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Transformation Model towards Sustainable Smart Cities: Riyadh, Saudi Arabia as a Case Study

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Abstract

The purpose of this research was to create a model that contributes to the transformation of Riyadh into a sustainable smart city, as well as to assess the extent to which Riyadh meets the requirements of smart cities in light of the proposed model. To achieve the study's objectives, the descriptive survey method was used, with a questionnaire that included (30) items to collect appropriate data from the study sample, which consisted of (400) specialists in the field of smart sustainable cities. The study's findings revealed that the model for transforming Riyadh into a smart sustainable city is built on a number of components, including sustainable urbanization patterns, urban systems and domains, data sources and storage services, cloud computing, big data applications and services, and urban communities and their activities. The study's findings also revealed that the developed model's contribution to the transformation of Riyadh into a smart sustainable city was significant, as the arithmetic mean of the respondents' responses to the components of the study model as a whole was high (3.85). Based on these findings, the study recommended that the city of Riyadh review the urban patterns of modern residential neighborhoods and increase their environmental efficiency, as well as expand the establishment of urban observatories that deal with urban and environmental affairs and emphasize their role in the interim review of residential neighborhoods, which supports the city's urbanization path. The study also recommended that the city of Riyadh develop and build massive data centers distributed across several regions, as well as work to enable the use of renewable energy production sources, in addition to consolidating Riyadh's role as a regional center for cloud computing and an attractive technology investment based on innovation in the region.

Keywords

Sustainable Smart City, Transformation Model, Riyadh

1. Introduction

Cities in the twenty-first century use two main approaches to improve life and meet contemporary human and social requirements and needs. The smart city model represents the first as a tool for city improvement. The sustainable city model represents the second approach, which is based on preserving and restoring the resources and energies available to the environment with unexploded health and environmental standards (Aina, 2017). The concept of smart cities emerged a decade ago as one of the manifestations of globalization embodied in informatics and modern technology represented in artificial intelligence technology, which harnessed information and communication technology to serve urban management systems and to solve problems resulting from the explosion of economic and social growth at rapid rates, and the emergence of major environmental problems.

Smart cities are cities that rely on electronic technologies developed during the information technology era, progressing from the digital to the electronic to the virtual. Smart cities are also used to describe creative systems in activities and institutions. The concept of a sustainable city aligns with the United Nations' seventeen goals for sustainable development, also known as the Global Agenda 2030, which is a global vision and call to action to eradicate poverty, protect the planet, and ensure that all peoples enjoy peace and prosperity by 2030. The Kingdom was among the first to commit to and sign the Global Compact for Sustainable Development Goals. This agreement differs from others in that not all 193 United Nations member states, as well as hundreds of thousands of stakeholders, have agreed on a long-term vision for our collective future.

These objectives covered four major areas: the environment, social issues, economic issues, and partnership issues. As a result, it represents a comprehensive roadmap aimed at addressing the root causes of poverty and uniting people to effect positive change for the entire world. This is what distinguishes the sustainable development goals from other goals because it focuses on the inclusiveness of all, as a country cannot work alone to achieve social and economic growth within its borders, but countries must join hands and cooperate to ensure goal achievement and sustainability for the entire world (Morton et al., 2017). The SDGs address a wide range of social, economic, and environmental issues. Despite the fact that the SDGs are not legally binding, governments take ownership of them and create national frameworks to achieve them. As a result, states bear the primary responsibility for following up on and reviewing progress made,

which necessitates the collection of qualitative data that is easily accessible and timely, so that regional follow-up and review are based on analyses conducted at the national level, contributing to global follow-up and review (Niestroy et al., 2019).

According to the State of Saudi Cities Report 2019, the Kingdom's efforts are focused in two directions, namely the path of smart cities and the path of sustainable cities. Regarding the path of smart cities, the Kingdom was eager to harness technology to serve its people, as the Kingdom heavily relies on modern technology. The National Transformation Program, which aims to automate information in all sectors of the country, has been launched, with the goal of increasing the productivity of government institutions and making them more effective and competitive. Concerning the path of sustainability, the Kingdom was one of the first countries to sign the Global Agenda 2030, for the goals of sustainable development, as the Kingdom is committed to implementing the goals of sustainable development and places them at the forefront of its priorities in accordance with their uniqueness and constants. In addition, the Kingdom has also developed many strategies and plans that promote the 17 sustainable development goals, including the revegetation strategy in all regions of the kingdom, including Riyadh.

2. Study Problem

Recently, interest has prevailed in the phenomenon of sustainable smart cities, despite the multiplicity of its terminology and its different aspects, as some countries, their governments and city administrations are seeking to apply the principles of sustainable smart cities and their applications to their main cities in line with global developments in this context (Pilipczuk, 2021). Here it is necessary to get acquainted with the concept of sustainable smart cities and their dimensions, in order to know the possibility of their transformation and their application to the city of Riyadh, so this study came to fill this research gap (Tabassum, 2020). On the other hand, dealing with the rapid urban growth of population and urbanization requires the efficiency of urban areas in the face of the multiple negative effects resulting from traditional urbanization, as the shift towards the sustainable smart cities project in Riyadh has become an urgent necessity, not a luxury (Bakry et al., 2019). Furthermore, sustainable smart city needs smart citizens who participate, interact and benefit from new technologies at the level of the city of Riyadh, allowing them to participate in all aspects of smart life. Therefore, sustainable smart cities idea in Riyadh may face the challenge of citizens' lack of awareness and knowledge of communication technologies, which will affect the functioning of the city in terms of electronic governance and smart city management (Al-Sayed et al., 2022). In this regard, Alqahtany & Aravindakshan (2022) also mentioned that smart cities face a number of economic and social challenges, similar to government initiatives, represented by population and economic demand for increased urbanization, user behavior, conflicting and

multiple goals, and resistance to change and conflicts. These efforts need further clarification, organization and coordination as a comprehensive approach to urban development that combines smart and sustainable urbanization (Alshuwaikhat et al., 2022).

The study's problem is summed up in the fact that Riyadh has begun to apply smart city data, and the efforts are visible in the introduction of sustainable city data, but these efforts did not reach the required level due to the lack of a clear mechanism for the transformation of Riyadh into a smart sustainable city. The Saudi government is working hard in the national development plan that it has approved, hoping that three Saudi cities, Riyadh, Jeddah, and Dammam, will become among the best (100) cities in the world. And because Saudi Arabia has a privileged location on the borders of three continents, Asia, Europe, and Africa, qualifying it to establish a new global city, it is also one of the most important countries in the Middle East, North Africa, and Turkey, and its financial market, Tadawul, is the dominant market in the GCC countries, with a market capitalization of (466) billion US dollars.

Saudi Arabia benefits from its population's passion for technology, as well as its changing demographics—nearly half of the population is under the age of 25—in addition to its economic strength (Alshuwaikhat & Mohammed, 2017). This prompted the Kingdom to take steps toward transforming existing large cities like Riyadh, Jeddah, and Dammam into smart cities. Riyadh has a number of smart projects that rely on technological inevitability in order to improve the quality of life of its residents, stimulate the growth of its private sector, and improve the efficiency and sustainability of its services. Improving its investment attractiveness, global competitiveness, creating job opportunities for its citizens, lowering unemployment rates, stimulating tourism and culture, as a result of expanding the scope of using technical solutions for information and communication systems in various aspects of life, which contributes to facilitating the daily lives of the population and raising the level of service quality in various sectors. Most previous models presented several distinct urban trends for twenty-first-century cities as well as new horizons for the development of future architectural thought.

In addition to its economic strength, Saudi Arabia benefits from its population's passion for technology and supports its changing demographics (nearly half of the population is under the age of 25) (Alshuwaikhat & Mohammed, 2017). This is what prompted the Kingdom to take steps toward transforming existing large cities like Riyadh, Jeddah, and Dammam into smart cities. Riyadh has a number of smart projects that rely on technological inevitability to improve the quality of life of its residents, stimulate the growth of its private sector, and increase the efficiency and sustainability of its services. Improving its investment attractiveness, improving its global competitiveness, creating job opportunities for its citizens, lowering unemployment rates, stimulating tourism and culture, as a result of expanding the scope of using technical solutions for

information and communication systems in various aspects of life, which contributes to facilitating the daily lives of the population and raising the level of quality of services in various sectors. Most previous models presented several distinct urban trends for twenty-first-century cities, as well as new horizons for the development of future architectural thought.

Furthermore, the Royal Commission for Development of Riyadh received the Certificate of Merit as one of the global cities that make contributions that help progress towards the transition to a smart city and contribute to the timely achievement of the goals of sustainable development 2030 AD, as Riyadh is considered a qualified city in partnership with cities that received the Certificate of Merit as one of the global cities that make contributions that help progress towards the transition to a smart city and contribute to the founders intend to establish a global standard for smart cities, but their definition, requirements, and deep analytical concept remain hazy and selective, and do not fit within an organized framework and plan that achieves smartness for the city of Riyadh. In terms of sustainability, Riyadh is one of the three most important Saudi cities that the Kingdom seeks to transform into a sustainable city, and many large projects are being implemented to transform Riyadh into a sustainable city, such as King Salman Park, the sports track, the Green Riyadh project, and the Riyadh Art project, but there are still many challenges, such as the city's current growth, which does not help in sustainable urban formation (Ghneim, 2019).

Cities do not become smart simply by relying on technology, and smart applications do not always contribute to sustainable urban formation; however, smart technology can be used to achieve it and become supportive of it, whether from the community or local government. There is an urgent need to investigate the use of smart methods to evaluate the practical application of urban formation patterns and concepts. In terms of their contribution to the context of sustainable smart cities, there is also a need to investigate better methods of understanding these patterns and concepts of sustainable urban formation with smart applications in order to improve sustainability performance. There have been and are efforts in both aspects of "intelligence and sustainability," but neither has reached the required and hoped-for extent, preventing a systematic transformation of Riyadh into a sustainable smart city that combines digital communication technologies and urban development on the one hand, and the goals of sustainable development "sustainable urban formation" on the other. A sustainable smart city, on the other hand, has its own concept, primary and secondary dimensions, and indicators. Cities, on the other hand, are not smart unless they are sustainable, and Riyadh is no exception.

3. Study Objectives

The study's objectives are to Creating a model that contributes to Riyadh's transformation into a smart, sustainable city. Also, assessing how well Riyadh meets the requirements of smart cities in light of the proposed model. To reach

these objectives, the study proposes two questions: 1) What are the most important model components that contribute to Riyadh becoming a smart, sustainable city? 2) To what extent has Riyadh met the smart city requirements?

4. Study Significance

The significance of the research lies in developing a model that contributes to Riyadh's transformation into a smart and sustainable city, as successful implementation of the proposed model will contribute to economic growth, prosperity, global competitiveness, improving innovation rates, providing better and faster services, as well as transparency and creating great opportunities for various sectors. The current study is also significant because the proposed model will assist decision-makers in developing solid outputs that will lead a global revolution in the green economy, rebuilding, using renewable energy, developing new lifestyles, and benefiting from technological revolutions in critical sectors such as transportation and communications, all of which contribute to reducing harmful emissions into the environment. This improves things, and the proposed model's strategic planning includes developing advanced future visions for Riyadh that meet the needs of future citizens and provide advanced digital infrastructure. Furthermore, the study will provide a unique opportunity to assess and apply the large number of lessons learned from nearly three decades of dedicated research and planning on sustainable cities, development, and implementation, as well as nearly a decade of developing and applying advanced technologies in smart cities to improve sustainability.

