*smart cities*

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*Review*

# Smart Cities—A Structured Literature Review

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**Abstract:** Smart cities are rapidly evolving concept-transforming urban developments in the 21st century. Smart cities use advanced technologies and data analytics to improve the quality of life for their citizens, increase the efficiency of infrastructure and services, and promote sustainable economic growth. Smart cities integrate multiple domains, including transportation, energy, health, education, and governance, to create an interconnected and intelligent urban environment. Our research study methodology was a structured literature review using Web of Science and Google Scholar and ten smart city research questions. The research questions included smart city definitions, advantages, disadvantages, implementation challenges, funding, types of applications, quantitative techniques for analysis, and prioritization metrics. In addition, our study analyzes the implementation of smart city solutions in international contexts and proposes strategies to overcome implementation challenges. The integration of technology and data-driven solutions in smart cities has the potential to revolutionize urban living by providing citizens with personalized and accessible services. However, the implementation also presents challenges, including data privacy concerns, unequal access to technology, and the need for collaboration across private, public, and government sectors. This study provides insights into the current state and future prospects of smart cities and presents an analysis of the challenges and opportunities they present. In addition, we propose a concise definition for smart cities: "Smart cities use digital technologies, communication technologies, and data analytics to create an efficient and effective service environment that improves urban quality of life and promotes sustainability". Smart cities represent a promising avenue for urban development. As cities continue to grow and face increasingly complex challenges, the integration of advanced technologies and data-driven solutions can help to create more sustainable communities.

**Keywords:** smart cities; digitization; data-driven solutions



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## 1. Introduction

The concept of a smart city is gaining popularity globally as a way to address urbanization, environmental concerns, and economic growth [1]. With the growing importance of technology in our daily lives, the notion of smart cities has become increasingly relevant. In recent years, governments and the private sector have invested heavily in smart city projects. Smart cities are becoming increasingly important as urban populations continue to grow and technology advances [2]. With the significant worldwide investments made by governments and the private sector in smart city projects, there is a growing need for systematic research on the current state of smart city research and applications.

We conducted a structured literature review to explore the frameworks that are used to guide the development of smart cities. To guide the research, we developed ten research questions and identified relevant literature using specific keywords to search databases. We systematically reviewed the literature for relevance to the research questions, and statistical analyses performed, to gain deeper insights into the data. We discuss the findings from each research question, along with the lessons learned from the literature review. We conclude the study with key takeaways and recommendations for future research in the field of smart cities.

## 2. Methodology

The first step in our literature review was to formulate the research questions, which we used to shape the scope of the study and guide the review process. The systematic review aimed to investigate the current state of smart cities, examining their definition, budget allocation, applications, quantitative techniques, metrics, benefits, advantages and disadvantages, root causes for implementation challenges, and solutions employed by cities to overcome those challenges. Our research questions are

1. What is the definition of smart cities?
2. What was the budget allocation for smart cities research, development, and procurement?
3. What type of smart city applications are currently being deployed?
4. What quantitative techniques are being utilized in smart cities to analyze benefits and costs?
5. What metrics are used to prioritize and select smart city projects?
6. What are the advocated benefits/costs versus achieved benefits/costs?
7. What are the advantages and disadvantages of smart city initiatives?
8. How are smart city solutions being implemented in international contexts?
9. What are the underlying root causes for smart city implementation challenges?
10. What are the strategies and solutions that cities have employed to overcome the challenges of implementing smart city initiatives?

After formulating the research questions, we established criteria to determine which research articles to include or exclude. The search process is illustrated in Figure 1 and involves searching Web of Science (WoS) Core Collection and Google Scholar using specific keywords listed in Table 1. Using multiple keywords was necessary to limit the number of articles identified, as a single keyword generated too many results to review.

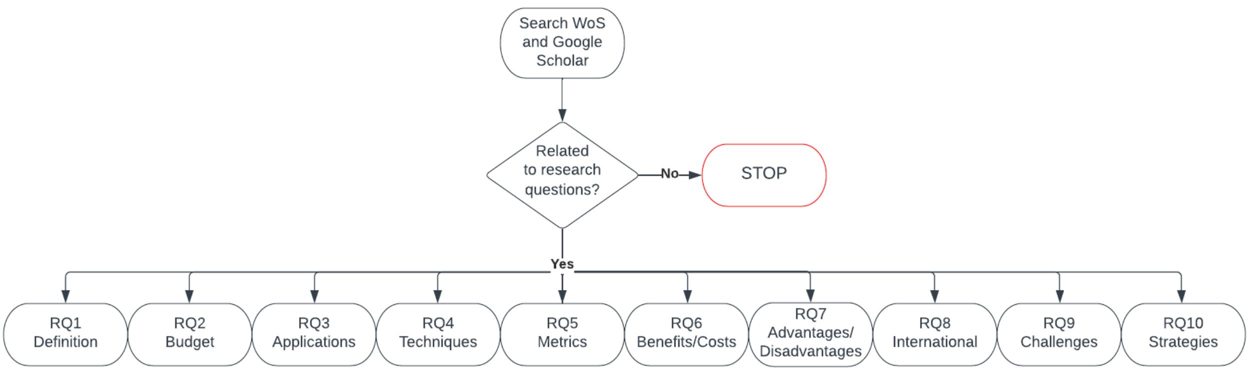


**Figure 1.** Literature Review Search Process.

The table below also indicates which literature was reviewed in the full-text analysis.

Figure 2 is modeled after Moher et al.'s four-phase flow diagram for systematic reviews and meta-analyses [3]. First, 100 papers were identified on Google Scholar and 2635 on Web of Science. They were all screened for relevance, and 100 papers remained for Google Scholar and 618 for Web of Science. In the initial review process, we screened the papers to determine if they were desirable by their title, keywords, and abstract for relevance to the research questions, which identified 103 papers. During the screening process, duplicates were eliminated, and any papers that were unavailable in full text online were also excluded. Through this process, we removed 13 papers due to them not having full-text access online. We examined the remaining 90 papers in a full-text review process, and 83 were included in the literature review for this study.

**Table 1.** Literature Review Keyword Search Results.

| Database | Keyword(s) | # Identified | Used? |
|---|---|---|---|
| Web of Science Core Collection | "Smart cities" | 10,505 | No |
| Web of Science Core Collection | "Smart cities" AND "army" | 19 | No |
| Web of Science Core Collection | "Smart installations" | 4 | No |
| Web of Science Core Collection | "Smart installations" AND "army" | 0 | No |
| Web of Science Core Collection | "Smart cities" AND "lessons learned" | 51 | Yes |
| Web of Science Core Collection | "Smart cities" AND "lessons learned" AND "United States" | 3 | Yes |
| Web of Science Core Collection | "Smart cities" AND "lessons learned" AND "world" | 14 | No |
| Web of Science Core Collection | "Smart cities" AND "applications" | 2674 | No |
| Web of Science Core Collection | "Smart cities" AND "applications" AND "weather" | 40 | Yes |
| Web of Science Core Collection | "Smart cities" AND "funding" | 840 | No |
| Web of Science Core Collection | "Smart cities" AND "funding" | 20 | Yes |
| Web of Science Core Collection | "Smart cities" AND "IoT" | 2340 | No |
| Web of Science Core Collection | "Smart cities" AND "IoT" and "Weather" | 39 | Yes |
| Web of Science Core Collection | "Smart cities" AND "procurement" | 31 | Yes |
| Web of Science Core Collection | "Smart cities" AND "challenges" | 2120 | Yes |
| Web of Science Core Collection | "Smart cities" AND "benefits" AND "challenges" | 177 | Yes |
| Web of Science Core Collection | "Smart cities" AND "development" AND "location" | 189 | No |
| Web of Science Core Collection | "Smart city" and "metrics" | 157 | Yes |
| Google Scholar | "Smart city" AND "challenges" AND "solutions" | 18 | Yes |
| Google Scholar | "Smart city" AND "implementation" AND "challenges" | 33 | Yes |
| Google Scholar | "Smart cities" AND "definition" | 14 | Yes |
| Google Scholar | "Smart city" AND "applications" | 42 | Yes |

