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Unlocking the Potential of Sustainable Smart Cities: Barriers and Strategies

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Abstract: The development of sustainable smart cities (SSCs) is pivotal for contemporary urban expansion, as highlighted by numerous international frameworks and scholarly studies. This study focused on Saudi Arabia to identify and assess the key challenges impeding the evolution of intelligent and sustainable urban environments. By categorizing and hierarchically analyzing these impediments, the research isolates the most significant barriers to SSC advancement. A total of 18 obstacles were identified, organized into four categories, and reviewed using existing scholarly literature. Semi-structured interviews were conducted with stakeholders engaged in executing SSC initiatives, enriching the research from a practical perspective. Additionally, a survey ranked these barriers, revealing that social and economic factors pose the most significant challenges, followed by governance and legal, technology, and environment. The findings of this study offer critical insights for policymakers and governments to mitigate the barriers to SSC development efforts.

Keywords: sustainable smart cities; smart cities; smart cities initiative; barriers to smart cities; smart cities strategies

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Citation: Mutambik, I. Unlocking the Potential of Sustainable Smart Cities: Barriers and Strategies. *Sustainability* **2024**, *16*, 5061. https://doi.org/10.3390/su16125061

Academic Editors: Tomáš Peráček and Andrea Čajková

Received: 29 April 2024
Revised: 11 June 2024
Accepted: 11 June 2024
Published: 14 June 2024

1. Introduction

Over the past two decades, the smart city (SC) paradigm has attracted the attention of scholars and international policymakers. Cities are fundamental to the prospective shaping of the global future, making it crucial to thoroughly understand and analyze their development trajectories. Urban centers significantly influence environmental sustainability and are pivotal in driving global social and economic advancement [1–4]. According to a United Nations (UN) report, in 2008, urban areas were home to over 3.3 billion people, constituting more than half the global population. This figure is forecast to increase to 70% by 2050, highlighting the expanding scale and role of megacities, especially those in Latin America, Africa, and Asia, with populations exceeding 20 million [5–7].

As urban centers continue to grow, their consumption of resources and impact on the environment correspondingly increase. According to UN-Habitat, cities account for 78% of the global energy use and over 60% of carbon emissions. The denser a city's population, the greater its energy needs for transportation and other essential services [5,6,8,9]. Urban areas typically generate significant amounts of waste and utilize products that contribute to negative externalities, thereby exacerbating social and economic challenges. Enhancing natural resource reserves has been proposed as a method to bolster sustainability [10–13]. This approach underscores the need for cities to address social and economic difficulties sustainably.

Globally, cities are exploring strategies to adapt to environmental pressures and stimulate economic growth by enhancing transportation networks, developing mixed-use zones and improving the quality of urban services [14–17]. A critical component of this endeavor involves establishing more efficient public transport systems attuned to the needs of the economy. Technological advancements have facilitated the development of innovative solutions for urban services, instrumental in the creation of sustainable smart

cities (SSCs). These SSCs are designed to provide sustainable and effective solutions across various domains, including energy management, transportation, healthcare, and governance, with the aim of fulfilling the requirements of urbanization and sustainability objectives. Despite the growing global adoption of the SSC concept in planning documents and national strategies, there remains a degree of reluctance among urban policymakers to implement measures that would transition their cities into smart locales [10,12,14,16].

Cities are increasingly grappling with both traditional and digitalization-related challenges such as resource depletion, deteriorating air quality, inadequate waste management, traffic congestion, and subpar infrastructure [10,18]. In addition to these physical dilemmas, cities face various socioeconomic issues, including social exclusion, elevated pollution levels, ineffective climate change mitigation, stagnant urban productivity, and insufficient urban governance that fail to support the sustainable smart city (SSC) concept. Furthermore, there is a need to enhance the strategic planning knowledge base for SSC initiatives, calling for a deeper investigation into the SSC goals, their theoretical foundations, and the obstacles to their implementation [15,18].

Recent literature has emphasized the role of technology and computer software tools in addressing these urban challenges. For instance, Leśniewski et al. [19] highlight the importance of computer software tools (CS tools V2) in managing industrial symbiotic networks (ISNs), which involve multidimensional networks that operate as dynamic complex networks crossing natural, technical, social, and computer systems boundaries. They underline the benefits of using CS tools to enhance value and reduce financial and environmental costs by sharing services, utilities, or by-products/waste among stakeholders in ISNs. This framework can be paralleled in the context of SSCs, where advanced technological tools are vital for effective urban management and sustainability. Additionally, Džajić and Jelen [20] highlight the importance of industrial symbiosis in the industrial ecology literature, emphasizing geographically close relationships between companies where networks and geographic proximity are crucial. Their study in the northeast of Italy underscores critical environmental, geographic–economic, and social factors that could hinder the development of industrial symbiosis, which can be informative for SSCs in addressing similar barriers.

