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Hybrid Approach for Developing Strategic ICT Framework for Smart Cities—A Case Study of Dubai's Toll Gates (Salik)

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Abstract: Information and communication technologies (ICT), systems, and people are driving innovative approaches and actions to address issues such as urbanization, demographic change, and carbon footprints of cities. Current research on smart city technologies is typically focused on the areas of technology and applications. As a result, a holistic strategic framework is lacking, as partner organizations often fail to adopt and comply with the necessary interoperability standards, which can undermine the effective and rapid roll-out and transformation of smart city project strategies. This study aims to develop an ICT framework on the determinants of smart city adoption that is developed to help society and policymakers achieve the goals pursued under the smart city initiative, such as maximizing synergies between different ICT infrastructure activities and avoiding large-scale investments without increasing their potential or focusing on short-term solutions without considering long-term needs. Based on data from the literature review and expert interviews, combined with a case study of the United Arab Emirates, this paper identifies the relevant determinants, which are conceptually grouped into seven basic dimensions. For each of these dimensions, relevant subdimensions are specified. The framework was developed and validated through three methods: interviews with experts, a desktop study of 62 smart cities, and finally a case study of the Salik system in Dubai based on the concept of the framework. By identifying key adoption determinants, the framework provides a useful analytical perspective for policymakers and researchers involved in the strategic feasibility roll-out and transformation of smart cities.

Keywords: smart cities; ICT framework; digital transformation; desktop research

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1. Introduction

Recently, several researchers, policymakers, public and private entities, and standardization institutions have put significant effort into putting the smart city concept into play. Indeed, the smart city concept aims to provide users with many services that touch every aspect of their lives, including health, transportation, homes, and education. Moreover, several emerging issues have pushed cities to become smarter by introducing simple approaches and innovative actions to solve problems associated with urbanization, demographic change, and carbon footprint. In 2018, the population living in urban areas was large. It increased continuously compared with the percentage of people living in rural areas. Specifically, the percentage of the population living in urban areas was 55% in 2018, while it was 30% in 1950. Furthermore, this figure is forecasted to increase to 68% of the world's population [1].

The smart city concept has a wide range of interpretations. These interpretations vary according to the researcher's point of view. This concept might be seen by an ICT sector researcher in terms of implementing technologies that facilitate the achievement of the smart city concept. For example, several buzz words in ICT are commonly used

when implementing the smart city concept, for example, Digital Twins, the Metaverse, Digital transformation, the Internet of Things (IoT), Ubiquitous computing, and many others. For public offices, such as commune administrations, the focus goes beyond the enabling technologies, as they see all ICT systems as tools to perform a certain set of tasks. Therefore, they might pay particular attention to the integration process of such a system into their already existing system and determining how to manage the resulting combination. Moreover, a management researcher might be more concerned about the effects of building, running, and maintaining a smart city. It is appropriate to mention that this paper focuses on the fundamental role of ICT in linking and providing city-wide services.

Automation is discussed in two aspects: the application level and the impact of intelligent information technology [2]. Using the modern technological perspective, "intelligence" denotes a computer-programmed or directed process in which there is some degree of intelligent self-regulation or automated action. Smart machines might take over a smart city's ecosystem. Smart machines equipped with enough intelligence, e.g., sophisticated wireless sensor networks and artificial intelligence models, can accomplish tasks more accurately, rapidly, and reliably than humans. For example, an operations center integrated and operated by IBM in Rio Janeiro is being set up to send text messages about flood mitigation to various city departments and to predict rainfall more accurately than normal weather forecasting systems can. These operation centers will allow cities to respond quickly and efficiently using information about city departments and will aid in the prediction of problems and the mitigation of the impact of situations. More advanced intelligent machines may use algorithms or protocols (such as system dynamics) to model and communicate strategic predictions [3]. Some researchers commented that a "weak human + machine + better process was superior to a strong computer alone, and more remarkably, superior to a strong human + machine + inferior process".

There is a growing belief that smart machines and humans must be used in combination. It has been reported that the most beneficial and productive firms have reinvented and modernized information flows, decision rights, and additional organizational capital to obtain the most value from technology infrastructure. They have re-engineered their business processes to adopt new ICT technologies and digital transformation techniques [2]. One of the most important features of automated processes is that smart machines are required to generate a large amount of data about creative and administrative activities. The generated data supporting organizational operations also include certain domains that play important roles in human–machine integration, such as reasoning, social and emotional intelligence, intuition, creativity, and improvisation [4,5]. From this perspective, several basic technologies can be used to develop smart cities with urban functions. However, associated with the human facet of the process, smart cities can bring unique benefits. Viewing cities as smart cities involves a common management system that allows leaders to coordinate smart systems and has smart governance [6]. According to the Open Cities project, a network for smart cities, the "smart city" concept combines all of the characteristics of modern cities related to organizational change and technological, economic, and social development [7].

Various smart city pilot and trial initiatives have ignored the need for community engagement with the government when creating their processes. These initiatives could have negative consequences if implemented on a larger scale [8]. Moreover, a lack of funds is the biggest obstacle to the development of smart cities. However, research shows that investment in human capital development can contribute to the successful adoption of smart cities [9]. Many researchers have criticized the authenticity of the smart city term and prefer to use the term "urban classification phenomenon" [10]. Therefore, the definition of a smart city is still vague and loose, leading to self-promotion, interest, and undisclosed assumptions. Smart cities are prone to massive failures, despite the need for greater automation and connectivity, as a single mistake can disrupt an entire city system [10]. Many open issues should be tackled before the world witnesses the diffusion

of mega-scale smart city initiatives. For example, cyber-attacks and privacy-related issues are expected to be major threats to smart cities, especially when many electrical devices and online platforms and systems are connected.

Scholars have also identified socio-political risks related to the smart city concept. ICT is embedded in the formation of many smart cities. More attention needs to be paid to issues such as the mistrust of ICTs and how to protect citizens' privacy. Additionally, many artificial city models dehumanize citizens. Extreme levels of surveillance and control can lead to social unrest. Furthermore, business-centric approaches to smart city development can hinder citizens if they fail to be competitive [11]. Smart cities are also criticized due to signs that the benefits of the city's digital revolution are not reaching everyone. This information gap can widen cultural and social gaps by widening the gap between skilled workers, IT illiterates, and low-educated citizens wanting to move to smart cities, instead of reducing the level of inequality among citizens. The literature has also raised the issue of whether environmental sustainability and economic development are possible in the context of smart cities and to what extent they can compete [10].

This work aims to develop an ICT Strategic Framework for the Smart City (SFSC) concept. Several other related works have focused on the evolution process of converting a city into a smart city or the evolution of a smart city into a much smarter city. More specifically, this study aimed to deliver a three-tiered framework of a cooperative and reliable system of systems that is able to handle dynamic and complex situations by including technologies and methods to enable cooperation among all city-related systems, leading to the development of a successful smart city. SFSC leverages an innovative three-view model, containing a Technology View, Systems View, and Strategic View, to promote the integration of these view types and to enable the creation of a new smart city that can support cooperation among the city stakeholders and operate in different vertical domains integrating heterogeneous, mass-market, and horizontal technologies and services, as well as people.

This research focused on ICT as a significant tangible enabler for smart city plans and initiatives across the globe as per the European Smart City Project. This study also aimed to create a holistic strategic ICT framework or model to serve as a planning tool for policymakers, planners, and implementers of smart city initiatives in smart cities. The paper discusses the validity of the proposed SFSC framework for fostering the diffusion of a successful smart city transformation in general. The framework was verified by three different methods, expert interviews to give a speculative understanding of smart cities, desktop research performed for sixty-two smart cities, and finally, a case study of the Dubai Salik system that was selected and applied against the SFSC concept. The researchers recognized the gap between the concept of a smart city developed by researchers and academicians and the city initiatives implemented by practitioners and experts (e.g., learning by doing) to create the proposed framework by incorporating the lessons learned from practitioners related to a smart city.

