Theoretical and Empirical Researches in Urban Management
Volume 21 Issue 1 / February 2026

# TOWARD SMARTER URBAN FUTURE: A STRUCTURED REVIEW OF THE CONCEPTS, IMPLEMENTATION STRATEGIES, AND GLOBAL APPLICATIONS

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**Abstract**
The concept of smart cities has emerged as a strategic approach to address complex urban challenges, aiming to enhance governance, infrastructure, digitalization, and citizen engagement through technology-driven approaches. However, the transition toward fully realized smart urban ecosystems is hindered by limited infrastructure readiness, regulatory and funding complexities, and socio-political challenges. This study utilizes a systematic literature methodology to gather information from Scopus database, a keyword-driven search was conducted for peer-reviewed articles published between 2015 and 2024. Inclusion criteria required are peer-reviewed status, empirical focus, thematic relevance to smart city domains (concepts, implementation, advantage, education, healthcare, governance, transportation, environment, energy, infrastructure, and cybersecurity), and geographic representation from both developed and developing regions. The paper evaluates the evolution of smart city definitions and conceptual frameworks, highlights effective implementation strategies, and identifies recurring challenges such as data interoperability, funding gaps, and policy misalignment. It further categorizes and maps solutions, including integrated urban platforms, adaptive policy frameworks, public-private partnerships, and AI-driven decision-making based on technological readiness, socio-economic adaptability, and institutional feasibility.
**Keywords**: Data governance, socioeconomic, inclusive digitalization, green renewable energy, smart urban ecosystems.

## 1. INTRODUCTION

Over the years, cities have grown tremendously with urban centers projected to reach over 70 % by 2050 (Lim et al., 2024). Despite such growth, cities face several challenges caused by the rapid growth of urban populations which increases the demand for space, energy, water, transportation, etc. In addition, environmental pollution, inadequacy of infrastructure services, and traffic congestion have also increased due to the rapid growth of urban areas (Prateeppornnarong, 2025). Such challenges create adverse effects such as scarcity of water resources, extreme climate events, loss of biodiversity, and poor air quality. In this regard, transforming cities via new technological tools such as Internet of Things (IoT), machine learning, and digitalization to develop smarter and sustainable cities is very much essential. However, developing sustainable smart cities also faces some challenges such as policies, legislation, funding, technological aspects, and infrastructure (Ismagilova et al., 2019).

Smart cities are complex, multidimensional ecosystems that leverage digital technologies and data-driven solutions to enhance urban life. Their structure can be understood through several core components such as society, quality of life, environment, governance, economy, and mobility (Figure 1) each contributing uniquely to the city's sustainability, resilience, and intelligence (Gracias et al., 2023). The interplay between these components defines the holistic success of smart city initiatives. For example, improvements in mobility can enhance quality of life and reduce environmental pollution, while smart governance strengthens both economic development and societal trust. Sanchez-Sepulveda et al. (Sanchez-Sepulveda et al., 2024) recently discussed and argued that the rapid urban development of smart cities pose major challenges to residents' well-being such as the infrastructure, mobility, and environmental pollution. Thus, for sustainable and scalable implementation, a balanced focus on all components is essential, supported by cross-sector collaboration and inclusive policy frameworks (Fadhel et al., 2024; N. S. e Silva et al., 2025; Svobodová & Bednarska-Olejniczak, 2020).

A smart society emphasizes inclusivity, digital literacy, social equity, and citizen empowerment. In addition, it fosters community engagement through participatory governance, accessible public services, and responsive civic platforms (Zhu et al., 2022). The features of smart society include e-governance tools for public participation, integrating education system with digital learning, and enabling public health services using AI and telemedicine (Svobodová & Bednarska-Olejniczak, 2020). Apart from that, quality of life in a smart city encompasses health, safety, housing, culture, and general well-being (Zhu et al., 2022). Enhancing life satisfaction is a central goal of smart urban development, facilitated by real-time services and efficient urban design. The features of the quality of life include the access to affordable and quality healthcare, clean and secure living environment and leisure, cultural and recreational amenities (Z. Chen & Chan, 2023).

Smart environment emphasizes sustainability through efficient resource management, pollution control, and climate resilience (Dai et al., 2024). IoT-enabled monitoring systems are utilized to reduce environmental footprints and preserve natural ecosystems. It includes the smart waste management systems, real-time air and water quality monitoring, and renewable energy integration and green buildings (Zhu et al., 2022). Smart governance involves transparent, accountable, and participatory decision-making, powered by digital infrastructure and data analytics (Nastjuk et al., 2022). It ensures efficient public administration, regulatory compliance, and adaptive policymaking. It includes the e-governance portals for services and feedback, open data platforms promoting transparency, and smart contracts and blockchains for secure transactions (Jiang, 2021). Smart economy drives innovation, entrepreneurship, sustainable economic development, fosters digital transformation across industries, supports start-ups, and promotes a knowledge-based economy (Y. Chen et al., 2024; Svobodová & Bednarska-Olejniczak,



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2020). It includes the digital marketplaces and fintech solutions, innovation hubs and incubators, and real-time analytics for economic planning. For example, Singapore's Smart Nation initiative supports tech-driven economic growth through innovation clusters and digital infrastructure. Smart mobility is essential for efficient and sustainable transportation systems. It integrates multi-modal transport, intelligent traffic management, and environmentally friendly travel options using real-time data (Bvuma, 2024; Yu et al., 2020). It includes various features such as the intelligent transportation systems, integrated public transit with mobile ticketing, electric vehicle infrastructure and mobility as a service platform (Paiva et al., 2021; Savastano et al., 2023). For example, Barcelona's Urban Mobility Plan combines bike-sharing, electric buses, and real-time transport apps to reduce congestion and emissions (Wolniak, 2023).

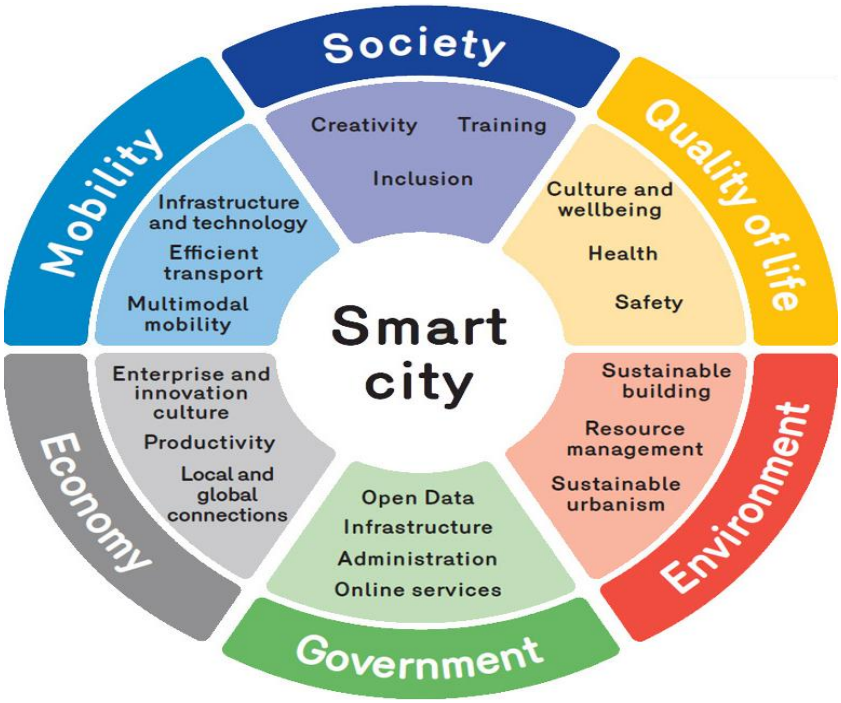


FIGURE 1 - SMART CITY COMPONENTS (SVOBODOVÁ & BEDNARSKA-OLEJNICZAK, 2020)

Therefore, smart cities are places where the conventional services and networks are made sustainable, efficient, and flexible via utilizing the new technologies such as machine learning (ML), IoT, sensors, and artificial intelligence (AI) to enhance service's efficiency for citizens (Sameer et al., 2024). These cities are safer, faster, greener and friendlier than traditional cities with various unique and smart transportation, infrastructure, energy, technology and healthcare systems. The advancement in technology has enabled the concept of smart city to gain popularity and relevance worldwide with emphasis on the economic growth, environmental concerns, and urbanization (Esmat Zaidan, 2025). Indeed, smart cities represent a transformative approach to urban living, integrating advanced technologies with sustainable practices to enhance the quality of life for residents while addressing environmental challenges (Alshamaila et al.,

2023; Xiao et al., 2024). The concept revolves around utilizing information and communication technologies (ICT) to optimize city operations, enhance service delivery, and foster economic growth. By leveraging data-driven solutions, these cities aim to create more efficient systems for energy, transportation, waste management, and public safety (Han & Kim, 2024).

