Integrated Information System Modeling for Municipalities in Indonesia Toward Smart Cities

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Integrated Information System Modeling for Municipalities in Indonesia Toward Smart Cities

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Abstract: To create a comfortable city to live in and a knowledgeable society, every government needs to formulate policies and provide supporting infrastructure to realize the concept of urban development in the future. Smart city is considered a positive performance indicator for a city because it is expected to provide benefits for government and social life of the community in various sectors. Indonesia's smart city policies are still unsustainable and sectoral. This study aims to (i) identify the smart city categories essential for municipalities in Indonesia, (ii) determine the information needs of municipalities in supporting smart city initiatives, and (iii) formulate an integrated information system implementation model tailored to municipalities in Indonesia. Data were collected in Pariaman City, West Sumatra, Indonesia, using questionnaires, focus group discussions (FGD), and interviews. The findings reveal that the top three smart city categories, prioritized in order, are Data Centers & Analytics, Government Planning & Policy Design, and Education Facilities. These ideas are valuable for guiding the development of a smart city strategy within the Municipality by emphasizing key priorities such as data centers, analytics, government planning, education, health amenities, and online civic services. The results of this research contribute to the field of Information Systems within government organizations.

Keywords: E-Government; Integrated Information Systems; Local Government Information Systems; Smart City

1. Introduction

Rapid urbanization and population growth have intensified city infrastructure and services strain. Policymakers and city authorities actively seek solutions to dynamically and sustainably provide new services. Many cities enhance the quality and performance of urban services through digital and smart approaches, aiding policy-making and urban development[1)].

The smart city concept, a superset of e-government, relies on a robust e-government foundation[2)]. Initiating e-government for smart city implementation should prioritize essential technology and services for citizens, with system sustainability as a prerequisite. Developing a functional e-government using Information Communication Technology (ICT) to enhance community service supports this sustainability. As one of the primary domains of a smart city, ICT implementation facilitates public administration and government, making it a focal point of this study concerning the digital aspect of smart city criteria, emphasizing ICT-oriented e-government.

Governments worldwide strive to provide optimal services to their citizens, offering online services for information access, communication with government agencies, and electronic transactions. E-Government involves digitally connecting citizens with their government, enabling access to information and services[3)]. The interactive e-government process comprises four relationships: government to government, government to business, government to employees, and government to citizens.

Advancements in technology, such as the World Wide Web, have transformed relationships between Government to Business (G2B) and Government to Citizen (G2C)[4)]. Traditionally viewed as bureaucratic, the government sector recognizes the potential for faster and easier

administration processes through e-government. This transformation is vital for improving relations with citizens, businesses, and other entities, enhancing the efficiency and effectiveness of public sector services[5]. E-government, facilitated by integrated Information Systems[6], contributes to more efficient public services by reducing reliance on face-to-face interactions.

While the smart city concept gains traction in Indonesian municipalities, experts and practitioners need more consensus on its implementation model. Megacities and metropolitan regions receive more attention than small cities[7], even though most of Indonesia's cities are categorized as small to medium-sized. Given Indonesia's diverse regional characteristics regarding culture and infrastructure, smart governance planning should align with regional missions, needs, conditions, and visions. Planning for Smart Cities in Indonesia must begin at the village, city/district, and provincial levels[8].

Rey-Moreno and Medina-Molina[9] emphasized that the government must consider organizational support, conversion costs, resistance to change, and uncertainty in implementing integrated information systems. Yusuf et al.[10] identified challenges in implementing integrated systems in China, including a lack of top management support, high costs and time requirements, cultural differences, technical complexity, insufficient professional staff, and internal resistance. Internal resistance poses a significant challenge in the Chinese context, influenced by the level of ownership and the company's size. They recommend establishing a well-integrated system implementation team, employing suitable Business Process Reengineering (BPR), providing adequate training, and partnering with a trusted Outsourcing-Application Service Provider to ensure successful implementation. In order to overcome the challenges, a study needs to be conducted.