5. Study Limitation

The purpose of this study is to develop a model that will aid in the transformation of Riyadh into a smart, sustainable city. The scope of this study was limited to the city of Riyadh.

6. Theoretical Framework

6.1. Smart Cities

Due to the diversity of technical trends, social backgrounds, and the time period in which these definitions appeared since 1997, when the Center for Studies and Technological Research defined a smart city as a "knowledge" city, a "digital" city, or a "eco" city whose services rely on Information and communication technology infrastructure, such as intelligent automated traffic systems, advanced security ma According to Ibrahim et al. (2015), a smart city is a location where individuals, governments, and businesses interact and integrate with smart technology in a coordinated manner, and these various components are linked by the Internet of things, which means that the objects or components of the city become connected to the Internet through sensors and global positioning devices such as "G BS" and others. According to Malih (2017), a smart city is

one that uses information, technology, and communications to improve the performance of various areas such as electricity, water consumption, parking, traffic, and waste management. Cities offer novel approaches to managing complexity, increasing efficiencies, lowering costs, and improving quality of life. Moreover, Yigitcanlar and colleagues (2019) defined smart city as an urban agglomeration with three basic components: a technical foundation, a social foundation, and an environmental foundation. In addition, smart cities are cities that rely on electronic technologies developed during the information technology era, beginning with the digital city, progressing to the electronic city, and finally to the virtual city (Kumar and colleagues, 2020).

Also, smart sustainable city is an innovative city that uses information and communication technology and other means to improve the quality of life, efficiency of urban operations and services, and competitiveness, while ensuring that the economic, social, and environmental needs of current and future generations are met (Winkowska et al., 2019). Therefore, transformation into sustainable smart city aims to meet human needs in the shortest time, with the least effort, and at the lowest cost by predicting the future and preparing to confront it with urban plans that achieve the goals of society in a specific place and time, and then transforming these plans into Urban development projects that meet the requirements of the current generation in terms of the transition to sustainable smart cities. The Kingdom in general, and Riyadh in particular, must adopt a comprehensive approach to urban development that combines smart urbanization with sustainable urbanization, as many cities around the world did before Riyadh, which is considered the capital of the Kingdom of Saudi Arabia, as it is located in the eastern part of the Najd Plateau, about 800 kilometers from Makkah Al-Mukarramah and Al-Madinah Al-Munawwarah, and it is the largest city in the Kingdom of Saudi Arabia, with an area of 1435 square kilometers. It is one of the fastest growing cities in the region, with a population of approximately 9.5 million people in June 2022.

6.2. Sustainable Development

Smart sustainable cities are a long-term initiative based on a set of elements aimed at providing citizens with a sustainable, high-quality environment. of experiments. While the European Union defined a more comprehensive vision for sustainable smart cities, it is based on six elements: smart economy, smart people who represent human and social capital, transparency and smart participation in decision-making, smart transportation based on modern technology, smart environment, and smart life that is concerned with health conditions. and individual safety, as well as enjoyment of educational facilities, housing, and good social cohesion, in order to improve life in urban areas through more sustainable integrated solutions, such as applied innovations, better planning, and smart use of information and communication technology (Haarstad, 2017; Bibri, 2018). According to Garau & Pavan (2018), the human being is the key and he is the one

who manages the intelligence system, interacts with it, and benefits from it, so he is the human element that drives every intelligence system, so the human must coexist with smart city systems effectively, whether as a resident of the city, a worker in one of its devices, or even one of its decision makers. A sustainable smart city, according to the International Telecommunication Union, is an innovative city that uses information and communication technology to improve the quality of life, the efficiency of urban operations and services, and the ability to compete. Smart City Sifa (Sang & Li, 2019). However, Belli et al. (2020) state that while the use of the Internet and technology is part of the concept of sustainable smart cities, it is not the comprehensive concept, as electronic services are part of those cities, but rather a secondary and supportive part, emphasizing that the important part is the applications of sustainable smart cities that try to meet the needs of the user and the resident, for example, in transportation, energy, infrastructure, parking, and so on.

6.3. The Relationship between Smart Cities and the Dimensions of Sustainable Development (The Economic Dimension, the Social Dimension, and the Environmental Dimension)

Smart city concepts are based on issues of sustainability and how to implement them. They also rely on an environmental, economic, and cultural vision with the overarching goal of sustaining the exploitation of renewable natural resources while reducing consumption of limited natural resources (Ahvenniemi et al., 2017). Smart cities invest in technology to promote economic growth, social progress, and environmental improvement. This is an economic and political challenge, not just a technological trend, because this type of city contributes to 65 percent of the global gross product between 2010 and 2025, as people move to cities in search of better opportunities in education and work, as well as higher incomes. Cities generate between 70 and 80 percent of each country's GDP and are the primary drivers of global economic growth. Smart cities have the ability to increase productivity through participant interdependence at the local and international levels, as well as to achieve a serious and fruitful climate, as well as good opportunities for investment in all sectors, as it is considered a stimulating environment for education and creativity, and we contribute to providing a sustainable environment that enhances the feeling of happiness. In essence, economic inclusion, social inclusion, and environmental balance. ICTs have the potential to provide an integrated strategic approach to sustainability, as well as smart sustainable cities, and to become key enablers of urban development (Xie et al., 2019).

Urban studies scholars have widely criticized the technology-centric and neoliberal vision of the smart city for sacrificing the economic, social, and environmental dimensions of sustainable development and focusing on consumer economic growth as the primary, if not the only, requirement for urban development (Glasmeier & Christopherson, 2015; Hollands, 2015; Wiig, 2016). Whereas

growth is envisioned through digital innovation and the digitization of urban infrastructure (for example, smart energy systems and mobility) on the one hand, and the creation of new consumer cultures (for example, the consumption of smart home technologies) on the other, these dynamics undercut hopes, expectations, and claims that a smart city can Supports urban sustainability. This axis will discuss smart urbanism and its relationship to the three dimensions of sustainable development, economic, social, and environmental (Al-Hathloul, 2017).

Critics argue that the smart city vision's primary goal of economic growth is incompatible with the promotion of social justice and environmental protection (Hollands, 2008; Viitanen & Kingston, 2014; Glasmeier & Christopherson, 2015; March, 2018). Financial gains from economic growth are distributed according to the market mechanism, which increases economic inequality between social classes rather than promoting social justice (Piketty, 2014). In the case of smart cities, critics predict that this trend will benefit primarily technology companies, digital economy investors, and highly skilled workers (Hollands, 2015; Söderström et al., 2014). Environmentalists argue that economic growth in Smart Cities is heavily reliant on increased demand for natural resources, hastening environmental degradation (Viitanen & Kingston, 2014). The smart city overestimates the potential of innovations and digital technologies, increasing consumption and demand for natural resources (Kostakis et al., 2015). They argue that economic growth will continue to be dependent on the ever-increasing consumption of natural resources, regardless of the alleged "green" benefits of the smart city's widespread adoption of digital technologies. Intelligence is not expected to reduce resource flows (energy, water, materials) and emissions (carbon dioxide and other waste) from cities to levels that respect the planet's life limits in the absence of detailed studies (Rockström et al., 2009; Steffen et al., 2009, 2015).

Critics of the smart city vision argue that the benefits of digital innovation will be unequally distributed among urban residents, with advantages accruing primarily to the wealthy (Hollands, 2015; Wiig, 2016; Glasmeier & Christopherson, 2015). Many argue that the smart city is part of a broader liberal vision of an urban utopia in which affluent residents live idealized lifestyles of consumer workers while populations lacking the economic resources to live the idealized lifestyles of affluent residents within the smart city are marginalized (Al-Hathloul, 2010). At best, the distribution of economic resources to low-income populations occurs during a downturn. As a result, concerns about the unequal distribution of the benefits of digital innovation arise from the direct and clear incompatibility between the goals of promoting social justice and the emergence of smart cities with two different social classes, marginalizing the broad sector of citizens rather than promoting social justice, and these concerns are exacerbated by wealthy consumers' lifestyles in the city. Smart that rely heavily on natural resources that are incompatible with environmental protection (March, 2018). Citizens, according to proponents of smart cities, are empowered to make better

(i.e., more efficient) decisions based on data generated by smart infrastructure, and they participate in urban governance via digital democracy platforms. Critics argue that citizens, whether voluntarily or unintentionally, become sensors and data sources, and that instead of enabling them to actively participate in the smart city, they are used (as living laboratories) as a tool to activate the role of digital infrastructure (Gabrys, 2014).

The expansion of democratic patterns of urban governance through smart participation has also been called into question, as digital innovation leads to the marginalization of citizens away from effective practices of urban governance, and as global technology companies control the data that always supports and justifies these companies' survival to manage services previously provided by local government. Wiig (2016) cites Viitanen & Kingston (2014). According to Al-Azzam & Alazzam (2019), there is a misalignment between population growth and available natural resources to meet the growing needs of the population in many smart cities. Population growth, the phenomenon of urban expansion, the continuation of migration from rural to urban areas, the spread of the phenomenon of inadequate housing, random urban expansion, as well as an increase in the number of the poor and unemployed, and deterioration of living conditions are all factors. Companies seeking to develop new markets for their products and achieve efficiency savings use a superficial concern for the environment to justify the digitization of urban infrastructure (Gabrys, 2014; Hollands, 2015; Wiig, 2016). At the same time, the smart city vision pays little attention to the ecosystems that are supposed to be protected, both inside and outside the city, because the question of how smart cities will reduce the demands they place on the ecosystems outside the city that provide resources and absorb waste is not addressed.

In smart city visions, urban ecosystems such as green spaces and infrastructure that improve citizens' quality of life while reducing the environmental impacts of urban metabolism are often overlooked (Karvonen et al., 2018). Critics contend that the consumer culture inherent in the smart city vision is incompatible with environmental protection because it drives increasing levels of natural resource consumption and associated environmental damage (Hollands, 2015; March, 2018). Smart technologies' potential environmental benefits, which are expected to reduce the environmental impacts of consumerism, are limited (Viitanen & Kingston, 2014). Furthermore, many smart cities are nearing capacity in terms of pollution and overcrowding (Saba et al., 2020). While Guevara & Auat Cheein (2020) demonstrated that smart cities house more than half of the world's population, consume half of the world's economic output, and generate half of the pollution, these rates are expected to worsen.

