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The Role of Big Data in Transforming Public Services Towards Smart City in Sidoarjo

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ABSTRACT

Objective: *This study aims to analyze the role of Big Data in accelerating the transformation of public services in Sidoarjo Regency toward the Smart City concept.* ***Method:*** *A qualitative research approach was employed, utilizing literature studies and in-depth interviews with officials from the Sidoarjo Central Bureau of Statistics (BPS).* ***Results:*** *The findings reveal that while several digital platforms such as SIPRAJA, SIAK, and e-Health have been implemented, the integration and effective utilization of Big Data remain limited. The challenges identified include data quality inconsistencies, lack of inter-agency system integration, and the absence of a strong data-driven organizational culture. This study further highlights five critical indicators in the Data-Driven Decision Making (DDDM) framework: data quality, analytical capability, decision-making processes, organizational culture, and technological infrastructure. Although infrastructure and analytical tools are in place, their effectiveness is constrained by weak data integration and limited application in public policy formulation.* ***Novelty:*** *This research provides a contextualized analysis of how Big Data adoption in local governance encounters institutional and cultural barriers, offering insights into the necessity of institutional reform, enhanced data literacy, and the development of a robust data ecosystem for achieving smart and responsive governance.*

INTRODUCTION

Public services are a collection of actions taken by the government to meet the needs of the community in various aspects of life, ranging from health, education, population administration, to transportation [1]. The main purpose of public services is to provide convenience, justice, and improve the welfare of the community [2]. Public services are undergoing a major transformation as a result of technological advances [3]. The transition from a manual system to a more efficient and integrated digitalization allows the process to be faster, more transparent, and easily accessible to the public without spending a lot of time and effort [4]. A growing concept is the smart city concept, which uses ICT to connect, manage, and optimize various public services in real-time [5]. The goal of smart cities is to create smarter, more responsive and sustainable neighborhoods by integrating data from various sectors to help make better decisions [6].

Big data is a term that refers to very large, diverse, and rapidly growing data sets that cannot be processed by conventional methods, and is a critical component that can help accelerate this transformation [7]. In general, big data is spread across electronic spaces, including the internet, and comes from a variety of complex sources. The management process is carried out in stages, including collection, filtering, storage, and analysis, all of which require a lot of resources. Given the large scale and complex procedures, big data is then categorized into five groups, namely: 1) data source; 2) content format; 3) data storage; 4) data staging; and 5) data processing [8]. Big data ini

berasal dari berbagai sumber, seperti transaksi digital, aplikasi pelayanan publik, media sosial, dan perangkat *Internet of Things* (IoT) [9]. Big data analytics helps governments find patterns, predict people's needs, and speed up responses to problems [10]. Social media can be categorized as big data because it is a source of information that can be shared and exchanged between individuals or groups (communities) through URLs [11]. Data specific to social media can be divided into two types: first, historical datasets that include information that has been previously collected and stored; second, real-time data that is captured live without any time lag, such as a live broadcast [12]. In the context of public services, big data plays a crucial role in improving the effectiveness and quality of services. For example, traffic data analysis can help alleviate congestion, while health information can be utilized to identify patterns of disease spread more quickly. By processing large volumes of data, the government can be more responsive to people's needs in a more efficient and targeted manner.

In the context of public services, big data plays a crucial role in improving the effectiveness and quality of services. For example, traffic data analysis can help alleviate congestion, while health information can be utilized to identify patterns of disease spread more quickly. By processing large volumes of data, the government can be more responsive to the needs of the community Sidoarjo Regency has started to implement digitalization in public services through various systems, such as SIPRAJA (Sidoarjo People's Service System) which allows citizens to access administrative services online. In addition, there is the Population Information System (SIAK) that aims to manage population data, e-Health that facilitates access to health services, and Simpatik (Education Management and Statistics Information System) for monitoring data in the education sector. Although these breakthroughs have shown progress, the utilization of big data to better integrate services still needs to be improved in a more efficient and targeted way.

