# A Novel Smart Cities Framework for GCC Countries

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**Abstract**

There is a need to create and develop smart cities that could help improve the quality of life in global countries. The goal of this paper is to develop a novel smart city framework for the GCC countries. This study presents a comprehensive analysis of smart city features across multiple cities worldwide, leveraging data from a reliable world cities database. Through exploratory data analysis and visualization techniques, we examined various aspects of smart city development, including mobility, environment, government, economy, people, and living standards. It turned out from the literature that globally, there is a focus on some of the dimensions of smart cities while others did not receive much attention. Smart economy and smart environment were not receiving much attention globally. A framework was developed for the GCC countries that focuses on all the dimensions of the smart cities, but most of the attention is on smart governance and smart economy since these two dimensions help improve the quality of life and diversify the sources of the economy in the country. This framework is useful for GCC countries as it would have great implications on the desired outcomes of smart cities and link with the strategic development goals that most GCC countries have, whether it is the 2030, 2035, or even the 2040 vision.

**Keywords:** Smart City; Smart Governance; Smart Mobility; Smart Economy; Smart People

## 1. Introduction

The rapid pace of urbanization worldwide is placing significant strain on governments to provide top-quality services to their citizens [1]. Therefore, to make cities better and more affordable, the idea of smart cities has become important. Advancements in technological innovation are accelerating the adoption of Information Communication Technology (ICT) solutions, resulting in increased expectations for the delivery of services through technology [1]. With the new urbanization rate and citizens' expectations, there is added pressure on governments to transform the way they deliver services.

Smart cities offer many advantages, such as better decision-making based on data, safer communities, improved transportation, greener environments, and public services that are more efficient. They also create new business opportunities, provide citizen-centric services, and help manage cities more effectively. One approach that governments are adopting is the transformation of cities into smart cities, which entails the consistent and uniform delivery of services, leading to a reduction in resources required to run these cities [2]. When considering the development of smart cities, several factors must be taken into account such as establishing trust with citizens to encourage them to utilize the services offered. Additionally, concerns over privacy and security abound, with many proponents of smart cities arguing that these systems may infringe upon individual privacy [3]. To address these issues, this study examines the literature on various smart city experiences from around the world, with the ultimate goal of proposing a framework for an optimal smart city in the GCC countries. While the efforts of these countries are commendable, there is currently a lack of direction regarding the specific layout and services that these smart cities should provide.

The development of smart cities has been an area of interest for researchers, with many studies exploring the dimensions that make up a smart city. However, there are challenges too. Developing smart cities requires a lot of money for technology, which can create a dependence on tech companies. Moreover, few studies have taken a holistic approach to the topic and proposed a framework for the optimal development of smart cities. This study aims to address this gap by proposing a comprehensive framework for the development of smart cities, particularly



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in the context of Kuwait. The framework takes into account the various dimensions identified in the literature. This study's contribution is a broad framework that can serve as a useful guide for the development of smart cities, particularly in countries like Kuwait.

The main contribution of this paper is that it provided an overall and comprehensive review of the studies that were conducted on smart cities. It was able to draw a full and realistic picture by analysing and visualizing data of smart city landscapes across the world and how smart cities were implemented. It was true that there are studies that presented similar findings. Furthermore, this paper was able to develop a framework that is built on the previous work and linked the dimensions of smart cities to the framework, which made it easier to visualize for the public to comprehend what smart cities need to be developed functionally.

The paper is organized as follows: Section 2 provides a Literature Review. Section 3 discusses the Methodology, explains the data we used and its analysis. Section 4 discusses the proposed framework for the optimal layout of a smart city in the State of Kuwait, summarises what we found, and suggests ideas for future research. Finally, Section 5 discusses the conclusion.

## 2. Related Work

### A. Smart City Definitions

According to [4], the concept of "Smart" in smart cities has evolved over time, focusing on technological advancements. In a similar work, [5] defined what makes a city "Smart," highlighting its contemporary aspects and intelligent features. As cities continue to expand in size, it has become essential to consider the transformation of these urban centers into smart cities, which can effectively manage the increasing demands for services [6]. There have been many definitions of smart cities, which stem from an Information and Communication Technology (ICT) perspective and the association with smart things and devices. The internet and the Wi-Fi are used to connect smart things or devices and to start interacting with them. According to [7], smart cities are about the move toward digitization of the services of the cities and making these new services available to the citizens. These actions help to make the transition for the cities to become smart cities [8].

### B. Smart City Dimensions

Various scholars, who have concluded that it comprises more than one dimension [1], have studied the concept of smart cities extensively. Six dimensions have been identified as the most significant in capturing the true essence of a smart city [9]: smart governance, smart economy, smart mobility, smart environment, smart people, and smart living. These dimensions are discussed in detail below.

### C. Smart Governance

Smart governance is widely regarded as a critical component of a smart city. This is because it can be used to support the democratic process in a country and to develop transparent and effective strategies for involving the public in the use of technology. This can be achieved through the development of rules and regulations that govern the relationship between the government and the people [10]. According to [9], utilizing advanced technologies can help to improve collaboration between cities and municipalities, leading to an increase in the quality of public services and a boost in public confidence. The New Kuwait Vision of 2035 includes the establishment of Strategic Development Goals, which emphasize the importance of transparency and accountability in government services. To achieve these goals, Kuwait should leverage technology to develop smart services that prioritize transparency and accountability. .

There is no universally accepted definition of smart governance in relation to smart cities, but certain studies have attempted to connect it to this concept. The study in [11] identified four main components of smart governance: government of the smart city, intelligent decision-making, efficient administration of tasks, and collaborative urban management. In their view, smart governance is a means of utilizing information and communication technology (ICT) to foster collaboration between government entities and citizens. [12] expressed similar sentiments, who emphasized the importance of citizen participation in smart governance, an idea that has been mentioned in some smart city literature. [13] linked smart cities with governance, implying that the two concepts are interrelated, with the goal of smart cities being to generate value for the people. Moreover, the authors highlighted that smart governance entails a strong emphasis on leadership, citizen engagement, accountability, transparency, and data sharing within government entities. Smart city governance pertains to the use and appropriate utilization of available technologies to create innovative collaborative methods that enhance outcomes and perceived value [11]. For this reason, new forms of governance emerging from smart cities and leveraging technology are essential for addressing the challenges of smart cities and fostering seamless collaboration within the government, as well as allowing citizens to enjoy greater value [14].

