Implementation of smart city concept: A case of Jakarta Smart City, Indonesia

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Abstract. The concept of a smart city has been proposed to solve urban problems. The concept has been implemented in different parts of the world, including in Jakarta, Indonesia's capital city. Jakarta has experienced environmental and socio-economic problems as the consequences of rapid urbanization. Therefore, the local government has initiated Jakarta Smart City since 2014. This paper aims to explain the implementation of the smart city concept in Jakarta based on the six elements of the Smart European Cities, namely, Smart Economy, Smart Governance, Smart People, Smart Mobility, Smart Environment, and Smart Living. The research data is gathered through in-depth interviews with a representative from the government of Jakarta and from the literature review. The results indicate that Jakarta's government has implemented the six elements of a smart city by using digital infrastructure, i.e., online platform and software application. However, there is still a lot of work to be done as there is still room for improvement to maximize the benefit for the city and its residents. One of them is that Jakarta's government needs to optimize the use of the existing applications and increase the awareness of users of these applications.

1. Introduction

Based on data from the World Bank, urbanization in Indonesia reached 55% in 2017, increasing from the urbanization rate of 51% in 2010 and 42% in 2000 [1]. Urbanization has a positive impact on cities in terms of economic growth with more human capital and increased consumption. Despite this, urbanization brings new socio-economic problems. Indonesia is listed as the country with the tenth highest congestion globally and environmental problems of pollution, waste, and land degradation. Limited access to environmental infrastructure and services led to various health problems, consequently lowering human capital quality [2]. A study has shown that environmental problems (such as pollution in cities on human capital quality) can slow down economic growth [3]. Besides, various social problems also arise due to the inequality of social and economic welfare in the community so that there are high poverty and crime rates in urban areas [4].

The growth in the adoption of communication and information technology facilitates and accelerates information flow in society. Simultaneously, the urban management concept that adopted technology, known as Smart City, was developed to address urbanization problems in emerging and developing cities. The concept of Smart City emerged intending to improve the quality of life of people in urban areas with human and social capital and information and communication technology [5]. Smart City enables cities to manage resources effectively and efficiently to solve urbanization
problems using innovative, integrated, and sustainable methods to improve various sectors' performance. The implementation of the concept in urban areas has created a smarter infrastructure, better data-driven decision making, safer environment, improve social services, and widespread digitalization that can simultaneously solve urbanization problems, bring economic growth, and improve the quality of life for the people and reach the sustainability [6]. Cities adopting the concept have become sustainable communities that allow knowledge creation and development [7].

According to Anthopoulos, Janssen, and Weerakkody [8], Smart City is an innovative city that uses information and communication technology to improve people's quality of life and the efficiency of the sectors urban areas. For instance, the local government of Busan (South Korea) had partnerships with private sectors and set up the App Development Centre to develop smart city services, and as of 2013, had developed 70 applications for public services [9]. In Singapore, the cities invested in its integrated transportation system that was easy to access and can provide traffic information to the public. San Francisco, mainly funded by the U.S. Federal Government, had developed a parking system with a real-time update for available parking spaces and utilized the data to match parking spaces with traffic and demand. Furthermore, Charlotte's government used mobile networks and other technology systems to reduce energy usage by 20% by launching smart meters and displaying energy consumption meters in buildings to educate their citizens on energy efficiency [9].

In Indonesia, the Ministry of Communication and Information Technology has implemented a pilot project for the Smart City Movement since 2017 with a target of 100 Smart Cities in 2020, which have diverse community and city characteristics. However, the implementation of Smart City in each city depends on how the local government adopts the concept to local characteristics [10]. Jakarta is the capital city and economic center in Indonesia, attracting people to move to the city, mainly to find employment. The capital city experienced a 1.15% annual change in population from 2015 to 2020, with an estimated population of over 10 million in 2016 and a density of 14,464 people per square kilometer [11]. The increase in population in Jakarta also raises various urban problems. Therefore, this is a challenge for Jakarta to develop the community's potential and the city while solving structural problems due to urbanization. Jakarta has adopted the Smart City concept since 2014 and has built a JSC or Jakarta Smart City with a vision of realizing Smart City before 2025 [12]. This project is expected to improve services to the community and increase the area's potential so that in the end, it can attract tourists and investors and increase the economic growth of the city and the welfare of the community in general [13].

