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The Strategic Vision 2030 As A Catalyst For Riyadh Smart City Making

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Abstract

The paper explores the process of smart city-making. The literature mentions two approaches to this process. One insists on the "hard" side of developing ICT infrastructure, Internet of Things (IoT) and smart buildings. The other, however, focuses on the "soft" side of the smart city which advocates the setup of a strategic vision and attendant policies to boost social transformation, a knowledge-based economy, continuous learning and building up human capital. In its intent to become a smart city, Riyadh starts by adopting the Strategic Vision 2030 and the accompanying programs and initiatives to instil social and economic changes followed by pouring the required investments to establish advanced ICT infrastructure, e-government and smart urban functions. The study relied on secondary data gathered from official websites, government reports and relevant documents to measure indicators of the six smart city components adopted. The results indicate that securing the political will from the highest authorities to instigate appropriate policies to foster the process of smart city-making has been proven necessary at least as seen in the case of Riyadh.

Keywords: *Riyadh; Smart City; ICT and IoT infrastructure; Vision 2030; Indicator Measures.*

1. Introduction

The smart city model has lately gained wider currency in the planning literature. Many cities all over the world are undertaking important strides to embrace smartness in their urban functioning. Cities usually, take one of two options in their process of smart city-making. One consists of attaching paramount attention to the "hard" side of the smart city which is the development of Information and Communication Technologies (ICT) infrastructure and the growth of its Internet of Things (IoT). The aim of such an option is to boost [1]the city's network to connect myriads of sensors, smartphones and all sorts of devices to collect, analyze and exchange data for better management and control of traffic, buildings, energy, water, waste and all aspects of city life [1,2,3]. The other focuses more on the "soft" side which involves the setup of a strategic vision and policies to foster the making of a knowledge society, creative class, education, continuous learning, knowledge-based economy, governance, innovation development, arts and culture [4,5,6]. Riyadh is no exception to this trend of becoming a smart city. But unlike many other cities, more interest was bestowed on the "soft" side. It started by developing in 2016 a new Strategic Vision 2030 which was set up by the highest political authority. In light of this vision, a new set of policies was drawn to put people at the centre and to foster human capital building, social transformation and a knowledge-based economy. Huge investments were then poured into the development of the "hard" side as exemplified by ICT and IoT infrastructure [7].

2. The Literature Review

Although the concept of smart cities has gained significant attention in recent years as a way to improve the quality of life, promote sustainability, and enhance efficiency in urban

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functioning, there is no widely agreed-upon definition of what is meant by the term “smart city” [1,8,3]. A common agreement, however, seems to exist among scholars on its components. The smart city relies on the ubiquitous use of big data and advanced cloud technologies to improve the monitoring of urban functions and enhance the city’s responsiveness to the needs and wants of citizens. In other terms, a smart city needs to be efficient, responsive, and participative [9,10,1,11].

The literature categorizes the smart city components into two sets, hard and soft. If many researchers have highlighted the physical or “hard” components, others have emphasized the social or “soft” ones. The former refers to tangible components like building structures, network infrastructure, energy grids, waste management, transport networks, etc. The latter concerns intangible assets like people, social networks, knowledge, education, quality of life, socioeconomic welfare, creativity and innovation [1,13,2].

The adepts of the smart growth movement advocate that revamping the “hard” physical space of a smart city would lead to curtailing the worsening effects of air pollution, fixing the loss of open space, easing traffic congestion, halting urban sprawl and restricting the skyrocketing costs of services [14,12,15]. In so doing, they claim that the “soft” components would necessarily follow, the social bonds would be enhanced, the quality of life improved, and the living standards raised [16,17]. Their detractors embrace different views. That is to make a smart city, they would rather proceed by the soft domain in which a strategic vision and a set of policies would be developed to promote social and economic change, encourage innovation and continuous learning, and motivate knowledge workers. All this would also ultimately be conducive to upgrading the hard elements of the city.

The view that insists on the “hard” components of smart cities has been criticized for being too techno-centric with less interest in people and the socioeconomic aspects of planning and its environmental features [18,19]. In this regard, many smart cities established in the high-tech corporate-designed models like Songdo (Korea), and Masdar City (UAE), were vehemently criticized for being too heavily dependent on higher technology. They suffer many shortcomings as they lack attention to the “soft” components like considering people, valuing education, nurturing knowledge, upgrading skills, promoting innovation and the creative class [20,21,22,23,24,25,26,27,29].

Golubchikov et al. [29] criticize this approach for limiting the analysis to “hard” and “soft” components. The smart city should transcend the hard-soft dichotomy to be thought of as a hybrid space with multiple dimensions. The smart city is not an “end state” nor an “accomplished reality”, but a continuous process. Being an “emerging concept-in-practice”, an “actually existing smart city” is not yet in operation. It is not enough, therefore, to reflect only on tangible and intangible structures and networks. It would be more significant to examine the strategies and policies set up to govern the experience of the city in its process of becoming smart [29].

Along this vein of reasoning, many academics contend that the smart city model is not limited to the diffusion of ICT but concomitantly denotes planning policies and programs that foster sustainable development, economic growth, better quality of life and wellbeing for city residents and their empowerment [30,31,32,33]. The proponents of the smart city as a process insist that ICT technology should be seen as a means not an end in itself. It is leveraged to improve the performance of the government, promote quality of life and boost social and economic transformation [34,35,36].

For a successful process in smart city making, it is important to juggle the components of both the hard and soft domains to achieve sustainability requirements, social inclusion and quality of life demands. Although the ICT technological

infrastructure alone cannot alleviate all the issues encountered in the process of smart city-making, it can to a great extent help ease and enable it. It is also of paramount importance that smart city planning blends both the hard and soft components with the concepts of sustainability and livability into smart city development [37]. To that end, a smart city needs to use public participation and stakeholders’ involvement to improve the quality of life of

citizens by leveraging smart infrastructure and digitalization to achieve an inclusive, sustainable and resilient city [38]. This way, the smart city model becomes not only an end in itself but rather a means to achieve a better quality of life, citizen empowerment and urban sustainability.

