

Lessons Learned from Building Smart Cities: A Systematic Literature Review of Case Studies in Singapore and Seoul

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Article Information

Article History

Received : July 29, 2024

Revised : September 03, 2024

Accepted : September 04, 2024

Keywords:

*Artificial Intelligence;
Smart City; Seoul; SLR;
Singapore*

Kata Kunci:

Artificial Intelligence; Kota Cerdas; Seoul; SLR; Singapore

ABSTRACT

This systematic literature review explores the characteristics and criteria essential for smart city development. The study adheres to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework and employs a meticulous approach to select relevant articles from the Scopus database. The inclusion criteria ensure that all selected articles were published between 2019 and 2023, are written in English, and originate from journals ranked within the Q1-Q4 quartiles of Scopus, thus guaranteeing the quality and relevance of the reviewed literature. This review probes into how the characteristics of residents and infrastructure motivate cities to develop their smart city initiatives. The study elucidates how technology digitizes various city aspects. Findings from the reviewed articles provide comprehensive insights into city development, integrating Information and Communication Technology (ICT), governance, and citizen participation in the process.

ABSTRAK

Tinjauan literatur sistematis ini mengeksplorasi karakteristik dan kriteria dalam pengembangan kota cerdas. Penelitian ini mengikuti pedoman yang tercantum dalam kerangka kerja Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020), serta mengadopsi pendekatan yang teliti dalam memilih artikel-artikel relevan dari basis data Scopus. Kriteria inklusi memastikan bahwa semua artikel yang dipilih telah diterbitkan antara tahun 2019 dan 2023, ditulis dalam bahasa Inggris, dan berasal dari jurnal yang masuk dalam kuartil Q1-Q4 Scopus, yang menjamin kualitas dan relevansi literatur yang direview. Ulasan ini juga menggali bagaimana karakteristik penduduk dan infrastruktur memotivasi kota-kota untuk mengembangkan inisiatif kota pintar mereka. Kajian ini menjelaskan bagaimana teknologi mendigitalisasi berbagai aspek dalam kota. Hasil dari artikel-artikel yang ditinjau menawarkan wawasan yang mendalam dalam pengembangan kota dengan mengintegrasikan Teknologi Informasi dan Komunikasi (TIK), tata kelola, dan partisipasi warga dalam prosesnya.

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INTRODUCTION

The evolution of smart cities is increasingly recognized as a pivotal strategy for addressing the complex challenges of modern urban environments. By leveraging advanced technologies, smart cities enhance planning and responsiveness, strengthening the interconnections among citizens, the environment, and governmental bodies (J. Lee et al., 2023). Urban areas, burdened by escalating population densities, face mounting pressures including heightened resource consumption, environmental deterioration, and escalating social issues. Addressing these concerns necessitates the integration of technologies to streamline urban management processes (Ang-Tan & Ang, 2022). Crucially, Information and Communication Technology (ICT) plays a vital role in the efficient collection, transmission, and analysis of data through machine learning and big data applications (Ferro-Escobar et al., 2022).

This systematic literature review (Hardani & Kristiyanti, 2022; Sanjaya & Faustine Ilone, 2023) specifically examines the exemplary models of Singapore and Seoul, two cities at the forefront of integrating sophisticated technologies into their urban management and planning frameworks. These cities serve as compelling case studies for smart city development due to their distinctive approaches to leveraging advanced technologies to enhance both infrastructure and citizen engagement.

Singapore's Smart City Initiatives

Singapore's transformation into a "Smart Nation" is marked by a comprehensive integration of digital technologies aimed at optimizing urban functions and enhancing the quality of life for its residents. Through initiatives like the Smart Nation Sensor Platform, Singapore harnesses real-time data from a nationwide network of sensors to improve urban services such as traffic management and public health (Shamsuzzoha et al., 2021). The integration of IoT, AI, and big data analytics facilitates a connected urban environment that not only streamlines city operations but also enhances environmental monitoring and emergency response capabilities.