Although there is a growing interest in smart cities, there are several gaps that require further investigation, particularly around the concepts, effective implementation, application, and evaluation of smart cities. There is no clear and universally accepted definition of a smart city that includes not only technological advancement but also the human aspects, such as social equity and inclusivity. In terms of the smart city implementation, there are limitations in terms of existing infrastructure readiness, regulator and policy constraints, limited budget, urban design, and safety and security concerns. Besides, there are limited and uneven integration and scalability, as well as specific smart frameworks for smart city applications in various sectors such as education, healthcare, transportation, and so forth. Another gap lies in the challenges of smart cities such as safety and security, limited existing physical infrastructures that support smart city projects, especially in developing nations, limited financial resources, resident resistance to change, etc. Thus, it's of particular importance to address these gaps with a comprehensive review to discuss these gaps and identify solutions.

This review paper aims to examine the Scopus database to determine the recent and widely accepted concept of smart city, discuss the strategic implementation of smart cities, and compare these strategies among developing and developed countries. Among these effective strategies are governance and policy frameworks, infrastructure readiness and technology integration, financial resources and budget optimization, urban design and proximity and safety, security, and data governance. The paper not only discusses these strategies in general but also provides examples of smart projects and comparative tables between developing and developed countries. Besides, the advantages and drawbacks of smart cities are also examined and tabulated. The applications of smart cities in healthcare, transportation, governance, environment, energy, safety and security, infrastructure, and education are discussed. In addition, specific frameworks for each application have been added to illustrate how smart cities use the physical and digital smart infrastructures and tools to reshape each application and provide sustainable services for residents. Apart from that, the challenges and possible solutions of smart city projects are addressed with examples from developed and developing countries. Finally, the concluding remarks and recommendations are stated that are useful for achieving smart, sustainable cities. The remainder of this paper includes the research methodology and strategy, the discussion and findings, advantages and drawbacks, applications and challenges of smart cities, and conclusion and recommendations.



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## 2. RESEARCH METHODOLOGY

### *2.1. Research Strategy*

The initial phase of the literature review involved the formulation of research questions, which served as a foundational framework for delineating this study's scope and guiding the systematic review processes. This review was conducted with the objective of critically examining the contemporary landscape that defines the concept of smart cities. Specifically, it explored the recent smart city concepts and definitions, the implementation and challenges of smart urban cities in both developed and developing countries, the advantages/benefits and challenges of smart cities, the applications of smart cities and the ways smart cities can respond to better address the implementation challenges. Finally, this review ends with a concluding remark and future recommendations for developing and implementing urban smart cities in both developed and developing countries, in ways to overcome the challenges of implementing such smart urban cities.

### *2.2. Research Questions*

The questions guiding this review were as follows:

1. How are smart cities are defined in the existing literature?
2. What are the most effective policies and strategies to implement and manage smart cities?
3. What are the commonly reported advantages and challenges of smart cities?
4. What are the applications of smart cities?
5. What are the root causes underlying the challenges associated with smart cities?

### *2.3. Inclusion Criteria and Analysis*

Following the development of these research questions, a set of inclusion and exclusion criteria was established to determine the relevance of literature sources. Figure 2 illustrates the research process which involved the search of the relevant papers from the Scopus database. A combination of specific keywords was employed to refine the search results (Table 1). The use of multiple keyword combinations was essential to manage the scope of retrieved literature, as individual keywords produced an unmanageable volume of articles for comprehensive review. The inclusion criteria utilized in this study to select the articles is summarized in the following points: Thus, articles before 2015 and after 2024, theses and books are also excluded.

1. The articles that discuss the definition and concept of smart cities
2. The articles that use English language and are a journal and a conference papers.
3. The articles are in the Scopus database
4. The articles published between 2015 to 2024

Thus, articles before 2015 and after 2024, theses and books are also excluded.

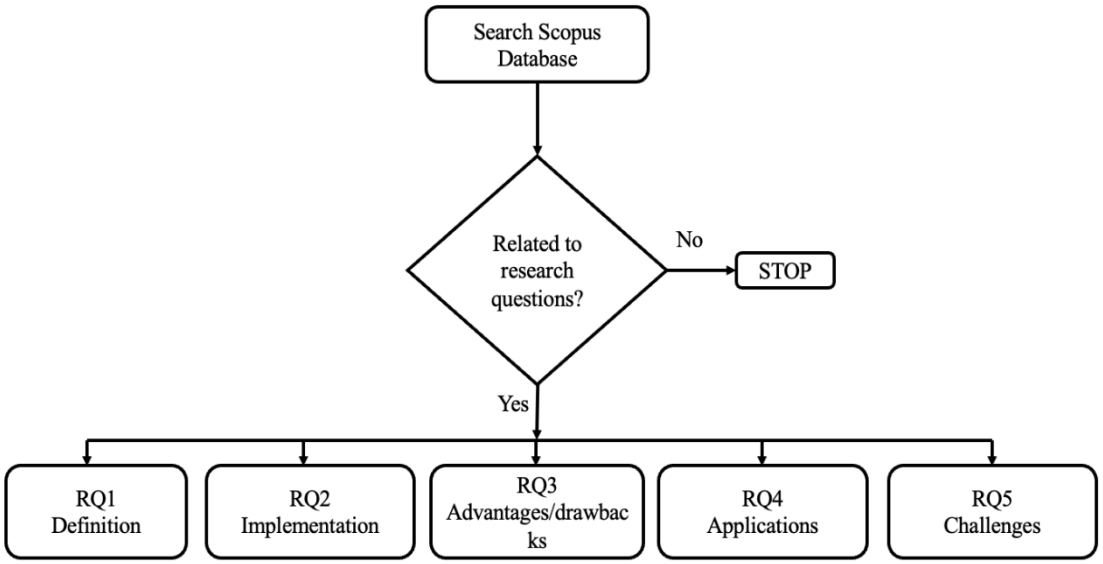


FIGURE 2 - THE LITERATURE REVIEW PROCESS

TABLE 3 - SEARCH KEYWORDS AND RESULTS (SOURCE; SCOPUS, DATE 27/03/2025)

| Database | keywords | #identified |
|---|---|---|
| Scopus database | "Smart cities" | 18,858 |
| Scopus database | "Smart cities" AND "definition" | 28 |
| Scopus database | "Smart cities" AND "implementation" | 337 |
| Scopus database | "Smart cities" AND "advantages" | 8 |
| Scopus database | "Smart cities" AND "applications" | 1,594 |
| Scopus database | "Smart cities" AND "challenges" | 640 |

## 3. DISCUSSION AND FINDINGS

In this section, the discussion and findings related to answering the research questions are presented as follows: to address question 1, Section 3.1 introduces recent definitions and concepts of smart cities, encompassing various terminologies of both digital and physical smart infrastructure. Section 3.2 addresses the second research question by discussing the strategies and policies necessary to ensure the effective implementation of smart cities. In Section 3.3, the advantages and challenges of smart cities coupled with critical solutions to the challenges (addressing the third research question). Section 3.4 addresses the fourth research question by discussing in detail the applications of smart cities, highlighting the importance of smart cities in various sectors, and finally, Section 3.5 brings about the challenges and solutions to ensure effective adoption of smart cities (addressing the fifth research question). Figure 3 demonstrates a pie chart showing the number of studies used during the analyses of each section in this study. Note that only relevant and recent papers were considered.