### D. Smart Economy



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The smart economy is another main dimension of a smart city, which is about the maximization of the value and the return from the new and innovative ways of conducting business in the smart city [1]. There is a high dependency on innovation in this sense to create value and enhance productivity for people and businesses in the market by developing a new business model [9]. The smart economy is thus about creating competitiveness in the city by putting more emphasis on innovation, entrepreneurship, trademarks, productivity and flexibility in the market. By utilizing the technology for smart cities, there is a great opportunity for the development of businesses locally and to attract businesses from abroad to conduct their businesses locally [15]. The development of smart city technologies allows business to be carried out in a smart way using portals and gateways, which helps in developing new opportunities and the enhancement of the services that the city is offering [16]. As an example, the Kingdom of Saudi Arabia (KSA) has added a service called "Ibshir", which is used for businesses to get all the required licenses and documentation from anywhere using the portal that it provides, thus eliminating the need to come to the government office to complete the transactions. These online services for businesses are executed in a matter of minutes, which is a huge savings in time and encourages individuals to start a new business or for existing businesses to grow their businesses [17]. With this concept in mind, it is worth mentioning that a smart economy would help in the integration of private businesses within the system of smart cities to enhance their capabilities of generating more revenue with greater accountability and transparency and to be able to benefit the public as well.

### E. Smart Mobility

Smart mobility is the third dimension of a smart city that is associated with the concept of transportation. Smart mobility is about the use of the latest technologies to facilitate the movement and transportation of people. A good example of smart mobility is electric buses that started to emerge across the globe. The electric buses are linked through the ICT network to provide live monitoring of the movement of the busses for the administrators and for the public. It helps in saving data about the trips and uses machine learning to optimize the best routes [1]. Another example of smart mobility is autonomous public transportation, such as autonomous taxis. These autonomous taxis employ machine learning and Artificial Intelligence (AI) to provide safe and fast journeys for commuters [18]. Therefore, smart mobility is a way of offering an efficient, clean, and reliable transportation network, not just for people but also for goods as well. It allows planners to use the technologies to develop optimized transportation methods [9].

### F. Smart Environment

The smart environment is the fourth pillar of a smart city, which is related to the optimization of the methods to protect the environment. It uses the databases that are available about the city to guide the decision-makers in the creation of an efficient, effective, and sustainable urban environment that helps in the betterment of the quality of life for citizens [9]. A smart environment is thus about the creation of natural conditions for living in a city, such as enhancement and control of green areas, waste management and environmental protection from pollution [1]. Waste management is becoming one of the critical aspects of a smart environment because it contributes to minimizing or eliminating the city from pollution, thus enhancing the quality of life [18]. Innovative technologies are used to monitor waste levels and to treat the waste in a manner that would make them safe for the environment and, in the process, recycle them to develop a new purpose for them. Another good example of a smart environment is the use of renewable energy sources and monitored and controlled green areas where oxygen levels are kept on the radar to maintain and increase it if possible [2]. All these actions help in improving the general ecological system in the city and to develop smarter and safer ways of interacting with the environment and using its resources.

### G. Smart People

The development of a smart city is vital as a concept and as a way of using and employing technology. However, it would not be of any value without the people who would use and enjoy the services that the city is offering [18]. Thus, smart people is about the participation of the people in the smart city urban life and the ability to use the smart city solutions and also provide feedback and innovative ideas on developing the services that the smart city offers, which helps them in their community as well. This dimension can be achieved and improved through educating people and helping them acquire skills that they need in their interaction with the smart city [9]. Therefore, smart people are about the development of the qualifications and the educational status of the people living in the smart city and creating social networks for people to interact with others as well, which helps in enhancing their information and knowledge [2]. For example, it is noticed that there is a focus in smart cities to use social media and e-portals to transmit knowledge to citizens about the features of the smart city and how to use the services. Doing so helps in increasing the creativity of the people and the level of participation to make the smart city technologies of greater value to them [1].

### H. Smart living



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Smart living is the last dimension of smart cities, which is about the availability of a management tool (or tools) to create a smart living atmosphere for the people. Thus, it is defined as the proper management of the facilities, public areas, and services with ICT technologies to satisfy the needs of the citizens and enhance the quality of their lives [9]. Under smart living, different aspects of quality of life are being monitored. There is concern from the officials of the smart city to monitor some important features of living, such as the health, safety, culture and living conditions of the people living in the smart city. In addition, this dimension is related to tourism as smart living would also encompass the use of technologies to manage events and the enjoyment of the city [18], which can be achieved by using digital billboards or mobile applications to push information about events that are planned in the city [1]. The use of ICT technologies also helps in the creation of initiatives that are innovative to improve health and safety as well as the lifestyles of the residents of smart cities [19]; [20].

## I. Challenges of Smart Cities

The development of smart cities is greatly influenced by the latest advancements in technology, such as cloud computing, open data, Internet of Things (IoT), and other related technologies. However, there are also challenges and limitations associated with these technologies. These obstacles arise from the implementation of smart cities present several difficulties for the advancement of smart city initiatives [21]. The development of Information Technology (IT) infrastructure, such as communication channels and sensors, is as a major challenge. The main reason is the mere fact that it needs to be installed and running before the initiation of the smart city services and the deployment to the key stakeholders [22]. The smart city needs devices, cabling, networking, switching, sensors and many other hardware to be ready. Security threats on the IT systems, such as those from viruses, intrusions, hackers, and worms, have also the potential to cause a disruption in the systems and the services of the smart cities, which may lead to staggering losses. Hence, policies are set in place to secure the most sensitive and critical data. Security and privacy are important considerations for ensuring that the services are available all the time and developing the trust of citizens in using the smart cities services [23]. The unforeseen complexity of how citizens interact with the smart city systems calls for significant changes in the policies and regulations, which is the role of the government. A huge concern is managing and processing data. This involves collecting the existing databases of the city and integrating them with the new databases for the smart city and also the sensors installed to have all the devices and systems communicate with each other, which presents a challenge in terms of security and privacy [24]. Threats that originate from the security and privacy of information and mostly from cyber activities, where external entities or individuals might gain unauthorized access to information can lead to undesired consequences, which highlight the importance and significance of focusing on security issues at the design phase of the smart city [25]. Many studies examined smart city security and highlighted the importance of security as a concrete cornerstone for building smart cities [18].

Smart cities have the potential to generate an enormous amount of data by utilizing the various interconnected systems. An efficient and effective data management system is deemed necessary to accommodate the various data types at a suitable speed. It is thus important that this data management system is operating with reliability and has scalability potential with the chance of limited or no downtime. The continuous generation, as well as processing of data from the various components of the smart city makes big data, which is sometimes a challenge to handle in real-time [26]. This means that the amount of data requires high processing speed and possibly the use of machine learning to be able to learn from previous transactions and take shortcuts when needed to speed up all the processes. Moreover, there is a need for proper infrastructure that can withstand the huge volume of data that is moving back and forth between the various services that the smart cities offer. However, having big data processed through smart cities is not only an issue of storage of the data but also having systems capable of making fast decisions when needed [27]. Smart cities require acquiring huge IT infrastructure that would make the entire network that is needed to run the smart city. Millions of sensors, thousands of networking equipment, and computing devices are required; consequently, the smart city requires a huge budget permanently [23]. Some of the countries might be interested in smart cities being developed and implemented in their countries.

