A SYSTEMATIC LITERATURE REVIEW: BIG DATA IN SMART CITY DEVELOPMENT

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Abstract — *The modernization of information technology has generated a large volume of data known as Big Data, which plays an essential role in supporting data-driven decision-making. With regard to Smart City development, Big Data contributes to enhancing the effective, efficient, and environmentally friendly public services. However, the utilization of Big Data in Indonesia still faces several challenges, including insufficient supporting infrastructure, limited technical expertise, and issues related to data security and privacy. This study aims to analyze the role of Big Data in Smart City development, identify the most frequently used technologies, and examine the challenges in implementing Big Data within Smart City initiatives. This study adopts the Systematic Literature Review (SLR) approach, following a structured study selection process, 40 articles were initially retrieved and evaluated, with 25 studies ultimately satisfying the methodological criteria for inclusion in the final synthesis. The results of the analysis indicate that Cloud Computing, Big Data, Artificial Intelligence (AI) and Internet of Things (IoT) are the most dominant technological components in Smart City implementation. Furthermore, the study emphasizes that the success of Smart City initiatives is contingent not merely upon technological progress but also on human resource readiness, data quality, and information protection. This research contributes to providing a strategic foundation for policy development and implementation planning of Smart Cities in Indonesia, particularly in strengthening data governance and national digital capacity building to support sustainable urban innovation.*

Keywords: *Big Data, Information, Smart City, Technology*

Intisari— *Perkembangan teknologi informasi telah menghasilkan data berskala besar yang dikenal sebagai Big Data, yang berperan penting dalam mendukung pengambilan keputusan berbasis data. Dalam konteks Smart City, Big Data berkontribusi pada peningkatan efektivitas, efisiensi, dan keberlanjutan pelayanan publik. Meski begitu, pemanfaatan Big Data di Indonesia masih menghadapi beberapa hambatan, seperti kurangnya fasilitas pendukung, keterbatasan kemampuan tenaga ahli, serta masalah keamanan dan privasi data. Penelitian ini diarahkan untuk mengkaji peran Big Data dalam pengembangan Smart City, mengidentifikasi teknologi yang paling sering digunakan, serta menganalisis tantangan dalam implementasi Big Data dalam pengembangan Smart City. Penelitian ini menggunakan pendekatan Systematic Literature Review (SLR) dengan menerapkan proses seleksi studi yang terstruktur, sebanyak 40 artikel berhasil diperoleh dan dievaluasi, dengan 25 studi akhirnya memenuhi kriteria metodologis untuk dimasukkan dalam sintesis final. Hasil analisis menunjukkan bahwa teknologi Internet of Things (IoT), Big Data, Cloud Computing dan Artificial Intelligence (AI) merupakan komponen paling dominan dalam implementasi Smart City. Selain itu, keberhasilan implementasi tidak hanya ditentukan oleh aspek teknologi, tetapi juga oleh kesiapan sumber daya manusia, kualitas data, dan perlindungan informasi. Penelitian ini berkontribusi dalam memberikan dasar strategis bagi pengembangan kebijakan dan perencanaan implementasi Smart City di Indonesia, khususnya dalam memperkuat tata kelola data dan kapasitas sumber daya digital nasional.*

Kata Kunci: *Big Data, Informasi, Kota Cerdas, Teknologi*

INTRODUCTION

With the advancement of information technology, millions, even trillions of data are generated every day from various sources. The utilization of this information technology then becomes crucial in the processes of managing, storing, and processing such large-scale data [1], [2], [3]. This vast collection of information is termed Big Data, which serves as a foundation for data-driven decision-making by providing deeper insights into patterns, trends, and public needs across multiple sectors [4]. The use of Big Data is not only limited to the business sector but has also become increasingly important in government as a key driver of the transformation toward Smart City.