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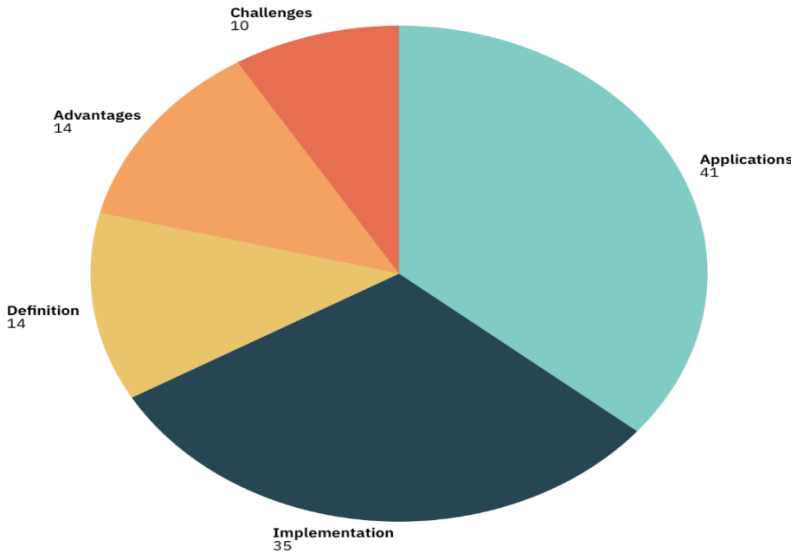


FIGURE 4 – SUMMARY OF THE NUMBER OF SELECTED ARTICLES FOR EACH SECTION.

### *3.1. Concept and Definition of Smart City*

The concept of smart cities has received significant traction and increased investments with various initiatives and projects underway in several countries worldwide; however, there exists no universal definition that describes a smart city very adequately (De Nicola & Villani, 2021; Tahmasseby, 2022). The lack of a universal and comprehensive definition that describes smart cities presents obstacles for cities' developers, policymakers, and shareholders (Trindade et al., 2017). According to a recent structured literature review on smart cities, there are several definitions of smart cities with different conceptual interpretations. For example, the term "smart" is replaced with alternative descriptive terms such as "intelligent" or "digital"(Gracias et al., 2023). Due to the wide range of initiatives and concepts that could be encompassed within the smart city definition such as technology sustainability, efficiency, rapidity, intelligence, quality of life, and socio-economic growth, various definitions of smart city that revolved around these terms could be found in the literature (Raspotnik et al., 2020; Ruhlandt, 2018). For example, Tahmasseby (2022) defined a smart city as an ultra-modernized city that utilizes ICTs to efficiently address the needs of citizens, businesses, and institutions. Meanwhile, Angelakoglou et al. (2019) defined a smart and sustainable city as a place that has efficient and sustainable resources. A smart city, as defined by Wang et al. (2024) refers to a place that uses ICTs to achieve comprehensive and real-time perceptions of urban operations. According to Baig et al. (2017), a smart city comprises various interconnected components that facilitate the exchange of data to improve citizens' quality of life. Gharaibeh et al. (2017) defined a smart city as a place that utilizes ICTs to collect, process, and disseminate data efficiently while maintaining the privacy and security of the data and promoting the quality of life of citizens in terms of health systems, government services, utilities, transportation, and

entertainment systems. Alsamhi et al. (2019) defined the smart city as a place that comprises intelligent components that achieve automatic and efficient improvement of quality of life and act as sustainable resource ecosystems. A smart city, according to Singh et al. (2022), refers to a place of innovations and intelligence that constantly values the quality of life of people in terms of efficient urban operation, service, and sustainable socio-economic values. According to Attaran et al. (2022) smart city is a place with unique infrastructure that uses ICTs to improve living standards and government services to citizens. Haque et al. (2022) defined a smart city as a place that creates and manages a sustainable environment with the integration of ICTs to promote high living standards and services for citizens. A smart city, according to Nicola and Villani (2021) is a place that encompasses complex cyber-socio-technical systems that ensure that the cyber, human and technical systems work together to achieve a common goal. Akpınar (2019) defined a smart city as a set of components connected via several networks across multiple scales, which aim to offer uninterrupted data about the environment and people toward supporting decisions about improving the structural, economic, and social forms. Finally, Gracias et al. (2023) defined a smart city as a place that uses ICTs, digital tools, and data analytics to develop efficient services for citizens and promote urban sustainability.

To sum up the recent advances in the definition of a smart city, Figure 4 illustrates the various terms that can be used to describe a smart city. A smart city is not just a place that encompasses intelligent advanced technologies, but a place that ensures residents' quality of life and the sustainability of resources and the environment. Thus, the goal of developing and implementing smart city projects is to ensure that human and technical systems work together to provide high standards and services to citizens.


FIGURE 4 – VARIOUS TERMS THAT REVOLVE AROUND THE CONCEPT OF SMART CITY (GRACIAS ET AL., 2023).



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### *3.2. Smart Cities Development and Implementation*

The development of smart cities has recently been initiated in various countries, especially due to the tremendous growth of information and communication technologies (ICT) (Wu et al., 2024). Despite being arguably far from a straightforward task, smart city implementation has various challenges in terms of readiness, socioeconomic and political factors. Indeed, the effective implementation of smart cities hinges on the strategic integration of technological, financial, spatial, and governance dimensions (Mohapatra, 2021). Thus, such implementation necessitates a multi-dimensional approach that integrates technological innovation with strategic governance, citizen engagement, data-driven decision-making, and infrastructure readiness (Attaran et al., 2022).

Despite these challenges, recent years have witnessed incredible progress in smart cities' development. For example, the smart cities and community lighthouse projects sponsored by the European Commission have been developed to encourage collaboration between the private and public sectors and society to seek solutions and resource efficiency. The developed project aims to provide sustainable and resilient urban policies, such as the contextualization of the smart city concept and implementation through an integrated and holistic approach (Camerin et al., 2024).

Besides, the development of transport operation and information services as an integrated system serves as one of the most advanced and sophisticated examples of Seoul's smart city (Anedda et al., 2023; Kim, 2022; Y. Lim et al., 2023). Italy has also developed the Smart Health 2.0 project that allows the development of digital health services tailored to enhance citizen well-being and healthcare accessibility (Anedda et al., 2023). Meanwhile, Singapore developed the Smart Nation Initiative emphasizes the optimization of traffic flow through advanced monitoring and management systems (Shamsuzzoha et al., 2021). Similarly, in Spain, Santander in Spain has deployed thousands of air quality sensors to collect real-time environmental data for pollution control and urban planning purposes. Meanwhile, Seoul, South Korea, has implemented an integrated platform that connects transportation infrastructure with building automation systems to enhance operational efficiency and urban connectivity (Prateeppornnarong, 2025).

Apart from that, smart cities development in developing countries is now being exploited in various cities, particularly in cities where pre-readiness of the ICTs and infrastructure services is readily available (Bhattacharya et al., 2020). Among such cities are Dubai, Lusail in Qatar, Balikpapan in Indonesia, and Kuala Lumpur in Malaysia, which are focusing on smart economy, smart living, smart environment and governance (AlAli et al., 2023). It is worth noting that the developed countries have benefitted from the advanced infrastructure, regulatory frameworks, and stable financing in contrast to the developing countries, which are struggling to demonstrate scalable smart cities implementation despite their poor

infrastructure, limited regulation, and resources (Duygan et al., 2022). To ensure effective implementation of smart cities, a strategic alignment of digital and physical infrastructures, community engagement, technology integration, urban planning and designing, and effective governance is required. A city is called smart if it can effectively integrate technology in an efficient manner that addresses residents' challenges, improves their quality of life and enhances sustainable development (Bhattacharya et al., 2020). Among the important key dimensions for successful implementation of smart city are the strategic governance and policy frameworks, technology integration and infrastructure readiness, budget optimization and financial resources, the urban safety and urban design, and the data governance and security, which are described in the following subsections.

