

Article

Achieving Human-Centered Smart City Development in Saudi Arabia

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Abstract

The shift from techno-centric to human-centric development is essential for smart cities to effectively leverage technological innovations and enhance the quality of life of citizens. Despite this recognition, there are limited studies that address the challenges and frame the conditions and impacts involved. This study employs a mixed-method approach, namely the combination of literature review, expert consultation, and case analysis, to investigate human-centered smart city development based on the example of Saudi Arabia. Drawing from the literature, it develops a conceptual framework that provides guidance for achieving human-centric smart cities. The findings indicate that while Saudi Arabia has achieved notable progress in smart city development, inclusivity, centralized planning, public engagement, capacity building, and data security hinder advancement. This study demonstrates that smart city initiatives must aim to go beyond mere buzzwords and integrate components in line with human values and societal expectations. The study's findings may help in framing urban humanization policies aligned with of Saudi Arabia's Vision 2030 and offer guidance for cities with similar contexts.

Keywords: smart cities; human-centred approach; SDGs; urban humanization; social equity; sustainability; Saudi Vision 2030

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1. Introduction

Compared to preceding decades, the population of cities has risen dramatically across the globe and continues to do so today. Currently, approximately 56% of the global population, about 4.4 billion people, live in metropolitan areas, and this figure is projected to double by 2050, resulting in unprecedented urban growth [1]. The ever-accelerating processes of urbanization, coupled with rapid population growth, give rise to multiple socio-technical, economic, and organizational challenges. These challenges threaten the efficient economic growth and environmental reliability of urban regions and underscore the need for new approaches to enhance the quality of life of the people and protect urban environments. Hence, many national governments worldwide have embraced “smart” approaches to enhance their administration and management of intangible as well as tangible assets and resources. However, there is a paucity of research on the human-centric smart city in the Global South, including Saudi Arabia.

The concept of human-centered smart city development focuses on enhancing people's quality of life through the combination of technology and urban design, in line with social

needs and welfare [2]. This approach seeks to ensure that technological innovation serves people-centric goals instead of being an independent driving force. Landa et al. [3] suggested that the two key trends that are influencing this approach are citizen engagement and co-creation. Urban areas are gradually leveraging electronic platforms to collect responses from citizens and verify that the growth of cities aligns with their expectations. Working together on creating services and policies by getting actively involved with community members promotes collective responsibility and social integration. Another noteworthy key trend in human-centered smart cities is the focus on equity and inclusivity. Human-centered smart cities emphasize inclusion, ensuring everyone benefits from technological advances regardless of economic standing. Well-being and good health represent significant fields for investigating human-centered smart city development [4]. Smart city initiatives aim to improve overall well-being and health through various programs and policies. The implementation of goals related to sustainability by smart cities promotes the achievement of Sustainable Development Goals (SDGs), especially SDG 11 [2]. Human-centered smart cities extend over mitigating carbon footprints, boosting energy conservation, boosting energy conservation, using renewable energy sources, and improving waste management systems to foster sustainability. Combating climate change and diverse crises is accepted as an essential part of the human-centered approach.

Ahmad et al. [5] critically investigated and found that considering data privacy and the ethical use of technology is crucial in smart city implementation. The responsible use of innovative technology and maintaining security of data and human rights are key to master smart cities functionality based on data and AI. Smart city managers are addressing the issue by establishing clear governance frameworks, enacting laws and regulations, securing data, and protecting privacy rights. The shift towards accountable artificial intelligence and ethical technology adoption builds confidence amongst the government and people. Furthermore, smart transportation solutions offering human-centered mobility have grown in relevance [6]. Urban managers have emphasized the adaptability of infrastructure and public services by leveraging technology to satisfy specific demands, which include e-governance systems for ensuring the effective availability of public services, smart electrical grids for utility management, and powered AI systems for modifying services across sectors like healthcare, education, mobility, and governance.

Despite these positive trends, significant obstacles persist in the advancement of human-centered smart cities, particularly regarding safeguarding data, ensuring data privacy and equitable access, and placing human beings at the center of urban design to ensure a sustainable human transition. Dependency on technology presents issues in managing information, security, and generation of digital systems [7]. The flow of information is very important in determining the success of smart city implementation [5]. Smart cities should adopt approaches that are beyond the use of technology to address challenges and deliver equitable urban services and improve the quality of life in cities [2]. The challenges and barriers to smart city development could differ across nations and geographic areas. For instance, in the Middle East, the issues highlighted above, have brought about additional duties on municipal authorities, given that many towns lack the resources and infrastructure required for transitioning to smart cities [8]. Consequently, only two Middle Eastern cities, Dubai and Abu Dhabi, are in the top twenty spots of the global smart city index [9].

A significant challenge in human-centered smart cities involves a lack of encouragement and support for smart city solutions. For instance, Italy with internationally recognized examples of smart cities, lacks the benefit of a native smart city framework [10]. This shows that some challenges cut across regions and cities adopting international best practices. Apart from Milan, medium-sized Italian cities, including Reggio Emilia, Modena,

Bergamo, Parma, and Trento, merit major focus for smart city development. The mentioned cities' scores are exceptional for financial stability, sustainable transport, safeguarding the environment, and technological advancement, whilst southern cities position at the bottom of the list. For instance, Florence excelled in quality of life, efficient transportation, innovation in technology, conservation of the environment, and governmental performance. The latest 2025 smart city ranking illustrates the existing gap between the country's southbound and northbound city areas, with the southbound urban areas situated among the lowest ranks due to the scarcity of infrastructure and the local population's unwillingness to become involved with the initiatives are certainly the main variables driving disparity [9].

In Saudi Arabia, there are cities serving as role models by demonstrating successful implementation of smart city development initiatives [11]. Saudi Arabia has the largest population in the Middle East, with 34 million inhabitants, of whom nearly 84% reside in urban areas [12] (Almulhim & Cobbinah, 2023). The growing pace of urbanization in Saudi Arabia has brought about multiple problems that require novel approaches. As a result, Saudi Vision 2030 established clear targets for completing a smart city program, with the Ministry of Municipal and Rural Affairs and Housing launching the initial smart cities plan and selecting 17 cities for smart initiatives. The cities include Riyadh, Neom, Makkah, Yanbu Industrial City, Medina, Al-Ahsa, and Jeddah. Gaul and Sumant [13] assessed the Saudi smart cities industry at \$3.5 billion in 2019. Therefore, evaluating the achievements of these cities in transitioning to human-centered smart cities helps improve decision-making and awareness. The King Abdullah Economic City (KAEC) exemplifies a successful transformation into a technological hub, contributing to the quality of life, tourism, and business interests. KAEC functions as a Vision 2030-equipped structure for multiple programs, testing smart city ideas and techniques. Its infrastructure supports the expansion of smart city offerings and the building of collaborations that strengthen the interconnected city ecosystem, exemplifying thoughtful preparation and implementation. For instance, its telecom services ensure smooth integration of applications for safety, accessibility, commercial, and safety network services [14]. Moreover, KAEC uses data analytics and advanced technology to optimize operations and foster economic development.

