Article

A Lifecycle-Based Smart Sustainable City Strategic Framework for Realizing Smart and Sustainability Initiatives in Riyadh City

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Abstract: Smart cities rely on innovative technologies, guidelines, and mechanisms to advance city dwellers' quality of life (QoL). Notwithstanding the global attention the smart city concept has received within the last decade, studies establishing pragmatic approaches for implementing smart sustainable city strategies in the Gulf region are rare. This study modelled a practical framework for implementing smart sustainable city strategies and megaprojects in one of the Gulf cities. A qualitative research methodology was used to assess smart city strategies from four cities to identify the optimum implementation strategies. This study design framework adopted a case study methodology, the identification of knowledge gaps, data collection and analysis, and interpretations of key findings. Best practices, paramount/relevant stakeholders, main issues/relevant considerations, 15 key performance indicators (KPI), and outputs/deliverables involved in diverse smart sustainable city strategies and project lifecycle phases were identified. The lifecycle phases adopted in the study were (i) conceptualization, (ii) planning/design, and (iii) installation/closure. A pragmatic understanding of how to effectively appraise, monitor, and implement smart sustainable city strategies and megaprojects is provided for policy/decision-makers and built environment experts in Saudi Arabia and globally. The proposed implementation strategic framework can perform the function of an appraisal tool for assessing each phase of the smart city project's life cycle progress, informing preventions of delays or implementation challenges. This study's contribution to research knowledge is the development of a model that reveals and illustrates the connections between different phases of smart sustainable city strategies and projects.

Keywords: smart cities; sustainable city strategy; quality of life; Riyadh; Saudi Arabia

1. Introduction

A sustainable city strategy is one of many urban planning approaches worthy of implementation to ensure long-term city growth and development [1–3]. Riyadh, the capital city of Saudi Arabia, is one of the main cities in the Gulf and Middle East with rapid growth and development [4,5]. Since introducing the Saudi Vision 2030 in 2016, Riyadh and other cities have adopted initiatives and programs to actualize the vision's goals. However, these initiatives have been sponsored by the vision realization programs (VRPs) handled and implemented by sectorial entities such as ministries, authorities, and governmental companies. As cities play a vital role in the vision, and to ensure effective alignment and implementation, there was a need for local governance. Thus, local governance has lately been enabled in Riyadh through the Royal Commission of Riyadh City (RCRC). The commission is also the central entity responsible for the city's strategies and plans. As RCRC is working on the city strategies, this study's research question (RQ) is:

RQ. How can the multi-phase smart city development projects of RCRC be effectively implemented?

In answering this question, there is the need to first lay down a foundation of knowledge about what a smart sustainable city is. The smart sustainable city is a recent urban development of the 21st-century based on advanced technologies [6]. It is a new concept that has developed and grown in the last decade, alongside the development and growth of technology, sustainability, and sustainable development concepts. Hence, the development, approaches, applications, and implementation strategies of smart sustainable cities vary between cities, regions, and countries. However, one of the highly used definitions which is in line with sustainability targets is adopted in this study. It is defined as:

> "[. . .] an innovative city that uses information and communication technologies (ICTs) and other means to improve QoL, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" [7].

In assessing the aim of this study (i.e., the development of a best approach framework for implementing smart city strategies and projects via lessons learned from specific quintessential cases), three objectives were set throughout this research. These are (i) review Saudi Arabia's smart sustainable city initiatives with a particular focus on Riyadh city, (ii) identify and analyze smart sustainable city strategic approaches in selected case studies, and (iii) formulate a lifecycle-based best method for implementing Riyadh's proposed smart sustainable city strategy. Thus, this study is different from the studies carried out by Alyami in 2019 and Asmyatullin and colleagues in 2020 [8,9] because pragmatic lessons from extant strategies were appraised to inform the smart sustainable strategy and project implementation in Saudi Arabia. Smart city strategies, programs, and projects are not exempt from failure, and selected projects globally have encountered challenges in implementing their stated goals and objectives [10,11].

When smart city strategies and projects are poorly implemented, the various comprehensive strategic plans initiated will either be delayed or not actualized. As such, there is a need for more studies and research exploring the best policies, methods, and practices to adequately implement the strategies and aims of smart cities. The goal and objectives of this study are novel as no research has addressed the implementation of smart sustainable city strategies in Saudi Arabia and the Gulf region via the case study method. Existing smart city-related studies within the Gulf region context [12,13] have failed to specifically assign an increased distinct best approach across diverse lifecycle phases of smart city strategies/projects. Extant studies have revealed the appropriateness of case study research as a replacement for interviews, consultations, and questionnaire surveys when obtaining comprehensive data concerning areas of construction and environment projects [14,15]. The case study methodology also establishes a practical framework that identifies the best approaches across multiple phases and links the KPI of individual stages. This results from the fact that smart city projects and their lifecycle phases are closely connected and intertwined.

This study's novelty is in the appraisal of lessons from the selected cases from top-class international cities. Important and pragmatic implications are also derived from this study's outcomes. The study gives an in-depth comprehension of specific strategies from extant strategies with a strong potential of advancing stakeholders' and practitioners' capacity to actualize better results in future action plans and strategies. The study proposes the best method/practice of implementing a proposed smart and sustainable city strategy for Riyadh, Saudi Arabia, which could also be utilized as a tool/model by relevant stakeholders across the globe to objectively and systematically assess strategy performance at the pilot/preliminary implementation phase to allow for prompt preventive/amendatory mechanism.

2. Literature Review

2.1. Overview of Sustainability, the Smart City, and the Smart Sustainable City

The synonymous usage of built environment buzzwords such as sustainability, sustainable development, urbanization, and smart cities reveals the ubiquity of these terminologies. Although there is a thin line between these terms, each concept is unique and requires clarification. This clarification will also address the implementation challenges of smart sustainable city strategies, plans, programs, and projects. Sustainability has been globally regarded as a critical concept to be incorporated into city planning and development [16]. Its origins could be linked to the commencement of discussions on the need for environmental protection and the elimination of the challenges confronting humans after the industrial revolution [17]. Aside from the recent sustainable development goals (SDGs) initiated by the United Nations, efforts such as numerous local and global declarations, policies, Millennium Development Goals, etc., have assisted the creation of sustainability awareness [18].

