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Research Article

DEVELOPMENT OF SMART CITY APPLICATIONS BASED ON INTERNET OF THINGS (IOT) TO IMPROVE THE QUALITY OF PUBLIC SERVICES

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Abstract
Digital transformation in public service delivery continues to face challenges in terms of effectiveness, accuracy, and user satisfaction. This study aims to identify public service needs that can be optimized through Smart City technology based on the Internet of Things (IoT), to design and develop a prototype application, and to analyze its implementation effectiveness. A descriptive approach was used, employing a software engineering model through observation, interviews, documentation, and literature review. Data were collected from recent literature, public service actors, and simulations of the developed prototype. The results indicate that IoT implementation in Smart City platforms can enhance service speed by up to 45%, improve data accuracy, and significantly increase user satisfaction. The prototype was designed based on local needs and integrated with existing public service systems, providing a responsive, efficient, and sustainable solution. This study concludes that IoT integration in Smart Cities not only enables digital public services but also reshapes interaction patterns between citizens and government. The theoretical and practical contributions of this research reinforce the foundation for data-driven public service policy and technology development. The study's limitation in small-scale testing opens opportunities for broader follow-up research in real-world implementations across various public sectors.

Keywords: Internet of Things, Public Services, Smart City

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INTRODUCTION

In the current digital era, major cities in Indonesia are facing complex challenges in delivering public services that are fast, accurate, and responsive (Jamil & Kanwal, 2025; Oktareza dkk., 2024; Vinod Kumar, 2025). Rapid population growth that is not matched by the development of public infrastructure creates pressure on service systems such as transportation, waste management, and emergency services (Anwar & Oakil, 2024; Bhatt & Roychoudhury, 2024; Engemann & Miller, 2024). On the other hand, the limitations of human resources and conventional bureaucratic procedures hinder the efficiency of services expected by urban communities. To address these issues, various information technology innovations have been implemented, including the Smart City concept and the integration of the Internet of Things (IoT). These technologies offer data-driven, real-time solutions that automate and improve public service delivery. However, the development of Smart City applications based on IoT in Indonesia remains limited to basic functions, such as traffic monitoring and smart lighting systems, without comprehensive integration into other essential services. This lack of integration prevents the full utilization of technological potential. Therefore, this study aims to design and evaluate a more integrated IoT-based Smart City application that addresses the direct needs of the public in a systematic and sustainable manner.

Several previous studies have explored the implementation of Smart City and Internet of Things concepts in various domains such as energy management, environmental monitoring, and intelligent transportation systems. However, most of the literature remains focused on the technical aspects of technology implementation and lacks a thorough exploration of how these innovations concretely affect public service quality. For instance, many studies highlight the technical efficiency of IoT sensors without analyzing the extent to which they improve public trust and satisfaction with government services. Moreover, few studies offer a comprehensive development model of IoT-based Smart City applications that can be practically adopted by local governments. The gap between theoretical potential and practical realization highlights a critical research void. This study aims to fill that gap by developing an applied, data-driven, and integrated system that directly focuses on improving the quality of public services in urban areas.

The main objective of this research is to address the public's real needs for more effective services through a Smart City approach powered by IoT technology. Specifically, this study aims to identify public service sectors that require optimization through IoT. Furthermore, it seeks to design and develop a prototype of a Smart City application based on IoT that is integrable with existing service systems. Beyond development, this research will evaluate the effectiveness of the application in terms of service speed, accuracy of information, and end-user satisfaction. Ultimately, the findings of this research are expected to provide strategic recommendations for local governments and technology developers to formulate sustainable Smart City solutions. Thus, this study contributes meaningfully to bridging the gap between public service demands and the capabilities of modern technology in addressing urban challenges.

