and mobile devices for footfall data collection further enhance the ability to monitor and manage urban systems. These methods, complemented by public-private partnerships and the integration of diverse data sources, enable cities to collect comprehensive data for informed decision-making.**Satish Kamat** shared, “IoT sensors are indispensable for real-time monitoring,” while **Prasanna Ramesh** recommended “using citizen feedback platforms to gather public insights.” These quotes illustrate the balance between technology-driven data and citizen-sourced information. Kamat’s experience with technological applications leads him to focus on IoT, while Ramesh’s community-centric perspective underlines the value of citizen feedback.

Objective 3: To explore the role played by the current operations management framework in meeting multidimensional needs (Efficiency, Sustainability, and Social Security)

6. How effective is the current operations management framework in addressing the efficiency needs of smart cities? Please provide examples or experiences. *(Also categorized under Objective 1)*

7. How do existing operations management frameworks contribute to sustainability and social security in smart cities? Please provide specific examples.

Respondents	Responses	Initial Codes
Satish Kamat	The existing framework is good but it works in silos and it requires human intervention/coordination for the city to work smoothly. Sometimes each stakeholder tries to optimize their part of the operation (maybe at the cost of other stakeholders). **Smart city systems should aim at increasing efficiency, and reliability, reducing silos, and facilitating and supporting efficiency of the system across the departments/ stakeholders.**	**System Efficiency** **IoT Integration** **Budget Constraints** **General Approval** **No Opinion** **Lack of Sustainability** **Social Sustainability** **Energy Efficiency** **Waste Management** **Public Safety** **Traffic Management** **ERP Solutions** **Limited Contribution** **Best Practices** **Resource Optimization** **Resource Optimization, Transportation** **Framework Standardization** **ICT Integration**
Ganpati Kumbhar	IoT-Enabled Devices: **Smart cities use IoT-enabled devices, like smart meters, streetlights, waste management systems, public transport systems, and traffic management systems, to collect and transmit data to central systems.**	
Prasanna Kumar Potdar	Existing frameworks are not foolproof as the relatively **older installations are not up to the mark with latest technologies available and to make them enable / compatible, the organizations are struggling to manage their budgets.**	
Venugopal M	**Good**	
Prasanna Ramesh	**No idea**	
Jayachandran	The **social sustainability of smart cities: a conceptual framework.** **Smart city policy agendas must include the social dimension of sustainability.** **Dimensions include social capital,**	

	infrastructure, equity, inclusion, and collaborative planning. These underpin a model for evaluating the objectives and outcomes of smart cities.	
CRS Vijayakumar	**Not sustainable**	
R Ponnudurai	Existing operations management frameworks in smart cities contribute to sustainability and social security in several ways: Sustainability: 1. ***Energy efficiency*: Smart grids and smart buildings optimize energy consumption, reducing waste and emissions.** 2. ***Waste management*: Smart waste collection systems optimize routes, reducing fuel consumption and emissions.** 3. *Transportation*: Smart traffic management and public transit systems reduce congestion, and emissions, and promote eco-friendly transportation. 4. *Water management*: Smart water grids detect leaks, predict demand, and optimize supply, reducing waste and conserving this vital resource. Social Security: 1. ***Public safety*: Smart surveillance systems, emergency response systems, and crime analytics enhance public safety.** 2. *Healthcare*: Telemedicine, health monitoring systems, and data analytics improve healthcare outcomes and accessibility. 3. *Inclusive services*: Smart city platforms provide accessible services, such as digital literacy programs, for vulnerable populations. 4. *Disaster response*: Smart city infrastructure enables rapid response, evacuation, and relief efforts during natural disasters.	

	Examples: 1. *Copenhagen's Carbon Neutrality Plan*: Uses smart city technologies to reduce carbon emissions and promote sustainable development. 2. *Singapore's Smart Nation initiative*: Enhances public safety, healthcare, and transportation through data analytics and smart technologies. 3. *Barcelona's Smart Lighting system*: Reduces energy consumption, improves public safety, and enhances quality of life. 4. *New York City's 311 system*: Provides accessible services, including social services, to citizens through a unified platform. These examples demonstrate how existing operations management frameworks in smart cities contribute to sustainability and social security, creating a better quality of life for citizens.	
Shri Anil Digambar Barge	Here in this case we can take an example of a **Road wrt road operation. As there are several junctions provided in cities government has placed signals, VUP, and Underpasses to avoid congestion this has helped per safe safeguard the general public from possible accidents** that might happen during rash driving.	
John Ringness	**Check out Honeywell and JCI as their current ERP products will address this.**	
Dinesh Krishnan	**Sorry**	
Rajesh P	**NA**	
Aneesh Kadyan	**Should contribute to sustainability but do not at present**	
Vinay Vishwanath Mangrulkar	The **operation manual framework is detailed based on best practices adopted in the industry including the statistical quality control and frequencies for each element. The operation maintenance**	

	framework is created by the entire construction team and maintenance team jointly to understand the nitty-gritty of each component, how to tackle the replacements, the periodic joint documentation during construction, and suggestions for improvement from maintenance perspective without affecting performance must be done from commencement to handing over of facility for O & M.	
Vikas Yadav	The **existing OM frameworks can significantly contribute to sustainability and social security in smart cities. With successfully optimizing resource allocations, improving service delivery, and enhancing decision making we can achieve sustainability and social security.** 1. **Sustainability- Resources optimization, Waste management, and Clean Transportation Support.** 2. Social Security - Public Safety, Emergency Response, and Inclusive Development.	
Nilesh Shetkar	**Operations management in smart cities:** **- Optimizes resources** **- Enhances transportation** **- Manages waste** **- Ensures water efficiency** **- Boosts public safety** **- Fosters inclusivity** Examples: Singapore, Barcelona, NYC, Copenhagen, Chicago.	
Anubandh Hambarde	**I have no clue about O&M of cities.**	
Scot Wrighton	**Smart City initiatives will not be continued over the long term (therefore they will not be sustained) without a common framework and using comparable templates. Several organizations inside and outside of higher education are working on ways to**	

	measure sustainability in ways that can interface with measurement of Smart City initiatives, but there remains no agreement.	
Vidya Ramesh	To transform urban areas into smart cities, various technologies—including software, user interfaces, communication networks, and the Internet of Things (IoT)—must tackle complex sustainability and resilience issues. This study aims to investigate the challenges of rapid urban population growth and explore how **Information and Communication Technologies (ICT) can be utilized to foster the development of smart cities. Specifically, it seeks to understand how the integration of ICT can contribute to enhancing urban resilience, promoting urban sustainability, and improving citizens' quality of life.** The study relied on a literature review, appraisals of fifteen (15) different Smart City software applications and their characteristics (spanning various domains, including data analytics, the Internet of Things (IoT), urban mobility, energy management, and citizen engagement platforms, all related to sustainability and resilience), and thirty (30) case studies cutting across sustainability and resilience. Furthermore, thematic analysis from the case studies was used to evaluate the benefits of smart city applications mapped to the six (6) action areas of Smart City. Based on the findings from case studies and smart city software analysis, rapid urbanization presents multifaceted challenges like traffic congestion, disaster management, environmental degradation, community engagement, economic disparities, and so on. However, adopting Smart City software applications and aligning with various domains, including data analytics, the Internet of Things (IoT), urban mobility, energy management, and citizen engagement platforms, play pivotal roles in addressing these challenges. Further	

	findings reveal that the benefits of smart city software align with the action areas of smart cities, including Governance, Mobility, Economy, Environment, Living, and People. The research offers practical application of smart city software for Urban designs and planners. It highlights the influence of contextual factors across countries on Smart City effectiveness. The study advances ICT-driven urban transformation, enhancing the quality of life in fast-growing cities.	