This study contributes to the conceptual and theoretical body of research on smart cities through four different aspects:

1. This study analyzes several project efforts and technologies that support the ultimate implementation goals of smart cities to identify key features (both technical and non-technical) and to provide a framework for effective planning and implementation of smart cities.
2. This study develops a conceptual framework for the deployment of smart cities. With the development of new technological advances focused on information and communication technologies, the concept of "smart cities" is emerging as a way to generate more efficient and sustainable cities.
3. To test and validate the suggested framework, this paper offers a case study from the Dubai Smart City/Salik toll gates to illustrate the applicability of the proposed framework developed. The main scenarios, projects, practices, and technologies of the smart city initiative are considered and identified.

4. To achieve its findings, this study designed and used a hybrid research methodology that collected data from various sources and then consolidated each data analysis technique into a holistic approach.

The rest of this paper is organized as follows. Section 1 introduces the importance of the SFSC conceptual framework for smart cities. Section 2 provides a literature review disclosing the lack of a generally accepted structured model or framework to study the role of ICT in smart cities. In addition, a summary of similar research papers/projects is presented, grouped into four different sections based on the adapted smart city concept and the required characteristics. Section 3 presents the research methodology used in this study, focusing on the collection and analysis of the research data. Section 4 presents the results of the study. Section 5 validates the proposed framework through a case study of the Salik toll booth application. Section 6 discusses the implications of the developed framework for research and practice. Finally, Section 8 concludes the paper and suggests future directions to enhance the proposed framework.

2. Literature Review

Neirotti et al. [11] introduced an important classification of the six most common application domains (along with each domain objective) that attract the most investments in smart city initiatives. According to this research and many others, ICT systems represent the enabling technologies in almost all six application domains. In addition, in [12], it is concluded that this method of classification lacks a clear, comprehensive vision of the ICT technology used in smart cities; indeed, a smart city is a system in which several levels and layers should be clearly well-defined, integrated, and interoperated. This is a serious issue, and as estimated in [12], "... Technology spending on smart city initiatives worldwide is forecast to more than double between 2018 and 2023, increasing from 81 billion US dollars in 2018 to 189.5 billion in 2023". The formation of a holistic vision of ICT technology in the smart city context will provide valuable guidelines for policymakers and city-wide planners. This important tool will facilitate the diffusion of smart cities worldwide. Many smart solutions related to smart cities and their applications have been proposed in [13,14].

Generally, the strategic role of ICT systems has attracted major global technology providers, such as IBM, Cisco, and Siemens. For example, in [3], IBM defines a smart city as a "system of systems" where ICT systems are the city's digital nervous systems that collect data from heterogeneous sources composing the city's infrastructure. Furthermore, ref. [3] stresses the role of ICT in enabling city planners and leaders to determine how these systems run, inter-relate, and communicate information to enable improved decision making. Thus, IBM has foreseen and customized solutions for smart cities for many city sectors and roles, including energy/utilities, retail, airports, transportation, healthcare, social services, education, communications, public safety, and economic development. IBM concluded that a smart city depends heavily on integrated technological solutions for sustainable urban infrastructure; such a conclusion stresses that it is necessary to develop a tool to facilitate the ability of city leaders and planners to determine how these ICT systems operate [3].

2.1. Smart City Concepts Related Work

This subsection summarizes several academic contributions related to smart city concepts. The summary aims to categorize related works into four groups based on high-level definitions, applications, and features of a smart city. Each part ends with a comprehensive comparison with the proposed work.

First Definition: Smart cities emphasize the use of ICT for automation and intelligence roles and activities and use their intelligence to organize and reorganize processes and data. The smart city design extends beyond community contributions to superior urban networks associated with city management and governance, where cities learn from each other's best practices and turn that wisdom into innovative applications [15]. Learning and relearning experiences involves the ability to measure performance, particularly through

defined metrics or key performance indicators based on the city's goals, initiatives, and objectives. The "Smart Cities Wheel" themes and pillars were developed with a focus on more than 100 indicators grouped into six comprehensive pillars: Smart Economy, Smart Environment, Smart Governance, Smart Living, Smart Mobility, and Smart People [15]. The goal was to develop a common language between citizens, city officials, the market, and the private sector and to describe interconnected processes for managing, monitoring, and utilizing collected data for future modeling and design.

Second Definition: Smart cities think, learn, and adapt through smart networks, systems, and sensors using measurements, monitoring processes, and feedback for performance management, learning, and growth. In this definition, a smart city is more than an intelligent machine concerned with applying functions to management [16]. For instance, previous research [11] has defined self-proclaimed smart cities by pointing out that ICT plays a limited role in changing the transformative potential of cities without human capital and the balance of power between governments, institutions, businesses, and communities. Other researchers [17] are against engineering-focused top-down visions of smart cities, where tech bureaucrats may consider some ICT and data-rich models in places such as China or Singapore to give them more control over how they operate cities. Smart cities work with governments and industries to embrace larger-scale innovation processes that are more social and inclusive. Researchers have warned of car-based cities that could overwhelm the social interests of those who already live in effective inclusion. Based on this definition, a smart strategy should focus on the intelligence of its inhabitants rather than on "a single city for" [18]. This definition also sees citizens as "creators of ideas, services, and solutions, rather than being beneficiaries", cities should encourage and facilitate civic efforts by making data publicly available. As such, the need for cities to engage with their communities should be emphasized. It also refers to leadership/governance, innovation forums, and network/community organizations as essential elements of the soft infrastructure of smart cities [18].

Third Definition: Smart cities include institutions, communities, businesses, research and education institutions, citizens, and others as partners in a framework that encourages and enables innovation and change. This definition includes collaborative processes between participating government departments. The authors of [19] expanded the definition of a smart city beyond the environmentally sustainable agenda of infrastructure and liveability to consider economic sustainability based on "economic fundamentals" [19]. An analysis of the performance of 70 European cities showed that cities are forced to focus on capital stocks (i.e., human, social, and physical infrastructure) [20]. Another study examined the business models of two smart German cities and their use of technology to provide or improve city services [18]. This analysis showed that the design of critical information architectures based on city technology assets and capabilities plays a significant role in determining how cities develop and innovate or improve city business processes. The point of observations is to monitor the performance of smart applications and the return on investment (ROI) of these smart applications according to the technical capabilities and resources of the city. They are the key to modeling and layering intelligent applications. This definition also covers organizations and governance (e.g., city capacity, available resources, etc.), partnerships between governments, institutions, companies, and communities (e.g., business models for smart applications, funding, implementation models, etc.), as well as the use of metrics to help measure business performance.

Fourth Definition Smart cities recognize human, social, and physical capital and invest in smart technologies and capabilities that deliver better economic, social, and environmental benefits. It is argued that a culture of innovation, learning, and partnerships between city components is essential to meet the needs or aspirations of smart cities [11]. In addition, population diversity is necessary to revitalize communities and increase knowledge exchange between citizens. Encouraging and retaining these types of citizens is often difficult because outdated public policies and organizational structures require restructuring.