To operate effectively, however, a smart city needs to develop a state-of-the-art sensing infrastructure to monitor road traffic, street noise, air pollution, city safety, etc. Not only do the use of advanced technologies and data mining help improve the functioning of the city and its infrastructure but they also lead to better service provision and higher living standards for smart city residents. It must therefore, integrate all its physical, social and digital components to optimize its urban functions like energy consumption, water use, and waste collection and disposal [39]. The next paragraphs will discuss the different components and indicators of smart cities.

2.1. Smart City Components and Indicators

Many frameworks and indicators have been commonly used to evaluate the smartness of cities and measure their performance, such as the IMD Smart Cities Index (2020) [40] the Smart City Wheel developed by Cohen (2012) [41], and Caragliu's et al. (2009) [34] approach. These indicators have mainly been grouped into six smart city components, that is economy, mobility, environment, people, living, and governance [42,43,34,44,45,46,47]. Sherifi [3] added one more component to the list, the data, whereas Lai and Cole [48] (2023) included three additional components, perception, privacy and cybersecurity and technology, to the six already mentioned. Huovila, Bosch and Airaksinen, [49] list the following dimensions: natural environment, built environment, water and waste, transport, energy, economy, education, culture, innovation and science, health, well-being and safety, governance and citizen engagement, and ICT, whereas the International Organisation for Standardisation ISO [50] used 19 and U4SSC [51] used only 3 dimensions. In their comprehensive review of the literature on smart cities, Yin et al. (2015) [52] identified four key dimensions: technology, governance, people, and sustainability. By all accounts, the dimensions usually cover three main areas, economic, environmental and socio-cultural. Even though other dimensions with different appellations may be found in the literature, like e-government, informational knowledge-based society, creative institutions, digital or ICT infrastructure and the like [52,15,53], they all eventually refer explicitly or implicitly to more or less similar sets of indicators.

To measure the performance of a smart city, researchers relied on the use of many indicators to assess each of the above smart city components. According to a review of the literature by Petrova-Antonova and Ilieva [47], some have used as many as 1152 indicators. The International Organisation for Standardisation (ISO) for instance, used 85 indicators, while the United for Smart Sustainable Cities (U4SSC) [51] and UN Habitat relied on 91 such indicators. Others like CITYKeys [53] developed an assessment framework with 75 indicators. Lombardi et al. [46] utilized 60 indicators whereas, the OECD [54] used 8 components with 21 indicators and Lazaroiu and Roscia [55] made use of only 18. As it was stated before, all the indicators were set to measure city performance on smartness, sustainability, quality of life and people’s well-being. As far as the Riyadh case is concerned, Bakry et al. (2019) [56] in their extensive review of the scholarly work on smart cities, settled on the indicators of three key dimensions considered to be of high relevance to the context of Saudi cities: smart governance, smart infrastructure, and smart mobility. The following section will delve into the opportunities and challenges of Riyadh's journey to becoming a smart city.

3. The Potential of Riyadh to Become a Smart City

The Riyadh smart city-making process is not seamless or challenge-free. The sprawling leapfrog urbanization, low-density development, car-dominated mode of transport, and large population concentration in the city where about a quarter of the Saudi population lives, are just some hurdles on the way. To face up to these challenges, the plausible option was to engage Riyadh in the process of becoming a smart city. In so doing, the smart city was not considered as an end in itself but a means to an end. That is a process to achieve the Strategic Vision 2030 objectives like fostering social transformation, knowledge-based

society, quality of life and environmental sustainability. By prioritizing knowledge and human capital build-up, the process of Riyadh Smart City places citizens at the center instead of assigning prime importance to digitalization and ICT-centered applications as is the case in many other cities. ICT and IoT infrastructure are taken as a means to serve the process of social change, urban sustainability and higher living standards.

The process of transforming Riyadh into a smart city has taken several key steps. First and foremost, it has secured a strong political will from the highest political authority that developed a strategic vision for the year 2030. Not only the Vision 2030 defined the mission and goals of the smart city initiative, but it has also identified the specific urban challenges that need to be addressed and the desired outcomes of the social and economic transformation to be reached. City stakeholders were called upon to join their efforts to implement strategies and projects to achieve the desired outcomes in line with the established vision and goals. The Vision has also set up a timeline, budget allocations, and performance indicators to track the progress of smart city-making [7].

From this account, it is clear that Riyadh in its journey to becoming a smart city has followed a different path in several aspects, primarily due to its strategic initiatives, developmental context, and sociocultural considerations. Unlike many other examples of smart cities in the world, Riyadh has prioritized the soft over the hard domain. If many other cities like Tokyo, Seoul, Singapore, Amsterdam, and Barcelona have focused essentially on developing ICT infrastructure and growing their Internet of Things (IoT), Riyadh has started by securing strong political support to launch a process of social and economic transformation and establish the necessary strategies and policies to foster the process of smart city making, then providing the required investments to technological advancement of its hard domains [7].

If Barcelona has focused mainly on citizen involvement and open data initiatives, Amsterdam insisted on sustainable technology and energy grid, whereas Tokyo, Seoul and Singapore have accorded attention to advanced technological infrastructure, with high-speed internet, widespread IoT (Internet of Things) integration, and robust digital services for citizens [57, 58]. Riyadh however, has first launched a social transformation program and economic diversification, leveraging smart technologies to shift from oil sectors to a knowledge-based economy, followed by significant investments in digital connectivity and cutting-edge high-tech infrastructure as part of the Saudi Vision 2030 program [7].

Although both Singapore's Smart Nation initiative and Amsterdam's Smart City program are government-led strategies that encompass various sectors [59], Riyadh's approach is unique because of its ambitious Vision 2030 platform that governs the Riyadh Smart City project intending to transform it into a world-leading smart city through strategic partnerships and investments in education, human capital building, healthcare and digital infrastructure [7].