This study aimed to analyze the implementation of the smart city concept in Jakarta based on the six elements of the European Smart Cities, namely smart governance, smart living, smart people, smart mobility, and smart environment, which were adopted by the Jakarta Smart City program [12]. This study's results were expected to provide input regarding six elements that could be improved in implementing ICT in the smart city concept in Jakarta.

1.1. Literature review

The concept of a smart city is not limited to the use of information and communication technology nor digitalization. It is also focusing on human capital, social, and environment, which are the essential parts of city growth [14]. Digitalization is needed to improve the traditional forms of urban management and accelerate city growth. A study from Romanelli [7] suggests that Smart City will actualize the smart community through community development and engagement. The smart city concept will also promote sustainable cities by utilizing information technology to transform organizational framework for innovation and governance. The community will evolve through knowledge creation and development [7].

In the development of a Smart City, several prerequisites are needed so that technology and information can be utilized to develop society and the city, including urban infrastructure planning that includes structural infrastructure, utilities, transportation, environment, government, and manufacturing [15]. Apart from the availability of adequate infrastructure in all sectors, it also needs network infrastructure that can increase the number of connected units in the business and government
sectors and the community [16]. This network infrastructure is needed to facilitate and improve connectivity, mobility, and information transmission vertically and horizontally. The existence of this physical infrastructure and network must also be accompanied by the ability to integrate data to become information that can be used for the benefit of the community and city development [15].

With the availability of an integrated web portal, the coordination and transaction between government and public and private sectors will be more efficient since physically coordinating with different divisions and departments is no longer there. However, the improvement of government services to the public through digitalization may be delayed due to changing the organizational infrastructure. A study by Ebrahim and Irani [17] discussed the architecture of e-government adoption that would be necessary for Smart City infrastructure and how e-business would be an essential part to enable integration between divisions inside the government and to the other parties. However, there would be some challenges in implementing the e-government, namely, the IT infrastructure, security and privacy, IT skills, organizational issues, and cost that the government must bear.

City governments can also implement Enterprise Resource Planning (ERP) to create the Smart City concept up to the infrastructure level. ERP GIS (Geographic Information System) is implemented by several countries that implement the digital infrastructure for smart governance and the environment [18]. With this system's use, activities related to the use of public facilities such as electricity, gas, water, irrigation, and communication networks can be known every day and in real-time and integrated. An integrated system with faster data transfer can improve energy saving and productivity through data-driven decision making. Although the development of an integrated system like this will cost a lot of money, it will increase the efficiency of capital and operational costs in the long term [18]. With the supporting infrastructure and proper controlling and monitoring at the government level, ERP can integrate the overall information functions to automate business processes and shorten decision-making. It supports high-level, financial, and human resource decision making and provides better relationships between government and public sector institutions [17].

Physical and network infrastructure are the main prerequisites before a city can become a Smart City. This is because there is a need for media or platforms so that the public and the government can connect to improve the performance within a sector and performance between sectors. With the rapid development of technology and the increasingly common use of smartphones in society, the Internet of Things (IoT) or digital applications and platforms are the catalysts in the efforts to build Smart City. Various platforms that can be used by the public and various entities in the city, such as social media, e-commerce, e-government, and cloud computing, are essential in realizing a Smart City [15] [19].

Regarding smart mobile applications, these applications can be divided into three categories based on the sensing scope, including Smart Personal Mobile Apps, which personally sense the device owner. The second is Smart Group Apps, which do crowdsourcing by collecting data from large groups such as Social Media Twitter or Facebook. The third is Smart Community Apps that can collect broader data, known as Community Apps, and can be used to solve problems at the city level [15].