Research using big data is still not widely recognized in Indonesia, especially among social researchers. One of the reasons is the limited software, most of which comes from abroad, as well as limited access to scientific publications related to big data [13]. The urgency of research in the application of big data, there are several drawbacks that need to be considered. First of all, data quality is often in question, as not all data sources can be effectively analyzed despite their huge volume. This requires analysts and data scientists to implement rigorous analytics systems in order to generate accurate and significant insights. Security risks are a major challenge in managing Big Data, especially for organizations that manage sensitive information. Therefore, strict safeguards are required to prevent data leakage and cyber-attacks [14]. In addition, as the volume of data to be processed increases, the need for adequate hardware becomes more pressing. Limited data experts are also an obstacle in optimizing this technology. Several previous studies have highlighted the benefits and challenges faced in implementing Big Data in the public sector. Oktatriani et al. (2023) revealed that Big Data analysis can improve operational efficiency and support data-based decision making. Meanwhile, research by Permana (2023) shows that the implementation of Big Data in Subang Regency has

successfully helped integrate data from various sources, accelerate services, and reduce operational costs, although it still faces technical obstacles and data security issues. One example of Big Data implementation in public services that is interesting to study is SIPRAJA, a system implemented in Sidoarjo Regency to digitize population administration. Sania and Rodiyah (2023) evaluated the effectiveness of SIPRAJA and found that the system has simplified the administrative process. However, some challenges still arise, such as limited internet access, low technological literacy among the community, and suboptimal communication between village officials and residents. Overall, the application of Big Data in public services has great potential to improve service efficiency and accuracy. However, for the benefits of this technology to be maximized, existing technical and social challenges need to be overcome.

In the ever-evolving digital era, data-driven decision making, also known as Data-Driven Decision Making (DDDM), has become a key factor in improving the effectiveness of public policies. Thomas H. Davenport, an expert in the field of data analysis and information systems, revealed that DDDM allows various organizations, including government agencies, to maximize the use of data at every stage of the decision-making process. The indicators include (1) Data Quality; (2) Analytical Capabilities; (3) Data-Driven Decision-Making Process; (4) Organizational Data Culture; (5) Technology & Infrastructure. With this approach, the resulting policy no longer depends solely on intuition or subjective experience, but is confirmed by accurate and systematic data analysis. Therefore, the Sidoarjo District Central Bureau of Statistics (BPS) has a vital role in providing data that supports regional policies. However, BPS still faces a number of challenges in implementing Big Data to support Smart City development. Some of the obstacles faced include data quality that is not yet optimal, limited access to information between agencies, and analytical capabilities that still need to be improved. The use of technologies such as artificial intelligence (AI) and machine learning has also not been fully maximized. In addition, decision-making at BPS is still not fully data-driven, while an organizational culture that does not support data literacy is a barrier to optimizing digital systems. In terms of technology and infrastructure, challenges such as lack of system integration and data security issues are also inhibiting factors. Therefore, to accelerate the transformation of public services towards Smart City, BPS Sidoarjo needs to improve the optimization of Big Data through improving data quality, improving analytical technology, and developing a data-based organizational culture. Based on the theory of Data-Driven Decision Making (DDDM), and the description of the problem, a research problem formulation can be prepared, namely, how the role of Big Data can help transform public services in Sidoarjo. This research focuses on analyzing the process of collecting, processing and analyzing data to improve service efficiency.