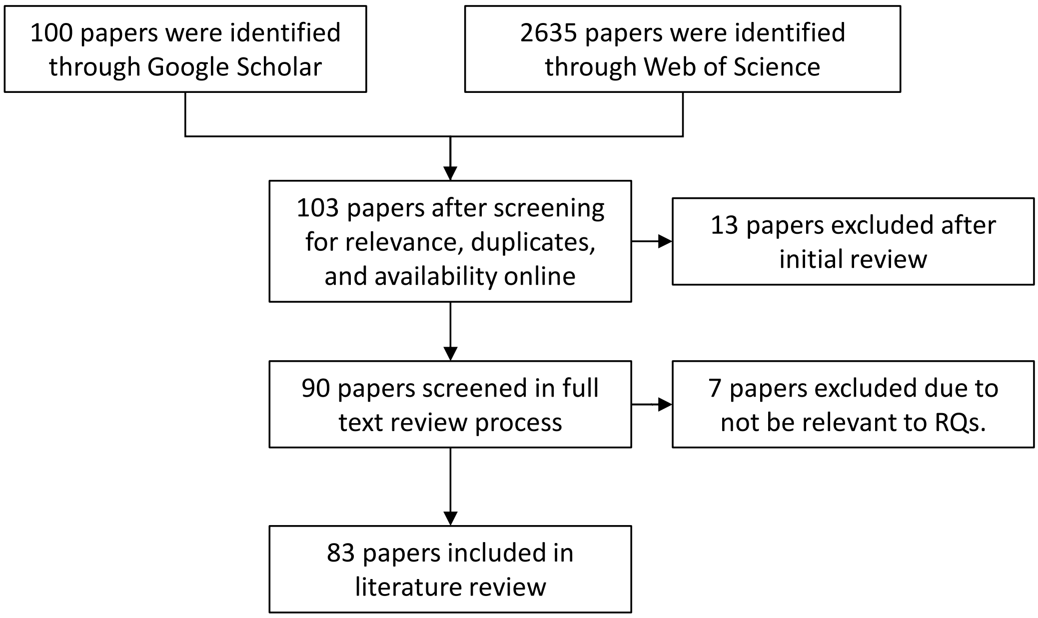


**Figure 2.** PRISMA 4 Phase Flow Diagram of Paper Screening Process [3].

*Literature Analytics*

We performed statistical analysis of the literature underwent to yield additional insights. The 83 papers were written by 261 different authors. A total of 14 authors were included in more than one publication. A total of 5 papers were conference proceedings, and the remaining 78 papers were articles published in 56 different journals. The average impact factor of the journals, if they were available and based on 2021) was 5.68, with a standard deviation of 6.31. The number of papers published per year, as illustrated in Figure 3, indicates that there is a general upward trend in papers regarding smart city research. We selected the papers for this study in January 2023. If the papers were pulled later in the year, we would expect the number of papers from 2023 to be comparable to that of 2019–2022.

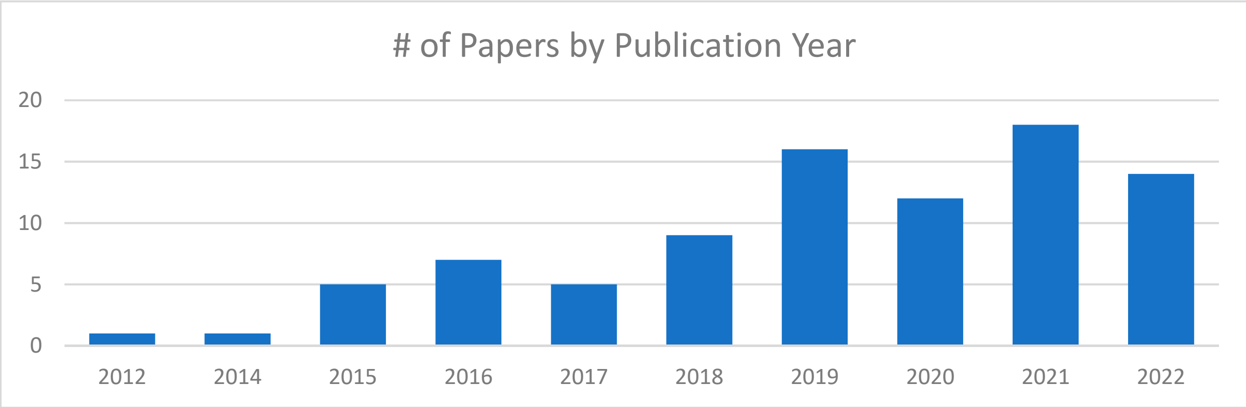


**Figure 3.** Number of Papers in the Structured Literature Review by Year.

## 3. Discussion

### *3.1. Smart City Definitions*

Smart cities have been a topic of significant interest and investment in recent years, with numerous initiatives and projects underway in various parts of the world. However, despite this interest and investment, there is no universally agreed definition of a smart city [4–7]. This lack of a clear definition can create challenges for policymakers, city planners, and stakeholders who seek to develop and implement smart city initiatives.

Our comprehensive examination of smart city definitions through a structured literature review revealed many definitions, with varying conceptual interpretations that often replace the term "smart" with alternative descriptors, such as "intelligent" or "digital" [2]. As a result, the term "smart city" remains a vague and ambiguous concept, with inconsistent usage across different contexts. While many smart city initiatives prioritize sustainability, efficiency, and quality of life themes [8], the lack of a universal definition is due to the wide range of ideas and initiatives encompassed within the term. These ideas and initiatives vary across different geographical and socio-economic contexts [9,10].

Our word cloud analysis conducted with smart city definitions revealed that the primary emphasis of smart city definitions revolves around enhancing the quality of life for residents, as shown in Figures 4 and 5. The prominence of the term "technology" suggests that this is the fundamental tool employed to execute smart city projects. However, it is essential to note that despite the prevalence of these themes, smart cities lack a universal definition. All the definitions used to create the word cloud and frequency plot are shown below in Table 2.

**Table 2.** Smart City Definitions.

| Definition | Reference |
| --- | --- |
| "One that employs ICT to fulfill market demand, i.e., the citizens."; "An ultra-modern urban area that addresses the needs of businesses, institutions, and especially citizens." | [5] |
| "Smart and sustainable cities are expected to form a cornerstone for achieving resource efficiency and sustainability worldwide." | [11] |
| "Smart city uses sensor technology and intelligent technologies to realize automatic, real-time operations, and comprehensive perception of urban operations on the basis of Digital City." | [12] |
| "Smart cities are comprised of diverse and interconnected components constantly exchanging data and facilitating improved living for a nation's population." | [13] |

**Table 2.** *Cont.*

| Definition | Reference |
| --- | --- |
| "A smart city employs a combination of data collection, processing, and disseminating technologies in conjunction with networking and computing technologies and data security and privacy measures encouraging application innovation to promote the overall quality of life for its citizens and covering dimensions that include: utilities, health, transportation, entertainment, and government services." | [14] |
| "Smart cities are: 1) sensible (sensors sense the environment) 2) connectable (networked devices bring the sensed information to the Web) 3) accessible (information on our environment is published and is accessible by users on the Web) 4) ubiquitous (users can access information at any time and in any place, while moving) 5) sociable (users acquiring information can publish it through their social network) 6) sharable (sharing is not limited to data, but also to physical objects that may be used when they are in free status), and 7) visible/augmented (the physical environment is retrofitted and information is seen not only by individuals through mobile devices, but also in physical places such as street signs." | [15] |
| "Cities that contain intelligent things which can intelligently automatically and collaboratively enhance life quality, save people's lives, and act as sustainable resource ecosystems." | [16] |
| "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, the efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of the present and future generations concerning economic, social and environmental aspects." | [17] |
| "Smart cities are aimed to efficiently manage growing urbanization, energy consumption, maintain a green environment, improve economic and living standards of their citizens and raise people's capabilities to efficiently use modern information and communication technology (ICT)." | [18] |
| "Smart cities employ information and communication technologies to improve: the quality of life for its citizens, local economy, transport, traffic management and interaction with government." | [2] |
| "A smart city aims to improve citizens' quality of life and build a sustainable urban environment by using modern advanced information and communication technology (ICT)."; "A smart city is a system that enhances human and social capital wisely using and interacting with natural and economic resources via technology-based solutions and innovations to address public issues and efficiently achieve sustainable development and high quality of life." | [19] |
| "Smart city is an urban environment that utilizes ICT and other related technologies to enhance performance efficiency of regular city operations and quality of services (QoS) provided to urban citizens." | [20] |
| "A smart city utilizes urban informatics and technologies for providing city services on a larger scale. It offers improved quality of life and a variety of innovative services such as energy, transport, healthcare, etc ... " | [21] |
| "Connecting the physical, IT, social, and business infrastructures to leverage the collective intelligence of the city." | [4] |
| "In smart city architecture, information and communication technologies are used to improve living standards and its management by citizens and government." | [22] |
| "The city that makes optimal use of all the interconnected information available today to better understand and control its operations and optimise the use of limited resources" | [23] |
| "Smart City is Use/Innovation of Technology/ICT coupled with favorable government policies that promote the development of infrastructure, ease of doing business and citizen engagement leading to sustainable economic growth and citizen satisfaction through improved quality of life." | [24] |
| (1) Proposed definition: "A smart city is said to be learn from Experience (E) with respect to some take (T), some performance measure (P) and resource optimization (O), if its performance on (T) as measured by (P) with respect to resource optimization (O) then task is improve with experience (E)." (2) Technical definition: IBM defines a smarter city as "one that makes optimal use of all the interconnected information available today to better understand and control its operations and optimize the use of limited resources." (3) Citizen purposeful definition: According to the Manchester Digital Development agency, "a 'smart city' means 'smart citizens' -- where citizens have all the information they need to make informed choices about their lifestyle, work and travel options." | [25] |
| "Smart city is the idea of creating a sustainable living environment along with state-of-the-art technology (ICT) integration."; "A smart city is a self-containing city that focuses on people's QoL above everything else." | [26] |
| "A smart city has been generally defined as a developed urban area that uses information and technology (ICT), human capital and social capital in order to promote sustainable socio-economic growth and a high quality of life." | [27] |