2.2. Related Work Discussion

From this discussion, it is not difficult to foresee the urgent and important need for new a ICT framework for cities to optimize their resources and provide a good and sustainable lifestyle for their citizens. "How do you create a 'smart city'?" is the next immediate question that comes to mind. Smart cities provide information and communication technologies (ICTs) and the Internet of Things (IoT) aim to improve the quality of life of citizens and stakeholders [21]. IoT-based systems are built using a variety of sensors that help collect data and share them with other connected devices. This allows such connected devices to operate autonomously, creating a "smart" ecosystem. A set of sensors (temperature, pressure, proximity, etc.) and networked systems allows nodes to exchange information jointly to improve overall efficiency and functionality [22]. The IoT is an emerging and rapidly growing field. This is especially important now because it helps you connect objects. You can control your device through the power of the internet. Remote monitoring of data and critical processes. This makes it unique. There are discounts for private and public institutions in smart cities' ecosystems [23]. The main purpose of the IoT is to provide end-to-end connections to systems, devices, services, and machines to machine (M2M) communication for process optimization and automation from a smart city perspective [24]. A new generation of technology, especially new ICTs, brings a new stage of technological revolution and industry transformation. The Smart Cities Project currently features cloud computing, big data, artificial intelligence, information, and communications. These technologies are also widely used in smart cities. New ICT advancements are key drivers for "people-centered" national development and an "innovation, coordinated, green, openness and sharing" philosophy; a new era of smart city construction is in full swing in the world. How to use new ICTs to enable smart city ICT infrastructure and other smart systems for smart urban implementation has now become a field of research [1,2]. This article describes the new smart ICT framework for the basis of a new ICT-based smart city infrastructure. The research combines works mentioned in initiatives, projects, practices, and technologies about smart cities. Surveying all these works is mandatory to understand the landscape of smart city ICT infrastructure requirements. To the best of our knowledge, this combined framework is not reported in any related research in the field of smart cities. Understanding the concepts and combining them is the first step toward understanding the complexity of smart cities "people-centered".

3. Research Methodology

To develop a holistic SFSC conceptual framework, we used a mixed methodology approach, shown in Figure 1, wherein several data source collection methods were used. Indeed, three data sources were used as follows:

(1) A detailed literature review was conducted aiming at summarizing main research papers addressing smart city applications, technologies, underlining theories, and research frameworks conceptualizing this concept.
(2) A review of fifty-two smart city initiatives, wherein five major cities were shortlisted with the objective of summarizing smart city initiatives and their underlying technologies and applications. These initiatives were mainly supported by prominent technology providers, which put more focus on their technologies and systems and neglected any conceptual framing of the smart city implementation.
(3) A survey of smart city decision makers who gave valuable input with regards to applications, technologies, and citizen perception of any smart city application initiative and implementation.

These data collection methods were used to conduct two main research methodologies, namely:

(1) Desktop research: In order to analyze smart city research papers, as well as technical reports of smart city initiatives mainly provided by several technology providers.

(2) Qualitative research: In order to analyze city planners' interviews then draw respective results.

Once data collected from hereinabove sources, the data analysis step allowed us to draw results that are adequately structured in the form of a consolidated SFSC conceptual framework for smart city implementation. Indeed, results extracted from these two research methodologies were consolidated in a framework for smart city implementation, which constitutes our main contribution in this research.

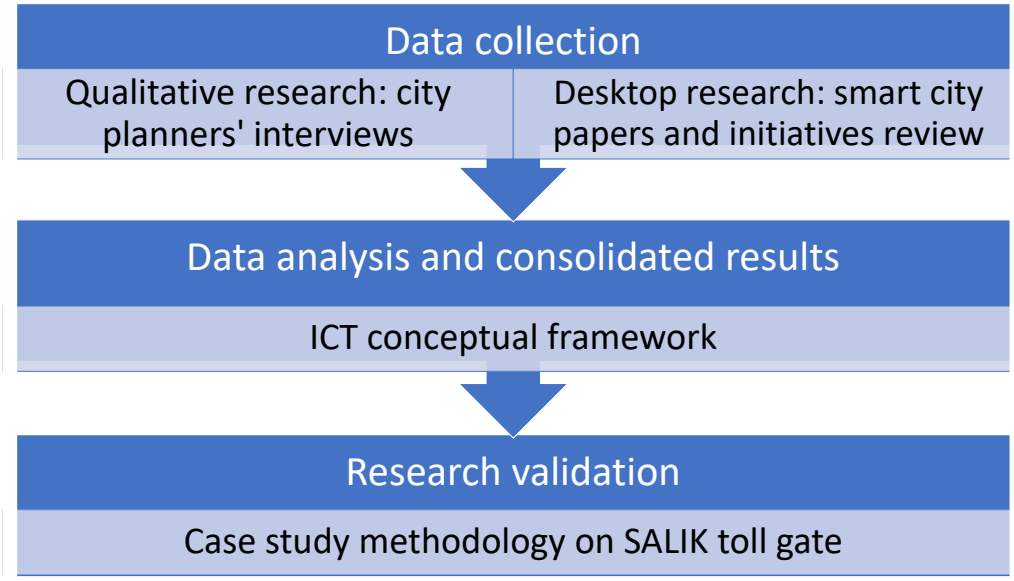

Figure 1. Mixed Research Methodology.

Finally, a case study methodology was used in order to validate the proposed framework. Indeed, due to geographical convenience and the researchers' good understanding of what is being implemented in Dubai, we concluded that, in the area of validation, significant attention is being paid to Dubai Salik. Dubai Salik was investigated as a case study of a real-life example of running a smart solution that serves the public using the latest technologies, such as RFID, and more importantly, a massively deployed product that touches the everyday lives of Dubai's inhabitants. Talking to experts in the exploratory phase of a project is a more efficient and concentrated method for gathering data than, for instance, selecting four experts through a participatory observation process. Conducting expert interviews can shorten time-consuming data gathering processes. In this study, the selected experts were seen as "experts" of practical insider knowledge and were interviewed interdependently to answer a set of questions. Details of the questions are discussed in the following sections. Expert interviews are also appropriate for situations where it might prove difficult or impossible to gain access to a particular smart city. For data collection, data can be collected from a variety of sources in this type of research. Analysts may communicate their requirements to the custodians of the data, such as information technology personnel within an organization. The data may also be collected from environmental sensors, such as traffic cameras, satellites, recording devices, etc. They may also be obtained through interviews.

4. Data Collection and Analysis

Data were primarily collected through three sources, namely (1) exploratory interviews, (2) a theoretical understanding of smart cities through research papers, and (3) desktop research conducted on 62 smart cities. The researchers identified a gap between how researchers and academics conceptualize smart cities and how practitioners align lessons learned from smart city practitioners to implement city initiatives (learning by doing) to generate the proposed framework. Indeed, we used desktop research for summa-

rizing research dealing with smart city applications and initiatives. Additionally, we used qualitative research to analyze interviews of city planners. In the following, we present the adopted research methodologies to collect and analyze the data.

4.1. Desktop Research

Several major smart city initiatives were used to assess urban planners' conceptualization/implementation of smart cities, including ICT implementation and engagement with technology providers. Research also relied on secondary data sources, including news articles, government websites, blog articles, city reports, and presentations. Many of these data sources are non-academic, so they can provide different perspectives and analyses of city efforts. Research on cities was conducted through desktop research conducted by technology providers and "Smart City" reports from City News. This list is not exhaustive and is expected to expand according to the requirements of information and communication technology use, as well as the addition of new technologies as an integral part of urban plans. There seems to be widespread and varied beliefs regarding "smart cities" worldwide. They all share a common theme, whereby there is widespread use of ICTs and new technologies in various applications. A second observation is that smart cities are at different stages of development. Several cities (such as Rio de Janeiro, Amsterdam, Santander, Oulu, Stockholm, Singapore, etc.) have already implemented current solutions. Meanwhile, a larger set appears to be in the conceptual or development stage. Third, almost one-third of these cities have reported collaboration with major global technology providers, such as IBM, Cisco, or Siemens. On the other hand, some cities have teamed up at the local or regional level with technology providers and research institutions as strategic partners. The technology providers for many other cities are not yet known, and more research is needed to determine how these cities are becoming smarter. The highlights of the 62 smart city initiatives:

1. There are three main providers of smart city technologies: Cisco, IBM, and Siemens.
2. Technology providers offer multiple solutions for intelligent urban transport, business, etc., to serve different areas of the city.
3. The smart city initiative includes several technological components, such as NFC (near-field communication), smart management, data and analytics, smart cards, the Internet of Things, and RFID. Cross-domain integration of RFID, wireless sensor networks, and network integration technologies with existing government websites and cloud computing is conducted.
   The use of technology for urban planning and city management is not new. However, the emergence of the "smart city" mode can be attributed to the increasing classification of urban efforts as "smart", the increasing use of widely available ICTs, and the efforts of technology providers to integrate these cities into "smart themes". This search was compiled by researchers using key data sources from 2014:
4. City websites and news reports.
5. Smart and Connected Communities Institute, 2012, Smart Cities Expose: 10 Cities in Transition.
6. ABI Research: Role of smart cities for economic development. New York: ABI Research. 2018. Research Report.
7. Pike Research, 2011, Smart Cities: Intelligent Information and Communications Technology Infrastructure in the Government, Buildings, Transport, and Utility Domains. Research Report 88 pages.
8. Wikipedia, 2022, Smart City. en.wikipedia.org/wiki/Smartcity, retrieved 20 July 2022.

The researchers selected five smart cities as samples of the sixty-two smart cities (the entire population). These cities were selected due to the availability of information related to the study. The intention was to obtain more information about the reported initiatives. Additionally, the samples were selected based on the key selection criteria formed by the researcher and derived from diverse perspectives and contexts, considering that the selected cities differed in terms of their scales/sizes, their backgrounds of governance, modes of city

planning, management and operations, geographical location, etc. The selection criteria applied were as follows:

- Relevance of possible application in ICT solutions for city planning and services offered to citizens: The broad nature of planning encompasses fields as wide-ranging as transportation and infrastructure planning to community engagement and citizen participation. The selection criteria were used to assess how the use of ICT or new technologies may be relevant or may be extended to applications for city planning.
- Real initiatives: The second criterion in this research was to select cities already implementing smart city initiatives to report on the range of "smart" initiatives available. This was to performed to allow a better understanding of the challenges or issues faced by city planners as well as the functional or organizational issues that have arisen during implementation of the strategic ICT framework, for example, cities with initiatives identified in partnership with technology providers were considered.
- Scope of application and initiatives: Cities with various initiatives in various fields were preferred, as having a variety of applications imitates the concept of being "smart".
- Diversity of political and socio-economic contexts: Cities with various political and socio-economic contexts were selected to assess how city planners' perceptions or conceptualizations of "smart cities" might vary or be related across different contexts.
- Diverse technology providers: Finally, cities collaborating with diverse technology providers were selected to provide a wider insight into city planners' perceptions or conceptualizations of "smart cities". Cities partnered with many technology providers were deemed to be healthier than cities relying on one technology provider. The five selected smart cities were Dubai, UAE; San Francisco, USA; Stockholm, Sweden; Singapore; and Amsterdam, The Netherlands.

Out of the five cities, the researchers chose to give the case of Dubai more concentration and focus.

4.2. Qualitative Research: City Planners Interviews

On 5 March 2014, a transformation strategy was announced to transform Dubai into a "smart city" by the Dubai government. This was entitled the Dubai Plan 2021. The strategy is based on six key pillars and 100 initiatives regarding infrastructure, communications, electricity, transport, financial services, and urban planning. Under the strategy, 1000 government services would transform into smart services over a three-year period. In 2016, the ITU considered Dubai to be an important case study from which concepts could be applied by other cities as part of their transformation into smart cities [25]. The researchers noted that Dubai's smart concept is to provide all services through smart devices. An example of a "smart" initiative is the Salik Toll Gate System transport initiative. Salik is an initiative of the Dubai Roads and Transport Authority. The solution is based on RFID technology, whereby RFID tags are used to identify vehicles crossing toll roads.

A common theme was found among most of the interviewees. Most of them projected that, in the next few years, there will be significant shifts and trends in society, technology, the environment, and politics initiated by cities deciding to transform into smart cities. The interviewer informed all of the interviewees about his academic research and asked whether they were willing to aid in the proposition of a strategic ICT framework for smart cities. Most of the interviewees showed an interest in developing a comprehensive strategic ICT framework or model. Each interviewee responded to the researchers' conversation according to their perceptions of smart cities. All interviews were conducted in a conversational tone. Foundation questions were formulated by the researchers. These questions were used as a starting point for discussing the research goals and objectives. Below are the questions formulated by the researchers:

- What is a smart city, and what are your perceptions about smart cities?
- Do smart city initiatives need a strategic ICT model to be followed?
- What are the emerging ICT technologies in the context of smart cities?
- What is the ICT infrastructure required for smart cities?

- How do we sustain smart cities and optimize their ICT resources?
- What are the types of security and governance required to protect the smart city ecosystem?

There is a large body of data in the context of a smart city; how can these data be used and presented to provide continuous improvement and radical openness? The researchers formulated some foundation questions to serve as a starting point for discussing the research goals and objectives.

Interviewees Profiles

This section presents brief information about the profiles of the persons interviewed (Table 1).

Table 1. Interviewees' Profiles.

Interviewee	Position	Organization Type
# 1	IT Strategy Director	Government
# 2	Excellence Advisor	Government
# 3	IT Manager	Government
# 4	Public Advisor	Multinational

4.3. Data Analysis

Descriptive statistics is the most commonly used qualitative method in information systems [26]. The reason for selecting this strategy was that this is an empirical study (qualitative), and more data need to be gathered by people serving in the smart city field to build the proposed research framework. For the sake of analyzing the collected data, a thorough study was conducted in order to review and summarize 62 smart city initiatives; these 62 initiatives were selected due to the availability of the information related to the study. Studying the said 62 initiatives enabled the researchers to answer three relevant questions:

- Who are the leading smart city technology providers?
- What are the main solutions of the technology providers?
- What are the main technological components relevant to smart city solutions?

The above study facilitated the setting up of the following five criteria to narrow the focus into a smaller number of initiatives: (1) the relevance of possible applications of ICT solutions in city planning and services offered to citizens; (2) real initiatives—the reported range of "smart" initiatives; (3) the scope of application and initiatives; (4) the diversity of political and socioeconomic contexts; and (5) the diverse technology providers. Additional explanations of these criteria are presented in the following sections. When applying these criteria, the researchers narrowed the focus of this work to only five smart cities: Dubai, UAE; San Francisco, USA; Stockholm, Sweden; Singapore; and Amsterdam; The Netherlands.

4.4. Using Frequency Analysis

Descriptive statistics are commonly used to summarize data frequency or central trend measures (mean, median, and mode). Frequency analysis indicates a response to each respondent selected by the respondent in a statistically described way. Using frequency analysis, Software Statistics calculates means, medians, and modes to analyze results and draw conclusions. Researchers used a frequency analysis to assess the list of articles found when acquiring data and literature research. With weak, medium, and high scales, the researchers built the proposed model by evaluating the occurrence of elements that have been found in office surveys, interviews, and research in the literature. Frequency distribution is a simple data analysis technology that offers a data overview. A frequency distribution is a table that shows the number of people or points in each category (see table below). A frequency distribution makes it possible to determine the frequency to which a

certain value or percentage for a variable is observed. A frequency distribution shows the number of observations of a particular variable for a particular technique. Histogram and bar chart types are available for this analysis.

5. Results

This section combines the results extracted from smart city initiatives/ research as well as results of the city planners' interviews analysis. A consolidated analysis of identified items from both results are presented, which led to propose a conceptual framework that integrates all the results.

5.1. Key Findings from Smart City Initiatives

Table 2 lists all the themes and applications for each type of ICT from the data analysis phase.