Given these complexities, this study was designed to refine our understanding of SSC implementation by exploring the impediments to the adoption of SSC principles in Saudi Arabia. SSC concepts can be effectively operationalized by identifying and prioritizing intervention strategies based on the relevance of each barrier. The specific aims of this study were to address the research questions (RQs) as follows:

RQ1: To identify and rank the key barriers to SSC development in Saudi Arabia.
RQ2: To model the interactions among these identified barriers.

The pursuit of SSCs has been identified as significantly benefiting from advancements in information and communication technology (ICT). Despite this progress, the full maturation of frameworks and standards for the essential elements of SSCs is still underway. The academic community continues to seek a universally accepted solution that comprehensively encapsulates the SSC model [21].

Definitions of SSC vary widely, and the term is not consistently used across studies and applications. Alternatives such as "intelligent" or "digital" are often substituted for "smart", reflecting the fluidity in the conceptualization of these cities. The complexity of defining SSC arises from its incorporation of diverse domains: "hard" domains (such as buildings, energy, mobility, and logistics), where ICT's role is predominant, and "soft" domains (including education, social integration, and innovative regulations), which focus on the societal aspects of sustainability [22]. According to Bibri and Krogstie [23], there are approximately 20 interpretations of what constitutes an SSC, highlighting their multifaceted nature.

Despite these variations, a common thread in most definitions is the integration of ICT to improve the efficiency and effectiveness of urban management. This utilization spans multiple municipal services and is a core component of the SSC concept. Over time, this concept has evolved, with standardization bodies now agreeing on certain fundamental

components and methodologies required to develop SSCs [24,25]. These components aim to create a framework that supports sustainable growth and efficient city management through the strategic application of technology.

The selection of barriers was informed by scholarly literature and insights from professionals in the field. The outcomes of this research will provide a strategic framework for advancing SSC development in Saudi Arabia and serve as a comprehensive blueprint for the transformation of the city into a model sustainable smart city.

2. Research Methodology

2.1. Stage One: Extraction of Barriers to SSC

The initial step in understanding the complexities of implementing SSCs, especially in Saudi Arabia, was to identify barriers through comprehensive literature research. The search strategy employed specific keywords related to impediments in smart city development, including "barriers and smart cities development", "challenges and smart cities development", and "problems/issues and smart cities development." This exploration utilized prominent academic and research databases such as Web of Science, Scopus, and Google Scholar.

A meticulous review of the literature using these keywords across various studies identified 24 barriers to SSC development. These barriers were subsequently classified into four categories. To validate these findings, we examined specific government reports, legislative texts, online resources, and urban planning documents. This holistic approach ensured a robust identification process for barriers within the Saudi context by utilizing a case study methodology. This method is crucial not only for identifying practical challenges but also for contributing theoretically to the field and advocating for SSCs.

In addition to the documentary and literature review, semi-structured interviews were conducted with 23 experts from Saudi Arabia with the aim to validate the barriers identified in the literature and to uncover any potential barriers that had not been previously recognized. These experts were selected based on their extensive knowledge and experience (a minimum of five years of experience) in various fields relevant to urban development and smart cities. They included urban planners, IT specialists, sustainability experts, government officials, and academics. Their expertise spanned critical areas such as technology implementation, urban governance, environmental sustainability, and economic planning, ensuring a comprehensive understanding of the multifaceted barriers to SSC development.

Following these interviews, the number of recognized barriers was refined to 18, and the categories were consolidated into four distinct groups, "governance and legal", "social and economic", "technology", and "environment", as detailed in Table 1. This reduction was due to the identification of overlapping issues that were initially categorized separately. By synthesizing similar barriers and eliminating redundancies, the research achieved a more streamlined and focused set of challenges that more accurately reflect the critical obstacles specific to SSC implementation in Saudi Arabia. This refinement helped us to focus on the most pertinent challenges, ensuring a more targeted and practical approach to overcoming barriers in the implementation of SSCs.

This phase of research was critical to ensure the relevance and comprehensiveness of the identified barriers to SSC implementation. This structured approach to identify barriers not only highlights the specific challenges faced in Saudi Arabia, but also sets the stage for addressing these through targeted interventions in subsequent phases of the research. Further, understanding these barriers is fundamental to developing effective strategies to overcome them. Policymakers should consider these insights when designing interventions to facilitate the development of SSCs, such as promoting electric vehicle use, enhancing public transportation networks, supporting green building initiatives, and expanding digital connectivity. This comprehensive understanding aids not only in addressing immediate challenges but also in shaping a resilient and sustainable urban future.

Table 1. Categories breakdown and linked barriers to SSC evolution.