While research exists on general smart city concepts and techno-centric development globally, studies that focus on the human-centered approach are very few. Moreover, there are fewer research articles on Saudi Arabia. Thus, the novelty of this study is its focus on assessing human-centered smart city development specific to Saudi Arabia. Accordingly, the objectives of the study are: (1) to develop a framework for the human-centered approach to smart city development; (2) to identify the gaps that exist in the unveiling of the status of human-centered smart cities in Saudi Arabia and to examine how achievable the transition beyond techno-centric smart city development is; (3) to highlight the trends, challenges, initiatives, and success of human-centric smart cities in Saudi. Analyzing such issues provides an understanding of human-centric smart cities and their development. To successfully utilize and practice the human-centric smart city approach, it would be necessary to review the smart city evolution and figure out how novel technologies and data can become human-centric as they are seamlessly incorporated with urban components, including citizens, infrastructure, and governance. Using this approach may bring about sustainable development and boost the quality of life of the populace.

2. Smart City Development: From Techno-Centrism to Human-Centrism

A smart city pertains to the intentional and smart utilization of sophisticated technologies for communication and information to improve the quality of life. Smart cities have consistently faced analysis from a techno-centric standpoint. Even so, the discussion on smart cities should be broader than the technical accounts. The human-centric

approach ensures that smart city development involves all stakeholders and their active participation in decision-making processes, thereby promoting citizen engagement and co-creation [15]. This shift in focus reflects a broader understanding that technology alone cannot solve urban problems without considering human experience. However, studies on human-centric cities vary in their focus, contexts, methodologies, and levels of analysis used to conceptualize and implement the approach.

In a contextual study, Moumen et al. [15] critically examine the smart city experience in Africa, indicating the need to adapt technology-focused narratives, mostly derived from Western models, to fit local socio-cultural and governance realities. They argue that the diverse cultural landscapes and governance structures across African cities necessitate a human-centered approach in urban planning and development. The contextual and social-cultural emphasis aligns with the study by Ji et al. [16] that foreground citizen perceptions and preferences in shaping smart city services. They highlight how Taiwan citizens evaluated smart city initiatives based on accessibility, participation, and user experience. In the study of Doha, Qatar, Syed et al. [17] conclude that needs to be more inclusive in its socio-cultural context to achieve its goals of smart city development. Together, these articles converge on the importance of considering the “citizen voice” in smart city governance, thereby countering techno-centric trajectories and resonating with Saudi Arabia’s context.

By contrast, Dashkevych and Portnov [18] take a global comparative approach to human-centered smart cities, developing a ranking system that integrates sustainability and inclusive indicators into performance evaluation. Their research aligns with Moumen et al. [15] in linking human-centeredness to sustainability yet diverges by focusing less on lived experiences and more on standardized metrics. This raises questions about the effectiveness of quantitative measures in capturing the complexities of human experiences in urban environments. In the same vein, Wu et al. [19] adopt a largely techno-centric orientation by emphasizing how big data management can optimize urban sustainability. While their framework indirectly supports human well-being, it downplays citizen participation or cultural contexts, highlighting a divergence in prioritization compared to perception-driven studies such as Ji et al. [16]. This reliance on data-driven solutions may overlook the nuanced needs and desires of diverse urban populations, highlighting a critical gap in the discourse.

Thus, human-centric development approach should be based on the integration of an array of societal and humanistic aspects of the advancement of smart city development, alongside the incorporation of strong governing concepts in smart city endeavors, by pointing out citizen involvement, participation, and welfare. Urban designers and managers who pursue the approach of “human-centered design” focus on four primary areas: highlight individuals and their environment; attempt to pinpoint and deal with the appropriate issues or the key problems; discover that all consists of deeply interconnected factors, and lastly, perform instantaneous interventions [20]. To ensure certain that the solutions fulfill the expectations of the intended users, the urban managers and designers consistently model, test, and make improvements to the services and products they provide.

The study by Luo et al. [21] attempts to reconcile the differing perspectives through their concept of a “perception-powered urban digital twin.” This innovative model integrates advanced technological systems with real-time citizen perception data, operationalizing human-centeredness in empirically grounded and digitally enabled ways. By incorporating citizen feedback into urban planning processes, this approach enhances the relevance of smart city initiatives and fosters a sense of ownership and agency among residents. Their approach illustrates an emerging convergence: rather than opposing human-centered and techno-centric models, future smart cities may rely on hybrid frameworks that integrate human perception with technological capabilities. This integration could lead to more

responsive and adaptive urban environments that better serve the needs of their inhabitants. Norman's work [20], though more conceptual and philosophical, provides an overarching normative anchor for these debates. By calling for "humanity-centered design," Norman transcends the immediate concerns of urban technology to position human-centeredness as a universal design ethic for creating meaningful and sustainable systems. This broader orientation converges with empirical studies in affirming human needs as central, yet diverges in method and scope, operating at a more theoretical level.

The continuous increase in interest in smart cities is due to their numerous functions in empirical settings and the emergence of a trend toward human-centered smart city development. For instance, smart management systems for buildings have been designed to achieve a better quality of life via the successful utilization of lighting and temperature, integrating digital means for improved energy usage, and such energy-effective solution coincides with the ultimate purpose of attaining sustainable urban settings [19]. Moreover, the healthcare sector also displays major advances through smart city approaches, which leads to a better economy, satisfied citizens, and a secure society. For instance, smart city improvements regarding healthcare monitoring have contributed to expanded healthcare offerings and transformational influence on the treatment of patients and health findings caused by smart city technologies [22]. In line with all these advances, smart cities incorporate various advanced technologies to deliver advanced and improved edge on computation and communication via complex networks and data processing in urban settings, which overall aids in a better quality of life and expansion of technological hubs [23]. In addition, effective governance becomes an important aspect of urban innovation, utilizing technological advances for streamlining procedures for administration, such as digital governance, to boost transparency and encourage participation by the public [24,25].

The principle of human centrality continues to gain relevance in present-day governance discourses; however, the smart city language has yet to encompass a lot of these components effectively. Governments constantly prioritize welfare and satisfaction. For instance, New Zealand launched a welfare budget, devoting resources to programs intended for boosting community-wide welfare [26]. On the other hand, the OECD in 2020, introduced the Better Life Index, allowing an increased awareness of the variables impacting the welfare of both individuals and countries, in addition to the steps needed to achieve improved development for everyone. It was just four years ago (December 2020) that the European Union approved the Berlin Declaration on Digital Society and Value-Based Digital Government designed to encourage a humanistic-centered, accountable, and common-good-intended advancement [27]. Such strategy aims to guarantee that programs are inclusive, confront issues facing society, and prevent the perpetuation of dangerous economic or social prejudicial views. Within human-centric smart city development, it is vital to embrace a development strategy centered around well-being or satisfaction [28]. In congruence, smart city development should communicate and collaborate with their inhabitants. In turn, collaborative creation and collaborative production are projected to be fundamental in guaranteeing the human-centricity of any smart city program's execution. The collaborative creation encompasses the participation of unconventional external relevant parties in the beginning, planning, delivery, and review stages of a new program to the public, signifying something that was planned [29]. Moreover, Snow et al. [30] indicated that collaborative creation predominantly relates to the provision of services.