Most cities implement the smart city concept using mobile network infrastructure and services, whether web-based or application-based [20]. Besides, most services are based on simple GPS location-based or unidirectional applications [21]. A report from GSMA described that transportation, including intelligent transportation and traffic management system, and ticketing applications accounted for the majority of smart city projects, followed by environment or energy safer, such as smart measurement and electric vehicles, and the third one was urban infrastructure services, including water and waste management [20].

For instance, the Amsterdam Smart City Programme was initiated in 2007 with the vision to solve its environmental problems and actualize an urban environment that was sustainable for the citizens [22]. The planning phase had a clear goal: to solve the climate change problem with its Climate Programme by encouraging energy efficiency to the citizens. In the execution phase, the government involved the participation of private sectors. It enabled private-public partnership for its smart green city with the financing that was mainly supported by the private sectors. Amsterdam provides an application to measure neighborhood participation pollution and safety [22].
As one of the early adopter countries, South Korea has developed the concept of Smart City and initiated the long-term project since 2013. It was first limited to several cities appointed as U-City to enact comprehensive specific regulations for the chosen regions and planned financing construction for the infrastructure development. The appointed cities’ infrastructure development encouraged people to commute to the new cities, and further grew the cities. There was an evolution from the construction of U-city towards the integration of service sectors. With the integrated ICT, they could share the information from CCTV to police stations to handle urgent crimes, infrastructure information to the fire stations for disaster management, and with the telecommunication company to share the real-time location with the police fire station to help vulnerable citizens in danger. There were two smart city pilot projects in Sejong and Busan, which focused on different themes. Sejong mainly developed smart mobility such as driverless vehicles and AI embedded traffic management systems to reduce traffic and used AI in health care as an early detector for medical emergencies. Meanwhile, Busan focused on smart water management including, smart watering meters, automated detection and drainage of pollutants, and a water reuse system. Korea also planned to help 100 more cities to become Smart City in 2023 with the concept of thematic city development that involved collaboration between local government and the private sectors [6]. Most initiatives from 58 cities in South Korea addressed transportation, public facilities, public administration, tourism, culture, and recreation. In terms of application initiatives, South Korea mostly offered single services, such as eco-mileage service, integrated public transportation, integrated public facility reservation, energy-saving app, children location tracking, and tourists’ applications. [21]

Study of Smart City Wien in Vienna suggested that Vienna focused on the quality of life, innovation, and resources. In the urban planning of Smart City Wien, Vienna targeted 13 areas in total for redevelopment [23] [24]. Based on each local condition, Vienna tried to solve each area’s problems and fulfill the essential needs in each area. In terms of environmental management, the Climate Protection Program and Viennese municipal energy efficiency program were enacted to minimize energy consumption. Vienna also managed to launch its eco-Business Plan to support local enterprises to stay aligned with environmental management. Through its Transport Master Plan, Vienna was one of the world’s densest public transportation networks and provided safe and eco-friendly mobility for its citizens [24].

Another research in Vienna identified the adoption of e-government and found that the likely adoption of e-government services was predicted by many factors, such as technical issues, trust, and awareness [23]. The same source stated that awareness was an essential part of implementing Smart City. Literacy within the government, private sector, and society towards the vision of Smart City was needed to develop the potential of the community and city. It was essential to build the necessary and useful services to the intended users based on specific needs. Like e-business, internal adaptation is as important as external adaptation so that barriers arose from within the organization could be avoided [17].

Implementing a Smart City is an essential part of realizing a Smart City, starting from the framework building and goal setting, strategic planning, and implementation in line with the Smart City [9]. The cities mentioned above were adept at being consistent with their goals and implementing ICTs through the public’s applications. Engagement with the private and public sectors was also a significant part of the implementation to gain support so that the projects themselves were useful and realistic to be implemented.