The applications of the smart city need to be reliable, fast and serve the needs of the citizens. Hence, the applications must be developed faster, to allow citizens to use the services that the smart city offers. These applications utilizes the collected and processed data to deliver efficient and effective services. Developing good applications can be a crucial element in the success or failure of the smart cities initiates as the systems might be there, but there is difficulty in navigating the systems that it offers because there are no proper applications developed for the daily use of the smart cities services that it offers. The lack of professional human resources, who are knowledgeable in technology development, is another challenge with smart city development [25]. Moreover, the challenges of recruiting talented individuals with the right set of skills for smart cities are triggering some enterprises and individuals to move their operations to other major cities with the hope that better professionals can be recruited in the new city of operation [28]. Another hurdle is the lack of participation and involvement of citizens with the smart cities application [29]. It is a challenge as the utilization of smart city services would be low, which defeats the purpose of creating and running smart cities. The vagueness of the policy



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process of smart city development are also related to the lack of clarity on how the citizens would participate in smart cities and the development of the solutions that could help them lead better lives [30]. It is also a good practice for government officials to include citizens in the evaluation and assessment of the smart cities' services based on their sociodemographic profiles.

### J. Models of Smart Cities

There has been growing interest in the development of smart cities around the world for the benefit of citizens and the country in terms of wise use of limited resources. There are many examples of smart cities from around the world.

- Worldwide

[16] discussed the experience of Brazil in smart cities in Curitiba, which is considered among the top ten smart cities. Six factors are seen in the City of Curitiba, such as integrated urban planning, pedestrian priority zones, waste management systems, awareness of environmental issues, an efficient and effective public transport network, and the presence of social justice. These factors allowed for the development of a sustainable smart city. Canada has promoted smart cities from day one with the development of multiple smart cities, such as the City of Edmonton and the City of Saskatoon [31]. The smart city was developed to accomplish positive outcomes for citizens that would enhance living standards and empower communities. Perhaps the example of Edmonton City with their endeavor of leading a full digital transformation in the city to enhance the quality of life [32]. They led the transformation by developing innovative smart solutions to meet the needs of present and future citizens. Another example was the city of Saskatoon with their connect initiative, which invests in youth in developing the technologies of the future that the city requires through employing artificial intelligence to make all the services in the city available and smart in the interactive sense [33].

Another smart city example in the United States is New York, which entered into a fast-moving pace toward the enhancement of government services and the living standards for the people [34]. The city developed and launched new digital centers for improving digital literacy and enhancing the quality of life by creating new employment opportunities. Moreover, it allowed the city to install free WiFi all over the city to make people connected to the services that the city offers [35]. In Europe, there were many examples of the use of smart cities. The city of Barcelona turned smart in Europe as the city experienced a full digital transformation in the area of smart governance and smart living. In its development, the city moved into smart people and a smart economy to become one of the most advanced cities in the world [31].

The United Kingdom (UK) created standards for developing smart cities, for establishing the framework for the delivery of smart cities across the UK [2], which helped in best practices to develop smart cities. The city of Manchester turned smart by deploying the Internet of Things (IoT) technologies to link all the hardware, solutions and systems around the cities using sensors to develop four main aspects, which are culture, environment, health, and transport [36]. A City Brain project, announced by Alibaba was based on the cloud. The idea is to use the video feeds of the traffic lights that are dispersed all over the city to provide analytics of the most suitable operations of the traffic lights to relieve the gridlocks in the City of Hangzhou, China. It was determined that traffic management has improved by 92% through the higher and optimal ability to recognize violations and provide aid and assistance to emergency vehicles that were able to reach their destination with a precision of higher than 50%, and road utilization increased by 15% [37].

As a model of a smart city, Woven is regarded as an advanced and comprehensive ecosystem that is powered by hydrogen fuel cells situated at the base of Mount Fiji [38]. The project is designed to accommodate residents and researchers who will contribute to the development of technologies such as robotics with various applications, smart homes for the public, and mobility solutions for the city. The construction will incorporate cutting-edge technologies, including the use of carbon-neutral wood through a partially robotized and partially traditional process [31].

Table 1 shows the worldwide application and use of the smart cities dimensions mentioned in this study earlier. The table shows that there was a higher focus on smart governance than the remaining dimensions, which shows the importance of having the government services deployed using the technology and linking all the services and systems of the various government entities, which would make life easier for people.



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**Table 1:** The application of smart city dimensions worldwide

| | Smart Governance | Smart Economy | Smart Mobility | Smart Environment | Smart People | Smart Living |
|---|---|---|---|---|---|---|
| *Brazil* | | X | | X | | X |
| *Canada* | X | | | | X | X |
| *USA* | X | | X | | X | X |
| *Barcelona* | X | X | | | X | X |
| *UK* | X | | X | X | X | |
| *China* | X | | X | | | |
| *Japan* | X | X | X | X | | X |
| *Percentage* | 75% | 38% | 63% | 38% | 63% | 63% |

- Gulf Cooperation Council (GCC) Countries

In UAE, open-minded government leaders have strived to accomplish to the UAE all the facilities that would improve the quality and standards of life for the citizens and residents [38]. The smart city of Dubai supports the enhancement of the quality of life and living standards for the citizens. The city of Dubai has developed and launched more than 130 initiatives such as the Dubai Blockchain Strategy, the Dubai Data Initiative, the Dubai Paper free strategy, and the Dubai AI Initiative [39], the optimal implementation of smart initiatives are linked with smart tourism since there is a high volume of visitors to Dubai city. Several initiatives were developed and implemented as part of the Bahraini government initiatives, and these include the various e-government channels, mobile applications, and smart cards, which all received huge attention and support from the public [40]. Moreover, Bahrain is proudly the first of the GCC countries that have approved and implemented the "Cloud First" policy to help the services of the government to the cloud as it provides additional layers of security and reduces the costs of the infrastructure required [31].

In 2017, Oman moved towards the digital transformation vision, and this materialized with the development of the Digital Oman 2030 strategy. The three main pillars that this strategy enforced: the full development and establishment of the entire IT industry, the societies in Oman, and the government services to transform them into online services [41]. A one and only city in Oman is the city of Duqm, which is an economic city that is structured in a way to become a smart city [1]. This smart city focuses on various functions such as tourism, transportation, traffic management, utility management, tourism industry, and smart building and waste management [42]. Qatar has advanced greatly in IT and technological strategies. There were numerous initiatives developed for the country such as various digital services and its supporting mobile applications and the utilization of cloud services, among others [43]. A good example of a smart city in Qatar is the city of Lusail, where most buildings in the city are operated by a centralized cooling system that helps monitor the temperature and saves on resources. Moreover, the city has a smart waste management system that links the city with pipes that transport waste directly to recycling plants outside the city. Besides, a smart metro system was developed to make life easier for people where the metro is fully automated and has driverless carts [1].