According to Lara et al. [31], a smart city features an urban area that continuously and effectively encourages the overall well-being of every person who lives there whilst guaranteeing an optimal degree of security, thereby continuously boosting the quality of life for residence, employment, and leisure. Carter et al. [32] determined that the key benefit of information technology resides not within its potential to innately generate

knowledgeable communities but rather in its easy availability for social applications, which improves awareness among citizens and promotes engagement in democratic participation related to the urban setting. Competent and trustworthy governance systems, alongside advanced and knowledgeable citizens, are expected to deliver the necessary encouragement for smart cities. Through successful collaboration, local production could strengthen, which is essential for bringing about significant expansion of the economy. Moreover, education continues to advance in the smart city actions, as modern innovations serve to improve educational procedures further while offering collaborative, geared educational opportunities for learners through digital education [33]. Finally, safety and security concerns are dealt with through making use of smart safety procedures as these attempts to reduce security threats and protect confidential data, valuable possessions, and people, guaranteeing an atmosphere of security and safety for citizens of smart cities [34].

Summarily, these studies reveal significant patterns crucial for the future of urban development. First, there is strong convergence on the necessity of embedding human-centeredness into smart city discourse, whether framed as inclusivity, sustainability, or citizen perception. Second, divergences emerge regarding scale (global rankings versus local case studies), methodology (metric-driven versus perception-driven), and the balance between technological optimization and social legitimacy. Finally, a subtle but growing convergence is visible in hybrid approaches such as Luo et al.'s digital twin [21], which suggests that the future of human-centered smart cities lies in integrating technological capacity with human perception, thereby reconciling what were once treated as opposing paradigms.

3. Methodology

To accomplish the aims of this research, the current research adopted a mixed-method approach, which includes a desktop study method that analyzes literature, databases, and publicly accessible materials, as well as expert interviews and case studies. The desktop study method is the strategy adopted to investigate relevant sources, obtain information, and evaluate secondary information. Search engines for research and academic writings, such as Google Scholar and Science Direct, were utilized within this research to locate and gather relevant articles by applying keywords including smart cities, human-centered smart city, smart city challenges, urbanization, information and communication technology, AI, smart citizenship, and Saudi smart city. Internet-based sources, notably papers from journals, released reports, papers from conferences, and the official websites of governmental and international development organizations, had also been accessed and consulted. Urbanization information was sourced from the United Nations; population figures were gathered from the General Authority for Statistics, alongside details surrounding Saudi Vision from the Saudi Vision 2030.

The study adopted content analysis in evaluating the acquired materials and secondary information, as this method aligns well with the study's aims. Content analysis constitutes a prominent qualitative research strategy [35], which is extensively covered throughout multiple research methodology documents and has been recognized to be among the most common methods for gathering information [36]. The study's investigation adopted a three-step iterative method in combination with the content analysis strategy. The collected documentation and secondary information have been grouped by applying the previously stated keywords. Nonetheless, multiple records and information could be classified into various groups. Secondly, the examination of acquired articles indicates two fundamental themes about trends in smart city development. This includes the growing trend towards human-centered smart city development and the elements that promote the adoption of this type of strategy. Lastly, the research findings and the information derived from the results were synthesized to frame the themes for discussion.

The outcomes from the data assessment and evaluation portion have been verified by discussions with professionals specializing in forming and advancing smart and sustainable cities within Saudi Arabia. This research adopted a semi-structured interview method that combines both unorganized and organized designs, employing an outline that includes significant subject matter and questions. Additionally, closed and open inquiries were implemented through expert interviews. A collection of 32 professionals, including planners, academics, and urban finance experts, participated in offering comments on the smart city efforts in the Kingdom and confirming the outcomes derived from the desktop study. About eight of the respondents who were unable to be interviewed received an email with an online survey that comprised the interview questions. The semi-structured interview questions were designed to gather expert perspectives on human-centered smart city development, with the objective of encouraging thoughtful responses and facilitating constructive discussion. All interviewees obtained the research information, and a consensus was reached for recording the interview. Eventually, the data provided by the interview respondents was examined using inferential and descriptive statistics.

The selection of experts followed a purposive sampling strategy to ensure both relevance and diversity of perspectives. Inclusion criteria required participants to have at least ten years of professional or academic experience in fields directly related to urban planning, smart city technologies, or urban policy in Saudi Arabia, and to be actively engaged in projects or initiatives connected to urban and digital transformation. Individuals with less than five years of relevant experience or with no direct involvement in smart city-related work were excluded. The final sample consisted of 32 experts with professional experience ranging from 10 to 20 years, providing a balanced representation of knowledge and practice. The participants contributed extensive expertise in areas such as smart city development, sustainability, urban development, and urban planning. A summary profile of the experts is provided in Table 1 to illustrate the breadth of their experience across different sectors.

Table 1. Characteristics of the Expert Participants.

Sectors	Number
Public Sector (Directors/General Managers/Planners/Engineers)	23
Private Sector (Directors/Managers/Investor/Finance)	6
Academic Sector	3
Total	32

Following the literature review, Table 2 below presents the case studies about the components of a human-centered smart city in the Kingdom that would guide the relevant research. The case study cities were selected purposively based on the presence of initiatives and projects explicitly linked to smart city development and human-centred urban transformation. This criterion ensured that the selected cases were directly relevant to the research objectives and provided practical examples of how human-centred principles are being applied in the Saudi context. By focusing on cities already engaged in such initiatives, the study was able to capture lessons, opportunities, and challenges that are most pertinent to advancing the national smart city agenda. Triangulation across data sources, including expert interviews, documentary evidence, and case study analysis, was employed to enhance validity. Reliability was strengthened through cross-checking of the data and discussion of interpretations within the research team. These measures ensured the robustness and credibility of the study's findings.

Table 2. Human-centered smart city case studies found in Saudi Arabia.

Component of Human-Centered Smart City (Case Studies)	Example Project/Cities	References
Knowledge economy	Neom city features a retooled economic model built in the interest of technological advancement, citizen welfare, and a progressive society.	[37–39]
Technological hub	Dhahran techno valley, Khobar and Dhahran smart city, and Neom City all serve as digital hubs for further innovation in smart city development.	[40–42]
Knowledgeable citizens	Saudi Vision 2030 serves as a guide towards achieving knowledgeable citizens in a smart city approach in Saudi Arabia.	[43]
Active engagement	Jeddah smart city and Riyadh smart city concentrated on strengthening their smarts through boosting citizen involvement over digital channels.	[44,45]
Public participation	Riyadh city paving the way toward achieving public participation and community engagement.	[46,47]
Quality of life	Madinah smart city and Riyadh smart city both focused on improving the quality of life for citizens through inclusion, technology, and diversity.	[48–50]
Saudi Green Initiatives	Riyadh Smart City serves as a key player in green innovation in real estate, green financing in responsible investments, and green building projects. Madinah Humanizing Cities Initiative, which include the enhancement of green spaces.	[51,52]
Strong governance	Madinah smart city and Riyadh smart city both conveyed their vision towards featuring clear governance procedures that guarantee digital innovations and technologies meant for enhancing the well-being of citizens.	[5,48,53]
Social and humanistic inclusion	Neom City focuses on social and humanistic inclusion by advocating connections with the community, boosting interpersonal relationships, and allowing residents the opportunity to utilize services that boost general wellness.	[54]
Social capital	GCC smart cities prove social capital as an integral component of smart cities as it renders cities more resilient, promotes innovation, preserves diversity, and progressively improves the standard of living for inhabitants.	[55]

4. Results and Discussion

4.1. Human-Centered Smart City Framework

Figure 1 illustrates a framework identifying the key components of a human-centered smart city. These components include citizen engagement, inclusivity and equity, health and well-being, sustainability and resilience, data privacy and ethics, smart mobility, transportation, and human-centric public services. These key elements are fundamental to developing a human-centered smart city. One of the study's results is that to effectively administer such cities, it is critical to focus on the well-being, engagement, and needs of the inhabitants. Therefore, it is pertinent to highlight the factors that support the implementation and success of human-centered smart cities, which are referred to as enablers.