Table 2. Key Findings from Smart City Initiatives.

Technologies Used	Smart City Fields	City
Artificial Intelligence	Smart Government	Dubai
Blockchain	Smart Government	Dubai
Geospatial Technology	Transportation	Dubai
Autonomous vehicles	Transportation	Dubai
Smart Grid	Energy	Dubai
Industry 4.0	Transports, Logistics, e-Health, and Telecommunication	Dubai
Metaverse	Smart Government and Education	Dubai
RFID	Transportation	Dubai
Mobile Applications	Smart Government	Dubai
Portals and Online Services	Smart Government	Dubai
Cloud Services and Grid Computing	Education	Dubai
Mash-Ups	Environment: Energy and Waste Management	San Francisco
Portals	Economy	San Francisco
Dashboards		Public Entities and Citizens
Portals	Citizens	Stockholm
Single ICT city infrastructure technology for multiple services	Transports, Logistics, e-Health, and Telecommunication	Stockholm
Web Portals and Data Analytics	Government and Citizens' Services	Singapore
Wireless Networks	Telecommunication	Singapore
NFC	e-Payment ICT City Infrastructure	Singapore
Grid Computing	Economy	Singapore
Mobile Apps	Transportation	Singapore
Web Portals and Data Analytics	Government and Citizens' Services	Amsterdam

5.2. Consolidated Analysis of Identified Items

Observations were based on a literature review, desktop research, and an empirical study. The interview data were transcribed, documented, and analyzed. At this stage, the researchers identified a list of items that could serve as essential inputs for creating the framework. Table 3 List of identified items and Table 4 shows items rating.

Through a literature review, desk searches, and interviews, the researchers found that many ICT components, such as ICT management technologies and practices, should be grouped into strategic frameworks or smart city models, as shoun on Table 3.

Table 3. List of Technology Items.

Artificial Intelligence	lockchain	Geospatial Technology
Autonomous Vehicles	Smart Grid	Industry 4.0
Metaverse	5G	Mobile Apps
Web Portals	Trusted service manager for security and privacy in the smart city	Data and Analytics
Mash-Ups	Unified ICT Infrastructure	Investment in ICT for smart cities
NFC	Grid and Cloud Computing	Internet of Things (IoT)
RFID	Social Networks for Awareness	Augmented Reality
Governance	Dashboards	Sensor Networks and Wi-Fi

Table 4. Item Occurrence Rate Table.

No.	Element	Literature Review	Desktop Research	Interview 1	Interview 2	Interview 3	Interview 4	Occurrence Rate
1	Artificial Intelligence	X	X		X	X		H
2	Blockchain	X	X		X	X		H
3	Geospatial Technology	X	X	X		X		H
4	Autonomous vehicles		X	X		X		M
5	Smart Grid	X	X	X	X	X	X	H
6	Metaverse			X		X	X	M
7	5G	X	X	X	X	X	X	H
8	Web Portals	X	X		X	X		H
9	Mash-ups		X	X		X		M
10	NFC	X	X	X		X		H
11	RFID	X	X	X		X		H
12	Sensor and Wi-Fi Networks	X	X	X		X		H
13	Smart City Unified ICT Infrastructure	X	X	X		X		H
14	Data and Analytics	X	X		X	X		H
15	Mobile Apps		X	X	X	X		H
16	Grid and Cloud Computing	X	X	X	X	X	X	H
17	Dashboards	X	X	X		X	X	H
18	Augmented Reality		X	X				L
19	API interoperability and Systems Integration			X		X	X	M
20	Trusted Service manager for security and privacy in smart cities	X	X		X	X		H
21	Investment in ICT for smart cities	X	X	X		X	X	H
22	Internet of Things (IoT)	X	X	X		X		H
23	Social Networks for Awareness			X	X		X	M
24	Governance		X		X	X		M

5.3. *Proposed ICT Strategic Framework*

By integrating results from different types of analyses, we developed a comprehensive ICT framework for smart city implementation shown in Figure 2. The proposed framework should have several levels or layers. To ensure all components of a successful smart city are included, each layer must involve a specific type of ICT, component, or mechanism.

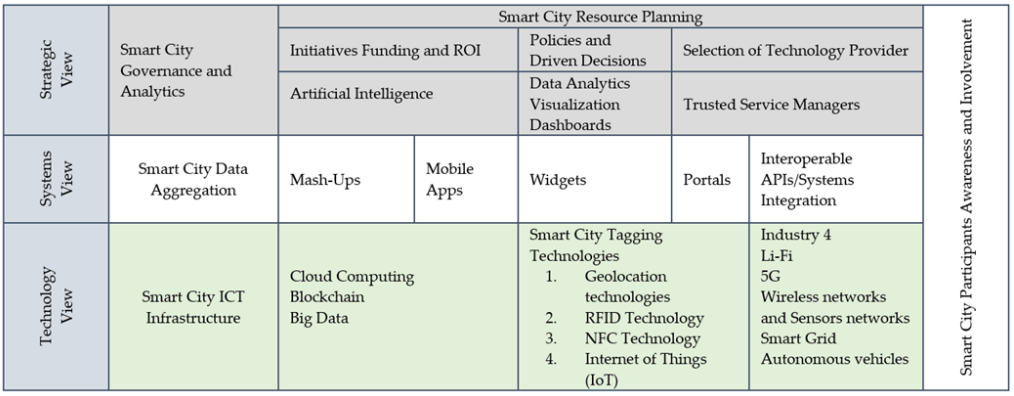

Figure 2. Strategic ICT Smart City Framework.

Smart City ICT Infrastructure (Technology View): This layer needs to be implemented and integrated into the city's existing infrastructure, along with all the necessary infrastructure. This layer maintains and outlines the smart city's connectivity model or solution. This level is the entrance point for any smart city utility or service. The components of this layer are cloud computing, RFID technology, NFC technology, the Internet of Things (IoT), and wireless and sensor network technology. *Smart City Data Aggregation (Systems View):* This is the middle layer of the proposed model. The purpose of this layer is to combine real data from different sources, capture them using different methods, such as widgets and portals, and provide additional smart applications that allow smart city participants to access the data captured in this layer. Each element of this layer is software-integrated or implemented in an object to allow real data to be captured from various sources. Integration between smart city systems is achieved by providing interoperable APIs. *Smart City Governance and Analytics (Strategic View):* The highest level of the framework (High Level) processes all of the collected data and provides them to the public and politicians. This layer is the data management and analysis layer. The Trusted Service Manager handles all aspects of participants' security, privacy, compliance, and authentication. Another important role of this level is the strategic role, where politicians can change existing policies and make decisions based on existing circumstances. Additionally, smart city technology providers are selected at this level, and investment return is calculated.

Finally, the entire model is covered by a top layer, called smart city resource planning. This section focuses on the optimization of all resources used by the framework. An important vertical support element of the system is the awareness and involvement of all participants in the smart city.

5.4. Framework's Expected Outcomes Categorized Based on the Framework Layers

The researchers highlight some of the expected outcomes of the model's implementation. The table illustrates the outcomes of different viewpoints regarding the proposed model, as shown in Table 5.

Table 5. Expected Outcomes of the Proposed ICT Strategic Framework.

Strategic View	Smart City Governance and Analytics	Overall combined strategic plan • ICT is highly optimized and used in all city domains. • Sustainability competence is built into all smart city domains. • Better decision making. • Development and continuous improvement. • Governance and security plans for the smart city.
Systems View	Smart City Data Aggregation	• Largely integrated smart city systems that provide real-time data and reporting. • Availability of data from all smart city participants in a regulated and secure manner based on the authorized level of access. • Effective high-level solutions (Fit for Purpose).
Technology View	Smart City ICT Infrastructure	• Various interface points using several technologies. • Two-way communication by implementing well-established channels among the entirety of smart city members. • Various data points capturing technologies through a unified ICT infrastructure that serves diverse smart city domains.