The smart city Neom, which has been allocated about $500 billion as a budget, main focus are the water supply, digital technology, tourism, the water supply, entertainment, education, health care, etc.. [1]. Neom would utilise the latest technologies for a unique experience of a smart city that is unparalleled elsewhere, as the manual labor of work would be robotized, and transport systems would be fully automated with technologies related to solar and wind energy to enhance the efficiency and reduce the required resources for the city [44]. Lastly, Kuwait New vision 2035 is geared toward the development of seven major areas, such as the development of the infrastructure,



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the governance of the public services, the enhancement of the health services, the nurturing of human capital creativity, the diversification of the economy and the enhancement of the standards of living for citizens and residents [45] The city of South Saad Al-Abdullah developed with smart solutions and technologies as its backbone, as some included traffic and infrastructure management. In mid-2018, the government started to work on of the smart city's goals, which is smart energy [1].

Table 2 shows the application of the smart cities dimensions in the GCC countries, as per the review. There is full support for smart governance initiatives in all the GCC countries. This is expected as the government services from the various entities are not linked together, and hence, improving the services by utilizing the technologies to make these services smart would improve the quality of life for the people.

**Table 2:** The application of the smart city dimensions

| | **Smart Governance** | **Smart Economy** | **Smart Mobility** | **Smart Environment** | **Smart People** | **Smart Living** |
|---|---|---|---|---|---|---|
| *UAE* | X | | X | | | |
| *Bahrain* | X | | | | | |
| *Oman* | X | X | | | X | |
| *Qatar* | X | | X | X | | |
| *KSA* | X | X | X | X | X | X |
| *Kuwait* | X | | | X | | X |
| *Percentage* | 100% | 33% | 50% | 50% | 33% | 33% |

## 3. Methodology

This paper utilizes the Literature Review to examine studies conducted on smart cities. The utilization of SNR offers three advantages. First, it enables the collection and summary of all pertinent information regarding the dimensions and challenges of smart cities. Second, it provides an opportunity to explore the approaches taken by various scholars in studying smart cities and the dimensions they identified. Third, it allows the development of a framework that can facilitate the optimal development of smart cities. The research question that has been specified in the beginning was developed with the aid of the literature where the gap was identified. Next, the review protocol was developed. The studies that examined the use of technology in creating smart cities were categories based on a number of factors such as the region and the maturity of the smart city and its applications. Then, this protocol was validated by assembling a checklist that would guide in exploring the studies and their outcomes.

The following step is conducting the review of the literature where we searched for the various studies on smart cities and their applications. Then, assessed the studies and selected the studies that are considered prime for achieving the objectives. Then, the quality of these studies was evaluated and categorized in terms of relevance and applicability. The last two actions of this step were to extract the data about smart cities and applications and synthesize the data based on the criteria that the researchers have chosen. After assessing all the information that was reviewed, the final activity was to validate the findings by creating a framework for smart cities and its applications and linking this framework to the recommendations that are proposed for creating a smart city that would fulfill the needs of the citizens and enhance the quality of life in the society. To form a well-informed opinion and proposal, the perspectives and data from real-world smart city cases and literature will be analyzed and visualized and various aspects of these smart cities will be assessed and categorized. The aim is to identify what can be implemented across different regional and geographical levels worldwide, particularly in the GCC region, and which factors hinder their establishment.

Based on the studies conducted and the resources available to the GCC and Kuwait, this research will propose a practical framework for establishing the infrastructure of smart cities.



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### A. Data Sets and Collection

The database we used is this study is World Cities Database, provided by SimpleMaps. It is a comprehensive and accurate collection of cities and towns worldwide. The database is compiled from reputable sources such as the NGIA, US Geological Survey, US Census Bureau, and NASA. It offers up-to-date information on over 4 million unique cities and towns from every country in the world. The dataset, last refreshed in July 2021, includes essential details like latitude and longitude coordinates, ensuring accuracy and precision. With concise field names and a straightforward structure, the database simplifies access to vital city information for a wide range of applications and analyses.

There are three datasets present in World Cities Database. The first dataset is of Smart_City_Index_Headers. It comprises of various attributes pertaining to different cities and their respective smart city indices. Each entry in the dataset is identified by a unique ID and includes information such as the city name, country, and several metrics representing different dimensions of smart city development. These metrics include indicators related to smart mobility, environment, government services, economy, people, and living conditions. Additionally, the dataset provides the overall SmartCity_Index score for each city, along with its relative value compared to a reference city (Edmonton). These attributes collectively offer insights into the comprehensive evaluation of smart city initiatives and their performance across various urban domains.

The second dataset is "worldcities" which encompasses information about cities around the globe. It includes attributes such as: the city's name ('city'), its ASCII representation ('city_ascii'), geographical coordinates indicating its latitude ('lat') and longitude ('lng'), the country in which the city is located ('country'), ISO 3166-1 alpha-2 code ('iso2'), ISO 3166-1 alpha-3 code ('iso3'), the administrative region or name ('admin_name'), whether the city is a capital or not ('capital'), the population of the city ('population'), and a unique identifier ('id'). These attributes provide a comprehensive overview of cities worldwide, facilitating various analyses and geographical studies.

The third dataset is "country_and_continent", which contains information about countries and their corresponding continents. Each entry in the dataset includes attributes such as the continent's name ('Continent_Name'), the continent's code ('Continent_Code'), the country's name ('Country_Name'), the country's ISO 3166-1 alpha-2 code ('Two_Letter_Country_Code'), the country's ISO 3166-1 alpha-3 code ('Three_Letter_Country_Code'), and a numerical code representing the country ('Country_Number'). These attributes provide a structured and comprehensive overview of countries and continents, facilitating analyses related to geographic regions, international relations, and various socio-economic studies.