Our uniqueness lies in prioritizing the elements of a smart city in a Municipality due to the fact that not all components of a smart city can be implemented simultaneously. In order to support smart city initiatives, this study seeks to (i) identify the critical smart city categories for Indonesian municipalities; (ii) ascertain the information needs of municipalities; and (iii) develop an integrated information system implementation model specifically for Indonesian municipalities. By identifying critical smart city categories, the study can find out the first priority of the smart city implementation, identify information needs and finally, a model for smart city implementation can be generated.

2. Literature Review

2.1 Smart City Implementation Model

The concept of a smart city was first introduced in 1998[11]. The term 'smart' denotes city policy and implementation[12], encompassing not only advanced technology and communication for citizens but also emphasizing system sustainability, attractiveness, and safety[13]. Key to enhancing the standard of living and improving government administration is investment in human development, social capital, and both traditional and modern infrastructure[14].

The United Nations defines a smart city as using innovative ICTs to improve the quality of life, the efficiency of public services, and competitiveness while addressing the needs of present and future generations, considering economic, social, and environmental aspects. Manville et al.[15] define a smart city as a place where networks and traditional services become more efficient through digital and telecommunications technology for both business and society. Smart city development focuses on improving community life[16], environmental efficiency, protection, and sustainability[17], all managed and monitored by a technological infrastructure.

Several researchers have attempted to conceptualize the smart city model. Some have employed the triple helix model to assess the influence of stakeholders on the Smart City[18-20]. Lombardi et al.[21] modified the triple helix, including citizens, and clustered smart city entities into Government, Economy, Human Capital, Living, and Environment. In their study, Leydesdorff and Deakin[22] introduced urban technology and its meta-stabilizing potential. Nam and Pardo[23] elaborated on institutional, technological, and human factors, providing a roadmap for successful smart city implementation. Chourabi et al.[24] placed smart city initiatives at the core of the model, identifying internal factors (technology, organizations, and policy) as more influential than external factors (Governance, People and Communities, Natural Environment, and Infrastructures). This model could aid in feasibility studies for local government planning. However, Kumar et al.[1] identified the largest number of categories for basic infrastructure development and smart city transformation framework.

Policies related to smart cities in Indonesia are still sectoral and unsustainable[25]. The goal of Indonesia's smart city programs, which are being implemented in several cities and districts, is to alleviate urban difficulties by developing digital infrastructure. So, smart governance planning must be planned wisely and guided by regional needs, conditions, vision, and mission. Smart City planning in Indonesia must start from villages, cities/districts and provinces[8]. The following cities have been honored for their efforts to create smart city features such as Bandung with its Smart Governance, Surakarta with its Smart Branding, Semarang with its Smart Economy, Yogyakarta with its Smart Society, Demak Regency with its Smart Living, Madiun City with its Smart Environment, and Wonogiri with its smart tourism. These honors and accolades demonstrate Indonesia's dedication to the Smart City Movement, which aims to assist towns and regions nationwide in planning and executing digitally-based

improvements specific to their own opportunities and difficulties.

A number of Smart City indicators have emerged as a result of the movement toward the deployment of smart cities. These indicators were designed to gauge the potential of both cities and smaller communities. Classifying smart cities in various categories is the goal of creating a maturity[26]. The readiness and maturity of smart cities can be precisely assessed using a variety of indicator models and frameworks. Based on a review of the literature and the outcomes of data extraction from smart city models, frameworks, and maturity models, 38 dimensions of smart cities were identified. Six categories of important smart city dimensions—Economy, People, Environment, Governance, Living, and Branding, can be used to organize these dimensions[27]. Systematic reviews were conducted to review the literature.

2.2 City Transformation

The transformation of a smart city is a complex and multidimensional process[28]. Urban transformation relies on the collective integration of technological, governance, institutional, and transitional components. A smart city can provide infrastructure, information-based services, and business opportunities for economic development[29]. To design smart services, city planners and administrators must consider expert and citizen opinions to address community priorities and needs[30]. Kumar et al.[1] presented 18 categories for developing basic infrastructure and a smart city transformation framework, as depicted in Fig. 1.