Seoul's Approach to Smart Urban Management

Similarly, Seoul's smart city strategy emphasizes digital governance and proactive citizen engagement. Projects like the Digital Mayor's Office and the Cheonggyecheon Restoration Project illustrate Seoul's commitment to using technology to improve urban aesthetics and functionality while boosting civic engagement. The city's use of AI in traffic management and public security further showcases its approach to integrating technology with urban governance, ensuring that innovations are closely aligned with citizen needs and governance processes (Escolar et al., 2019).

A Comparative Perspective

Both cities demonstrate how smart technologies can be deployed to address key urban challenges, from improving governmental responsiveness to enhancing social and cultural cohesion within urban communities. Singapore and Seoul's strategies highlight the potential of smart cities to transform urban centers into more livable, efficient, and sustainable environments. However, these advancements also require careful consideration of privacy, security, and social inclusion, as the integration of such technologies into everyday life raises significant governance and ethical questions (von Richthofen et al., 2019).

Smart cities, as defined by their ability to manage networks and services effectively using digital and telecommunication technologies, aim to increase economic and political efficacy and enhance social and cultural cohesion through their technological frameworks. The meticulous coordination of critical infrastructure elements such as subways, seaports, and communication networks is crucial to maximizing resource efficiency and security. Through the integration of advanced ICT and big data, smart cities like Singapore and Seoul are not only advancing sustainability but are also setting benchmarks for global urban development. This introduction sets the stage for a deeper exploration of how specific smart city characteristics can drive sustainable urban development while addressing the pressing challenges of modern urban environments,

underscoring the importance of adaptive, responsive city planning that embraces the complexities of integrating technology with urban life.

RESEARCH METHODS

This systematic literature review (SLR) on the terms and conditions of smart cities adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) guidelines. The PRISMA framework facilitates the verification of article relevance in an SLR and enhances the transparency of the review process.

Research Questions

The research questions for this study include:

1. What are key factors driving the development of smart cities?
2. What characteristics are essential in the development of a smart city?
3. What are the challenges and opportunities associated with developing a smart cities?

Search Process

The search involved targeted queries in the Scopus database using combinations of keywords related to smart cities in Seoul and Singapore. Boolean operators facilitated a focused search, yielding specific results relevant to our study objectives:

- ('seoul' AND 'singapore' AND 'smart city') yielded 14 results.

Identification of Inclusion and Exclusion Criteria

The inclusion criteria involve:

1. Foundational studies that are seminal in the field.
2. Candidate studies selected based on title and abstract relevance to the research objectives.
3. Selected studies that are analyzed and synthesized to address the research questions.

The exclusion criteria include:

1. Exclusion of articles published before 2019 and after 2023 for relevance and timeliness.
2. Ensuring a detailed article identity structure including title, author, and journal name.
3. Eliminating duplicate articles to maintain the integrity and consistency of the SLR.

Review and Selection of Studies

The review and selection processes were restricted to literature from the Scopus databases, following the established inclusion and exclusion criteria. The outcomes of the literature search are summarized in a PRISMA flow diagram.

Data Extraction

Data extraction began in October 2023, resulting in 915 documents initially identified in the Found Study phase, including journal articles, books, and conference papers. After applying exclusion criteria, including the removal of proceedings, books, and other non-journal sources, 14 journal articles were selected for detailed review and analysis to contribute to this research. The results of the literature search are summarized in Table 1.

RESULTS AND DISCUSSION

The answer to the research question provided based on Table 1. Previous research table:

(RQ1) What are key factors driving the development of smart cities?

Smart city is a city that incorporates ICT in developing infrastructure, facilities, communication, transportation, and governance systems. By examining citizens behavior in smart cities, such as Singapore and Seoul, there are two key factors in driving the development in smart cities. Education and culture play a vital role in driving the development in smart cities. Education as the foundation of character development and culture as the practice within the society.

Smart cities empowered citizens with technology in order to achieve a smart nation for meaningful and fulfilled lives. Citizens had to change their behavior and usual lifestyle through a feasible education in their early life about smart city development and programs and subsystems which includes government, finance, communities, resources, cultural impact, etc. The role of the education system in preparing children for diversity and intelligent aspects affects the output they will bring in the future to develop a smart city. Therefore, in order to achieve a smart city, a developed education system must be fulfilled (Šulyová & Vodák, 2020).

(RQ2) What characteristics are essential in the development of smart city?