### B. Exploratory Data Analysis and Visualization

In data analysis, for Smart_City_Index_Headers dataset, we calculated correlation between different smart city indices. The correlation matrix provides valuable insights into the relationships between them, highlighting key factors that contribute to a city's overall smartness. The analysis results are:

- The 'Id' column exhibits strong negative correlations with all the SmartCity indices ('SmartCity_Index' and 'SmartCity_Index_relative_Edmonton'). This suggests that the unique identifier 'Id' is not significantly related to the smart city indices.
- The features like 'SmartCity_Index' and 'SmartCity_Index_relative_Edmonton' show negative correlations with 'Smart_Mobility', 'Smart_Government', and 'Smart_People'. This indicates that cities with lower scores in these categories tend to have lower overall smart city indices.
- Conversely, both 'SmartCity_Index' and 'SmartCity_Index_relative_Edmonton' exhibit positive correlations with 'Smart_Environment', 'Smart_Economy', and 'Smart_Living'. This implies that cities with higher scores in these categories tend to have higher overall smart city indices.
- The correlation between 'SmartCity_Index' and 'Smart_Living' is particularly high (0.765068), indicating a strong relationship between the quality of living standards and the overall smart city index.
- As expected, there is a perfect positive correlation of 1.000000 between 'SmartCity_Index' and 'SmartCity_Index_relative_Edmonton', since the latter is a relative index compared to the former.



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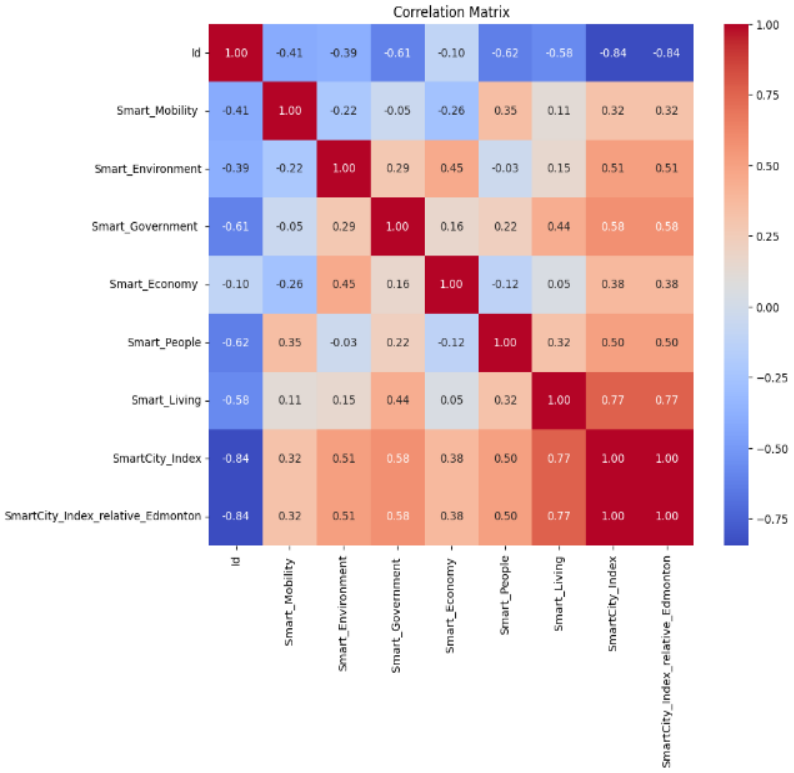


**Figure 1.** Correlation Matrix between Smart City Indices

Next, the mean SmartCity_Index grouped by country is calculated. It provides insights into the average level of smartness across different countries, highlighting areas of strength and potential areas for improvement in smart city development. Here are some observations:

- Netherlands has the highest mean SmartCity_Index of 7311.0, followed closely by Norway with a mean of 7072.75 and Canada with 6898.0. These countries demonstrate strong overall smartness in their cities based on the aggregated indices.
- Russia has the lowest mean SmartCity_Index of 4278.0, followed by Hungary with 4453.0 and United Arab Emirates with 4423.0. These countries have comparatively lower levels of smartness in their cities based on the aggregated indices.
- There is variability in the mean SmartCity_Index across different countries, indicating differences in the level of smart city development and implementation of smart initiatives.
- Some regions show consistency in their mean SmartCity_Index. For example, Scandinavian countries like Norway and Sweden, as well as countries in the Benelux region like Netherlands and Belgium, demonstrate relatively high mean SmartCity_Index values, suggesting a strong emphasis on smart city development in these regions.
- While the United States and the United Kingdom have relatively high mean SmartCity_Index values (6506.57 and 5862.67, respectively), they are not the highest among the listed countries, indicating areas for further improvement in smart city initiatives despite their overall development.

The top 5 countries ranked by their average Smart Mobility and Smart Environment scores is analysed. These scores reflect the level of integration of smart technologies and sustainable practices within urban infrastructure and governance. The United States emerges as a leader, demonstrating significant advancements in Smart Mobility (7553.57) while maintaining a commendable stance in Smart Environment (4874). Following closely is the Netherlands, highlighting excellence in both Smart Mobility (7540) and Smart Environment (5558). Japan secures its position with notable scores in Smart Mobility (7510) and Smart Environment (4637), reflecting its commitment to technological innovation and environmental sustainability. The United Arab Emirates displays promising developments in Smart Mobility (7291) despite a relatively lower score in Smart Environment (1979), indicating a strong focus on transportation infrastructure. Lastly, China demonstrates steady progress in Smart Mobility (6874.33) and Smart Environment (3091.33), underscoring its efforts to enhance urban mobility and environmental quality. The overall analysis is given in the Fig 2.



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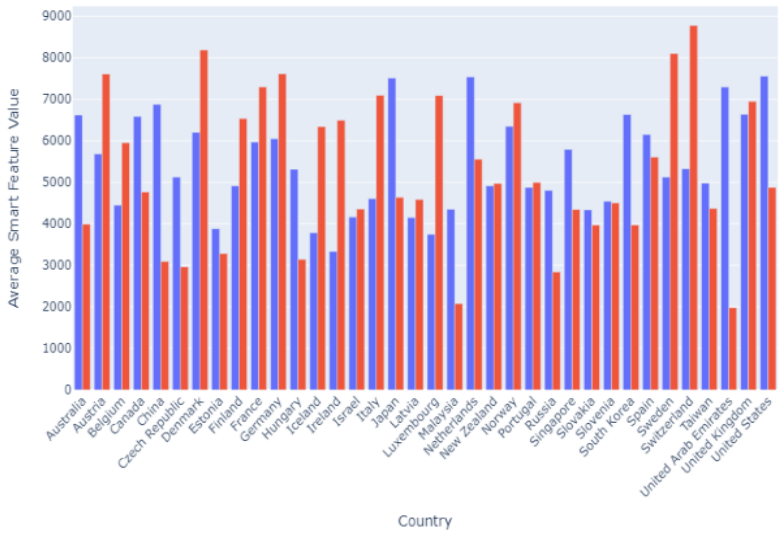


**Figure 2.** Average Smart Features by Country – Mobility and Environment

Similarly, the top 5 countries leading in Smart Government and Smart Economy is analysed. Netherlands emerges as the leader, giving high scores in both Smart Government (8528) and Smart Economy (8095). Luxembourg follows closely, excelling in Smart Economy (8440) while maintaining robust governance practices (8254). Sweden secures its position with significant strides in Smart Government (7863.33) despite a relatively lower score in Smart Economy (5518.33). Estonia demonstrates a balanced approach, scoring well in both Smart Government (7640) and Smart Economy (7585). Finally, Iceland stands out with a remarkable Smart Economy score (9225), complemented by a respectable performance in Smart Government (7604). These rankings highlight the diverse strengths and areas of expertise among these nations, offering valuable insights into their smart city development strategies. The overall analysis is given in Fig 3.