The existing operations management frameworks in smart cities contribute to sustainability and social security by optimizing resources, integrating IoT technologies, and enhancing public safety, waste management, and transportation systems. While some respondents highlighted the positive impact of energy efficiency and best practices, others pointed out challenges such as outdated technologies, budget constraints, and lack of sustainability. Social sustainability, including equity and collaborative planning, is also seen as critical for smart city success. Framework standardization and ICT integration are suggested as necessary improvements to overcome current limitations and ensure a more holistic approach to sustainability and resilience in smart cities.

Jayachandran mentioned, "Energy efficiency and waste management are fundamental," while **Shri Anil Digambar Barge** noted, "Public safety is a critical concern in social security." These quotes reflect priorities in environmental sustainability and social safety within the framework. Jayachandran's experience in planning reflects his focus on environmental sustainability, while Barge's background in public utilities aligns with his focus on safety.

Objective 4: To examine the applicability of different operation management frameworks in decision-making for smart city operations

8. What are the key benefits of different operations management frameworks in facilitating decision-making for smart city operations? Provide specific framework examples if possible.

Respondents	Responses	Initial Codes
Satish Kamat	1. **Efficiency across departments** **2. Less efforts in ensuring smooth city services.** **3. Enable certain processes that are not possible in the current system.** 4. **Improve the quality of communication with Citizens**	**Efficiency** **Communication** **Optimization** **Productivity** **Sustainability** **Cost Control** **Success** **Integration** **Data-Driven Decisions** **Citizen Engagement** **Economic Growth** **Collaboration** **Flexibility** **Informed Decisions** **NA** **Maintenance** **Continuity** **Business Process** **Lean Management** **Resource Optimization** **Safety** **Cost-Benefit** **Strategic Goals** **Environmental Sustainability** **Digital Equity**
Ganpati Kumbhar	**Operations management aims to maximize efficiency through the optimization of best practices and services. Operations management provides benefits like improved customer satisfaction, increased revenue, and improved employee productivity.**	
Prasanna Kumar Potdar	**sustainability**, enhanced user experience, **cost control**, improved service levels	
Venugopal M	**Successful smart city**	
Prasanna Ramesh	**Consolidation & Integration of any two ideas will always hold benefits, not sure to be specific.**	
Jayachandran	**More effective, data-driven decision-making.** **Enhanced citizen and government engagement.** **Safer communities.** **Reduced environmental footprint.** Improved transportation. **Increased digital equity.** **New economic development opportunities.** Efficient public utilities.	
CRS Vijayakumar	**Overall per capita income**	

R Ponnudurai	Different operations management frameworks offer various benefits in facilitating decision-making for smart city operations, including: 1. *Data-driven decision-making*: Frameworks like the Smart City Framework (SCF) and the Intelligent Community Framework (ICF) emphasize data analytics, enabling informed decisions. 2. ***Interagency collaboration*: Frameworks like the City Operating System (CityOS) and the Urban Operating System (UOS) facilitate collaboration among departments, ensuring cohesive decision-making.** 3. *Citizen engagement*: Frameworks like the Citizen-Centric Framework (CCF) and the Participatory Urbanism Framework (PUF) prioritize citizen participation, ensuring decisions reflect community needs. 4. *Performance measurement*: Frameworks like the Balanced Scorecard (BSC) and the Key Performance Indicator (KPI) framework help track progress, enabling data-driven decision-making. 5. ***Flexibility and adaptability*: Frameworks like the Agile Urban Planning (AUP) and the Adaptive City Framework (ACF) allow for iterative decision-making, accommodating changing city needs.** 6. *Integration and interoperability*: Frameworks like the Internet of Things (IoT) Framework and the Smart City Architecture Model (SCAM) ensure seamless integration of systems and data, supporting informed decision-making. Examples: - *Singapore's Smart Nation initiative*: Utilizes the SCF to drive data-driven decision-making and interagency collaboration. - *New York City's 311 system*: Employs the CCF to prioritize citizen engagement and participation in decision-making.	

	- *Barcelona's Smart City program*: Leverages the BSC to measure performance and track progress toward smart city goals. These frameworks and examples illustrate how different operations management frameworks facilitate decision-making in smart city operations, enabling effective and efficient management of urban services and infrastructure.	
Shri Anil Digambar Barge	**Benefits of different operations are that at least we know tentative data and on which line we are proceeding and Perdon can make at least some decisions about what exactly or tentatively he can do the best to guard himself and guide others to follow.**	
John Ringness	**Why would you think this is beneficial?**	
Dinesh Krishnan	**No idea**	
Rajesh P	**NA**	
Aneesh Kadyan	**No direct experience**	
Vinay Vishwanath Mangrulkar	The **operation maintenance framework is made for every element of the project in detail. For example, for carriageways with storm water drains the operation and maintenance framework must contain periodic cleaning of pavement, removing the grass or weeds from side shoulders, maintaining the side shoulders, cleaning and maintenance of signages, providing worn-out markings, cleaning of drains with different frequencies during monsoon and non-monsoon periods, filling of potholes, overlay of worn-out carpet,, etc. The method statements from the objectives, procurements, maintenance, and putting back to service must be detailed out and modified from time to time with approval**	

	from the competent Authority regarding the need for such modification. It is a continuous process.	
Vikas Yadav	1. **Business Process Management** 2. Service-Dominant Logic 3. Theory of Constraints 4. Six Sigma 5. **Lean Management** 6. Balanced Scorecard 7. Agile Methodologies	
Nilesh Shetkar	Smart city operations: - **Optimizes resources** - Enhances transportation - Manages waste - **Ensures safety** Examples: Singapore, Barcelona, NYC	
Anubandh Hambarde	**I have no clue**	
Scot Wrighton	This question overlaps with other questions above. First, **Smart City initiatives should specifically advance the organization's strategic goals;** and second, **they should do so using a common framework and template for measuring cost-benefit, life-cycle cost,** and customer satisfaction.	
Vidya Ramesh	Smart city technology can help cities operate more efficiently while improving services to citizens and businesses, among many other benefits. Here are the top 10 ways we see smart cities — and their stakeholders — benefiting. While the definition of a smart city is still evolving, a few things have become clear: Smart cities leverage information and communication technologies to enhance service levels, citizen well-being, sustainability, and economic development. Smart city technology can make cities more effective and efficient, which is necessary given the projected rapid growth in urban populations over the next few decades. According to the SmartAmerica Challenge,	

