Enhancing Smart City Maturity Through Digital Transformation: A Success Factors Analysis

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***Abstract*— Improving smart city maturity through digital transformation is becoming increasingly crucial in facing the challenges of rapid urbanization and the need for more efficient city governance. However, the lack of a unified understanding of key drivers and challenges in this domain has limited the effectiveness of existing strategies. This study aims to explore the role of digital transformation in improving Smart City maturity by identifying key success factors and best practices adopted by cities worldwide. This study used the systematic literature review (SLR) methodology based on the PRISMA framework, which included systematic steps in selecting, collecting, and analyzing relevant literature. The study results reveal six factors influencing Smart City maturity: Information and Communication Technology (ICT) infrastructure, data integration, government policies and strategic planning, stakeholder engagement, environmental sustainability, and innovation and human resource development. Unlike previous studies, this study synthesizes global best practices and success factors, offering actionable insights for policymakers and practitioners to design inclusive, sustainable, and forward-looking digital transformation strategies. Furthermore, the study underscores the need for context-specific research to optimize implementation and drive meaningful progress in diverse urban settings.**

Keywords—Digital Transformation, Smart City Maturity, Success Factor, Best Practice, PRISMA

I. INTRODUCTION

Digital transformation has become one of the key elements in addressing the challenges arising from rapid urbanization and the increasing complexity of urban governance in the modern era [1]. By leveraging digital technologies, especially Information and Communication Technology (ICT) infrastructure, cities worldwide can create innovative solutions to improve the efficiency of public services, environmental sustainability, and the community's quality of life [2]. Digital transformation supports daily city operations and paves the way for developing a mature, smart city. The smart city concept integrates advanced technologies, innovation management, and strategic policies to create an efficient, resilient, and sustainable urban system [3].

Rapid urbanization has put enormous pressure on city infrastructure, such as transportation, energy, and waste management, requiring a smarter and more integrated approach [4]. Smart cities are a promising solution that leverages digital technology and data to create cities more responsive to community needs. Digital transformation enables cities to manage resources more efficiently, reduce carbon emissions, increase community engagement, and optimize public services [3], [5]. However, the success of digital transformation depends not only on the adoption of technology but also on social and cultural readiness and collaboration between stakeholders such as the government, the private sector, and civil society.

While studies have explored individual aspects of digital transformation and smart cities, a more holistic approach is lacking to understand the relationship between the two concepts. Many studies focus on technological elements such as ICT infrastructure or data-driven applications but rarely link them to smart city maturity holistically. For instance, robust ICT infrastructure is a cornerstone for smart city development, enabling public data management, big data networks, IoT device deployment, AI applications, and cybersecurity [6], [7]. Complementing this, effective data integration is crucial for ensuring interoperability between public services, enhancing data-driven decision-making, and improving service quality [8], [9]. Other studies show that government policies and strategic planning further amplify these efforts, demonstrating the transformative impact of digitalization-focused initiatives in sectors like education and healthcare [10], [11]. In addition, stakeholder engagement is equally vital, as evidenced by initiatives such as online community consultations and public-private collaborations, which underline the importance of inclusivity and cross-sector cooperation [6], [8]. Moreover, environmental sustainability, supported by IoT and sensor technologies for resource management, highlights the need for long-term ecological solutions [7], [12].

Despite these advancements, there is an urgent need to identify broader success factors, including policy, governance, social innovation, and environmental sustainability. With a more integrated approach, the challenges hindering smart city development are hoped to be effectively addressed. Based on these considerations, this study seeks to answer the following research question: What are the key success factors of digital transformation in accelerating the maturity of smart cities?

This study aims to fill this gap by conducting a Systematic Literature Review (SLR) using the PRISMA framework [13].