While Riyadh's approach shares some similarities with global counterparts like Singapore, Barcelona, Tokyo, Amsterdam and Vienna, in its focus on digital transformation, governance and sustainability, the Riyadh case is distinct in several aspects as its experience is quite recent and still evolving. Unlike these world-class cities which have a long-standing history of leveraging technology for smart urban solutions,
particularly in digital governance, smart mobility, and sustainable living [58,59], the Riyadh approach is unique in its recency and emphasis on establishing first the ambitious Vision 2030 initiative which aimed at diversifying the economy and reducing oil dependence by focusing on areas such as smart transportation, smart governance, digital services for citizens, and environmental sustainability.

If Singapore, Barcelona and Amsterdam offer insights into how cities can leverage technology to enhance citizen engagement and sustainability, Riyadh presents a lesson on how to gain political support, and harness partnerships with different stakeholders to speed up the process of smart city-making.

In conclusion, Riyadh's approach to transforming into a smart city is interesting in many

ways. It offers lessons for cities worldwide willing to engage in the process of becoming smart cities by retrofitting their smart city components and upgrading their urban structures to integrate advanced technological infrastructures and the Internet of Things (IoT). The Riyadh smart city model can be inspiring for cities in the developing world, particularly Arab Gulf cities that can pour significant investments into leveraging smart technologies for smart urban solutions to face up to their urban challenges. The Riyadh smart city showcased a process with a unique blend of traditional urban structures and ultra-modern city initiatives integrating cutting-edge technologies to improve various smart city dimensions such as economic growth, governance, environmental sustainability, citizen engagement, living standards and urban mobility.

4. Materials and Methods

This section delves into the measurement method adopted in this study to assess the indicators of Riyadh's process of becoming a smart city. It relies mainly on the IMD Smart Cities Index [40]. The measures used rely mainly on the widely used frameworks developed by Giffinger et al. [15], Caragliu et al. [34] and Cohen [41] (2012) Smart City Wheel. They all identified six dimensions to evaluate the smartness of a city: smart economy, smart mobility, smart environment, smart people, smart living conditions, and smart governance. Each dimension is further divided into specific indicators and metrics that can be used to evaluate the smartness of a city. For that matter, the study utilized another commonly used index, the Smart City Index, which was developed by the IMD World Competitiveness Center to appraise the level of smartness based on indicators covering a wide range of factors delineating the six smart city dimensions [40].

The method adopted for this study is based mainly on qualitative analysis using essentially secondary data collected from various official websites and reports. They could be government websites and reports emanating from different public and private institutions or smart city platforms, newspaper articles, official documents, and literature in the field. The Saudi Vision 2030, the Riyadh Municipality, the IMD Smart City Index, and the Royal Commission for Riyadh City (RCRC) websites, are just one such institutions whose websites provide valuable information about the process of Riyadh's transformation into a smart city. The data gathered was used to assess the indicators set to measure the six smart city components detailed below.

The study used only indicators for which metrics and data were provided from the secondary sources cited above. The assessment of indicators relies on rankings provided by international or research institutions like the Global Cybersecurity Index, and the Institute of Management Development (IMD). It could also be some figures adopted as targets by some national or local institutions like zero CO2 emissions by 2060, the increase of per capita greens in Riyadh from 1.75 to 28 m2, or else the reduction of fatal accidents per 100000 citizens from 28 to 13 as a result of SAHIR traffic smart monitoring, etc. The economic competitiveness index was used to measure the smart economy component. The fact that Riyadh has improved its position 23 places within the last three years, is a good indicator of its economic performance. Similarly, other indicators of the smart economy like public finances, economic reforms, technical development financing, and support for technical development were evaluated by using rankings issued by the IMD smart city index or other measures reported by different publication outlets such as reports,

newspapers, etc. The same assessment method was used for all other smart city component indicators. It must be emphasized that the aim of Riyadh's process to become a smart city is not on how high the indicator metrics are but on how far the process has gone to reach the targets set in the Vision 2030 initiative for Riyadh to become a leading smart city.

Table 1: The six smart city components and their indicators**.**

Smart City Components	**Indicators**

Smart Economy	foreign financial institutions, world smartest capitals ranking, economic performance indicator, the city's business efficiency, Competitiveness, public finances; economic reforms, financing and support for technical development, real GDP growth rate, employment-long-term growth, government's ability to adapt to economic changes, unemployment legislation, cybersecurity, resilience of the economy, inflation rates for consumer prices, digital transformation in companies, the market capitalization of the stock market, and venture capital availability, e-commerce market increase, online shoppers growth, increase of online stores, the online market volume projection, compound annual growth rate, patent registration, citizens opinions about employment opportunities created by the economy, views about that job finding services, accessibility to job listings, starting new businesses.
Smart environment	per capita green space, air quality, reducing annual power consumption, use of smart meters for water and energy consumption, projections at planting 7.5 million trees, use of recycled water for their irrigation, environmental cleanliness by reducing the city carbon footprint, net-zero emissions of greenhouse gas by 2060, production of clean energy from renewables, decrease of total energy consumption.
Smart mobility	smart traffic management, walkability, cyclability, and public transport as primary modes of mobility, safety on the road: reduction of car accidents and fatalities, walk score index, e-scooter and e-bike-sharing market growth, public transport, environmentally friendly metro and bus system, citizens views about the most serious traffic issue, satisfaction public transport.
Smart living	the knowledge-based society, city quality of life, higher living standards, educational attainment, continuous learning, creative workers and innovation, social reforms and social inclusion, and public participation, high-speed broadband coverage penetration, increasing government online services, smart city living ranking, educational attainment, investments in ICT market, healthier living through CO2 emissions reductions, recreation projects and entertainment events, social inclusion

Smart people	human capital building, achieving social transformation and, increasing the living standards of residents, progress on the United Nations human development index, HDI 'rating scale', Riyadh smart city rating, the share of university students enrollment, the innovation index, expected years of schooling, Gross National Income (GNI) per capita, citizen views on basic sanitation needs, satisfaction with medical services provision, views about accessibility to health services, satisfaction with public safety, housing affordability, online security, satisfaction with green spaces and cultural events, quality of schools, IT skills acquisition, Lifelong continuous learning
Smart governance	government efficiency, e-government services, accountability, responsiveness, and transparency (ART), red light sensors at intersections, social transformation program, Accessibility to information on local government decisions, Corruption of city officials, citizen participation, public private partnership program (SHAREEK), Residents contribution to decision making of local government, Residents' provision of feedback on local government projects.