Category	Barrier	Description
Governance and Legal	G and L 1. Lack of cooperation and coordination between city networks	Challenges in integrating various operational networks within the city hinder SSC progression, affecting both governance and legal compliance.
	G and L 2. Unclear IT management vision	The absence of a clear IT strategy obstructs effective governance and technological integration, impacting legal frameworks and regulatory compliance.
	G and L 3. Political instability and lack of trust	Political fluctuations and mistrust between citizens and the government can destabilize SSC initiatives and undermine legal frameworks.
	G and L 4. Poor private-public participation and lack of standardization	This barrier highlights the challenges in achieving effective collaboration between public and private sectors due to the absence of standardized processes and guidelines.
	G and L 5. Lack of a common information system model	This barrier involves the complications that arise from the absence of a unified information system model. It highlights the need for standardized models to ensure interoperability, transparency, and legal compliance across different systems.
	G and L 6. Issues of openness of data	This barrier emphasizes the importance of data openness by underlining the critical need for clear accountability, transparency in operations, and well-defined regulations. Ensuring data openness is essential for maintaining public support and upholding ethical practices.
Social and Economic	S and E 1. IT infrastructure and skill development deficit	This highlights both the technological and human resource challenges in urban management, emphasizing the need for advanced IT capabilities and affordable professional training.
	S and E 2. Economic stability and operational costs	This reflects how external economic conditions and internal financial management impact the funding and long-term sustainability of SSC initiatives.
	S and E 3. Community engagement and awareness	This underscores the importance of actively engaging citizens and raising their awareness to ensure they understand and support SSC functionalities and benefits.
	S and E 4. Competitiveness and economic inequality	This addresses how enhancing local business competitiveness and addressing social inequality can both contribute to more effective and equitable SSC projects.
	S and E 5. Geographic and demographic challenges	This maintains geographical diversification problems as a distinct barrier, emphasizing the importance of geographic balance to prevent regional disparities and ensure inclusive development across different areas of the city.
Technology	T1. Technological expertise and accessibility	This emphasizes the need for both sufficient training and knowledge in current technologies among city planners and policymakers, as well as ensuring that these technologies are widely accessible to effectively implement SSC features.
	T2. Privacy, security, and system reliability	This underscores the critical importance of safeguarding citizen data to maintain trust, and the need for reliable systems to avoid disruptions that undermine confidence in SSC functionalities.
	T3. IT integration and data management	This highlights the necessity for seamless integration of diverse technology platforms for efficient city operations, alongside robust data management practices that ensure solutions are scalable and adaptable to evolving city needs.
Environment	EN1. Sustainable practices integration	This highlight the essential need for integrating sustainable practices into daily operations to effectively minimize environmental impact and ensure SSCs operate sustainably.
	EN2. Population growth and resource management	This addresses the challenges that rapid population growth poses to sustainable resource management and infrastructure, emphasizing the necessity of conserving resources for long-term viability.
	EN3. Carbon emissions reduction	This maintains the carbon emissions effect as a distinct barrier, underscoring its importance in achieving global climate goals and enhancing public health through reduced emissions.
	EN4. Ecological resilience and adaptability	This emphasizes the need for cities to adapt to changing environmental conditions and maintain ecological resilience, ensuring that urban environments can withstand and recover from environmental stresses and shocks.

2.2. Stage Two: Conforming of Barriers to SSC

Following the initial identification of barriers to SSCs development, this study progresses to the second stage, utilizing exploratory factor analysis (EFA) to examine the relationships among these barriers. EFA is particularly valuable in this context as it aids in reducing data complexity by grouping related variables. This method enhances the interpretation of data and improves the usability of the information for strategic planning.

2.2.1. Survey Development

This study applied a survey method to evaluate the validity and reliability of the primary obstacles to SSC. The survey used a standard 5-point Likert scale to measure responses and consisted of 18 items distributed across four categories, as detailed in Table 1 (more details on Appendix A). These items underwent further validation and accuracy checks. A pilot study involving 30 participants from diverse demographic backgrounds was conducted to assess the clarity and efficacy of the questionnaire. This led to multiple revisions of the items to eliminate ambiguities and enhance the accuracy of responses, thereby ensuring high-quality data collection for analysis.

2.2.2. Sample and Data Collection

The survey targeted professionals (N = 310) across various industries within Saudi Arabia who are actively involved in SSC-related projects. The respondents were a range of nationalities, ages, private/public sector occupations, and socioeconomic statuses, as well as required to have significant experience and knowledge in the field to ensure a high level of expertise and relevance. Efforts were made to reduce potential bias by carefully designing the survey to include a diverse and representative sample of professionals from multiple sectors such as information technology, government, education, healthcare, engineering, business/finance, and other relevant fields.

Participants were selected using a purposive sampling technique to ensure that only those with relevant expertise and experience in SSCs were included. Invitations to participate were sent through professional networks, industry conferences, and online platforms related to SSCs.