RESEARCH METHOD

This research adopts a qualitative method with a literature study approach and interviews to analyze the role of Big Data in the transformation of public services towards Smart City in Sidoarjo. As explained by Creswell (2014), qualitative methods aim to

understand social phenomena through the perspective of participants in a particular context [15]. This research provides an opportunity to explore in depth how Big Data is used in public service governance. Data collection was conducted through two techniques, namely literature review and in-depth interviews. The literature study aimed to examine various sources, including scientific journals, books, government policies, and official reports related to the utilization of Big Data in public services (Bowen, 2009) [16]. On the other hand, interviews were conducted with staff from the Sidoarjo District Central Bureau of Statistics (BPS), which plays an important role in managing and utilizing data to support Smart City policies. These semi-structured interviews provided flexibility in exploring in-depth information about the challenges and opportunities faced in implementing Big Data in public services (Kvale and Brinkmann, 2009) [17]. For data analysis, this research follows the interactive model proposed by Miles and Huberman (1994), which includes data reduction, data presentation, and conclusion drawing. Data obtained from the literature study and interviews were coded, categorized and interpreted to gain a more comprehensive understanding of the application of Big Data in the transformation of public services in Sidoarjo [18].

RESULTS AND DISCUSSION

Results

In the era of digital disruption, public service transformation is not enough to provide online-based services. Success does not depend solely on the existence of digital systems, but on the ability to analyze, interpret, and utilize the data generated from these systems in decision-making. In this case, Big Data has a very important role. It is not just a collection of large amounts of information, but a strategic guide for the government to understand the needs of the community in real-time, respond to challenges with a more predictive approach, and develop more targeted policies. Sidoarjo district has taken the first steps towards digital transformation through various systems, such as SIPRAJA, SIAK and IKD, which have generated massive data flows from population administration activities. However, the challenge lies not in the volume of data available, but in the ability of institutions to process and interpret the data strategically. This is where the role of Big Data becomes very important, as it can bridge the gap between digitization of service systems and intelligence in public policy.

To understand the extent to which Big Data plays a role in supporting the transformation of public services in Sidoarjo, this discussion will refer to the Data-Driven Decision Making (DDDM) approach. This approach emphasizes five key indicators: data quality, analytic capabilities, decision-making processes, organizational culture, and data technology and infrastructure. These five aspects are interrelated and mutually supportive, forming a data ecosystem that will determine the success of smart city implementation not only as an idea, but as a reality in people's lives.

Discussion

1. Data Quality

In the implementation of e-government systems, the use of big data technology is very important to support data processing and storage. According to Dumbill (2012), in the Big Data ecosystem, data quality is a very important foundation. Without accurate, relevant, and reliable data, the decision-making process will be at risk of bias and error [19]. In Sidoarjo district, data infrastructure is already in place with various public service systems such as SIPRAJA, SIAK and IKD. In theory, these systems are capable of generating massive and sustainable population data, service transactions and usage patterns. However, an interview with the Central Statistics Agency (BPS) said, "the data collection process is still done conventionally, through censuses and manual surveys by field cadres. Although validation is done with several layers, the utilization of automation technology in data collection has not been fully implemented". This indicates a mismatch between the potential of the existing digital system and the quality of the data produced. In addition, the data generated is mostly historical, not real-time. As a result, data-driven policy responses lack responsiveness. For example, while SIPRAJA records administrative service transactions, there is no sign of using the data to predict service needs in specific areas or to identify bottlenecks in public service delivery.

One government agency that has successfully utilized big data is the Central Bureau of Statistics (BPS), which uses big data for information-based data collection. The source of big data can come from various platforms, including digital and e-commerce. One form of data processing that can be seen is the number of internet users that has been analyzed previously from big data, which can now be presented on the BPS website. The following is a table adapted from information regarding the utilization of big data;

Table 1. Internet usage generated by BPS

Characteristics	Ever Used a Cell Phone (HP) / Nikabel or Computer (PC / Desktop, Laptop / Notebook, Tablet)	Ever Used the Internet (Including Facebook, Twitter, Youtube, Instagram, WhatsApp, etc.)
Gender of household head		
Male	86,80%	84,60%
Female	89,32%	83,25%
Expenditure quintile		
Bottom 40 percent	79,08%	74,83%
Middle 40 percent	82,67%	80,91%
Top 20 percent	91,30%	91,34%
Highest education of ART		
Elementary school and below	66,61%	64,01%
Junior high school and above	82,70%	81,25%
Sidoarjo district	86,59%	83,74%

Source: Statistics Indonesia, National Socio-Economic Survey (Susenas) March 2024.