A Smart City represents an urban development paradigm that leverages information and communication technology (ICT) to enhance citizens' quality of life and create a safe, comfortable, livable, and sustainable environment. The synergy between Big Data and the Internet of Things (IoT) facilitates real-time data acquisition, improving public service efficiency and advancing societal well-being, with a specific emphasis on domains including transportation, energy management, environmental monitoring, and public safety [5], [6], [7]. The convergence of Big Data and Smart City represents a synergistic relationship where data analytics serves as the foundation for intelligent urban management. Big Data and Smart City are mutually supportive, where Big Data provides valuable information for understanding urban conditions in real time [8]. These data originate from diverse sources, including IoT sensors, citizen reports, and digital platforms [9]. Meanwhile, Smart City serves as the implementation framework for Big Data technologies, enabling improvements in public service efficiency, transportation management, security, and urban resource management.

The deployment of Big Data has transcended the boundaries of business and commercial applications, demonstrating significant potential in transforming public governance and urban administration. Government institutions increasingly recognize the value of data analytics in formulating evidence-based policies, enhancing service delivery efficiency, and addressing complex societal challenges. Through systematic analysis of large-scale datasets, public sector organizations can identify emerging trends, allocate resources more effectively, and respond proactively to citizens' evolving needs. This paradigm shift toward data-driven governance represents a fundamental transformation in how modern governments operate and serve their communities

Despite its transformative potential, the application of Big Data within Smart City development in Indonesia remains suboptimal and faces significant challenges. Decision-making processes are often based on incomplete and non-integrated data, lacking real-time capabilities [10] This gap between the potential and actual utilization of Big Data technologies represents a critical barrier to effective Smart City implementation in the Indonesian context. However, obstacles such as lack of ICT infrastructure, limited expertise in data analytics, and lack of coordination between agencies often become obstacles for the government to provide effective and efficient services [11], [12], [13].

The effective realization of the Smart City concept necessitates robust collaboration among public stakeholders, private, and community sectors [14]. Because the development and application of modern technology can only be successful through synergy from various parties [15]. With this approach, Big Data can be utilized optimally to support various aspects of a Smart City, such as transportation management, security, environment, health and education services [16], [17]. Therefore, this study aims to: (1) analyze technologies are most widely adopted for Smart City development in Indonesia, (2) identify Big Data contribute to Smart City development, and (3) examine the challenges and barriers in implementing Big Data for Smart City.

MATERIALS AND METHODS

In this study, the method used was Systematic Literature Review (SLR), where the method used to collect, evaluate, and combine all relevant research that has been conducted to answer the research question [9]. In the Systematic Literature Review (SLR) method contains six steps used, namely: 1) Research Question; 2) Search Process; 3) Study Selection; 4) Data Extraction; 5) Data Collection; 6) Data Analysis

Research Questions

This study aims to elucidate the relationship between Big Data and Smart City development. These questions also help build a systematic framework for analyzing relevant literature. Each RQ is aimed at answering a specific aspect that is the primary focus of the research. The following table shows Research Questions and explanations.

Table 1. Research Questions

Code	Question
RQ1	Which technologies are most widely adopted for Smart City?
RQ2	How does Big Data contribute to Smart City development?
RQ3	What are the identified gaps and challenges in Big Data implementation for Smart City based on existing literature?

Source : (Research Results, 2025)

Search Process

The literature search phase aims to ensure that the data and information used are comprehensive, organized, and credible. The search was conducted using the journal database Google Scholar, which provides access to scientific articles, conferences, and academic publications on Big Data in Smart City development. The primary keywords used were " Smart City", "Big Data", and "Technology ".

Selection Study

Study selection is carried out to identify literature that answers the research questions. The data inclusion criteria in Table 2.

Table 2. Data Inclusion Criteria

No.	Inclusion
1	Published articles between 2021 to 2025
2	Article obtained from sources trusted like Google Scholar
3	The article is relevant to discussion topic, specifically Big Data and Smart City
4	The article is open access

Source : (Research Results, 2025)

Data Extraction

At this stage, data filtering is carried out to facilitate and expedite systematic data analysis. Several criteria can be seen in Table 3.