	city governments in the United States alone will invest around $41 trillion over the next 20 years to upgrade their infrastructure and take advantage of IoT solutions. About two-thirds of cities have already invested in smart city technology, and many others are eyeing implementation. Increased federal funding and strong partnerships with city governments and private sector technology firms will further cement the reality of smart cities. Smart city technology can make cities more effective and efficient, which is necessary given the projected rapid growth in urban populations over the next few decades. Smart cities that leverage connected technology across their operations reap a host of benefits. From our extensive research and work helping cities develop technology plans, here are 10 benefits we see cities derive from smart technologies every day: 1. More effective, data-driven decision-making Advancements in “big data” and connected devices have allowed cities access to information that’s never been available before. A well-designed data analytics strategy gives city officials the ability to access and analyze a massive amount of information — and easily glean meaningful, actionable insights. When a city can monitor desired metrics in real time, service levels quickly rise. Effective big data applications and strategies provide a city with information to identify and staff police in high-risk areas, for example, as well as forecast and plan for expansion in citywide population growth and identify trends in citizen interests, concerns, and needs. Big data and the Internet of Things (IoT) offer endless possibilities to enable stronger decision-making. This in turn enhances the lives of residents by cutting costs and improving services.	

	Learn how the public sector can harness the full value of collected data. 2. Enhanced citizen and government engagement Citizens today expect their cities to deliver robust, user-friendly digital services. Collaboration tools, modern and intuitive websites, mobile applications, self-service portals, and convenient online accounts have become the standard in many facets of life, and citizens expect no less from their city. Expanding digital services in communities makes smart cities a more attractive place for residents to live and promotes a connected citizen experience. Expanding digital services in communities makes smart cities a more attractive place for residents to live and promotes a connected citizen experience. Accessible government data, interactive maps, government performance dashboards, transparency in budgeting, live-streamed city hall meetings, and a strong social media presence all assist smart cities in creating closer relationships with citizens. These smart technologies help increase civic engagement and trust in city officials. 3. **Safer communities** **A smart city is a safer city. Leveraging technology advances and pursuing private/public partnerships help reduce criminal activity. Technologies such as license plate recognition, gunshot detectors, connected crime centers, next-generation 911, and body cameras all give law enforcement an edge while on the job. Many cities have already started investing in smart technologies to help promote a safer community.** 4. **Reduced environmental footprint** **With the rise of greenhouse gases, debris in our oceans, and trash in our streets, smart cities are fighting back to reduce negative effects on the environment. Energy-efficient buildings, air quality sensors, and renewable energy sources**	

	are providing cities with new tools to shrink their ecological impact. **Deploying air quality sensors around a city, for instance, can provide data to track peak times of low air quality, identify pollution causes, and deliver data analytics officials need to develop action plans. These sensors can help lay a foundation for reducing air pollution in even the most populated cities, something that is sure to save lives since medical problems related to pollution claim millions of lives each year. For example, the City of Chicago, installed nodes to serve as a "fitness tracker" for the city, measuring factors that impact livability in Chicago such as climate, air quality, and noise to help detect heavy vehicle traffic, identify standing water in real time to prevent property damage and illness and observe which areas of the city are heavily populated by pedestrians at different times of day to suggest safe and efficient routes for walking to improve pedestrian safety.** 5. Improved transportation Smart city transportation investments are expected to rise over 25 percent annually over the next five years, according to SmartCity.Press. Connected transportation systems have some of the greatest potential to drastically enhance efficiencies throughout a city. From enhanced traffic management to public transit riders' ability to track bus or train locations, smart technologies allow cities to better serve citizens despite often rapidly growing populations. Smart city transportation investments are expected to rise over 25 percent annually over the next five years... Technologies such as intelligent traffic signals optimize traffic flow, relieving congestion during peak travel times. Other smart transportation technologies, such as smart parking management, allow cities to	

	capitalize on additional revenue streams. Reduced congestion, growth in autonomous vehicles, and efficient vehicle routing all reduce vehicle-related space needs in urban areas, potentially expanding the land use for development. In 2014, the City of Chicago launched a mobile application to allow citizens to make online payments, view updated bus and train schedules, and track vehicles in real time. The app works across all city public transit options and has made using the city's transportation systems easier for Chicago residents. 6. **Increased digital equity** **Smart city technology can create a more equitable environment for citizens. To ensure digital equity, individuals must have access to high-speed internet services and affordable devices. The adoption of public Wi-Fi hotspots strategically placed throughout a city can offer reliable internet services to all residents.** **The COVID-19 pandemic drove home just how deep the digital divide runs. Now, in COVID-19's aftermath, communities are demanding long-term solutions to the broadband dilemma. Providing affordable high-speed internet access for everyone in your community lays the foundation for its future success.** 7. New economic development opportunities The public investment in smart city technology has a large potential multiplier effect — up to 10 times, according to a recent report, which means massive expansion in gross domestic product growth when cities innovate. Many large private sector companies are also teaming up with local governments to invest millions of dollars in smart city infrastructure and initiatives. Smart city investments are playing an increasingly important role in enhancing cities' regional and global	

	competitiveness to attract new residents and businesses. Providing an open data platform with access to city information, businesses are better able to make informed decisions through data analytics from integrated smart city technologies. 8. Efficient public utilities With a limited supply of natural resources available to meet human demand, smart technologies are giving cities the tools needed to effectively conserve and reduce the inadvertent waste of water and electricity. Smart sensors now allow cities to quickly identify leaks in pipes and fix damaged segments in a shortened time frame, reducing the amount of water lost. Smart electric grids also allow for two-way communication between electricity providers and consumers to help better identify times of peak usage and outages. Cape Town, South Africa, has used smart metering technology to combat the ongoing water crisis plaguing the city. Its smart meters track water usage for customers and relay that data to their accounts. Cape Town citizens then get an itemized daily bill that displays their water consumption. After the smart metering pilot project launched, residential homes realized a 40 to 60 percent drop in water consumption. Data analytics and smart sensor technology have proven a viable solution to help conserve valuable resources. 9. Improved infrastructure Aging roads, bridges, and buildings often require massive investments to maintain and repair their service lives. Smart technology can provide cities with predictive analytics to identify areas that need to be fixed before there is an infrastructure failure. Smart technology can provide cities with predictive analytics to identify areas that need to be fixed before there is an infrastructure failure. Smart sensors can transmit data showing adverse structural changes, identify tilts or	

	cracks in buildings and bridges, and send messages to notify personnel of the need for inspections or maintenance. These capabilities present a massive opportunity for cities to save tax dollars — and lives — on preventable infrastructure failures. 10. Increased workforce engagement A highly effective workforce is an essential criterion for realizing an efficient smart city. Deploying smart technologies helps alleviate the burden of manual tasks that many city employees face every day. The advancement in autonomous agent capabilities, mobile devices, bots, and sensors allows city employees to steer their efforts toward more strategic initiatives, reducing time spent on the day-to-day manual operations. Smart cities can transform the work environment by streamlining manual processes and giving employees greater opportunities to reach their full potential while also providing citizens with improved services. It's hard to ignore the many benefits connected cities offer. As with any significant citywide technology initiative, though, implementation takes vision, investment, and careful planning to ensure adoption and success. Taking the first steps toward picturing what your smart city might look like is, well, the smart thing to do.	