Recently, sustainability challenges have become compelling, and the need to unify the protection of the planet's natural environment with increasing human present and future QoL in both developed and developing nations has also become important [19]. As a result of human non-sustainable socioeconomic activities, the world is witnessing various difficulties [20] that include but are not limited to transportation, crime, health, housing and infrastructure, and social inclusion. Without the sustainable use of resources and the protection of the natural environment and human health, we might face the challenges of not "meeting the needs of the present and therefore compromise the ability of future generations to meet their own needs" [21]. Hence, sustainability is the main framework, the optimal objective of all other concepts and approaches that fall underneath it. Throughout the literature review, urbanization is one of the leading sustainability challenges [22], in relation to the rapid growth and sprawl of cities, especially considering its impacts.

However, achieving sustainable development is a broad goal, and the United Nations have developed 17 goals with indicators to measure sustainable development performance in 140 countries around the globe [23]. These goals range from improving the good health and wellbeing of the global populace to achieving sustainable cities and communities worldwide. On the other hand, smart city concepts, approaches, and applications differ from one city to another. Even in the literature definitions, smart cities comprise multidisciplinary definitions that define smart cities based on experts and specialists. One of the leading sustainability journals noted that "the smart city is a catchphrase that draws increased attention among research institutes, universities, governments, policymakers, and ICT companies. Notwithstanding the wide use of the concept today, there is still unclear and inconsistent understanding of its meaning" [6]. In contrast, the smart sustainable city is a new concept that has emerged in the last few decades. While not always explicitly discussed, it "is used to denote a city that is supported by a pervasive presence and massive use of advanced ICT, which, in connection with various urban domains and systems and how these intricately interrelate, enables cities to become more sustainable and to provide citizens with a better QoL" [6].

The substantial discrepancies between accomplishing sustainable development, smart city, and smart sustainable city projects demand an advancement in the old-fashioned implementation model to ensure the involvement of critical stakeholders to actualize and appraise the achievement of smart city projects in a well laid out approach. Lifecycle-based management provides an efficient implementation of built environment-related projects (such as smart sustainable cities) via the disintegration of the project's accomplishment channel into unique stages based on their technicalities, essential stakeholders, stated aims and objectives, outputs, and time-line, as well as the approval and control mechanism involved [24]. In this paper, the lifecycle stages for the smart sustainable city project for Riyadh city are (i) conceptualization, (ii) planning/design, and (iii) termination/closure stage. The lifecycle framework in the study has been adopted and modified from extant studies [25,26]. In the following sub-sections, Saudi Arabia's vision 2030 and smart

sustainable city initiatives focusing on Riyadh city are reviewed to achieve the study's first objective.

2.2. Smart Sustainable City Initiatives Included in the Saudi Vision for 2030

In the recently published Saudi vision for 2030, the country considered utilizing modern technology as its real wealth despite oil being the mainstay of its economy [27]. Three main pillars, which are (i) an ambitious nation, (ii) a thriving economy, and (iii) a vibrant society, serve as the strategic vision of the nation with several goals under the individual pillars that are anticipated to be accomplished on or before the end of 2030. The country seeks to establish a more diverse and sustainable smart economy through this strategic vision. The vision set goals to transform the Kingdom into a resilient, sustainable international trade nation [27]. Moreover, there are 24 goals that the entire country seeks to collaborate on and work to achieve, such as having three cities amongst the highly ranked 100 cities across the globe.

During the transformation journey in the past five years, Saudi Arabia has achieved many targets and goals, especially in the housing-related targets, such as raising the percentage of Saudi homeowners from 46 to 60 per cent, as well as in other industries and targets such as health, sports participation, happiness, road traffic fatalities, entertainment, heritage, environment, etc. [28]. In the past half-decade, multiple initiatives associated with smart sustainability cities have been announced, such as the Saudi Green Initiative and the Green Middle East [28]. Hence, five specialized environmental centers have been established to work on the environmental regulations and enablement to ensure the implementation of the related initiatives. Moreover, the Public Investment Fund has established the Saudi Investment Recycling Company (SIRC) as one of its subsidiaries that involves building national capabilities and engaging non-governmental institutions in the establishment and development of waste management to ensure the actualization of the Saudi circular economy [29].

However, the Saudi Smart Cities Initiative has undergone many transformations in understanding approaches and applications. The initiative was recently developed by the Ministry of Municipal, Rural Affairs, and Housing (MoMRAH). It had been re-evaluated and revisited to align with Vision 2030 programs initiatives. The Smart Cities Initiative was first transferred from MoMRAH to a specialized new entity that focuses on Smart cities in Saudi Arabia, called Smart Cities Centre, under the Saudi Authority for Data and Artificial Intelligence (SDAIA). In fewer than five years, such changes show that the main challenge in Saudi Smart Cities Initiative is understanding the smart cities concept and its governance.

Moreover, extant studies have revealed that there are 20 drivers for smart cities, where 15 concentrate on city governance and the other five focus on technology [30]. The results also showed seven main drivers that experts rated as essential: urban planning, cities infrastructure, mobility, public safety, health, sustainability, and public policies [30]. All the seven fall underneath the governance group and not technology. Hence, this shows that the real challenge for smart city initiatives is governance and its consequences. Based on the previous efforts in Saudi Arabia for Smart Cities Initiative, the key driver can be digital infrastructure, which includes the existing digital-integrated data center led by the National Information Center and SDAIA.

2.3. Riyadh Sustainability City Strategy and Its Challenges

After the lunch of Vision 2030, Riyadh adopted a high portion of the objectives and goals based on its importance as the capital and the most populated city in the Kingdom. Riyadh city was one of the few cities that had a development authority, where it transformed into a royal commission. Thus, in 2019 the Riyadh Development Authority was transformed into RCRC, responsible for strategic planning and development of the city and its mega projects.

However, RCRC has launched several programs and projects that have contributed to the smart sustainable city and Vision 2030, some of which were established before the announcement of vision 2030. The first is the Riyadh Metro, a complete public transport network in Riyadh that includes metro, BRT, and bus networks. The Riyadh Metro program started in 2011 and is in its last phase. Second, the Wadi Hanifa program is one of the first programs in Riyadh city that began in 1987. The program is embedded with smart sustainable city rehabilitation and development projects such as environmentally friendly roads, a GIS database, and a bioremediation facility park. In 2019, four new smart sustainable megaprojects were designed for implementation via innovative procedures, approaches, technical know-how, and methodology, which are missing in the traditional transportation and urban planning development. These are the (i) King Salman Park project, (ii) Riyadh Sports Boulevard, (iii) Riyadh Art, and (iv) Green Riyadh. Recently, RCRC announced the Riyadh Sustainability Strategy during the Green Saudi Initiative Forum to transform the city into one of the most sustainable cities in the world. However, the Sustainability Strategy includes launching more than 68 ambitious initiatives in the sectors of (i) energy and climate change, (ii) air quality, (iii) water management, (iv) waste management, and (v) biodiversity and natural areas. The strategy includes multiple goals covering the increase in electric vehicle usage, renewable sources, recycling waste, green space, and a decrease in carbon emissions and greenhouse gases.