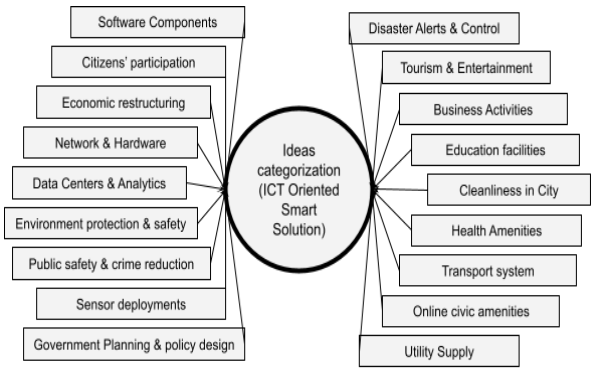

Fig. 1: Smart City Basic Infrastructure Development Category[1].

2.3 The Case of Pariaman

Pariaman municipality was established based on Indonesian law no—12 in 2002. Geographically located in the west of Sumatra Island with the Indonesian Ocean on its coast, Pariaman is surrounded by Padang Pariaman Regency to the north, south, and east. The population is 85.7 thousand people, and the city is administratively subdivided into four districts (*kecamatan*): South Pariaman, Central Pariaman, East Timur, and North Pariaman. Approximately half of the inhabitants reside in Central Pariaman. The city is surrounded by the rural Regency (Kabupaten) of Padang Pariaman. The research focused on this city due to its categorization as a small city with a significant plan for implementing the smart city concept, making it an ideal representation for most small-medium cities in Indonesia. Figure 2 shows the Pariaman City Area.

Pariaman, located in the province of West Sumatra, has a land area of 73.36 square kilometers and a sea area of 282.56 square kilometers, with a coastline length of 12.00 kilometers. As of 2023, it has a population of 96,719 people. Pariaman is prone to various natural disasters, including earthquakes, land movements, floods, tsunamis, liquefaction, extreme waves, and abrasion. However, despite these challenges, the city has received numerous awards in the field of Information and Communication Technology (ICT), including the First Best Award from the Indonesian Ministry of Communication and Information Technology (*Kemenkominfo RI*) for the Utilization of Multidomain Mail at the Municipal Government level in 2023. It is also selected as one of the cities in the Movement Towards Smart City 2022 by the Indonesian Ministry of Communication and Information Technology. It is recognized as Public Transparency on the PPID Website in 2020, 2021, 2022, and 2023 by the West Sumatra Provincial Government. Awarded in 9 categories of Smart City by the Digital Transformation Rating Indonesia (RTDI) and RKCI 2021, Pariaman was awarded as Small City Towards Smart City, Small City Smart Economy, Small City Smart Society, Small City Smart Environment, Small City Smart Mobility, Small City Smart Health, Small City Resilient City, Small City Climate Change Resilience, and Small City Smart Energy. Despite facing significant challenges, Pariaman continues to excel in the field of ICT, demonstrating its commitment to innovation and resilience in the face of adversity.

Fig. 2: Pariaman Area.

3. Research Methodology

This research adopts a development research (research and development/R&D) approach called the ADDIE approach. The ADDIE development procedure includes five stages, namely: Analyze, Design, Develop, Implement,

and Evaluate. The ADDIE model is commonly used in development research because it has systematic stages to obtain an integrated implementation model of the smart city system in Indonesia. This research is the initial steps for implementation of Smart city in Pariaman that employ Analysis, Design and Development. Three steps were employed in this study to address the research problem. Figure 3 illustrates the methodology for developing the conceptual model, divided into an initial step (Step 1: Analysis), survey and focus group discussion (Step 2: Design), and conceptual model development (Step 3: Development).