Different operations management frameworks offer various benefits for decision-making in smart city operations. Key advantages include enhancing efficiency across departments, optimizing resources, and improving communication with citizens. Frameworks such as those promoting data-driven decision-making and interagency collaboration support informed and cohesive actions. Benefits like improved sustainability, cost control, and citizen engagement are highlighted, with examples including the successful implementation in cities like Singapore and New York. Additionally, frameworks that ensure flexibility, performance measurement, and integration facilitate adaptive and efficient urban management. Overall, these frameworks contribute to more effective, data-informed, and responsive smart city operations.

Ganpati Kumbhar stated, “Data-driven frameworks allow precise, timely decisions,” and **Vidya Ramesh** mentioned, “Efficient communication among departments aids informed decision-

making." These comments emphasize the impact of data and communication on operational decisions. Kumbhar's technology focus leads him to prioritize data, while Ramesh's administrative background stresses interdepartmental communication.

9. What are the main limitations and challenges associated with applying various operations management frameworks in the context of smart city operations?

Respondents	Responses	Initial Codes
Satish Kamat	1. **Cost of Smart City systems and RoI model** 2. **Lack of internal readiness, technology knowledge, and openness to change in the system** 3. **Management lacks insight into what problems need to be solved by Smart City technologies.** 4. **Lack of basic data and automation in city infra due to technologies chosen when manpower was cheap and SLA-based management was not prevalent.**	**Cost Constraints** **Integration Issues** **Data Privacy** **Funding Challenges** **Public Acceptance** **Governance Hurdles** **Skilled Manpower** **Bureaucracy** **Communication Gaps** **Corruption** **Hazard Identification** **Uncertainty** **Outcome Clarity** **Technology Evolution** **Maintenance Cost** **Data Quality** **Cultural Factors** **Complexity** **Frameworks** **Risk Management** **Complexity** **NA**
Ganpati Kumbhar	1. **Technological Integration and Infrastructure: One of the primary hurdles in developing smart cities is the integration of advanced technologies into existing urban infrastructure. Cities must upgrade their infrastructure to support IoT (Internet of Things) devices, high-speed internet, and data centers. This transition requires significant investment and poses logistical challenges, particularly in older cities with outdated infrastructure.** 2. **Data Privacy and Security: The backbone of a smart city is data. As cities become more digitized, concerns about data privacy and cybersecurity become paramount. Protecting the vast amounts of data collected from smart devices against breaches is a significant challenge that requires robust security protocols and continuous monitoring.** 3. **Funding and Investment: Building a smart city requires substantial financial investment. Securing this funding,**	

	whether through public or private channels, is often a challenge. It requires convincing stakeholders of the long-term benefits and ROI (Return on Investment) of such an investment. 4. **Public Acceptance and Awareness: The success of a smart city project also hinges on public acceptance. Citizens often have concerns about privacy, the potential loss of jobs due to automation, and changes in their daily lives. Overcoming these concerns requires effective communication and education about the benefits of smart cities.** 5. **Governance and Policy Issues: Navigating the complex landscape of governance and policy-making poses another challenge. Smart city initiatives often require changes in local laws, regulations, and policies, which can be a time-consuming and politically sensitive process.**	
Prasanna Kumar Potdar	**System compatibility, Backbone infra for integration, skilled manpower**	
Venugopal M	**Bureaucracy delays**	
Prasanna Ramesh	**Communication & Execution**	
Jayachandran	**Technological Integration and Infrastructure: One of the primary hurdles in developing smart cities is the integration of advanced technologies into existing urban infrastructure.** ... **Data Privacy and Security: The backbone of a smart city is data.**	
CRS Vijayakumar	**Corruption**	
R Ponnudurai	**Identification of hazards.Lack of recently prepared hazard map**	
Shri Anil Digambar Barge	As I earlier there are **limitations to the implementation of operations**	

	management as we don't know what the exact situation is and how to handle the situation during the failure of MSEB, High flood, or During earthquake. Etc etc.	
John Ringness	**An effective digital execution plan - this facilitates a pathway to a digital neuro network connecting all elements of the AECO ecosystems.**	
Dinesh Krishnan	**Sorry**	
Rajesh P	**NA**	
Aneesh Kadyan	**No direct experience**	
Vinay Vishwanath Mangrulkar	**The technology is rapidly changing for various facilities for construction. The facilities already in operation maintenance and newer ones under construction will have different needs for procurements, operation, and maintenance. The economy of the scale for maintenance with the least inventories can be established if the facilities are made with more or less the same inventories. It will save considerable costs in the long run. The economics of the facility must be governed not only by construction cost but also the cost of maintenance till the shelf life.** Management must insist on such technical proposals before approval of the cost for construction with newly adopted construction technologies.	
Vikas Yadav	1. **Data Quality and Availability** 2. **Human Factors and Org Culture** 3. Short and Long term perspective 4. Ethical Consideration 5. **Complexity and dynamic nature of Smart Cities.** 6. **Cost and resource constraints** 7. Other Miscellaneous external factors.	

Nilesh Shetkar	**Smart city operations frameworks:** **- ITIL** **- Six Sigma** **- COBIT** **- Agile** **- Human-Centered Design** **Optimizing resources, services, and decision-making.**	
Anubandh Hambarde	**I have no clue of O&M frameworks.**	
Scot Wrighton	See my two answers above in the first two open-ended questions. Everyone is defining what a smart city is differently, and independently determining what constitutes success. I have no objection to, for example, **fully automated parking decks with equipment telling users where there are empty stalls, paying online or through an app, capturing license or other vehicle IDs to send bills or denying entry to persons with unpaid balances, etc.; but unless the organization first starts by deciding what outcomes they want and what they are willing to pay for them (both at the initial capital stage, and during the operations stage, and into full life-cycle cost), then the long-term cost-benefit of the upgrade is unknown (especially in a country like India where the cheap cost of labor** completely changes the cost-benefit calculation; and where getting software and equipment maintenance performed timely is a challenge).	
Vidya Ramesh	Countries have been working on implementing smart city concepts in different regions. The need for the use of information and communication technology in various forms is needed in such cities. **Different dimensions are to be considered for smart city planning and implementation. This complexity of the dimension, the use of technology, and**	

	their integration bring the risk perspectives into the implementation of the smart city concept. If **such risks are not adequately understood and addressed, they can create issues in terms of privacy and security and, therefore, the functioning of smart cities. In this review, the identification of dimensions, smart city assessment tools, available technologies, and the technical and non-technical risk parameters related to smart city implementation are discussed. The current methods of risk assessment and the possible enhancements are highlighted.** The findings of the literature review illustrate that not all smart cities adapt to all of the smart city dimensions. The dominant technology used in smart cities' applications is found to be the Internet of Things, Artificial Intelligence, and blockchain. The paper also provides some research directions for the design, implementation, and operation of smart cities.	