On the national level of Saudi Arabia, Vision 2030 is progressing as it has set clear objectives and goals. Riyadh plays a vital role in the vision as the most populated city in the Kingdom alongside its rapid growth. Some targets have not yet been achieved, such as having three Saudi cities be recognized in the top-ranked 100 cities globally and raising the nation's ranking in the Government Effectiveness Index from 80 to 20. Other target gaps from the baselines have increased, such as raising the country's position from 26 to 10 in the Social Capital index. According to the World Bank, the current ranking of Saudi Arabia in the Social Capital index is 49 [31]. In addition, the target of raising the current position of Saudi Arabia from 25 to the top 10 countries on the Global Competitiveness Index needs to be highlighted and emphasized by the main cities such as Riyadh. The World Bank also put the Saudi Global Competitiveness Index of 2017 to 30 [32]. To achieve these targets, cities around Saudi Arabia are the main factors, especially Riyadh, due to the focus and the positive rapid transformation and adaptation.

On the local level of Riyadh City, there are some challenges in the current strategic planning approach. The current strategic system of Riyadh City in terms of sustainability, smartness, and sustainable development has some gaps, as illustrated in Figure 1.

The red circles in Figure 1 show the gaps between Riyadh City's strategic and well-structured national strategic planning. Therefore, multiple stand-alone initiatives, programs, and projects have been launched and announced in the city of Riyadh, where some of them, later on, have been either fully or partially linked with the Riyadh Sustainability Strategy, such as Green Riyadh and Riyadh Metro. On the other hand, Riyadh has many elements of smart cities, such as the technology and transport network in the Riyadh Metro program and Air Quality sensors deployment around the city. Still, there is a lack of an umbrella that guides the city's technology, ICTs, and smart city initiatives and projects and aligns them with sustainability and sustainable development. These challenges and the missing link between the megaprojects, strategies, and national initiatives warrant an innovative framework ensuring the involvement of essential experts in the successful implementation, management, and appraisal of smart sustainable city projects in a well-linked approach.
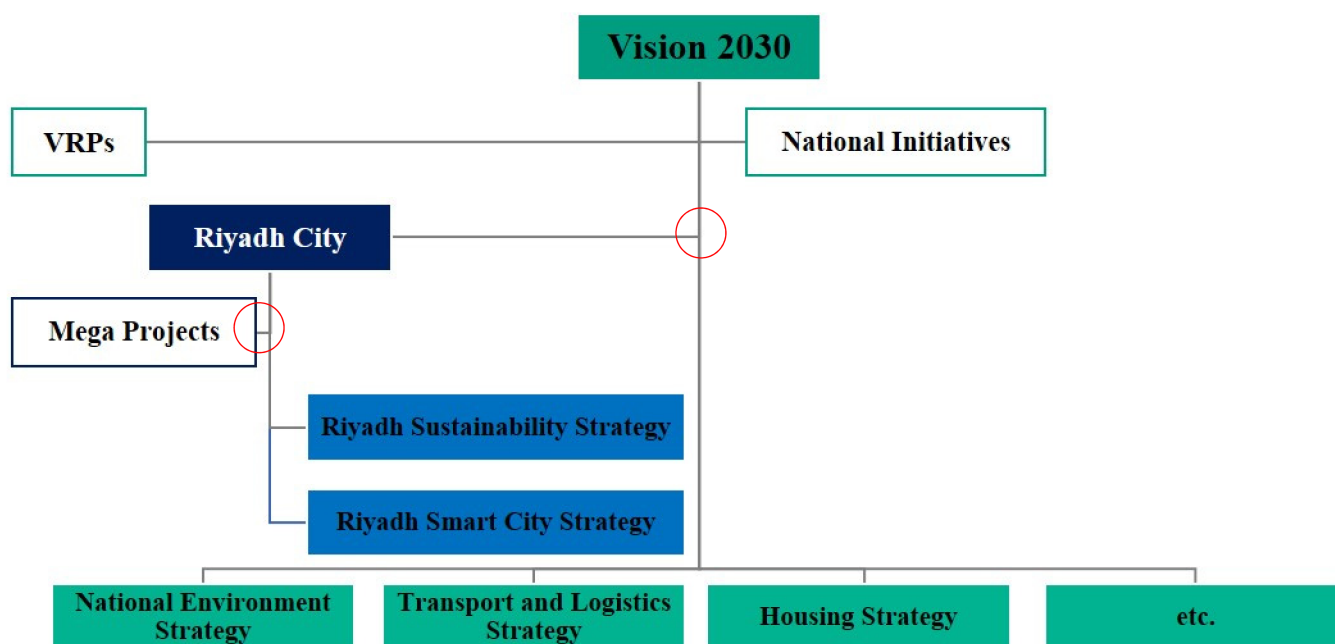
Figure 1. Riyadh strategies structure.

3. Research Methodology

3.1. Research Approach and Rationale

A qualitative research method was utilized in this study in which lessons from extant smart sustainable city strategies and projects were reviewed and analyzed to identify the best practices for implementing Riyadh's smart sustainable city strategy and megaprojects. The pragmatic and scientific benefits of case study utilization have been derived in different fields, such as construction management and management decision [14]. Expressly, the methodological stages utilized in conducting case studies have been adjudged comprehensive and appropriate for carrying out a practice-based appraisal in which the context is essential, and the cases have particularities [14]. In this study, a "case" refers to a specific smart sustainable city strategy of a city (and their implemented projects) instead of the confined approach of the case study research method.

A case study research approach was utilized in this study due to the following justifications. Firstly, it allowed the authors to answer why and how questions in comprehending the complex nature of construction projects [14], such as smart sustainable city megaprojects. Secondly, it effectively explores areas with limited research and allows for pragmatic appraisal practices [15]. This method effectively appraised the management of a smart sustainable city strategy with lagging research in Saudi Arabia and the Gulf region. Third, it allowed for an extensive comprehension of the multifaceted inter-relationships between humans and advanced ICTs in completing smart sustainable city projects. Fourth, it ensures the assessment of efficient and pragmatic practices. Lastly, it ensured that the authors comprehended the components and requirements of a successful implementation of smart sustainable city projects.