2. Method
This study used a qualitative research method to identify the conceptual framework and analyze to what extent the smart city concept was addressed in Jakarta Smart City. In this study, Jakarta was chosen because it is the city with the highest urbanization level and the highest population density in Indonesia, and Jakarta is included in the transitioning city together with Beijing. Jakarta is an early adopter of Smart City in Indonesia since 2014 and has digitized it in several sectors. However, Jakarta is also facing various problems such as housing problems, floods, waste management problems, and
other socio-economic problems [8]. The discussion on the implementation of Smart City in Jakarta will be based on the Smart European Cities’ six main elements. The reference was selected as the Jakarta Smart City used the six pillars similar to Smart European Cities’ elements [12].

The data used in this study was obtained through in-depth interviews and secondary data regarding Smart City and Infrastructure in Indonesia. Semi-structured interviews were conducted with two representatives of the DKI Jakarta Government Officials for Jakarta Smart City to gain an in-depth understanding of the Jakarta Smart City program through video conference. The respondents were chosen as they were involved in the planning and execution of the project. Meanwhile, the secondary data was obtained from official government sources and publications related to smart city and ICT Infrastructure in Jakarta. Regarding the paper discussed in the study, they were obtained by searching on the Google Scholar website. Analysis of the Jakarta Smart City program's implementation was then conducted to identify the room for improvement and innovation.

3. Results and discussion
As the center of urbanization in Indonesia, Jakarta has adopted the concept since 2014 [12]. In that year, the governor of Jakarta promoted the smart city by raising issues of governance, mobility, environment, and community service. Since then, Jakarta has been building an integrated management system throughout the public sector by utilizing information and communication technology by working with private parties and academics. There are various programs planned to achieve Smart City.

It is a challenge for Jakarta as a transitioning city, namely a city experiencing a high level of urbanization, so it requires necessary infrastructure and smart infrastructure for city development. To meet these needs, the Jakarta government has built a system using the Smart City Wheel Framework that allows Jakarta to transition from its current state to the desired condition to become a Smart City before 2025. Jakarta adopts six Smart City categories: smart living, smart mobility, smart governance, smart environment, smart economy, and smart people.

![Figure 1. Jakarta Smart City Components [12].](image-url)

3.1. Jakarta Smart City Readiness
The Smart City Master Plan, Preparation Guidance Book, mentions three main elements to assess the readiness, including structures, infrastructures, and superstructures elements. The main three components in smart city infrastructures used are Physical, Digital, and Social Infrastructure. Research conducted by Mahesa [13] measures the infrastructure readiness of big cities in Indonesia and Jakarta...
as one of the cities. It obtains full scores on 16 physical infrastructure indicators, seven digital infrastructure indicators, and five social infrastructure indicators. Compared to Semarang (the capital city of Central Jakarta province) with the highest score in the assessment, Jakarta still needs to improve its superstructures elements, including the availability of the existence of regulations for Regional Smart City council, executives, and master plan, also the standard of operations of the procedure.

3.1.1. CT Development Potential and Challenges in Jakarta. Based on Hootsuite January 2020 data, internet penetration in Indonesia reached 64%, 17% from internet users in 2019. Moreover, social media users in Indonesia account for 59% of the total population in Indonesia, an increase of 8.1% from 2019. Of all internet users between the ages of 16 - 64 years, 94% use Smart Phones. The development in the use of smartphones and the IoT (IoT) creates an essential element in the networked infrastructure. The information available on the internet network is in greater quantity and is more prosperous for the city to national scale decision making. An increase in government applications should accompany the increased adoption of technology and the internet.

The Jakarta city government has built technological infrastructure and implemented it to be used by the community to achieve a Smart City in 2025. However, there is still plenty of room to develop the potential of a Smart City in Jakarta with an innovation and improvisation program that departs from problems in society so that the solutions offered to match Jakarta's needs. In its application, the government needs to intervene directly, as it requires cashless and application use [25]. The following is the application of ICT and opportunities for improvement in the city of Jakarta:

3.2. Smart City Elements of Jakarta

3.2.1. Smart Economy. The government is digitizing Micro, Small, and Medium Enterprises (UMKM) to facilitate Jakarta's business practitioners. The JAKmikro program provides several services to business users, including MikroBina, as a medium for business assistance and consultation for MSME players. Then there is also MikroPay as an application that helps entrepreneurs to make financial records more easily. The Jakarta government also forcibly and directly carry out digital intervention on the community by requiring cashless use in various public sectors such as government employee salaries, payment of school fees, toll access, and public transportation such as city buses and commuter line [12].