Table 3. Data Extraction Criteria

No.	Criteria
1	Relevant studies that discuss Big Data implementation in cities in Indonesia
2	The article must discuss the connection between Big Data and Smart City, including its implementation, benefits, and challenges

Source : (Research Results, 2025)

Data Collection

After the list of articles was compiled in a Google Sheet, important data was extracted, including information including title, year, methodology, and main findings. This step was designed to facilitate and expedite analysis in a systematic and consistent manner.

Data Analysis

Data analysis aims to combine information from the selected and extracted literature and then analyze it to answer the research questions. This stage not only systematically answers the research questions but also makes a tangible contribution to the literature and practice of Big Data-based Smart City development.

RESULTS AND DISCUSSION

Through the steps applied in the Systematic Literature Review (SLR) method: This chapter presents the research findings obtained from the literature identification, selection, extraction, collection, and analysis processes. The results are then discussed in depth to answer the research questions and relate them to theory and previous research. The following results are obtained:

Search Process

The literature search process was conducted using Google Scholar, focusing on research related to Big Data and Smart City. Each article was evaluated based on predetermined exclusion and inclusion criteria. Consequently, 40 articles met the inclusion criteria

Selection Study

The study selection process involved 40 articles that met the initial inclusion criteria. During the quality assessment stage, every article was assessed in terms of methodological soundness, alignment with the research questions, and scholarly contribution. Of the 40 articles assessed, 25 articles (62.5%) passed the quality evaluation and proceeded to the data extraction stage, while 15 articles (37.5%) were excluded due to insufficient quality, lack of empirical evidence, or limited relevance to Big Data in Smart City contexts.

Data Extraction

The data extraction process produced a set of articles that met the inclusion and exclusion criteria, and the resulting data also matched the research focus, namely from 40 data but only 25 articles discussed the relationship between Smart City and Big Data. This selection was carried out by considering several aspects, including whether the article discussed the utilization of Big Data in Smart City development, as well as explaining what the application of Big Data is like in cities in Indonesia.

Data Collection

The primary data obtained from the articles was recorded in Google Sheets so that analysis could

be conducted in a more structured and consistent manner. Data collection can be seen in Table 4.

Table 4. Data Collection

No.	Title	Year
1	Proses Pembangunan Smart City di Indonesia Menggunakan Metode Big Data Analystis Dalam Penerapan E-Commerce [18]	2021
2	Peran Big Data Dalam Membangun Smart City Untuk Sistem Perpajakan Daerah [19]	2023
3	Integrasi Big Data Dan AI Untuk Pengambilan Keputusan Dalam Smart City [20]	2025
4	Paradigma Smart City Dalam Memanfaatkan Potensi Big Data [21]	2024
5	Evaluasi Implementasi Komponen Smart City di Bali: Literature Review [22]	2025
6	Tinjauan Pustaka Sistematis : Pemanfaatan Big Data Dalam Konsep Smart City [23]	2022
7	Big Data Pada Smart City: Konsep Dan Manfaat [5]	2023
8	Analisis Strategi Pemerintah Provinsi Dalam Membangun Konsep Smart City: Studi Kasus Pemerintah Provinsi DKI Jakarta [24]	2024
9	Analisis Smart City Menggunakan Konsep Smart Society 5.0 Pada Electronic Policing [25]	2024
10	Analisis Big Data Untuk Pemantauan Kualitas Udara: Pendekatan, Implementasi, Dan Tantangan Dalam Studi Lingkungan[26]	2024
11	Kota Cerdas Berbasis Masyarakat Cerdas Di Kota Bandung: Sebuah Inovasi Sosial [27]	2023
12	Faktor Kunci Dalam Implementasi Big Data Untuk Kota Cerdas: Sebuah Analisis Sistematis Tinjauan Literatur [28]	2021
13	Penggunaan Bigdata Transportasi Berpotensi Meningkatkan Efisiensi Sistem Transportasi Kota [17]	2023
14	Implementasi Smart City Dalam Mendukung Layanan Masyarakat di Daerah Istimewa Yogyakarta [29]	2023
15	Transformasi Digital 4.0: Inovasi Yang Menggerakkan Perubahan Global [30]	2023
16	Integrasi IOT Dan Big Data Untuk Optimasi Logistik Dan Rantai Pasokan [8]	2024
17	Unleashing The Power of Big Data: The Phenomenon Behind Indonesia's Smart City Policy Implementation [31]	2023
18	Teknologi Pintar Dalam Mewujudkan Kota Berkelanjutan [32]	2024
19	Challenges And Opportunities: Assessing Smart City Readiness in Magelang City for Sustainable Change [33]	2024
20	Implementasi Konsep Smart City dalam Peningkatan Kualitas Pelayanan Publik Perkotaan [34]	2024
21	Pemanfaatan Infrastruktur Teknologi Informasi Dan Komunikasi (TIK) Dalam Pengembangan Smart City: Studi Kasus Pemerintah Kota Batu [35]	2022
22	Manfaat Teknologi Informasi Komunikasi (TIK) AI Dalam Mengembangkan Smart City di Jakarta [36]	2025