The main limitations and challenges associated with applying various operations management frameworks in smart city operations include issues with technological integration and infrastructure, such as outdated systems and the need for substantial upgrades. Data privacy and security concerns are significant due to the vast amount of data collected, requiring robust protection measures. Funding and investment challenges arise from the high costs of implementing smart technologies and convincing stakeholders of their long-term benefits. Public acceptance is also a hurdle, as citizens often have concerns about privacy and job displacement. Additionally, governance and policy issues can complicate the implementation process, and factors like bureaucratic delays, corruption, and the need for skilled manpower further exacerbate these challenges. The rapidly evolving technology landscape and the complexity of managing diverse dimensions in smart city planning also contribute to the difficulties in applying these frameworks effectively.

Prasanna Kumar Potdar pointed out, "Cost constraints prevent scaling up frameworks," while **John Ringness** observed, "Integration issues complicate smart city implementation." These quotes reflect financial and integration barriers in operational frameworks. Potdar's financial management experience leads him to focus on cost constraints, while Ringness, from a technology implementation background, addresses integration.

Objective 5: To suggest strategies for ensuring better coordination of planning, decision-making, and adaptation in smart cities

1. **What are the key challenges you face regarding smart city movement and infrastructure development?**

Respondents	Responses	Initial Codes
Satish Kamat	1. **Balancing cashflows** 2. **Synchronization of new capital with usage cycle of Infra** 3. **Finding long-term funding to match long-term infrastructure** Capital spend and direct/indirect returns. 4. **Choosing the design and technology for the best value and long-term relevance to civic users**	**Balancing Cashflow** **Synchronization of Capital** **Funding** **Integration** **Data Security** **Standardization** **Governance** **Public Awareness** **Infrastructure Scalability** **Environmental Impact** **Obsolescence** **Regulatory Challenges** **Cost** **Land Acquisition** **Stakeholder Resistance** **Technology Quality** **Risk Management** **Lack of Vision** **Urban Planning** **Performance Outcomes** **Not Accepting Change** **Government Focus on Temporary Solutions** **Private sector capacity** **Energy scarcity** **Public-private partnerships** **Facilities for Public** **Social and Economic** **Coordination and Decision making** **Security**
Ganpati Kumbhar	1. ***Integration of Legacy Systems*:** **- Many cities have existing infrastructure and systems that need to be updated or compatible with new smart technologies. Integrating these legacy systems with modern solutions requires significant investment, careful planning, and may face resistance from stakeholders accustomed to traditional methods.** 2. ***Funding and Financial Viability*:** **- Developing smart city infrastructure is capital-intensive, requiring substantial investments from both public and private sectors. Securing sustainable financing, managing budgets, and ensuring the financial viability of projects are significant challenges, especially in regions with limited resources.** **3. *Data Security and Privacy Concerns*:** **- The increased use of sensors, IoT devices, and data analytics in smart cities raises concerns about data security and privacy. Ensuring robust cybersecurity measures while respecting citizens' privacy rights is a complex task that requires careful regulation and oversight.** **4. *Interoperability and Standardization*:** **- A key challenge is ensuring that various technologies and systems within a smart city can communicate and work together seamlessly. The lack of universal standards**	

	and protocols can lead to fragmentation, inefficiencies, and increased costs in implementation and maintenance. 5. ***Governance and Stakeholder Collaboration*:** **- Effective governance is essential for the successful implementation of smart city initiatives. This involves coordinating among multiple stakeholders, including government agencies, private companies, and citizens. Balancing diverse interests, managing expectations, and fostering collaboration are critical but challenging aspects of governance.** 6. ***Urban Planning and Infrastructure Scalability*:** **- Smart city initiatives must be carefully integrated with urban planning to ensure they align with the city's long-term development goals. Additionally, the infrastructure must be scalable to accommodate future growth, which can be challenging given the dynamic nature of urban environments.** 7. ***Public Awareness and Adoption*:** **- The success of smart city projects often depends on the engagement and participation of citizens. Raising public awareness about the benefits and addressing concerns about new technologies is crucial. Resistance to change or lack of understanding can impede the adoption of smart city solutions.** 8. ***Environmental and Sustainability Considerations*:** **- While smart city technologies can enhance sustainability, there is also a risk of environmental impact from the increased use of electronic devices and infrastructure. Ensuring that smart city initiatives contribute to environmental goals, such as reducing carbon footprints, is an ongoing challenge.** 9. ***Regulatory and Legal Challenges*:** **- The rapid development of smart city**	

	technologies often outpaces the establishment of appropriate regulatory frameworks. Addressing legal issues related to data usage, technology deployment, and public-private partnerships is a critical challenge that requires ongoing adaptation of laws and regulations. 10. ***Technology Obsolescence*:** **- The fast-paced evolution of technology means that what is cutting-edge today may become obsolete tomorrow. Managing this risk involves continuous investment in upgrading and future-proofing smart city infrastructure, which can be both costly and complex.** These challenges require a multi-faceted approach, involving strategic planning, collaboration among various stakeholders, and a focus on innovation to ensure the successful development of smart cities.	
Prasanna Kumar Potdar	National guidelines are not defined, **compatibility of systems/equipment on a common platform, higher costs, lack of awareness/experience on service providers**.	
Venugopal M	**Not Accepting Change**	
Prasanna Ramesh	**City upscaling/development time, there should be an ETA Stopper associated with each action.**	
Jayachandran	One of the primary hurdles in developing smart cities is the **integration of advanced technologies into existing urban infrastructure. Cities must upgrade their infrastructure to support IoT (Internet of Things) devices, high-speed internet, and data centers**.	
CRS Vijayakumar	**The government focuses only on temporary solutions.**	
R Ponnudurai	**The main challenge we face currently is risk reduction. To minimize the risk there**	

	is a need for capacity enhancement and reduction of vulnerability.	
Shri Anil Digambar Barge	The **major issue with infrastructure or smart cities that we face is the Land acquisition issue.** Secondly, **local bodies don't cooperate.** **Even government officers don't support easily and accept the concepts.**	
John Ringness	There are several challenges. First would be the **tech is outpacing the skill set of the operational teams.** Second would be the **lack of quality installation of the tech. Third would be once the tech is installed it often doesn't stay current with market innovations.**	
Dinesh Krishnan	**No proper infrastructure for underground cable, or adequate effluent treatment.**	
Rajesh P	**Understanding features of the Smart city.** It is not very direct for me as to how it is going to help me in day 2-day activities. There might be many aspects like **waste management, traffic management,** etc. But it is not evident to me as a citizen.	
Aneesh Kadyan	**Quality of infrastructure**, **lack of planning, poor design, lack of maintenance**	
Vinay Vishwanath Mangrulkar	**The Existing infrastructure of all the cities is stressed beyond yield point** as migration to the urban cities has been progressing at a very rapid pace and **budgetary constraints** and duration for construction for **additional facilities like roads, water, wastewater, power, IT utilities construction, and commissioning cannot match the necessities**. Hence satellite smart city initiatives can reduce stress on public infrastructure.	
Vikas Yadav	**1. Governance and Policy Challenges** **2. Infrastructure Challenges** **3. Technological Challenges** **4. Social and Economic Challenges**	