3.2.2. Smart People. Jakarta aimed to build a culture of tolerant urban community and awareness in maintaining the city. Therefore, the local government has strengthened the Betawi culture with other cultures through the cultural icon, Model-model, and coconut flour in various buildings and events [12]. Jakarta adopts the concept of Smart People 21st century education and combines education with technology in its curriculum. The government built an Education portal that can be accessed from all schools in Jakarta to integrate public and private schools to get information regarding schools more efficiently. Jakarta also has an online library platform known as Jakarta, where the residents can read books online via personal mobile devices.

3.2.3. Smart Governance. Currently, Jakarta has a Smart City Portal, which is a central website that can be used by the public to obtain important information about Jakarta from its various related Departments and Bureaus [12]. The public can obtain necessary information such as CCTV, schools, health units, disasters affected locations, and locations of real-time brawls, from one centralized platform. The local government provides an integrated one-door platform (PTSP) to improve public services, including business entities and individual activity permits. The long queue can be eliminated, and all legal processes can be done more efficiently and in an integrated manner.

The Jakarta government has made efforts to build e-government infrastructure with the Jakarta Smart City and Qlue portals. However, a survey conducted by the DKI Jakarta Communication and
Information Agency in 2019 showed that only 12.88% of all respondents were aware of the Jakarta Smart City portal. Only 11.85% of all respondents accessed the portal. The intensity of using the portal owned by the Jakarta government also tends to be low, namely 2-3 times a week. There are needs to increase the community's awareness regarding the government portals and the use of the existing platform so that e-government can be maximally utilized.

There is also an e-governance platform that allows people to participate in the development of Smart City with the Qlue application. With this application, the public can provide various reports or problems in real-time such as congestion, traffic violations, damaged public facilities, garbage, floods, fires, to crime. Besides, the public can also monitor the performance of DKI Jakarta employees. E-Governance can be implemented because Jakarta Smart City digitizes government data so that it is possible to share the necessary information and can be shared with the public with the Smart City platform.

Jakarta has nearly 10 million people spread across five cities, so a large amount of data that goes into the Qlue application and the Jakarta government's online services cannot be processed in real-time and quickly. One of the problems and challenges for Smart City is limited resources that can process data leading to wasted and unprocessed data. Hence, collecting data with sensors and processing them with data analytics and machine learning is needed to implement Smart Governance.

**Figure 2.** Knowledge and Experience in Accessing the DKI Jakarta Smart City Portal [26].

**Figure 3.** Community Intensity in Accessing the Portal belonging to the DKI Jakarta Provincial Government every week [26].
3.2.4. Smart Mobility. As one of the Jakarta Smart City programs, Jakarta builds physical infrastructure by building a centralized system for streetlights that connects more than 90,000 LEDs. The Jakarta government's efforts to integrate a centralized streetlight system with automatic sensors allow the dematerialization of electrical energy in Jakarta. Besides, the government also encourages public transportation to reduce congestion and pollution caused by vehicles.

In the last five years, the DKI Jakarta government has built transportation infrastructure, both physical and digital, to improve connectivity between cities and satellite cities. The government provides data transparency to the public to facilitate mobility with the KAI Access application for intercity trains, KRL Access for inner-city trains, and Tijeku for Trans Jakarta. The application provides access to the public to find out train or bus schedules, station locations, and Trans Jakarta bus stops [27].