6.4. Previous Studies

Abubakar & Aina (2018) presented the concept of a sustainable smart city, the most important of which was highlighting aspects of the smart city and its sus-

tainability elements in modern ways, in order to preserve it from a social, cultural, and environmental standpoint, as well as connecting it to modern systems. The study also addressed smart system and sustainable city standards. To achieve new results and indicators that contribute to the creation of an effective smart city, it is necessary to create a healthy environment for users and to prepare special databases. While the study of Joss et al. (2019) the characteristics of sustainable smart cities as one of the innovations of the information technology era, and the link between the characteristics of those cities and sustainable cities to get to the truth whether smart cities are sustainable cities, and the results of the study showed that the smart city consists of four basic components: networks, databases, and applications, and the citizen, and the smart city meets all the criteria for sustainability.

The study of Trindade et al. (2017) that sustainable smart cities primarily consider the requirements of sustainable development, so they are greener and more sustainable, as the study presented the city of Seoul, South Korea's capital, as a model for a smart city that uses information and communication technologies as a basic infrastructure to improve the performance of services provided, achieve citizen happiness, and raise the quality of life. While Khan et al. (2017) study to highlight the reality of Dubai as a sustainable smart city and a model for developing countries, based on quality of life, smart growth, and smart urbanization, and this should not be achieved without referring to information and communication technology and other means to improve the quality of life, the efficiency of urban operations and services, and the ability to compete while ensuring that it meets the needs of individuals. Dubai evolved through successive historical stages and civilizations until it was influenced by social change, technological advancement, and urban development.

According to the Bibri & Krogstie (2020) study, sustainable smart cities are the most important reality experienced by countries at the moment, differing structurally from other cities. Smart city services are changing in economic, cultural, and social ways. The study also revealed that smart cities are important because they are part of a larger program to modernize cities, including urban planning, the environment, and information technology, and this is accomplished through the use of innovative methods to solve daily problems and meet the needs of its citizens. In ways that improve the quality of life for everyone who lives in these cities. The Aina (2017) study also sought to clarify the importance of the social and economic dimensions in sustainable development, particularly in preserving and sustaining smart cities, which serve as the world's primary engine for economic growth on the one hand, and as the primary beneficiary of their services on the other. Furthermore, in the context of sustainable development, there is constant discussion about resource sustainability and the preservation of current generation rights without prejudice to future generations' rights.

From here, smart cities appear to be one of the mechanisms for protecting the

environment and preserving resources by using technology to stimulate economic growth, promote social progress, and improve environmental conditions. clean, which reduces waste to achieve energy efficiency. Jasrotia's (2018) study clarified the relationship between smart cities and sustainability by emphasizing the smart city's role in advancing sustainable development in sectors such as education, health, energy, and economy, all of which serve as supportive elements for sustainable cities in the long and short term. In addition, D'Auria et al. (2018), it says that the sustainable smart cities environment is a familiar environment with an easy and deliberate single global language, so the private sector and entrepreneurs have become strategic partners in sustainable smart cities technologies, but challenges remain for sustainable cities, the most important of which is the lack of financial resources available to states, pushing them towards private sector partnership due to lack of budgets as a global phenomenon.

Konbr (2019) also emphasized that sustainable smart cities are a must for Egypt 2030 to achieve well-being and quality of life, as the establishment of sustainable smart cities is an unavoidable decision to integrate into the coordinates of the fourth industrial revolution, and it was only an awareness of global challenges, and as an infrastructure to absorb foreign investments, to achieve development. An economic system that provides financing for sustainable cities, as the activation of Egypt's Vision 2030 towards sustainable development stimulates smart city applications to achieve and advance sustainable city standards through technology, and to find innovative economic solutions to provide financial financing to achieve logical goals that suit society, citizen behavior, and can raise employee awareness in Management and the citizen digitally and environmentally.

Rivera et al. (2015) sought to determine the nature of the role played by electronic communication in sustainable smart cities, which have spread widely and coincided with the massive development of communication networks. Because of the importance of information production and efficient use in all areas of societal activity, smart cities are linked to the activation of electronic means of communication. Electronic communication also contributes to the development and diversification of services, as well as the prevention of problems and crises, by providing a forward-looking vision for smart cities based on accurate data analysis.

Bibri (2018) explained in its study that sustainable smart cities are characterized by specifications that differ from other patterns of ordinary cities that do not consider modern technologies as one of their means of operation, which can be summarized in the following points: integration of ICT infrastructure; provide a central administrative device for the Smart City; provide continuous training for users for multi-application smart city characteristics.

According to Albasri (2018), sustainable smart cities are now the ideal model for technological development in the fields of construction, urbanization, and planning. Human life, and the protection of individuals' basic rights and free-

doms from cybercrime, which is one of the negative consequences of this modern development of digital and information technologies.

In summary, the success of the idea of sustainable smart cities lies in the long-term vision, as the responsibility lies with the government, companies and citizens alike by moving forward with an integrated system of smart solutions, as it is the only way to integrate sustainability and intelligence side by side. Numerous studies have shown that the transformation into a sustainable smart city is not limited to the technical side only, because the promotion of innovation and institutionalization includes multiple beneficiaries that require building relationships across groups that are able to contribute to improving the current situation. Whereas, the purpose of establishing a system of partnerships around smart sustainable cities is to bring diverse beneficiaries to discuss goals, procedures, policies and financing mechanisms for the adoption of new technologies that can ultimately benefit the city as a whole, as any innovation system that seeks to find win-win solutions would encourage the launch of specific initiatives for smart sustainable cities. Despite the trend in most cities towards building sustainable smart cities to raise the rates of economic growth, social welfare and sustainable development, these endeavors are hampered by serious obstacles on the way to transforming the concept of smart societies. Where we conclude that these cities face a group of common global challenges, such as the absence of a comprehensive definition of a sustainable smart city to encompass the general features of these cities, which make them part of the comprehensive national strategy and compatible with local reality. This is in addition to the exorbitant cost, limited economic resources, lack of qualified human resources to develop and invest in information and communication technology, as well as the absence of a legislative framework that contributes to controlling smart city applications, and problems of privacy violations. It seemed clear that smart sustainable cities have become a model for what cities of the future should look like, and synonymous with urban development as it seeks to invest in technology to stimulate economic growth, promote social progress, and improve environmental conditions. Therefore, the process of establishing sustainable smart cities requires the availability of an intelligent human element capable of employing, using, and even developing and improving modern technology.

Most of the previous studies presented several distinct urban trends for the cities of the twenty-first century and new horizons for the development of future architectural thought, as smart sustainable cities today represent the ideal model of technological development in the field of construction, reconstruction and planning, as they have achieved significant achievements in the era of technology and modern information. However, these models differ in the rationality of each of them to reduce costs and consumption of resources and energy, and to engage more effectively and realistically with human activities and social needs through their impact on the quality of life. This necessitated the attempts of this study to find solutions to integrate the previous models into a unified model in

order to meet those requirements, activities, and the social and human needs, to make it more prepared to face the economic, environmental and social challenges. It also requires determining the level of current ICT usage, and identifying existing governance mechanisms that will allow for efficient and effective management of solutions in smart sustainable cities.

7. Proposed Study Model

The Greenfield & Brown Field model, as well as a theoretical logical model for transformation towards smart sustainable cities, served as the foundation for the study model. The Greenfield and Brown Field model divides the transformation process into phases, which are further subdivided. These frameworks' most common phases are: planning phase, initiation phase, design phase, delivery phase, integration phase, conversion phase, and operation phase. However, the proposed sub-phases vary from framework to framework. For example, the framework's main stages can be divided into a number of sub-stages, such as the development of a strategy for international cooperation, business cases, improvements to the economic, social, and environmental pillars, strengthening the city's network infrastructure, and providing electronic services to citizens. Each existing transformation framework approaches the transformation process from a unique perspective based on the needs and characteristics of the city in which it will be implemented (Ibrahim et al., 2015).

Greenfield cities are built from the ground up on wasteland, as these areas are usually identified a little away from the city area where the field of development appears possible, and those areas are identified after comprehensive studies about them, usually those areas have never seen any kind of development before. Because the primary goal of creating new societies is represented in the process of raising the social, economic, and cultural level, and thus can overcome the problems posed by reality in the traditional society, the process of creating new societies is based on bringing about a series of comprehensive changes that are within the framework of studied scientific foundations.

Greenfield cities are built from the ground up on wasteland, as these areas are usually identified a little away from the city area where the field of development appears possible, and those areas are identified after comprehensive studies about them, usually those areas have not seen any kind of development before. The process of creating new societies with integrated aspects is based on bringing about a series of comprehensive changes that are within the framework of studied scientific foundations, because the primary goal of creating new societies is represented in the process of raising the social, economic, and cultural level, and thus can overcome the problems posed by reality in the traditional society.

Moreover, EPIC transformation framework towards sustainable smart cities indicates the need to improve service delivery to ensure that citizens' needs are brought to the fore. This usually includes several principles, including connec-

tivity, data exchange, back-office operations, service delivery systems, city governance processes, and exchange of management information. The application of this model contributes to raising the level of population satisfaction, providing decent livelihoods, improving the efficiency of city management, and reducing negative environmental impacts, as well as being an important means for attracting internal and external investments, creating job opportunities, preserving the city's natural resources and raising its efficiency by preserving its assets. EPIC roadmap for smart cities is based on five axes that are the development of an integrated and smart city with the improvement of mobility and digital communication systems, a commitment to developing a dynamic future city that takes into account issues of energy efficiency, waste management, water resources, and climate change, harnessing human capital to empower entrepreneurs and promote innovation and prosperity, promoting a young city that continuously involves youth in the development process, and encouraging the population to positive and fruitful work (EPIC, 2013).

In addition, Choi & Song (2022) provided a foundational framework that analytically links city development, sustainability, and ICT, and shows how and to what extent sustainability and ICT have become influential in city development. This framework primarily aims to orient urban actors in their practices towards sustainability and analyze their impact. Also, Blasi et al. (2022) illustrated that smart sustainable cities of the future can be viewed as a holistic approach to urban development that seeks to bring together sustainable cities and smart cities as urban endeavors in ways that address and overcome major shortcomings in terms of their contribution to the SDGs. This happens by integrating and utilizing what each concept offers to achieve sustainability in terms of the spread of computing, advanced information and communication technology, design concepts and planning principles, with the pure aim of promoting sustainability in a computerized and civilized world. Moreover, El-Hallaq et al. (2019) developed a GIS web-based 3D model to promote sustainable urban development, including buildings, services and other facilities, as it creates a visualization of data on a map for immediate, actionable insights, and uses these insights to track city service delivery and highlight areas where local council services need improvement.

Furthermore, Bibri (2021) developed a novel model for data-driven smart sustainable cities, which includes offering new services and providing more job opportunities, and making improvements in the ways of resource allocation and use, innovation and opportunities for pioneering business projects that will positively affect the economy as a whole. In light of this model, cities will be able to highlight and invest in their smart and sustainable capabilities to enhance their competitive advantages related to their geographical location in order to attract new investments and competencies. At this stage, cities can be designed in a way that considers the requirements of preserving the environment through measures that lead to waste reduction, carbon footprint reduction, and the use of re-

newable energy sources. Also, this model seeks to put forward initiatives and project plans to bring about the desired transformation towards a sustainable smart city. This change includes services, energy and water networks, systems, economic tools, governance, and agreements.