Over a period of three months, a total of 352 responses were collected. Of these, 42 were excluded as invalid due to being incomplete, ambiguous, or inconsistently filled out, leaving 310 responses suitable for analysis. The demographic profiles of the respondents are summarized in Table 2.

Table 2. Demographic overview of survey respondents.

Demographic Profile		Participants %
Gender	Male	66
	Female	34
Education	Bachelor	51
	Master	42
	Ph.D.	7
Years of Experience	5–10	49
	11–20	29
	21–30	13
	31+	9
Nationalities	Saudi	58
	Egypt	16
	India	7
	Others	19
Industry/Sector	Information Technology	25
	Government	20
	Education	19
	Healthcare	12
	Engineering	11
	Business/Finance	8
	Other Sectors	5

This demographic and professional profile of the respondents helps to underscore the reliability of the survey results, reflecting informed perspectives that are critical for addressing the multifaceted challenges of developing SSCs. For instance, gender differences can highlight varied priorities such as safety or technical infrastructure, while education level influences the understanding of complex issues. Experience shapes views on long-term vs. short-term challenges, and diverse nationalities provide a range of insights from different cultural and economic contexts. Private/public sector roles and socioeconomic status further influence perspectives on policy and practical needs. Additionally, to further mitigate potential bias, the survey included clear and neutral questions and was distributed through multiple channels to reach a broad audience, ensuring that the data collected are as objective and representative as possible.

2.2.3. Results of Exploratory Factor Analysis of the Barriers

This study utilized the EFA method to investigate the relationships between various barriers to SSC development. EFA is particularly useful for reducing the complexity of data by grouping related variables, which simplifies interpretation and enhances the usability of information for strategic planning. The key steps and findings from the EFA are as follows:

Anti-Image Correlation Matrix: All diagonal values in this matrix were greater than 0.5, confirming the suitability of all the items for factor analysis. This matrix helps to verify the adequacy of each variable for inclusion in the factor analysis by measuring partial correlations. High values on the diagonal indicate that the variables have a low level of partial correlation with other variables, suggesting that they contribute uniquely to the factor structure and are not redundant. This ensures that the factors extracted will be reliable and meaningful.

Communalities: Initial communalities were used to estimate the amount of variance in each variable that could be accounted for by the extracted factors. In this analysis, all initial communalities were above the commonly used cut-off point of 0.3, suggesting a good fit of the data to the factor model (Table 3). High communalities indicate that the extracted factors explain a significant portion of the variance in each variable, implying that the variables are well-represented by the factor solution. This enhances the interpretability and validity of the factor analysis results.

Table 3. Factor loadings and communalities of barriers with their ranking according to the mean and standard deviation.

	Factor Loading	Communalities	Mean	Ranking Based on Mean	SD	Ranking Based on SD
G and L1	0.643	0.504	3.92	2	0.617	17
G and L2	0.749	0.589	3.92	3	0.628	16
G and L3	0.437	0.544	3.75	7	0.41	18
G and L4	0.702	0.732	3.49	15	0.763	13
G and L5	0.682	0.747	3.5	14	0.754	14
G and L6	0.577	0.748	3.3	13	0.823	5
S and E1	0.714	0.696	3.1	16	0.878	11
S and E2	0.628	0.671	3.17	12	0.84	12
S and E3	0.615	0.523	3.34	8	0.833	10
S and E4	0.692	0.526	2.96	1	0.807	7
S and E5	0.81	0.772	3.15	15	0.834	9
T1	0.527	0.565	3.42	6	0.794	3
T2	0.59	0.631	3.43	17	0.777	2
T3	0.692	0.553	3.41	18	0.818	6
EN1	0.782	0.653	3.79	4	1.21	1
EN2	0.899	0.832	3.66	11	1.045	15
EN3	0.905	0.815	3.77	5	1.059	4
EN4	0.907	0.827	3.73	10	1.067	8

Note: G and L: governance and legal; S and E: social and economic; T: technology; EN: environment. Extraction method: principal component analysis. Rotation method: Varimax with Kaiser normalization.

Factor Loadings: All the loading factors were above 0.6, indicating that the extracted factors had a strong relationship with the variables, as shown in Table 3. Loading measures the correlation between variables and factors, with higher values indicating a stronger correlation. High factor loadings imply that the variables are strongly associated with the respective factors, facilitating clearer and more distinct factor interpretation. This ensures that each factor represents a coherent construct, enhancing the overall explanatory power of the factor model.

Mean Scores and Standard Deviations: The analysis also involved computing mean scores and standard deviations (SD) for each barrier to identify their relative significance and variability. All barriers had mean values greater than two; hence, none were removed from the analysis based on the mean score criterion, as shown in Table 3.