| No.	Title	Year
23	Smart City: Upaya Pembangunan Kota Surabaya [37]	2023
24	Using Big Data Methods in Bandung City Planning Research: Urban Resilient Governance with Smart City [38]	2025
25	Big Data in Smart Cities: Usage in Kota Jababeka For Customer Satisfaction [39]	2021

Source : (Research Results, 2025)

Data Analysis

A total of 25 articles were carefully examined in relation to predefined research questions (RQ). The analysis was carried out systematically by addressing each RQ to generate findings aligned with the research objectives. Process of data interpretation in relation to the RQ is presented as follows:

RQ1: Which technologies are most widely adopted for Smart City?

Based on a comprehensive analysis of 25 selected articles retrieved from Google Scholar database (covering publications from 2021 to 2025), the results show that Big Data stands as the predominant technology in Smart City implementation, with 22 journals or 88% of the total articles reviewed. Furthermore, Smart City initiatives also incorporate Internet of Things applications. Internet of Things (IoT) was used in 17 journals or around 68%. then Artificial Intelligence technology Intelligence (AI) as many as 10 journals from all the reviewed publications. Then Cloud Computing had 7 journals, and others had 1 journal, such as Machine Learning (ML) and Cyber-physical Systems (CPS). These results can be seen in Figure 1. Graph of the Most Used Technologies in Smart City Implementation
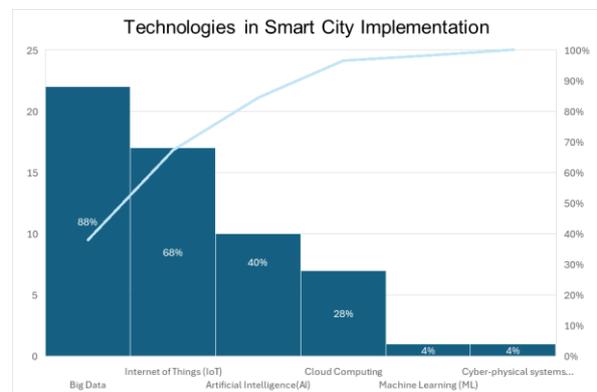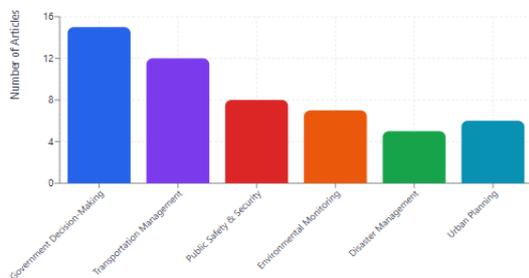

Source : (Research Results, 2025)
Figure 1. Graph of the Most Used Technologies in Smart City Implementation

Figure 1. This bar chart illustrates the frequency of technology adoption in Smart City implementation based on 25 reviewed articles. Big Data shows the highest adoption rate (88%), followed by IoT (68%), AI (40%), Cloud Computing (28%), and also other technologies including ML and CPS (4% each).

