West Science Nature and Technology
Vol. 1, No. 02, December 2023, pp. 64~72

Implementation of Digitalization of City Infrastructure for Improved Sustainability: Case Study on Smart City Project in Surabaya, Indonesia

Loso Judijanto[1], Moh. Erkamim[2], Erlin Dolphina[3], I Wayan Karang Utama[4]
[1]IPOSS Jakarta, Indonesia
[2]Universitas Tunas Pembangunan Surakarta
[3]Universitas Dian Nuswantoro
[4]ITB Stikom Bali

Article Info

Article history:

Received December 2023
Revised December 2023
Accepted December 2023

Keywords:

Digitalization City
Infrastructure
Improved Sustainability
Smart City Project
Surabaya
Indonesia

ABSTRACT

The application of digitalization in urban contexts, particularly through Smart City initiatives, has become an important avenue to address the complexities of modern urban life. This study focuses on the Smart City Project in Surabaya, Indonesia, aiming to quantitatively analyze the impact of digitalization on sustainability indicators from a community perspective. A quantitative approach, including a survey of 190 residents and regression analysis, was used to comprehensively explore the relationship between demographic factors, perceptions of digital infrastructure and sustainability outcomes. The results showed statistically significant improvements in sustainability indicators, with waste reduction behavior and community satisfaction being particularly important. Regression analysis shows that age, income, and digital literacy significantly influence sustainability outcomes. These findings contribute to the growing body of knowledge on Smart Cities initiatives, offering insights for policymakers, urban planners, and community leaders to increase the effectiveness of digitalization in fostering sustainable urban environments.

Corresponding Author:

Name: Loso Judijanto
Institution: IPOSS Jakarta, Indonesia
Email: losojudijantobumn@gmail.com

1. INTRODUCTION

Cities around the world are exploring innovative approaches to improve sustainability and the quality of life for their residents. These approaches include developing local environmental regulations to supplement national and environmental laws [1]. Sustainable urbanization is seen as a way to create employment opportunities, enhance land utilization efficiency, and provide better services and living standards [2]. The concept of smart cities, which utilize new technologies and managerial approaches, is gaining importance in the 21st century [3]. Technological advancements are being used to make cities more sustainable, livable, and accessible, with a focus on reducing carbon emissions, optimizing resource consumption, and improving safety and health [4]. The 15-Minute City model has emerged as a popular approach, emphasizing mixed land-use and the use of smart

technologies to create more sustainable and inclusive cities [5]. These various strategies and paradigms aim to address the challenges of urbanization and promote sustainability in cities worldwide.

The Smart City concept has emerged as a transformative paradigm that leverages digital technologies to optimize urban services, resource utilization, and overall efficiency [6]. The integration of digital technologies in the urban planning of Surabaya, Indonesia, through its comprehensive Smart City Project, raises interesting questions about the impact of the initiative on sustainability from a community point of view [7], [8]. The concept of Smart Cities promises increased efficiency and performance of urban areas, but it is important to ensure that it is driven by deeper values and integrated into the delivery of solutions to multiple local and global needs [9]. The use of emerging technologies, such as blockchain, can improve processes development for smart cities, ensuring scalability and community participation [10].

2. LITERATURE REVIEW

2.1 Urbanization Trends and Challenge

The global phenomenon of urbanization has led to significant changes in the demographic and spatial landscapes of cities. As populations migrate towards urban centers, there are several challenges that arise. These include increased demand for energy, strained transportation systems, and heightened environmental stress [11]. Urbanization has resulted in increased population density and built-up patch density, particularly in Asia and Africa, while urbanization in Europe and North America has been steadier [12]. Urban areas in the Global South tend to be more sustainable in terms of land-energy-air sustainability compared to rural areas, while urban areas in the Global North are less sustainable than their surrounding rural regions. Urbanization processes have not slowed down the achievement of Sustainable Development Goals (SDGs) after a turning point [13]. Integrating Earth Observation data is crucial for tracking urbanization and SDGs, and can guide context-specific strategies towards a sustainable and livable future for cities. Understanding these trends is crucial for framing the context within which Smart City initiatives, like the one in Surabaya, aim to address the complexities of urban living.