Characteristics within a smart city are various. Smart city needs to be livable by citizens while developing advanced education and culture. As it was said in the definition, advanced technology development while developing e-governance platforms also stands as a criteria in developing a smart city. Citizen-oriented governance which centers on citizens, incorporating AI in city development, advanced transportation system, and established energy waste reduction system are also characteristics in a smart city. Further discussions are provided in points below.

A. Advanced in Technology Development and Digital E-Government Platforms

A nation that harnesses the power of networks, technologies, and data in order to build a closer community is required to build a smart city. The swift enhancement of technology has altered many aspects, such as social, political, economic, environmental, and legal landscapes, resulting in direct effects and modifications that influence urban development in cities. This enhancement led many governments to develop online platforms for citizen participation to take part in decision-making processes. Technology driven nations are crucial in global economic competition (Repette et al., 2021), (Joo, 2023). Nations are very aware of the importance of using technology to create a better version of a city which is a smart city in the global economy market (Joo, 2023). City infused with technology brings extensive advantages and increases efficiency.

In order to develop the city, it is required to use analytics methods to analyze citizen's behaviors towards the country. For example, in 2017, a survey was conducted in Seoul and later was analyzed using big data analytics. This survey platform is called Democracy Seoul where citizens can voice their opinion about the city. This platform helps the government in handling the city's problem and develop a feasible smart city solution. (Kim et al., 2021).

B. Citizen-Oriented Governance

Involving components of a nation, such as citizens, companies, agencies, etc, has a vital role in order to develop national identity. This alignment fosters a sense of belonging and ownership among citizens, leading to increased civic engagement and participation in shaping the city's development. Citizen-oriented governance in a smart city collaborates with stakeholders to drive innovation, economic growth, and job creation within the city. The city's enabling environment for technological advancement will strengthen the national identity as a center of excellence and progress (von Richthofen et al., 2019).

Singapore, a citizen-oriented governance, has enhanced their public transportation since 1970. The government's goal is to develop a superior transportation system that serves with exceptional service yet is economical and convenient without traffic. In order to achieve this goal without wasting any road or land, Singapore built a MRT system that provides a transportation system under the city (O. L. Lee et al., 2019).

Seoul, a multi-level governance city, developed their public transportation system in 2002 in order to incorporate both communication and technology. This reformation was held by the Seoul Metropolitan Government (SMG) in organizing the transportation system in Seoul. In this case, SMG made a reformation in transforming the bus lane to enhance mobility but later it was protested due to rapid bus transit, reduced car-lanes and causing congested roads. In 2017, SMG formed the Bus Reform Civic Committee that participated in transforming the system and later formed smart transportation. This committee later was in charge of restructuring bus routes and operational systems while monitoring citizen's welfare towards the smart transportation system (J. Lee et al., 2023).

Table 1. Previous research

#	Author	Article Title	Journal
1	(Ang-Tan & Ang, 2022)	Understanding the smart city race between Hong Kong and Singapore	Public Money and Management
2	(Choi & Kim, 2022)	History of Seoul's Parks and Green Space Policies: Focusing on Policy Changes in Urban Development	Land
3	(Escolar et al., 2019)	A Multiple-Attribute Decision Making-based approach for smart city rankings design	Technological Forecasting and Social Change
4	(Ferro-Escobar et al., 2022)	Smart and Sustainable Cities in Collaboration with IoT: The Singapore Success Case	Intelligent Systems Reference Library
5	(Joo, 2023)	Developmentalist smart cities? the cases of Singapore and Seoul	International Journal of Urban Sciences
6	(Jung et al., 2020)	Monthly electric load forecasting using transfer learning for smart cities	Sustainability (Switzerland)
7	(Kim et al., 2021)	A value of civic voices for smart city: A big data analysis of civic queries posed by Seoul citizens	Cities
8	(J. Lee et al., 2023)	Smart city as a social transition towards inclusive development through technology: a tale of four smart cities	International Journal of Urban Sciences
9	(O. L. Lee et al., 2019)	A Smart City transportation System of Systems Governance Framework: A Case Study of Singapore	2019 14th Annual Conference System of Systems Engineering, SoSE 2019
10	(Prabowo & Rosalinda, 2022)	Development of Smart City Sustainable Key Performance Indicators in line with IT Infrastructure Library	9th International Conference on ICT for Smart Society: 2022 - Proceeding
11	(Quan et al., 2019)	Artificial intelligence-aided design: Smart Design for sustainable city development	Environment and Planning B: Urban Analytics and City Science
12	(Repette et al., 2021)	The evolution of city-as-a-platform: Smart urban development governance with collective knowledge-based platform urbanism	Land
13	(Shamsuzzoha et al., 2021)	Smart city for sustainable environment: A comparison of participatory strategies from Helsinki, Singapore and London	Cities
14	(von Richthofen et al., 2019)	Identifying communities within the smart-cultural city of Singapore: A network analysis approach	Smart Cities