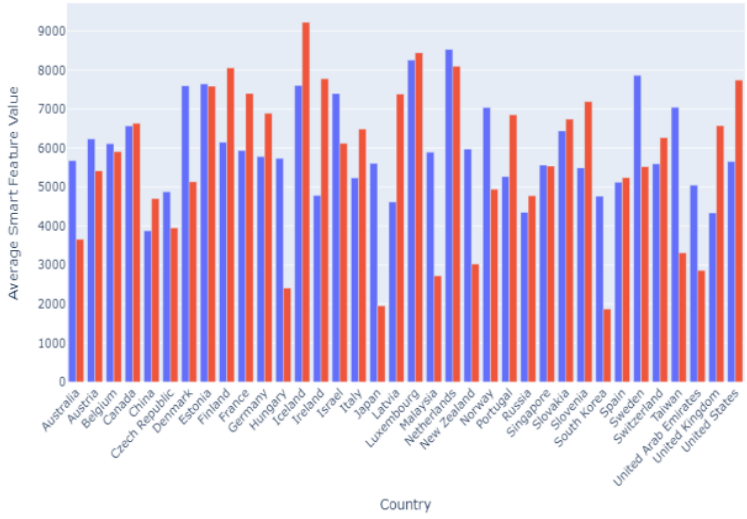


**Figure 3.** Average Smart Features by Country – Government and Economy

Next, the top 5 countries by average smart people and smart living are analysed. Singapore leads the list with remarkable scores in both Smart People (9695) and Smart Living (10000), reflecting its dedication to fostering education, healthcare, and overall quality of life. Austria follows closely, demonstrating strength in Smart People (8580) while also maintaining high standards in Smart Living (7500). South Korea shows a balanced approach, excelling in Smart People (8247.5) while making steps in enhancing Smart Living (4710). Norway exhibits notable achievements in both Smart People (7955.25) and Smart Living (9090), highlighting its commitment to citizen well-being and quality living standards. Lastly, Taiwan showcases a commendable focus on Smart People (7858), coupled with efforts to enhance Smart Living (7350), indicating a holistic approach to urban development and citizen welfare. The overall analysis is shown in the Fig 4.



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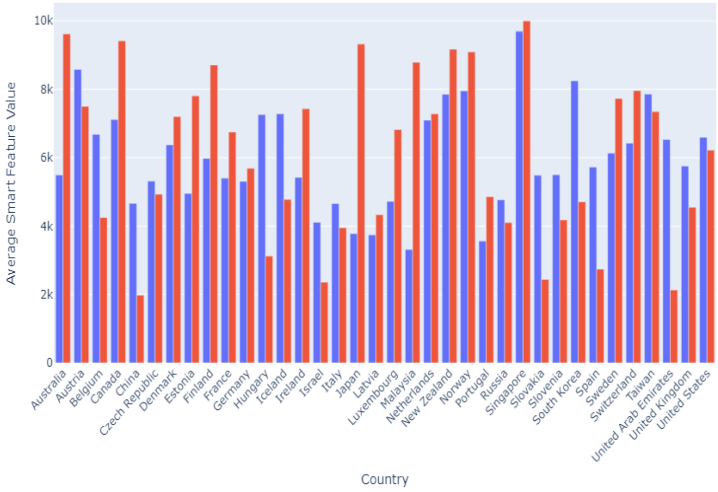


**Figure 4.** Average Smart Features by Country – People and Living

The total smartness score for each city or continent is calculated. It creates a new column named 'Smart_Total' in the DataFrame 'cities_continents_visualization'. The total smartness score is computed by summing up the individual smartness scores from six different aspects: Smart_Mobility, Smart_Environment, Smart_Government, Smart_Economy, Smart_People, and Smart_Living. By summing up these individual scores, we obtain a comprehensive measure of a city's overall smartness. It provides insights into how well a city performs across various smart city dimensions, helping stakeholders understand the city's overall level of development and efficiency in implementing smart initiatives as shown in the fig 5;

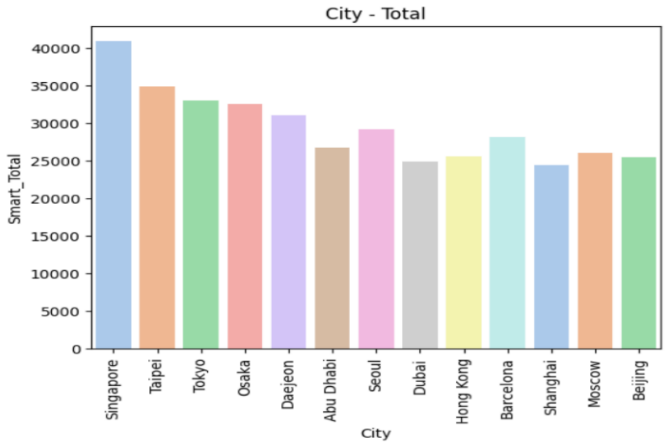


**Figure 5.** Smart Total vs City Total

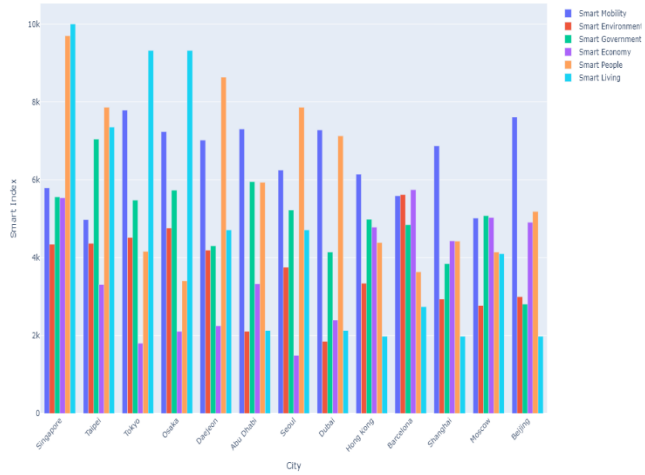


**Figure 6.** Smart Index Bar Plot for Each City



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A visual representation of the smart index is provided for each city across different smart features such as Smart Mobility, Smart Environment, Smart Government, Smart Economy, Smart People, and Smart Living. Each subplot corresponds to a specific smart feature, and the bar height represents the average smart index value for each city in that particular category. This visualization allows for easy comparison of the smart index across different cities and smart features, helping to identify patterns or trends in the data. Additionally, the rotation of the city names on the x-axis ensures better readability when comparing multiple cities. As shown in the Fig 6.