2.2 Smart Cities and Digital Infrastructure

The emergence of smart cities represents a paradigm shift in urban development, leveraging digital technologies to enhance efficiency, sustainability, and the overall quality of life for residents. Digital infrastructure, including interconnected sensor networks, data analytics, and IoT devices, plays a crucial role in optimizing city services. By integrating smart technologies, cities aim to manage resources more effectively, reduce environmental impact, and enhance the resilience of urban ecosystems [14], [15]. Smart city policies have been found to significantly promote the construction of digital infrastructure, with positive spatial spillover effects [16]. The effective management of heterogeneous sensor systems and the role of metadata are key in enabling disaster responses in smart cities [17] [4]. The digitization of society and the economy through innovative use of ICTs has great potential for growth and is the basis for further development and competitiveness [18].

2.3 Sustainability Indicators

Measuring sustainability in urban contexts requires a comprehensive framework that encompasses economic, social, and environmental dimensions. Existing literature offers various sustainability indicators, including energy efficiency, waste management, air quality, and community well-being [19], [20], [21], [22]. These indicators are used to assess the effectiveness of management strategies and progress towards sustainability goals and objectives. Stakeholder engagement and participation are crucial in identifying and selecting these indicators to ensure credibility and reliability. Additionally, frameworks

such as ISO 37130:2018, United Nations Sustainable Development Goals (UN SDGs), and customized frameworks for sustainable cities (CFSS) provide reliable sources for selecting criteria and indicators for assessing the sustainability performance of cities and communities. However, there is a need for more comprehensive insights into sustainable development, particularly in the areas of urban sustainability and economic growth. The integration of sustainability dimensions into urban planning practices is still limited, but there is a growing awareness of the importance of considering dimensions such as greenhouse gas emissions, rainwater management, and urban green spaces. Practical solutions, such as web-based applications, can help collect relevant data and compute sustainability scores for cities, promoting sustainable urban development. The identification and measurement of these indicators provide a lens through which the impact of digitalization on sustainability can be assessed in the specific context of Surabaya [23].

2.4 Community Perspectives on Digitalization

Communities are not just passive recipients of urban development initiatives but active participants whose perspectives shape the success or failure of such endeavors [24]. Understanding how communities perceive and interact with digital infrastructure is essential for evaluating the broader implications of Smart City projects [25]. Literature in this domain explores the socio-cultural aspects of technology adoption, the digital divide, and the potential for technology to empower or disenfranchise different segments of the population [26].

2.5 Digital Divide and Social Equity

Smart City initiatives have the potential to exacerbate existing social inequalities, particularly through the digital divide that results in differential access and utilization of digital technologies. Examining literature on social equity in the digital age is crucial for understanding the unintended consequences of Smart City projects on marginalized communities. Fried emphasizes the importance of designing policies that ensure shared benefits for everyone and promote open and democratic processes to smartness [27]. The individual's role in the smart city is often misinformed, and real political participation is hindered without a clear political vision preceding the technical dimension [17]. Almarri and Boussabaine highlight the need to consider critical success factors for public-private partnerships (PPP) in smart city infrastructure projects, including partnership and collaboration, financial sustainability, and contract governance [28].

2.6 Success Factors and Challenges in Smart City Implementation

Successful implementation of Smart City initiatives requires overcoming challenges such as governance structures, stakeholder engagement, technological interoperability, and adaptive urban planning [29], [30]. Literature in this area explores the factors influencing the success or failure of Smart City initiatives and emphasizes the need for resilient and adaptable urban planning [10]. Additionally, the importance of designing policies for smart cities and the influence of governance on policy design are highlighted. The use of emerging technologies, such as Blockchain, is proposed as a solution to overcome the limitations of current smart city approaches [31]. Furthermore, it is crucial to consider the concerns and perspectives of citizen-stakeholders in the development of smart cities, as their acceptance and engagement are essential for success. Overall, the literature emphasizes the need for a holistic approach that addresses various dimensions, including governance, stakeholder engagement, technological interoperability, and citizen perspectives, to ensure the successful implementation of Smart City initiatives.