Initially, for the Analysis Step, a literature review was conducted on smart city-related journals, covering the basic concept of a smart city, the need for smart cities, the relationship between smart cities and e-government, past smart city practices, and evaluations of their implementation. The results of this literature review were utilized to support the second step, namely, Survey and Focus Group Discussion (FGD). The survey and FGD involved selecting top, middle, and low-level management in Pariaman City, which was recognized to influence the decision-making process. A focus group discussion (FGD) was held regarding Smart City transformation in the city of Pariaman. The FGD activity was attended by all department heads, representatives, sub-district heads and village heads in the Pariaman City regional government. During the FGD activity, a questionnaire was distributed to all participants to find out what public services will be developed as the first step in Smart City transformation. Before the questionnaire was distributed, all participants were given an understanding of the smart city implementation plan in the city of Pariaman.

Demographically, in Table 1, the number of respondents who filled out the questionnaire was 39 respondents representing each department in Pariaman City. Representatives consist of department heads, secretaries, subdivision heads, staff and village heads in Kota Pariaman.

The management was asked to assign priority scores to the 18 deployment categories outlined by Kumar et al.[1)] (1 = highest priority, 18 = lowest priority). Lastly, documentation played a crucial role in the third step, especially during model building, by elaborating on the top ten priorities and their relation to government office services. These methods are considered appropriate for addressing the research questions, indicating a mixed-methods approach.

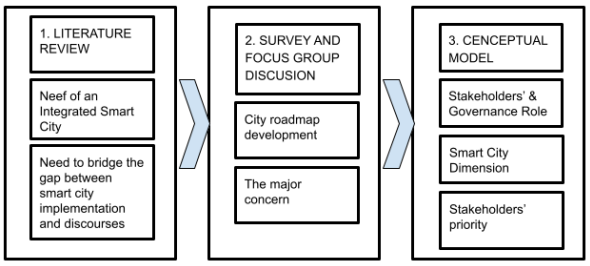

Fig. 3: Research Framework.

4. Results and Discussions

In the initial stage, a literature review was conducted to acquire knowledge about smart city categories. It was determined that the framework developed by Kumar et al.[1)] provided a suitable concept for further exploration in this research. Therefore, this study adopts the 18 categories outlined by Kumar et al. as the primary framework for identifying the smart city categories essential for improving the quality of life for citizens in Indonesian municipalities.

In the second stage, a focus group discussion involving 39 top, middle, and low-level management members identified the top ten ICT service priorities. The demographic profile of the respondents is presented in Table 1. Notably, most respondents were male (66%), and a significant portion held a bachelor's degree (55.3%). The average length of work experience was 14 years and seven months.

Table 1. Profile of Respondent Demography.

	Demography	Quantity	%
1.	Sex		
	Male	26 people	66 %
	Female	13 people	34 %
2.	Age		
	Highest	68 y/o	-
	Lowest	26 y/o	-
3.	Education Level		
	Junior high school	0 people	0 %
	Senior high school	2 people	5.3 %
	Diploma	2 people	5.3 %
	Bachelor degree	21 people	55.3 %
	Master degree	14 people	34.2 %
	Doctoral Degree	0 people	0 %
4.	Length of work		
	Longest	30 years	
	Shortest	8 months	
	Average	14 years and 7 months	

The categories were ranked based on the cumulative scores from the 39 respondents. Table 2 presents the rankings, with the lowest score denoting the main priority (1) and the highest score indicating the last priority (18) for each category during the focus group discussion. The results indicate that Data Centers & Analytics emerged as the top priority, followed by Government Planning & Policy Design, Education Facilities, Health Amenities, Online Civic Amenities, Environmental Protection &

Safety, Public Safety & Crime Reduction, Tourism & Entertainment, Utility Supply, Network & Hardware, Transport System, Business Activities, Software Components, Disaster Alerts & Control, Citizens' Participation, Cleanliness in City, Economic Restructuring, and Sensor Deployments.

Table 2. The Rank of Smart City Categories.