Infrastructure, transportation, communications, financial services, urban planning, and electricity are the six "pillars" on which the development strategy is built. While a theoretical logical model for Smart Sustainable Cities generates initiatives and project plans to bring about a change in the city's life, and this change in the city leads to the desired transformation towards the smart sustainable city, and in general, it is possible to distinguish This model requires four types of changes to be activated, and these concerns about change lead to a strong orientation toward development. Clear and appropriate technological change is required, with examples including appropriate design, emerging technology, and environmental interoperability. Adoption of modern technology, such as cloud virtualization, network platforms (Web Platform), and cloud service systems, is usually advised (Sass, Laas). With an emphasis on service integration. It is also recommended to incorporate smart technology whenever possible. The Internet of Things and RFID identification are also part of this technology. Speech recognition, open data applications, multimodal sensors, and location-aware applications are just a few examples. The emphasis in a smart city may not be on industry, but industrial change cannot be ignored, and there are many aspects of technology that are required for the basic operations of a smart city that are not necessarily information technology.

It is necessary to encourage technology developer networks and put pressure on them to standardize sensors used in service provision, energy and water networks, and all smart city applications. In addition to large-scale applications, it is usually recommended to encourage the collaboration of large corporations and major cities. Social change may be the most difficult to achieve. This is due not only to the difficulty of reconciling human nature with human factors in order to achieve social change, but also to the fact that economic change is inextricably linked to other types of change, such as economic, cultural, educational, and others. The fundamental elements of social change are behavior, routines, values, preferences, requirements, users, and so on. Reduced spending on information technology, security, disaster management, service continuity, and strengthening the curve of higher education are also strategic goals of social change. Policy changes are also important because they indicate the need for the city government to change its policies. This transformation includes systems, economic tools, governance, agreements, and legislative and legal amendments to develop policy proposals. This study concluded, based on the global models mentioned above, with a set of mechanisms that must be included in the study model, as shown in **Figure 1**, in order to contribute to Riyadh's transformation into a sustainable smart city.

Depending on **Figure 1**, the study form consists of the following components:

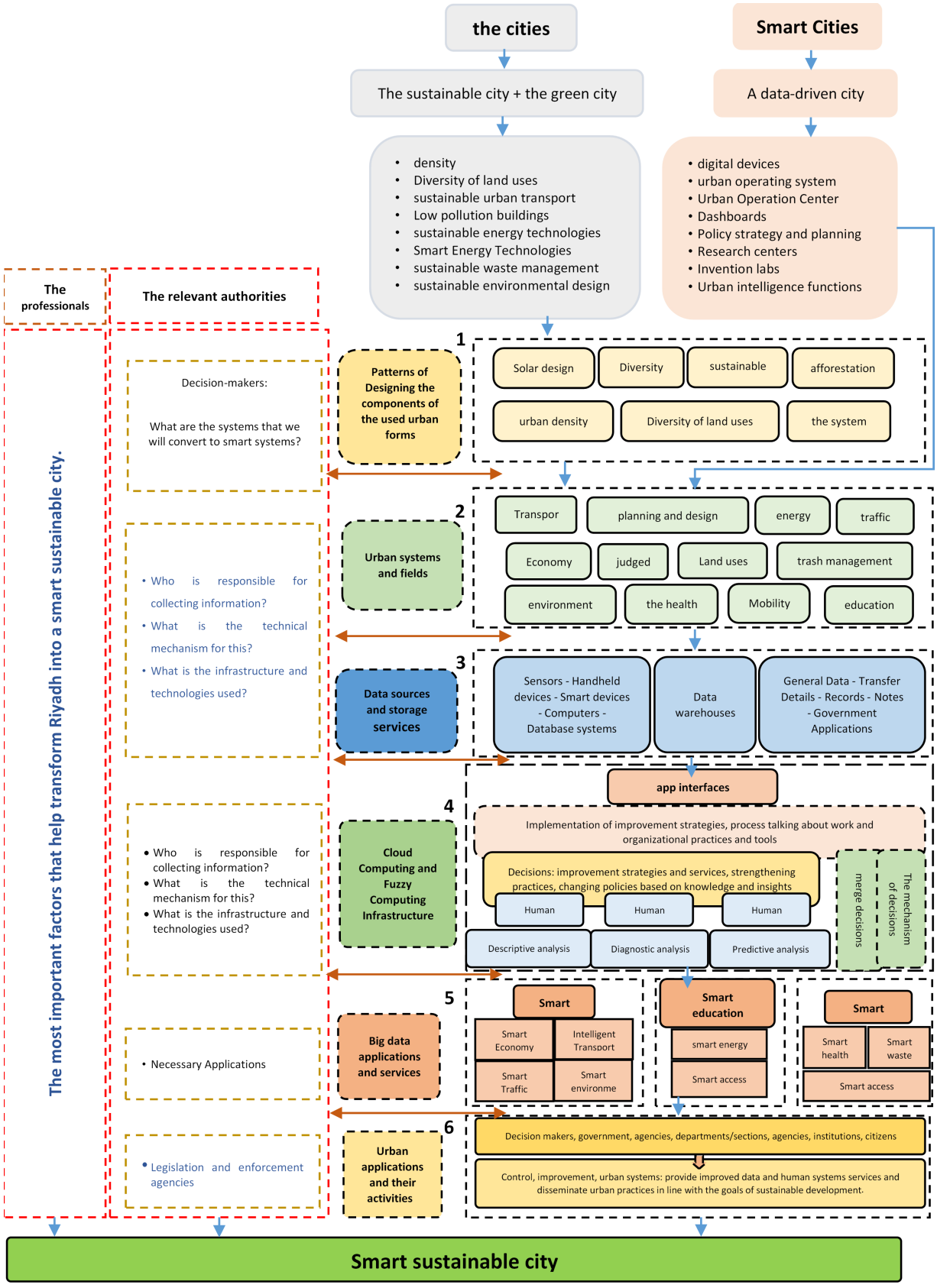

Figure 1. The proposed research model.

1) Patterns of sustainable urbanization:

Sustainable transportation, greening, and passive solar design as design concepts, are major strategies for achieving the required level of sustainability in the context of sustainable urban forms (compact city, eco-city, green urbanization, new urbanism, afforestation diversity, solar design). As a result, these urban components must be supported by high environmental and urban management standards, with the long-term effects of these patterns and concepts including transportation savings, travel behavior, mobility, accessibility, energy efficiency, pollution reduction, economic viability, quality of life, and social justice. Because Riyadh is characterized by a changing and complex template that contains a number of human activities and is vulnerable to environmental impacts, specialists and decision-makers are urgently needed to develop and innovate a new form of comprehensive and monitored urban planning. To achieve a sustainable city, we must first understand the relationship between people, services, transportation policy, and energy products. As a result, decision-makers' roles revolve around translating desired developmental directions into sustainable urban patterns that use urban planning as a mode of operation, style, and performance, by developing sustainable urban planning policies and strategies that consider the dimensions that control land use methods to address the problem of population growth and density, economic blocs and their monopolies, and environmental pollution in all its forms Negative.

2) Urban systems and domains:

Many systems and domains must operate and be managed using advanced information and communication technologies, such as big data analytics and context-aware computing as a group of advanced technologies and their new applications, as well as working together with the aforementioned design concepts and patterns above, resulting in heterogeneous and massive amounts of data being available as inputs for big data and context-aware computing. In its diversity, scale, and velocity, urban data is always labeled spatially and temporally, is largely streamed from various perceptual sources and stored in databases, is generated routinely and automatically, and is consolidated and aggregated into data warehouses for city-wide use. As a result, this component includes various sectoral and cross-sectoral sources of urban data of various types and sizes that are collected, stored, and retrieved for processing, analysis, dissemination, and sharing across the information landscape to support urban processes, functions, services, practices and policies, systems, and urban domains in smart sustainable cities. Transportation, education, energy, governance, mobility, the environment, waste management, land use, planning and design, economics, traffic, and health are all topics covered. As a result, the specialists' and decision-makers' roles revolve around finding solutions to the problems plaguing Riyadh's urban areas, which includes changing the patterns currently used in designing and implementing the urban environment to make it more sustainable. A comfortable way of life for citizens, with an emphasis on reducing resource

consumption and encouraging economic growth and stability. Adopting sustainability as a comprehensive methodology for evaluating urban projects and working to apply their concepts as much as possible is sufficient to ensure economic growth continuity.

3) Data sources and storage services:

The relationship between systems, urban areas, and data sources is critical because this model demonstrates the concept of integrating physical elements of urban areas using big data sources and applications, from which urban data flows as a result of digital devices associated with IoT in terms of hardware. connected to physical and digital objects scattered across urban environments. As a result, data streams are stored, managed, processed, and analyzed using cloud computing or fog/edge computing solutions, and the analytical results produced by these processes are intended to support decisions, automate them, and improve services. This model aims to improve and support smart decisions regarding processes, functions, services, strategies, and policies in this context. This component includes data warehouses, data warehouses, and public data silos for data collection, storage, and management. Warehousing, as a method used in the urban field, entails the consolidation of data from various databases, which are then maintained as distinct urban units with brief historical information.

Cloud storage can also be fully virtualized, and all devices are completely transparent to urban components as cloud users, who can connect to cloud storage over the network, enabling storage equivalent to full cloud storage capacity and linear performance and capacity expansion. The added value of combining cloud storage with intelligent compression methods lies in the ability to efficiently store all types of big data and context information that belong to the domains of smart sustainable cities. The Communications and Information Technology Commission is the entity in charge of regulating the Kingdom of Saudi Arabia's communications and information technology sector. As a result, it works to improve the quality of services provided, their performance, and the level of networking and interaction between them by utilizing information and communication technology (ICT). It also aims to reduce burdens, conserve resources, and improve communication. between citizens and government service centers.

The adoption of a smart device policy ensures that relevant data is identified and put into service, so urban planning experts must specify the data they want to measure. Given the large amount of data that can be measured, they must select a sample of the data based on the smart city's priorities and the decisions that are about to be made. As a result, the stage of designing and analyzing data should occur early in the preparation of smart sustainable city programs, because decisions about the type of data that should be collected may affect the design of the city or some of its systems. In order to accommodate the growing large volumes of data, planners and decision makers must visualize the data storage mechanism in addition to collecting it.

4) Cloud computing:

To achieve seamless interoperability between wireless technologies, the relationship between cloud computing and data sources necessitates adaptable access technologies and advanced architectures. In terms of middleware, innovative pervasive computing applications will allow citizens, urban entities, sensors, and application servers to interact within existing physical service environments, which will necessitate a well-designed, standardizable architecture for managing urban data associated with urban context information. It is expected that interoperable information management will take some time to achieve and disseminate in the context of smart sustainable cities. This component is dedicated to the processes of knowledge discovery, data mining, and context information. Subprocesses involved in knowledge discovery include selection, preprocessing, transformation, mining, interpretation, and evaluation.