**Table 2.** *Cont.*

| Definition | Reference |
| --- | --- |
| "A smart city is a complex cyber-socio-technical system where human, cyber artifacts, and technical systems interact together to the purpose of achieving a goal related to the quality of life in urban areas." | [28] |
| "A set of instruments across many scales that are connected through multiple networks and provide continuous data regarding people and environment in support of decisions about the physical and social form of the city." | [29] |
| "A city that invests in human and social capital, political participation of citizens, management of natural resources, and traditional and modern networked infrastructure." | [30] |
| "Smart cities are cities that balance economic, environmental, and societal advances to improve the wellbeing of residents through a widespread introduction of ICT and other technological tools." | [31] |
| "City that increases the pace at which it provides social, economic, and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment." | [32] |
| "A smart city is a system integration of technological infrastructure that relies on advanced data processing with the goals of making city governance more efficient, citizens happier, businesses more prosperous and the environment more sustainable." | [1] |
| "A city is smart if investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" | [33] |
| A smart city is the concept could be briefly described as cities that "use information and communication technologies in order to increase the quality of life of their inhabitants while contributing to a sustainable development." | [34] |
| Smart city is "a futuristic approach to alleviate obstacles triggered by ever-increasing population and fast urbanization which is going to benefit the governments as well as the masses." Smart cities are "an endeavor to make cities more efficient, sustainable and livable." | [35] |
| "A smart city is a utopian vision of a city that produces wealth, sustainability, and well-being by using technologies to tackle wicked problems." | [36] |
| "Smart cities are urban areas in which information and communication technologies are used to solve their specific problems and support their sustainable development in social, economic and/or environmental terms." | [37] |
| "A smart city is capable of identifying its problems and mitigating root causes by generating and processing engineered quality data in a continuous and inclusive matter." | [38] |
| "A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business." | [39] |
| "A smart city is an urban area that uses technological or non-technological services or products that: enhance the social and ethical wellbeing of its citizens; provide quality, performance and interactivity of urban services to reduce costs and resource consumption; and increase contact between citizens and government." | [40] |

Although the list does not aim to encompass all possible definitions for smart cities, it goes beyond the commonly referenced sources such as the Institute of Electrical and Electronics Engineers (IEEE), International Council on Systems Engineering (INCOSE), International Organization for Standardization (ISO), and the European Commission, by including 30 additional definitions from the literature. Numerous other papers have explored and presented multiple definitions [6,10,41,42]. We propose the following definition to identify the key technologies, the focus on services, and the clear goals of smart cities:

> "Smart cities use digital technologies, communication technologies, and data analytics, to create an efficient and effective service environment that improves urban quality of life and promotes sustainability."

The definitions in the above table do not have all of these three components. Our definition captures the key elements of what a smart city is, including the use of digital technologies, communication technologies, and data analytics to improve urban life while promoting sustainability. By providing a clear definition of a smart city, this research can help guide policymakers, city planners, and stakeholders in developing and implementing smart city initiatives that are consistent with the goals of improving urban life and promoting sustainability. While the lack of a universally agreed definition of smart cities poses challenges for stakeholders seeking to develop and implement smart city initiatives, the definition proposed in this research can provide a clear framework for understanding what a smart city is and what its goals should be. This research can have a significant impact on the development of smart city initiatives by guiding stakeholders toward a shared understanding of a smart city.


**Figure 4.** World Cloud Generated Using Compiled List of Smart City Definitions.

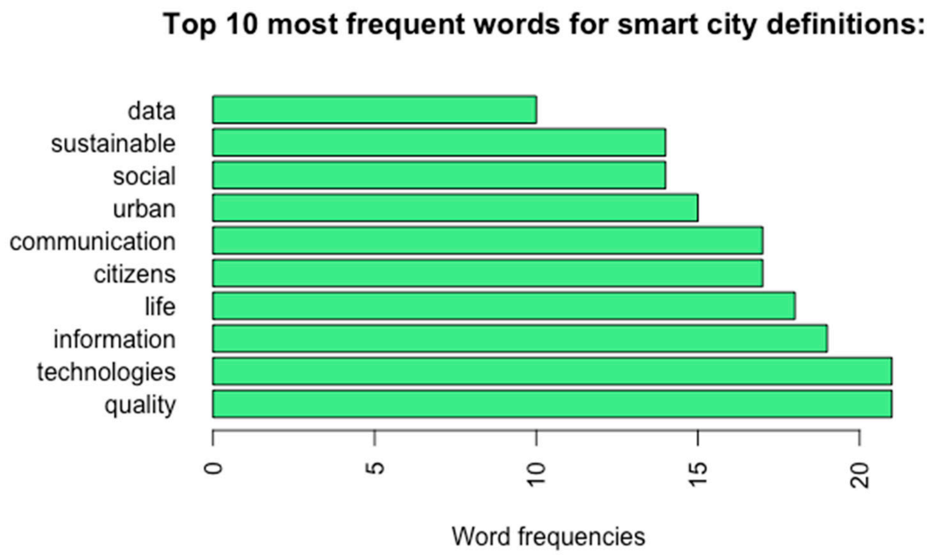


**Figure 5.** Word Frequency Plot Generated Using Compiled List of Smart City Definitions.

*3.2. Budget Allocation for Smart Cities—What We Know and What We Do Not Know*

In the structured literature review, we were unable to find any concrete information on budget allocation for smart cities research, development, and procurement. While there are many studies that discuss the potential benefits and challenges of smart cities [2,10,18,41,43–45], few provide detailed information on the financial aspects of implementing these initiatives.

One possible reason for this lack of information is that budget allocation may not be a top priority for researchers or practitioners in the field, or the budget data may be sensitive. Instead, many studies focus on the technical aspects of smart cities, such as the development of new technologies and the integration of existing infrastructure [12,45–48]. Another possible explanation for the lack of information on budget allocation is that it may be difficult to obtain. Smart city initiatives are often complex and involve multiple stakeholders, including government agencies, private companies, and community organizations [35]. Tracking the financial resources that are allocated to these initiatives may be challenging, especially if funding comes from multiple sources.

Despite the lack of budget data, it is important to recognize the importance of budget allocation for the success of smart city initiatives. Without adequate financial resources, it may be difficult to implement the necessary infrastructure and technologies to make cities smarter, more efficient, and more sustainable. In order to address this gap in knowledge, future studies could investigate budget allocation for smart cities research, development, and procurement more explicitly. This could involve surveys or interviews with key stakeholders in the field, as well as case studies of successful smart city initiatives that have received significant financial support.

While our literature review was unable to provide concrete information on budget allocation for smart cities, it is important to recognize the significance of this issue for the success of these initiatives. By acknowledging the limitations of our study and suggesting future research directions, we hope to contribute to a better understanding of the financial aspects of smart cities and their potential impacts.

### *3.3. Smart City Applications*

In recent years, the proliferation of smart applications has revolutionized the way we live and work. These applications are powered by emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and big data. They have been deployed across various domains, including healthcare, governance, environment, transportation, energy, safety and security, infrastructure, and education, to address complex challenges and improve the quality of life for individuals and communities (Figure 6). Our structured literature review aims to provide an overview of the type of smart city applications being deployed in these domains and their impact on society.