2.7 Global Perspectives on Smart City Initiatives

A comparative analysis of Smart City initiatives globally provides insights into diverse approaches, lessons learned, and best practices. Understanding how other cities have navigated the complexities of digitalization in urban contexts informs the

evaluation of Surabaya's Smart City Project within a broader international framework. The analysis of smart city projects reveals key directions in transportation, governance, energy, and water sectors, as well as the importance of multidisciplinary approaches and sustainability in assessments [32], [33], [34]. The study of smart city initiatives in the European Union highlights the different levels of development and the relationship between smart cities and socio-economic characteristics [35]. Evaluating the social impacts of smart city technologies and services is crucial, and there is a need for more coherent and analytical approaches to comprehending impacts and building narratives of change [36]. These findings can provide valuable insights for evaluating Surabaya's Smart City Project and inform decision-making in the context of international best practices.

2.8 Gap in the Existing Literature and Rationale for Current Study

While existing literature provides a solid foundation for understanding the theoretical underpinnings of Smart Cities and their potential impact, there is a notable gap in empirical studies that specifically analyze the quantitative effects of digitalization on sustainability indicators, especially from a community perspective. This literature review sets the stage for the current research, which aims to bridge this gap by conducting a rigorous quantitative analysis of the Smart City Project in Surabaya, Indonesia, focusing on its impact on sustainability and community dynamics.

3. METHODS

The quantitative component involved a survey-based approach, targeting a sample size of 190 residents of Surabaya, Indonesia, selected through a stratified random sampling method. The survey explored perceptions, experiences and preferences regarding the digitization of city infrastructure and its impact on sustainability. Surabaya, as the focus of this research, is a sprawling metropolis that has actively embraced the Smart City paradigm. The case study design involved a comprehensive examination of Surabaya's Smart City Project, which includes digital infrastructure implementation, policy frameworks and community engagement initiatives. This design enabled a contextualized understanding of the specific dynamics at play and facilitated the extraction of nuanced insights.

3.1 Quantitative Data Collection

The primary method for quantitative data collection was a structured survey questionnaire. The survey is designed to collect demographic information, community perceptions of digital infrastructure, and responses regarding sustainability indicators. The survey will be distributed using a multichannel approach, including online platforms, physical copies at community centers, and in-person interviews. The data collection period is expected to last four weeks to ensure a diverse and representative sample.

3.2 Survey Instrument

The survey instrument was developed based on the established sustainability indicators, community engagement framework, and technology adoption model. The questions are designed to elicit responses that measure the impact of digitization on various aspects of sustainability, including energy efficiency, waste management, and overall community well-being. A Likert scale of 1-5, multiple-choice questions, and open-ended questions were strategically integrated to capture quantitative insights.

3.3 Sampling Strategy

A sample size of 190 respondents was determined based on considerations of statistical power and the diversity of Surabaya's population. Stratified random sampling ensured representation of various demographic categories, including age, gender, socio-economic status, and residential zone within the city. This approach increases the generalizability of the findings to the wider population in Surabaya.

3.4 Data Analysis

Quantitative data collected through the survey will be analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics, including frequencies, percentages, and averages, will be used to summarize demographic characteristics and survey responses. Inferential statistical techniques such as regression analysis and correlation assessment will be used to explore relationships between variables and identify significant factors that influence sustainability indicators.

4. RESULTS AND DISCUSSION

4.1 Demographic Sample

The analysis of data collected from 190 survey participants in Surabaya provides quantitative insights into the impact of the Smart City Project on sustainability indicators and community perspectives. The following numerical values represent key findings:

The analysis of data collected from 190 survey participants in Surabaya provides quantitative insights into the impact of the Smart City Project on sustainability indicators and community perspectives. The demographic profile of the participants reveals that 35% of the participants are aged between 18-30 years, 40% are aged between 31-45 years, 20% are aged between 46-60 years, and 5% are 61 years or older. In terms of gender distribution, 45% of the participants are male and 55% are female. Regarding income levels, 25% of the participants have low income, 45% have moderate income, and 30% have high income. The residential zones of the participants are divided into three categories, with 40% residing in the urban core, 30% in suburban areas, and 30% in the outskirts.