### 3.2.1. Strategic Governance and Policy Frameworks

The effective implementation of smart cities requires strategic governance that ensures the smart projects follow the urban design and development goals and a policy framework that provides a regulatory framework for stakeholder collaboration, technological integration and data management (Kaluarachchi, 2022). Thus, both terms are fundamental and essential for smart city implementation to not only ensure efficient implementation and transparency but also enhance quality of life and accountability (Kaiser, 2024). Governance in a smart city allows efficient coordination between various stakeholders such as the government, private organizations, citizens, and the academe. It includes three approaches, which are centralized governance, decentralized governance, and public-private partnerships (PPP) governance. The centralized governance focuses on clear strategic directions, the decentralized governance deals with local innovations, and the PPP focuses on technical expertise and financial availability and provides a balance between public and private sectors (Yoo, 2021).

Apart from that, the policy frameworks in smart cities focus on creating regulatory and legal frameworks that ensure effective use of the urban technologies and resources (Razmjoo et al., 2021). Among such policies are the data privacy and governance protocols (e.g., data protection, storage and ownership), and policies for urban use and urban planning (e.g., legal regulations for urban developments) (Bellini et al., 2022). For instance, Copenhagen has set various policies that ensure the safety of the data, efficient usage and planning of urban spaces, and effective policies for financial investments (Bjørner, 2021). Singapore has also implemented a centralized government and policy frameworks that coordinate various activities such as data governance, residents' engagement, collaboration and urban sustainable planning via a system called Nation and Digital Government Office (SNDGO) (Joo, 2023).

On the other hand, the data governance and policy frameworks in developing countries are limited due to the availability of digital and physical infrastructure and the absence of effective governance and policies



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(Antwi-Afari et al., 2021). However, the literature indicates fragmented governance models and structures in the developing nations. For example, India's special purpose vehicles (SPVs) system in India aims to provide decentralized governance as part of the smart city initiatives in India (Aggarwal & Solomon, 2020). Finally, Table 2 provides a summary of the governance and polices in the smart cities in both developed and developing countries.

TABLE 5 – SMART CITIES POLICES AND GOVERNANCE AMONG DEVELOPED AND DEVELOPING COUNTRIES

| Policy area | Developed countries | Developing countries |
|---|---|---|
| Governance model | Strong central or hybrid governance with clear national strategies | Fragmented governance, often lacking national coordination |
| Data privacy policies | Comprehensive data protection laws (e.g., GDPR compliance) | Limited or weakly enforced data protection laws |
| Urban planning policies | Integrated smart infrastructure within existing land-use policies | Challenges in integration smart solutions due to informal urban settlements |
| Financial regulations | Structured public-private partnership models and sustainable funding strategies | Reliance on donor aid, pilot programs, and foreign investment. |
| Public engagement | Strong emphasis on citizen participation and digital literacy | Limited citizen involvement due to low awareness and digital divide |

### 3.2.2. Infrastructure Readiness and Technology Integration

The availability of robust digital and physical infrastructure is a major predictor for seamless implementation and integration of smart technologies (such as AI, big data, machine learning, smart computing etc.), services, smart functionalities and applications (Delavar et al., 2025). In contrast to developing countries, developed nations have the advantage of pre-existing physical and digital infrastructures, which allow easier and efficient integration of smart technologies and services. An example of that is Amsterdam which has a superior and advanced existing transportation system along with advanced energy infrastructure which makes the integration of smart traffic systems, data policies, smart grids, data and traffic control easy. However, in cities such as Nairobi, the limited pre-existing infrastructures require slower, targeted and phased implementation of smart technologies such as their M-Pesa and Ma3Route for digital payment and traffic navigation, respectively. In addition, Lagos in Nigeria faces challenges in deploying smart transport and utility systems due to the limited physical infrastructures such as roads, inconsistent electricity supply and informal urban development patterns. Infrastructure readiness of smart city can be classified into physical and digital infrastructures (Delavar et al., 2025; Sameer et al., 2024). Thus, it is worth noting that, without an adequate physical (sustainable smart grids, water systems, transportation, waste systems, etc.) and digital (AI, cloud computing and storage, wireless capabilities, internet connection, etc.) infrastructures, the deployment of smart technologies can be ineffective or unsustainable (Delavar et al., 2025; Sameer et al., 2024).

Apart from this, the technology integration is vital to enable smart city functionalities. It refers to the adoption and synchronization of various digital technologies to automate services, improve operational

efficiency, and enhance urban living. There are several key technologies that allow such integration which are the IoT, AI and machine learning, big data analytics, and blockchain (Wolniak & Stecuła, 2024). Interoperability and systems integrations are essential to ensure that the smart city's technologies can communicate and function cohesively and automatically in a unified digital infrastructure. For example, the urban platform of Barcelona aggregates real-time data from multiple domains (transport, energy, water) into a single interface, enabling integrated decision-making. Meanwhile, Bangalore, India, has struggled with fragmented IT systems across government departments, limiting the effective integration of smart city technologies. Table 3 depicts the infrastructure readiness and technology integration comparison between the developed and developing countries.

TABLE 6 – INFRASTRUCTURE READINESS AND TECHNOLOGY INTEGRATION AMONG DEVELOPED AND DEVELOPING COUNTRIES

| Dimension | Developed countries | Developing countries |
|---|---|---|
| Infrastructure readiness | Advanced physical and digital infrastructure | Inconsistent or underdeveloped infrastructure |
| Technology adoption | High adoption of AI, IoT and big data analytics | Emerging adoption, often donor-or vendor led |
| Systems interoperability | Standard platforms and integrated systems | Siloed and legacy system hinder integration |
| Policy and regulation | Mature regulatory environment for digital ecosystems | Gaps in digital governance and enforcement |

### 3.2.3. Financial Resources and Budget Optimization

The successful implementation of smart city initiatives requires substantial financial investment, strategic budgeting, and sustainable funding mechanisms that allow for not only developing smart urban infrastructures and advanced technologies but also enabling long-term operational sustainability and managing resources effectively (Wolniak et al., 2024). Financial planning is significant to ensuring effective implementation of smart city initiatives, balancing costs with economic benefits over the long term, controlling the size and scope of the project, and ensuring transparency and efficiency (Nguyen, 2024). In contrast to developing countries, the developed nations have larger budget allocations and funds and PPP for implementing and sustaining smart city projects (Bjørner, 2021; Dai et al., 2024; Kolhe et al., 2023). For instance, the strategy of Barcelona to become a smart city is funded by not only government investments but also by the private sector and also the European Union funds. Meanwhile, limited budgets and funds are observed in developing countries which makes low-cost projects easier to implement. For example, the smart street surveillance and lighting system in Rwanda (Kigali city) has been implemented only in certain zones because limited funds were secured. Thus, the smart city funding is essential to ensuring the success of implementing smart city initiatives. Table 4 depicts the financial funds among developed and developing nations.



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TABLE 7 – THE FINANCIAL ASPECTS AMONG DEVELOPED AND DEVELOPING COUNTRIES

| Financial aspect | Developed countries | Developing countries |
|---|---|---|
| Government funding | Significant direct public investment; national and municipal budget allocation | Limited national budget allocation; reliance on international funding |
| PPP implementation | Well-regulated PPP models ensuring efficiency and accountability | Challenges in regulatory frameworks; risk of monopolization |
| International funding | Minimal reliance, self-sustained economic models | Heavy reliance on world bank, ADB, AfDB, and foreign donors. |
| Revenue models | Advanced user-based pricing and data monetization strategies | Limited ability to generate revenue due to affordability constraints |
| Budget optimization | Integrated financial planning for long-term sustainability | Budget constraints result in fragmented and phased implementation. |

### 3.2.4. Urban Design and Proximity

One of the great indicators of a smart city is the effective urban design that prioritizes accessibility, proximity, and sustainability for services, applications, and resources (Allam & Sharifi, 2022). These qualities not only define the smart city but also improve residents' quality of life, enhance the efficiency of services, reduce environmental impact, and improve residents' lives. Thus, smart city design must encompass digital infrastructure with the physical infrastructure in an effective and strategic manner to ensure equal access to all services such as transport, education, healthcare, and commercial aspects (Esmat Zaidan, 2025).

Proximity in the urban design of smart city refers to the optimal travel distance between residents and services and it include serval key goals such as (1) encouraging walkability, (2) connecting urban areas, (3) prioritizing emergency lanes and times, and (4) exhibiting the public transporting systems and make them efficient and accessible (Clement et al., 2023). For instance, Paris aims to implement the 15-minute city model in urban design which means that the residents can access public services in a 15-minute period.