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The PRISMA framework was selected for its rigor and transparency in synthesizing existing research. Its systematic approach ensures a comprehensive and unbiased selection, collection, and analysis of relevant literature, enabling the identification of patterns and gaps in the field. By leveraging this methodology, the study ensures the findings are grounded in a robust and reproducible evidence base. This study will identify various success factors and best practices that cities can adopt to accelerate their digital transformation process. By providing a more comprehensive understanding, the results of this study are expected to be the basis for developing more effective strategies for supporting innovative, inclusive, and sustainable smart cities.

II. RESEARCH METHOD

This study uses a Systematic Literature Review (SLR) approach to analyze relevant literature related to the contribution of digital transformation to smart city maturity. SLR was chosen because this method allows researchers to systematically identify, evaluate, and synthesize existing findings in the literature, thus providing a strong basis for drawing valid and relevant conclusions. The SLR process in this study follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework [13], which provides structured guidance for each study stage, as seen in Fig 1.

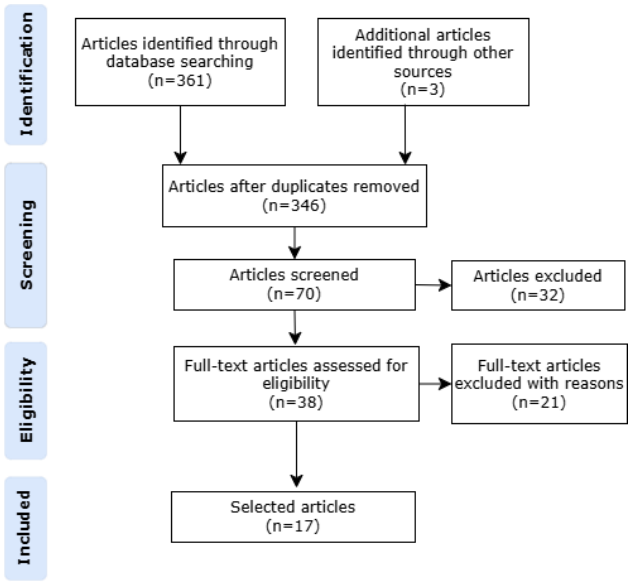

Figure 1. Prisma Work Flow

A. Literature Identification

The first stage of the review process involves identifying relevant literature on the contribution of digital transformation to smart city maturity. A systematic literature search was conducted across prominent academic databases, including Google Scholar, Scopus, IEEE Xplore, and ScienceDirect, to ensure comprehensive coverage of high-quality articles. The search was carried out using targeted keywords such as "digital transformation," "smart city," "maturity model," and "success factors," combined with Boolean operators (AND, OR) to refine the search. For example, one of the queries used was: ("Digital Transformation") AND ("Smart City") AND ("Maturity Model" OR "Success Factors"). This search was limited to articles published in the last 10 years (2014–2024) and written in English to ensure the relevance and accuracy of the findings. Only peer-reviewed articles were included to guarantee the credibility of the data.

B. Literature Screening

After identifying the literature, the next step is screening, ensuring that only relevant articles are considered for analysis. This process follows predefined inclusion and exclusion criteria to focus the review on quality studies. The literature screening includes two steps: first, reviewing titles, abstracts, and keywords to assess relevance; second, analyzing full-text articles to confirm their alignment with the study's focus. The inclusion criteria specify that the articles must be published in English, be peer-reviewed, and directly relate to digital transformation or smart city maturity models. Exclusion criteria include studies with a narrow geographic scope or articles that do not provide empirical data. A PRISMA flowchart was used to document this selection process, summarizing the number of articles screened, excluded, and ultimately included. Table 1 summarizes the inclusion and exclusion criteria used in literature screening:

TABLE I. CRITERIA SELECTION

Inclusion	Exclusion
Publication during the period of 2014 to 2024	Publications not written in English
Titles, abstracts, or keywords include search terms	Publications not subjected to the peer-review process
Publications are written in english	
The publication goes through the peer-review process.	