4.2 Descriptive Statistics

Digital infrastructure plays a crucial role in supporting corporate and business unit strategic objectives, influencing both business unit competitive performance and firm performance growth. The accessibility, reliability, and user-friendliness of digital services are important factors in shaping perceptions of digital infrastructure. Participants in the study rated the accessibility of digital services at 4.2 ± 0.6, the reliability of digital services at 4.1 ± 0.5, and the user-friendliness of digital services at 4.3 ± 0.4. Understanding how digital infrastructures influence business unit performance and firm performance growth is a key contribution of the research.

Sustainability indicators were quantitatively assessed on a Likert scale, with energy efficiency practices scoring 3.8 ± 0.7, waste reduction behaviors scoring 4.0 ± 0.6, and community satisfaction with sustainability initiatives scoring 3.9 ± 0.5.

4.3 Regression Analysis

Regression analysis was used to identify factors affecting sustainability outcomes. The results showed the following coefficients and significance levels:

The coefficient for age is 0.154, with a significance level of $p < 0.01$. This indicates a statistically significant positive correlation between age and sustainability outcomes. Younger participants tend to exhibit more sustainable behavior. The positive coefficient for age indicates that, on average, younger individuals are more likely to engage in sustainable practices. This is in line with existing literature that highlights the younger generation's receptiveness to environmental issues. Therefore, urban planners and policy makers should consider age-appropriate strategies when designing interventions to promote sustainability.

The coefficient for income is 0.124, with a significance level of $p < 0.05$. This indicates a statistically significant positive correlation between income level and sustainability outcomes. Participants with higher incomes tend to engage in more sustainable practices. The positive coefficient for income indicates that, on average, participants with higher incomes are more likely to adopt sustainable behaviors. This finding underscores the socio-economic dimension of sustainability and emphasizes the importance of inclusive strategies to ensure that the benefits of sustainability can reach individuals at different income levels.

The coefficient for digital literacy is 0.184, with a significance level of $p < 0.01$. This indicates a statistically significant positive correlation between digital literacy and sustainability outcomes. Participants with higher digital literacy tended to adopt more sustainable behaviors. The positive coefficient for digital literacy highlights the influential role of technology education in shaping sustainability outcomes. As individuals become more digitally literate, they are better equipped to engage with and benefit from the digital infrastructure implemented in the Smart Cities Project. Policymakers should prioritize digital literacy initiatives to improve the overall impact of Smart Cities projects on sustainability.

DISCUSSION

Impact on Sustainability Indicators

Quantitative analysis showed statistically significant improvements in sustainability indicators. The mean scores for energy efficiency practices, waste reduction behavior, and community satisfaction with sustainability initiatives in particular were higher than neutral (3.0), indicating a positive influence of the Smart Cities Project on residents' sustainability practices. The results showed that, on average, participants in Surabaya engaged in more sustainable practices after the implementation of the Smart City Project. This positive impact is particularly evident in waste reduction behavior, reflecting a community that is receptive to and supportive of sustainability initiatives.

Community Perspectives on Digitalization

Qualitative analysis of the open-ended responses revealed diverse community perspectives. While 70% of respondents expressed appreciation for the convenience brought by digital infrastructure, 30% voiced concerns regarding data privacy and the perceived digital divide. This underscores the importance of continued community engagement to address these concerns and ensure equitable benefits. The diverse community perspectives highlight the need for a balanced approach in Smart City initiatives, addressing both the positive aspects and concerns voiced by residents. Effective communication, transparency and targeted interventions can contribute to bridging the gap and foster a more inclusive and participatory Smart Cities ecosystem.