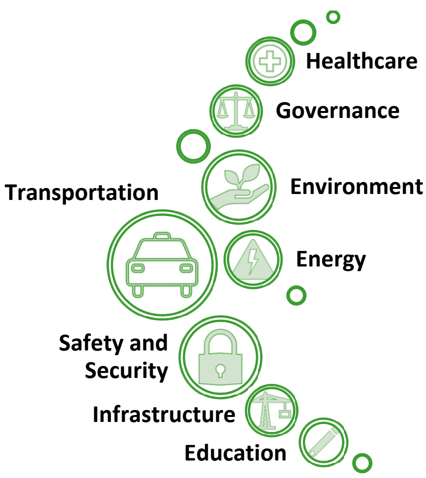


**Figure 6.** Smart City Application Domains.

#### 3.3.1. Healthcare

Smart applications in healthcare have shown tremendous potential in improving patient outcomes, reducing costs, and increasing efficiency. Examples include remote monitoring of patients using IoT devices and predictive analytics [2,20,26,49]. Remote monitoring devices allow patients to track their health conditions and receive timely alerts when intervention is required. Predictive analytics uses AI and machine learning algorithms to analyze large datasets and identify patterns that can help predict disease outbreaks and inform public health policies.

#### 3.3.2. Governance

Smart city applications in governance have the potential to transform the way cities operate, providing greater transparency, accountability, and citizen participation. By using Internet of Things (IoT) devices and sensors, smart cities are able to collect and analyze large amounts of data in real time, providing valuable insights that can be used to optimize the use of urban infrastructure and resources.

For instance, in traffic management, smart city technology can help reduce congestion and improve road safety by using sensors to monitor traffic flow and adjust traffic signals in real-time [2,21,45,50,51]. By analyzing data from traffic sensors and GPS devices, smart city applications can also provide drivers with real-time information about traffic conditions, suggesting alternative routes and modes of transportation to avoid congestion.

In addition to improving the efficiency and effectiveness of public services, smart city technology can also increase citizen participation by providing new channels for engagement and communication between citizens and their government. This can help to build trust and enhance collaboration between citizens and their government, improving the overall quality of life in the city.

#### 3.3.3. Environment

Smart applications in the environment aim to address the pressing challenges of climate change and environmental degradation. Examples include smart grids, precision agriculture, weather forecasting, and smart waste management [22,31,52–55]. Smart grids use IoT devices and sensors to monitor and manage energy consumption, reducing waste and increasing efficiency. Precision agriculture uses sensors, drones, and AI to optimize crop yields and reduce the use of pesticides and fertilizers. Smart waste management uses IoT devices and sensors to monitor and manage waste collection and disposal, reducing the environmental impact of waste.

#### 3.3.4. Transportation

Smart applications in transportation aim to improve mobility, safety, and efficiency. Examples include intelligent transportation systems (ITS), autonomous vehicles, and ride-sharing platforms [15,16,18,41,54,56,57]. ITS uses IoT devices and sensors to monitor traffic and manage traffic flow, reducing congestion and improving safety. Autonomous vehicles use AI and machine learning algorithms to navigate roads and reduce the risk of accidents. Ride-sharing platforms use digital platforms to connect passengers with drivers, reducing the number of cars on the road and increasing efficiency.

#### 3.3.5. Energy

Smart applications in energy aim to reduce carbon emissions, improve energy efficiency, and increase the use of renewable energy sources. Examples include smart grids, energy storage systems, and renewable energy management systems [20–22,27,57–59]. Smart grids use IoT devices and sensors to monitor and manage energy consumption, reducing waste and increasing efficiency. Energy storage systems use batteries and other technologies to store energy and release it when needed, reducing the need for fossil fuels. Renewable energy management systems use AI and machine learning algorithms to optimize the use of renewable energy sources such as solar and wind power.

#### 3.3.6. Safety and Security

Smart applications in safety and security aim to prevent crime, respond to emergencies, and improve public safety. Examples include smart surveillance systems, emergency response systems, smart lighting systems, and public safety applications [16,20,29,58,60]. Smart surveillance systems use AI and machine learning algorithms to monitor public spaces and detect suspicious behavior, reduce crime, and increase safety. Emergency response systems use IoT devices and sensors to detect emergencies and alert first responders, reducing response times and improving outcomes. Public safety mobile applications allow citizens to report incidents and receive alerts from authorities, increasing transparency and accountability.

#### 3.3.7. Infrastructure

Smart applications in infrastructure aim to improve the management and maintenance of physical assets such as buildings, bridges, and roads. Examples include smart building systems, bridge monitoring systems, and road condition monitoring systems [8,14,61–63]. Smart building systems use IoT devices and sensors to monitor and manage energy consumption, indoor air quality, and other factors, thus reducing costs and improving the occupant experience. Bridge monitoring systems use sensors and other technologies to monitor the structural health of bridges, detecting potential issues before they become catastrophic. Road condition monitoring systems use IoT devices and sensors to monitor road conditions such as potholes and cracks, allowing authorities to prioritize maintenance and repairs.

#### 3.3.8. Education

Smart applications in education aim to improve learning outcomes, increase access to education, and enhance the student experience. Examples include personalized learning platforms and learning analytics [22,26,56]. Personalized learning platforms use AI and machine learning algorithms to tailor learning materials to individual students, improving their engagement and understanding. Learning analytics use data analysis techniques to identify patterns in student performance and provide insights to teachers, improving their ability to provide targeted support.

#### 3.3.9. Summary

Smart applications are transforming the way we live and work with their deployment across various domains, including healthcare, governance, environment, transportation, energy, safety and security, infrastructure, and education. These applications leverage emerging technologies such as IoT, big data, and AI to address complex challenges and improve the quality of life for individuals and communities. While there are challenges and concerns around privacy, security, and ethical issues, the potential benefits of smart applications are significant, making them an important area of research and development for the future.

### *3.4. Quantitative Techniques for Analyzing Benefits and Costs in Smart Cities*

Smart cities are designed to leverage technology and data to improve the quality of life of their citizens while addressing issues such as sustainability and economic growth. In order to achieve these goals, smart cities often use quantitative techniques to analyze the benefits and costs of different projects and initiatives. We explore several of these techniques and their applications in smart cities. Figure 7 presents an overview of the prevailing techniques identified in the literature, including widely used methodologies such as cost-benefit analysis (CBA), lifecycle analysis (LCCA), return on investment (ROI) analysis, multi-criteria decision analysis (MCDA), risk assessments, machine learning algorithms, and big data analytics.

One commonly used technique is cost-benefit analysis [5,14,15,41,45,61]. CBA is used to evaluate the benefits and costs of projects, enabling policymakers to make informed decisions by comparing the expected benefits and costs of different projects. By understanding the economic impact of different initiatives, decision-makers can prioritize projects with the best return on investment.

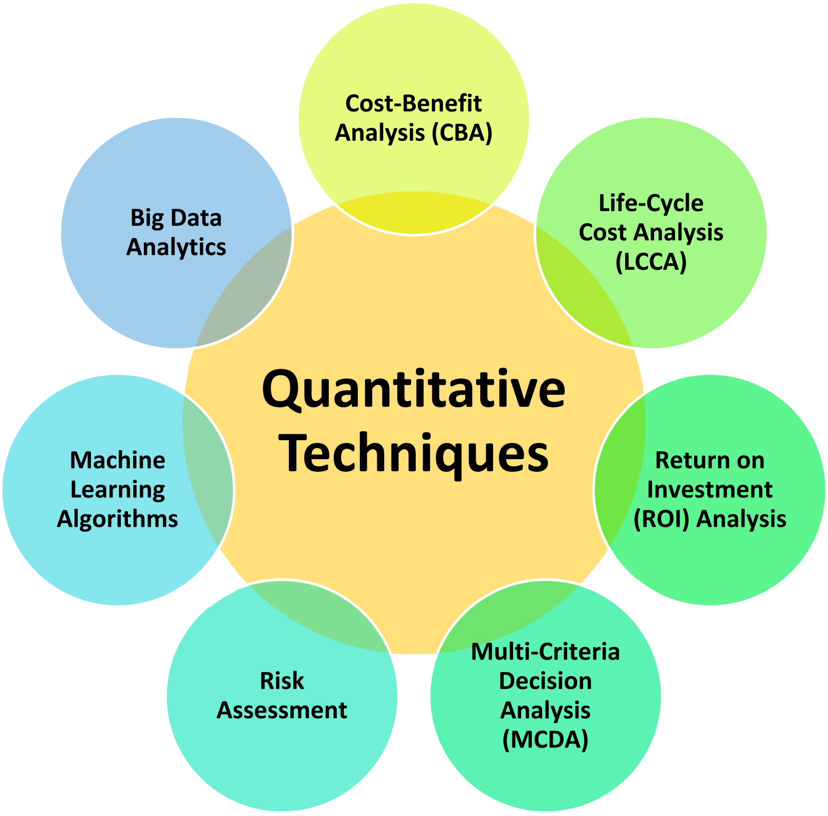


**Figure 7.** Common Quantitative Techniques for Analyzing Benefits and Costs in Smart Cities.

Another technique used in smart cities is multi-criteria decision analysis [5]. MCDA evaluates projects against multiple criteria, such as social, environmental, economic, and technical factors. This approach ensures that smart city projects are not only economically viable but also socially and environmentally sustainable. MCDA helps to identify trade-offs between different objectives and prioritize projects that have the greatest overall benefit.