Existing studies have been carried out on smart city strategies via case studies [33–37]. However, this study's methodological approach was a lifecycle-based smart city sustainable strategy, focusing more on best practices, lessons learned, and lifecycle phases for implementing the proposed model. This is novel to studies in the smart city literature, specifically within Saudi Arabia and the Gulf region. In actualizing the study goal, the authors used substantial guidelines for carrying out research via the case study approach involving (i) database search and case study selection, (ii) data collection and analysis, and (iii) interpretation and inferences of the results [14,15].

3.2. Case Study Selection Process

Between August 2021 and March 2022, the authors conducted a desktop database search of diverse world cities' smart city strategies. The utilization of varied strategies from different parts of the world allowed for the identification of standard/optimum implementable practices and smart sustainable city indicators that cut across different cultures and philosophical approaches. Four case studies from Hong Kong, Australia, Singapore, and the United States of America (USA) were identified. The selection of these case studies was based on (i) data availability in written documents, (ii) incorporation of the national vision to the city's smart city strategies, and (iii) geographical location. These criteria were adopted to ensure that the selected cases were spread across the world's continents, embedded their national vision, such as the Saudi Arabia Vision 2030, and possessed written documents for references and for extracting relevant data.

Cases that did not meet the study's selection criteria were excluded and not considered for further analysis. For instance, Johannesburg's smart city strategy met the geographical location criteria, but did not have a written document outlining its smart city strategies, or a national vision embedded into the city's smart city strategy. Likewise, Ghent and Sao Paulo met the geographical location and national vision embedded into their smart city strategies criteria. However, no official written documents were available for the study's essential data collection for analysis. Over 30 smart city strategies were also identified from the study's desktop outcomes but were standalone (i.e., smart city strategies associated with individual units, ministries, departments, or agencies). The main characteristics of the four smart city strategies are illustrated in Table 1.

Table 1. Main characteristics of the four smart city strategies cases.

Case # Detail	#1	#2	#3	#4
Country	USA	Australia	Singapore	Hong Kong SAR
City	New York	Sydney	Singapore	Hong Kong
Document title	IoT Strategy: The New York City Internet of Things Strategy	Smart City Strategic Framework: City of Sydney	National Artificial Intelligence Strategy: Advancing Our Smart Nation Journey	Hong Kong Smart City Blueprint 2.0
Published date	March 2021	August 2020	November 2019	December 2020
Property of	New York City Mayor's Office of the Chief Technology Officer (CTO)	City of Sydney	Smart Nation and Digital Government Office	Innovation and Technology Bureau, Office of the Chief Information Officer
Successfully implemented smart projects reported	Building a Smart + Equitable City			

3.3. Data Collection and Analysis

After successfully selecting the study's cases, the authors developed a codebook to document essential data in each strategy and project. The study's codes and their interpretation are contained in Table 2. Notes related to important data highlighted in the study's codebook were comprehensively explored and appraised from the authors' four selected published smart city strategies. All essential themes were contained in the codebooks to extract the needed information for a comprehensive data analysis of the individual case. The themes ensured a systematic collection of relevant data. The extracted relevant data structured format after that allowed for the study's analysis. Thematic content analysis was utilized to allow for the authors' well-structured, grouped, and summarized data based on the study's adopted codes (see Table 2).

Table 2. Codes utilized as guidelines for data collection and analysis.

Code	Definitions of Codes
Best practices	[. . .] "a technique or method that, through experience and research, has proven reliably to lead to the desired result." (p. 7, [38]). The best practices also entail challenges encountered, best practice indicators, and lessons learned.
Main issues	Major considerations in every phase of the smart sustainable city strategies and projects.
Paramount stakeholders	Relevant players, experts, practitioners, etc., involved at every stage of the smart city strategies and projects.
Outputs	Major deliverables in each phase of the smart city strategies and projects.

The code "best practices" is not utilized in this study to depict a condition of flawlessness or gold standard status for implementing smart sustainable city strategies. However, the outcomes are restricted as well as concentrated on single or multiple compartments of the smart sustainable city strategies being examined or executed. Therefore, reporting, employing, and utilizing the lessons learned regarding implementation challenges and justifications for its unsuccessfulness are fundamental components of a best practice to avoid such mistakes in similar or future strategies and projects. This study extracted successful smart city strategy implementation practices in the four cases. After that, the practices for delivering the desired smart sustainable city implementation in Riyadh city were filtered and consolidated to propose the study's best practice framework. Two of the authors extracted the best practices, relevant stakeholders, key considerations, and deliverables from case strategies and all the reported smart projects with accessible reports. The third author resolved all discrepancies in the initial findings by improving and validating the study's proposed framework.

3.4. Study Areas: Brief Description of Riyadh City, Its Strategic Plan, and the Selected Case Study Cities

Riyadh city is situated at the heart of the peninsula of Western Asia with over 5 million inhabitants. Located more than 550 m above sea level, the city is a conglomerate of 20 sub-municipalities [5]. Under RCRC, the city/regional planning is divided into (i) Riyadh Downtown Development Program, (ii) Riyadh Regional Plan, (iii) Riyadh Urban Observatory, and (iv) Comprehensive Strategic Plan. The Metropolitan Development Strategy regulates the future development of Riyadh city and the connotative plans for the Arriyadh Region under the approval of RCRC.

Aside from the smart and sustainable megacity projects by RCRC previously highlighted in the Literature Review section, several other development alternatives and execution programs are also currently at different implementation phases. The following are brief descriptions of the selected cities and their smart sustainable city strategies.

Case #1: New York City, with over 8 million inhabitants, is situated along the northeastern shoreline of the USA and occupies a land area of more than 750 km^2 and over 10,500 per km^2. The city is one of the densest locations in the world, with an expected increase in its population in the next two decades [39]. As such, advanced technology and innovation have become essential for the city's development to ensure its livability and smart growth [40].

This study, Case #1, is a smart sustainable city strategy for New York City in the USA, with a detailed description of IoT utilization across the city. The strategy is designed around six major smart city areas viz-a-viz (i) openness with citizen participation, (ii) efficiency in a sustainable manner, (iii) fairness, (iv) security and peace of mind, (v) privacy and openness, and (vi) collaborative governance. In addition to these six broad areas, five short-term goals are also outlined. These goals cover (i) advancing innovation, (ii) encouraging transparency and data distribution, (iii) enhancing governance and technology connection coordination, (iv) partnership value-driven, and (v) industrial engagement and community advocacy.