There are several principles of smart urban design, such as compact and high-density development, smart mobility and transportation networks, and digital twin technology for urban optimization (Wolniak et al., 2024). For example, Singapore's urban redevelopment authority has implemented high-density, mixed-use developments that integrate residential, commercial, and transit-oriented spaces within close proximity. In contrast, developing cities face greater challenges in implementing proximity-based smart city designs due to rapid urbanization, informal housing, and inadequate infrastructure investment. However, innovative strategies such as urban infill development, land readjustment policies, and community-driven planning can enhance proximity and urban functionality. Table 5 illustrates the urban design factors and compares them in both developed and developing countries. Figure 5 depicts an example of an optimal design of an urban smart city.

TABLE 8 – URBAN DESIGN AMONG DEVELOPED AND DEVELOPING COUNTRIES

| Urban design factor | Developed countries | Developing countries |
|---|---|---|
| Land use planning | Well-regulated zoning laws with mixed-use developments | Unregulated expansion and informal settlements leadings to urban sprawl |
| Smart mobility infrastructure | Integrated public transit, bicycle lanes, pedestrian friendly zones | Limited public transport, reliance on informal transit (e.g., minibuses, tuk-tuks) |
| Proximity to essential services | Well-distributed healthcare, education, and commercial hubs | Unequal access to services, requiring long travel distances |
| Urban density management | High-density development with compact city layouts | Overcrowding in informal settlements, inefficient land use |
| Technology integration in urban design | Use of digital twins, AI-based traffic control, and IoT monitoring | Limited use of advanced technology due to budget constraints |

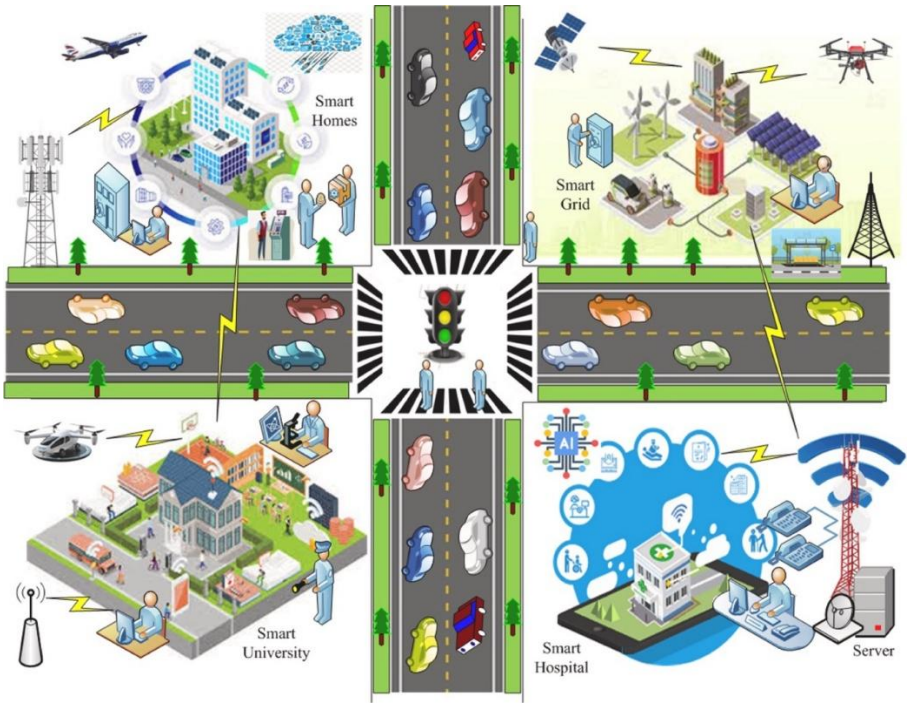


FIGURE 5 – AN EXAMPLE OF AN OPTIMIZED SMART CITY DESIGN WITH EXCELLENT PROXIMITY (ULLAH ET AL., 2025).

### 3.2.5. Safety, Security, and Data Governance

The successful implementation of smart cities depends on robust safety, security, and data governance frameworks. As smart cities integrate advanced technologies, including the IoT, AI big data analytics, and cloud computing, ensuring the physical security, cybersecurity, and ethical data governance of these interconnected systems becomes paramount (Wolniak & Stecuła, 2024). A failure to implement strong security measures and regulatory policies can lead to risks such as cyberattacks, data breaches, and threats to public safety.

The safety and security in smart cities encompass both physical security (protection of people, infrastructure, and urban assets), and cybersecurity (protection of digital systems and data networks)

(Prateeppornnarong, 2025). Effective security frameworks must address the threats to critical infrastructure, cyber threats, and public threats.

Physical security measures in smart cities focus on crime prevention, disaster resilience, and emergency response. These include the intelligent surveillance systems (e.g., London's live facial recognition technology that helps police identify and track criminals), smart traffic and public transport security (e.g., Singapore's Smart Traffic Management System uses AI to prevent congestion and enhance road safety), and emergency and disaster management systems (e.g., Japan's Early Earthquake Warning System integrates sensors and AI analytics for rapid disaster response) (Joo, 2023; Singh et al., 2022). As smart cities rely on real-time data exchange across connected networks, they become targets for cyberattacks. Cybersecurity threats include data breaches and identity theft, denial-of-service attacks, IoT vulnerabilities, and ransomware and malware threats (Li et al., 2024; Wolniak et al., 2024; Wolniak & Steculа, 2024). To mitigate cybersecurity risks, smart cities must implement encryption and secure communication protocols to protect data transmission between IoT devices and servers, detect and identify real-time threats via AI and machine learning, and zero zero-trust frameworks to restrict unauthorized access and verify the identity and permission. For example, Estonia, a leader in digital governance, has implemented blockchain-based cybersecurity to protect its national data infrastructure.

As smart cities generate vast amounts of data, ensuring ethical, secure, and transparent data governance is essential. Data governance refers to the policies, regulations, and frameworks that govern how data is collected, stored, processed, shared, and utilized while safeguarding privacy and security. Among the principles of smart city data governance are transparency, privacy preserving, interoperable, and ethical and inclusive. There are some challenges in smart city data governance such as data privacy concerns, regulatory gaps, and monopolization of urban data. Developing nations face challenges in data localization, regulatory compliance, and securing smart city data, requiring international collaborations to establish stronger governance frameworks. Table 6 summarizes the best practices for data governance in smart cities and compares them in both developed and developing countries.

TABLE 9 – GLOBAL BEST PRACTICES AMONG DEVELOPED AND DEVELOPING COUNTRIES

| Best practice | Developed countries | Developing countries |
|---|---|---|
| Comprehensive data protection law | Strong laws (GDPR, CCPA) regulating smart city data usage | Partial regulations; gaps in enforcement |
| Data ownership and citizen consent | Residents have legal control over personal data | Limited public awareness and weak legal frameworks |
| Public-private data partnership | Transparent regulations for private tech firms handling urban data | Concerns over corporate controls of smart city infrastructure |
| Cybersecurity standards | Advanced encryption, AI-driven security monitoring | Limited cybersecurity infrastructure and expertise |

To sum up, the effective strategies for successful implementation of smart cities have been discussed, which are governance and policy frameworks, infrastructure readiness and technology integration, financial resources and budget optimization, urban design and proximity and safety, security, and data governance. Effective implementation of smart city requires multi-dimensional methods that integrate advanced technologies with strategic governance, infrastructure readiness, resources, and data safety and security. In the above section, examples of specific smart projects and frameworks have been presented, which indeed integrated the physical infrastructure with the intelligent systems to provide better services for citizens.