5. Results and Discussion

5.1. Smart Economy Indicators

Being the capital city and by far the largest one in the country, Riyadh is trying hard to strengthen its position as an emerging financial and business hub at the global level in keeping with the Vision 2030 goal to promote it to become among the 100 top-ranked world cities. As a result of the many programs set to achieve the city's economic transformation, Riyadh is attracting direct foreign investments and multinational companies' regional headquarters making it among the fastest-growing economies in the G20 in 2022 [60]. Fundamental to this rising smart economy is the city's cutting-edge ICT infrastructure and the mega projects being realized which in turn led to increasing foreign direct funds being poured into the local economy as seen in the number of foreign financial institutions which has risen from 453 in 2019 to more than 2900 in 2022 [61]. The factors mentioned above are all indicators of the city's smart economy. No wonder, Riyadh is ranked the third-smartest capital among G-20 states, jumping 23 places within only three years according to the Institute for Management Development Smart Cities Index [62]. This would not have been possible without the embracing of government policies that are conducive to economic reforms in recent years to enhance the city's competitiveness among the world's leading smartest capitals. These economic reforms seem to have had an impact on the city's economic performance indicator which led to a huge leap being made on a global level from 48th to 6th place within the span of just two years (2021 - 2023) [63,64]. The city's business efficiency indicator as measured by the extent to which enterprises are performing in an innovative, profitable and responsible manner has jumped from 26th to 13th rank globally within the same period (2021- 2023) [63].

Competitiveness is another important indicator of a smart city economy. In this regard, Saudi Arabia and by extension, Riyadh has managed to advance its ranking on a global level from 32nd in 2021 to 17th position in 2023. It has also been ranked third among highly competitive economies hence, well ahead of many G20 countries. In its 2023 report, the World Competitiveness Center of the International Institute for Management Development (IMD) showed significant improvements on many smart economy indicators. The first rank on a global level was accomplished on indicators like public finances; economic reforms, financing and support for technical development.

The second rank was also attained on indicators like real GDP growth rate, employment-long-term growth, government's ability to adapt to economic changes, unemployment legislation, cybersecurity, and legal environment support for the development and application of technology. The third rank was also reached on indicators like the resilience of the economy, inflation rates for consumer prices, digital transformation in companies, the market capitalization of the stock market, and venture capital availability [63].

The development of e-commerce and related applications are other indicators of a city's smart economy. Nearly all companies and commercial establishments have their services and transactions provided through their websites and applications. Suffice it to note that the e-commerce market is increasing sharply. The figures show 12.9 million online shoppers in 2018 and is expected to reach 19.3 million by the end of 2023. The number of online stores has also increased from around 29 thousand to about 36 thousand between 2020 and 2021 [65]. The e-commerce online share is currently at 7.1% and is estimated to increase to 10.1% by 2027. The online market volume is estimated at $11,619.1 million by 2023 and projected to reach $14,833.2 million by the year 2027 with an expected compound annual growth rate (CAGR 2023-2027) of 6.3%, placing it the 29th largest market for e-commerce on a global level [66]. This is an indication of the staggering growth of Riyadh's smart economy due to the significant city-wide internet penetration, improvements in high-speed broadband coverage, widespread internet technologies, and smartphones, which have boosted the e-commerce market.

The smart city economy is mainly driven by innovations produced by cutting-edge research within universities and research centres. Riyadh's smart city economy is no exception in this respect as it attempts to become innovation-based. In this regard, King Saud University has made a big leap in patent registration which amounted to 1592 in 2022 [67].

Both quantitative objective and qualitative subjective indicators are used for smart economy component measurement. The former set of indicators is discussed above. Concerning the latter set of subjective indicators, the analysis relies on the opinions expressed by Riyadh respondents to a questionnaire survey conducted by Smart City Index. As far as employment opportunities are concerned as an indicator of a smart economy, a large proportion of citizens (68.6%) think the city economy and businesses are creating new jobs. In keeping with this opinion, a high percentage (61.3%) of respondents declared that job-finding services are readily available. Similarly, 78.8% of respondents acquiesced that finding employment is being made a lot easier by online access to job listings. Likewise, 76.8% of them say that starting new businesses is being quite remarkably facilitated owing to the online services and platforms that Riyadh Smart City has provided [68].

5.2. Smart Environment Indicators

Kumar (2020) asserts that cleanliness, greenness, and the provision of recreational opportunities for residents of all backgrounds and all ages are used as indicators to assess the smart city environment component. Regarding the greenness indicator, it is measured by the per capita green space which is currently at 1.75 square meters and projected to amount to 28 m2 as set by the Green Riyadh Project. Pursuing this objective would not only make Riyadh greener but it would also improve the air quality in the city by cutting CO_2 concentration by 3-6% and reducing dust accumulation in the air which will boost the city's environment quality. By so doing, it is hoped to lower the Summer ambient temperature by 2 Celsius degrees and by 8-15 Celsius degrees in the afforested locations in the city. This will also have an important repercussion in reducing annual power consumption by 650 gigawatts per hour [68]. A network of stations for monitoring air quality has been put in place throughout the city by King Abdulaziz City for Science and Technology (KACST). To monitor water and energy consumption, smart meters for each type were deployed [69].