Data mining subprocesses include data comprehension, data preparation, modeling, evaluation, and dissemination. These two processes, which aim to discover new knowledge or extract useful knowledge from large sets of data, share urban domains and sub-domains related to sustainability. The knowledge discovered or extracted includes intelligence functions and deep insights, and it is the result of Hadoop MapReduce data processing and management on the cloud. That strategic decisions are used in terms of control, management, and optimization depending on the domain of application (for example, traffic systems vs. energy systems), and deep insights revolve around specific trends, gaps, and weaknesses related to different urban systems and domains in relation to their performance in line with the Sustainable Development Goals, and thus related to urban planning, design, development, and governance in terms of improving practicability.

The relevant authorities (Communications and Information Technology Commission) seek to encourage government agencies to use cloud computing services by establishing a clear framework for the digital transformation of information technology and e-government services via the cloud and facilitating more rapid uptake of cloud services. It also addresses the role of stakeholders in ensuring consumer protection, rights retention, and service satisfaction by establishing a governance framework and defining obligations for cloud service providers to ensure basic protection of consumer rights and interests. She also emphasized that one of the policy's main goals is to define a clear direction for Riyadh's future in cloud services as part of the digital transformation plans and long-term national plans, as well as to set a national vision and clear goals for the development of national cloud computing.

This component is dedicated to processing inputs that describe the processes involved in urban contextualization, such as data collection, pre-processing, analysis, representation, inference, decision-making, and action, where urban contextualization is associated with purpose-oriented functions (decision support, automation of process controls and tools operational, service provision), as

well as the results of this information carried. Inferential algorithms infer higher-level abstractions of urban contexts using descriptive logic, probabilistic logic, logical programming, rule-based logic, or the integration of these or other forms of logic from the semantic web. Based on sensor observations and dynamic models, these algorithms are used to generate new knowledge about the current state of affairs in urban systems and citizens. Contextual modeling and inference, depending on the application domain, aid in the collection, evaluation, and dissemination of urban context information in pervasive computing environments. The support that inferences about urban context information can provide, as well as the actual performance of these inferences, are where current approaches to information modeling differ. Furthermore, the inputs to urban context information processing are derived from data routinely collected from multiple sources and formats of sensors over time about various situations, events, environmental conditions, settings, and activities.

5) Big Data Applications and Services:

Cloud computing is a key enabler of big data, where the analytical and computational outputs of data mining processes and inference mechanisms are intended, supported, or automated to varying degrees depending on the scope of the application. Big data analysis and context information processing as a set of computational processes aimed at optimization and decision support and related to the control, management, and enhancement of urban operations. Services concern the operation of the city and its executive management in terms of infrastructure, facilities, and resources, as well as city services aimed at improving citizens' quality of life and well-being in the context of sustainability. This component includes a variety of applications centered on sustainability-related data for various urban areas. Depending on the type of urban sustainability problem to be solved, an application typically includes many solutions related to different sub-domains of each urban domain.

To put it another way, these data-centric applications include system behavior, service delivery, practice improvement, strategy and policy change, and the implementation of improvement strategies, action processes, practices, policies, and organizational tools. As a result, it implements actions, provides services, disseminates practices, and issues policies based on the type of decision made based on useful knowledge or extracted from data, which includes varying degrees of human intervention (input), depending on the type of analysis method used to address the problem of urban sustainability. This component includes various strategy and decision support systems in conjunction with urban processes, functions, services, designs, practices, and policies. In terms of practices and policies, the emphasis is on smart planning, design, development, and governance in terms of using big data analytics to improve practices and policies through a more accurate representation of reality, to determine which of them fail to achieve the desired or desired changes in relation to the SDGs, and to act accordingly.

In other words, the focus is on the control, automation, management, and improvement of urban systems as a set of operations, regulation, efficiency, and enhancement of the ecosystem and human services, which includes smart planning, smart transportation, smart environment, smart traffic, and others. This component also includes a number of necessary applications that initiate the execution of actions and the provision of services in accordance with decisions made based on the conclusions reached regarding urban processes, functions, and services relevant to the SDGs. A context-aware application, like a big data application, typically includes a number of solutions related to various subdomains of each urban domain, depending on the desired intelligence function in relation to urban systems and citizens. Context-aware applications, in other words, include system behavior, service delivery, and decision support. This component also includes the implementation of optimization strategies and action processes in relation to system performance and the provision of urban services. System behavior and decision support are concerned with the control, management, and optimization of urban systems, such as the operation and regulation processes of urban life, while service delivery is concerned with ecosystem enhancement and human services. It should be noted that while big data and context-aware applications provide different types of services and involve different types of decisions, they overlap in the context of urban sustainability domains, implying that they share the same basic enabling technologies.

6) Urban communities and their activities:

The synergy between urban communities and their activities based on big data technologies and their applications, as well as sustainable urban strategies, has become a reality, and as a result, a shift toward sustainable smart urbanization is required. This component includes various urban stakeholders who use big data technologies and thus benefit from applications related to various aspects of urban sustainability. These applications offer numerous advantages to various urban entities, such as government, authorities, administrators, departments, companies, agencies, and citizens, in terms of control, improvement, management, planning, development, governance, and service enhancement. The ultimate goal is to contribute to the Sustainable Development Goals by deploying advanced solutions to address a wide range of challenges and problems affecting the long-term health and efficiency of smart sustainable cities, as well as the quality of life of their citizens, thereby improving various aspects of sustainability. Many actors are involved in the transformation process, including urban designers, policymakers, technology companies, and governments, with the goal of integrating traditional principles with contemporary needs and offering a new vision to rethink how cities are designed, built, and managed. The implementing agencies' role in the city of Riyadh is to link the organizational charts with the regional plans and the national strategy in order to determine the size and direction of urban expansions, as well as their general functions, based on the relationship between urban agglomerations and their activities. Concentrate on your

strengths, understand and strengthen your weaknesses, seize available opportunities, and avoid obstacles and limitations. This is in addition to the preservation of valuable lands (historical areas and agricultural lands) and the avoidance of settling uses.

8. Procedures and Study Methodology

The descriptive survey method was used in this study. This type of research necessitates the selection of an entire study population or a study sample representative of the majority of the community. The goal is to describe the phenomenon's nature. Members of the research community or a large group of them, with the goal of describing the studied phenomenon solely in terms of its nature and degree of existence, without going beyond that to study the relationship or deduce the causes, for example (Al-Qahtani et al., 2020). Survey research is also defined as a research method that involves gathering information and data on a phenomenon or incident with the goal of identifying it, determining its current status, and identifying its strengths and weaknesses in order to determine the validity of this situation or the extent to which partial changes are required (Al-Assaf, 2012). Survey research is one type of descriptive method, and this type of study is distinguished by its breadth and comprehensiveness, as it covers a large number of cases in order to define reality, diagnose it, accurately describe it, and evaluate it. In this work, the researcher employs statistics and data that he attempts to collect and categorize, as well as its analysis (Al-Qahtani et al., 2020).

8.1. Study Population and Sample

All specialists involved in projects to transform Riyadh into a sustainable smart city are included in the study population. Normally, the size of the questionnaire study sample is 10% of the total study population; however, due to the large size of this category, the appropriate sample size for the questionnaire in those cases is 380 (Rahi et al., 2019). As a result, in this study, the questionnaire was designed and distributed to the study sample, which consisted of (400) smart sustainable cities specialists.

8.2. Study Tool

The questionnaire was designed for the purpose of providing data related to the study after considering the opinions of a group of researchers and writers in the field of the subject of the study, with the goal of obtaining primary data to complete the applied side of the study. The questionnaire was divided into two sections: The first section is concerned with the demographic variables of the study sample, which include gender and age. The following is the second section: It was divided into four sections: sustainable urbanization patterns (five paragraphs), urban systems and fields (five paragraphs), data sources and cloud computing (ten paragraphs), and big data and its applications in urban communities (five paragraphs) (ten paragraphs). **Table 1** depicts the questionnaire's

Table 1. Axes of the questionnaire and its paragraphs

Axis	Axis vertebrae
Sustainable urbanization patterns	• The city of Riyadh is watching its steady population growth expected in the coming years. • The city of Riyadh is developing urban projects capable of helping citizens, businessmen and civil organizations. • The city of Riyadh seeks to raise the level of quality of life and preserve the environment and its natural resources that achieve sustainable environmental security • The city of Riyadh follows strict building instructions for thermal insulation and operates the city using renewable energy. • The city of Riyadh adopts the initiatives of afforestation, environmental protection, preservation of vegetation cover and combating desertification.
Urban systems and domains	• The city of Riyadh works to improve the infrastructure, including water, energy, information and communications, transportation, public utilities, buildings, waste management, and others • The e-government program in the city of Riyadh contributes to citizens' access to government services anywhere and on any mobile device. • The city of Riyadh works to develop and maintain public facilities and pay attention to the safety and security of pedestrians. • The city of Riyadh supports its residents in defining their priorities and needs, in order to establish innovative and pioneering projects. • The city of Riyadh applies safety and health measures to ensure the proper functioning of the city.
Data sources and cloud computing	• The city of Riyadh uses the infrastructure of information and communication technology in order to facilitate interaction between citizens and the relevant government institutions. The city of Riyadh adopts wireless sensors to measure air quality, temperatures, wind speed, and traffic congestion in the city. • The city of Riyadh is working on developing digital government services in the city. • The city of Riyadh uses modern technologies to anticipate crisis management and security and economic risks. • The city of Riyadh seeks to integrate the smart services of various government agencies so that citizens can complete their services. • The city of Riyadh seeks to update policies and practices related to the use of information and communication technology in the city. The city of Riyadh adopts electronic platforms to improve the quality of services provided to citizens. • The city of Riyadh implements a set of procedures aimed at allocating resources optimally. The city of Riyadh follows modern devices to collect information and data spread throughout the city. The city of Riyadh works to change policies based on knowledge, visions, and the interest of citizens.

axes and paragraphs.

9. Results

The questionnaire tool was distributed to 400 specialists in projects to transform Riyadh into a smart sustainable city in order to evaluate the contribution of the developed model in the transformation of Riyadh into a smart sustainable city. The outcomes were as follows:

Table 2 shows the relative distribution of the study sample individuals based on demographic variables (gender, age), revealing that the number of males in the study sample was (213), with a percentage of (53.3 percent), and the number of females in the study sample was (187), with a percentage of (46.7 percent). It is also clear that the age groups 30 - 39 years had the highest frequency, as the number of respondents in this age group reached (94) with a percentage of (20.5

percent), and the number of respondents aged 20 - 29 (79) with a percentage of (17.2%). The total number of respondents aged 40 - 49 was (86), with a percentage of (19.0 percent). The number of respondents between the ages of 50 and 59 was (73), with a percentage of (15.8 percent). Finally, the number of respondents older than 60 (68), with a percentage of (14.5 percent), ensures that all ages are represented in the city of Riyadh.

9.1. The Results of the Descriptive Statistical Analysis

The respondents' responses to the study elements were extracted using arithmetic means and standard deviations, with the questionnaire consisting of six basic components for the transformation of Riyadh into a sustainable smart city, which are sustainable urbanization patterns, urban systems and areas, data sources and storage services, cloud computing, big data applications and services, clusters urbanization and its activities, as shown in Table 3.