## 4. ADVANTAGES AND DRAWBACKS OF SMART CITIES

Smart cities aim at enhancing people's quality of life, addressing environmental challenges and promoting economic growth, however smart cities initiatives and projects should be considered, planned, implemented and monitored to certify that the negative impacts are minimized, and the positive impacts are maximized (e.g. citizens' quality of life) (Kwak & Lee, 2021). By using technological advances, smart cities can improve the safety of the public, economic growth, transportation system, and better accessibility to all services (healthcare systems, education, and services) which would not only improve the well-being of citizens but also create environment where efficiency and accessibility to services are paramount (Elberzhager et al., 2021). In smart cities, residents will have access to better jobs, continuous growth and innovation, and cost savings due to the increased efficiency of city services. In addition, smart cities will also promote a sustainable future by utilizing renewable energy, reducing greenhouse and carbon footprint and promoting a sustainable economy by optimizing resource utilization and generation (Duygan et al., 2022). In addition, smart cities will encourage citizen engagement through digital platforms that enhance communication between residents and local governments. This participatory approach not only fosters a sense of community but also empowers citizens to contribute to decision-making processes that affect their lives. As urban populations continue to grow, the integration of sustainability and smart technologies becomes crucial in addressing the pressing issues of urbanization, such as pollution, resource depletion, and social inequality. In summary, sustainable smart cities are pivotal in creating resilient urban environments that prioritize human well via the integration of smart technologies, IoT and AI. Indeed, the benefits of sustainable smart cities extend beyond mere technological advancements. They facilitate a significant reduction in carbon emissions and resource consumption, contributing to climate change mitigation. Additionally, these cities promote social equity by ensuring that urban development achieves the current and future requirements of people, thereby enhancing overall societal well-being. For instance, smart transportation systems can reduce traffic congestion, while smart energy solutions can optimize energy use and promote renewable sources (Shamsuzzoha et al., 2021).



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Despite all the mentioned advantages, several drawbacks may be associated with smart city initiatives such as the high cost of implementing and developing smart city projects and technologies, the increased concerns of people on their data security and privacy, the lack of comprehensive standards, and the complexity of integrating conventional infrastructure with newer ones (Li et al., 2022). Indeed, the development of such cities with advanced technologies and applications is a time-consuming and costly task. Additionally, people tend to be concerned about their privacy in case of data breach occurs because smart cities constantly collect and use their data for further optimization and processing in order to improve service efficiency (Tzioutziou & Xenidis, 2021). Another concern is the lack of comprehensive standardization because newer systems and technologies might not be compatible with existing ones which may create inefficiencies and hinder the effectiveness of smart cities (Kwak & Lee, 2021). Besides, the new systems and technologies might not be able to integrate efficiently with existing ones, which could create issues and disrupt service efficiency (Ahad et al., 2020). Furthermore, there may not be equal distributions of smart city benefits across the various groups in the city. To overcome these challenges, the proper planning, developing and implementing smart technologies and applications must be conducted and agreed upon by stakeholders with continuous monitoring and evaluation to always prioritize the quality of life of people. Table 7 further summarizes the benefits and challenges of smart cities' technologies and applications.

TABLE 10 – THE MAJOR BENEFITS AND DRAWBACKS OF SMART CITIES

| Benefits | Drawbacks | Refs. |
|---|---|---|
| Enhanced life quality for citizens | Require high cost in terms of developing and implementation | (Gracias et al., 2023; Maiti et al., 2022) |
| Improved the growth and efficiency of economy | The security and safety of data and people is concerning | (Ahad et al., 2020; Joshi et al., 2016) |
| Improved the greenery and sustainability | Lack of standardizations | (Gracias et al., 2023; Ruhlandt, 2018) |
| High efficiency for various services and environment | Integrating these new technologies with existing conventional infrastructure is rather difficult task | (Yigitcanlar et al., 2019) |
| High interconnectivity and operate-ability among various systems | There are concerns on the equal distribution of benefits across various socio, economic, and cultural groups. | (Ang & Seng, 2021; Haque et al., 2022) |
| Improved innovations and advances | There is concern on displacement effects caused by gentrification | (Akpınar, 2019; Elberzhager et al., 2021) |
| Improved governance (services, efficiency, etc.) | There is concern on the job losses or displacements | (Joshi et al., 2016; Ruhlandt, 2018; B. N. Silva et al., 2018) |

To sum up, benefiting from the advanced technologies such as ICT, IoT sensors, AI, and intelligent governance platforms, a smart city is vital to enhance residents' quality of life, enhance public services, improve efficiency and economic growth, improve governance, and ensure interoperability between various systems. However, there are some concerns in the literature with regard to the smart city projects,

such as the loss of jobs, gentrification, equity of resources across various socioeconomic and cultural groups, and safety and security. Despite these concerns, the literature indicates the importance of smart city projects for improving services and sustainability.

## 5. APPLICATIONS OF SMART CITIES

In smart cities, the use of smart technologies and applications such as IoT, sensors, and AI is expected to be revolutionary in various sectors such as healthcare, governance, transportation, data safety and security, urban infrastructure, and education (Akpınar, 2019; Elberzhager et al., 2021). The use of advanced technologies and applications will solve various complex issues to improve service efficiency and environment and life quality for citizens. These application domains are further explained in detail in the following subsections.

### *5.1. Healthcare*

In smart cities, healthcare systems are undoubtedly one of the most essential aspects in which the smart systems such as IoT, AI, and ML aim to transform healthcare by minimizing cost, improving patient outcomes, providing targeted medicine and dietary guidelines, and increasing the service efficiency along with excellent patients' remote monitoring and predictive analytics of any disease (B. N. Silva et al., 2018). These advanced technologies will monitor, track, and pre-assess patients at all times to not only facilitate timely intervention when required but also to provide critical data for analyzing and predicting other patterns of disease biomarkers before they even occur. Such systems will not only improve patient outcomes and experience but also provide solutions for preventing diseases, reducing aging, and improving the quality life of people (Ang & Seng, 2021; Haque et al., 2022).

The integration of healthcare within smart systems will be achieved through the interconnected technologies, digital and physical infrastructures, real-time data analytics, and the efficiency of medical services. This integration is a transformative step to efficient, accessible, predictive, responsive, and patient-centered medical services. In smart cities, the digital infrastructure (e.g., IoT platforms, electronic health records, and telemedicine platforms) is integrated with digital health tools such as wearable health devices, electronic recording circuits, and wearable patches to enable real-time monitoring, personalized care, early diagnosis, and remote monitoring. In addition, the use of AI, machine learning, big data, and cloud computing allows for an efficient prediction of disease outbreaks, public health risk assessment, and resource allocation. In smart cities, not only does the quality of air and water improve via electronic sensors, but the emergency response is also enhanced via the interconnected digital and healthcare infrastructure, such as faster ambulance response, data, proximity, and readiness of hospitals. Therefore,



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the effective integration of health care with other urban systems (digital and physical infrastructures) enables smart cities to create a holistic, responsive, and inclusive health care system.

### *5.2. Governance*

There is a huge potential for smart applications in the governance domain with the usage of AI, IoT and ML to provide means of transforming the way government operates in terms of services, accountability, citizens' participation and transparency. These smart technologies and applications will enable not only gathering and processing large amounts of data but also suggesting important insights for optimizing the use of urban infrastructures, resources, reducing congestion, monitoring and managing the city, and improving the efficiency of government services (Din et al., 2019). In addition, citizens' participation with government can establish better communication and engagement as well as enhance the safety and efficiency of the data and services to ultimately improve the life quality of citizens. This will allow building and strengthening the mutual trust between citizens and their government, and improve transparency and accountability (Joshi et al., 2016; Ruhlandt, 2018; B. N. Silva et al., 2018).

The smart governance framework (SGF) is a robust and widely accepted approach in smart cities that uses digital infrastructure such as ICT tools, cloud computing, AI, machine learning, and data analytics tools, and e-governance platforms learning to ensure high transparency, efficiency, and better citizen engagement. The integration of these technologies enables the creation of robust e-governance platforms that empower digital inclusion, real-time analytics, data-driven policies, accountability, and citizen participation in the decision-making process. It also allows efficient response to public needs while fostering inclusivity, trust, efficiency, safety, and security. Thus, this approach not only improves the relationship between citizens and governments but also supports sustainability through reducing costs, optimizing resources, and providing predictive planning

### *5.3. Environment*

The environment in a smart city is an essential component in which the smart technologies can be beneficial to address the various pressing issues, such as environmental degradation, climate change, weather forecasting, smart grids, precise agriculture, and smart management of wastes (Ang & Seng, 2021). These advanced technologies are going to use AI, IoT and machine learning for real-time monitoring and managing of climate change, waste, consumption, plantation, crop yields optimization, waste and toxin reduction and disposal, and so on (Akpınar, 2019; De Nicola & Villani, 2021).