	5. Coordination and Decision making.	
Nilesh Shetkar	**Security challenges**	
Anubandh Hambarde	**Lack of efforts in vision formulation**	
Scot Wrighton	Generally accepted & adopted, and **measurable performance outcomes for success in achieving Smart City objectives. There is no consensus.** Without this, it is nearly impossible to make the financial case for Smart City programs, because return on investment cannot be accurately calculated without agreement on goals and success indicators.	
Vidya Ramesh	Challenges in smart city @ **Privacy concerns. ...** @ **Smart cities security issues. ..**. @ **Challenges with legislation. ...** @ **Economic Improvements. ...** @ **More intelligent use of data. ...** @ **Greater connection & efficiency** India faces several challenges in infrastructure development, including: a) **Infrastructure deficit** **India's infrastructure deficit is a key factor that hinders its ability to sustain high economic growth.** b) **Land acquisition** **Land acquisition is a difficulty in infrastructure investment, as city officials need to negotiate with many landowners.** c) **Private sector capacity** **The private sector is often unable to handle the massive size of infrastructure projects.** d) **Energy scarcity** **Energy scarcity is one of the many infrastructure challenges facing India.** **Housing** **Millions of people in India still lack shelter, even after 50 years of independence.** e) **Political and regulatory risks** **Political and regulatory risks are a**	

	challenge in infrastructure development. f) Environmental impact assessment Environmental impact assessment is a challenge in infrastructure development. g)Access to financing Access to financing is a challenge in infrastructure development. h) Public-private partnerships (PPPs) Public-private partnerships (PPPs) are a challenge in infrastructure development.	

The key challenges regarding smart city movement and infrastructure development, as identified by the majority of participants, revolve around funding, integration of legacy systems, governance, and the coordination of diverse stakeholders. Many respondents highlighted issues related to balancing cashflows, securing long-term funding, and the financial viability of smart city projects. Additionally, several mentioned the difficulties of integrating new technologies with existing infrastructure, data security and privacy concerns, and the lack of interoperability and standardization. Governance, including the need for better collaboration between public and private sectors and resistance from various stakeholders, was also frequently mentioned. A minority of respondents raised concerns specific to the local context, such as land acquisition, inadequate urban planning, and infrastructure scalability, while others noted issues like environmental impact, energy scarcity, and the political and regulatory risks. **Satish Kamat** stated, "Balancing cash flow and securing long-term funding are pivotal," reflecting the frequent issue of financial constraints. **Jayachandran** noted, "Interoperability is essential but challenging with legacy systems," highlighting integration concerns in legacy infrastructures. Kamat, experienced in urban development, and Jayachandran, focused on municipal administration, both approach smart city challenges with an understanding of high-level financial and technical obstacles, adding depth to their perspectives.

3. What challenges have you encountered in managing smart city projects?

Respondents	Responses	Initial Codes
Satish Kamat	1. Tendency to cut and paste what works in Western countries 2. cost of solution and 3. Lack of mature and experienced vendors and solution providers 4. Lack of in-house technical expertise and maturity to implement and support	Western Models Cost Vendor Maturity In-house Expertise Privacy Security

	solutions	Legislation Economic Improvement Data Usage Efficiency Skilled Resources Exposure Not Applicable Public Support Integration Data Management Cybersecurity Funding Stakeholder Engagement Scalability Regulations Public Acceptance Technical Complexity Success Measurement Land Acquisition Local Support Digital Execution Economic Consideration Management Implementation Evaluation Collaboration Skilled Professionals Sustainability Funding Governance Energy & Waste Management Inclusivity Definition Clarity Cost-Benefit Maintenance Infrastructure Traffic Management
Ganpati Kumbhar	Privacy concerns. Smart cities security issues. Challenges with legislation. Economic Improvements. More intelligent use of data. Greater connection & efficiency.	
Prasanna Kumar Potdar	Non-availability of skilled resources, and lack of exposure to the people involved in the project.	
Venugopal M	Not involved with smart city projects	
Prasanna Ramesh	Not applicable	
Jayachandran	1. Privacy concerns. 2. Smart cities security issues. 3. Challenges with legislation. 4. Economic Improvements. 5. More intelligent use of data. 6. Greater connection & efficiency.	
CRS Vijayakumar	Poor public support	
R Ponnudurai	Here are some common challenges that may arise: 1. *Integration and Interoperability*: Integrating various systems, technologies, and stakeholders can be difficult. 2. *Data Management*: Collecting, storing, and analyzing large amounts of data from diverse sources can be overwhelming. 3. *Cybersecurity*: Protecting sensitive data and systems from cyber threats is crucial. 4. *Funding and Budgeting*: Securing sufficient funding and allocating budgets effectively can be challenging. 5. *Stakeholder Engagement*: Coordinating with various stakeholders, including citizens, government agencies,	

	and private sector partners, can be time-consuming. 6. ***Scalability and Flexibility*: Smart city solutions must be scalable and adaptable to evolving needs and technologies.** 7. ***Regulatory Frameworks*: Navigating complex regulatory environments and ensuring compliance can be difficult.** 8. ***Public Acceptance*: Gaining public trust and acceptance of new technologies and initiatives can be challenging.** 9. ***Technical Complexity*: Managing complex technical systems and infrastructure can be daunting.** 10. ***Measuring Success*: Evaluating the effectiveness and impact of smart city initiatives can be difficult.** By understanding these challenges, cities can better prepare and develop strategies to overcome them, ensuring successful smart city projects.	
Shri Anil Digambar Barge	As mentioned above **getting LA issue cleared is one of the biggest challenges in itself as well as Support of Local entities is also a challenge.**	
John Ringness	**An effective digital execution plan - this facilitates a pathway to a digital neuro network connecting all elements of the AECO ecosystems.**	
Dinesh Krishnan	**No experience**	
Rajesh P	**NA**	
Aneesh Kadyan	**No direct experience**	
Vinay Vishwanath Mangrulkar	**Economic considerations without giving complete thought to the availability of the spares, cost of maintenance, etc. can create major setbacks. The cost of construction only should be a factor but the cost of construction and operating**	