3.2.5. Smart Environment. The centralized streetlight system allows the dematerialization of electric energy in Jakarta. Besides, the government’s encouragement to use public transportation has helped to reduce congestion and air pollution. To improve efficiency in waste management, the government set a GPS in each garbage truck to monitor the travel route to minimize vehicle abuse that has been an issue in Jakarta waste management before and for decision making so that the travel route management can be more efficient. The public can also access the garbage truck's location in real-time via the government portal [12].

However, the Jakarta government faces challenges in limited public space in Jakarta, causing limited green areas. Besides, there is limited space for pedestrians and cyclists. These two challenges can be improved by the Jakarta government to provide a smart environment for its residents.

3.2.6. Smart Living. The Jakarta government has installed more than 6000 units of CCTV (surveillance cameras) to improve security. This allows early detection of floods and brawls, and the data can be shared with the public more quickly. The Jakarta government provides public Wifi in several public places in Jakarta to expand the network for the people of Jakarta. However, the use of public Wifi is still not optimal. A survey conducted by the Jakarta Communication and Informatics Office in 2019 showed that 69.33% of all survey respondents did not know of the government WiFi facility, and 12.88% of respondents knew but did not use it. While 82.63% of all the citizens in Jakarta who have access to ICT are frequently using the internet, only 17.79% know about public WiFi and use it. Most of the respondents do not use it due to lack of awareness, inaccessibility, not knowing the password from Wifi, and the perception of low network speed [26]. The public WiFi facilities are only available at several RPTRA (Child-Friendly Integrated Public Space), local parks and libraries, and hospitals. Hence, the government needs to expand the range of WiFi networks to locations where people still experience limitations accessing the internet. Table 1 represents ICT implementation of Smart City elements in the Jakarta Smart City project that has been carried out and the room for improvements recommended to Jakarta's government.

| Table 1. Application of Smart City in DKI Jakarta and Innovation Room. |
|---------------------------------------------------------------|
| **Element** | **ICT Application Description** | **Innovation/Improvement** |
| Smart Economy: | JAKmikro [28] | MSME business consultation, real estate monitoring, providing public protection for online loans [16] |
| Entrepreneurship and innovation, productivity, and connected locally and globally [12] | | Start-Up Centers [8] |
| Smart People: | Disdik Jakarta Online [29] and Jakarta [30] | Volunteering and culture portal [8] |
| Education with the use of technology, inclusive society, and respect for | | |
creativity and innovation
[12]

Smart Governance: E-Governance, transparency and data openness, supply and demand policies [12]
PTSP Jakarta [31], Qlue, and JSC Website [12]

Smart Mobility: Access to transportation modes, environmentally friendly transportation, and integrated with ICT [12]
KAI Access, KRL Access, Tijeku [27]

Smart Living: A society with a culture that is happy and vibrant, safe and healthy [12]
Public Wifi and CCTV [12]

Smart Environment: Environmentally friendly development planning, environmentally friendly energy, and environmentally friendly buildings [12]
Public Transportation, Smart Street Lighting System, Jakarta Air Quality Index Report, Flood Map [12]

Transparency and policy updates through an integrated portal [8]
The integrated transportation system, access for pedestrian and bicycle [9][16]
Community service portal for people with special needs (jobless, elderly) [8]
The real-time platform for women and child abuse [16]
Waste management system, disaster management, green area, smart watering [9][16]

4. Conclusion
This study discusses the implementation of the Smart City concept in Jakarta. The Jakarta government has implemented the six Smart City categories by relying on ICT in online platforms or applications that are close to the public. On the other hand, there is still room for innovation and improvements that need to be done to become a Smart City before 2025. To achieve the goal of Jakarta as a safe, comfortable, prosperous, productive, sustainable, and globally competitive capital city according to the vision of Jakarta Smart City, the developed programs must be aligned with that vision. The government also needs to ensure that the existing applications and platforms can be utilized optimally. Furthermore, the government needs to conduct socialization and regular monitoring so that people are aware of the provided online platform. Besides, the government also needs to show transparency, responsiveness, and accountability so that the services provided can be trusted and utilized, and supported by its residents.

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