Figure 1. Framework for Human-Centered Smart City. (Developed by the authors).

As depicted in Figure 1, the findings of this study suggest that the enablers for success include strong citizen engagement, inclusivity and equity, integrated governance, technological innovation, sustainability focus, data privacy, and security, smart mobility solutions, education and capacity building, funding and investment, and sustainability and resilience planning. Each enabler encompasses specific factors contributing to their achievements. Under strong citizen engagement, key factors include public participation, which actively involves residents in the decision-making process; co-creation, which facilitates collaboration between governments and residents; and transparent communication, ensuring an open channel between inhabitants and authorities [5,28]. Regarding inclusivity and equity, essential aspects are accessibility to technology, addressing social inequality, and digital literacy programs that promote digital training for all residents [5,56]. Integrated governance includes collaboration across sectors involving all stakeholders, establishing clear policy frameworks supporting a human-centered approach, and promoting accountability and transparency through clear communication [57]. In terms of technological innovation, key factors are data-driven decision-making utilizing big data, AI, and IoT; smart infrastructure investments; and digital platform services offering streamlined access to services [58]. For sustainability focus, renewable energy, smart waste management, and climate resilience are some of the key combinations of factors [15,25]. Data privacy and security encompass ethical data use, which means personal data are protected; cybersecurity, which guarantees strong security protocols, the flow of information, and citizen trust through data collection transparency [5].

In the realm of smart mobility solutions, key factors include sustainable transport systems reducing carbon emissions, traffic management using AI to minimize congestion, and ensuring accessibility for all inhabitants, including the elderly [59]. For education and capacity building, smart literacy, training programs for city staff, and academic-industry partnerships are some of the key combinations of factors [60]. Funding and investment involve public and private investments, international support, and innovative financial

models [61]. Lastly, sustainability and resilience planning encompass green infrastructure, adaptation to climate change, and long-term vision [56,58]. Overall, the findings suggest that incorporating these factors into urban planning and development processes ensures cities become resilient, centered, inclusive, and technologically advanced, ultimately improving the lives of residents.

4.2. Review of Human-Centered Smart City Development in Saudi—Status and Challenges

The Kingdom of Saudi Arabia is progressing with the establishment of smart cities as part of its Vision 2030 initiative. The nation is committed to reshaping its urban environments through the implementation of technological advances [42] whilst prioritizing human-centered developments [41]. The vision of a human-centered smart city is to promote citizen well-being, inclusiveness, and equal opportunity by integrating technological innovations. Despite the Kingdom's determination towards these improvements, several challenges need to be addressed. Currently, large-scale developments are driving the creation of smart cities in Saudi Arabia, notably Neom [42], along with efforts in Riyadh [46], and Yanbu Industrial City [62]. The E-Government Development Index of 2022 listed Saudi Arabia as 31st among 193 nations [63] while the 2022 Global Cybersecurity Index (GCI) ranked it 2nd out of 182 nations [64], and the Global Innovation Index (GII) placed it 41st amongst 132 nations [65]. These rankings demonstrate Saudi Arabia's success in advancing its cities through smart initiatives. Such efforts endeavor to utilize sophisticated innovations, including sustainable infrastructures or green buildings, the Internet of Things (IoT), and artificial intelligence (AI) to elevate city quality of life and keep cities more productive, sustainable, and adaptable.

Neom, as an example, has been described as one of the world's most ambitious smart city initiatives, designed as an autonomous urban ecosystem with a human-centric perspective [37]. The program aspires to present an exceptional education system, digital connection, and medical care whilst stressing the preservation of the environment. Similarly, Jeddah and Riyadh, representing the two biggest metropolitan areas in Saudi Arabia, have concentrated on strengthening their smarts through the implementation of sustainable transportation responses, reforming public infrastructure with artificial intelligence, and boosting citizen involvement over digital channels [45]. Madinah's human-centered smart projects are also noteworthy, given that they strive to improve the quality of life for citizens and travelers utilizing smart city endeavors, incorporating IoT-enabled structures and innovative mass transit systems [48,66]. The Madinah humanization initiative, a leading project Saudi Arabia, aims at reducing car-dependency, improving walkability and expanding green spaces [52]. These efforts showcase Saudi Arabia's devotion to including long-term viability, technological innovation, and the welfare of people within its development of cities.

Despite significant progress and innovations, various obstacles hinder Saudi Arabia's goal of building human-centered smart cities. These challenges are common in developing smart cities globally, although they may manifest differently depending on the specific context. One concern relates to the centralized, top-down planning model, which may limit opportunities for citizen engagement and participation [44]. Moreover, issues related to inclusivity and social equity arise as smart city initiatives risk unintentional exclusion of disadvantaged communities [67]. In Saudi Arabia, which features both rural and urban areas with varying access to technology, fostering inclusivity requires addressing geographic and economic disparities. Thus, rapid digitalization risks widening the socio-economic inequalities, thereby reinforcing existing divides. Numerous municipalities internationally face issues with properly including inhabitants in the smart city planning stage; however, in Saudi Arabia, the issue could be accentuated by cultural norms and the newly

emerging phase of community engagement in policymaking. Fostering greater public engagement within a customarily hierarchical system of governance might call for specialized approaches. Spicer et al. [68] exemplified this challenge by reporting that citizens' notion of a smart city differs from the local government. Thus, smart cities should be planned for the citizens by engaging them in the design process. Challenges also occur regarding sustainability. Sustainability has become a popular target for urban centers internationally; however, in Saudi Arabia, it has become of special importance given the country's lack of water, dry setting, and its dependency on energy sources that are not renewable [69]. Moreover, fluctuating oil prices increase the risk to the financial sustainability of large-scale projects. As a result, the sustainability issues grow more serious within the current setting, as the continent brings together rapidly growing cities with inadequate resource availability.

There are further challenges regarding data privacy and security. Data privacy and cybersecurity remain widespread problems affecting the establishment of smart cities [70]. Within Saudi Arabia, wherein the leadership is enthusiastically pursuing its digitization plans, this responsibility could also include developing specific legislation that protects private information whilst boosting innovations. Technological integration additionally brings about certain difficulties. Communities in cities worldwide have problems incorporating novel technologies into the structures they currently have. Within Saudi Arabia, the problem comes towards the demand for substantial development of infrastructure and advances in technology, especially for older metropolitan areas like Jeddah and Riyadh, as opposed to creative endeavors such as Neom, which have been envisioned with advanced infrastructure in mind from the very start [70]. Lastly, challenges could come up alongside capacity building and education [71]. These constitute inherent obstacles. Nonetheless, it could be particularly acute in locales wherein the use of technology is still developing. Therefore, technological dependencies pose risks to long-term resilience and local capacity building. Within Saudi Arabia, boosting knowledge of digital technologies and educating urban designers and residents on technological advances in smart cities serves as the main goal for ensuring the effectiveness and inclusiveness of initiatives about smart cities.