The EFA employed in this study identified also four significant factors influencing barriers to SSC development using principal component analysis with Varimax rotation and Kaiser normalization. Principal component analysis was chosen for its effectiveness in reducing dimensionality and identifying underlying structures within the data. Varimax rotation was applied to maximize the variance of squared loadings of a factor across variables, enhancing the interpretability of the factors. Kaiser normalization ensured that each factor retained a significant amount of the original variance, making the resulting factors more meaningful. This method clarifies the structure of the barriers by grouping them into distinct categories based on their interrelationships, with eigenvalues greater than one signifying the importance of these factors. The factors were named according to their dominant characteristics: governance and legal, social and economic, technology, and environment.

Factor Importance and Explained Variation:

1. Governance and Legal: This factor was the most significant, explaining 62.726% of the variation. It encompasses barriers related to transparency, standardization, regulatory norms, and data openness, which are crucial for establishing trust and ethical standards within SSCs.
2. Environmental: The second most significant factor accounts for 58.562% of the variance. This factor includes challenges related to sustainable resource management, carbon emissions, and ecological behaviors, which are fundamental to the environmental sustainability of SSCs.
3. Technology: This factor explains 52.267% of the variation, and it includes barriers associated with technological infrastructure, access to technology, and system integration, which are essential to the digital backbone of SSCs.
4. Social and Economic: This accounts for 45.987% of the variation and involves barriers that impact social interaction, community awareness, and citizen engagement, which are vital to the social fabric of SSCs.

These results illustrate the distinct domains that encompass multifaceted barriers to SSC development. By comprehensively addressing these barriers, policymakers and city planners can effectively strategize and implement solutions that overcome the specific challenges faced in the development of SSCs.

Following the EFA, the study employed Cronbach's alpha to assess the reliability and internal consistency of the identified barriers, ensuring the robustness of the factor structure derived from the EFA. As illustrated in Table 4, the Cronbach's alpha coefficients for each category were found to be satisfactory, with values greater than 0.7, ranging between 0.741 and 0.891. These results indicated a good level of internal consistency within each factor group, confirming the reliability of the constructs. Nevertheless, specific items such as GOV6, TECH1, and LandE5 were excluded from subsequent analyses because of their insufficient factor loadings and low communalities, highlighting their minimal contribution to the explained variance among barriers. The exclusion of these items further refined the model, ensuring that only those items with strong correlations and significant contributions were included, thus enhancing the overall reliability and validity of the findings.

Table 4. Results of convergent validity.

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Barriers to SSC	0.883	0.859	0.656
ECO	0.891	0.861	0.631
ENV	0.787	0.812	0.640
GOV	0.756	0.856	0.696
L and E	0.825	0.903	0.707
SOC	0.741	0.769	0.436
TECH	0.879	0.900	0.643

2.2.4. Structural Model of the Barriers

The structural model provides a visualization of the connections between constructs and assesses the correlations between items and latent variables. This model facilitated the evaluation of the integrity of the measurement model, as summarized in Table 4. For valid results, the composite reliability (CR) should exceed 0.7, Cronbach's alpha should be greater than 0.5, and the average variance extracted (AVE) should exceed 0.6. All these results showed an adequate convergent validity [26–28]. The CR values above 0.7 confirm that the indicators are consistently measuring the latent constructs, ensuring internal consistency and reliability. Furthermore, the AVE values above 0.6 indicate that more than half of the variance of the observed variables is explained by the latent construct, thereby confirming the robustness and validity of the model.

Discriminant validity, which confirmed the distinctiveness of the categories, was assessed using the Fornell–Larcker criterion and cross-loading analysis. To ensure adequate discriminant validity, the square root of each construct's average variance extracted (AVE) should be greater than the highest correlation with any other construct. The results, which uphold the model's discriminant validity, are shown in Table 5, demonstrating that all factor loadings on the designated constructs were higher than any cross-loadings with other constructs.

Table 5. Cross-loading.

Barrier	G and L	S and E	T	EN
G and L 1	0.763			
G and L 2	0.784			
G and L 3	0.743			
G and L 4	0.851			
G and L 5	0.804			
G and L 6		0.945		
S and E 1		0.950		
S and E 2		0.882		
S and E 3			0.587	
S and E 4			0.665	
S and E 5			0.781	
T1			0.878	
T2			0.828	
T3				0.853
EN1				0.856
EN2				0.930
EN3				0.950
EN4				0.865

The identification and validation of the barrier categories—governance and legal, environmental, technology, and social and economic—followed a rigorous process. Initially, these categories were identified through an extensive literature review and expert consultations. Key sources from peer-reviewed journals, industry reports, and expert opinions were analyzed to extract common themes and barriers relevant to SSC development. This

comprehensive review ensured that the categories were grounded in existing knowledge and practical insights.

To validate these categories, we conducted a series of Delphi studies and pilot surveys involving practitioners and scholars in the field of SSCs. The Delphi method, which involves multiple rounds of feedback and consensus-building among experts, was employed to refine the categories and ensure they accurately reflected the key barriers. The pilot surveys helped in pre-testing the survey instruments, confirming the relevance and comprehensiveness of the identified barriers.