C. Incorporate Artificial Intelligence in Development

Artificial intelligence (AI) became a major role in designing a smart city aiding towards a more sustainable and improved city. Artificial intelligence is vital to assess the data to recognize

and interpret patterns in data (Repette et al., 2021). AI plays an important role in planning decision support systems for continuous development. First, human problems are identified to grasp local challenges comprehensively. Second, presenting issues in mathematical representations in order to examine both objective and representational models. The objective model clarifies the system's purpose, while the representational model codes parameters mathematically, crucial for interpreting goals, factors, and limitations within mathematical frameworks. Third, optimizing the system to refine and enhance models, improving evaluation criteria across key domains, such as environment, transportation, and economy. Fourth, interpreting system optimization in a form of 2D or 3D as a human-system interaction, aiming to facilitate seamless human-computer interaction during implementation.

Seoul has incorporated AI in building a more sustainable smart city. Cooperating these stages, Seoul, specifically Gangnam, urbanization grows rapidly at an unprecedented rate causing rapid development and manifesting a group of superblocks. This leads to impractical space and streets might have been used for building sites. This issue will be represented in diagrams of the city superblock and interpreted into a formula for calculation. Diagrams will be interpreted into a design and blueprint of the city that will be interpreted in a form of mathematical representations coded into an algorithm using Python. This leads to final decision making by comparing the iteration of these stages and finding the best design of the city to be implemented (Quan et al., 2019).

D. Advanced Transportation System

In urban centers such as Seoul, escalating car usage and parking congestion have led to imbalanced utilization of public transportation. Seoul's implementation of smart transportation reforms in 2002 aimed to address these challenges by enhancing accessibility and mobility. Initiatives included bus route adjustments and technological system upgrades. In 2017, the Seoul Metropolitan Government (SMG) restructured bus routes to improve service quality while fostering competition among companies.

Introduction of a smart transit system by SMG facilitated citizen access to transportation information and services, promoting development through public engagement. Additionally, SMG's role in designing transportation lanes evenly across areas serves to bolster local business profitability (J. Lee et al., 2023).

Singapore is developing infrastructure involving ICT to enhance transportation systems with advanced smart public transportation, smart road systems, and e-government to organize systems (Joo, 2023). In order to reduce traffic congestion and car usage within the city, Singapore developed a system for public transportations. One of the most seen example is the MRT system that was built under the city to decrease land usage (O. L. Lee et al., 2019).

E. Implemented Energy Waste Reduction System

Smart city utilizes ICT to manage resources that do not damage the environment while achieving digitalization in developing a digitalized and green ecosystem (Prabowo & Rosalinda, 2022). Greenhouse gas and energy resource depletion have become major issues in cities. For example, reducing greenhouse gas emissions. Smart city aims to reduce greenhouse gas emissions by reducing traffic and and increase alternative energy, such as electric vehicles and renewable energy (Jung et al., 2020).

Seoul in particular improves the environment in order to enhance the quality of life for urban inhabitants and implement policies concerning environmental sustainable infrastructure. Seoul develops parks, landscapes, and communities to preserve greenspace (Choi & Kim, 2022). One of the current trends in developing greenspace includes building zero-energy buildings for the public sector in 2020 and private buildings in 2025. This development aims to reinforce performance standards for insulation and windows to reduce energy demand from buildings. These efforts are significant to reduce energy waste, especially in offices. Government imposes restrictions, e.g Green Building Construction Support Act, to reduce energy waste and increase

greenspace (Ko et al., 2020).