RQ2: How does Big Data contribute to Smart City development?

Analyzing Big Data has proven instrumental in shaping Smart City development was conducted across all 25 selected articles. Figure 2 presents the distribution of Big Data applications across various Smart City sectors, revealing the diverse implementation contexts.

Source : (Research Results, 2025)
Figure 2. Big Data Contributed to Smart City Development

This bar chart illustrates the contribution of Big Data utilization across various Smart City sectors based on analysis of 25 reviewed articles. Government decision-making shows the highest application frequency (60%), followed by transportation management (48%), public safety and security (32%), environmental monitoring (28%), urban planning (24%), and disaster management (20%). Note that percentages may exceed 100% as individual articles often address multiple application domains. Analysis of selected articles states that The utilization of Big Data serves to strengthen government operations in taking fast and correct decisions based on data [19], [20], [21].

Real-time data analysis provides accurate and fast information, so that policies can be formulated precisely. As in the research "Analysis of Provincial Government Strategy in Building a Smart City Concept: A Case Study of the DKI Jakarta Provincial Government" and "Leveraging Big Data in transportation holds significant potential to enhance urban system efficiency" discusses Big Data used for real-time transportation analysis, which supports traffic management to minimize congestion, as well as supports public transportation planning [25], [29], [40]. The use of

Big Data is also used as a tool for predicting and anticipating urban problems, this is also discussed in the research entitled "Digital Transformation 4.0: Innovation that Drives Global Change". With big data, the government can take earlier and faster action in preventing and handling disasters, such as conducting early evacuations, creating emergency preparedness plans, and allocating resources more efficiently to deal with disasters such as floods, earthquakes, or forest fires [30]. Big Data contributes significantly to city security by enabling the analysis of information collected from surveillance technologies (CCTV), sensors, and electronic devices [24], [25]. This data is used to build an early warning system that functions to detect potential crimes.

RQ3: What are the identified gaps and challenges in Big Data implementation for Smart City based on existing literature?

The analysis of implementation challenges was conducted across all 25 selected articles, with 18 articles (72%) explicitly identifying specific barriers. Figure 3 illustrates the frequency distribution of major challenges encountered in the implementation of Big Data in Smart City development.
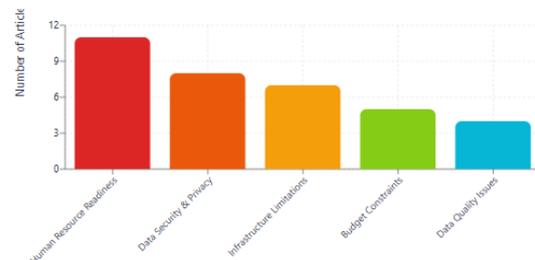
Source : (Research Results, 2025)
Figure 3. Challenges in Big Data Implementation for Smart City

Figure 3. This bar chart presents the frequency of implementation challenges identified in Big Data-enabled Smart City initiatives across 25 reviewed articles. Human resource readiness emerges as the most frequently cited challenge (44%), followed by data security and privacy concerns (32%), infrastructure limitations (28%), budget constraints (20%), and data quality issues (16%). These findings highlight the multifaceted barriers which require resolution to facilitate effective Big Data deployment in Smart City environments.

Then, Table 5 presents data on the challenges in implementing Big Data for Smart City, based on a review of 25 articles, many challenges arise related to the implementation of Big Data for Smart City. Of

the 25 journals analyzed, 11 journals mentioned the biggest challenge frequently mentioned is the lack of readiness of human resources (HR). Human resources who can use technology related to big data needed, such as collecting, analyzing, and understanding data, can help in driving organizational transformation in implementing big data [19].