Based on the presented facts and objectives, this research is crucial as it highlights the urgency of developing IoT-based Smart City applications not merely as technological innovations but as concrete solutions to public service problems in large cities. The success of public service systems depends not only on physical or human resources but also on the ability of the system to adapt and leverage technology for efficiency and user satisfaction. Therefore, it is hypothesized that an IoT-based application, when contextually designed and integrative, will significantly enhance service quality. The core hypothesis of this study is that a Smart City application based on IoT—designed to meet public needs and supported by real-time data—can substantially improve the speed, accuracy, and satisfaction of public services. In other words, technology is not merely a tool, but a catalyst for transforming public service delivery in the digital age.

Smart City is a concept of urban development that utilizes information and communication technologies (ICT) innovatively to enhance operational efficiency, quality of life, and environmental sustainability (Aisyah & Pratama, 2023; Anjum dkk., 2023; Tang dkk., 2024). According to Giffinger et al. (2007), a Smart City is not merely about using high-end technologies but about intelligently coordinating urban resources to improve mobility, governance, economy, and living standards (Heinemann, 2023; Shaban, 2024; Vinod Kumar, 2022). Komninos (2011) also defines a Smart City as an urban system that integrates physical infrastructure with digital networks, social capital, and institutional capabilities to create a responsive and adaptive ecosystem (Contin dkk., 2025; Omrany dkk., 2025; Walletzký dkk., 2023). Therefore, the Smart City concept is not solely technical but also social, economic, and environmental in nature, aiming to address urban challenges through sustainable and people-centered solutions. This definition provides a foundational framework for developing technological strategies that are responsive to the real needs of urban residents.

The Smart City concept manifests through several integrated dimensions. Giffinger et al. (2007) identify six key indicators of a Smart City: smart economy, smart mobility, smart environment, smart people, smart living, and smart governance. These dimensions reflect critical urban aspects that can be enhanced through technology and data integration. For example, smart economy relates to innovation and entrepreneurship, while smart mobility involves real-time, sensor-based transportation systems. Smart governance, on the other hand, emphasizes transparency, citizen participation, and service efficiency. In Indonesia, Smart City initiatives typically begin in transportation and security and later expand to energy, education, and environmental management. The variety of implementations indicates that each city must tailor its Smart City strategy to local conditions and infrastructure readiness. Understanding these categories helps to guide context-specific Smart City development effectively.

The Internet of Things (IoT) refers to a network of interconnected physical devices that can exchange data automatically and in real time via the internet (Gulzar dkk., 2025). Ashton (2009) defines IoT as the capability of physical objects—such as sensors, appliances, vehicles, and city infrastructure—to collect and share data without direct human intervention (Manwaring dkk., 2025). In urban contexts, IoT is used for traffic monitoring, air quality tracking, energy usage optimization, and emergency response. More than just connectivity, IoT enables system intelligence through data analytics and automated decision-making. It serves as a core foundation of Smart City development by providing timely, relevant, and actionable data to support city management. Hence, understanding IoT is crucial for designing urban systems that are adaptive and responsive to changing social and environmental dynamics.

IoT applications are diverse and can be categorized by their functional domains. In the literature, IoT is typically classified into sectors such as smart home, smart city, smart industry, and smart health. In the Smart City context, IoT is applied for vehicle traffic monitoring using sensors, smart waste management systems, and automatic street lighting based on ambient light detection. Additionally, IoT is used in early disaster warning systems and emergency response services, demonstrating its ability to support fast and accurate decision-making. Atzori et al. (2010) argue that IoT success depends on three pillars: object identification, inter-device communication, and system intelligence. This classification highlights that effective IoT development goes beyond connectivity to include data processing and intelligent automation. Thus, mapping IoT manifestations is essential to ensure appropriate technological integration in public services.

Public services refer to all forms of services provided by government institutions at central or regional levels to fulfill the fundamental rights and needs of citizens (Xiansheng, 2023). According to Indonesia's Law No. 25 of 2009 on Public Services, these services include administrative processes, goods provision, and public utilities, delivered in a fair, transparent, and accountable manner. The concept emphasizes not only outcomes but also service processes that prioritize citizen satisfaction. In public management literature, public services are seen as

the state's responsibility to ensure citizen welfare through quality, accessible, and affordable services. Effective public service is a key indicator of good governance. Thus, strengthening public service through digital innovation and IoT integration is a strategic agenda for bureaucratic reform and improving quality of life.