Big data analytics is also used in smart cities to analyze benefits and costs. This approach involves collecting large amounts of data from various sources (e.g., sensors) and processing it using various algorithms to extract meaningful insights about a particular problem or situation at hand [61,64,65]. Big data analytics can identify patterns and trends, predict outcomes, and optimize resource allocation.

Machine learning algorithms, such as decision tree analysis (DTA), artificial neural networks (ANNs), and clustering, are used to identify patterns and relationships in large datasets [14,45,64]. This helps inform decision-making and identify opportunities for optimization.

Quantitative techniques such as life cycle assessment (LCA) and risk assessment can also be used to analyze the benefits and costs associated with different projects or initiatives in smart cities [15,41]. LCA helps evaluate the environmental impact of different projects over their lifecycle, while risk assessment helps identify potential hazards and prioritize risk mitigation measures.

Other quantitative techniques being used in smart cities to analyze benefits and costs include k-means clustering algorithms, which can analyze big datasets and convert them into a graph with three seasons [66]. Probabilistic methods, multimodal actions/reactions, and constructs examining city heat amplification are used to analyze the anticipated impacts of environmental hazards on individuals or populations [67]. Hadoop with Spark, VoltDB, or Storm is used for real-time processing of IoT data, MapReduce programming is used for analyzing offline historical datasets, and machine learning algorithms such as regression models and decision trees to identify patterns from large amounts of collected data [64].

Quantitative techniques are essential for analyzing the benefits and costs associated with different projects and initiatives in smart cities. By utilizing a combination of these techniques, smart cities can achieve their goals of improving the quality of life, promoting sustainability, and driving economic growth.

### *3.5. Prioritizing Smart City Projects: Metrics*

As cities continue to grow, the need for efficient and sustainable management becomes increasingly pressing. Smart cities offer a potential solution to this challenge by leveraging technology to improve quality of life, sustainability, economic competitiveness, and government performance. However, with limited resources, how can city leaders prioritize and select smart city projects that will deliver the most impact? This section explores the metrics used to assess and prioritize smart city projects. Figure 8 lists the most comment metrics we found in the literature.

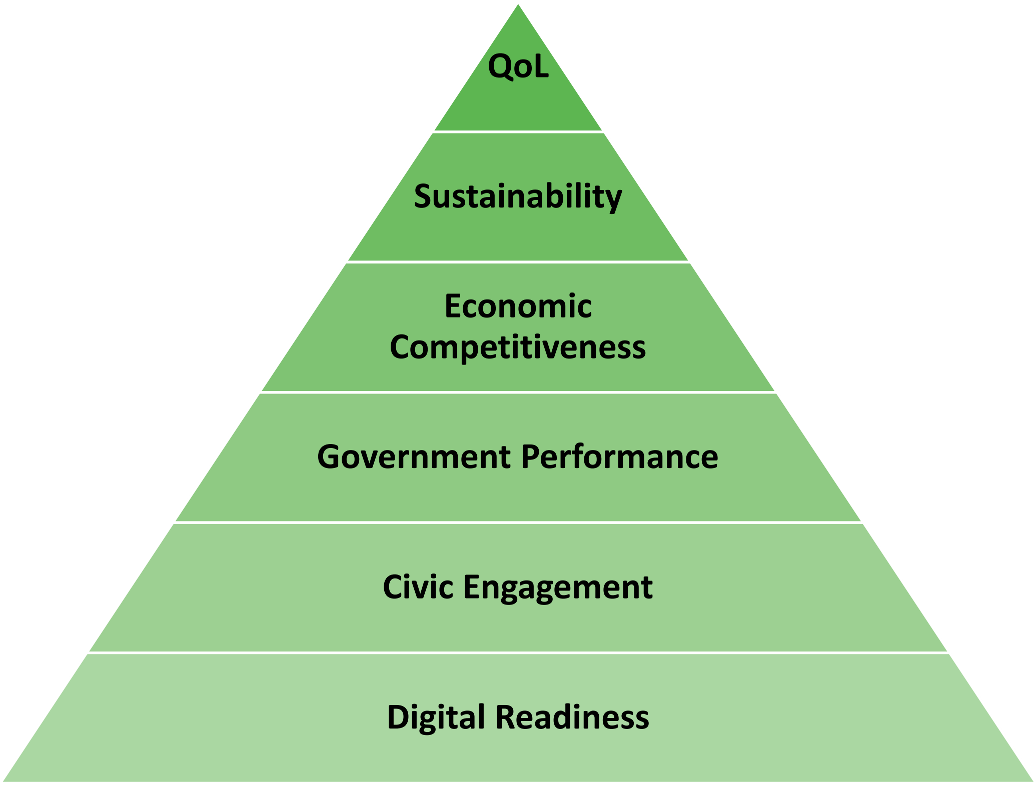


**Figure 8.** Smart City Metrics Commonly Used for Prioritizing Smart City Initiatives.

Metrics: In our literature survey, the following metrics emerged as key factors in prioritizing and selecting smart city projects:

Quality of Life (QoL): This metric measures the well-being of citizens in terms of health, safety, education, and other factors that contribute to their overall quality of life. Smart city projects that prioritize QoL may include initiatives to improve healthcare access, reduce crime, or promote public transportation [2,16,46,64,67,68].

Sustainability: Sustainability measures the city's ability to meet the needs of the present without compromising the ability of future generations to meet their needs. This includes environmental sustainability and resource management. Smart city projects that prioritize sustainability may include initiatives to reduce carbon emissions, improve energy efficiency, or promote recycling [24,51,52,69,70].

Economic Competitiveness: This metric measures the city's ability to attract and retain business and talent, promote innovation, and create economic opportunities for residents. Smart city projects that prioritize economic competitiveness may include initiatives to improve transportation infrastructure, expand broadband access, or promote entrepreneurship [8,20,37].

Government Performance: This metric measures the efficiency and effectiveness of city government in delivering services and addressing citizens' needs. Smart city projects that prioritize government performance may include initiatives to streamline permitting processes, reduce bureaucracy, or improve transparency and accountability [2,31,36].

Civic Engagement: This metric measures the level of citizen participation and involvement in decision-making processes, as well as the city's ability to facilitate citizen input and feedback. Smart city projects that prioritize civic engagement may include initiatives to expand public forums, create online feedback portals, or implement participatory budgeting processes [2,31,44].

Digital Readiness: Digital readiness measures the city's level of technological advancement, including infrastructure, digital services, and data management capabilities. Smart city projects that prioritize digital readiness may include initiatives to expand public Wi-Fi, deploy smart sensors to monitor traffic or air quality or implement data analytics to improve decision-making [31,52].

The prioritization and selection of smart city projects depend on multiple factors, including the specific needs of the city, available resources, and political priorities. However, by using metrics such as QoL, sustainability, economic competitiveness, digital readiness, government performance, and civic engagement, city leaders can better assess and prioritize smart city projects that will have the greatest impact on their citizens and communities.

### *3.6. Advoated versus Achieved Benefits and Costs*

Smart city initiatives have been promoted as a means to achieve a range of benefits, including improved efficiency, increased economic growth, increased sustainability, enhanced public safety, and better quality of life for citizens [20,51,71,72]. However, there are also costs associated with implementing these initiatives, including financial investments, potential loss of privacy, and concerns about data security [45,64,73]. The question of how the advocated benefits and costs of smart city initiatives compare to their achieved benefits and costs is an important one to consider when evaluating these projects. Figure 9 summarizes the advocated benefits and costs of smart city projects.