In this regard, despite such problems experienced across urban areas internationally, they could display distinct features in Saudi Arabia attributable to the nation's environmental, social, and economic circumstances. Even so, Saudi Arabia's drive to human-centric smart city development brings multiple possibilities wherein the Kingdom could apply its ample assets to stimulate creative thinking, boost equitable advancement, and position its standing as a leading nation in smart city development. By proactively tackling issues related to sustainability, data privacy, inclusion, local capacity building, and citizen engagement—the core elements of a human-centered smart city framework—Saudi Arabia can ensure that its smart cities remain cutting-edge, socially inclusive, and environmentally sustainable. Without addressing these issues, Saudi smart cities risk perpetuating existing underlying challenges instead of achieving meaningful transformation.

4.3. Expert Opinions on Human-Centered Smart City Development

This section details the survey results from experts on smart and sustainable cities in Saudi Arabia. The results of the semi-structured questions present expert opinions concerning human-centered smart city development. As shown in Figure 2, a total of 81.25% of the expert respondents agree that Saudi smart city projects are primarily described as being technologically centered based on their experience. This is consistent with the findings of the studies by Alshuwaikhat et al. [72] and Balfaqih and Alharbi [70], which indicated that smart cities are expanding in Saudi Arabia, but they focused on the technological approach like most cases worldwide [73]. On the other hand, only 18.75% agree that Saudi smart city projects can be described as human-centered, indicating a significantly low utilization and

practices of this approach within the Kingdom's cities. Moreover, one of the respondents succinctly stated this concern in an open-ended response, *"The focus of smart city projects in Saudi Arabia is currently on technology applications and governance. There is little attention given to the socioeconomic implications of such projects and no visible attention is given to city resilience as an outcome of smart cities. Such imbalance will hinder Saudi cities from truly reaching sustainability goals."* In terms of governance, most respondents believe that the type of governance approach adopted in Saudi smart city development is the top-down approach (46.88%), but others believe that it is a mix of both the top-down and bottom-up approach (40.67%), as seen in Figure 3. Aina et al. [74] present findings similar to the former, whereas Aina [62] suggests a blend of both methods to support urban sustainability.

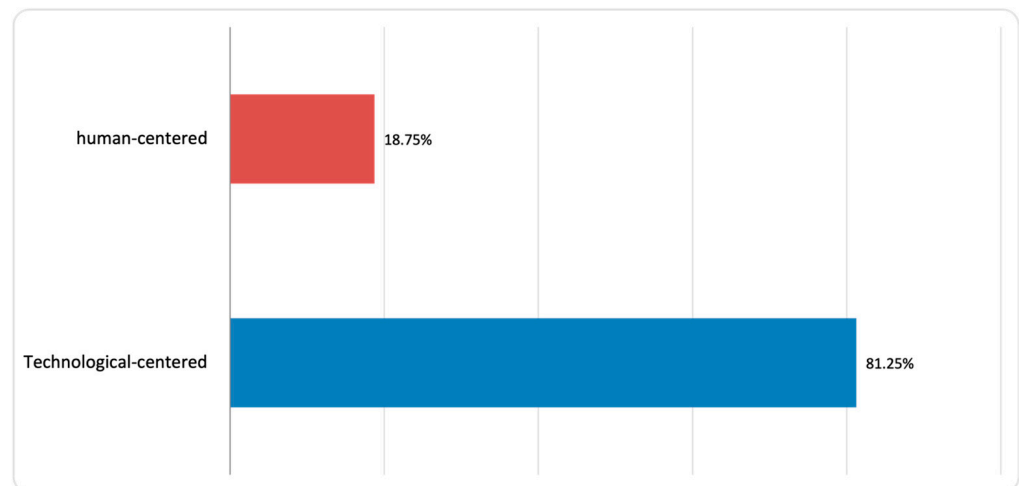


Figure 2. The technocentric approach of Saudi smart cities.

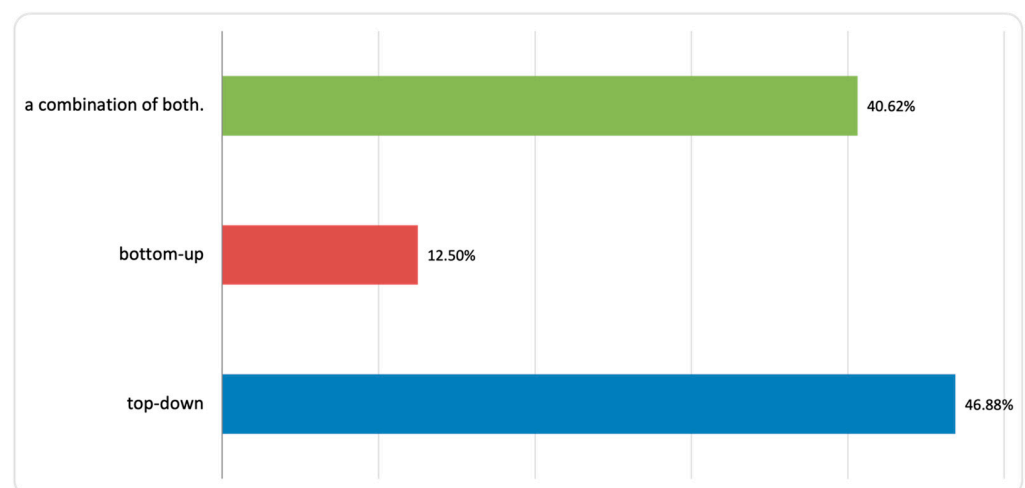


Figure 3. The governance approach of Saudi smart cities.

The next survey question result presents the differing perspectives of the expert respondents, following which dimension of smart city development is mostly implemented in the Kingdom, as seen in Figure 4. Among the five dimensions of smart city, smart governance (34.8%) is tied at the top with smart economy (34.8%). These results show an agreeable background as it is in congruence with the study of Alamoudi et al. [75], who also found smart governance as a leading dimension towards achieving smart city development. On the other hand, le Duc [39] and Asmyatullin et al. [38] both highlighted the smart economy as a major dimension of a smart city in Saudi Arabia, like Neom. However, among the six dimensions of smart cities, smart people were found to have 0%

votes among the expert respondents, which is in direct opposition to the study presented by Aldegheishem [76], who argues that smart people as a dimension of a smart city is implemented in Saudi Arabia through providing knowledge to the community and improving learning processes which is inherent in the cases of King Abdulaziz University (KAU) in Jeddah and King Abdullah University of Science and Technology (KAUST) which are examples of the Kingdom's global hubs for knowledge.