Case #2: The city of Sydney is the capital of New South Wales state and the most populated city in Australia, with 4.9 million inhabitants [41]. The city of Sydney has developed more than 39 strategies based on sectors or focuses. However, they have developed the main framework, i.e., Sustainable Sydney 2030, as the highest-level plan that identifies the communities' main priorities with a clear vision, "Sustainable Sydney is a plan for a green, global and connected city." Pg. 11 [41]. Moreover, the plan considers the 17 United Nations SDGs, which link directions, objectives, and targets to the overall SDGs. The plan has ten goals and ten strategic directions to make the city more sustainable, and each direction has a set of objectives.

However, this study's Case #2 is a smart city strategic framework for Sydney to enhance the city's livability and fight against rapid urbanization via innovation and smart technologies. The purpose of the framework is centered around (i) establishing a sustainable approach to achieving smart city principles, (ii) connecting the dots, (iii) collaboration, and (iv) being a leader in Greater Sydney's smart city transformation. It is a comprehensive framework highlighting five strategic outcomes and a clear vision. Under each strategic outcome, there are objectives and three priorities each. The Sydney Smart City Strategic Framework aims to set the stones of smart cities' understanding, processes, enablers, and objectives, and identifies five primary outcomes: a city supporting, a city fueling, a city future-proofing, a city cultivating, and a city providing.

Case #3: Singapore is a leading global country in many fields, such as smart cities and sustainable development [42], with over 5.6 million inhabitants. Unlike Sydney, Singapore has a centralized government; strategies are developed nationally in sectors by the responsible ministry or agency, alongside the national strategies and plans as movements or initiatives that all industries and entities align with.

This study's Case # 3 is a smart sustainable city strategy for Singapore to ensure that the whole nation becomes a global forerunner in developing and utilizing practical artificial intelligence outputs, programs, and products in significant segments of the economy to boost prosperity and populace wellbeing by 2030. The strategy proposed five smart city megaprojects covering freightage, housing, health, education, and immigration. To successfully implement the proposed megaprojects, four enablers focus on global collaboration, education/smart city talent hunt, an industrial/research/government partnership, and data infrastructure.

Case #4: Hong Kong Special Administrative Region (SAR), with an estimated population of 8 million, is located along the southern shoreline of mainland China, with a land coverage of over 1100 km^2 [43]. Based on the city's location as a major international business hub, there is high population density and smart and innovative technology implementation. In its 2020/2021 annual report, the Hong Kong Trade Development Council identified digital transformation as a significant trend in the city since the emergence of the COVID-19 pandemic [44]. Although these advancements in smart technology and online platforms have provided a series of development and opportunities within the last decades, the pandemic abruptly increased these trends. Undeniably, this digital transformation has been essential to recent stability in Hong Kong.

Case #4 is a second version of the Hong Kong smart city blueprint. The first blueprint was released in late 2017 with 76 initiatives spread across six smart sustainable city categories. Smart sustainable city projects and initiatives in the area of efficient banking and financial transaction, the installation of free accessible internet facilities to the general public, and the establishment of various government digital and smart applications were successfully implemented. The second blueprint with more than 130 initiatives was designed to expand smart cities and the benefits of advanced and innovative technologies to the city residents to improve their QoL and convenience in daily activities. Smart sustainable city projects related to tourism, transportation, big data analysis, the COVID-19 pandemic, and software for planning, designing, operating, and constructing buildings, facilities and infrastructure were highly prioritized in smart city 2.0.

4. Results and Discussion

4.1. Lifecycle-Based Primary Considerations, Relevant Stakeholders, and Deliverables for Smart and Sustainable City Projects

This study's appraisal of the case studies showed the relevance of the selected primary considerations at every phase of the smart and sustainable city strategy implementation process. Figure 2 reveals the usual nature of smart technologies, outputs/deliverables, significant stakeholders, and paramount considerations associated with the different life cycle stages of smart and sustainable city projects. It reveals that implementing smart city strategies depends upon certain major agreements and the pristine engagement of paramount strategy collaborators at multi-phases of the lifecycle. Although specific primary considerations are pertinent and suited to traditional city projects, some practices were identified that are mainly relevant to smart city projects. An essential point from Figure 2 is the interconnection and linkages between the various selected case studies in their specified outputs. A consortium of professionals and stakeholders from multiple facets of the society with specific aims, objectives, perspectives, and duties were identified at various phases of the smart city strategy implementation. As such, it is imperative to utilize a cooperative approach that allows for the efficient alliance, joint effort, and intercommunication among stakeholders and professionals to prevent misunderstandings that might lead to differences in aims and objectives.
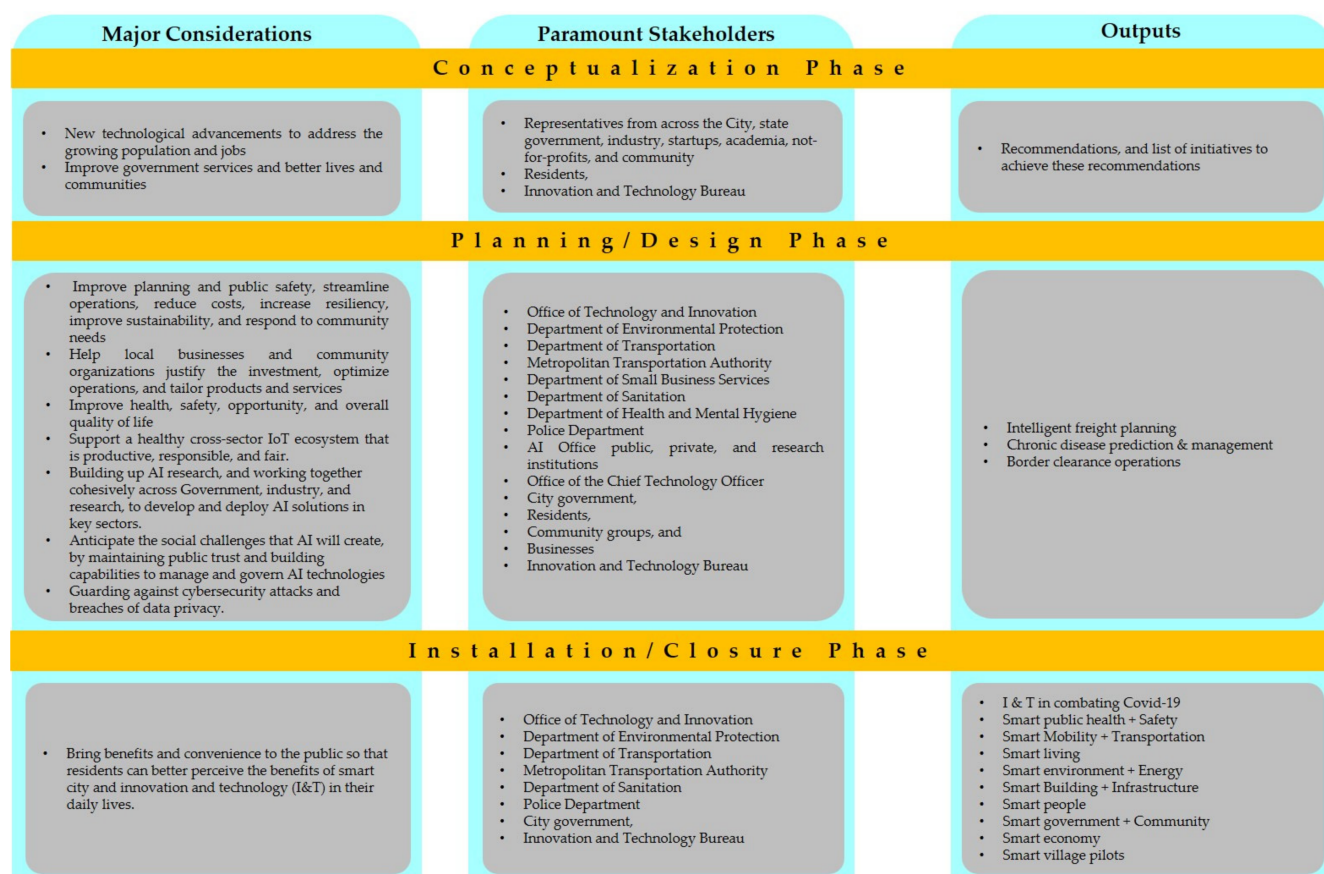