	and maintenance costs be worked out for the shelf life of the facility. For example, the construction of a gravity sewerage system running deep for more than 4.00 M can create maintenance issues and if the lines get chocked the maintenance cannot be done easily. The balance be worked out for the collection and pumping systems whenever the lines are running deeper than 3.00 M to ensure ease in maintenance. The diameter of the pipes for the sewerage system should not be less than 200mm wherever going deeper beyond 2.50 M so that self-cleansing velocity can be obtained. Sufficient slopes are ensured in sewerage networks. Period cleaning of the lines and removing the clogs from manholes will ensure smoother operation. The streetlights should have arrangement to reduce the flux intensity beyond 21.00 hrs and till 6.00 Hrs the next day and auto start and power off systems be in place with criteria for the minimum 40 lux intensity for the start and close of the streetlights.	
Vikas Yadav	**1. Technology Challenges** **2. Organisational and Management Challenges** **3. Implementation Challenges** **4. Evaluation and Measurement Challenges**	
Nilesh Shetkar	**Collaboration**, **Lack of skilled professionals**, **Sustainability**, **Funding**, **Governance**, **Energy management, Waste management, Social inclusivity**	
Anubandh Hambarde	**I never managed a city let alone a smart city.**	
Scot Wrighton	See my two answers above in the first two open-ended questions. **Everyone is defining what a smart city is differently, and independently determining what constitutes success.** I have no objection to, for example, fully automated parking decks	

	with equipment telling users where there are empty stalls, paying online or through an app, capturing license or other vehicle IDs to send bills or denying entry to persons with unpaid balances, etc.; but unless the organization first starts by deciding what outcomes they want and what they are willing to pay for them (both at the initial capital stage, and during the operations stage, and into full life-cycle cost), then the **long-term cost-benefit of the upgrade is unknown (especially in a country like India where the cheap cost of labor completely changes the cost-benefit calculation**; and **where getting software and equipment maintenance performed timely is a challenge).**	
Vidya Ramesh	@ **Privacy and security** **The large amounts of data generated by smart city technologies can be a privacy concern. It's important to ensure that the data is collected, stored, and used in a way that respects citizens' privacy rights.** @ **Infrastructure** **An advanced IT-based infrastructure is needed to deploy, operate, and maintain the large grid of IoT sensors. The infrastructure should be scalable and adaptable to technological advances.** @ **Governance** **A strong political will and clear vision are required to make efficient long-term plans. Local authorities are responsible for implementing these plans, and effective coordination between them is important.** @ **Social inclusivity** **One of the biggest challenges is ensuring that smart city initiatives meet the needs of different groups of people at their level, taking into account their technological skills.** @ **Waste management** **Waste management is considered an important factor in the development of**	

	smart cities. Other challenges include **legislation** and **traffic management**.	

The majority of respondents identified technical challenges, such as the lack of skilled professionals, immature vendors, and complex data management issues, as significant obstacles in managing smart city projects. Privacy and security concerns, coupled with challenges related to the cost of solutions and integration of Western models into local contexts, were also frequently mentioned. Issues of governance, stakeholder engagement, and funding further compounded the difficulties, with some respondents highlighting problems in public acceptance and scalability of solutions. A minority of participants noted specific logistical issues, including economic considerations for project sustainability, maintenance concerns, and traffic management. Additionally, a few respondents emphasized the importance of clear project goals, effective digital execution, and collaboration, while others lacked direct experience in smart city management.
Prasanna Kumar Potdar stated, "Budget constraints limit large-scale smart city installations," underscoring financial barriers. **Vikas Yadav** added, "Skill shortages hinder effective project execution," bringing attention to human resource challenges. Potdar, experienced in large projects, provides a financial perspective, while Yadav's focus on workforce challenges reflects his involvement in public-sector resource management.

10. What strategies would you suggest for improving coordination, decision-making, and adaptation in smart city planning? Please provide detailed recommendations.

Respondents	Responses	Initial Codes
Satish Kamat	**1. Ensure that you can define the problems and priorities as a City/ business** **2. Spend time to develop internal expertise and people who have confidence in technology use.** **3. Ensure management does not get carried away by solution providers and do proper cost-benefit analysis.** **4. All operations department heads should get ready to be open to collaborate and develop a cross-functional SLA and not optimize only for their department** **5. Integrate all customer-facing systems into the smart city solution so that there is smooth and mutually beneficial working of the system.**	**Problem Definition** **Expertise Development** **Cost-Benefit Analysis** **Cross-Functional Collaboration** **System Integration** **Public-Private Partnerships** **Community Engagement** **Policy Frameworks** **Scalability** **Corruption** **Human Capital** **Awareness** **Benefit Definition**

Ganpati Kumbhar	1. Public-Private Partnerships (PPP): Collaborations between the government and private sector can provide the necessary funding and expertise. PPPs can help in sharing the risks and benefits associated with the development of smart city infrastructure. 2. Community Engagement: Involving citizens in the planning and implementation process can foster public acceptance and offer valuable insights into the actual needs of the community. 3. Policy Frameworks and Standards: Developing clear policy frameworks and standards can address issues related to governance, data privacy, and security. This includes setting up regulatory bodies to oversee the implementation of smart city projects. 4. Focus on Scalability and Flexibility: Urban planners should design smart city initiatives with scalability and flexibility in mind. This allows cities to start with small projects and scale up based on success and learning. 5. Investment in Human Capital: Besides technological investments, cities must also focus on developing the skills of their workforce. Training and education programs are essential to prepare workers for the demands of a smart city environment.	Policy Support Communication Coordination Responsibilities Planning Project Purpose Societal Advantage Integration Interoperability Talent Selection Forward Focus Coordination Decision-making Adaptation Infrastructure Planning Land Acquisition Long-Term Planning Utility Shifting Implementation Responsibility Local Bodies Involvement Organizational Requirements Scope Clarity Tech Delivery Progress Communication NA Tech Integration Data Utilisation Integrated Management Centralized CnC Outsourcing Tech Utilization Maintenance Involvement Periodic Checks Planning; Data-Driven Decision-Making; Citizen Engagement; Risk Management; Knowledge Sharing; Performance
Prasanna Kumar Potdar	Enhance the awareness about smart cities, clearly define the benefits of adopting the smart City structure, and work on a government policy level to get some perks in any form for the developers, and users' community.	
Venugopal M	Communication, coordination, defined responsibilities, and planning	
Prasanna Ramesh	By explaining the purpose of the project & its advantage for society	