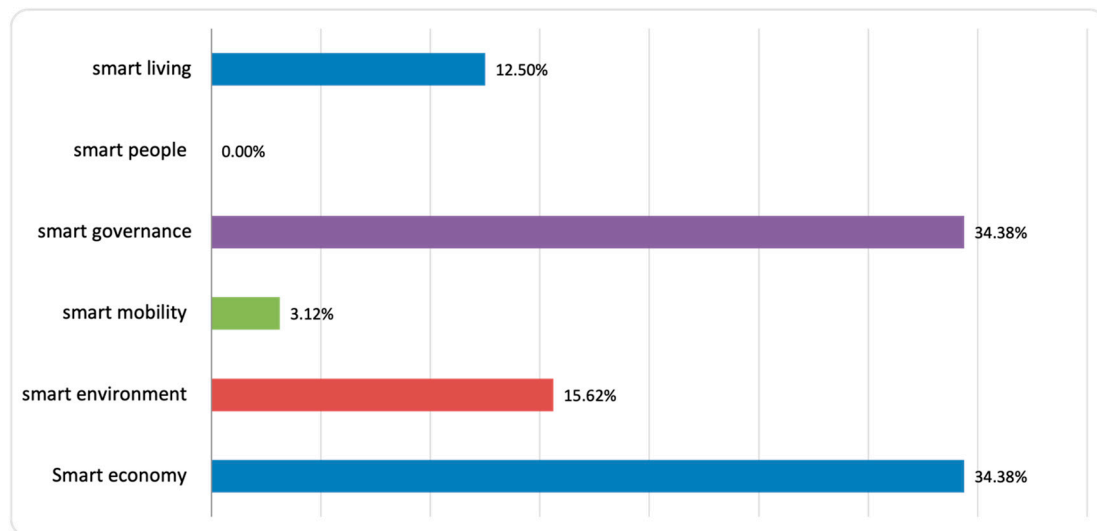


Figure 4. The dimensions implemented in Saudi smart cities.

A survey item, from the Likert scale group of questions, addresses whether Saudi smart city development ensures citizen participation. As seen in Figure 5 and Table 3 results, 38% agree, followed by 25% of the expert respondents who disagree with the notion that Saudi smart city development ensures citizen participation. The majority who agree that Saudi smart city development ensures citizen participation is in congruence with Alamoudi et al.'s study [43], as it highlights how valuable citizen involvement is in decision-making and public urban planning. However, the mean response (Table 3) indicates that the experts are mainly undecided. This is encapsulated in an expert opinion, *“Smart city development in Saudi Arabia is owned and governed by various national government entities, with limited influence by the cities and limited people participation.”*

Table 3. Statistics of rating scale responses.

Item	Mean	Standard Deviation	Rank	Degree
Saudi smart city developers consider the socio-cultural aspect of urban development	3.47	1.03	3	Agree
Saudi smart city development promotes healthy and livable city principles	4.04	0.95	2	Agree
Centralized planning is a challenge to smart city development in Saudi	4.28	0.57	1	Strongly Agree
The knowledge centers such as universities provide adequate support and capacity for smart city development	3.24	1.07	4	Undecided
The Saudi smart city development ensures citizen participation	3.12	1.05	5	Undecided
Average	3.63	0.934		Agree

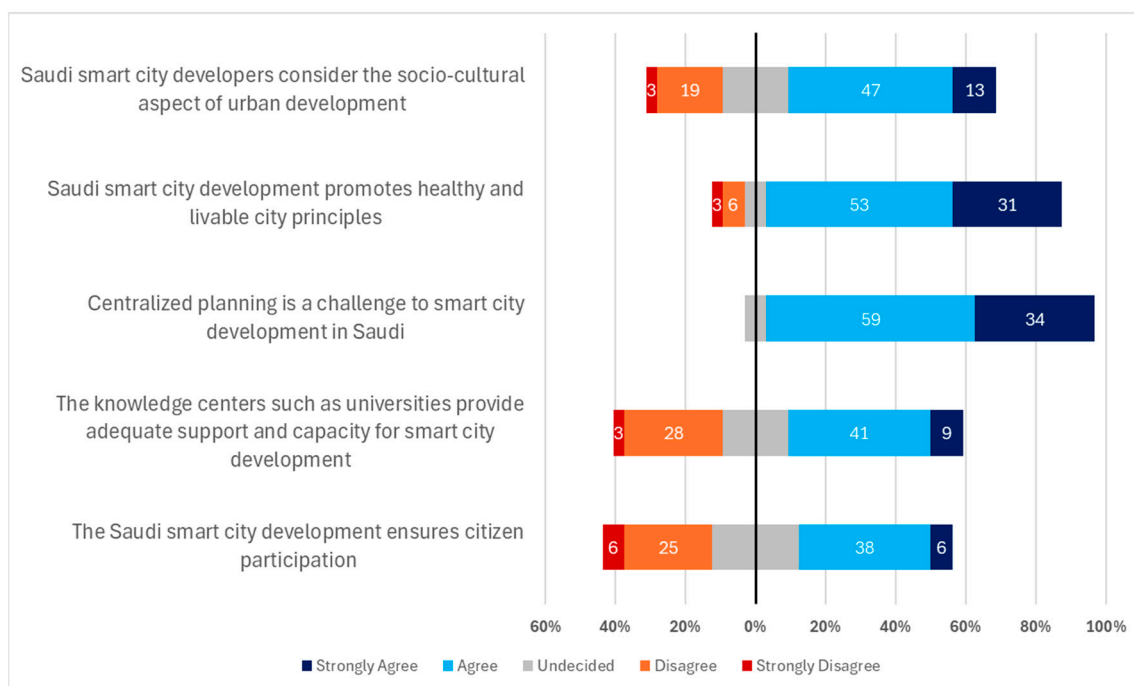


Figure 5. Responses to rating scale questions.

As shown in Figure 5, the majority of respondents (40.62%) agree that knowledge centers such as universities provide adequate support and capacity for smart city development. This result is in congruence with the study by Doheim et al. [77], discusses how support from universities by providing the appropriate education, partnerships between universities, provision of adequate funding for education related to smart city development are practiced in Saudi Arabia, proving adequate support and capacity of these institutions to achieve smart city development. In the next question, most of the expert participants (59%), as seen in Figure 5 and Table 3, agree that having centralized planning is a challenge to smart city development in Saudi Arabia. Centralized planning pertains to a hierarchical structure in which a central authority makes all the decisions that influence the overall program. For a smart city to be practiced, several dimensions, as previously mentioned, are involved, including smart governance, smart mobility, smart economy, smart people, smart environment, and smart living. Thus, having a centralized approach would make it difficult for the development of smart cities in the Kingdom.

On urban design principles such as health and life quality standards, most expert respondents agree (53%) that Saudi smart cities promote the implementation of the principles of a healthy and livable city. The mean response for this item is “Agree” indicating that the experts view Saudi smart cities as being healthy and livable. Thus, the quest to establish healthy and livable cities. However, an expert expressed the concern that a livable city agenda may be tokenized as merely green area development. *“I see that the humanization applied now tends towards the green cosmetic element more than the smart element. Smart city is for citizens and should be human and it needs to be about them”*. Finally, the last survey question inquires whether expert respondents agree that Saudi smart city developers consider the socio-cultural aspect of urban development. Results, as seen in Figure 5 show that the majority (47%) agree that socio-cultural factors, most likely projects that influence citizens’ values, behaviors, feelings, interactions, beliefs, and attitudes, are considered. This is further supported by Mutambik [78], with examples of a culturally informed technology aiding in the transition towards smart cities, as well as Alsheddi [79], who considered the

impact of socio-cultural beliefs and values in adopting smart technological innovation in Saudi Arabia.