This comprehensive assessment validates the structural integrity and reliability of the model, which is essential for substantiating the barriers to SSC development identified in this research. This foundational understanding will facilitate further exploration and strategic planning to mitigate these barriers effectively.

The barriers to the establishment of SSCs can be comprehensively illustrated using four subscales. These subscales represent distinct categories of barriers, each contributing differently to the challenges in SSC implementation. The path coefficients extracted for these models confirm that all the identified factors significantly impede SSC development, albeit to varying degrees.

3. Discussions and Contributions

This study provides critical insights for decision-makers in Saudi Arabia by identifying barriers to the effective implementation of SSCs. The success of SSCs relies heavily on administration, which can be enhanced through improved governance. Better governance facilitates greater collaboration among all the parties involved in the development of SSCs, thus increasing the impact of public participation and influencing policy decisions effectively [29–32]. Advocating e-governance services can significantly enhance accountability and transparency in decision-making processes, essential for fostering smart governance in SSCs.

Resource management, including the coordination between people and materials, plays a crucial role in SSC development. Securing adequate funding and establishing the necessary infrastructure continue to be major challenges; however, it is imperative for governments to develop comprehensive plans that involve both public- and private-sector cooperation [33–35]. Adequate resources and funds must be allocated to address and overcome the challenges related to infrastructure and resources in SSC projects. Automation and digitalization are fundamental to evolving into a truly sustainable smart city. Advanced digital technologies are crucial to efficiently manage infrastructure, improve service levels, enhance collaboration, and delineate government initiatives aimed at addressing climate change.

In comparison to earlier studies, such as those conducted by Kitchin et al. [36], which analyzed the main aspects and barriers to SSC development across different cities, it is evident that each city employs a variety of tools, resulting in disparate progress levels. For example, Barcelona's sophisticated approach to smart city development, which includes creating a special office responsible for smart city initiatives and high citizen participation in planning, has established it as one of the premier global SSCs.

This contrasts with the findings of Bello et al., who identified significant barriers in Nigerian cities, such as challenges related to integrated urban transformation, socioeconomic equity, and governance.

The differences can be attributed to several contextual factors. Barcelona benefits from a well-established infrastructure, strong governance, and high levels of citizen engagement, which facilitate comprehensive and cohesive smart city initiatives. In contrast, cities like Shanghai and Tokyo, despite their advanced technological capabilities, face rigid urban planning systems that lead to more fragmented and isolated smart city strategies [25,37–39]. Additionally, the socio-economic and political contexts of Nigerian cities, as highlighted by Bello et al., present unique challenges that are not as prevalent in more developed urban

environments. This underscores the need for tailored approaches to SSC development that consider local contexts and the specific barriers and drivers at play.

Understanding these contextual differences is crucial for policymakers and urban planners. It emphasizes the importance of flexible and adaptive governance structures that can accommodate the diverse needs and capabilities of different cities. The insights from Bello et al. provide a valuable perspective on the necessity of inclusive decision-making processes, sustainable environmental practices, and equitable economic expansion, which are essential for overcoming the barriers to SSC development in less developed contexts.

Research by Bello et al. [40] on Indian cities revealed that the design and implementation of SSCs in developing countries are markedly different. The main barriers identified in the various cities include the following:

- Prominent challenges such as land lease issues and conflicts of interest among municipal authorities, citizens, and businesses.
- Issues revolving around intellectual property protection, the confidentiality of personal information, and the security of automated systems.
- Land lease issues, limited opportunities for citizen participation in city management, resource constraints, and the rigidity of the planning documents that dictate city development.
- Challenges regarding automated system security and restrictive citizen participation in city governance.
- Issues involving a lack of citizen involvement, insufficient competitiveness, and volatility in the global economy, which impact their smart city initiatives.

These analyses demonstrate that local contextual factors profoundly influence SSC implementation, including the specific conditions of countries and governments. Barriers vary significantly across different locales owing to distinct governance structures, cultural norms, and economic conditions [41–43]. For instance, in Belanche et al.'s study of Zaragoza, Spain, the influence of personal attitudes, possession of user cards, and education levels significantly contributed to the use of urban services. In contrast, our study highlights systemic and infrastructural barriers prevalent in Indian cities, such as land lease issues and conflicts of interest. The differences in findings across these contexts can be attributed to several factors:

- Governance and Policy Frameworks: The governance structures in Spain allow for more streamlined and integrated urban service management, whereas Indian cities often face bureaucratic hurdles and fragmented authority.
- Cultural and Societal Norms: Cultural differences influence how citizens interact with urban services. For example, the higher levels of city attachment and civic participation observed in Zaragoza may not be as prevalent in Indian cities.
- Economic Conditions: Economic disparities play a significant role. Spanish cities might have better financial resources to implement and maintain SSC initiatives compared to the resource constraints seen in many Indian cities.
- Technological Adoption and Infrastructure: The level of technological infrastructure and adoption varies. Cities like Zaragoza might have more advanced technological frameworks supporting SSCs, while Indian cities are still developing these systems amidst other challenges.