The urban environmental monitoring and management framework (UEMMF) is a widely adopted framework that utilizes IoT, AI-enabled smart technologies (sensors and analytics) to examine and

monitor environmental indicators such as water and air quality, waste generation, noise levels, and urban heat and winds in real-time. This framework also benefits from the integrated digital and physical infrastructure to provide environmental assessment, predictive measures, resource optimization, and ecological preservation for a sustainable urban environment. In addition, through these technologies, cities can make informed decisions on various aspects such as pollution control, resource optimization, and quality of air and water while engaging citizens via governance systems and portals. Thus, the framework not only promotes green infrastructures and the reduction of carbon footprints using renewable energy sources and circular economy models but is also adaptable for both developed and developing countries (Ahvenniemi et al., 2017; Bibri & Krogstie, 2020; Kumar et al., 2022).

### *5.4. Transportation*

In smart city, the transportation is an essential factor where technologies will improve the mobility, safety, and efficiency thereby transforming our transportation system to more efficient, safe and comfortable experience such as the use of intelligent transportation system (ITS), smart cars, and smart platforms for people to share a ride (Paiva et al., 2021). These technologies will constantly use sensors, IoT, ITS, AI and ML to improve the transportation experience in terms of safety, less congestion, finding alternative routes, improving passengers' interconnectivity and participation as well as their riding experience(Allam & Sharifi, 2022; Anedda et al., 2023).

The intelligent transport systems (ITS) framework integrates ICT, AI, IoT, cloud computing, machine learning, and data analytics to assess and optimize mobility, improve commuter experience, and reduce emissions. This framework also provides real-time monitoring and optimization of traffic flow, reduces congestion, interconnectivity, and multi-modal systems for electric cars, and timely maintenance of urban mobility infrastructure. To support real-time monitoring of urban mobility as well as the traffic signals, congestion, and parking slots, the framework uses a centralized data center with AI and other data analytics capabilities to collect the data from the traffic cameras, sensors, and GPS data. Thus, this framework enables efficient transportation and urban mobility of citizens with high safety, accessibility, and reduces carbon footprint (Zhou et al., 2020; Shaheen & Cohen, 2019; Nam & Pardo, 2011).

### *5.5. Energy*

Energy is a very essential aspect of a smart and sustainable city in which the carbon emissions are reduced or replaced with renewable and sustainable sources with better efficiency (Alsamhi et al., 2019). Various smart energy grids that utilize IoT and AI are going to monitor and manage energy consumption, reduce energy waste, improve energy efficiency and promote energy sustainability (Guerrieri et al., 2019).



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In addition, these technologies aim to manage energy well to determine optimal usage and storage of the renewable energy.

One of the widely adopted frameworks to assess smart cities's application in the energy sector is the smart energy systems (SESs) framework which enables the integration of renewable energy sources, energy efficiency, and smart technologies to create inclusive and sustainable urban energy ecosystems (Bousnina & Guerassimoff, 2024; Hoang & Nguyen, 2021; Mishra & Singh, 2023). The SES framework utilizes ICTs, AI, IoT, and cloud computing to assess, manage, optimize, and balance the energy supply and demand across various sectors, including transportation networks, electricity, and heating. This framework also leverages physical and digital technologies to generate and harness energy using solar panels and microgrids with high reliability and efficient storage. While promoting decentralized energy generation and storage of renewable energy to support a low-carbon transition, this system also enables the integration of smart meters, energy forecasting platforms, and automated demand response platforms to provide equitable energy access to all residents. Thus, this holistic approach provides accessible energy for all urban residents and promotes environmental sustainability and operational efficiency (Hoang & Nguyen, 2021; Thornbush & Golubchikov, 2021).

### *5.6. Safety and Security*

The role of smart technologies and applications is very crucial as to prevent crimes, rapidly respond to emergencies and enhance the safety and well-being of the public. Among such smart applications are the smart surveillance systems, smart lighting systems, public safety domain and emergency response platforms (Guerrieri et al., 2019; Kwak & Lee, 2021). These smart technologies utilize machine learning, smart sensors, and AI to monitor and manage public spaces to detect and identify suspicious activities and respond in a rapid manner that ensures the safety and security of the public. Detecting emergence and responding to such scenarios in an efficient manner is very important in which the smart technologies along with the collaborative actions from public will be important role in ensuring not only reporting incidents in a timely manner but to improve transparency and accountability of public towards safety and security of the city (Baig et al., 2017; Gracias et al., 2023).

The smart secure city framework (SSCF) is a suitable framework that aims to assess safety and security in smart cities by integrating advanced surveillance platforms, real-time data analysis, and citizen-centric designs for enhancing public safety (Hussain, 2024; Ismagilova et al., 2022). This system also uses AI-enabled monitoring systems, IoT sensors, emergency response platforms, and city policies to determine, respond, and prevent threats related to safety and security, such as accidents, cyber-attacks, crimes, and natural disasters. It also allows the interoperability of data platforms to connect emergency services, law

enforcement, and governance to provide a proactive approach to safety and security. In addition, cybersecurity is also embedded across various digital infrastructures to ensure optimal protection and safety of sensitive data. This approach allows and promotes citizen engagement and data governance to optimize surveillance with the privacy rights of residents. Thus, this smart framework enables smart cities to provide a safe and secure environment while fostering technological accountability and inclusivity (Ahmad et al., 2022; Sefati et al., 2024).

### *5.7. Infrastructure*

In smart cities, smart technologies play an important role in the infrastructure of the city in terms of improving and managing bridge systems, buildings, and roads in smart and efficient manners that ensure optimal conditions (Paiva et al., 2021; Sanchez-Sepulveda et al., 2024). The use of machine learning, ICT, IoT, and AI to continuously monitor and manage not only indoor quality in buildings, but also to use energy sources for powering buildings, bridges, and roads. In addition, these smart technologies will monitor the structural conditions of the bridges and roads to ensure safety and to detect any cracks or potential issues before they even occur (Höjer & Wangel, 2015; Yin et al., 2015). The infrastructure maturity model (IMM) is an example of a smart city framework that can be utilized to assess infrastructure readiness across dimensions such as digital monitoring, connectivity, adaptability, and interoperability. The model enables the real-time monitoring of roads, bridges, and utilities via integrated sensory and IoT systems and provides prediction measures and maintenance plans via AI and big data. In addition, this framework allows for efficient integration of geographic information systems (GISs) with digital infrastructure technologies for better urban planning. Moreover, the model also allows cross-sector collaborations, regulatory alignment, and the scalability of infrastructure innovations that suit environmental conditions. Thus, embedding smart digital technologies into the physical infrastructures contributes to optimizing operational cost and resource usage, and improves quality of life.

### *5.8. Education*

In education, the application of smart city technologies focuses on enabling learning environments via AI-driven tools, digital infrastructure, and accessible and inclusive access. Various smart applications such as learning analytic systems and personalized learning systems are expected to revolutionize education to not only increase the accessibility and quality of education but to enhance the learning experience, outcomes, and environment (Haque et al., 2022). Learning analytic systems utilize techniques such as data analyses to determine patterns and evaluate student performances and then offer insights and suggestions to the teachers on ways to provide targeted support to each student. Meanwhile, personalized learning systems utilize machine learning and AI to provide learning subjects tailored to



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individual students based on their ability to learn to ultimately improve their understanding and engagement (Albino et al., 2015).

Among the smart city frameworks that can be used to transform education are the smart education readiness index (SERI) and smart education system (SEF) by providing structured approaches to evaluate the integration of digital technologies (e.g., ICT), institutional readiness, and personalized learning. Such frameworks provide comprehensive models to reshape education in smart cities to ensure internet connectivity, strategic alignment of policy and governance, and data analytics for adaptive learning. Therefore, these frameworks leverage the smart technologies in smart cities to provide innovative, accessible, and enhanced learning outcomes that align with national digital education plans and governance practices. To sum up, education is not confined to the conventional classroom approach but is an integrated system of digital technologies, data analytics, and interconnected infrastructure that aims at fostering an inclusive, adaptive, and accessible learning ecosystem. Smart learning systems such as SEF leverage the use of IoT, machine learning, AI, and cloud computing to create data-driven learning experiences that enable interactive, real-time learning and accessible and customized content. Thus, with the efficient integration of digital technologies and educational governance, education will be efficient and accessible for better self-directed and collaborative learning.