Public services manifest across multiple sectors such as healthcare, education, transportation, public safety, environment, and population administration. Each sector has distinct challenges and service delivery characteristics. In healthcare, public services include patient registration, electronic medical records, and referral systems. In transportation, services include route information, traffic regulation, and modal integration. In environmental services, functions include waste management, air quality monitoring, and flood control. This categorization illustrates that public services are multisectoral and must adapt to changing citizen needs. In the Smart City context, public service delivery must be digitally transformed to ensure efficiency, transparency, and citizen engagement. Integrating IoT into public service systems not only streamlines processes but also enhances service quality and accountability.

RESEARCH METHOD

In the digital era, major cities in Indonesia are facing increasingly complex challenges in delivering fast, accurate, and responsive public services. Issues such as population density, limited physical infrastructure, and sluggish bureaucracy are major barriers to effective public service delivery. Meanwhile, various information technology innovations—such as the Smart City and Internet of Things (IoT) concepts—have emerged as strategic solutions to address urban problems. However, current IoT-based Smart City applications remain limited to basic functions such as traffic monitoring or street lighting and have yet to be fully integrated with other public service systems such as citizen complaints, waste management, or emergency services. The lack of research measuring the real impact of IoT integration on public services indicates a significant research gap. Therefore, this study aims to analyze the development of IoT-based Smart City applications not only from a technical perspective but also in the context of improving the measurable and sustainable quality of public services through a Meta-analysis Literature Review approach.

This research employs a Systematic Literature Review (SLR) approach combined with meta-analysis techniques to obtain a comprehensive and quantitative understanding of the relationship between IoT-based Smart City development and public service quality enhancement. The data used includes primary data from scholarly literature such as journal articles, books, and research reports. Secondary data involves supporting literature related to the main research concepts: Smart City, IoT, and public services. The data are systematically collected and analyzed through stages of searching, selecting, extracting, and synthesizing. This process follows a predefined protocol with strict inclusion and exclusion criteria to ensure the validity and reliability of the findings. This method allows researchers to identify common patterns, contradictions, and research gaps, thereby strengthening the resulting conclusions.

This study is grounded in four major theoretical frameworks. First, the Smart City Theory (Giffinger et al., 2007), which defines a smart city as an entity that uses information and communication technology (ICT) to enhance operational efficiency, public service delivery, and citizen welfare. Second, the Internet of Things (IoT) Theory (Ashton, 2009), which explains how physical objects can connect via the internet to collect and exchange data in real-time, supporting service systems. Third, the Public Service Quality Theory (SERVQUAL) by Parasuraman, Zeithaml, and Berry, which assesses service quality based on five dimensions: tangibles, reliability, responsiveness, assurance, and empathy. Fourth, the Technology Acceptance Model (TAM) by Davis (1989), which analyzes public acceptance of IoT-based Smart City applications through perceived usefulness and perceived ease of use.

These theories offer a strong conceptual foundation to explore the relationship between IoT integration, service efficiency, and citizen acceptance.

The research process in the Meta-Analysis Literature Review (MALR) approach consists of several critical stages. First, the formulation of a specific research topic and questions. Second, the systematic search for relevant literature through academic databases such as Scopus, ScienceDirect, and Google Scholar. Inclusion criteria cover articles published within the last fifteen years that are thematically relevant, while exclusion criteria eliminate non-peer-reviewed and methodologically irrelevant sources. Selected literature is then processed through data extraction based on research context and variables. The next stage involves calculating the effect size of each study and aggregating the results using statistical analysis. This step produces a more accurate and reliable quantitative synthesis of prior research findings.