3. (RQ3) What are the challenges and opportunities associated with developing a smart city?

Opportunities and challenges are faced within developing a smart city. One of the biggest challenges is handling complaints, informations, and reports from citizens about the city. This involves complaints about traffic congestions, energy waste, pollution, and difficulty in conveying information to the government. Resolving these issues, Seoul and Singapore provide platforms and smart applications to report complaints and informations within the city. This also helps the government in handling issues and develop the city into a more developed one.

CONCLUSION

The systematic literature review on the development of smart cities in Singapore and Seoul reveals a nuanced understanding of the key drivers, essential characteristics, and associated challenges and opportunities inherent in urban transformation. The findings underscore the pivotal role of education and culture as fundamental factors shaping the trajectory of smart city initiatives. A robust education system not only cultivates the necessary skills but also instills a mindset conducive to sustainable living among citizens. Concurrently, cultural norms and values influence the adoption and integration of smart technologies, emphasizing the significance of societal readiness in embracing technological advancements.

Moreover, the review delineates key characteristics that define smart city development. Advanced technology deployment, particularly through digital e-government platforms, fosters connectivity and citizen engagement, empowering individuals to actively participate in decision-making processes. Citizen-oriented governance emerges as a cornerstone, emphasizing inclusive models that involve stakeholders in shaping urban policies and initiatives. Artificial intelligence emerges as a transformative tool, facilitating data-driven decision-making and optimizing urban systems across various domains, from transportation to environmental management. Advanced transportation systems and implemented energy waste reduction strategies further exemplify the commitment to sustainability and efficiency in smart city development.

However, alongside these opportunities lie inherent challenges. Managing citizen grievances, addressing urban issues such as traffic congestion and pollution, and ensuring effective governance remain critical hurdles. Nonetheless, these challenges offer fertile ground for innovation and improvement. Leveraging smart technologies and citizen feedback mechanisms presents cities with the opportunity to enhance service delivery, optimize resource utilization, and foster sustainable urban development. Ultimately, the systematic literature review underscores the holistic nature of smart city development, advocating for integrated approaches that synergize technology, governance, and citizen engagement to realize the vision of smart, sustainable, and inclusive urban environments.

Future research should focus on enhancing public engagement by developing and testing innovative methods to increase citizen participation in smart city initiatives, including leveraging digital platforms and social media for real-time feedback. Additionally, exploring the integration of AI and machine learning in smart city applications like traffic management, waste reduction, and energy optimization will be crucial. These areas promise to advance the practical implementation of smart city concepts, ensuring they are both effective and responsive to the needs of urban residents.

Limitations of the Study:

This systematic literature review, despite its comprehensive approach, encounters several limitations that must be acknowledged. First, the confinement of the literature search to only Scopus

databases might have omitted relevant studies published in other databases or journals not indexed therein, potentially limiting the scope of analysis. Second, the reliance on English language articles excludes potentially valuable research published in other languages, which could offer diverse perspectives on smart city development. Furthermore, the selection criteria, while rigorous, are constrained by the publication timeframe from 2019 to 2023, excluding seminal works that could still hold relevance to current smart city initiatives. Additionally, the study focuses predominantly on quantitative research, which might overlook qualitative insights that are equally critical to understanding the nuances of smart city development.

Future Research:

Given the identified limitations, future research should expand the scope of literature review to include a wider range of databases and journals to capture a broader spectrum of studies. Including research published in multiple languages would enrich the analysis, offering a more global perspective on smart city development. Future studies could also benefit from a longitudinal approach, examining the evolution of smart city concepts over a more extended period to incorporate both historical and recent innovations. Moreover, integrating qualitative research could provide deeper insights into the human and social dimensions of smart cities, which are often overshadowed by technological aspects. Lastly, future research should consider a more interdisciplinary approach, incorporating insights from fields such as urban planning, sociology, and environmental science to holistically address the complex challenges of smart city development.

ACKNOWLEDGEMENTS

The successful completion of this research has been made possible thanks to the unwavering support and invaluable assistance provided by Universitas Multimedia Nusantara and Big Data Lab from Information Systems Study Program Universitas Multimedia Nusantara

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