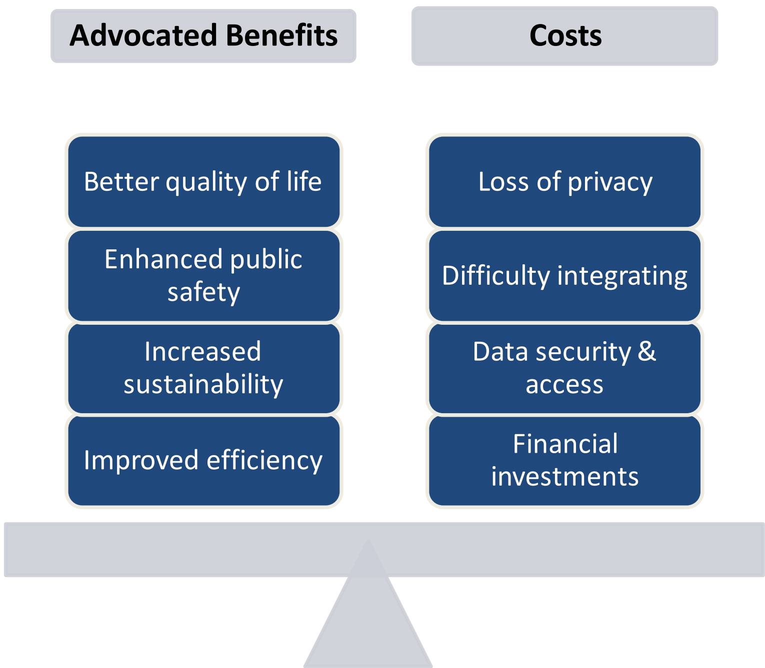


**Figure 9.** Benefits and Costs of Smart Cities.

Despite the importance of this question, there is a dearth of literature that specifically addresses the comparison between advocated and achieved benefits/costs of smart city initiatives.

The advocated benefits of smart city initiatives include improved efficiency, increased sustainability, enhanced public safety, and better quality of life. Improved efficiency may be achieved through the use of technologies such as real-time traffic monitoring, smart energy grids, and automated waste management systems. Increased sustainability may be achieved through the use of renewable energy sources, green buildings, and smart transportation systems. Enhanced public safety may be achieved through the use of technologies such as smart surveillance systems and emergency response systems. Better quality of life may be achieved through the provision of better healthcare, education, and social services.

However, there are also costs associated with smart city projects, including financial investments, potential loss of privacy, data security and access concerns, and the potential for unintended consequences such as increased social inequality.

The achieved benefits and costs of smart city initiatives are highly dependent on the specific context. For example, Singapore's "Smart Nation" initiative has achieved improvements in healthcare, transportation, education, and environmental impact [12]. However, these achievements have come at a high cost and with potential privacy concerns.

### *3.7. Advantages and Disadvantages*

Smart city initiatives have gained significant attention as a means to enhance the quality of life for residents, promote economic growth, and address environmental challenges. However, these initiatives come with both advantages and disadvantages that need to be carefully considered and managed to ensure that the benefits are maximized and negative impacts are minimized. This section explores some of the potential benefits and drawbacks of smart city initiatives, highlighting the trade-offs that need to be managed to ensure that the benefits are maximized and negative impacts are minimized. Table 3 shows the major advantages and disadvantages of smart cities.

**Table 3.** Advantages and Disadvantages of Smart Cities.

| Advantages | Disadvantages |
|---|---|
| Improved quality of life | High implementation costs |
| Enhanced economic growth | Increased privacy and security concerns |
| Increased sustainability | Lack of standardization |
| Improved efficiency | Difficulty integrating into existing infrastructure |
| Increased interoperability between different systems | Unequal distribution of benefits across different socio-economic groups is a plausible scenario |
| Promotes innovation | Potential displacements effects due to gentrification |
| Enhanced governance | Potential job displacement |

One of the primary advantages of smart city initiatives is improved quality of life [5,13,41,61,74]. By utilizing technology, cities can enhance public safety, improve transportation systems, and provide better access to public services, such as healthcare and education. This can lead to greater convenience, reduced commuting times, and improved overall well-being for residents.

In addition to improving the quality of life, smart city projects can also enhance economic growth [2,6,44,75,76]. They can attract new businesses, create jobs, and drive innovation. Moreover, the increased efficiency of city services can lead to cost savings for both businesses and residents, which can contribute to greater economic growth.

Promoting sustainability is also a potential benefit of smart city projects [2,19,57,77]. By promoting the use of renewable energy, reducing waste, and improving transportation systems, cities can reduce their environmental footprint and promote a more sustainable future.

Smart city initiatives can also improve efficiency by utilizing technology to streamline processes and optimize resource utilization [8,20,22,52,77,78]. This can lead to faster response times, reduced congestion, and improved overall effectiveness.

Moreover, smart city initiatives can enhance interoperability between different systems [14,46,54]. By integrating various technologies and systems, cities can create a more cohesive and interconnected infrastructure, enhancing their ability to respond to various challenges and providing a more seamless experience for residents.

Despite these potential benefits, smart city initiatives also come with several drawbacks. High implementation costs are one of the most significant challenges, as developing and implementing new technologies and infrastructure can be expensive and time-consuming [22,49,50,52]. Increased privacy and security concerns are another potential disadvantage of smart city initiatives [6,36,54,79]. As cities collect and use more data to optimize services and improve efficiency, there is a risk of data breaches and privacy violations, which can erode public trust and lead to a backlash against smart city initiatives.

Lack of standardization is another potential challenge [2,41], as different technologies and systems may not be compatible with one another. This can create inefficiencies and limit the effectiveness of smart city initiatives.

Difficulty integrating into existing infrastructure is also a potential disadvantage [44], as new technologies may not be easily integrated into existing systems. This can lead to delays and increased costs, as well as potential disruptions to existing services.

Furthermore, the benefits of smart city initiatives may not be distributed equally across different socio-economic groups, leading to further inequality [4,22,52]. Addressing these potential drawbacks requires careful planning, stakeholder engagement, and ongoing evaluation and monitoring. For example, high implementation costs may be balanced by the potential for enhanced economic growth, while increased privacy and security concerns may be balanced by improved efficiency. Similarly, difficulty integrating into existing infrastructure may be balanced by the potential for increased interoperability between different systems. The potential for trade-offs highlights the importance of careful planning, stakeholder engagement, and ongoing evaluation and monitoring to ensure that the benefits of smart city initiatives are maximized and the negative impacts are minimized.

While smart city initiatives offer significant potential benefits, they also come with several potential drawbacks. Addressing these potential drawbacks requires careful planning, stakeholder engagement, and ongoing evaluation and monitoring to ensure that the benefits are maximized and negative impacts are minimized.

### *3.8. Smart City Solutions in International Contexts*

The implementation of smart city solutions in various international contexts has been an emerging global phenomenon. Smart city solutions are tailored to meet the specific requirements and needs of local communities while promoting sustainable development and enhancing the quality of life for residents. This section of the literature review explores the implementation of smart city solutions in international contexts, highlighting the importance of considering the cultural, political, and economic landscape of each country.

#### 3.8.1. Implementation of Smart City Solutions

Smart city solutions are being implemented worldwide, taking into account various cultural, political, and economic factors. Different countries have adopted various smart city solutions, such as intelligent transportation systems, security cameras, air quality sensors, and smart lighting. These solutions are customized to meet the unique needs of each locality.

For instance, the Smart Health 2.0 Project in Italy aims to develop beneficial services that meet the healthcare needs of citizens [14], while Singapore's Smart Nation Initiative is used to monitor and manage traffic flow [12,46,69]. Santander (Spain) has deployed thousands of air quality sensors to collect data on the levels of air pollution [46], while

Seoul (Korea) has developed an integrated platform to connect transportation networks and building automation systems [46].

#### 3.8.2. Tailoring Smart City Solutions to Meet Local Needs

Smart city solutions are tailored to meet the specific needs and requirements of local communities. For instance, Amsterdam's Connected Mobility Platform was implemented to meet the needs of a densely populated urban area with limited parking space. Similarly, Bhubaneswar (India) implemented a camera and video system to provide security for all residents, especially women and children [14].

In addition, these solutions are designed to address specific challenges such as traffic congestion, air pollution, and public safety concerns. For example, smart parking and intelligent transportation systems were implemented in Qatar to improve traffic flow and reduce air pollution [5]. Barcelona's smart lighting system reduces energy consumption and light pollution [8], while Oulu's smart lighting system and mobile app provide real-time information on public transportation [9].