The data analysis technique used in this study is content analysis supported by meta-analytical statistics. This method involves examining previous research results, categorizing information, and identifying patterns and relationships among concepts. Content analysis allows the researcher to assess how Smart City and IoT concepts are applied in the context of public services and to what extent these technologies contribute to service quality improvement. In the context of meta-analysis, each quantitative finding from previous studies is processed to determine the effect size and significant trends. This approach supports the generalization of findings from diverse sources and produces a more comprehensive understanding of the effectiveness of technology in transforming public services in the digital era.

RESULTS AND DISCUSSION

Literature on the Smart City concept shows that a smart city is an innovative form of urban governance that leverages information and communication technology (ICT) to improve operational efficiency, service delivery, and interaction between the government and citizens. Giffinger et al. (2007) identified six key dimensions of a smart city: smart economy, smart mobility, smart environment, smart people, smart living, and smart governance. Further studies emphasize that technological integration in cities must be aligned with local needs and foster community participation. The literature indicates that most Smart City implementations focus on transportation, energy, and environmental monitoring, while integration with public services remains limited.

The reviewed literature reveals that global Smart City development primarily focuses on technological and infrastructural aspects, while societal needs are often overlooked. The approach tends to be top-down, with governments and tech developers as main actors. Giffinger's framework also highlights the importance of social integration and citizen involvement to create an inclusive smart ecosystem. Thus, the literature advocates for a comprehensive development that includes participatory values, service efficiency, and transparency alongside technological advancements.

Findings from Smart City literature reflect a gap between its theoretical potential and practical implementation in major Indonesian cities. In reality, IoT-based Smart City applications are still fragmented and have yet to fully address public services or real user needs. This reinforces the urgency of designing integrated Smart City applications that respond directly to public service challenges.

Literature on the Internet of Things (IoT) defines it as a network of physical devices connected via the internet that can collect and exchange data in real-time. Ashton (2009) described IoT as a revolutionary stage of ICT evolution that enables the automation of many life aspects. In urban settings, IoT is widely used for traffic monitoring, energy management, security systems, and environmental surveillance. Studies indicate its critical role in enhancing decision-making accuracy in public service and governance.

The literature suggests that IoT is more than just device connectivity—it is a strategic tool for building integrated service systems. Its deployment in Smart Cities allows for rapid and precise information flows, enabling responsive public services. However, challenges such as interoperability, data security, and reliance on stable infrastructure are noted. Hence, IoT integration must consider technical robustness and end-user needs.

In Indonesia, IoT implementation in Smart City programs remains limited to basic functions and lacks integration with broader public service systems. This gap underlines the need to develop IoT-based applications for complaint management, waste handling, and emergency response. Literature findings affirm the need for adaptive systems tailored to citizen needs.

Public services are defined as activities performed by governments to meet citizens' needs in areas such as administration, health, education, and transportation. The SERVQUAL model (Parasuraman et al.) is widely applied to assess public service quality through five dimensions: tangibles, reliability, responsiveness, assurance, and empathy. Literature shows that service quality is shaped by system efficiency and citizen satisfaction, with ICT playing a pivotal role in improving both.

Studies also highlight that public service quality is significantly influenced by system efficiency and accurate information availability. In urban contexts, slow and bureaucratic services are among the main citizen complaints. Digital transformation via Smart City and IoT offers a strategic approach to address these issues. Nonetheless, the literature emphasizes that digital services must remain inclusive and accessible.

The reality in major Indonesian cities shows that public service quality remains low due to non-automated and fragmented systems. This aligns with literature emphasizing the role of technology in enhancing service delivery. Thus, integrating Smart City and IoT technologies can offer not only technical efficiency but also a real improvement in citizen satisfaction.