C. Eligibility Evaluation

Following the screening process, the next step is the eligibility evaluation, where the selected articles are reviewed in more detail to assess their relevance to the study's objectives. This evaluation aims to ensure that the articles provide valuable insights into the factors contributing to the success of digital transformation in the context of smart city maturity. Each article is evaluated based on the following criteria:

a) Key Success Factors: *The article should address specific factors that influence the successful implementation of digital transformation, such as ICT infrastructure, data integration, governance, innovation, stakeholder engagement, and sustainability.*

b) Contextual Relevance: The article should focus on the role of digital transformation in enhancing the maturity of smart cities rather than discussing only technological or generic city management aspects.

c) Empirical Focus: The article should provide empirical evidence, case studies, or data that illustrate the application of digital transformation success factors in real-world smart city contexts.

This evaluation ensures that only those articles that directly contribute to understanding the success factors for digital

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transformation in smart city maturity are included in the final analysis.

D. Data Extraction

Once the articles pass the eligibility evaluation, relevant data is extracted for further analysis. This phase systematically gathers information related to the identified success factors of digital transformation in smart cities. The data extraction follows a standardized template to maintain consistency and ensure that only the necessary and pertinent information is collected. The key data points extracted include:

a) Success Factors: Articles that identify or discuss key factors contributing to the success of digital transformation in smart cities are prioritized. These factors may include technology infrastructure, data-driven decision-making, stakeholder involvement, government policies, and sustainability practices.

b) Best Practices: Articles highlighting best practices in implementing digital transformation in smart cities are extracted to provide practical insights for other cities. These best practices may include successful governance models, stakeholder collaboration strategies, or technological implementations that have led to positive outcomes in specific cities or regions. Best practices offer valuable lessons for cities aiming to accelerate their journey toward smart city maturity.

c) Case Studies and Examples: Extracting case studies or practical examples where digital transformation success factors have been successfully implemented in cities. These case studies provide real-world evidence of how these factors are applied in the context of smart city development.

E. Data Analysis, Synthesis, and Validation

The selected literature was analyzed using a thematic approach to identify success factors in digital transformation that contribute to smart city maturity. This process involved thematic coding and identifying key recurring themes in the literature, such as the role of technology infrastructure, innovation governance, stakeholder collaboration, and strategy sustainability. These findings were then synthesized to provide more structured insights into the factors that support the development of mature, smart cities. After the analysis, the results are validated by comparing the main findings with relevant case studies or empirical reports. This step ensures the research findings are practically applicable and relevant to smart city development.

III. RESULT AND DISCUSSION

A. Result of Literature Review

Based on the analysis of 17 research papers, it was identified that the success of digital transformation in accelerating smart city maturity hinges on six key factors: ICT Infrastructure, Data Integration, Government Policies and Strategic Planning, Stakeholder Engagement, Environmental Sustainability, and Leadership and Human Resource Development. These factors have been demonstrated through best practices adopted by various cities globally, showcasing effective strategies to achieve higher maturity levels. While distinct in their focus, these factors are deeply interconnected, collectively shaping and driving the development of smart cities cohesively.

Figure 2 illustrates the six success factors essential for

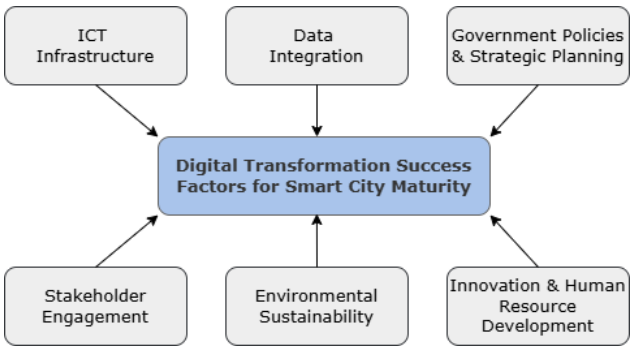

Figure 2. Digital Transformation Success Factors for Smart City Maturity

achieving Smart City maturity through digital transformation. These factors, ICT Infrastructure, Data Integration, Government Policies and Strategic Planning, Stakeholder Engagement, Environmental Sustainability, and Innovation and Human Resource Development, function as interconnected pillars that collectively drive the development of smart cities. Each factor contributes uniquely to the transformation process while supporting and reinforcing the others, ensuring a holistic and sustainable approach to urban growth.