## 6. CHALLENGES AND SOLUTIONS OF SMART CITIES

The implementation of smart cities presents a transformative opportunity to enhance urban efficiency, sustainability and quality of life for residents (Kolhe et al., 2023). However, integrating advanced technologies, data-driven decision making and sustainable urban planning is accompanied by significant challenges. Among such challenges are the financial and budget allocations, technological aspects of smart city, the polices and regulations guiding the smart city projects, concerns on data privacy and security, residents' ability to engage with government services, socioeconomic and digital challenges, and environmental and climate concerns (Marchesani et al., 2023; Syalianda & Kusumastuti, 2021). These challenges and ways to overcome them are listed as follows:

- Challenges concerning finance and budget allocation: This is one of the major challenges when implementing smart city projects as such projects require huge budgets to develop physical, digital frameworks and integrate them to suit residents' requirements (Nguyen, 2024). This challenge is even worse when it comes to the developing nations where limited fundings, limited investments and poor pre-existing infrastructures are found which makes developing smart projects are very costly. For instance, countries in Africa and Asia are struggling to finance large-scale physical and digital infrastructures due to limited budgets. In order to overcome such

constraints, the PPP may provide sufficient encouragement for public and private partnerships and investments in these smart projects. The PPP model in Barcelona's smart city is an example of such collaboration between multiple stakeholders. Seeking international grants and opening up for private investors could also help secure some investments.

- Challenges concerning technology and infrastructure: Having an advanced digital and physical infrastructure is key for smooth integration and implementation of smart cities; however, many cities, especially in developing countries, lack the basic infrastructures required for developing and implementing smart cities (Nguyen, 2024). For instance, Jakarta suffers from outdated infrastructures which makes implementing and integrating smart technologies very challenging. To overcome such a challenge is to prioritize incremental adoption of smart technologies starting with essential services such as transportation, energy, and waste management. In addition, investing in the next generation wireless communication networks to improve connectivity, such as the 5G's powered smart cities in Busan, South Korea that leverage ultra-fast internet for real-time urban monitoring.
- Challenges concerning data security, privacy, and governance: As smart cities rely on big data, IoT sensors, and AI-driven analytics, concerns over data privacy, cybersecurity, and ethical governance have intensified because weaker data security poses serious risks to residents and infrastructures (Laufs et al., 2020). An example was Atlanta's ransomware occurred in 2017 which caused disruption of vital government services. To overcome this, governments should have strong cybersecurity frameworks to further enforce encryption, multi-factor authentication and AI-powered threat detection. In addition, adopting transparent data policies to protect data by law and ensure ethical handling of urban data as well.
- Challenges concerning residents' resistance to change and lack of engagement: Many smart city projects face resistance from residents due to concerns over privacy, displacement or lack of awareness (Chang & Smith, 2023; Yu et al., 2020). Additionally, some local governments and businesses may be reluctant to embrace new technologies due to bureaucratic inertia or fear of disruption. For example, the sidewalk labs project in Toronto faced strong opposition from the public due to concerns over data privacy and corporate control over urban spaces. To overcome this, governments should implement community-driven smart cities where residents could engage in urban decision-making through participatory platforms, digital town halls, and open data initiatives. In addition, raising awareness about the benefits of smart city initiatives can reduce resistance.



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- Socioeconomic and digital divides: The adoption of smart city solutions risks exacerbating inequalities if digital services remain inaccessible to marginalized populations (Svobodová & Bednarska-Olejniczak, 2020). A lack of digital literacy, affordability issues, and infrastructure gaps can prevent lower-income communities from benefiting. For example, lack of digital infrastructure, especially at low-income districts. To overcome this, governments should prioritize digital inclusion programs by subsidizing internet access and smart technology in underserved areas such as public WIFI hotspots, and affordable smart broadband to ensure all socioeconomic groups benefit.
- Environmental sustainability and climate resilience: While smart city projects aim to improve energy efficiency, waste management, and urban sustainability, rapid urbanization and rising energy consumption pose threats to environmental sustainability (Prateeppornnarong, 2025). For example, many smart city developments in China have faced increasing carbon emissions and energy demands due to high levels of digitization. To overcome this, implementing green smart cities that integrate renewable energy sources, smart grids, and energy-efficient buildings into urban design such as Copenhagen's smart climate plan which aims to make the city carbon-neutral by 2025. Table 8 summarizes the smart city challenges in both developed and developing countries.

TABLE 11 – SUMMARY OF SMART CITY CHALLENGES IN DEVELOPED AND DEVELOPING COUNTRIES

| Challenge | Developed countries | Developing countries |
|---|---|---|
| Funding constraints | High initial investment, but access to smart bonds and PPPs | Limited funding, reliance on international grants and aids |
| Infrastructure gaps | Legacy systems slowing digital transformation | Lack of basic infrastructure (e.g., electricity, 4G/5G) |
| Data security & privacy | Advanced cybersecurity laws (e.g., GDPR) | Weak data protection frameworks and regulatory gaps. |
| Citizen engagement | Increasing participation through e-governance | Digital illiteracy limiting awareness and adoption |
| Climate resilience | Focus on smart grids, carbon neutrality | Struggles with pollution, flooding, and waste management |

### *6.1. Summary of the Solutions*

The successful implementation of smart cities requires a multidimensional approach that integrates technological innovation, inclusive governance, financial sustainability, and environmental responsibility (Prateeppornnarong, 2025). While cities have focused on data security, building advanced physical and digital infrastructures and encouraging residents' engagement, a strategic and transformative planning is still required to develop effective urban smart designs, establish effective governance and policies and

also benefiting from private and public as well as international investments and funds (Marchesani et al., 2023). Thus, to overcome such challenges, smart cities should also focus on the following:

- Leveraging public-private partnerships and alternative funding models to address budgetary constraints.
- Adopting cybersecurity best practices to protect urban digital systems.
- Investing in sustainable urban designs that ensure proximity and equity to all.
- Focusing on green infrastructure and improving climate resilience.
- Fostering global knowledge-sharing and policy innovation worldwide to ensure safer and more sustainable urban environments for future humanity.
- Establishing international funding aid to support countries especially to aid the transition of developing countries into smart cities.

## 7. Conclusion and recommendation

In conclusion, smart cities are defined by the effective integration of the physical and digital infrastructures in a smart and sustainable ways that address residents' and climate requirements. There are many advantages that can be obtained via smart city projects such as proximity, inclusiveness, mobility, healthcare, education, and so forth. However, there are many challenges such as the infrastructure readiness, policies and regulations, urban designs and proximity, the effective integration of technologies, data storage and safety, citizen resistance, environmental concerns, and socioeconomic and digital divide. To overcome these challenges, cities are required to have effective polices and legal regulations to guide the development and implementation as well as optimizing budgets and technological integration and enable private and public investments in the urban smart designs. To achieve smart sustainable ecosystems, cities need to have resilient and robust digital and physical infrastructures that allow for smart mobility, green energy, effective and optimized waste and recycling systems, smart super safe digital services and IoT and AI-services. In addition, this study recommends smart cities to do the following:

- Develop comprehensive plans that integrate urban design and budget optimization, polices and regulations, and private and public partnerships to ensure future smart projects are both adaptive and resilient for smart integration.
- Encourage socioeconomic and digital inclusiveness as well as improve citizens' engagement across all demographics.



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- Develop and strengthen measures for cybersecurity and legal for data governance and establish trust between citizens, government and stakeholders.
- Encourage innovations and support startups and entrepreneurship to foster sustainable and optimal ecosystems.
- Focus on only energy-efficient projects that are green and safe for the climate and sustainable for future generations.
- Have strong policies and legal frameworks for future integration of newer technologies to ensure privacy rights and continuous growth of the smart urban ecosystems.

## Acknowledgements

This research was supported and funded by the research sector of the Arab Open University. Kuwait Branch under decision number 25144

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