Categories	Rank
Data Centers & Analytics	1
Government Planning & Policy Design	2
Education facilities	3
Health Amenities	4
Online civic Amenities	5
Environment protection & safety	6
Public safety & crime reduction	7
Tourism & Entertainment	8
Utility Supply	9
Network & Hardware	10
Transport system	11
Business Activities	12
Software Components	13
Disaster Alerts & Control	14
Citizens' participation	15
Cleanliness in City	16
Economic restructuring	17
Sensor deployments	18

The rankings of smart city categories in Pariaman were used to formulate an integrated system model for delivering services to the community. Each local government organization or department in Pariaman City will be involved based on its functionality for all service categories. Table 3 illustrates service priority categories and the regional government organization/department (called OPD) related to services provided to the community in Pariaman. Each department will be responsible for providing data for smart city services. The Department of Communication and Information is vital in managing central data analysis, online civic amenities, networks, and hardware technology. It will serve as the hub for preparing a smart city in Pariaman.

The education department oversees service categories such as education facilities, and health facilities fall under the purview of the health department, as outlined in Table 3. However, managing these services extends beyond the specific department; other departments are involved since the system is integrated with the same database.

To realize the smart city, a model of smart city implementation for the municipality must be developed. The model integrates all ICT priorities, the necessary data, and the departments responsible for providing data for the services. The departments do not need their own application systems to serve their customers. As depicted in the model, a Municipality can serve customers through an integrated information system using a one-door service center.

The Municipality smart city model implementation, as depicted in Fig. 4, is a system integration model designed based on the most priority service category in Pariaman to support the smart city. The following explanations outline each component of the smart city implementation.

Table 3. Top Ten Categories and Related Departments.

Categories	Department
Data Centers & Analytics	Department of Communication and Information
Government Planning & policy design	Regional Planning, Research, and Development Agency
Education Facilities	Education Department
Health Amen and Analyticities	Public Health Department
Online civic amenities	Regional Planning, Research, and Development Agency
Environment protection & safety	Environmental Department
Public safety & crime reduction	Civil Service Police and Fire Department
Tourism & Entertainment	Government Tourism Department
Utility Supply	Agriculture & Food Department Marine Department

4.1 ICT Priority Services

The local government offers the community several services according to the ten priorities of ICT services. The local government's services will be consolidated on a single webpage/information system accessible to the public. Individuals can select their desired services through this unified system. Although each department or OPD has developed its information/web systems in the current development, its weakness lies in the lack of integrated data between departments[31]. New smart technologies can assist organizations in becoming more competitive as they seek efficient and affordable production processes[32].

Given this situation, an integration model is proposed, as shown in Fig. 4. Each service provided to the public will lead to a database or system integrated with different services. As a result, the public can access each of these services using an ID card.

4.2 Data Integration and Services Analysis

The data integration process requires a high-capacity database capable of consolidating various forms of services for the community. The Department of Communication and Information is pivotal in this database integration process. There are three primary types of data integration: government data integration, population data integration, and regional data integration. These serve as the foundation for the national information system, aiming to integrate data for all e-government functions. Following data integration, each department will assess service requirements and process the data based on specific duties and functions. Machine learning is valuable for aiding information analysis and collection, utilizing samples from vast data and information[33].