The other indicator to achieve smart environmental sustainability which is associated with

the Green Riyadh Project aims at planting 7.5 million trees to enlarge the size of green

spaces which will be irrigated by leveraging the recycled water in the city through an efficient management system [68]. Needless to say, water conservation and minimizing its consumption are of paramount importance for the smart city environment. A campaign known as “TARSHID” is currently underway to launch and accomplish more water and energy retrofit projects to encourage people to rationalize and save non-renewable resources.

The environmental cleanliness indicator would be appraised by reducing the city's carbon footprint. In keeping with Riyadh's strategic sustainability goal and the making of a low-carbon environment, the government has pledged to achieve net-zero emissions of greenhouse gas by 2060 [70]. As a result, a target of 278 MtCO2eq of GHG emissions the production of clean energy and a goal of 50% renewables in the power capacity mix in 2030 was set. The “TARSHID” policies have managed to decrease the total energy consumption by about (1.4%/year) to around 232 Mtoe in 2021. This is a huge leap compared to the previous 4% per year increase over 2010-2015. [71]. All these measures would contribute to upgrading the urban resiliency of Riyadh smart city and raise its capacity to survive and thrive the stresses and shocks that climate change would produce.

However, Riyadh City faces several urban challenges that may hamper any attempt to achieve its environmental sustainability. Among such challenges are the huge population influx of newcomers to establish themselves in the city which leads to growing dependence on foreign goods, materials and food to support the needs of residents and increases demands for water consumption and energy use. All this would cause a much bigger ecological footprint of the city putting a huge burden on its infrastructure and threatening its environment [72,73,74,75]. Riyadh Residents account for about a quarter (25.3%) of the total Saudi population (8.660.885 out of 34.218.169) [76]. The current ecological footprint per capita for Saudi Arabia is estimated at 5.77 global hectares per person. The size of Riyadh’s ecological footprint would therefore be around 50 million global hectares (5.77*8660885) [77]. This would mean that the area required to maintain Riyadh's lifestyle would be 253 times the size of the city. Such a situation is utterly unsustainable. Therefore, it is time to foster the smart city model to address these sustainability challenges. The Smart City uses technological advancements in terms of wireless sensors, real-time data exchange, digital infrastructure, and the like to achieve system optimization, innovation, knowledge society and behaviour changes to support the city environmental sustainability [78].

To figure out how a smart city model would work, a prototype with the name ALNAMA Project is being planned in Riyadh over an area of 10 square kilometres to become a smart zero carbon district. It is intended to promote a smart self-sufficient community with sustainable living where only renewable energy and recycled water are used. it is also characterized by a zero-waste, car-free city and 37 kilometres dedicated to a running and cycling track [79].

5.3. Smart Mobility Indicators

Smart mobility is another key measure of a smart city. It is about improving urban mobility using advanced technologies and smart traffic management systems. Riyadh has made significant progress in this regard. Smart transportation systems have been implemented using sensors to collect data, and real-time monitoring, to improve the decision-making process and smart parking solutions [56]. This has greatly improved the efficiency and effectiveness of the city's transportation infrastructure, reducing traffic congestion and improving the overall mobility and commuting experience for city residents.

Following Vision 2030 targets which insist on retrofitting city streets and neighbourhoods to become walkable friendly by putting people at the centre of the design and planning process. Accordingly, smart mobility focuses more on people than on cars. Its main indicators would thus be smart traffic management, walkability, cyclability, and public transport as primary modes of mobility.

As far as smart traffic management is concerned, Riyadh City is covered by an automated

traffic management camera system known as the “SAHIR” system. The system is connected to a control and command centre to track and monitor road traffic in the city. The platform provides video streaming to instantly screen the traffic flow all over the road system. There are plenty of sensors and cameras installed at the intersections of the road network to control and safeguard the traffic environment to improve traffic safety and enhance the road network efficiency. This has managed to limit excessive speed and enforce obedience to red-light signs at intersections. This smart monitoring has significantly lowered traffic accidents by about a third of what it was. The official figures show that during the last five years, car accidents have been reduced by 34% and fatal ones by 51% making important savings to public finances of more than $1.6 billion. The number of deaths per 100 thousand has also dropped from 28 to 13.5 in 2022 [80].

Riyadh city walkability is another indicator used to assess the smart mobility component. Walkability is evaluated by the walk score index which is for Riyadh 81 out of 100. This score value means that walkability in the city is very good, in the sense that most service destinations can be reached on foot as most amenities are within walking distance from an address [81]. The Vision document has also stressed walkability as an objective in planning and reshaping city neighbourhoods. In this regard, a pedestrian network all over the city neighbourhoods with some cycling roads has been introduced.

Cyclability is another measure of smart city mobility. E-scooters and e-bike-sharing are gaining growing popularity among Riyadh citizens who are increasingly taking to micro-mobility to get around city streets. The E-Scooter sharing market size in Riyadh is rising fast at an annual growth rate of 5.72% between 2023 and 2027. The projected market volume for 2027 is estimated at US$3.630.000 [82]. The user penetration is expected to be around 0.5% in 2023. E-scooter and e-bike-sharing use and sales are accomplished exclusively online via smart devices and applications [83].

Public transport is an indicator of paramount importance to smart mobility in a city. Riyadh has been working hard to integrate public transport into its smart mobility system. Alongside the conventional mode of transportation dominated by the private car, the city has also adopted a major public transport system with 176 km metro lines coupled with a combined 1905 km bus route network length to cover all residential neighbourhoods. A highly developed ICT infrastructure was set up to run the system. It is worth mentioning that the metro has a smart and safe driverless train control system and automatic electrification. Both metro trains and buses are equipped with free on-board Wi-Fi service, LED lighting, lower energy consumption, CCTV monitoring and a smart ticketing system [69]. All this would contribute to smarter and interconnected modes of transport in the city.