According to Table 3, the level of evaluation of the developed model's contribution to the transformation of Riyadh into a sustainable smart city was high, as the arithmetic mean of the respondents' responses to the components of the

Table 2. The distribution of sample members according to demographic variables.

Variants	Class	Repetition	Percentage (%)
Sex	male	213	53.3
	female	187	46.7
Age	30 - 39	79	17.2
	40 - 49	94	20.5
	50 - 59	86	19.0
	60 and older	73	15.8
	30 - 39	68	14.5

Table 3. The arithmetic means and standard deviations of the respondents' responses to the study elements.

Axis number	Axis	SMA	Standard deviation	Class	Arrangement
1	sustainable urbanization patterns	3.82	0.835	High	**6**
2	urban systems and domains	3.84	0.841	High	**4**
3	Data sources and storage services	3.86	0.825	High	**2**
4	Cloud Computing	3.84	0.814	High	**4**
5	Big data applications and services	3.86	0.839	High	**2**
6	urban communities and their activities	3.89	0.798	High	**1**
	Total average	**3.85**	**0.776**	**High**	

study model as a whole was (3.85), and the arithmetic mean ranged between (3.82 - 3.89). The previous table shows that the axis of urban communities and their activities had the highest arithmetic mean (3.89) and standard deviation (0.798), indicating a high score, while the axis of sustainable urbanization patterns had the lowest arithmetic mean (3.82) and standard deviation (0.835), indicating a high score as well. The arithmetic means and standard deviations of the sample's responses to each element of the study were calculated to identify the level of evaluation of the developed model's contribution to the transformation of Riyadh into a smart sustainable city in each of the questionnaire phrases, as shown in the first axis of Table 4.

The arithmetic means of the study sample's responses to the sustainable urbanization patterns axis ranged between (3.70 - 3.90) with a high degree of appreciation, as shown in Table 4. The table also states in the third paragraph, "The city of Riyadh seeks to improve the quality of life while preserving the environment and its natural resources." Those who achieve long-term environmental security" received the most votes, with an average of (3.90) and a standard deviation of (0.988). It has a value of (3.70) and a standard deviation of (1.200), and the average is also high.

To determine the level of evaluation of the developed model's contribution to the transformation of Riyadh into a smart sustainable city in the phrases of the second axis (urban systems and domains), the arithmetic means and standard deviations of the sample responses were calculated on each of the phrases of the second axis of the developed model's components, as shown in the axis. The second example is from Table 5.

The arithmetic means of the study sample's responses to the urban systems

Table 4. The arithmetic means and standard deviations of the respondents' responses on the first axis (sustainable urbanization patterns).

phrase number	phrase	SMA	Standard deviation	Class	Arrangement
1	The city of Riyadh is watching its steady population growth expected in the coming years.	3.70	1.200	High	5
2	The city of Riyadh is developing urban projects capable of helping citizens, businessmen, and civil organizations.	3.87	1.004	High	**2**
3	The city of Riyadh seeks to raise the level of quality of life and preserve the environment and its natural resources that achieve sustainable environmental security.	3.90	.988	High	**1**
4	The city of Riyadh follows strict building instructions from thermal insulation and operates the city using renewable energy.	3.79	1.007	High	**4**
5	The city of Riyadh adopts the initiatives of afforestation, environmental protection, preservation of vegetation cover and combating desertification.	3.83	1.054	High	**3**
	The average of the first axis	**3.82**	**.835**	**High**	

Table 5. The arithmetic means and standard deviations of the respondents' responses on the second axis (urban systems and domains).

phrase number	phrase	SMA	Standard deviation	Class	Arrangement
1	The city of Riyadh works to improve the infrastructure, including water, energy, information and communications, transportation, public utilities, buildings, waste management, and others.	3.74	1.080	High	**5**
2	The e-government program in the city of Riyadh contributes to citizens' access to government services anywhere and on any mobile device.	3.91	1.057	High	**1**
3	The city of Riyadh works to develop and maintain public facilities and pay attention to the safety and security of pedestrians.	3.84	1.024	High	**3**
4	The city of Riyadh supports its residents in defining their priorities and needs, in order to establish innovative and pioneering projects.	3.82	1.037	High	**4**
5	The city of Riyadh applies safety and health measures to ensure the proper functioning of the city.	3.87	1.038	High	**2**
	The average of the second axis	**3.84**	**.841**	**High**	

and domains axis ranged between (3.74 - 3.91) with a high degree of appreciation, as shown in Table 5. The table also shows that the second paragraph, "The e-government program in Riyadh contributes to citizens' access to government services anywhere and on any mobile device," received the highest response, with an average (3.91) and a standard deviation of (1.057).

It is also noted that the first paragraph, "Riyadh City works to improve infrastructure, including water, energy, information, communications, transport, utilities, buildings, waste management, etc.", has received the lowest average calculation (3.74) and standard deviation (1.080), the average indicates a high degree as well.

To determine the level of evaluation of the developed model's contribution to the transformation of Riyadh into a smart sustainable city in the third axis phrases (data sources and storage services), the arithmetic means and standard deviations of the sample responses were calculated on each of the third axis phrases of the components of the developed study model, as shown in the third axis of Table 6.

According to Table 6, the arithmetic averages of the study sample's responses to the data sources and storage services axis ranged between (3.75 - 3.92) with a high degree of appreciation. The table also shows that the second paragraph, "The city of Riyadh adopts wireless sensors to measure air quality and temperatures, wind speed, and traffic congestion in the city," received the most responses, with an average of (3.92) and a standard deviation of (1.001). "competent government" has the lowest arithmetic mean of (3.75) and a standard deviation of (1.050), and the mean also indicates a high degree.

To determine the level of evaluation of the developed model's contribution to the transformation of Riyadh into a smart sustainable city in the phrases of the fourth axis (cloud computing), the arithmetic means and standard deviations of

the sample responses were calculated on each of the phrases of the fourth axis of the components of the developed study model, as shown in the second axis from Table 7.

According to Table 7, the arithmetic averages of the study sample's responses to the cloud computing axis ranged from (3.76 - 3.90), indicating a high level of appreciation (3.34 - 3.54). "All over the city" received the most votes, with an average of 3.90 and a standard deviation of 0. (1.031). The lowest arithmetic mean (3.76), as well as the standard deviation (1.025). The mean also indicates a high score.

To determine the level of evaluation of the developed model's contribution to Riyadh's transformation into a sustainable smart city in the fifth axis phrases

Table 6. The arithmetic means and standard deviations of the respondents' responses on the third axis (data sources and storage services).

phrase number	phrase	SMA	Standard deviation	Class	Arrangement
1	The city of Riyadh uses the infrastructure of information and communication technology in order to facilitate interaction between citizens and relevant government institutions.	3.75	1.050	High	**5**
2	The city of Riyadh adopts wireless sensors to measure air quality, temperatures, wind speed, and traffic congestion in the city.	3.92	1.001	High	**1**
3	The city of Riyadh is working on developing digital government services in the city.	3.91	1.047	High	**2**
4	The city of Riyadh uses modern technologies to anticipate crisis management and security and economic risks.	3.88	1.021	High	**3**
5	The city of Riyadh seeks to integrate the smart services of various government agencies so that citizens can complete their services.	3.83	1.037	High	**4**
	The average of the third axis	**3.86**	**0.825**	**High**	

Table 7. The arithmetic means and standard deviations of the respondents' responses on the fourth axis (cloud computing).

phrase number	phrase	SMA	Standard deviation	Class	Arrangement
1	The city of Riyadh seeks to update policies and practices related to the use of information and communication technology in the city.	3.76	1.025	High	**5**
2	The city of Riyadh adopts electronic platforms to improve the quality of services provided to citizens.	3.87	1.024	High	**2**
3	The city of Riyadh implements a set of measures aimed at allocating resources optimally.	3.82	1.012	High	**4**
4	The city of Riyadh follows modern devices to collect information and data spread throughout the city.	3.90	1.031	High	**1**
5	The city of Riyadh works to change policies based on knowledge, visions, and the interest of citizens.	3.84	1.038	High	**3**
	The average of the fourth axis	**3.84**	**0.814**	**High**	

(big data applications and services), the arithmetic means and standard deviations of the sample's responses on each of the fifth axis phrases from the components of the developed study model were calculated, as shown in the fifth axis of Table 8.

The arithmetic averages of the study sample's responses to the big data applications and services axis ranged between (3.74 - 3.93) with a high degree of appreciation, as shown in Table 8. The table also shows that the third paragraph "The city of Riyadh adopts artificial intelligence and machine learning strategies to improve daily life." received the most responses, with an average of (3.93) and a standard deviation of (1.054). It has a value of (3.74) and a standard deviation of (1.068), and the average is also high.

To determine the level of evaluation of the developed model's contribution to the transformation of Riyadh into a smart sustainable city in the phrases of the sixth axis (urban communities and their activities), the arithmetic means and standard deviations of the sample responses were calculated on each of the phrases of the sixth axis of the components of the developed study model, as shown in the sixth axis of Table 9.

According to Table 9, the arithmetic averages of the study sample's responses to the urban communities and their activities axis ranged between (3.82 - 3.94) with a high degree of appreciation on the highest response with a (3.94) average and a standard deviation of (0.993). The average denotes a high level. It is also worth noting that the first paragraph, "Decision makers in Riyadh seek to manage the city as an integrated network, not as a group of separate unilateral sectors," has the lowest arithmetic average of (3.82) and a standard deviation of (1.084), and the average also indicates a high score.

9.2. Summary of Results

- The model for transforming Riyadh into a smart sustainable city is built on a

Table 8. Arithmetic means and standard deviations of the respondents' responses on the first axis (big data applications and services).

phrase number	phrase	SMA	Standard deviation	Class	Arrangement
1	The city of Riyadh uses a set of advanced technologies that enable it to know the needs of citizens.	3.74	1.068	High	**5**
2	The city of Riyadh seeks to reduce waste of resources and increase the efficiency of energy management and available resources.	3.86	1.003	High	**3**
3	The city of Riyadh adopts artificial intelligence and machine learning strategies to facilitate the daily lives of residents.	3.93	1.054	High	**1**
4	The city of Riyadh seeks to provide all means to make the city smarter, more connected, and more efficient.	3.91	1.002	High	**2**
5	The city of Riyadh supports companies to achieve a competitive advantage by understanding their customers, their ways of thinking and desires.	3.86	1.041	High	**3**
	The average of the fifth axis	**3.86**	**.839**	**High**	

Table 9. The arithmetic means and standard deviations of the respondents' responses to the sixth axis (Urban communities and their activities).

phrase number	phrase	SMA	Standard deviation	Class	Arrangement
1	The city of Riyadh uses a set of advanced technologies that enable it to know the needs of citizens.	3.82	1.048	High	5
2	The city of Riyadh seeks to reduce waste of resources and increase the efficiency of energy management and available resources.	3.93	1.011	High	2
3	The city of Riyadh adopts artificial intelligence and machine learning strategies to facilitate the daily lives of residents.	3.94	0.993	High	1
4	The city of Riyadh seeks to provide all means to make the city smarter, more connected, and more efficient.	3.90	0.963	High	3
5	The city of Riyadh supports companies to achieve a competitive advantage by understanding their customers, their ways of thinking and desires.	3.88	1.020	High	4
	The average of the sixth axis	3.89	**0.798**	**High**	

number of components, including sustainable urbanization patterns, urban systems and domains, data sources and storage services, cloud computing, big data applications and services, and urban communities and their activities.