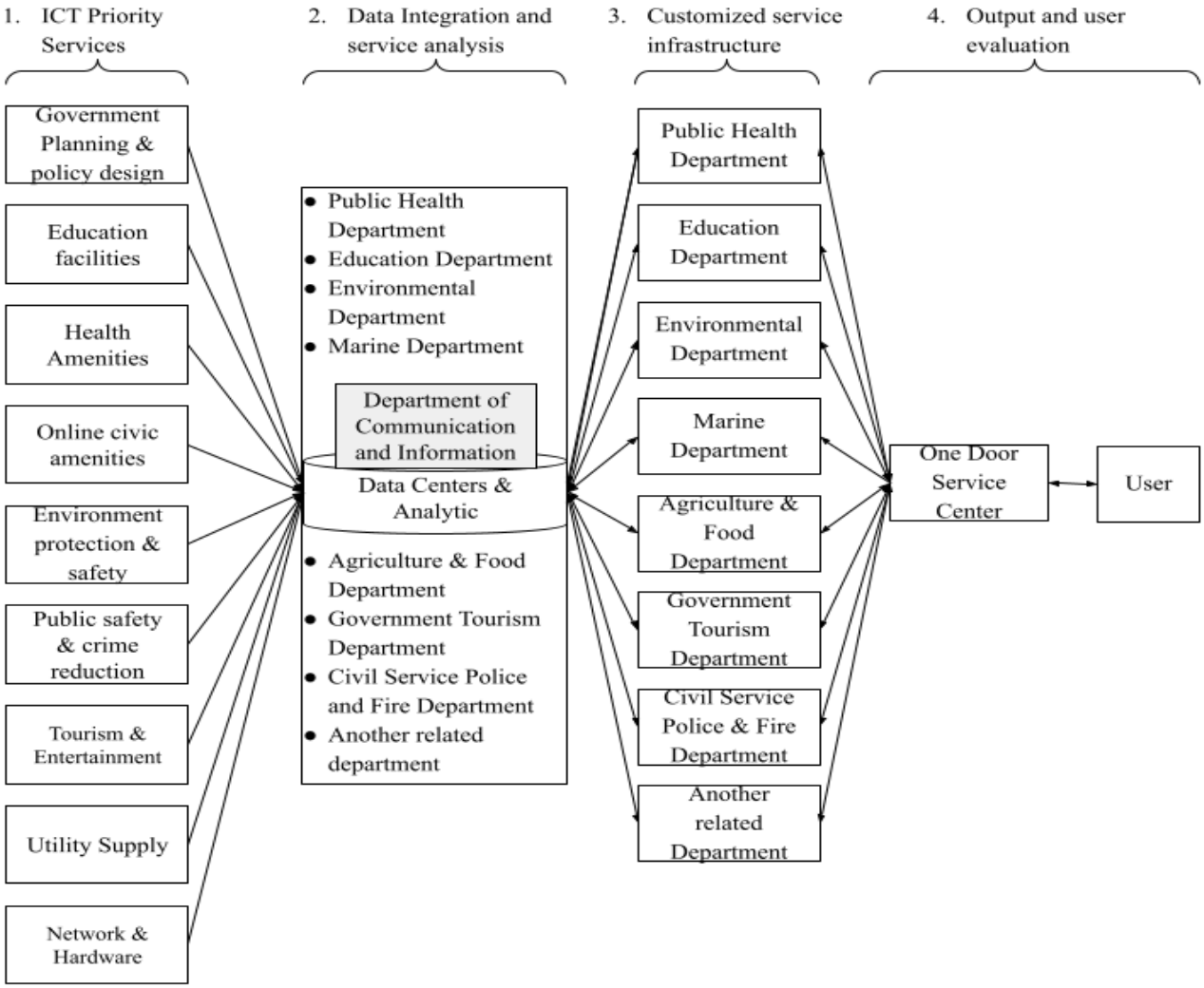

Fig. 4: Municipality Smart City Model Implementation.

Figure 4 shows that all services related to smart city categories have access to an integrated database. Examples of data integration in a smart city context encompass.

- Population Data Integration: Involving departments such as the Population & Civil Registration Service, Education Department, Health Service, and Labor Agency. This integration is crucial to encompass all aspects of resident data, including medical history, family members, and more.
- Regional Data Integration: Encompassing services such as Tourism, Fisheries & Marine Services, Agriculture & Food Services, and Regional Planning, Research, and Development Agencies. Integration in this context aids information disclosure related to natural resources, regional tourism, and regional planning.
- Government Data Integration: Involving departments such as the Regional Finance Agency, Human Resources, Human Resources Development, and Legislative Council.

This comprehensive integration ensures a seamless flow of information across various smart city services, facilitating effective decision-making and service delivery. The proposed conceptual model successfully addresses the internal government's demands within the Municipality, establishing essential relationships between relevant departments. Notably, the Department of Communication and Information emerges as a central player in the model, serving as a linchpin for ICT solutions and crucial data integration. This department is identified as the most fitting entity for database and system management. The focal point for smart city preparation within the Municipality is the Department of Communication and Informatics. The Education Department oversees various service categories, encompassing educational and healthcare facilities. With the system integrated into a unified database, managing these services extends to other departments, and the specific department oversees each service.