Figure 2. Lifecycle stages of smart and sustainable city strategies with primary considerations.

Figure 2 also reveals the effectiveness of good governance in successfully implementing smart city strategies, especially at the conceptualization phase. In Case #1, "improve governance and coordination" was identified as one of the five steps to achieving the city smart city deliverables. For instance, the adoption of the advanced IoT/technologies for smart city projects, logistics, and bureaucratic processes involved in the conceptualiza-

tion phase will significantly affect the financing, effectiveness, and timeline as well as the durability of the smart city projects.

The fundamentals of this study's lifecycle-based smart sustainable city strategic framework for implementing smart megaprojects in Riyadh city are briefly illustrated.

Conceptualization Phase: This phase constitutes the commencement of a successful smart sustainable city project implementation in which the detailed documentation of a clear vision, financing, timeline, etc., are prepared [24]. Decisions made at this phase are paramount, with consequential ramifications on other stages. Diverse key considerations lead to the resolution of implementing smart city projects in our selected cases. For instance, the smart city project was considered in Case #2 to address the challenges of the increase in population and unemployment. On the other hand, an improvement in the city administration's services and increased communal QoL were considered essential for smart city project implementation in Case #1.

Planning/Design Phase: The technicalities and feasibility of utilizing smart technologies for megaprojects are determined at this phase. Although not enough data are generated at this phase, the amount of data collected at this stage is regarded as being enough in decision-making to affect the other decisions. Contrary to the planning phase, the design phase is the most critical stage of the pre-implementation phases of smart and sustainable city projects. This is because any changes made after this phase will significantly affect the project's economic feasibility. While more than five city departments (i.e., Transportation and Environmental Protection) were involved in the designed phase in Case #1, the Innovation and Technology Bureau professionals were assigned the design responsibility in Case #4.

Installation/Closure Phase: Extensive deliberations, discussions, and sessions with paramount stakeholders and the resolution of all financial expenses are critical to the success of this phase. In Case #4, convenience emanating from smart city project implementation was prioritized at the closure phase. It is best practice to involve all relevant stakeholders, i.e., representatives from across the city, to believe in the goodness and realness of the project before the conclusion, as observed in Case #1.

4.2. Proposed Strategic Structure for Implementing Lifecycle-Based Smart and Sustainable City Projects

Table 3 reveals the comparison outcomes between Riyadh city and the four selected cases. The adopted comparison criteria were chosen from extant studies that (i) carried out a comparability analysis [12] and (ii) an identification of essential drivers to advancing smart sustainable cities [30]. The smart city governance appraisal criteria were based on a top-down vs. bottom-top approach to smart sustainable city strategies and project implementation. The sustainability criteria were utilized to appraise their consideration for the concept in the cities' strategy for smart project implementation.

Table 3. Comparison of Riyadh city with the selected case study cities.

Cities	City Governance Approach	Sustainability
Riyadh	Top-down	Not Available
New York	Top-down	Efficiency + Sustainability as one of the fundamental principles
Sydney	Top-down + Sustainable Engagement across three levels	Sustainable Sydney as the primary city strategy
Singapore	Top-down	SG Green Plan
Hong Kong	Top-down	Embedded in the city's strategic mission

The outcomes indicate that while some of the primary attributes for smart city attributes have been incorporated in Riyadh, others have not. Concerning smart city gover-

nance, the top-down smart city governance approach in Case #4 is based on the high-level connection among various ICT departments headed by the city's Chief Executive Officer. In Case #1, one of the six major principles of the city smart city strategy is "governance and coordination". By this, the CTO concentrates on ensuring the utilization of IoT and advanced technologies are distributed across the city's departments, agencies, city projects, etc. In Case #2, "leadership and governance" was identified as one of the vital cardinal factors in ensuring an enabling environment for the populace. Here, the city governance is based on (i) a top-down approach and (ii) prolonged engagement/responsibility from administrators across—academia and community, government, and industry. As such, the city smart city governance shared in the cases is a centralized/main city strategy as support for the city.

As mentioned in the challenges, gaps can be identified in the current strategic approach in Riyadh city. However, New York, Hong Kong, Singapore, and Sydney have good rankings in Smartness and Sustainability, and these cases embedded the Smart Sustainable City strategy as either part of the essential principles, plan, or mission despite the different approaches. Sydney has made multiple efforts to develop sectorial or designated field strategies. The city leadership identified the need for a primary strategy that guides the other plans underneath it, so they launched Sustainable Sydney as the primary city strategy. Still, they excluded the Smart City Framework Strategy from that umbrella with the alignment between the two strategies. The case of the Sydney strategies before the Sustainable Sydney Strategy has some similarities to the case of Riyadh nowadays, where there is no clear vision and guidance on what national objectives, targets, and initiatives to adapt to the city.