- The developed model's contribution to the transformation of Riyadh into a smart sustainable city was significant, as the arithmetic mean of the respondents' responses to the components of the study model as a whole was high (3.85).
- The axis of urban communities and their activities had the highest arithmetic mean (3.89) and standard deviation (0.798), indicating a high score, while the axis of sustainable urbanization patterns had the lowest arithmetic mean (3.82) and standard deviation (0.835), indicating a high score as well.

10. Discussion

The study's findings revealed that the developed model is built on a number of components, including sustainable urbanization patterns, urban systems and domains, data sources and storage services, cloud computing, big data applications and services, and urban agglomerations and their activities. The application of the study model in the city of Riyadh, on the other hand, is primarily based on activating the role of big data in various fields, as this data enables obtaining accurate information about the city's population and daily trends, by making better use of the infrastructure and improving its performance. The use of data collected over long periods of time makes walking and passing easier. Analyzing this data reveals patterns that can be used to develop smart ways to reduce traffic congestion and make traffic management easier. Big data analytics also contributes to a reduction in the number of road accidents by providing a clear picture of active roads, densities, and hotspots.

The developed model provided a set of solutions that support efforts to trans-

form Riyadh into a sustainable smart city by conducting a proactive and periodic assessment of electronic risks, developing plans and preparing capabilities in response to challenges, and reviewing and evaluating the cyber security system on an ongoing basis. and monitoring of the operational technology infrastructure. The model also emphasized the importance of cities benefiting from the development of an innovative digital business environment, such as automation using robots, "blockchain" technology, and artificial intelligence, in addition to developing an advanced methodology to deal with various cyber challenges, enhancing the flexibility and readiness of smart cities, and staying up to date with developments. Technology, to ensure the security of city systems, the enhancement of cybersecurity capabilities, and the modernization of procedures and processes aimed at developing effective response systems to future challenges.

At the city level, Riyadh requires expansion and density plans in order to accommodate expected growth in a sustainable and prudent manner in the future. A rational urban structure should be considered in order to reduce transportation and service delivery costs, maximize land use, and support the protection and regulation of urban open spaces. Suburbanization, district redevelopment, design of new areas with higher densities, development of neglected land, i.e. rehabilitation of land formerly used for industrial purposes, and transportation-friendly building conversions and construction should all be included in planning initiatives. The goal of expansion plans and population concentration is to provide enough land and spatial structures to support urban development, so cities must ensure that large areas of land are available for development, accommodate a growing population with less environmental impact, and achieve the benefits of economic agglomeration (including lower costs of providing infrastructure and services), as well as strengthen social interaction (e.g. allowing multipurpose land use and taller building structures).

The developed model focuses on giving distinctive properties and special artistic values to the city of Riyadh's urban systems and areas by studying the city's urban spaces and identifying the dimensions influencing their formation and placing them in the appropriate and required focus. As a result, the goal of this model is to track the progress of urban planning and design in Riyadh. And the social and technological dimensions influencing and benefiting from its formation throughout the ages, which greatly influenced the process of urban formation in general and the formation of urban spaces in particular. Examples of new or ongoing projects to determine the extent of their impact on the process of urban planning and space design. As a result, the study model is based on several measures of urban space that are commensurate with the human scale by studying the natural characteristics of man, his movements and activity, while ignoring the main elements that comprise this space, such as squares, streets, walkways, cultivated spaces, open squares, and how these elements integrate with one another in Riyadh.

With regard to urban design, the proposed model focuses on the importance

of the overall shape and sense of Riyadh City, public spaces, public infrastructure, their relationship to quality of life, social development and other key components related to human well-being. Moreover, Riyadh is more likely to attract a creative, innovative and skilled workforce as well as the investments required to drive the urban economy. Unfortunately, when this is absorbed, lack of funding and capabilities often diminishes the importance of urban design versus more pressing development needs such as enhanced provision of basic services. The current rapid urbanization of the city of Riyadh poses many challenges to the spatial distribution of people and resources as well as with regard to land use and exploitation, where in some areas urban land has increased faster than urban population, resulting in patterns of land use that are less dense and more inefficient.

Riyadh's orderly expansion necessitates that the urban planning and design process be accompanied by strong regulatory frameworks. The national urban policy will also serve to guide sectoral ministries and urban service providers, as well as to improve consultation with urban stakeholders.

The study's findings also revealed that the developed model's contribution to the transformation of Riyadh into a sustainable smart city was high, with the arithmetic average of the respondents' responses to the components of the study model as a whole being (3.85), and the arithmetic averages ranging from (3.82 - 3.89), all indicating to a high degree. The policy change strategy factor is one of the most important elements of transforming Riyadh into a smart sustainable city, owing to its strong connection to the issue of changing all Riyadh-approved policies. As a result, we conclude that this factor necessitates a change in the existing systems to make them compatible with the new reality. In economic tools, governance, and all previous agreements, we also find that the factor of change in policies is absolutely and unequivocally dependent on expert reports in order to shift to the model of sustainable smart cities, as well as its reliance on legislative and legal amendments that are required to develop proposals for change.

11. Recommendations

In light of the findings, the study recommends the following:

- Reviewing the urban patterns of modern residential neighborhoods in Riyadh and improving their environmental efficiency, expanding the establishment of urban observatories dealing with urban and environmental affairs, and emphasizing their role in the interim review of residential neighborhoods, which supports Riyadh's urbanization path.
- Developing and constructing large-scale data centers spread across the city of Riyadh, as well as working to enable the use of renewable energy production sources, and the city of Riyadh must be able to integrate new services and technologies, in addition to existing services, to support the process of transformation into a sustainable smart city.
- The availability of high, medium, and low-density residential areas, with high

densities concentrated near the nerve centers of activity and commercial centers, as well as the development of the city of Riyadh's new northern and eastern suburbs in accordance with its approved structural plans.

- Establishing Riyadh as a regional cloud computing hub and an appealing technology investment destination based on regional innovation.
- Creating a comprehensive and integrated electronic services system in all Riyadh institutions, as well as developing oversight in service development processes and improving community access to social and public services.
- In Riyadh, planning initiatives should include concentrating the population in the suburbs, redeveloping areas, designing new areas with higher densities, developing neglected lands, i.e., rehabilitating land previously used for industrial purposes, and undertaking building conversions and public transportation-friendly construction.
- The significance of collaboration, joint action, and the exchange of different experiences on the transition to sustainable cities, strengthening policies, strategies, programs, and initiatives to raise awareness of the concept of a sustainable smart city in Riyadh, strengthening technical capabilities, facilitating access to the financial resources needed to implement the transformation, and restructuring and strengthening institutions.
- Adopting an integrated approach to raise awareness and promote adoption and participation of all stakeholders in the city of Riyadh in order to build a smart, sustainable, and flexible city, transfer knowledge and technologies, and form a committee to work on this, as well as the need to consider issues related to data governance and select a comprehensive economic model.
- More applied research on the characteristics of sustainable smart cities is being conducted in Riyadh.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Abubakar, I. R., & Aina, Y. A. (2018). Achieving Sustainable Cities in Saudi Arabia: Juggling the Competing Urbanization Challenges. In Information Resources Management Association (Eds.), *E-Planning and Collaboration: Concepts, Methodologies, Tools, and Applications* (pp. 234-255). IGI Global. https://doi.org/10.4018/978-1-5225-5646-6.ch011

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What Are the Differences between Sustainable and Smart Cities? *Cities, 60,* 234-245. https://doi.org/10.1016/j.cities.2016.09.009

Aina, Y. A. (2017). Achieving Smart Sustainable Cities with GeoICT Support: The Saudi Evolving Smart Cities. *Cities, 71,* 49-58. https://doi.org/10.1016/j.cities.2017.07.007

Al-Assaf, S. b. H. (2012). *Introduction to Research in the Behavioral Sciences.* Dar Al Zahraa for Publication and Distribution.

Al-Azzam, M., & Alazzam, M. B. (2019). Smart City and Smart-Health Framework, Challenges and Opportunities. *International Journal of Advanced Computer Science and Applications, 10,* 171-176. https://doi.org/10.14569/IJACSA.2019.0100223

Albasri, N. A. R. H. (2018). The Impact of Technological Progress in the Spatial Organization of the City Elements. *KnE Engineering, 3,* 103-114. https://doi.org/10.18502/keg.v3i4.2164

Al-Hathloul, S. (2017). Riyadh Development Plans in the Past Fifty Years (1967-2016). *Current Urban Studies, 5,* 97-120. https://doi.org/10.4236/cus.2017.51007

Al-Hathloul, S. b. A. (2010). *The Arab Islamic City: The Impact of Legislation on the Formation of the Urban Environment.* Saudi Society for Urban Sciences.

Al-Qahtani, S., Al-Amiri, A., Al Madhhab, M., & Al-Omar, B. (2020). *Research Method in the Behavioral Sciences.* Obeikan Publishing.

Alqahtany, A., & Aravindakshan, S. (2022). Urbanization in Saudi Arabia and Sustainability Challenges of Cities and Heritage Sites: Heuristical Insights. *Journal of Cultural Heritage Management and Sustainable Development, 12,* 408-425. https://doi.org/10.1108/JCHMSD-07-2020-0108

Al-Sayed, A., Al-Shammari, F., Alshutayri, A., Aljojo, N., Aldhahri, E., & Abouola, O. (2022). The Smart City-Line in Saudi Arabia: Issue and Challenges. *Postmodern Openings, 13,* 15-37. https://doi.org/10.18662/po/13.1Sup1/412

Alshuwaikhat, H. M., & Mohammed, I. (2017). Sustainability Matters in National Development Visions—Evidence from Saudi Arabia's Vision for 2030. *Sustainability, 9,* Article No. 408. https://doi.org/10.3390/su9030408

Alshuwaikhat, H. M., Adenle, Y. A., & Almuhaidib, T. (2022). A Lifecycle-Based Smart Sustainable City Strategic Framework for Realizing Smart and Sustainability Initiatives in Riyadh City. *Sustainability, 14,* Article No. 8240. https://doi.org/10.3390/su14148240

Bakry, S. H., Al-Saud, B. A., Alfassam, A. N., & Alshehri, K. A. (2019). A Framework of Essential Requirements for the Development of Smart Cities: Riyadh City as an Example. In A. Visvizi, & M. D. Lytras (Eds.), *Smart Cities: Issues and Challenges* (pp. 219-239). Elsevier. https://doi.org/10.1016/B978-0-12-816639-0.00013-2

Belli, L., Cilfone, A., Davoli, L., Ferrari, G., Adorni, P., Di Nocera, F. et al. (2020). IoT-Enabled Smart Sustainable Cities: Challenges and Approaches. *Smart Cities, 3,* 1039-1071. https://doi.org/10.3390/smartcities3030052