4.4. Human-Centered Smart City Cases

Following the case studies presented in Table 1 about human-centered smart cities in Saudi Arabia, ten components were identified: knowledge economy, technological hub, knowledge clusters, knowledgeable citizens, active engagement, public participation, quality of life, Saudi green initiatives, strong governance, social and humanistic inclusion, and social capital. In the case of the knowledge economy, a project that exemplifies this component is Neom City. Angelidou [80] enunciates how the knowledge economy serves as a factor that forms the concepts of a smart city. A study by le Duc [39] sheds light on sustainable investments like Neom, along with utilizing infrastructures like individual transportation and communal transit, net-zero buildings and ecological infrastructure, and renewable energy, storage options, and electrical networks, among others. Neom City features a retooled economic model built in the interest of technological advancement, citizen welfare, and a progressive society [37]. These programs within the Neom project adhere to the knowledge economy since they feature innovative solutions and building human resource capabilities for smart economic projects [81].

Technological hubs and knowledge clusters also serve as components of human-centered smart cities. The most significant benefit of technological hubs resides not in their potential to generate smart societies automatically but instead in their accessibility for utilization in society, which expands public awareness and promotes engagement in participatory democracy about cities and their surroundings. In the case of Saudi Arabia, specific projects of this component are found in Dhahran Techno Valley [82], which fosters development, research, and innovation activities, as well as Khobar and Dhahran Smart City [72] and Neom city [42]. Knowledgeable citizens also serve as an element of a human-centered smart city. The premise of knowledgeable citizens rests on the perceptive engagement of individuals in smart urban living, wherein their willingness to welcome innovative ideas that promote innovative thinking and flexibility is necessary for an urban area to be considered smart [77]. For instance, education is the most important tool for further developing this component [83]. Alamoudi et al. [43] further emphasize evidence showing the critical component of education as provided by the goal inherent within the Saudi Vision 2030 program since knowledgeable citizens aid in giving citizens awareness and power through knowledge and create programs and decisions that would aid towards smart urban development. The expressed ambitions in the Saudi Vision suggest that the smart city's perception respects the principles, skills, and capacities of its population, developing opportunities that benefit all, notably the younger Saudi generations.

Active engagement, along with public participation, is found to be a key component of a human-centered smart city. Public participation represents an approach that enables private citizens to affect public decision-making and has traditionally happened to become fundamental to the democratic procedure for making decisions [84]. In a case found by Mutambik et al. [44], Jeddah Smart City and Riyadh Smart City concentrated on strengthening their smarts by boosting citizen involvement over digital channels. Results demonstrate that the sense of belonging and working together, generated through citizens' perspectives, proves essential for generating public support and active involvement in the establishment of smart cities. This shows that an essential prerequisite for promoting smart city involvement is to foster an impression of responsibilities and accountabilities as citizens. In terms of public participation, Zamin et al. [46] and Madakam and Bhawsar [47] further posit that Riyadh is paving the way toward achieving public participation and community engagement.

Quality of life is another component of a human-centered smart city. A smart city is an effectively operated urban area that considers the necessities of its citizens, oversees public areas, and puts together operations to create ideal circumstances to boost the quality of life for its inhabitants whilst achieving the targets of the appropriate stakeholders [50]. Alotaibi et al. [49] present Riyadh's smart city as an example that features quality of life as a component of a human-centered smart city as it incorporates not only smart technologies but also enhances the quality of life of its inhabitants through the six dimensions of smart cities. Martinez [48] also exemplifies Madinah's smart city as it focuses on improving the quality of life for citizens through inclusion, technology, and diversity.

Saudi Green Initiatives also serve as a key component of a human-centered smart city based on findings from the literature. Riyadh Smart City, for instance, serves as a key player in green innovation in real estate, green financing in responsible investments, and green building projects [45]. In a case study by Islam and Ali [51] in Riyadh's smart city, the authors found that the Green Riyadh program, which aimed at planting 7.5 million trees, led to notable progress and success in ecological initiatives, resulting in improved access to green spaces, good quality air, and the well-being of the citizens within the urban area. Green areas, accessibility, and transportation mobility all receive prominence in human-centric smart cities in comparison to simply productivity or maximization. The physical and mental wellness of the citizens is directly affected by each of these factors, making the Saudi Green Initiative an important component of human-centered smart cities.

Strong governance is also found to be another key component of a human-centered smart city. The smart city concept involves a distinctive or human-centric method that focuses on establishing a technologically advanced, secure future that is sustainable [85]. It is greatly dependent on strong governance across its governmental bodies and numerous official and unofficial groups across the organizational scale. It additionally underscores the formulation and propagation of knowledge management regulations, the construction of national plans, visions, and desired outcomes, and the setting up of financial frames for national advancement. In a case study by Deeb et al. [53] in Riyadh's smart city, the author found that strong governance served as a key component in Riyadh's smart city development, with smart business systems, cooperation, transparency, and open communication functioning as the key elements. Competent and trustworthy governance systems, alongside advanced and creative staff, are projected to deliver the crucial backing for smart cities. Through successful cooperation, local production could improve, which is a necessity for promoting substantial growth in the economy.

Social and humanistic inclusion also serves as a key component of a human-centered smart city based on findings from the literature. Individual mobility is essential for lowering the social marginalization of those most vulnerable in the setting of smart cities, as this approach preserves their professional and social connections along with their access to necessary amenities [86]. In a case study by Ondiviela [54] in Neom's smart city, the authors found that advocating connections with the community, boosting interpersonal relationships, and allowing residents the opportunity to utilize services that boost general wellness, social and humanistic inclusion further enhances both mental and physical well-being. From this, an atmosphere of encouragement may decrease strain while elevating citizens' quality of life. In addition, integrating social inclusion further encourages community involvement by empowering locals to play an active role in urban planning decisions [43]; as such, it builds trust across residents and authorities via citizen empowerment, which fosters simpler and productive urban responses that consider a broad spectrum of necessities faced by the public.

Finally, social capital also serves as a key component of a human-centered smart city based on findings from literature. Regarding Saudi Arabia's human-centered smart cities

to effectively develop and operate efficiently, social capital serves as a vital component as it renders cities more resilient, promotes innovation, preserves diversity, and progressively improves the standard of living for inhabitants, according to the case study following analysis within GCC countries by Brahimi & Bensaid [55]. Social capital within smart cities promotes resident satisfaction, leading to an enhanced sense of community and good governance as it utilizes collaboration, partnerships, and communication, as well as a positive impact on town planning policy.

Overall, the findings provide crucial insights into the alignment between Saudi Arabia's smart city initiatives and the conceptual framework established in this study. The framework emphasizes some key components and enablers of human-centered smart city development: governance, human-centric public service, participation, socio-economic equity, technology and sustainability. The results suggest that while progress has been made in establishing human-centric public services, citizen engagement remains underdeveloped, thereby challenging the framework's emphasis on participatory inclusivity. For example, only 38% of respondents agreed that citizens have adequate channels to influence decision-making processes, indicating a gap between top-down planning and bottom-up participation. Similarly, while technological innovation and infrastructure development align with the framework's dimension of sustainability, concerns over long-term economic viability and socio-cultural integration extend and complicate the framework's assumptions. Quantitative evidence from the expert survey further highlights these dynamics: 53% of experts viewed integration of livable city principles as a critical strength, yet less than half expressed confidence in the adaptability of current models to local socio-cultural contexts. There is a concern about the centralized governance model if it can deliver human-centric smart cities. These findings demonstrate that Saudi Arabia's smart city initiatives both confirm and challenge the conceptual framework, underscoring the need for ongoing refinement to account for context-specific socio-cultural realities.