6. Validation of the Proposed Framework

Dubai has made great strides in smart governance and is using various technologies to extend its services to millions of Dubai residents. We have compiled a list of Dubai's most successful and cost-effective smart city initiatives. The Smart Tolling System—Salik ("clean and moving" in Arabic) is a fully automatic tolling system using ICT legislation, using tags based on Radio Frequency Identification (RFID) technology. Salik supports transport, as it encourages avoiding unnecessary road toll trips, using public transport, or carpooling to school or offices.

The researchers conducted an exploratory qualitative case study of the Dubai Salik case to understand aspects related to the formation of a smart city within the context of Dubai. A case study approach was employed for two reasons: (1) the description of a situation can be used to infer conclusions about the phenomenon under study in a general manner, and (2) a case study such as this offers something interesting, unique, or new and can provide a detailed understanding of the smarter city transformation process. The uniqueness of this case study lies in the participants chosen for this study: four expert members working in the field of smart cities on Salik. The interesting aspect of studying ICTs of this type is that they are some of the most important enablers for the diffusion of smart cities globally and were among the first to be used in smart cities in the Middle East and the United Arabs Emirates. This study adopted a thematic analysis technique. This technique deals with a reduced volume of data by organizing it into categories/themes. The transcribed data are then assigned to the identified suitable ICT.

Finally, due to geographical convenience and the researchers' good understanding of what is being implemented in Dubai, we concluded that, in the area of validation, significant attention is being paid to Dubai Salik. Dubai Salik was investigated as a case study of a real-life example of running a smart solution that serves the public using the latest technologies, such as RFID, and more importantly, a massively deployed product that touches the everyday lives of Dubai's inhabitants. Talking to experts in the exploratory phase of a project is a more efficient and concentrated method for gathering data than, for instance, selecting four experts through a participatory observation process. Conducting expert interviews can shorten time-consuming data gathering processes. In this study, the selected experts were seen as "experts" of practical insider knowledge and were interviewed interdependently to answer a set of questions. Details of the questions are discussed in the following sections. Expert interviews are also appropriate for situations where it might prove difficult or impossible to gain access to a particular smart city. For data collection, data can be collected from a variety of sources in this type of research. Analysts may communicate their requirements to the custodians of the data, such as information technology personnel within an organization. The data may also be collected from environmental sensors, such as traffic cameras, satellites, recording devices, etc. They may also be obtained through interviews.

The researchers validated the model using one of the reported initiatives presented in this research. The researcher selected an initiative called Salik (e.g., Dubai's Toll Gate System). Table 6 presented below summarizes the initiative's details.

Table 6. Details of the Salik Initiative.

	Initiative Details
Initiative Name	Salik Toll Gate System
City	Dubai
Country	United Arab Emirates
Smart City Domain	Transportation
Initiative Description	This is a toll gate system based on RFID technology that is used for vehicle recognition (RFID Tag). It contains a cloud for data storage and data processing, portals and mobile apps for data access, and has other components such as the ability to top up the balance of users' accounts and dashboards for reporting the gathered and processed data to smart city participants (in this case, the Road and Transport Authority (RTA), which is part of the Dubai government).

The following table 7 demonstrates an application of the proposed framework by mapping all of the items involved in the Dubai initiative into the proposed framework, along with the outcomes measured after implementing the model. The demonstration is a kind of conceptual validation; however, the model still needs to be tested in other smart city initiatives and other smart city domains.

Table 7. Implementation Scenario for The Proposed Framework: Strategic ICT Smart City Framework for Salik.

	Model Layers	Outcomes
Smart City Governance and Analytics (Strategic View)	• Dashboards for the top management. • Security Standards in the used RFID technology and security for the portals ensured using a secure https protocol. • Technology providers selected for the full solution. • ROI justified.	• Secure Solution Provided. • Planned the Road Capacity for future improvement and maintenance projects. • The peak time and road congestion rate are known. • Improved decision making.
Smart City Data Aggregation (Systems View)	• Portals for users to track trips, recharge their accounts, provide a list of all vehicles registered under each user's account, etc. • Payment gateway for recharging the account (integration). • Mobile apps for Android and IOS. • Integration with the Dubai Police for Salik fine payments. • Integration with the Government Resource Planning system of the Dubai government	• Overall integrated systems, which provide real-time data and reports. • Accessibility of data by all smart city participants in a controlled and secure manner, based on the authorized level of access.
Smart City ICT Infrastructure (Technology View)	• RFID Tags • Wireless Network. Cloud-Based Data Storage	• RFID for Traffic Management. • One Unified ICT infrastructure that is used by different government entities.

7. Implications

This section discusses the implication of the proposed ICT framework on smart city research and practical implementations.

7.1. Implications for Research

The findings from this study have significant research implications. First, it is evident from a growing number of real-world examples that smart city technologies and applications are rapidly expanding. However, based on the research and evaluation conducted in this study, this integration process is not yet complete, as it still faces several pending difficulties that may be addressed in future improvements. For example, there are interoperability issues due to the existence of numerous IoT protocols, formats, and frameworks [27], and this aspect is exacerbated by the fact that many smart city applications were originally developed as vertical silo applications [27,28], each with its own solution for data ingestion, storage, and utilization. Addressing the interoperability challenge can have a positive economic impact. Indeed, achieving higher levels of interoperability between devices, applications, and services requires reducing the cost of developing entirely new and different solutions for deployment [29], allowing backward compatibility through the use of legacy systems as well as incremental deployment and integration. The proposed ICT framework for smart city implementation sets the path for future research into the use, development, and integration of effective smart city implementation technologies. In reality, independent of the proposed technology vendor's smart city implementation solution, this conceptual framework provides what we need for a successful smart city implementation in terms of technology application and overall strategy.

Second, the development of a holistic ICT framework that allows the acceptance of event-driven and push protocols [27,30] opens the way not only for sensing cities but also for acting through actuators and building event-driven applications. However, most solutions described in the literature are still domain-specific, solving unique problems with little or no software reuse [27]. In contemporary IoT-based smart city systems, microservice-oriented architectural paradigms have been progressively exploited [31] to handle a wide range of IoT devices and applications. This enhances the scalability and usability of IoT frameworks, while reducing the complexity of typical service-oriented architectures (SOA) [32]. The increased scalability represents the ability to collect and

analyze an increasing amount of data for IoT-based applications. Improved scalability demonstrates the ability of IoT-based solutions to efficiently collect and process progressively larger volumes of data, which often leads to higher accuracy in data analysis and often enables real-time or near real-time processing [33].

Third, the ICT infrastructure of smart city platforms is expanding to multi-tenant, cross-organizational IoT platforms and applications. This allows the creation of large-scale infrastructures that can serve multiple enterprises, enhance scalability, and reduce infrastructure costs as they are shared by multiple operators [31]. This feature is directly related to the reuse of components in the smart city framework and attempts to coordinate and overcome the effort required to build specialized platforms for each city or specific environment, which is economically wasteful [29]. These factors imply significant social engagement, for example, in terms of security and resilience, as they enable the development of more resilient tools capable of real-time analysis and simulation, such as those used by local governments for early warning and alerting during critical events, such as disaster management [34] and resilience planning. Other possible future approaches include the deployment and dissemination of new network technologies such as 5G [31]. The importance of technological improvements in network and device solutions cannot be overemphasized. Indeed, combining the latest network technologies (e.g., 5G) with more efficient building technologies and processes, adhering to a net-zero energy infrastructure paradigm, can result in net-zero carbon building solutions [35]. Moreover, the introduction of new computing paradigms, such as deep learning and artificial intelligence solutions, as well as the introduction and integration of semantic technologies and natural language processing (NLP), will increase the level of interaction between smart devices and all smart city participants and enable the creation of smarter services to improve quality of life.