As they run on ultra-low-sulfur fuel, the Riyadh public transport buses are thus environmentally friendly contributing to reducing CO2 emissions and traffic congestion in the city [69]. This is a vital characteristic of the sustainability of the smart Riyadh city.

The opinions expressed by citizens about mobility issues in their city are also used to assess the smart mobility component. The study relied on the findings of a questionnaire survey conducted by Smart City Index among Riyadh residents. The results show that the majority (72.7%) of respondents consider traffic congestion as a serious issue in the city. Consequently, a large proportion of them (60.8%) thought that public transport would be satisfactory as it helps to some extent, circumvent the congestion problem in Riyadh [68].

The effects of smart mobility and public transportation are manifold. Not only do they promote residential satisfaction, increase safety on the road and contribute to lower environmental pollution, but they also ease all sorts of movement, save time, enhance walkability and public health. They also foster smart living which will be discussed below.

5.4. Smart Living Indicators

If in many cases, smart cities have been techno-centric with a focus on the “hard” side as

exemplified by a focus on ICT infrastructure and buildings [18,37], Riyadh smart city however, has people at its centre by first emphasizing the “soft” side to which all the indicators of smart living refer. These indicators are mainly the knowledge-based society, city quality of life, higher living standards, educational attainment, continuous learning, creative workers and innovation, social reforms and social inclusion, and public participation. Not only has the Saudi Strategic Vision 2030 referred to all these indicators in one way or another but it has also insisted on setting up the required cutting-edge infrastructure by leveraging advancements in ICT and developments in IoT. Huge investments have been made in this regard so much so that high-speed broadband coverage has well surpassed 90% with increasing government online services [7].

The Vision document requested for Riyadh to become one of the top-ranked 100-word smart cities that offer smart living conditions for citizens to live, work, and thrive. In this regard, the International Institute for Administrative Development indicated that Riyadh has attained some qualitative advancements on its "IMD" index of smart cities for the year 2020. As such, Riyadh has outperformed many well-known world-class cities such as Tokyo, Rome, Paris and Beijing, jumping 18 places to rank fifth among G20 capitals in smart city living. This progress would not have been possible had Riyadh City not embraced digital transformation, data management and artificial intelligence in keeping with Vision 2030 objectives. This accomplishment reflects the progress achieved through the widespread use of smartphone apps and digital platforms provided by the local government which in turn had a great impact in raising health and safety indicators for Riyadh citizens. [84].

Although the economic shift from fossil-based to knowledge-based was first laid out in the Eight Development Plan (2005–2009), the social and economic transformation process gained momentum right after the promulgation of the Saudi Vision 2030 in 2016. The Vision set up a special program to bring about social transformation to achieve smart living which entails that city residents would enjoy higher living standards within a safe, secure and vibrant urban environment. In this respect, the document highlighted the retrofitting of the urban environment to be more liveable, walkable and sustainable. It should also ensure quality of life, foster effective and transparent e-government, and promote innovative digital infrastructure [7].

Saudi authorities have attached a special importance to the capital city of Riyadh. They have made clear that the knowledge-based economy and society coupled with state-of-the-art ICT infrastructure will be the cornerstone for the city's future development (MEP, 2010). For that, smartness, quality of life and sustainability were key issues that have to be met along with effective widespread e-government and expanding government online services. A recent report by Datareportal mentions that the internet penetration rate in Saudi Arabia stood at 99.0 per cent which is slightly better than that of Northern Europe (97.4%) [85]. As a result, many government services are provided online through e-government portals.

Educational attainment and higher education institutions are other indicators to measure city-smart living. Being the capital city, Riyadh has the largest proportion of residents with higher educational attainment. It has also many public and private universities and research institutions. All these institutions foster the formation of knowledge workers and increase the share of the creative class within the urban community.

Quality of life is another indicator to evaluate smart living. Many programs have been established in recent years for Riyadh to boost its quality of life and by the same token, to get a higher rank in the top 100 world-class cities as stated in Vision 2030. For that matter, it was decided to make Riyadh a smart city [86], and the city municipality has managed to procure a larger share of the $500 billion allocated to 285 municipalities in the country to achieve this goal by integrating smartness in both the “hard” and “soft”

domains of the city [87]. The hard domain consists of developing the ICT infrastructure to run smart buildings, smart mobility, and smart management of energy, water and waste [2]. Whereas the soft domain involves the making of an urban environment of quality where

the creative class would appreciate living in the city and also where the knowledge society would thrive through continuous learning, good governance, and the development of arts and culture [1,22]. This would improve city management and attract investments to create job opportunities while improving the city environment [87,88].

Riyadh is also developing local knowledge-based clusters and financial districts such as Riyadh Knowledge City (RKC), Riyadh Techno Valley (RTV) and King Abdullah Financial District (KAFD), to foster the knowledge-based society and concomitantly enhance smart living [89,90]. Needless to say, these projects constitute the building block of smart city-making and hence, smart living. As such, huge investments are required to develop cutting-edge ICT infrastructure. For this reason, the Saudi ICT market invested $24.62 billion in 2022 and the amount is expected to increase up to $195.96 billion by 2027 [91].

Smart living involves healthier living as well. For that, the National Energy Services Company (Tarshid) in partnership with Siemens plays a vital role in creating a healthier and cleaner environment through cutting CO2 emissions in government buildings by 4300 tons [92]. Smart living, however, does not only require healthy living and ICT infrastructure, a pleasurable lifestyle, and green urban spaces for recreation and entertainment are crucial elements to making cities smarter. The Green Riyadh project cited above is set to provide city residents with the opportunity to follow a smarter lifestyle within the confines of a cleaner healthier urban environment.

As far as entertainment festivals are concerned, Riyadh season, a state-sponsored annual entertainment and sports festival, is one of the largest winter entertainment events usually running from October to March. The 2022 event has attracted more than 7 million visitors of all ages in less than two months [93]. Through these events and projects, Riyadh Smart City organizes activities and events that celebrate life and nature, and promote art and local cultural heritage as is the case with the Diriyah Gate Project [94]. Social inclusion is an indicator of smart living. The Smart City Index survey conducted in Riyadh found that 68.6% of its citizens support the claim that minorities feel welcome in the city [68].