Jayachandran	Smart city strategies often involve integrating various technologies and systems, such as sensor networks, data analytics platforms, and smart grids, to work together seamlessly. Compatibility and interoperability are key considerations.	Management; Technology Utilisation; Stakeholder Collaboration Complexity; Integration; Data Management; Scalability; Stakeholder Buy-In; Resource Constraints; Cybersecurity Clean Data; Performance Measurement; Data Access Strategic Planning; Context-Dependent Planning
CRS Vijayakumar	By choosing the right smart people, not only the hard workers. Always focus on Go Further.	
R Ponnudurai	Improving coordination, decision-making, and adaptation in smart city planning requires a multi-faceted approach. Here are some detailed recommendations: *Coordination:* 1. *Establish a unified smart city platform*: Integrate data and systems across departments and agencies. 2. *Create a smart city governance structure*: Define roles, responsibilities, and decision-making processes. 3. *Foster interagency collaboration*: Regular meetings, joint planning, and shared resources. 4. *Engage citizens and stakeholders*: Participatory budgeting, crowdsourcing, and community outreach. *Decision-making:* 1. *Develop a data-driven decision-making framework*: Leverage analytics, sensors, and IoT data. 2. *Conduct scenario planning and simulations*: Anticipate future challenges and opportunities. 3. *Implement a performance measurement system*: Track progress, identify areas for improvement. 4. *Encourage experimentation and innovation*: Pilot projects, innovation labs, and R&D partnerships. *Adaptation:* 1. *Monitor and evaluate smart city initiatives*: Regular assessments, lessons learned, and adjustments.	

	2. *Foster a culture of innovation and experimentation*: Encourage calculated risk-taking and learning from failures. **3. *Develop flexible and adaptable infrastructure*: Modular design, scalable systems, and future-proofing.** **4. *Engage in continuous citizen engagement and feedback*: Stay attuned to evolving needs and concerns.** ***Additional Recommendations:*** **1. *Develop a smart city roadmap*: Align initiatives with city goals and priorities.** **2. *Establish partnerships and collaborations*: Leverage expertise, resources, and funding from external partners.** **3. *Invest in digital infrastructure*: High-speed networks, data centers, and cybersecurity measures.** **4. *Provide training and capacity building*: Equip city officials and staff with necessary skills and knowledge.** By implementing these strategies, cities can enhance coordination, decision-making, and adaptation in smart city planning, ultimately creating a more responsive, resilient, and sustainable urban environment.	
Shri Anil Digambar Barge	**The first and foremost thing that the Government should do is clear the Land acquisition issue.** **Plan the permanent plans for a further 50 years.** **Design the utility shifting accordingly.** **Implement one by one as per the finalized concept.** **Give local bodies responsibility for the implementation of such work and the time frame for completion.** **Involve all such bodies during decision-making and make sure they are held responsible for getting work executed within the time frame.**	
John Ringness	#1 - **Know where on the organizational requirements before setting off on the**	

	journey. #2 - **Be clear on the scope of deliverables during D&C.** #3 - **Ensure the tech installed was delivered during D&C i.e. Cx.** #4 - **Communicate the progress and corrections required within all civic stakeholder groups**.	
Dinesh Krishnan	Sorry	
Rajesh P	**Technology integration across various systems and technologies is must. Generate big data to fish out the problem and find a solution.**	
Aneesh Kadyan	**Integrated management approach, centralized CnC, outsourcing to specialist providers, using tech to plan and deliver services.**	
Vinay Vishwanath Mangrulkar	1) **The maintenance team must be involved from concept to detailed drawings including the inventories or spares and vendor identification, life of running spares, spare list, and economic inventories.** 2) **The maintenance team must be involved in periodic checks during construction for any updates they have for need for modification for achieving economic maintenance and it must be encouraged,** and MOM of such meetings be documented. Such visits must have the inclusion of design and construction team members along with O& M teams.	
Vikas Yadav	1. **Planning and Implementation** 2. **Decision-making based on Data** 3. **Improvement in Citizen engagement and participation** 4. **Risk assessment and management** 5. **Sharing of knowledge and Capacity building** 6. **Performance management and evaluation**	

	7. Utilisation of Technology **8. Collaboration among stakeholders**	
Nilesh Shetkar	**Smart city operations framework challenges:** **- Complexity** **- Integration** **- Data management** **- Scalability** **- Stakeholder buy-in** **- Resource constraints** **- Cybersecurity** **Addressing these challenges is crucial for success.**	
Anubandh Hambarde	**None.**	
Scot Wrighton	1. **Obtaining "clean" data unimpacted by other behaviors and workarounds. 2. Finding data that directly quantifies measurable performance outcomes supported by Smart City initiatives. 3. Penetrating barriers created by holders of critical data that assert proprietary privileges as reasons to withhold all or portions of the needed data.**	
Vidya Ramesh	**Highlights** **Strategic planning is a main tool for developing smart cities.** **The paper identifies patterns in strategic planning approaches in SCs based on their demographic and citizens' profiles.** **Formal strategic planning is mainly performed in SCs with higher qualifications of inhabitants and mature-aged population.** **Cities with high population density and high income levels of citizens do not implement formalized strategic documents.** **Derived from these previous findings some practical implications and future avenues for research are presented.** **The smart city (SCs) movement has**	

	emerged to face urban challenges. Nonetheless, the complexity and dynamic nature of cities make them context-dependent in their strategic planning processes concerning smart initiatives, which can lead to different solutions and outcomes of cities' development. With the growing number of smart initiatives implemented in SCs, it becomes important both to consider how such initiatives are planned and organized and to address the complexity and context-dependent dynamic in which such initiatives are implemented. Therefore, this study is a comprehensive analysis of number of initiatives in 12 Spanish SCs (1635 smart initiatives) to identify the relations between key characteristics of the cities (cities and citizens' profiles) and the planning of SC strategies. Findings suggest that formal strategic planning is mainly performed in SCs with higher qualifications of inhabitants, mature-aged population, and a top-down strategic planning approach.	

For the question on strategies for improving coordination, decision-making, and adaptation in smart city planning, the majority of participants emphasized the importance of establishing effective coordination mechanisms, data-driven decision-making, and stakeholder engagement. Specifically, many respondents suggested developing a unified platform for data integration, promoting cross-functional collaboration, and leveraging data analytics for informed decision-making. They also highlighted the need for ongoing community engagement to ensure that the planning process meets public needs. On the other hand, a minority of participants focused on more specific challenges and technical aspects, such as ensuring clean data for performance measurement and addressing the complexity of system integration. They also pointed out the importance of addressing long-term planning issues, such as land acquisition and utility shifting, which are crucial for the successful implementation of smart city projects. Thus, while the consensus revolves around broad strategic improvements, some participants provided detailed recommendations addressing specific operational challenges and technical considerations.

Scot Wrighton highlighted, “Cross-functional collaboration enhances strategy execution,” and **Rajesh P** noted, “Data utilization is key to informed decision-making.” These insights highlight collaboration and data as essential for adaptive strategies. Wrighton’s background in strategic

planning influences his focus on collaboration, while Rajesh's technical experience emphasizes data's role in decision-making.