In further analysis, DataFrame named 'cities_continents_visualization' is used, aiming to generate a pivot table named 'cities_continents_pivot' organized by cities and continents, with Smart Index values for various smart features as the data. The resulting pivot table offers a structured representation where each row corresponds to a city, and each column signifies a continent. Within the table, the values denote Smart Index scores for specific smart features within each city and continent pairing. This arrangement facilitates a comprehensive view of how smart features vary across different cities and continents, aiding in comparative analysis and visualization of smart city initiatives' progress and effectiveness globally. For each city, the pivot table provides the Smart Index scores for different smart features across various continents. The comparison provides insights into how cities around the world are performing in terms of these smart features relative to one another, providing valuable information for urban planners, policymakers, and researchers interested in smart city development and sustainability. Based on the provided pivot table, we can identify the cities that excel in specific smart feature categories:

- Tokyo has the highest Smart Mobility score of 7787, indicating that it has implemented effective mobility solutions and infrastructure to improve transportation systems within the city.
- Singapore stands out with the highest Smart Environment score of 4344, suggesting successful initiatives to enhance environmental sustainability and conservation efforts in the city.
- Abu Dhabi leads in Smart Government with a score of 5948, highlighting efficient governance practices and technology integration to enhance public services and administrative processes.
- Osaka demonstrates strong performance in Smart Economy with a score of 5732, indicating a thriving economic ecosystem supported by innovation, entrepreneurship, and investment.
- Singapore tops the list in Smart People with a score of 9695, reflecting initiatives to invest in education, healthcare, and social services to enhance the quality of life and well-being of its residents.
- Singapore also excels in Smart Living with a perfect score of 10000, indicating high standards of living, quality infrastructure, and amenities that contribute to residents' comfort and convenience.

These insights help identify cities that have made significant strides in specific smart feature categories, providing valuable benchmarks for others to aspire to or learn from in their smart city development initiatives. The correlation matrix of city with smart features is given in Fig 7.

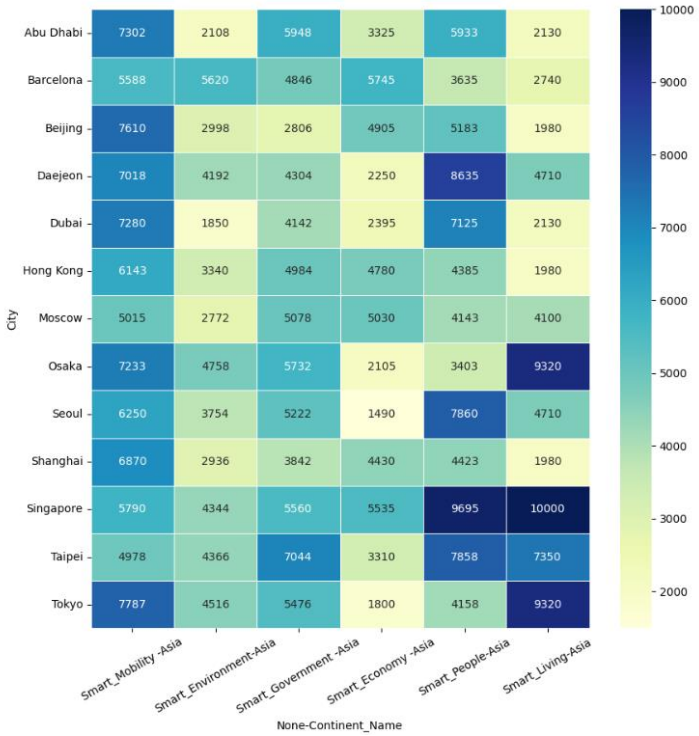


**Figure 7.** Correlation Matrix – City vs Smart Features



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## 4. Kuwait Readiness FOR Smart Cities

Smart city development is a key element of Kuwait's New Vision for 2035, which aims to transform the country's cities into digitized, sustainable, and resource-efficient urban environments. However, achieving readiness for smart cities requires several critical steps to be taken. First, there must be high-level coordination among all stakeholders involved in smart cities, including government entities, the private sector, solution providers, and the general population. Currently, Kuwait is lacking in this area, which could hinder its progress towards full-scale smart city development. Additionally, public awareness campaigns are necessary to educate the public and stakeholders about the benefits of smart cities and how they can improve their quality of life. While Kuwait has initiated a pilot project for a smart city, the accompanying awareness campaign was inadequate. In terms of legislation, more work is needed to establish general guidelines and policies for the development of smart cities. For example, the Ministry of Interior (MOI) must draft legislation to regulate the use of autonomous smart mobility solutions. Overall, Kuwait needs to take urgent action to improve coordination, raise public awareness, and develop comprehensive legislation to support its smart city development goals.