5.5. Smart People Indicators

Smart people are another component of smart cities. The indicators measuring smart people revolve basically around human capital building, achieving social transformation and, increasing the living standards of residents. To that end, Riyadh is undertaking a conspicuous change particularly as policies stemming from the Human Capital Development Vision Realization Program are put into play. This is only one of thirteen programs set to address reforms to boost human capital and improve educational attainment as advocated by the Saudi Vision 2030. As a result, important progress has been made on the United Nations human development index (HDI) which improved from 0.583 in 1980 to 0.875 in 2021 on a scale ranging from 0 to 1 [95]. Similarly, the Institute for Management and Development (IMD) assigned Riyadh to group 1 among countries with the highest HDI quartile with BB ‘rating scale’ in 2023. This constitutes a rise from its previous B rating in 2021. Concurrently, Riyadh smart city rating has improved from 39 to 30 between 2021 and 2023 [68].

In line with the Vision 2030 recommendations, Riyadh accounts for the largest share of university students enrolled in 250 study programs offered by 16 universities. That is 28.3% of the total number of higher educational institutions in the country [96]. Consequently, the innovation index developed by Cornell University, INSEAD, and the WIPO, has increased from 30.90 in 2020 to 33.40 in 2022 on a measurement scale of 0 to 100 [97]. Educational attainment is a vital indicator of the smart people component. In its 2023 report, the smart city index indicates that the expected years of schooling in Riyadh have increased from 15.7 to 16.1 between 2018 and 2021 [68].

The Gross National Income (GNI) per capita is often used as a good indicator of

smart people's well-being, living standards and the average level of education per person. In this regard, Riyadh has seen its GNI per capita in purchasing power parity increase from $5.072 in 2018 to $5.745 in 2021 [68].

Establishing a knowledge-based society and the creative class are the building blocks of smart people and, by the same token, smart cities. Accordingly, KSU has launched two main promising projects to pave the way to the process of making Riyadh a smart city. These are a knowledge hub to foster a knowledge-based society known as Riyadh Knowledge Corridor (RKC) and a science and technology park known as Riyadh Techno Valley (RTV) [97,98,89,90]. King Abdulaziz City for Science and Technology (KACST), King Abdullah Financial District (KAFD) and the City of Information and Communication Technology (CICT) are other projects to work for similar objectives.

The compounded indicator of health and safety is also used to assess the smart people component. In its Riyadh survey, the Smart City Index found that 84.9% of respondents declared that basic sanitation meets the needs of the poorest areas 81.4% found medical services provision satisfactory and 72.2% of them thought that recycling services are suitable. A great majority of respondents (88.2%) thought that online arrangements of medical appointments have improved access to health services. About half of the respondents (49.4%) said that public safety is not a problem in Riyadh while 81.1% thought that CCTV cameras managed to make people feel safer. About 64% seem to find the city's air pollution to constitute a serious problem. 56.3% found housing affordability not to be an issue at all [62].

Online security is another measure of smart people. Here again, the Global Cybersecurity Index revealed that Saudi Arabia has made a strong leap moving up 11 places within two years to be ranked second in the world by 2020. [99].

As far as recreational and cultural activities are concerned, the survey that Smart City has conducted, revealed that a majority of respondents were satisfied with green spaces provided, and also with cultural activities like shows and museums with a percentage of 69.2% and 77.2% respectively. For that, 84.6% of respondents found that online purchasing of tickets has eased attendance at cultural and artistic events [68].

Not only basic education is provided to all children, but most of them have access to good schools as declared by 78.6% of citizens who participated in the survey. 74.1% of them think that IT skills are taught well in schools which is a vital qualification that the new job market requires desperately. Lifelong continuous learning is an important characteristic of knowledge-based societies which is also crucial to smart cities. Local institutions in Riyadh tend to provide this lifelong learning to its citizens as declared by 72.8% of respondents [68].

5.6. Smart Governance Indicators

Concerning smart governance as a smart city component, its indicators are government efficiency, e-government services, accountability, responsiveness, and transparency (ART), red light sensors at intersections, social transformation program, Accessibility to information on local government decisions, Corruption of city officials, citizen participation, public-private partnership program (SHAREEK), Residents contribution to decision making of local government, Residents' provision of feedback on local government projects.

Aligned with Saudi Vision 2030, electronic government or E-government is now widely used in Riyadh. The widespread use of smart devices and the advancement of ICT applications have led to ensuring efficiency, transparency and participation in performing government functions and providing all sorts of public services. To develop good governance, many applications are now in use to fulfil a wide array of public services ranging from filing complaints to business registration, child school enrollment, auto registry, building permits, real estate development, and many more services.

To boost such smart governance services and internet-based facilities, the Saudi Data and Artificial Intelligence Authority (SDAIA) upgraded the "Tawakkalna Services" application to provide well over 241 with seamless and enhanced service delivery to beneficiaries to improve citizens' quality of life in the city. The provided services include health, education, transport, public services, entertainment events, and many other services [100].

Government efficiency as a measure of smart governance, was assessed by the extent to which government policies were effective in improving city competitiveness. As a result of this efficiency, Riyadh has managed to progress 11 places on the competitiveness index from 24th to 11th position within just two years (2021-2023) [63].

Concerning accountability, responsiveness, and transparency (ART) as indicators to Riyadh smart governance, the municipality has developed an electronic services portal named “Madinaty” (my city), to allow citizens to inquire about different government measures and activities. The “Madinaty” portal contains more than 24 services to cater for the needs of city residents and visitors. The electronic services provided range from building, construction and excavation permits, to commercial activity licenses and investment services, booking appointments with officials, filing reports or complaints, searching for parks and events and the like. A specialized team deals with all filed complaints about all sorts of municipality services and a response must be provided within 5 days or less. Such a portal helps deliver public services efficiently and effectively [101].