#### 3.8.3. Promoting Sustainable Development and Enhancing Quality of Life

Smart city solutions promote sustainable development and enhance the quality of life for residents. The implementation of these solutions can lead to reduced carbon emissions, improved air quality, and increased public safety. In Qatar, smart parking and intelligent transportation systems have led to improved traffic flow and reduced air pollution [5], while Amsterdam's Connected Mobility Platform has reduced the number of cars on the road, resulting in lower carbon emissions and improved air quality [12].

Similarly, Santander's air quality monitoring system promotes environmental sustainability [46], while Barcelona's smart lighting system reduces energy consumption and light pollution [8]. Bhubaneswar's camera and video system have improved public safety [14], and Oulu's smart lighting system and mobile app have enhanced the quality of life for residents by providing real-time information on public transportation [9].

The implementation of smart city solutions in international contexts is a rapidly growing phenomenon. These solutions are tailored to meet the specific requirements and needs of local communities, promote sustainable development, and enhance the quality of life for residents. Smart city solutions can address various challenges, such as traffic congestion, air pollution, and public safety concerns. By taking into account the cultural, political, and economic landscape of each country, smart city solutions can be effectively implemented, leading to a more sustainable and improved living environment.

### *3.9. Uncovering the Root Causes: Challenges in Implementing Smart City Solutions*

Smart city implementation is an emerging and complex phenomenon that involves the integration of various technologies, stakeholders, and domains to improve the quality of life of citizens, enhance sustainability, and promote economic growth. However, the implementation of smart cities is not without challenges. The purpose of this section is to examine the underlying root causes for smart city implementation challenges, with a focus on technical, financial, legal, social, and cultural challenges. Figure 10 identifies the three major challenges.

Technical challenges are among the most prominent factors that hinder the implementation of smart cities. Lack of standardization and interoperability are two primary technical challenges that cities face [2,8,16,22,23,27,44,49]. Smart city technologies are typically developed by different vendors and organizations, which can lead to fragmentation, complexity, and compatibility issues. This can make it difficult for different technologies to work together seamlessly, resulting in increased costs and delays in implementation. Therefore, the development of standardized interfaces, protocols, and data models is essential for creating a seamless smart city ecosystem.


**Figure 10.** Challenges in Implementing Smart City Solutions Categorized into Three Domains.

Financial and legal challenges are also major factors that hinder smart city implementation. Funding and financing are two of the most significant challenges that cities face when implementing smart city projects [2,46,54,64,69]. While the terms "funding" and "financing" are sometimes used interchangeably, there is a subtle difference between the two. "Funding" generally refers to the money or resources provided by an external source, such as a government grant or a private investor, whereas "financing" refers to the means by which a project is funded, such as loans. Smart city initiatives are often costly, and city budgets are typically limited. Additionally, smart city projects often require a long-term investment, which can make it difficult for cities to secure funding. Furthermore, legal and regulatory challenges, such as data privacy and ownership, can create barriers to the adoption and implementation of smart city technologies [44,80–82]. Therefore, cities must develop innovative financing models and work closely with legal experts to navigate these challenges.

Social and cultural challenges are another set of factors that can hinder smart city implementation. Resistance to change is a common challenge that cities face when implementing smart city projects [6,31,36,43]. Citizens may be hesitant to adopt new technologies or change their behavior, leading to a slow adoption rate and delays in implementation. Additionally, privacy and security concerns are common among citizens, who may be worried about how their data are being collected, stored, and used [14,16,45]. Addressing these concerns is critical for building public trust and support for smart city projects.

Smart city implementation is a complex process that requires the integration of various technologies, stakeholders, and solution domains. Technical, financial, legal, social, and cultural challenges are among the most prominent factors that hinder smart city implementation. Addressing these challenges requires a collaborative and innovative approach that involves all stakeholders. By doing so, cities can overcome these challenges and create a more sustainable and livable future for all citizens.

### *3.10. Strategies and Solutions Employed by Cities to Meet the Challenges*

The implementation of smart city initiatives is often fraught with challenges that can impede progress. However, various strategies can be employed to overcome these challenges, and these strategies can be grouped into three categories: Policy and Governance, Partnerships and Collaboration, and Technology and Infrastructure.

In the category of Policy and Governance, cities can adopt a strong governance framework that fosters transparency, accountability, and participation of all stakeholders [1,10,41,42]. Developing flexible policies tailored to specific smart city goals and creating clear legal frameworks for data collection and sharing can also help mitigate challenges. Additionally, standardization protocols and regulatory frameworks that promote interoperability, scalability, and sustainability of smart city solutions can facilitate progress [2,16,43,83].

Partnerships and Collaboration are also critical strategies that can be employed to overcome challenges in implementing smart city initiatives. Encouraging citizen participation through innovative approaches such as participatory planning processes or other forms of community outreach [70,84–86], offering incentives to businesses to participate in the smart city initiative [41,61,80], and fostering collaboration between governments, institutions, and companies through Public–Private Partnerships (PPPs) can support the development and implementation of smart city solutions [12,45,64,80]. Investing in capacity-building programs aimed at upskilling local workforces and empowering them to participate in the development and implementation of smart city solutions can also facilitate progress.

Lastly, the category of Technology and Infrastructure is crucial for the success of smart city initiatives. Developing Open Data Platforms (ODPs) [5,14,45,53] and digital infrastructure that promote the sharing of data and enable the development of innovative solutions by various stakeholders, investing in existing infrastructure and developing new infrastructure, leveraging novel techniques such as machine learning algorithms [18,45], big data analytics [87], IoT, or cloud computing technologies, adopting an integrated, flexible, holistic, and adaptive approach to smart city planning, and using pilot projects to test and refine smart city solutions can all support the successful implementation of smart city initiatives [27,49,79].

These strategies can lead to improved quality of life, increased efficiency, sustainability, and economic development for communities. Future projects looking to implement smart city initiatives can benefit from these strategies by adopting a holistic and adaptive approach, fostering citizen participation and public–private partnerships, and leveraging innovative technologies and infrastructure to achieve their goals.

Implementing smart city initiatives requires a comprehensive approach that considers the diverse needs and perspectives of all stakeholders. Employing the strategies of Policy and Governance, Partnerships and Collaboration, and Technology and Infrastructure can help overcome challenges and lead to successful implementation. The benefits of smart city initiatives are vast, and by utilizing these strategies, cities can achieve their smart city goals and improve the lives of their citizens.

### *3.11. Major Research Findings*

Smart cities have emerged as a response to urbanization and the need for cities to become more sustainable, livable, and efficient. The adoption of smart technologies is aimed at improving the infrastructure, services, and quality of life for citizens. Several lessons have been learned that can guide future smart city initiatives.

#### 3.11.1. Collaboration Is Key

Collaboration has been identified as a key lesson learned from smart cities. Successful smart city initiatives involve partnerships and collaborations between different stakeholders, including government agencies, private sector organizations, and citizens. Collaboration is necessary to ensure that everyone is working towards the same goals and that projects are sustainable and scalable.

Partnerships between government agencies and private sector organizations can lead to the creation of innovative solutions that address the challenges faced by cities. For instance, cities can partner with technology companies to develop smart transportation solutions that improve traffic flow and reduce congestion. Collaboration with citizens can also lead to the co-creation of solutions that reflect the needs and preferences of the community. Engaging citizens through community meetings, surveys, and social media can help ensure that projects reflect the needs and preferences of the community.

#### 3.11.2. Data Are Critical

Data are a crucial component of smart cities. Collecting and analyzing digital data is necessary to make informed decisions that benefit citizens. Cities must prioritize the collection, analysis, and sharing of data to identify problems, measure progress, and make informed decisions about the allocation of resources.

Data can be used to identify the challenges faced by cities and develop solutions to address them. For instance, data can be used to identify traffic hotspots and develop smart transportation solutions that reduce congestion. Data can also be used to monitor air quality and develop solutions that reduce pollution levels.

Data are a critical component of smart cities, and it is essential for cities to prioritize the collection, analysis, and sharing of data to make informed decisions. By leveraging data from various sources, cities can optimize city services, improve public safety and security, and empower citizens with valuable information. Smart cities that prioritize data collection and analysis are better equipped to make data-driven decisions that benefit their citizens and promote overall community well-being.

#### 3.11.3. Citizen Engagement Is Critical

Citizen engagement is a critical aspect of smart cities, and it is essential for cities to prioritize initiatives that involve residents in decision-making processes. Engaging citizens in the planning and implementation of smart city initiatives can help ensure that these initiatives are tailored to the needs of the community and that everyone's voice is heard.