On the other hand, in Singapore they have developed two stand-alone plans; the first one is SG Green Plan, which includes multiple plans and initiatives such as SG Clean, Climate-friendly, and Reach for everyone for the active citizenry at home initiative. Still, in the Smart Nation Plan, the approach was different. It set clear targets and objectives and identified eight national projects associated with different categories such as economy, governance, mobility, and resource consumption. The best practices/lessons learned from the selected case studies can be noted as the following:

- Importance of the Main Strategy as an umbrella for the city that guides the other plans and programs, and initiatives under strategic objectives;
- Setting a foundation for the understanding of a smart city and a framework emphasizing how it contributes to sustainability;
- People centricity and continuous reach and participation, informing that smartness and sustainability serve the city, environment, people, and future generations;
- Centralized city strategy, encouraging better alignment and collaboration with clear objectives, initiatives, programs, and projects;
- Linkage with international and global agreements, agendas, and standards, such as United Nations SDGs, Paris Agreement, and ISO 37120.

As such, adopting the best practices/lessons learned from the benchmarks and filling the gaps and challenges in the city of Riyadh's strategic approach requires a guiding strategy. Therefore, this guiding strategy can be Riyadh's Smart Sustainable Strategy, which will fill the gap in the strategic structure of the city, as shown in Figure 3. Introducing the proposed Riyadh's Smart Sustainable Strategy will eliminate such misunderstandings of smart city implications by identifying a clear and unified vision, approach, objectives, framework, targets, programs, and initiatives. Thus, it will also act as an umbrella of the community plan of the city, which will ensure the alignment of smart technologies and digital transformation with sustainability and sustainable development. In the end, Riyadh's Smart Sustainable Strategy will accelerate the cooperative progress of achieving the Vision 2030 objectives, especially regarding the rankings of the livability index, social capital, and competitiveness index.
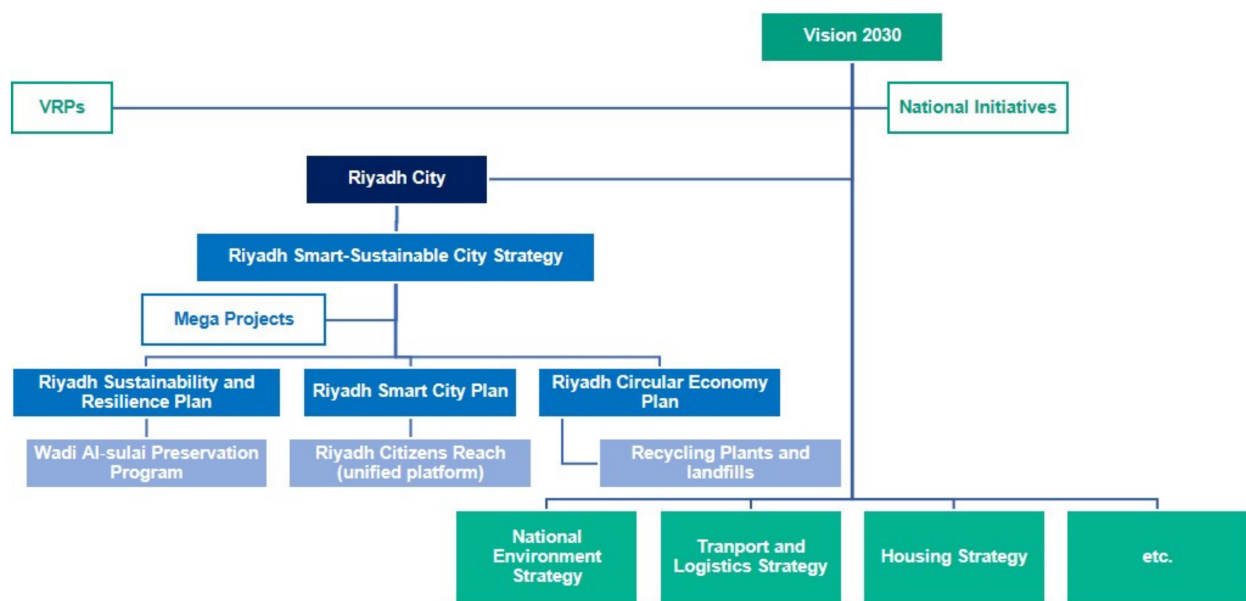
Figure 3. Proposed Strategic Structure.

Figure 4 outlines the lifecycle-based best practices for actualizing the smart sustainable city initiatives derived from the four selected cases. As such, it should be given paramount consideration when implementing Riyadh's smart city mega projects. Based on the continuous monitoring and review process of the lifecycle stages of smart sustainable cities megaprojects and initiatives, the KPI at every stage ensures either the success or failure of their implementation. Therefore the KPI at every phase guarantees the actualization of the best practices in the succeeding phase [45].
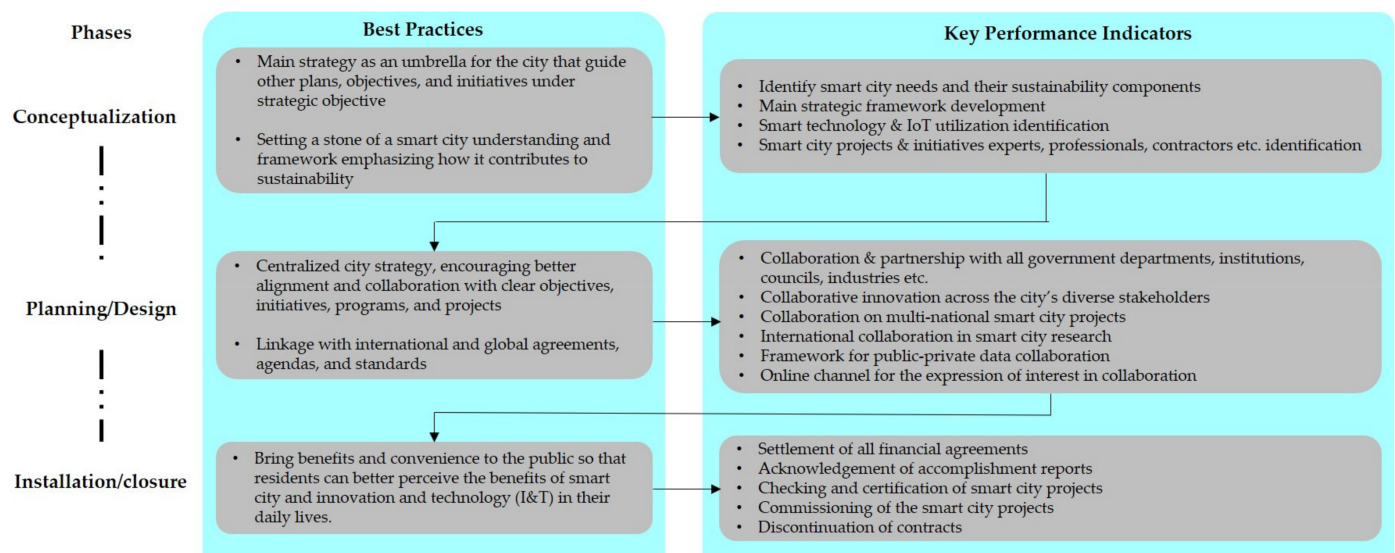