Finally, this study surveys the research literature on contemporary smart city frameworks. As such, the results of this study provide a basis for understanding and classifying recent trends in the adoption of emerging technologies such as the Internet of Things, big data, artificial intelligence, and cloud computing, which are key drivers for the efficient and sustainable development of smart cities. Therefore, this study highlights the main open questions that must be addressed and tackled in the future. Based on the literature study conducted for this research, the technologies underlying smart city approaches and frameworks studied from an architectural perspective are grouped into eight domains, reflecting the main application areas. According to this report, the integration of new technologies and smart city frameworks in recent years has enabled increased complexity and broader applications beyond the previous generation of domain-specific vertical applications based on silos. This creates new added value on many platforms by allowing the exchange of protocols, data, and results, as well as by allowing greater and more effective collaboration between all participants and stakeholders (users, software and network providers, universities, enterprises, etc.). To this end, a new generation of intelligent applications will manage and optimize an increasingly complex collection of different information, data, systems, sensors, devices, etc. However, this process is still in its early stages, as it must address several outstanding technical and societal challenges (e.g., efforts to harmonize many different standards for smart city policies and protocols, interoperability and scalability issues, and achieving sustainability goals) in order to move towards microservices-oriented architectures, event-driven/data-driven applications, and more sustainable solutions. Finally, all relevant stakeholders and participants are increasing their knowledge and becoming more involved in the smart city environment, not only as consumers of services but also as providers of useful materials and information.

7.2. Implications for Practice

In addition to theoretical implications, the results of this study have a number of key implications for the implementation and development of smart cities. First, the framework can help smart city stakeholders understand and analyze the complexity of project implementation. This can enable the effective implementation of system integration, reusability,

and interoperability for smart city projects. Smart governance, smart businesses, and smart residents are all needed for a smart city. A smart city is a city that effectively uses technology, infrastructure, public policy, and citizen engagement to promote economic development and productivity, innovation, social mobility, inclusiveness, and sustainability. Smart infrastructure powered by information and communication technologies will undoubtedly help a city become smart and sustainable. Critical infrastructure is the collection of systems, networks, and assets that are critical to a country's security, economy, public health, and/or safety and are required for their continued operation. The vast network of roads, connecting bridges and tunnels, trains, utilities, and buildings needed to support normal daily life are known as critical infrastructure. These critical systems are essential for transportation, trade, clean water, and energy. Organizations can generate business value by using information infrastructure technologies to define, organize, share, integrate, and manage data and content. Today, critical information infrastructures are the backbone and foundation of any modern civilization or community.

Second, big data, IoT, data analytics, artificial intelligence, digital twinning, cloud computing, 5G, and virtual, augmented and mixed reality are being adopted in cities under the planned ICT framework to enable smart policies, smart governance, and smart people. Technology platforms for cities must be built to improve government efficiency and public access to critical data. Cloud computing services, sensor networks, and data centers, as well as traffic control systems for road congestion management and public transportation systems, such as subways and light rail, can all fall into this category. Policies created on top of these platforms include e-government portals and e-government services that enable users to access data through shared application interfaces and use this information to better serve their communities. With the emergence of new technologies and ICT domains such as artificial intelligence, big data, robotics, cloud computing, and the Internet of Things, the significance of standardization extends beyond the interoperability needed to create a global digital single market. Given the rapid pace of change in our world and the impact it may have on our societies and workforce, the choices made by all countries are geared toward maximizing the benefits of the digital revolution. In some cases, standards may need to be in place before policies or laws can be implemented. The challenges of safety and security of "smart" products, automated devices, and the Internet of Things, as well as the reliability and effectiveness of artificial intelligence, data, and privacy protection, may require the development and application of standards for regulatory or public policy purposes.

Third, the findings of this study demonstrate the need to develop sustainable solutions for a balanced ecosystem by enabling individuals to understand and use nature-inspired design concepts. In addition, we must build a repository of resources, initiate design challenges that allow people to learn by doing, provide complete assistance in bringing innovations to market, and create an enabling atmosphere and platform for a worldwide network of innovators. In short, it is imperative that joint efforts be made to research, teach, and practice the development of essential alternatives for our society. To ensure that the efforts and initiatives of the various branches of government, the executive branch, and the legislative branch reap the benefits, it is critical that the tools they each develop are consistent and contribute to a seamless and homogeneous framework in which standards, regulations, and policies coexist. The development of smart cities will lead to the emergence of smart nations, which will then give rise to a nature-conscious society that balances social, economic, and technological progress with climate and natural equilibrium. This society will put the principles of the circular economy into practice, using nature-inspired technological advances to make our planet carbon neutral. Finally, this study highlights the significance of the need for data sharing between organizations and city residents. Systems can interact at the operational level, and at the strategic level, information is used to manage the efficient use of resources to effect positive change. However, the vocabulary and language used to categorize data are often specific to the department collecting the data. Each department has its own model and vocabulary, which makes it possible to locate and understand data within that department, but this can be a barrier to

terminology interoperability with other departments. This problem should be addressed by interoperability features that facilitate seamless exchange between various ecosystems. The interoperability of different systems is a key feature of a smart city. The interactions between various urban services and systems determine the most efficient use of resources in a complex metropolitan environment. Communication between many-component systems is necessary to determine the most efficient use of resources (e.g., combining power usage monitored by smart meters with external heating and sunlight measurement of structures to minimize power consumption).

8. Conclusions

The smart city concept is broad, and until city planners reach an agreement on a framework for its adoption, the concept will remain ambiguous from an ICT perspective. Industry practitioners should test and refine the framework proposed by the researchers. Information and communication technologies form the essential nervous system of smart cities, and citizens and businesses need to have access to services at all times. More research is needed to understand more about the concept of smart cities and the success of smart city initiatives. In this study, the status of smart city initiatives was reviewed, experiments were conducted, and innovations and improvements were made. The empirical research conducted in this study was limited to four participants from the United Arab Emirates. Research in this area should follow a qualitative approach. The research model should be validated with more initiatives from different smart city areas, and further work is needed to improve the model. The proposed framework for smart cities is a two-dimensional classification scheme guiding the implementation of a modern city. It was derived through observation of various smart city elements such as applications, technologies, initiatives, policies, and governance guidelines to tackle the complexity of a smart city. Areas or topics of study include, but are not limited to:

- Industry 4.0: This is the new concept of existence of any product on the internet. This topic still needs more research on technology, challenges, etc.
- Data analysis and artificial intelligence technology: a smart city collects data, analyzes the collected data, correlates it with other data, and provides meaningful information for decision making.
- Smart city: How will smart cities be structured with different integrated technologies for use in different smart city contexts?
- Governance and security (both technical and non-technical): How will interorganizational relationships be managed within the information system of a smart city, a radically open space, and an interconnected world?
- Privacy issues: How will citizens trust the government when they provide personal information, and what will the model of trust be?
- Video surveillance/image processing/gesture recognition: How are all related flow and measurement devices designed, tested, installed, and maintained to adapt smart cities?
- Creation of new economic models: How are organizations restructured and business processes designed or restructured to enable the transition to a smart city model?
- Smart city environmental sustainability: How can cities protect their resources for long-term maintenance?