ICT Infrastructure provides the foundational technology required to support innovations in public services, such as mobility, healthcare, and safety systems while enabling efficient communication and data-sharing processes [7]. Data Integration is a critical enabler, allowing disparate systems to interoperate and ensuring seamless coordination across sectors, thereby supporting efficient governance and sustainable resource management [9]. Government Policies & Strategic Planning are crucial in aligning technological investments with societal needs, ensuring that initiatives are feasible, forward-looking, and adaptable to future challenges [10]. Stakeholder Engagement is vital in fostering inclusivity and encouraging the participation of various groups, governments, private sectors, and communities in the development process. This ensures that smart city initiatives remain relevant and sustainable over time [8]. Environmental Sustainability emphasizes the importance of aligning digital transformation efforts with ecological considerations, leveraging technology to optimize resource management and reduce environmental impact [12]. Finally, Innovation & Human Resource Development ensures the capacity to manage, adapt, and sustain digital innovations by investing in skills, training, and visionary leadership capable of navigating technological and societal shifts [6], [14].

These factors do not operate in isolation but are highly interdependent. For example, robust ICT Infrastructure facilitates effective Data Integration, while supportive Government Policies drive Stakeholder Engagement and public-private partnerships. Similarly, a strong commitment to

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Environmental Sustainability requires capable leaders and skilled human resources to implement green technologies and practices. By integrating these six success factors, cities can address diverse challenges and achieve higher levels of smart city maturity, as depicted in Figure 2.

Table 2 categorizes and highlights the best implementation practices for the six success factors identified as essential for achieving Smart City maturity through digital transformation. These best practices are derived from cities worldwide that have successfully adopted and integrated innovative approaches to enhance their maturity levels.

TABLE II. DIGITAL TRANSFORMATION SUCCESS FACTORS FOR SMART CITY MATURITY

No.	Success Factor	Best Practice	City/ Country	Study
1.	ICT Infrastucture	Public data management, traffic management, and public service management	Bandung, Surabaya, Depok, Surakarta Indonesia Bad hersfeld, Germany & Brazil	[6], [8], [10], [12], [15]
		Application of IoT, big data, and cloud platforms to monitor vehicles, environment, and city conditions	Shenzhen & Hangzhou, China, Manado, Indonesia & Turkey	[7], [9], [16], [17]
		Development of internet networks, data centers, and cyber security to maintain system reliability and service integration.	Cerete, Columbia, Manado, Indonesia	[11], [18], [19]
		Use of AI and CPS technology to increase responsiveness to community needs	Surakarta, Indonesia	[6]
2.	Data Integration	Using middleware and open systems (open data) for interoperability between services	Depok, Indonesia	[8]
		Integrating data through big data analytics, cloud computing, and intelligent grid for operational efficiency	London, UK, Cerete, Columbia & China	[9], [14], [18]
		Provides a centralized data system and online portal that enables comprehensive integration of information	Brazil	[10], [20], [21]
3.	Government Policies & Strategic Planning	Develop strategic policies that support digitalization, including education, health, and security.	Shenzhen & Hangzhou, China, Manado, Indonesia & Brazil	[7], [10], [11]
		Using business cases as a guide in planning smart city initiatives	Depok, Indonesia	[8]
		Improving economic quality through the development of digital-based educational, tourism, and tourist attraction facilities	Surabaya & Bandung, Indonesia, Sao Paolo & Rio de Janeiro, Brazil	[12], [21], [22]
4	Stakeholder Engagement	Engaging citizens through online participation platforms such as Musrenbang and co-creation	Depok & Manado, Indonesia	[8], [11], [19], [20]
		Leveraging social media, hackathons, and feedback tools to design collaborative solutions	China, Bad hersfeld, Germany, Scheidam, Netherlands	[9], [15], [20], [23]
		Fostering collaboration between the public and private sectors, for example, through revitalizing digital markets	Surakarta, Indonesia	[6]
5.	Environmental Sustainability	Managing waste, air, and water pollution through environmentally friendly technologies	Bandung & Surabaya, Indonesia, Turkey & Shenzhen, China	[7], [12], [17]
		Monitoring air, water, and energy quality using IoT and environmental automation systems	Hangzhou, China	[7]
6.	Innovation & HR Development	Using innovative visualization and planning methods such as the Rich Picture method for smart city initiatives	Surakarta, Indonesia	[6]
		Improving human resource readiness with digital technology training and data-based leadership	Manado, Indonesia & London, UK	[14], [16]
		Managing infrastructure and public services adaptively with trained human resources	Manado, Indonesia	[11]