Figure 4. Lifecycle-based KPI framework for implementing smart sustainable city projects and initiatives.

Overall, there are 15 identified KPI or best practices indicators across the three-project lifecycle: four at the conceptualization phase, six at the planning/design phase and four at the installation/closure phase. The KPI concerning stakeholders' partnership, involvement, and collaborations is shared among all selected cases. In Case #1, the launching of smart city collaboration, an online collaborative channel, and the organization of an IoT forum for various ministries, departments, and agencies, among several other performance indicators,

were strategized for smart city implementation appraisal. The KPI regarding public–private partnership and research–industry–Government collaboration is peculiar to Case #3. If adopted in Riyadh and other Gulf cities, these six KPIs in the planning/design project lifecycle phase could be leveraged to assess their smart cities' present and future strategies and initiatives.

Appraising smart sustainable city strategies, projects, and initiatives via a lifecycle approach is essential due to the provision of a structured pathway to arrive at the comprehension and knowledge regarding the implementation of the phases/stages, in addition to opportunities for continuous review and monitoring. The identified extant studies [31,34–37] via a comprehensive literature review revealed that this study's lifecycle-based framework for smart city implementation is a prominent feature of strategy construction. However, the findings regarding the top-down and collaborative approach being the most widely utilized methodology for establishing smart city strategies agrees with smart sustainable cities-related studies [35]. Moreover, existing studies within the Gulf Region have been carried out with different smart city perspectives. In the United Arab Emirates, a smart city framework specifically focused on enhancing tourism users' participation has been proposed [13]. The economic dimension of smart cities in the cities of the Gulf region has also been comparatively appraised by some scholars [8]. Likewise, within the context of Saudi cities, studies ranging from geographic information systems and ICTs for advancing smart cities [12] to selected green cities project evaluations have been carried out [9]. These studies are also distinguished from this article's research approach and findings.

5. Conclusions

This study is relevant for all cities worldwide and goes well with 100 cities Zero Carbon and Smart Cities launched by the European Commission. A lifecycle-based smart sustainable city strategic framework for implementing Riyadh smart city projects and initiatives was proposed in this study via selected international best practices. The study utilized a qualitative research methodology where four smart city cases from Singapore, the USA, Hong Kong, and Sydney were analyzed to determine a premier framework. This is novel as no existing studies within smart sustainable cities, especially in Saudi Arabia and the Gulf region, have developed a model demonstrating the connection between lifecycle best practices and critical considerations of smart city strategies and projects. Based on the smart city strategies and project outcomes at every phase, stakeholders and outputs for appraising the successful implementation were identified. The strategy's present, medium, and long-term plans could be effectively evaluated based on the dynamic connection between the identified primary considerations, KPI, and the lifecycle phases.

With this proposed framework, the authors have provided an initial attempt to fill the gap in the lifecycle-based smart city knowledge and implementation of smart city projects and initiatives in Riyadh city. Some pragmatic, governance, and management-based implications were identified in this study. First, this study revealed some pragmatic considerations to built environment experts on effectively planning, designing, and implementing smart sustainable city strategies and projects for actualization in Riyadh. The study's developed framework recommended emphasizing efficient management and commitment at the beginning and post-implementation phases to ensure the successful implementation in the latter phases of smart city projects in Riyadh. Second, identifying key considerations, major stakeholders, and outputs at all the lifecycle phases ensures the insightful and effective management and evaluation of the smart city projects' performance by smart city project managers and policy/decision-makers. Moreover, the demand model can perform the function of an appraisal tool that allows all parties involved in the smart sustainable city projects to objectively assess the feasibility in advance, allowing for prompt adjustments and modifications in due course.

However, there exist some limitations that demand future research. First, a comprehensive best practice implementation framework of smart city strategies and projects is large and differs across Saudi cities, the Gulf region, and the world. These practices cannot

be fully addressed within any peer-review publication. However, gaps between higher education institutions' research and governmental administrative practice regarding smart city strategies have been bridged. Second, due to the comprehensive review and exploration of smart city strategies from selected cities worldwide, the differences across these cities might hinder the framework application in Riyadh cities. This is because the smart city strategies were conceived differently across the selected cities. However, these differences do not affect the identified best practices, KPIs, and technology for successful smart city projects in these cities. As such, a different configuration of the proposed framework might be required for contextualizing different smart city project phases in Riyadh city. Third, the developed framework is not proposed as a conclusive manual for delivering smart city strategies due to the rapid advancement in smart innovation, technologies, information, infrastructure, and devices. Constructively, the proposed framework has been designed for scholars in academia, smart city practitioners, professionals, administrators, inventors, etc., as a reference for contextualizing smart projects for successful implementation and not a fit-all solution manual. Therefore, policymakers/project managers are encouraged to utilize this study's framework for modifying and advancing the governance of smart city strategies and projects.

Based on the identified knowledge gaps and the best practices/lessons learned from the selected cases, the following are expected from Riyadh. First, future research directions based on an optimal algorithm for creating a smart city strategy by decision makers and related professionals is also recommended. Second, Riyadh and other Gulf city officials are advised to consult city planners, urban designers, developers, etc., of smart city strategies and projects for the efficient implementation of smart city strategies. Third, boost the city governance and coordination by creating a smart city collaborative and regular workshops for various agencies and stakeholders. Others include but are not limited to (i) recent green technology adoption, (ii) advancing the overall city digital transformation, and (iii) the adoption of the proposed lifecycle-based smart city framework for implementing all the recently launched initiatives by the Amanas.

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