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References

1. United Nations, Department of Economic and Social Affairs. *Population Division*; United Nations: New York, NY, USA, 2019.
2. Shoshana, Z. *In the Age of the Smart Machine: The Future of Work and Power*; Basic Books, Inc.: New York, NY, USA, 1988.
3. Treinish, L.A.; Praino, A.P.; Cipriani, J.P.; Mello, U.T.; Mantripragada, K.; Real, L.C.V.; Sesini, P.A.; Saxena, V.; George, T.; Mittal, R. Enabling high-resolution forecasting of severe weather and flooding events in Rio de Janeiro. *IBM J. Res. Dev.* **2013**, *57*, 7:1–7:11. [CrossRef]
4. Gorbis, M. *Human Plus Machine*; Institute for the Future: Palo Alto, CA, USA, 2011.
5. Daugherty, P.R.; Wilson, H.J. *Human + Machine. Ripensare il Lavoro Nell'età Dell'intelligenza Artificiale*; goWare e Guerini Next: Milano, Italy, 2019.
6. Belissent, J. *The Core of a Smart City Must Be Smart Governance*; Forrester Research Inc.: Cambridge MA, USA, 2011.
7. Scardovi, C. Open Data in Open Cities. In *Sustainable Cities*; Springer: Cham, Switzerland, 2021.
8. Zhao, F.; Fashola, O.I.; Olarewaju, T.I.; Onwumere, I. Smart city research: A holistic and state-of-the-art literature review. *Cities* **2021**, *119*, 103406. [CrossRef]
9. Al-qudah, R.; Khamayseh, Y.; Aldwairi, M.; Khan, S. The Smart in Smart Cities: A Framework for Image Classification Using Deep Learning. *Sensors* **2022**, *22*, 4390. [CrossRef]
10. Hollands, R.G. *Will the Real Smart City Please Stand Up?: Intelligent, Progressive or Entrepreneurial?* Routledge: London, UK, 2020; pp. 179–199.
11. Neirotti, P.; De Marco, A.; Cagliano, A.C.; Mangano, G.; Scorrano, F. Current trends in Smart City initiatives: Some stylised facts. *Cities* **2014**, *38*, 25–36. [CrossRef]
12. Alsop, T. *Smart City Initiative Investment Worldwide in 2018–2023*; Statista GmbH: Hamburg, Germany, 2020.
13. Tarapiah, S.; Atalla, S.; Muala, N.; Tarabeh, S. Offline public transportation management system based on GPS/WiFi and open street maps. In Proceedings of the 2014 Sixth International Conference on Computational Intelligence, Communication Systems and Networks, Tetovo, Macedonia, 27–29 May 2014; IEEE: Piscataway Township, NJ, USA; pp. 182–185.
14. Tarapiah, S.; Aziz, K.; Atalla, S.; Ismail, S.H. Smart real-time healthcare monitoring and tracking system using GSM/GPS technologies. *Int. J. Comput. Appl.* **2016**, *142*, 19–26. [CrossRef]
15. Georgia, W. The Top 10 Smartest European Cities. 2014. Available online: https://medium.com/business-chief/top-10-smart-cities-in-europe-cd137bce2df1 (accessed on 3 November 2022).
16. Allwinkle, S.; Cruickshank, P. Creating smart-er cities: An overview. *J. Urban Technol.* **2011**, *18*, 1–16. [CrossRef]
17. Albino, V.; Berardi, U.; Dangelico, R.M. Smart cities: Definitions, dimensions, performance, and initiatives. *J. Urban Technol.* **2015**, *22*, 3–21. [CrossRef]
18. Pettit, C.; Bakelmun, A.; Lieske, S.N.; Glackin, S.; Thomson, G.; Shearer, H.; Dia, H.; Newman, P. Planning support systems for smart cities. *City Cult. Soc.* **2018**, *12*, 13–24. [CrossRef]
19. Sorin-George, T.; Andreea, S. The world's smartest cities in the metropolitan century. *Ovidius Univ. Ann. Econ. Sci. Ser.* **2018**, *18*, 111–116.
20. Caragliu, A.; Del Bo, C.; Nijkamp, P. Smart cities in Europe. In *Smart Cities*; Routledge: London, UK, 2013; pp. 185–207.
21. Fantin Irudaya Raj, E.; Appadurai, M. Internet of things-based smart transportation system for smart cities. In *Intelligent Systems for Social Good*; Springer: Singapore, 2022; pp. 39–50.
22. Chaudhary, V.; Kaushik, A.K.; Furukawa, H.; Khosla, A. *Towards 5th Generation AI and Iot Driven Sustainable Intelligent Sensors Based on 2D Mxenes and Borophene*; ECS Sensors Plus; IOP Publishing Limited: Bristol, UK, 2022.
23. Rejeb, A.; Rejeb, K.; Simske, S.; Treiblmaier, H.; Zailani, S. The big picture on the internet of things and the smart city: A review of what we know and what we need to know. *Internet Things* **2022**, *19*, 100565. [CrossRef]
24. Mishra, A.; Jha, A.V.; Appasani, B.; Ray, A.K.; Gupta, D.K.; Ghazali, A.N. Emerging technologies and design aspects of next generation cyber physical system with a smart city application perspective. *Int. J. Syst. Assur. Eng. Manag.* **2022**, *21*, 1–23. [CrossRef]
25. ITU. From Dream to Reality: Developing Sustainable Smart Cities in the United Arab Emirates. 2016. Available online: https://www.itu.int/hub/2020/08/from-dream-to-reality-developing-sustainable-smart-cities-in-the-united-arab-emirates (accessed on 3 November 2022).
26. Orlikowski, W.J.; Baroudi, J.J. Studying information technology in organizations: Research approaches and assumptions. *Inf. Syst. Res.* **1991**, *2*, 1–28. [CrossRef]
27. Ahlgren, B.; Hidell, M.; Ngai, E.C.H. Internet of things for smart cities: Interoperability and open data. *IEEE Internet Comput.* **2016**, *20*, 52–56. [CrossRef]
28. Gyrard, A.; Serrano, M. Connected smart cities: Interoperability with SEG 3.0 for the internet of things. In Proceedings of the 2016 30th International Conference on Advanced Information Networking and Applications Workshops (WAINA), Crans-Montana, Switzerland, 23–25 March 2016; IEEE: Piscataway Township, NJ, USA, 2016; pp. 796–802.
29. Rifkin, J. *The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism*; St. Martin's Press: New York, NY, USA, 2014.
30. Rieke, M.; Bigagli, L.; Herle, S.; Jirka, S.; Kotsev, A.; Liebig, T.; Malewski, C.; Paschke, T.; Stasch, C. Geospatial IoT—The need for event-driven architectures in contemporary spatial data infrastructures. *ISPRS Int. J. Geo-Inf.* **2018**, *7*, 385. [CrossRef]

31. Li, Z.; Seco, D.; Sánchez Rodríguez, A.E. Microservice-oriented platform for internet of big data analytics: A proof of concept. *Sensors* **2019**, *19*, 1134. [CrossRef]
32. Niknejad, N.; Ismail, W.; Ghani, I.; Nazari, B.; Bahari, M. Understanding Service-Oriented Architecture (SOA): A systematic literature review and directions for further investigation. *Inf. Syst.* **2020**, *91*, 101491. [CrossRef]
33. Tönjes, R.; Barnaghi, P.; Ali, M.; Mileo, A.; Hauswirth, M.; Ganz, F.; Ganea, S.; Kjærgaard, B.; Kuemper, D.; Nechifor, S.; et al. Real time iot stream processing and large-scale data analytics for smart city applications. In Proceedings of the Poster Session, European Conference on Networks and Communications, Bologna, Italy, 23–26 June 2014; p. 10.
34. Ray, P.P.; Mukherjee, M.; Shu, L. Internet of things for disaster management: State-of-the-art and prospects. *IEEE Access* **2017**, *5*, 18818–18835. [CrossRef]
35. Xiao, Y.; Krunz, M.; Shu, T. Multi-operator network sharing for massive IoT. *IEEE Commun. Mag.* **2019**, *57*, 96–101. [CrossRef]