Factors Affecting Sustainability Outcomes

The positive coefficient for age indicates that, on average, younger individuals are more likely to engage in sustainable practices. Urban planners and policymakers should consider age-appropriate strategies when designing interventions to promote sustainability. The younger generation has shown a high level of environmental awareness and generally positive environmental attitudes [37]. This is in line with existing literature highlighting the younger generation's acceptance of environmental issues. By involving youth in environmental initiatives, such as youth-based programs implemented by government and non-governmental organizations, their active participation can be encouraged [38]. Additionally, sustainable urban planning should take into account the long-term visions and comprehensive approaches based on sustainability principles [39]. This includes interventions into existing urban spaces, such as urban recycling, to adapt to contemporary needs [40]. By incorporating renewable energy, new technologies, and smart solutions, cities can improve their efficiency in resource use and reduce their environmental impact [41]. Therefore, considering the younger generation's environmental awareness and attitudes, age-appropriate strategies should be implemented to promote sustainability in urban planning and policymaking.

The positive coefficient for income indicates that, on average, participants with higher incomes are more likely to adopt sustainable behaviors, in line with [42]. This finding underscores the socio-economic dimension of sustainability and emphasizes the importance of inclusive strategies to ensure that the benefits of sustainability can

reach individuals at different income levels [43].

Digital literacy plays a crucial role in shaping sustainability outcomes in the context of Smart Cities projects. As individuals become more digitally literate, they are better equipped to engage with and benefit from the digital infrastructure implemented in these projects. This highlights the need for policymakers to prioritize digital literacy initiatives in order to improve the overall impact of Smart Cities projects on sustainability [44].

Implications

The implications of the results suggest that a multifaceted approach is necessary for sustained and inclusive success in Smart City initiatives. Policymakers should consider demographic variations and invest in education and outreach programs that cater to different segments of the population.

Limitations and Future Research Directions

It's important to acknowledge limitations, including the cross-sectional nature of the study and potential confounding variables. Future research could employ longitudinal designs, delve deeper into the specific mechanisms through which age, income, and digital literacy influence sustainability outcomes, and explore the impact of additional variables not considered in this study.

5. CONCLUSION

The Smart City project in Surabaya has had a noticeable impact on sustainability indicators and community dynamics, including positive trends in energy efficiency practices, waste reduction behaviors, and overall community satisfaction. Demographic factors such as age, income, and digital literacy play an important role in shaping the outcomes of Smart City initiatives, highlighting the need for customized interventions. Community perspectives show a diverse landscape, with an appreciation of the convenience brought by digital services but also concerns about data privacy and potential digital divides. Regression analysis showed a positive correlation between digital literacy and sustainable behavior, emphasizing the importance of education and technological empowerment. The results of this study offer practical implications for refining policies, prioritizing education programs, and addressing community concerns in Surabaya's journey towards Smart Cities. This research contributes to the scientific discourse on Smart City initiatives, providing insights for informed decision-making in sustainable urban development.

REFERENCES

[1] V. Sankaran and A. Chopra, "Creating Global Sustainable Smart Cities (A Case Study of Masdar City)," *J. Phys. Conf. Ser.*, vol. 1706, no. 1, 2020, doi: 10.1088/1742-6596/1706/1/012141.

[2] A. Hasan Rashed, "The Impacts of Unsustainable Urbanization on the Environment," *Sustain. Reg. Plan.*, no. February, 2023, doi: 10.5772/intechopen.110089.

[3] A. Sanjaya, S. A. Krisna, and T. B. Mursito, "Research Trends of Smart City in Indonesia: Where Do We Go from Here?," *Ina - Rxiv Pap.*, pp. 1–7, 2018.

[4] A. T. Rosário and J. C. Dias, "The New Digital Economy and Sustainability: Challenges and Opportunities," *Sustain.*, vol. 15, no. 14, 2023, doi: 10.3390/su151410902.

[5] Z. Allam, S. E. Bibri, D. Chabaud, and C. Moreno, "The Theoretical, Practical, and Technological Foundations of the 15-Minute City Model: Proximity and Its Environmental, Social and Economic Benefits for Sustainability," *Energies*, vol. 15, no. 16, pp. 1–20, 2022, doi: 10.3390/en15166042.

[6] Z. Allam and P. Newman, "Redefining the smart city: Culture, metabolism and governance," *Smart Cities*, vol. 1, no. 1, pp. 4–25, 2018, doi: 10.3390/smartcities1010002.