The finding is in line with research conducted by Martin[34]. They found that a sustainable smart city's platform is one of the most important parts of its Open Data Ecosystems (ODEs). The platform is a digital infrastructure that facilitates data collecting, processing,

storing, publishing, sharing, and reusing. Integrating with various data sources and offering tools to aid in decision-making are essential components of a successful platform. All stakeholders should be able to locate, access, and use the platforms with ease.

4.3 Customized Services and Infrastructure

Upon accessing the integrated database and conducting the necessary analysis, each relevant department evaluates the infrastructure required for public provision. Although the department indirectly serves the community, it does so through a unified one-door service, interconnecting all departments. The significance of urban innovation and the impact of smart city initiatives on performance are pivotal for establishing high-quality economic growth and nurturing a nation that values innovation. The development of smart cities not only enhances urban innovation performance but also ensures sustainable promotional effects[35].

Their findings emphasize that the degree of openness is a determining factor in advancing smart city urban innovation performance. Simultaneously, the extent of economic development, information infrastructure, and financial innovation expenditure exert a positive influence on fostering innovation performance in smart city construction. We must embrace smart building technologies to shape and influence the future of building management[36].

4.4 Output and User Evaluation

The generated output aligns with the smart city service category, and users/public can access online and offline one-door services. Users can review the output received and verify its alignment with their needs. In the case of an evaluation, the one-door service system will collaboratively re-coordinate with the relevant department. The government must address citizen dissatisfaction not only with "the right technologies," "the right rules," and "the right information" but also by fostering critical citizenship. This empowerment is achieved through initiatives such as "the right to smart city education," "the right to participate," and "the right to challenge"[37].

Effective governance structures promoting the close integration of various stakeholders are essential for efficiently delivering services that meet citizens' requirements[38]. Each department collaborates in information exchange during service provision, enabling users to select the category of service they need. Users then receive the output in either hardcopy or softcopy through a one-door service, eliminating the need for community visits to department offices. The system comprehensively fulfills all community needs. There is a growing interest in developing applications encouraging citizen participation in identifying urban problems and contributing to decision-making processes[39]. Citizens, acting as agents, can report issues, monitor specific environmental parameters, and share opinions to support city management. In agriculture, the proven effectiveness of smart farming in enhancing efficiency and effectiveness, along with its numerous advantages and cost-effectiveness, has led to widespread implementation in Thailand's agricultural and plantation industries[40].

Therefore, the proposed integration model necessitates a data center accessible to all departments. An integrated database, which centralizes data from several city operations, including traffic management, public services, and utilities, can make a big difference in the effectiveness of smart city projects. This centralization makes better resource management and city planning possible, facilitating more effective data analysis and decision-making. In addition, it makes it easier to respond quickly to urban problems, improves citizen service delivery, and encourages the creation of new services—all of which contribute to cities' liveability, sustainability, and resilience. This is because the integrated database can enhance smart city utilization[41].

5. Conclusion

A Municipality's pursuit of a smart city is anchored in key priorities, with data centers & analytics taking precedence, followed by government planning & policy design, education facilities, health amenities, and online civic amenities. The Department of Communication and Information assumes a pivotal role, particularly in central data analysis, online public services, and the implementation of network and hardware technologies. This paper advocates consolidating all offered services into a singular hub, termed a one-door service center. However, there is room for further development to align the model more closely with citizens' demands, given its current government-centric perspective. Future research endeavors should focus on integrating all 18 categories and involving all departments under Municipality authorities. Exploring citizen participation in the success of smart cities in Indonesia holds the potential to propel the flourishing of smart cities across the nation. This article only focuses specifically on one Municipality's pursuit of a smart city. It may not be generalized well to other municipalities or cities with different socio-economic, cultural, or technological contexts. The findings and conclusions drawn may be limited in their applicability beyond the specific case studied, so future research can compare some smart city implementation in some cities in Indonesia.

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