1) ICT Infrastructure

ICT infrastructure is the main foundation of the development of a smart city, and it supports the dimensions of smart mobility and smart living. Best practices in this case include public data management, big data network development, use of IoT devices, application of AI, and strengthening cybersecurity [6], [7], [9], [11], [19]. The significant impact of the application of this technology is seen in increasing the efficiency of public services, traffic management, and response to natural disasters [10], [12], [15], [16]. Examples of the best implementations can be found in Shenzhen, Hangzhou, and Surakarta, which have integrated digital systems to monitor city conditions in real-time using cloud platforms, environmental sensors, and IoT technology [6], [7]. This technology helps these cities manage traffic and provides valuable information for handling problems quickly and efficiently.

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2) Data Integration

Data integration is essential to support interoperability between various public services, supporting the dimensions of Smart Governance and Smart Environment. Best practices in this regard include the use of middleware, big data, cloud computing, and smart grids [8], [9], [20]. Good data integration, such as that implemented through online portals, enables better coordination between sectors [21]. Cities such as Depok have successfully applied data integration to improve the quality of data-based decision-making [8]. In both cities, using middleware and big data analytics has increased data management efficiency and coordination between sectors, improving public service quality.

3) Government Policies & Strategic Planning

Government policies that support digitalization and strategic planning play a significant role in the success of smart cities, especially in the dimension of smart governance. Policies that support digital-based education, security, and health sectors are top priorities in various cities [10]. For example, in Brazil and Manado, policies focused on developing smart infrastructure and digitizing essential sectors such as education and health have created infrastructure planning that is more adaptive to technology [10], [11]. The impact of this policy is the creation of an ecosystem that is more responsive to the community's digital needs, as well as progress in building smarter and more efficient infrastructure.

4) Stakeholder Engagement

Stakeholder engagement is a key factor in ensuring the sustainability of Smart City initiatives. Best practices in this regard include online Musrenbang in Depok, co-creation through hackathons in Schiedam, and digital market revitalization in Surakarta through public-private collaboration [6], [8], [23]. These successes demonstrate the importance of community participation in decision-making and policy implementation. For example, in Depok, online Musrenbang allowed communities to participate directly in digital-based development planning [8]. In Schiedam, hackathons and co-creation became essential to engage communities in creating technology-based solutions [23]. Surakarta also successfully engaged the private sector in digital market revitalization, strengthening cross-sector collaboration and increasing community participation in smart city development [6].

5) Environmental Sustainability

Environmental sustainability is a significant focus in the Smart Environment dimension. Many cities have leveraged technology to monitor air, water, and energy quality more efficiently. Surabaya and Hangzhou, for example, have used sensor and IoT technology to monitor air pollution and water quality and optimize energy use [7], [12]. This technology contributes to better management of natural resources and helps reduce negative environmental impacts. Using this technology, both cities can more efficiently manage their environment, leading to long-term sustainability and a reduced ecological footprint.