Based on the table above, it shows that around 86.59% of the population aged 5 years and above have used digital devices, and 83.74% of them have accessed the internet. This shows great potential for obtaining high-quality data directly from the public. However, this also requires standardizing interoperability between systems and increasing the capacity of data officers, so that the data collected is not only large in volume, but also rich in meaning and ready for analysis. Improving data quality in Sidoarjo is therefore not only a technical issue, but also an organizational strategy to build a fast, adaptive and contextual data collection and validation system. Without good data quality, Big Data will only become a passive pile of information that cannot effectively drive the transformation of public services.

The results of the study, that data collection in Sidoarjo still relies heavily on manual and census methods, are also explained in the study by Oktatriani et al. (2023). The study shows that the main challenge in implementing Big Data in the public sector is the low quality of data input, caused by limited infrastructure and technical literacy in the field. This shows that the problem of data quality is not only a technical issue, but also relates to the readiness of human resources and quality control mechanisms that have not been evenly distributed throughout the region.

2. Analytical Capabilities

In today's information age, the availability of large amounts of data will be meaningless without the ability to analyze and provide meaning. In Sidoarjo, the Central Bureau of Statistics (BPS) has demonstrated good analytic capabilities by utilizing various software such as SPSS, Python, Google Data Studio, and Power BI. This indicates that the analytics infrastructure at the local level is starting to experience positive developments. However, this study also found a dissonance between the technical potential and the reality on the ground. In interviews with BPS staff, it was revealed that despite the availability of tools and training, the utilization of big data is still limited. This is due to unclear regulations regarding privacy and information distribution. Concerns about the possibility of misinterpretation keep some data from being fully utilized, which in turn has an impact on the slow data-driven response to dynamic public needs. Furthermore, there is a gap between BPS' analytical capabilities and operational data from public service systems such as SIPRAJA.

Although BPS has the capability to process data, actual and rich service transaction data from SIPRAJA is not available or integrated. As a result, the analytic potential that could have been used to identify congestion patterns, service spikes, or region-specific needs is not optimized. This condition emphasizes the importance of an integrated data ecosystem design between agencies. By processing data from digital services such as SIPRAJA through BPS analytic capabilities, we can produce evidence-based policies. Without such integration, data will only become digital archives that have no added value in policy making. The transformation of public services that should be driven by data intelligence is hampered by limited coordination and cross-institutional data frameworks.

Permana (2023) in his research in Subang Regency revealed that analytic capabilities actually exist, but their utilization is not optimal. This is due to the lack of integration and the absence of institutional policies that encourage data analysis between sectors. This situation is similar in Sidoarjo, where although the Central Statistics Agency (BPS) has adequate analytical tools, data from service systems such as SIPRAJA still cannot be accessed or analyzed strategically by other agencies.

3. Data-driven Decision-Making Process

One of the main indicators of the success of Big Data implementation in public services is the extent to which data is used as a foundation in the decision-making process. In Sidoarjo District, this research shows that data-driven decision-making is not yet fully integrated, especially at the technical and operational levels of public services. Based on interviews with BPS staff, the policy-making process at the local level often relies on intuition, experience or political pressure, rather than systematic, data-driven analysis. This reflects that data is not yet considered a strategic asset in governance, but only serves as an administrative complement. In fact, with the existence of digital service systems such as SIPRAJA and adequate analytical capabilities from BPS, there is a great opportunity to encourage a more predictive and responsive planning model. The lack of connection between operational data and the decision-making process creates what is called "data deadlock", where although data is available, its use in formulating policies is minimal. For example, data from the SIPRAJA digital service should be able to inform spikes in service demand in certain villages or areas with the highest administrative complaints, which should form the basis for redistributing officers or increasing service capacity.