4.5. Lessons and Recommendations

Overall, three methodological approaches were utilized within this research about attaining human-centered smart city development in Saudi Arabia. These approaches include background reviews, expert opinions, and case studies on human-centered smart city development in Saudi Arabia. Under the background review, it was found that Saudi Arabia is a country leading the majority of its cities towards smart development, like Jeddah, Riyadh, Neom, Yanbu Industrial City, Medina, Makkah, and Al-Ahsa. Riyadh, in particular, is a leading smart city capital in Saudi Arabia, as it has proven its efforts through projects and programs to reach sustainability and resilience through smart projects and initiatives. However, these programs present certain challenges, especially in terms of human-centered smart cities when it comes to having strong governance both locally and nationally, as well as public participation and active engagement. Nonetheless, in terms of a knowledgeable economy, technological hub, and Saudi green initiatives as part of smart cities, the Kingdom has achieved these goals. The following policy-oriented discussion of the lessons could be helpful in developing more human-centric cities in Saudi Arabia.

In terms of the gathered information from the survey garnering expert opinions, it was found that there is a significant lack of utilization and practices of human-centered smart cities within the Kingdom in comparison to the technocentric approach [70,72]. It was also found that among the five dimensions of a smart city, smart governance Alamoudi et al. [75] and smart economy le Duc [39] are the top responses of the experts, as can probably be seen from the example of Neom City and how it flourishes under these dimensions. However, it was also noticed that smart people did not rank among the experts, which is likely due to a lack of awareness or practice of this dimension in Saudi Arabia's smart cities.

Citizen participation [43] along with knowledge centers [77] that support and capacity for smart city development were both believed by experts to be key components in human-centered smart cities. The experts also believe that centralized planning for smart city development will be a challenge instead of a top-down approach [74] or a hybrid of top-down and bottom-up approaches [62]. While the top-down approach can provide strategic direction and resources, it risks imposition by technocrats and the exclusion of diverse community opinions. On the other hand, bottom-up approach fosters inclusion and contextual knowledge. However, the approach risks bias in representation and low institutional uptake. In the Saudi context of centralized planning, the government strives to promote citizen engagement and participation by trying to involve communities and enhance feedback mechanisms. This has been done by carrying out workshops, forums, and surveys among inhabitants to help determine the community's preferences and needs. For example, some cities have organized co-design hall meetings where citizens can give feedback on intended plans.

More efforts should be made to improve the level and quality of participation, for example, by making greater use of digital platforms for collecting feedback. However, the ethical use of technological tools for inclusiveness, and the cultural factors that shape engagement should be considered. In Saudi Arabia, social norms, values, gender dynamics, and trust in government institutions play a significant role in influencing citizen participation and the ethical use of technology. In the with the culture sensitivity, expert respondents agree that Saudi smart city developers should consider the socio-cultural aspect of urban development [79], proving further the human-centered approach as a valuable and integral factor of achieving smart city development in Saudi Arabia.

In terms of the case study method, ten components of a human-centered smart city in Saudi Arabia were identified, including the knowledge economy [39], technological hub and knowledge clusters [40], knowledgeable citizens [43], active engagement [44], public participation [47], quality of life [49], Saudi green initiatives [51], strong governance [53], social and humanistic inclusion [54], and social capital [17,55]. The Saudi context of the cases provides academic insights for human-centric smart city development. Under each case study, it was found that although technology is the common presumption when the smart city is discussed, several factors behind its operation significantly require a human-centered approach to be effective, as seen in several cases practiced within the Kingdom among its projects and cities like Neom city, Riyadh smart city, Dhahran techno valley, Khobar and Dhahran smart city, and overall application of the Saudi Vision 2030. Without the human-centered approach to smart cities, how innovations would be implemented, accepted, organized, engaged, or followed by citizens would be non-existent since the technological-centered approach mainly focuses on information technology, artificial intelligence, and machine learning developments.

Saudi Arabia's human-centered smart city approach, such as Riyadh [46], Neom [42], Madinah [87], and the Saudi Vision 2030, provides substantial insights that other cities aspiring for equivalent progress could employ. For instance, Saudi Arabia utilizes technology in its daily lives through user-friendly applications and smart city infrastructures. Easy accessibility to city services, community resources, and transportation, as well as the implementation of energy-efficient infrastructures, proper waste management systems, and smart mobility allow inhabitants to have a greater quality of life. Other cities can also learn from Saudi Arabia's major dedication to sustainability efforts through sustainable practices and green spaces. This can be done by utilizing green areas within urban planning as well as practicing sustainable efforts like the use of renewable energy sources to boost citizen well-being along with environmental sustainability. Saudi Arabia also practices data-driven decision-making through transparency by making data available to its citizens,

further boosting empowerment and trust. Saudi Arabia also concentrates on economic development by creating public–private collaborations and supporting hubs for innovation.

The mentioned lessons and recommendations are just a few of the things other cities can learn from Saudi Arabia’s human-centered approach to smart cities. Nonetheless, cities nationwide could boost their smart city activities by specializing around the mentioned human-centered ideas in application throughout this research. The primary focus ought to be building technologically cutting-edge cities to enhance the well-being, quality of life, and active involvement of inhabitants. Through this manner, the efficient execution of human-centered smart city programs by other cities could be adopted into Saudi Arabia’s strategy.

5. Conclusions

The paper examines human-centered smart city development in Saudi Arabia, contrasting it with the technological-centered approach. While most studies focused on the technological-centered approach to smart cities, the human-centered approach poses an integral component to achieving sustainability, organization, and efficiency in smart cities. Technological advancements are just that: innovation, digital works, and machines. For novel technologies and data to become human-centric, they seamlessly become incorporated with urban components, including citizens, infrastructure, and governance. This study adds value to scientific research in the field and strengthens sustainable development by exemplifying utilization of the human-centric approach. The approach supports boosting the quality of life for populations and serves as the backbone for the successful application of these innovations and technologies as it covers how initiatives should be distributed, how leaders should govern and exercise authority to achieve smart goals, how to spread awareness and public participation.

The paper was also able to address the four questions brought up at the beginning of the paper. The trend in human-centered smart city development was significantly presented in this paper. The challenges posed by human-centered smart cities were also discussed. The initiatives to implement human-centered smart city development were also found with the help of the case studies discussed. Success rates were found in both the background review results and the case studies presented. Overall, an in-depth comprehension of human-centric smart cities and their development in Saudi Arabia has been explored. Nonetheless, further research can be achieved, especially by exploring the concept of a human-centered smart city approach, as there exists very little study about the topic. It is recommended that a comparison of the human-centered approach to that of other approaches for smart cities, like technological-centered, can be researched. Further exploration of the smart city dimensions in detail is another area for future studies. Nevertheless, the current research has provided significant knowledge and data in the field of human-centered smart cities in Saudi Arabia, which would aid policymakers, educators, students, and local and national authorities.

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