6) Innovation and Human Resource Development

Visionary leadership and human resource capacity development are crucial in ensuring the success of Smart City projects, especially in the Smart People dimension. The cities of Surakarta demonstrate that human resource capacity development through digital training and innovative methods such as Rich Picture can enhance the ability of individuals and organizations to manage Smart City projects [6]. Strong leadership and investment in human resource training and development enable cities to be better prepared for the challenges of technological change and increase the effectiveness of implementing existing technology initiatives.

B. Comparison of Smart City Implementations: Local Context, Challenges, and Opportunities

A comparison of Smart City implementations in various cities shows that each region has a different approach tailored to its local characteristics and needs. Surabaya and Hangzhou, as examples of large cities, utilize high technology to address complex urban challenges, such as air pollution and traffic congestion. In both cities, the use of the Internet of Things (IoT), big data, and cloud platforms have enabled real-time traffic management and air quality monitoring [7], [12]. These technologies not only improve the operational efficiency of the city but also provide solutions to environmental and mobility problems that large cities often face. In contrast, smaller cities such as Schiedam and Depok rely on a more participatory approach in integrating data and involving the community in decision-making. In Schiedam, for example, co-creation through hackathons and citizen participation in online Musrenbang in Depok has contributed significantly to developing technology-based solutions tailored to the needs of the local community [8], [23].

Local context greatly influences how technology is implemented in each city, with large cities tending to rely on advanced technology solutions while smaller cities focus more on empowering citizens. Larger cities, with denser populations and more significant infrastructure challenges, tend to require more sophisticated systems, such as IoT and big data, to manage resources and solve big problems. Smaller cities, on the other hand, focus more on strengthening citizen participation and streamlining administrative processes through digital platforms. The main challenges facing cities transitioning to Smart Cities are budget constraints, lack of coordination between stakeholders, and resistance to technological change. However, there are also significant opportunities, primarily through public-private collaborations, that can open up access to new technologies and the potential for increased citizen engagement that is increasingly open through digital platforms.

IV. CONCLUSION

The findings of this study emphasize that the success of digital transformation in advancing smart city maturity is shaped by six critical factors: ICT infrastructure, data integration, government policies and strategic planning, stakeholder engagement, environmental sustainability, and innovation in human resource development. These factors are pivotal in enabling cities to enhance operational efficiency, sustainability, and responsiveness to urban challenges. Specifically, robust ICT infrastructure facilitates the

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deployment of smart technologies, while data integration enables real-time decision-making, essential for managing urban dynamics. Strong government policies and strategic planning create a supportive regulatory environment, guiding smart city initiatives. Engaging stakeholders, from citizens to the private sector, ensures that solutions are inclusive and well-adapted to the community's needs. Moreover, environmental sustainability addresses long-term urban viability, while innovation in human resource development ensures the availability of skilled personnel to manage and maintain smart city systems.

The best practices identified, such as using IoT and big data in large cities like Jakarta and Shenzhen and participatory initiatives like hackathons and online Musrenbang in cities like Depok and Schiedam, underscore the importance of context-specific approaches. Larger cities leverage advanced technological systems to tackle complex urban challenges, benefiting from their higher resource base. In contrast, smaller cities often prioritize community-driven, participatory methods, which foster inclusivity and adaptability in the face of limited resources. This contrast highlights the necessity of aligning smart city strategies with local needs, capacities, and socio-political contexts. While challenges such as budget constraints, stakeholder coordination, and resistance to change persist, opportunities for public-private partnerships and greater citizen engagement offer significant pathways for overcoming these barriers. By addressing these factors holistically and tailoring strategies to local conditions, cities can foster innovative, inclusive, and sustainable urban development.

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