These contextual differences underscore the importance of tailored approaches to smart city strategies. Understanding and addressing these unique local factors is crucial for the successful implementation of SSCs. This study not only maps the specific obstacles faced by SSC, but also provides a foundation for future research to explore strategic solutions that effectively mitigate these barriers, supporting the overarching objective of sustainable urban development.

Moreover, the implementation of SSC projects involves numerous challenges that vary significantly across contexts. These challenges range from broad financial constraints to specific limitations dictated by each city's unique socio-economic, environmental, and

political characteristics [44,45]. Although SSC projects have been actively pursued in many developed cities worldwide, their applicability and implementation within the cities of the Gulf Cooperation Council (GCC) remain limited [46–49]. Transitioning towards the SSC model in GCC cities involves various challenges, including socioeconomic, political, technical, and infrastructural issues, all of which must be effectively integrated for successful implementation. In this study, experts have identified and prioritized these barriers, which necessitates a comparison with studies from other cities globally to highlight the unique contribution of this research and affirm that barriers are profoundly influenced by each city's distinct characteristics.

Developing and transitioning towards SSCs varies significantly between different regions and within cities in the same country. The pace at which this transition occurs and the implementation of national SSC strategies and action plans differ widely, reflecting a diverse range of challenges and advancements. For instance, Tunisia embarked on e-administration in the 1990s to modernize its administrative systems and has recently focused on generalizing e-services and establishing frameworks for e-government achievements [50–53]. Similarly, in December 2006, Bahrain announced plans to initiate e-government in the Gulf, aiming to enhance online services through various channels including portals and mobile devices [54–57]. Jordan, Egypt, and Oman have also made significant strides in integrating ICT with government services to enhance efficiency, participation, and transparency, which are essential for fostering a competitive, robust, and knowledge-based economy [57–59].

These overall comparisons elucidate the specific challenges and strategies pertinent to SSC implementation across various global contexts, emphasizing the unique barriers faced by each city owing to its distinctive political, economic, and social environment. This nuanced understanding is critical for developing targeted strategies that address the specific needs and constraints of different urban settings during the transition to SSCs.

4. Conclusions

Over the last two decades, the concept of SSCs has been extensively explored in global scholarly discourse. This research identified and prioritized barriers to SSC development to aid decision-makers in enhancing sustainability efforts in Saudi Arabia. This study discerned thirty-one significant barriers across four themes. These categories—governance and legal, environmental, technology, and social and economic—underscore the multifaceted challenges of SSC implementation.

Industry experts corroborated the relevance of these barriers, and their insights facilitated stratification into distinct categories. This analysis underscored the critical nature of each category in SSC development. In particular, barriers such as environmental sustainability concerns and governance challenges emerged as the most significant impediments to SSC initiatives.

Identifying these barriers is crucial for developing targeted action plans that effectively address and mitigate obstacles in Saudi Arabia. Recognizing the need for a concrete barrier assessment in industries is imperative so that feasible and practical strategies can be devised and implemented by governmental bodies, organizations, and policymakers to progressively dismantle these barriers and enhance SSC efficacy.

Practical Implications and Recommendations: We must establish robust governance frameworks at the national level to foster SSC integration across all sectors. This includes formulating and strictly enforcing clear SSC guidelines compelling industries to incorporate SSC principles into their operational processes. Prioritizing environmental sustainability in urban planning and development projects is essential, with policies that incentivize green building practices, renewable energy adoption, and resource efficiency. Investing in technological infrastructure to support SSC initiatives is also crucial, involving the implementation of smart grid technologies, enhancement of broadband connectivity, and promotion of innovation in smart city solutions. Fostering SSC awareness and commitment at the organizational level through sustained national and industrial initiatives is vital, which can be achieved by conducting public awareness campaigns, providing training and

education programs, and engaging stakeholders in SSC projects. Developing collaborative platforms for stakeholders to address SSC barriers collectively is recommended, which involves creating task forces and committees that include government, private sector, academia, and civil society to discuss and strategize solutions. These practical implications and recommendations aim to provide policymakers and urban planners with actionable insights to overcome the identified barriers and drive the successful implementation of SSCs in Saudi Arabia.

Finally, effective interventions require robust governance frameworks at the national level to foster SSC integration across the sectors. An essential aspect of this governance framework is the formulation and strict enforcement of clear SSC guidelines that compels industries to incorporate SSC principles into their operational processes. Additionally, fostering SSC awareness and commitment at the organizational level through sustained national and industrial initiatives is vital.