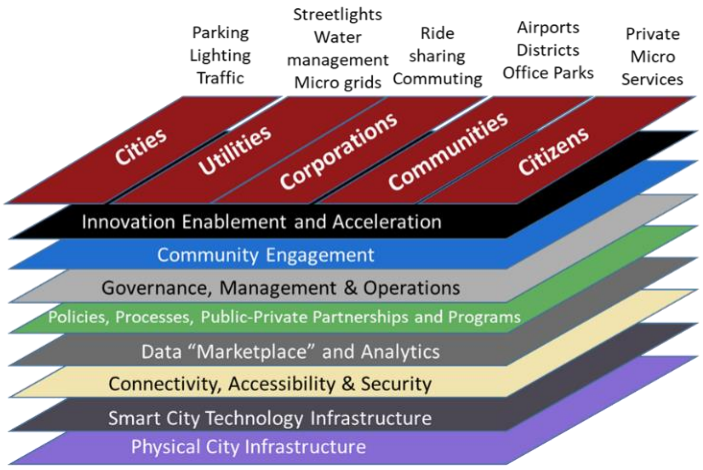


**Figure 8.** Proposed Smart City Ecosystem Framework of GCC Source [34].

## 5. Use and Adoption of Smart Cities

Various studies have investigated the concept of information security and privacy and its significant role in the development of smart city services [46]. It has been acknowledged that the security and privacy of information are crucial factors in the utilization of smart city services by individuals. For instance, [47] explored the continued use of smart cards, user identification systems, and payment systems, as well as individuals' attitudes toward these systems. The data collected from users in a developed country such as Spain revealed that security concerns play a major role in the continuance of users' usage of smart cards. However, the usage intention of smart cards was not primarily based on privacy concerns. The authors' rationale was that the amount of personal information stored on the smart card was limited, thus minimizing privacy concerns. This study recommended that public managers and development organizations issuing smart cards should increase their security measures, as these measures directly affect individual usage. Other studies assert that the success of projects that rely on the masses is based on the trust that individuals have in these service. Moreover, the latter authors examined and assessed the relationship between security, privacy and trust in shared services that the smart cities offer. The study that was conducted in Africa revealed that the security of the private information of the mass systems is mainly related to the trustworthiness of the systems. Hence, the privacy worries of the individuals using smart city services can be mitigated with the enhancement of the trustworthiness of the system. Similarly, a study [46] examined the factors that can contribute toward the mitigation of the security concerns of citizens who are using smart city solutions and public services. The study revealed that there are pressing concerns, such as the confidentiality of personal information, as well as the integrity and availability of the information, were major issues for the individuals. Thus, these findings show that it is important to have legislation and regulations in place that can enhance the protection of information. On a related note, individuals must be aware of the information security control to help protect the data. However, there were varying results on the importance of privacy of information. As per [24], there are varying concerns for individuals when it comes to using and utilizing smart city services. These concerns range from low-level to high-level concerns. Moreover, the study examined how specific technologies such as smart bins, smart parking, and data usage could raise privacy concerns for individuals.



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## 6. Proposed Framework for Smart Cities

The potential for smart city initiatives and frameworks is vast. Among the chief objectives of any nation is the enhancement of the quality of life, which can be accomplished through the development and integration of smart cities. Fig 8 illustrates the recommended smart cities framework for the Gulf Cooperation Council (GCC) nations to follow. This framework was deemed optimal for the GCC countries because several of these nations lack many of the components included in this framework. This framework comprises eight interconnected layers. The foundational layer (or layer 0) is the physical city infrastructure. Several of the GCC countries, such as Kuwait and Oman, have a considerable way to go in developing the physical infrastructure. The physical infrastructure refers to the actual locations and places where the database hardware is located, where to run the connectivity devices, and the sites of the smart devices and sensors, for instance. This would necessitate a commitment from the GCC governments and the ability to make prompt decisions. The second layer is the smart city technology infrastructure. Following the preparation and readiness of the physical infrastructure, the next step is to source and install all the smart city devices, systems, switches, networking cables, sensors, and so on. Although this may seem simple on paper, it is considered the most difficult step as it also requires a substantial investment, which some politicians may view as an unnecessary expense. The third layer is connectivity, accessibility, and security. .

The GCC countries boast a diverse array of mobile network operators, some of which provide services across multiple GCC countries. These operators are capable of delivering the necessary connectivity for smart city technology infrastructure. It is crucial to guarantee uninterrupted access to these systems and to safeguard data security. The data marketplace and analytics layer is characterized by interoperability among all smart city systems, generating vast amounts of data that can be monetized to aid decision-makers in making informed choices. The next layer involves the development of policies, processes, public-private partnerships, and programs by key stakeholders, such as government officials. This ensures that services cater to the needs of both individuals and businesses.

The governance, management, and operations layer necessitates government oversight to guarantee the impartial enforcement of policies and fair private-public partnerships. Effective community engagement with smart city services is a critical objective for governments, as is fostering innovation through the adoption of pioneering ideas to maximize the return on investment in smart cities. Across all the layers, there are the main stakeholders, which are cities, utilities, corporations, communities and citizens. These groups of stakeholders would consume the services that the smart cities offer to individuals and businesses. The services are the facilities that are proposed and initiated through the smart cities for the citizens. As seen from the framework, there is a focus on smart mobility through parking and lighting traffic to make them smart. One of the ideas is to make the traffic lights smart in the sense of using cameras to detect traffic and to allow the movement of vehicles smoothly when there is high traffic, which would also help in reducing the CO2 emissions in the air and gas consumption. Another important service that can be developed is smart waste management to control waste and protect the environment. Governments of GCC countries should also focus on the development of government services, which are being done and focus on smart people. Educating people to use smart city technologies is an important element toward the success of smart city initiatives. Of course, there is a need to develop a full set of policies and procedures for handling smart city technologies. There is an increasing movement toward the use of Artificial Intelligence (AI) among the services that smart cities offer [48]. The lack of policies and procedures governing the use of AI in GCC countries must be addressed, as this is essential for the successful implementation of smart cities. The benefits of implementing smart cities are numerous, including improved quality of life, enhanced governmental efficiency, economic development, and growth, safe mobility, and enhanced public safety. By following a well-designed framework, GCC countries can realize these benefits. For instance, the implementation of smart cities could lead to increased efficiency and productivity, as citizens have more time to focus on their daily lives, and government procedures can be completed on their behalf. Furthermore, the quality of health and well-being of citizens could improve due to reduced stress and anxiety. Additionally, the establishment of businesses, both local and foreign, could increase, leading to economic growth and sustainability of resources. Dubai provides an excellent example of the benefits of implementing smart cities, as it has attracted numerous organizations to establish their operations and headquarters in the region. Overall, the implementation of smart cities in GCC countries could have a positive impact on the economy, public safety, and quality of life.

## 7. Conclusion

Smart cities are the future of the development of urban life, which is becoming key to the success of countries in managing the limited resources that it has. The GCC countries are oil-dependent countries where the need to diversify and conserve resources is even more important. Smart city dimensions can help the GCC countries achieve their goals. All the GCC countries have developed their Smart cities to improve the quality of life. However, there was a lack of attention on smart economy and smart people. To enhance and diversify the sources of the economy, the GCC countries need to improve and develop standards for attracting investors to the country. This can be achieved through the development of rules and regulations that can be easily applied through



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technological solutions to allow foreign investors to come to the country and invest locally. A good example of this initiative is what is deployed in Dubai, where the city has developed an excellent technological framework for investors to bring their operations into the country. To have good smart cities that can fulfill the needs and requirements of the cities, there is a need to develop the infrastructure. A good note to make is that GCC countries are making good progress towards the development of the infrastructure to support the development of their smart cities. Smart cities, hold immense potential to address urban challenges and enhance quality of life. By leveraging data-driven insights and innovative solutions, smart cities can optimize resource management, improve infrastructure, and promote sustainability. However, while smart cities offer numerous benefits, such as efficiency and innovation, they also pose challenges related to privacy, equity, and sustainability. Therefore, the study suggests the need for comprehensive strategies that balance technological advancements with ethical considerations and inclusive urban development principles to ensure the long-term success and resilience of smart cities. Having said the above, there might be a need to conduct a future study that would investigate the development of the businesses and the use of the smart economy dimension, in particular, to develop an environment that is welcoming for both local and foreign investors. In conclusion, GCC countries are riding the wave of smart cities by developing smart cities in their countries, and hence, proper, and correct implementation of the framework is required to ensure its success.

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