However, without an integrated system and policy dashboard based on real-time data, decisions are reactive and generalized, rather than contextual and evidence-based. The transformation of public services towards Smart City requires a paradigm shift: from perception-based policies to data-based policies. Therefore, an important recommendation from this research is the need to build a data feedback loop, where data from the service system (SIPRAJA) is analyzed by technical agencies (BPS), used by policy makers, and the results are evaluated based on new data. Without this mechanism, Big Data will never reach its full potential in truly transforming public services.

A similar statement was also made by Sania and Rodiyah (2023), who revealed that decisions taken at the village level are often less data-driven. This is due to low access to integrated information systems and a lack of training in the use of data to formulate policies. A similar situation can be seen in Sidoarjo, where the public decision-making process is still reactive and has not utilized dashboards or decision support systems equipped with real-time data analysis.

4. Organizational Data Culture

BPS Sidoarjo has taken a significant step in developing a data-driven culture by launching a Learning Management System (LMS) online learning platform. This platform is not only intended for internal employees, but can also be accessed by the general public. Through this LMS, various training topics are available, including courses on Big

Data, which aim to improve data literacy among employees and the wider community. This initiative reflects BPS' commitment to expanding the understanding and mastery of data technology within the organization. For those interested, the LMS can be accessed through the official website at https://lms.bps.go.id/. In addition, BPS also conducts internal training programs for field officers so that the data collection process can be carried out in accordance with high quality standards. Based on the interview, "In addition, we also periodically organize data collection training for field officers, which shows our commitment to standardization and human resource capacity building. However, there is still a need to strengthen the internalization of a data-driven culture, especially at the technical level and among decision-makers at the village level". Permana (2023) in Subang district also identified a similar pattern. Although the data infrastructure is in place, decision-making is still not fully data-driven. This is due to the lack of adequate training and decision support systems.

5. Technology & Data Infrastructure

In general, BPS Sidoarjo has developed adequate technological infrastructure to support digitization efforts. Various software such as Art Studio, IFIUSE, SPSS, Python, and various visualization tools have been actively used. In addition, BPS also provides a "Statistics Corner" in a number of strategic locations, such as on campus (UMSIDA) and local government offices. Nevertheless, the main challenges faced still revolve around system integration between agencies and data security. Although the technological infrastructure is in place, maintaining sustainability and consistency in its use to support integrated public services remains an issue that needs attention.

Despite the availability of software such as SPSS, Python and Power BI, Sidoarjo's main challenge lies in system fragmentation and weak data protection. Permana (2023) emphasizes that without policies that ensure integration and connectivity between information systems, sophisticated infrastructure will not function optimally. This view is in line with the opinion of Oktatriani (2023) who state that interoperability is a key requirement for the application of Big Data in public services. In Sidoarjo, there is still no single master system capable of integrating data from SIPRAJA, SIAK and other institutions into an integrated policy dashboard. Therefore, technology modernization will only serve as a digital storefront without strong substance support.

CONCLUSION

Fundamental Finding : This research concludes that the transformation of public services towards the Smart City concept in Sidoarjo Regency has not yet embodied the essence of data-driven governance, as digital initiatives remain largely procedural due to weak data integration and limited organizational commitment to data-based decision-making. **Implication :** These findings imply that institutional reforms, enhancement of data literacy, and the establishment of an integrated data ecosystem are crucial to ensure that Big Data functions as a strategic driver of responsive and evidence-based public policy rather than a mere administrative tool. **Limitation :** Nevertheless, the study is

constrained by the limited number of informants and institutional scope, which may not fully capture the complexity of Big Data implementation across different levels of governance. **Future Research :** Therefore, further studies are recommended to expand the analysis at the village level or across inter-institutional collaborations, in order to provide a more comprehensive understanding of the structural and cultural prerequisites for successful Smart City transformation.

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