The next challenge is the lack of security and safety of personal data, as many as 8 journals discussed this challenge. The collection and application of extensive datasets derived from heterogeneous sources, including IoT sensors can cause problems if personal data is not protected with an adequate security system. Where the collected data has the potential to be used by irresponsible parties, thus compromising privacy and creating security risks [20]. Then there are 4 journals that mention that another challenge in the implementation of big data is data quality which is seen in terms of accuracy, completeness, and non-uniform data formats [18], [21], [23], [26]. Especially when using low-quality sensors that are easily affected by environmental conditions such as temperature and humidity, so that the resulting data is less accurate if not properly calibrated [26].

Table 5. Challenges in Big Data Implementation for Smart City

No.	Title	Challenges in implementing Big Data for Smart City
1	Proses Pembangunan Smart City di Indonesia Menggunakan Metode Big Data Analystis Dalam Penerapan E-Commerce	Challenge: Problem data quality and accuracy
2	Peran Big Data Dalam Membangun Smart City Untuk Sistem Perpajakan Daerah	Challenge: Complete but poorly managed data. Inadequate technology support related to infrastructure and devices for processing big data. Furthermore, human resources (HR) must be able to utilize Big Data-related technologies.
3	Integrasi Big Data Dan AI Untuk Pengambilan Keputusan Dalam Smart City	Challenge: Data privacy and security issues. If personal data are collected and used on a large scale without proper protection, it can lead to misuse or abuse.
4	Paradigma Smart City Dalam Memanfaatkan Potensi Big Data	Challenge: Problems that arise because the data is not structured and unstructured the same so that difficult for

No.	Title	Challenges in implementing Big Data for Smart City
		processed and analyzed in a way efficient.
5	Evaluasi Implementasi Komponen Smart City di Bali: Literature Review	Challenge: Lack of infrastructure technology.
6	Tinjauan Pustaka Sistematis : Pemanfaatan Big Data Dalam Konsep Smart City	Challenge: Limited data accessibility, and varying data quality.
7	Big Data Pada Smart City: Konsep Dan Manfaat	Challenge: Lack of infrastructure technology. Technology is used to extract data and obtain more specific information as value from the data.
8	Analisis Strategi Pemerintah Provinsi Dalam Membangun Konsep Smart City: Studi Kasus Pemerintah Provinsi DKI Jakarta	Challenge: Difficulty data integration to in ecosystem city Because Jakarta own amount large population.
9	Analisis Smart City Menggunakan Konsep Smart Society 5.0 Pada Electronic Policing	Challenge: Lack of security and safety of personal data.
10	Analisis Big Data Untuk Pemantauan Kualitas Udara: Pendekatan, Implementasi, Dan Tantangan Dalam Studi Lingkungan Kota Cerdas Berbasis Masyarakat Cerdas	Challenges: Data quality and accuracy. Data from sensors and the public typically come in different and inconsistent formats. Furthermore, there are limitations in computing and network infrastructure.
11	Di Kota Bandung: Sebuah Inovasi Sosial	Challenge: Lack of readiness from HR
12	Faktor Kunci Dalam Implementasi Big Data Untuk Kota Cerdas: Sebuah Analisis Sistematis Tinjauan Literatur	Challenge: Limited data accessibility, lack of infrastructure technology, as well as privacy and security.
13	Penggunaan Bigdata Transportasi Berpotensi Meningkatkan Efisiensi Sistem Transportasi Kota	Challenge: Data security and privacy issues, as well as limited human resources (HR) knowledge, then lack of technology and accessibility to data.
14	Implementasi Smart City Dalam Mendukung Layanan Masyarakat	Challenge: Human resource (HR) needs are not yet optimally met, reflecting their skills. Furthermore, there is a