Bibri, S. E. (2018). A Foundational Framework for Smart Sustainable City Development: Theoretical, Disciplinary, and Discursive Dimensions and Their Synergies. *Sustainable Cities and Society, 38,* 758-794. https://doi.org/10.1016/j.scs.2017.12.032

Bibri, S. E. (2021). A Novel Model for Data-Driven Smart Sustainable Cities of the Future: The Institutional Transformations Required for Balancing and Advancing the Three Goals of Sustainability. *Energy Informatics, 4,* Article No. 4. https://doi.org/10.1186/s42162-021-00138-8

Bibri, S. E., & Krogstie, J. (2020). The Emerging Data-Driven Smart City and Its Innovative Applied Solutions for Sustainability: The Cases of London and Barcelona. *Energy Informatics, 3,* 1-42. https://doi.org/10.1186/s42162-020-00108-6

Blasi, S., Ganzaroli, A., & De Noni, I. (2022). Smartening Sustainable Development in Cities: Strengthening the Theoretical Linkage between Smart Cities and SDGs. *Sustainable Cities and Society, 80,* Article ID: 103793. https://doi.org/10.1016/j.scs.2022.103793

Choi, H. S., & Song, S. K. (2022). Direction for a Transition toward Smart Sustainable Cities Based on the Diagnosis of Smart City Plans. *Smart Cities, 6,* 156-178. https://doi.org/10.3390/smartcities6010009

D'Auria, A., Tregua, M., & Vallejo-Martos, M. C. (2018). Modern Conceptions of Cities as Smart and Sustainable and Their Commonalities. *Sustainability, 10,* Article No. 2642. https://doi.org/10.3390/su10082642

El-Hallaq, M. A., Alastal, A. I., & Salha, R. A. (2019). Enhancing Sustainable Development through Web Based 3D Smart City Model Using GIS and BIM. Case Study: Sheikh Hamad City. *Journal of Geographic Information System, 11,* 321-330. https://doi.org/10.4236/jgis.2019.113019

EPIC (2013). *EPIC Roadmap for Smart Cities.* European Union, European Platform for Intelligent Cities (EPIC), Version 1.0, Project No. 270895.

Gabrys, J. (2014). Programming Environments: Environmentality and Citizen Sensing in the Smart City. *Environment and Planning D: Society and Space, 32,* 30-48. https://doi.org/10.1068/d16812

Garau, C., & Pavan, V. M. (2018). Evaluating Urban Quality: Indicators and Assessment Tools for Smart Sustainable Cities. *Sustainability, 10,* 575. https://doi.org/10.3390/su10030575

Ghoneim, S. A. R. M. (2019). The Concept of Smart City as a Driver for the Urban Transformation of Egyptian Cities towards Sustainability: Opportunities and Challenges. *Journal of Engineering Sciences, 47,* 601-626. https://doi.org/10.21608/jesaun.2019.115728

Glasmeier, A., & Christopherson, S. (2015). Thinking about Smart Cities. *Journal of Regions, Economy and Society, 8,* 3-12. https://doi.org/10.1093/cjres/rsu034

Guevara, L., & Auat Cheein, F. (2020). The Role of 5G Technologies: Challenges in Smart Cities and Intelligent Transportation Systems. *Sustainability, 12,* Article No. 6469. https://doi.org/10.3390/su12166469

Haarstad, H. (2017). Constructing the Sustainable City: Examining the Role of Sustainability in the 'Smart City' Discourse. *Journal of Environmental Policy & Planning, 19,* 423-437. https://doi.org/10.1080/1523908X.2016.1245610

Hollands, R. G. (2008). Will the Real Smart City Please Stand up? Intelligent, Progressive or Entrepreneurial? *City, 12,* 303-320. https://doi.org/10.1080/13604810802479126

Hollands, R. G. (2015). Critical Interventions into the Corporate Smart City. *Cambridge Journal of Regions, Economy and Society, 8,* 61-77. https://doi.org/10.1093/cjres/rsu011

Ibrahim, M., Adams, C., & El-Zaart, A. (2015). Paving the Way to Smart Sustainable Cities: Transformation Models and Challenges. *JISTEM-Journal of Information Systems and Technology Management, 12,* 559-576. https://doi.org/10.4301/S1807-17752015000300004

Jasrotia, A. (2018). Smart Cities & Sustainable Development: A Conceptual Framework. *Asian Journal of Research in Business Economics and Management, 8,* 42-50. https://doi.org/10.5958/2249-7307.2018.00017.8

Joss, S., Sengers, F., Schraven, D., Caprotti, F., & Dayot, Y. (2019). The Smart City as Global Discourse: Storylines and Critical Junctures across 27 Cities. *Journal of Urban Technology, 26,* 3-34. https://doi.org/10.1080/10630732.2018.1558387

Karvonen, A., Cugurullo, F., & Caprotti, F. (2018). *Introduction: Situating Smart Cities.* Routledge.

Khan, M. S., Woo, M., Nam, K., & Chathoth, P. K. (2017). Smart City and Smart tourism: A Case of Dubai. *Sustainability, 9,* Article No. 2279. https://doi.org/10.3390/su9122279

Konbr, U. (2019). Smart Sustainable Cities—Vision and Reality: The Egyptian Context as a Case Study. *Resourceedings, 2,* 101-127. https://doi.org/10.21625/resourceedings.v2i1.455

Kostakis, V., Bauwens, M., & Niaros, V. (2015). Urban Reconfiguration after the Emergence of Peer-to-Peer Infrastructure: Four Future Scenarios with an Impact on Smart Cities. In D. Araya (Ed.), *Smart Cities as Democratic Ecologies* (pp. 116-124). Palgrave Macmillan. https://doi.org/10.1057/9781137377203_8

Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards Smart Cities: Solutions That Lead to the Smart City Transformation Framework. *Technological Forecasting and Social Change, 153,* Article ID: 119281. https://doi.org/10.1016/j.techfore.2018.04.024

Malih, Y. (2017). Smart Cities in Morocco: Foundations, Experiences and Application Possibilities. *Journal of Pathways to Thought, Politics, and Economics-Morocco, No. 84,* 189-208.

March, H. (2018). The Smart City and Other ICT-Led Techno-Imaginaries: Any Room for Dialogue with Degrowth? *Journal of Cleaner Production, 197,* 1694-1703. https://doi.org/10.1016/j.jclepro.2016.09.154

Morton, S., Pencheon, D., & Squires, N. (2017). Sustainable Development Goals (SDGs), and Their Implementation: A National Global Framework for Health, Development and Equity Needs a Systems Approach at Every Level. *British Medical Bulletin, 124,* 81-90. https://doi.org/10.1093/bmb/ldx031

Niestroy, I., Hege, E., Dirth, E., Zondervan, R., & Derr, K. (2019). *Europe's Approach to Implementing the Sustainable Development Goals: Good Practices and the Way Forward.* Policy Department for External Relations Directorate General for External Policies of the Union.

Piketty, T. (2014). Capital in the Twenty-First Century: A Multidimensional Approach to the History of Capital and Social Classes. *The British Journal of Sociology, 65,* 736-747. https://doi.org/10.1111/1468-4446.12115

Pilipczuk, O. (2021). A Conceptual Framework for Large-Scale Event Perception Evaluation with Spatial-Temporal Scales in Sustainable Smart Cities. *Sustainability, 13,* Article No. 5658. https://doi.org/10.3390/su13105658

Rahi, S., Alnaser, F. M., & Abd Ghani, M. (2019). Designing Survey Research: Recommendation for Questionnaire Development, Calculating Sample Size and Selecting Research Paradigms. In *37th International Scientific Conference on Economic and Social Development—Socio Economic Problems of Sustainable Development* (pp. 1157-1169).

Rivera, M. B., Eriksson, E., & Wangel, J. (2015). ICT Practices in Smart Sustainable Cities—In the Intersection of Technological Solutions and Practices of Everyday Life. In *Proceedings of EnviroInfo and ICT for Sustainability 2015.* Atlantis Press. https://doi.org/10.2991/ict4s-env-15.2015.36

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F. S., Lambin, E. et al. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society, 14,* Article No. 32. https://doi.org/10.5751/ES-03180-140232

Saba, D., Sahli, Y., Berbaoui, B., & Maouedj, R. (2020). Towards Smart Cities: Challenges, Components, and Architectures. In A. Hassanien, R. Bhatnagar, N. Khalifa, & M. Taha (Eds.), *Toward Social Internet of Things (SIoT): Enabling Technologies, Architectures and Applications. Studies in Computational Intelligence* (Vol. 846, pp. 249-286). Springer. https://doi.org/10.1007/978-3-030-24513-9_15

Sang, Z., & Li, K. (2019). ITU-T Standardisation Activities on Smart Sustainable Cities. *IET Smart Cities, 1,* 3-9. https://doi.org/10.1049/iet-smc.2019.0023

Söderström, O., Paasche, T., & Klauser, F. (2014). Smart Cities as Corporate Storytelling. *City, 18,* 307-320. https://doi.org/10.1080/13604813.2014.906716

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015). The Trajectory of the Anthropocene: The Great Acceleration. *The Anthropocene Review, 2,* 81-98. https://doi.org/10.1177/2053019614564785

Tabassum, K. (2020). An Intelligent Metro Tracking System for Riyadh Smart City. *International Journal of Information Technology, 12,* 1103-1109. https://doi.org/10.1007/s41870-020-00435-7

Trindade, E. P., Hinnig, M. P. F., Moreira da Costa, E., Marques, J. S., Bastos, R. C., & Yigitcanlar, T. (2017). Sustainable Development of Smart Cities: A Systematic Review of the Literature. *Journal of Open Innovation: Technology, Market, and Complexity, 3,* Article No. 11. https://doi.org/10.1186/s40852-017-0063-2

Viitanen, J., & Kingston, R. (2014). Smart Cities and Green Growth: Outsourcing Democratic and Environmental Resilience to the Global Technology Sector. *Environment and Planning A, 46,* 803-819. https://doi.org/10.1068/a46242

Wiig, A. (2016). The Empty Rhetoric of the Smart City: From Digital Inclusion to Economic Promotion in Philadelphia. *Urban Geography, 37,* 535-553. https://doi.org/10.1080/02723638.2015.1065686

Winkowska, J., Szpilko, D., & Pejić, S. (2019). Smart City Concept in the Light of the Literature Review. *Engineering Management in Production and Services, 11,* 70-86. https://doi.org/10.2478/emj-2019-0012

Xie, J., Tang, H., Huang, T., Yu, F. R., Xie, R., Liu, J., & Liu, Y. (2019). A Survey of Blockchain Technology Applied to Smart Cities: Research Issues and Challenges. *IEEE Communications Surveys & Tutorials, 21,* 2794-2830. https://doi.org/10.1109/COMST.2019.2899617

Yigitcanlar, T., Han, H., Kamruzzaman, M., Ioppolo, G., & Sabatini-Marques, J. (2019). The Making of Smart Cities: Are Songdo, Masdar, Amsterdam, San Francisco and Brisbane the Best We Could Build? *Land Use Policy, 88,* Article ID: 104187. https://doi.org/10.1016/j.landusepol.2019.104187