One way to promote citizen engagement in smart cities is through community meetings and forums. These meetings can provide a platform for residents to share their ideas and concerns, as well as discuss potential solutions to community issues. Community meetings can also help build trust between residents and city officials, which is crucial for the success of any smart city initiative.

Another way to engage citizens in smart city initiatives is through surveys and feedback mechanisms. These tools can provide valuable insights into the needs and priorities of residents, helping cities to tailor their initiatives to the community's needs. Surveys can also help measure the effectiveness of smart city initiatives, allowing cities to make data-driven decisions on future initiatives.

Social media is another powerful tool for citizen engagement in smart cities. By leveraging social media platforms, cities can reach a broader audience and facilitate two-way communication with residents. Social media can also be used to share information on upcoming smart city initiatives, as well as to collect feedback and opinions from residents.

Citizen engagement is crucial for the success of smart city initiatives. Engaging residents in the planning and implementation of these initiatives can help ensure that they are tailored to the needs of the community and that everyone's voice is heard. Community meetings, surveys, feedback mechanisms, and social media are all valuable tools that can be used to promote citizen engagement in smart cities. By prioritizing citizen engagement, cities can build more livable and sustainable communities that work for everyone.

#### 3.11.4. Sustainability Is Important

Sustainability has emerged as an important consideration for smart cities. Cities must prioritize sustainable initiatives to ensure that they are environmentally friendly and reduce their carbon footprint. This can include initiatives such as green buildings, renewable energy sources, and sustainable transportation options.

Sustainable initiatives can also lead to cost savings for cities and citizens. For instance, the implementation of energy-efficient technologies can lead to reduced energy bills for citizens and reduce the operating costs of public facilities. Sustainable initiatives can also improve the quality of life for citizens by reducing pollution levels and promoting healthier lifestyles.

3.11.5. Technology Is Not a Silver Bullet

While technology is undoubtedly a crucial component of smart cities, it is important to recognize that it is not a silver bullet that can solve all urban problems. Cities must balance their technological solutions with other considerations, such as budget constraints, citizen privacy, and cybersecurity concerns.

Firstly, while investing in new technologies may seem like the obvious solution to many urban problems, it can be expensive. Cities must be mindful of their budget constraints and prioritize investments that offer the greatest return on investment. Additionally, investing in new technologies must be performed strategically to avoid creating new problems, such as increasing the digital divide between different segments of the population.

Secondly, privacy concerns are a significant consideration when it comes to adopting new technologies. Many smart city technologies rely on data collection, which can pose a risk to citizen privacy if not managed appropriately. Cities must have strong data privacy policies and security protocols in place to protect the data of their citizens.

Finally, the adoption of new technologies also poses cybersecurity concerns. Cities must ensure that their technologies are secure and that appropriate measures are in place to prevent cyber-attacks. A security breach could have disastrous consequences, including exposing sensitive citizen data or disrupting critical infrastructure.

While technology is an important tool for addressing many urban challenges, it is not a panacea. Cities must take a holistic approach, balancing their technological solutions with other considerations such as budget, citizen privacy, and cybersecurity concerns. By adopting a comprehensive approach that takes into account the full range of urban challenges, cities can create smart city initiatives that are both effective and sustainable over the long term.

3.11.6. Smart Cities Are Ongoing Processes

It is important to note that creating a smart city is an ongoing process that requires continuous evaluation and improvement. Cities must remain open to feedback and be willing to adapt their strategies as necessary to ensure that their initiatives remain relevant and effective. As technology continues to evolve at a rapid pace, smart cities must stay up to date with the latest advancements to ensure that they are maximizing the potential of these technologies. Additionally, cities must remain mindful of the potential ethical implications of new technologies, such as privacy concerns, and ensure that appropriate safeguards are in place to protect citizens.

Moreover, an ongoing process requires cities to engage in continuous evaluation of their initiatives. By analyzing the outcomes of their initiatives, cities can determine their effectiveness, identify areas for improvement, and make informed decisions about future smart city projects. This evaluation process should involve input from all stakeholders, including citizens, private sector organizations, and government agencies, to ensure that the needs and preferences of all parties are taken into account.

The ongoing nature of smart city projects underscores the need for flexibility, adaptability, and continuous evaluation. Cities that embrace these principles are more likely to create sustainable, livable communities that benefit all citizens. Smart cities represent an exciting opportunity to address many of the challenges facing modern urban areas, and it is critical that cities remain committed to an ongoing process of collaboration, data collection and analysis, citizen engagement, sustainability, technology adoption, and ongoing evaluation to ensure that they realize the full potential of these initiatives.

## 4. Comparison with Previous Smart Cities Literature Searches

We found four published literature surveys. Table 4 provides a comparison of the four survey papers. Two of the papers used data analysis techniques, one used a systematic review, and one used a non-systematic review. Our paper is a structured literature search with 10 research questions. After obtaining the answers to our research questions, we also used data analysis to create the figures in this paper. Web of Science was used on three of the papers, and Google Scholar on one. Our search period, from 2012 to May 2023, is more recent. Our research sources were the Web of Science and Google Scholar. The major difference between our paper and the four literature surveys is the research focus. Anthopoulos [88] focused on schools of thought, organizations that deal with smart cities, and discovering alternative approaches, models, architectures, and frameworks. Winkowska, J., Szpilko, D. and Pejić, S. [89] sought to identify smart city areas of research. Camero, A. and Alba, E. [90] explored the computer science and information technology smart city literature using data analysis. Laufs, J., Borrion, H. and Bradford, B. [91] sought to explore new smart city security challenges.

**Table 4.** Previous Smart City Literature Reviews.

| Paper Comparison Factor | Anthopoulos [88] | Winkowska, J., Szpilko, D. and Pejić, S. [89] | Camero, A. and Alba, E. [90] | Laufs, J., Borrion, H. and Bradford, B. [91] |
|---|---|---|---|---|
| Year Published | 2015 | 2019 | 2019 | 2020 |
| Type of Literature Review | 32 International Journals, "non-systematic search" | bibliometric analysis using Visualization of Similarities | analysis of all CS/IT publications on smart city, using data analysis techniques. | systematic review |
| Focus | Smart city domain | Smart city concept | Smart city and information technology | Security and smart city |
| Research Sources | SCOPUS, Science Direct, Google Scholar 1998 to 2014 | Scopus and Web of Science, January 2009 to May 2019 | Web of Science, to 1997 to October 2017 | Scopus, Web of Science, Proquest, Zetoc, Technology specific databases: IEEE Xplore, ACM Digital Library and Grey Literature Databases: British Library EThOS; Open Grey 2009–2018 |
| Research focus | "discover and classify the particular schools of thought, universities and research centres, and companies that deal with smart city domain and discover alternative approaches, models, architecture and frameworks" | 'identify the areas of research analysed in the international literature in the field of smart cities.' | "explores the computer science and information technology literature about Smart City" | "explores the recent literature concerned with new 'smart city' security technologies" |

Our research contribution is the insights we provide for the ten research questions. Questions one, three, and eight are included in some of the four surveys. We provide updated information on these questions and propose a new definition for smart cities. Our primary contributions are insights from the other seven questions. We compare the advocated and achieved benefits and costs. We identify quantitative techniques and metrics used to assess smart cities. We summarize the advantages and disadvantages of smart cities. Finally, we describe the root causes of smart city implementation challenges and identify how the challenges are being overcome.

## 5. Conclusions

Our research has several limitations, including the research questions, the search engines used, the selection of keywords, the time spent on the survey, and the experience and expertise of the authors in assessing the results. We have tried to write our findings to be clear and concise. For example, we only included six major metrics. In addition, we did not describe the evolution of concepts and current trends.

We have explored the current state of smart cities, their applications, and the challenges involved in their implementation. Through analysis of the research questions, we have discovered that there is a growing trend toward the adoption of smart technologies by cities, with a focus on improving citizen engagement, sustainability, and efficiency. However, there are also significant challenges involved, including budget allocation, quantitative analysis, and project prioritization.

Section 3.11 provides the major research findings. This literature survey emphasizes the importance of collaboration, data, citizen engagement, sustainability, technology, and ongoing evaluation in successful smart city initiatives. These lessons provide a framework for cities to create sustainable, livable, and efficient communities that prioritize the needs and preferences of citizens. As urbanization continues to grow, it is imperative that cities adopt smart technologies and embrace the lessons learned to create a brighter, more sustainable future for all.

Future research could focus on strategies for overcoming the challenges involved in smart city implementation, as well as ways to measure and compare the benefits and costs of these initiatives.

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