No.	Title	Challenges in implementing Big Data for Smart City
15	di Daerah Istimewa Yogyakarta Transformasi Digital 4.0: Inovasi Yang Menggerakkan Perubahan Global	lack of funding for various programs and activities. Challenge: Digital inequality, lack of security cyber, and needs source Power human resources (HR) who have not support.
16	Integrasi IOT Dan Big Data Untuk Optimasi Logistik Dan Rantai Pasokan	Challenge: Lack of data security, interoperability devices, and data management.
17	Unleashing The Power of Big Data: The Phenomenon Behind Indonesia's Smart City Policy Implementation	Challenge: Protection right privacy individual is very important thing important, especially in cases involving complaint confidential and private.
18	Teknologi Pintar Dalam Mewujudkan Kota Berkelanjutan	Challenge: There is a gap infrastructure, limitations budget, and lack of readiness source power human resources
19	Challenges And Opportunities: Assessing Smart City Readiness in Magelang City for Sustainable Change	Challenge: Lack of security and safety of personal data.
20	Implementasi Konsep Smart City dalam Peningkatan Kualitas Pelayanan Publik Perkotaan	Challenge: Lack of infrastructure technology and privasi data
21	Pemanfaatan Infrastruktur Teknologi Informasi Dan Komunikasi (TIK) Dalam Pengembangan Smart City: Studi Kasus Pemerintah Kota Batu	Challenge: Capacity for storing, processing, and analyzing large amounts of data remains limited. Suboptimal city asset management complicates the control and operational functions of public services. Furthermore, human resources (HR) readiness is lacking.
22	Manfaat Teknologi Informasi Komunikasi (TIK) AI Dalam Mengembangkan Smart City di Jakarta	Challenge: Uneven development of digital infrastructure across Jakarta. In addition, there are limitations in strengthening the capacity of human resources (HR).
23	Smart City: Upaya Pembangunan Kota Surabaya	Challenge: Inhibiting factors like resistance culture, financing or capital and issues data security.
24	Using Big Data Methods in Bandung City Planning Research: Urban Resilient Governance with Smart City	Challenge: Data security and privacy, as well as tension between frequency data high and challenging structural term length faced city.

No.	Title	Challenges in implementing Big Data for Smart City
25	Big Data in Smart Cities: Usage in Kota Jababeka For Customer Satisfaction	Challenge: Lack of readiness source Power human resources (HR) and limitations budget

Source : (Research Results, 2025)

CONCLUSION

Through a systematic review of the literature, this study synthesizes key findings to present a comprehensive account of Big Data's role in Smart City development. A review of 25 selected articles published across 22 journals reveals that the implementation of Big Data is the most dominant element in Smart City initiatives. The Internet of Things (IoT) is discussed in 17 journals, followed by Artificial Intelligence (AI) in 10 journals, Cloud Computing in 7 journals, and other technologies such as Machine Learning (ML) and Cyber-Physical Systems (CPS) in one journal each. In practical application, Big Data contributes significantly to government decision-making, real-time transportation management, urban planning, as well as disaster prediction and mitigation.

Big Data serves as a pivotal instrument in strengthening public safety measures through sensor-based early warning systems and CCTV surveillance. However, despite many benefits, several challenges remain in its implementation. Among the reviewed studies, 11 journals highlight the issue of limited human resources, 8 journals emphasize security and data privacy concerns, while 4 journals focus on data quality and diversity problems.

The implications of this study suggest that strengthening data management policies, developing human resource capacity, and promoting cross-sector collaboration are essential to optimize Big Data–driven Smart City ecosystems, particularly in developing countries such as Indonesia. Nevertheless, this study has certain limitations. It focuses solely on secondary data obtained from existing literature and does not include experimental integration of Big Data with other technologies.

Therefore, future research is recommended to conduct empirical or experimental studies integrating Big Data with IoT, AI, and Cloud Computing to assess how these technological combinations can enhance public service quality and urban management efficiency. Moreover, comparative analyses between cities or developing countries are suggested to explore variations in infrastructure readiness, digital culture, and policy

effectiveness in adopting Big Data technologies. Overall, this study contributes to a deeper understanding of how Big Data supports Smart City transformation and provides critical guidance for policymakers, researchers, and practitioners in shaping data-driven urban innovation strategies.

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