Similarly, all government agencies and offices use applications to accomplish all the required services online. For instance, the Ministry of Interior services like issuing and renewing passports or delivering birth and death certificates are made online through ABSHER applications. The Ministry of Education developed (NOOR) applications to provide all services related to schooling, or following students’ performance in class and the like.

Not only do these electronic services portals enhance smart governance through the provision of speedy and efficient services but they also allow citizens to get involved in city affairs and give feedback about service delivery and government decision-making. More precisely, Riyadh municipality has developed an e-participation (TAFAUL) platform to enhance citizen participation to have a say in city matters and promote collaboration with beneficiaries or even raise complaints to appropriate government entities.

In the context of a highly centralized governance system with a primarily top-down planning approach, public participation was not a priority in the planning agenda. This was confirmed in a report issued by the Ministry of Municipality and Rural Affairs (MOMRA) which revealed the limited citizen participation in city planning. However, in compliance with Vision 2030 objectives, Riyadh has adopted a new way of governance where electronic government, transparency, public participation, urban entrepreneurship and public-private sectors partnership reinforcement program (SHAREEK) [102] are key elements in the process of Riyadh smart city making. This is a clear indication that in the case of Riyadh, the “soft” side has priority over the “hard” side in smart city making. The “Shareek” program could pave the way towards a bottom-up approach intertwined with a top-down one for an effective implementation of Riyadh smart city. Joining these seemingly inconsistent approaches in smart city implementation has also been suggested by other researchers like Breuer et al. [103], Capdevila and Zarlenga [104] and Doheim et al. [105].

This new approach towards more public involvement in city affairs has been corroborated by a recent questionnaire survey conducted in Riyadh by the Smart City Index in 2023. The questionnaire results revealed that 60.7% of respondents declared that residents contribute to the decision-making of local government and 63% of them give feedback on government projects. As a result of such involvement, 82.7% of respondents confirmed that they have easy access to information on local government decisions which may

enhance public participation made a lot easier because of online platforms allowing

residents to propose ideas to improve city life according to 76.8% of citizens participating in the survey. This public participation will increase even more if online voting is provided as avowed by 73.3% of respondents [68].

6. Conclusions

Being the capital city of Saudi Arabia, Riyadh has immense potential to make giant jumps towards becoming a smart city. As a major economic hub in the region, a thriving business sector, a high GDP per capita and above all, supportive government policies make it a prime candidate for smart city transformation. However, the prime asset for Riyadh is not its cutting-edge technological infrastructure, but its growing young and tech-savvy population, well-equipped to embrace and utilize smart technologies, which is essential for the success of smart city initiatives.

The Strategic Vision 2030 insists on building human capital and improving the quality of life in the city. It is precisely for this reason that, in its journey to becoming smart, Riyadh's focus was more on the soft rather than the hard domain of smart city making. The Vision has set up a comprehensive smart city strategy that outlines the goals, objectives, and key policies and initiatives necessary for the process of Riyadh's smart city-making to succeed.

The already existing strong infrastructure, well-developed transportation network, modern public transport and metro system, and advanced telecommunications and high-speed internet coverage play a crucial role in the successful implementation of smart city mobility while using cutting-edge technologies to provide efficient and sustainable transportation solutions to reduce carbon footprint and preserve the environment.

City planners tend to be inclined towards smart digital technologies to come to grips with urban issues like the staggering rate of urbanization, the influx of urban dwellers and their increasing demands for access to urban services and resources, and the critical issues related to climate change and environmental pollution. However, Riyadh appears to have realized that the “hard” side alone, like smart buildings, ICT infrastructure, and smart devices, would not be enough to tackle these challenges and achieve a successful process in smart city making. A Strategic Vision with strong political will from higher authorities is required to support this objective. Many programs, initiatives and policies were set to foster the “soft” side as expressed in social and economic transformations to accomplish the smart city components that are smart economy, smart environment, smart mobility, smart living, smart people and smart governance. The measurement indicators cited above lend support to the preeminence of the “soft” over the “hard” domain for a successful process in smart city making at least as is shown in the case of Riyadh.

Based on the above analysis and findings, the following recommendations can be suggested for Riyadh to successfully transition into a smart city:

Riyadh should prioritize the development of educational infrastructure to promote its human capital assets and improve the skills and qualifications of its tech-savvy young population to support the implementation of smart city technologies. This includes investing in educational systems, high-speed internet connectivity, and improving the availability and accessibility to continuous learning and skills training and upgrading.

It is important for a smart city relying on Internet technology and data-driven solutions to implement strict data protection regulations, encryption protocols, and regular security audits to establish strong data privacy and security measures. The personal information of citizens must be protected and the integrity of data collected and used in smart city initiatives needs to be secured.

It is also crucial to ensure citizen engagement and public participation in the process of Riyadh's smart city-making through their involvement in discussions and shaping of smart agenda. This can be achieved through increased digital online platforms and

mobile applications to report issues and complaints, provide feedback about city

management and engage in discussions regarding city matters.

Advancement in ICTs, development of IoTs and progress in application platforms not only help improve service provision but also contribute to raising transparency and accountability, boosting public participation, enhancing smart governance and fostering the process of social transformation that has been put in place as stated in the Vision Document.

It is also crucial to foster partnerships and collaborations with all stakeholders from all backgrounds (all sorts of organizations and NGOs, technology companies, academic institutions, business groups, etc.) to leverage their expertise and accumulated knowledge for effective management and efficient implementation of smart city initiatives.

Although cutting-edge technological infrastructure and developed IoT are necessary they are not sufficient to achieve a smart city. It is important to promote radical socioeconomic change, human capital building, good governance and public participation where top-down and bottom-up approaches in decision-making are blended to provide the bedrock for a set of policies to get the process of a smart city becoming off the ground.

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