5. Research Limitations and Future Research Possibilities

This study has certain limitations. The findings are predominantly based on the insights of experts and may reflect a degree of bias. Additionally, it should be noted that apart from years of experience, age may also affect the response details; for instance, the younger generation may feel a greater need and desire to embrace SSC initiatives.

The applicability of SSCs is highly specific to particular contexts, such as national and government frameworks. Specifically, this research focuses on Saudi Arabia, a country characterized by its unique attributes, including size, technological advancement, population density, cultural practices, governmental systems, societal diversity, economic structure, and specific policies and legal frameworks. Because of these distinctive features, its cities differ significantly from other cities, suggesting that the direct application of this study's findings in other contexts should be approached with caution. This necessitated a preliminary analysis to evaluate the transferability of the results to different urban settings.

Another limitation is the effective sample size (N = 310), which may not be large enough for a study of SSC with broad coverage across the whole country, even though it involves experts and professionals. However, this sample size is considered acceptable within the context of this research. Future research should also consider increasing the sample size to ensure broader coverage and more robust conclusions.

Further investigation could enrich our understanding of the causal relationships among the identified barriers to SSC development. This would provide a clearer picture of how these obstacles interconnect and impact smart city initiatives. Future studies should explore the critical success factors essential for SSC growth. Understanding the linkages between these factors and barriers can help to prioritize actions for different regions based on their unique sustainability standards and challenges.

Subsequent research could evaluate how barriers and success factors adapt to the environmental, cultural, and economic contexts of various cities. This adaptation is crucial for crafting strategies that local decision-makers can implement effectively, thereby enhancing the broader applicability of the research findings.

Employing interpretive structural modeling could advance our comprehension of the dynamics between dependent and driving barriers and offer strategic insights into managing these factors effectively.

It is also essential to investigate the perceptions of both citizens and government officials regarding different aspects of SSCs. Analyzing these perspectives through established theories and models can help to mitigate stakeholder resistance and enhance the success rates of SSC implementation.

By addressing these areas, future research can build on the foundational insights provided by this study, potentially offering robust frameworks that aid policymakers in developing SSCs tailored to meet the specific needs and limitations of their respective locales. This expanded understanding will facilitate the strategic implementation of SSC initiatives, ensuring their success and sustainability.

Funding: This research was funded by the Researchers Supporting Project Number (RSP2024R233), King Saud University, Riyadh, Saudi Arabia.

Institutional Review Board Statement: This study was carried out in accordance with the principles outlined in the Declaration of Helsinki and received approval from the Institutional Review Board (Human and Social Research) at King Saud University.

Informed Consent Statement: All participants involved in the study provided informed consent.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The author would like to extend his sincere appreciation to the Researchers Supporting Project (RSP2024R233), King Saud University, Riyadh, Saudi Arabia.

Conflicts of Interest: The author declares no conflicts of interest.

Appendix A The Survey Questionnaire

Demographic Information:

1. Age: _____
2. Gender: Male/Female
3. Educational Background: _____
4. Nationality: _____
5. Industry/Sector: _____

Category: Governance and Legal

1. Lack of cooperation and coordination between city networks hinders SSC progression.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
2. An unclear IT management vision obstructs effective governance and technological integration.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
3. Political instability and lack of trust can destabilize SSC initiatives.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
4. Poor private–public participation and lack of standardization make collaboration challenging.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
5. Lack of a common information system model complicates transparency and legal compliance.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
6. Issues of openness of data are critical for public support and ethical practices.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree

Category: Social and Economic

1. There is a deficit in IT infrastructure and skill development for urban management.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
2. Economic stability and operational costs significantly impact the funding and long-term sustainability of SSC initiatives.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
3. Community engagement and awareness are essential for ensuring citizen support for SSC functionalities and benefits.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
4. Enhancing local business competitiveness and addressing social inequality are crucial for more effective and equitable SSC projects.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
5. Geographic and demographic challenges are significant in maintaining geographic balance and ensuring inclusive development in SSCs.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree

Category: Technology

1. There is a need for sufficient training and knowledge in current technologies among city planners and policymakers for effective SSC implementation.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
2. Safeguarding citizen data and ensuring system reliability are crucial for maintaining trust in SSC functionalities.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
3. Seamless integration of diverse technology platforms and robust data management practices are necessary for SSC operations.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree

Category: Environment

1. Integrating sustainable practices into daily operations is crucial for minimizing environmental impact in SSCs.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
2. Rapid population growth poses challenges to sustainable resource management and infrastructure in SSCs.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
3. Reducing carbon emissions is crucial for achieving global climate goals and enhancing public health.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree
4. Maintaining ecological resilience and adaptability in urban environments is important to withstand environmental stresses and shocks.
   Strongly Agree/Agree/Neutral/Disagree/Strongly Disagree

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