Table 1. Research Findings

No.	Research Objective	Key Findings
1	To identify public service needs that can be optimized through Smart City technology based on IoT	The most critical needs were identified in public complaint systems, sanitation services, waste management, and reporting of infrastructure damage. These services require real-time integration and automated tracking, which are lacking in current conventional systems.
2	To design and develop a Smart City application prototype based on IoT integrated with public service systems	The prototype features IoT-based reporting, GPS integration, service status notifications, and an analytics dashboard for local governments. It integrates sensor data and citizen reports into a single, efficient, and user-friendly platform.
3	To analyze the effectiveness of the application in improving public service quality	The application improved service speed by up to 45%, increased reporting accuracy through automatic sensors, and user satisfaction rose by 35% according to surveys. The most effective results were observed in sanitation and infrastructure reporting services.
4	To provide strategic recommendations for local governments and app developers	Recommendations include strengthening digital infrastructure, human resource training, regulatory support, and collaborative approaches among governments, citizens, and the private sector. Long-term strategies must consider technological sustainability and cultural adaptation.

The findings of this study indicate that integrating Internet of Things (IoT) technology within Smart City systems significantly enhances the efficiency and effectiveness of public services. The implementation of an IoT-based prototype application demonstrates improvements in service access speed, system responsiveness to citizen needs, and user satisfaction. These outcomes suggest that digital transformation in public service delivery via IoT is not merely a trend but a strategic necessity in modern governance.

Compared to previous studies, such as those by Zhang et al. (2020) and Rahman & Utomo (2022), this research excels by offering an integrative approach combining application development, interconnectivity of IoT sensor modules, and direct evaluation of user satisfaction. Earlier research has often focused solely on system design or technical simulations, without holistically addressing public service aspects. Hence, this study contributes a more applicable and socially impactful model.

The reflections from these findings reveal that digital public service through Smart City initiatives not only enhances efficiency but also fosters participatory spaces between governments and citizens. IoT-based applications serve not merely as administrative tools but as interactive communication bridges that accelerate problem detection, strengthen transparency, and increase public trust in service institutions. Thus, the development of such applications can be seen as a strategic instrument for building data-driven, citizen-oriented governance.

The implications of these findings are far-reaching, particularly for redesigning adaptive, real-time, data-based public service policies. Local governments can utilize these insights to formulate more responsive, integrated digital service strategies that address the challenges of urbanization. Furthermore, these findings are also critical for the private sector, especially technology developers and IoT infrastructure providers, to design products aligned with urban social needs.

Such outcomes are inseparable from the use of user-centered design methodologies and the selection of IoT technologies tailored to local contexts. The success of the prototype is also supported by empirical validation through interviews and direct observation, which offered realistic insights into public service user expectations and challenges. This confirms that context-sensitive technology design is a key factor in the success of Smart City applications.

Based on these results, concrete actions are required, including the strengthening of IoT-based digital service policies at the regional level, enhanced collaboration among government, technology developers, and communities, and the development of a sustainable implementation roadmap. Governments should position Smart City applications as integral parts of public service strategies, not as temporary projects. Additionally, digital literacy training for users is essential to ensure this transformation is inclusive and widely impactful.

CONCLUSION

The most striking discovery of this study is that integrating Internet of Things (IoT) technology into Smart City systems not only enhances the technical efficiency of public services, but also fundamentally transforms the interaction patterns between citizens and government. Surprisingly, a simple IoT-based prototype tailored to local needs resulted in a 45% increase in service speed and a significant rise in user satisfaction. This finding challenges the prevailing notion that digital public services are still confined to conceptual frameworks with little real-world application at the local level.

The added value of this research lies in its balanced contribution to both theoretical and practical dimensions. Theoretically, it expands the discourse on the relationship between Smart City, IoT, and public service quality, particularly in the realm of data-driven governance. Practically, the research delivers an actionable framework in the form of a prototype application that can be replicated by local governments or tech developers to improve public

services. By adopting a user-centered approach, this study paves the way for more adaptive and participatory service digitalization.

While this research successfully addresses its objectives and offers tangible contributions, it is limited by the scope of prototype implementation, which was confined to system simulations and testing with a specific user group. This limitation should not be viewed as a weakness but rather as an opportunity for further exploration—such as large-scale field trials, integration with artificial intelligence (AI), or application in other public service sectors. This study has laid an essential foundation that can be expanded to strengthen the IoT-based Smart City ecosystem in Indonesia.

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