[7] A. De Bem Machado, J. R. Dos Santos, A. Sacavém, and M. J. Sousa, "Digital transformation: Management of smart cities," *Smart Cities Digit. Transform. Empower. Communities, Limitless Innov. Sustain. Dev. Next Gener.*, pp. 59–83, 2023, doi: 10.1108/978-1-80455-994-920231004.

[8] C. Carpentiere, I. Mancuso, V. Albino, A. Petruzzelli, and U. Panniello, "Innovative Business Models for the Future Smart City," *Resourceedings*, vol. 3, no. 1, pp. 01–12, 2023, doi: 10.21625/resourceedings.v3i1.950.

[9] F. Michelotto and L. A. Joia, "Unveiling the Smart City Concept: Perspectives from an Emerging Market via the Social Representation Theory," *Sustain.*, vol. 15, no. 10, 2023, doi: 10.3390/su15108155.

[10] M. Fiore and M. Mongiello, "Blockchain for smart cities improvement: an architecture proposal," 2023, [Online]. Available: http://arxiv.org/abs/2305.03534

[11] J. E. K. Akubia and A. Bruns, "Unravelling the frontiers of urban growth: Spatio-Temporal dynamics of land-use change

and urban expansion in greater Accra metropolitan area, Ghana," *Land*, vol. 8, no. 9, pp. 1–23, 2019, doi: 10.3390/land8090131.

[12] P. Moran, M. Bosse, J. Marien, and W. Halfwerk, "Historical human activity shapes the genomic landscape of urban and forest t ′ ungara frogs," p. 628345, 2023.

[13] Y. Tian, N. E. Tsendbazar, E. van Leeuwen, R. Fensholt, and M. Herold, "A global analysis of multifaceted urbanization patterns using Earth Observation data from 1975 to 2015," *Landsc. Urban Plan.*, vol. 219, no. June 2021, p. 104316, 2022, doi: 10.1016/j.landurbplan.2021.104316.

[14] J. H. Hong and Y. T. Shi, "Integration of Heterogeneous Sensor Systems for Disaster Responses in Smart Cities: Flooding as an Example," *ISPRS Int. J. Geo-Information*, vol. 12, no. 7, 2023, doi: 10.3390/ijgi12070279.

[15] T. Dias, T. Fonseca, J. Vitorino, A. Martins, S. Malpique, and I. Praça, "From Data to Action: Exploring AI and IoT-Driven Solutions for Smarter Cities," *Lect. Notes Networks Syst.*, vol. 740 LNNS, no. Ml, pp. 44–53, 2023, doi: 10.1007/978-3-031-38333-5_5.

[16] M. Cook and A. Karvonen, "Urban planning and the knowledge politics of the smart city," *Urban Stud.*, 2023, doi: 10.1177/00420980231177688.

[17] M. Song, Y. Xiao, and Y. Zhou, "How Does the Smart City Policy Influence Digital Infrastructure? Spatial Evidence from China," *Land*, vol. 12, no. 7, pp. 1–14, 2023, doi: 10.3390/land12071381.

[18] N. Cvar, J. Trilar, A. Kos, M. Volk, and E. S. Duh, "The use of iot technology in smart cities and smart villages: Similarities, differences, and future prospects," *Sensors (Switzerland)*, vol. 20, no. 14, pp. 1–20, 2020, doi: 10.3390/s20143897.

[19] C. A. Poveda, "The Criticality of Using Frameworks Designed by Consensus (FDC) to Identify and Select Criteria and Indicators to Assess Sustainability Performance of Cities and Communities," *Challenges Sustain.*, vol. 11, no. 1, pp. 19–33, 2023, doi: 10.12924/cis2023.11010019.

[20] D. Wang, L. Dong, and S. Di, "Corrigendum: Data-driven comparison of urban sustainability towards sustainable urban development under sustainable development goals (SDGs): a review based on bibliometric analysis(Front. Energy Res., (2023), 11, (1168126), 10.3389/fenrg.2023.1168126)," *Front. Energy Res.*, vol. 11, no. October, p. 2023, 2023, doi: 10.3389/fenrg.2023.1319498.

[21] N. Ehlers, K. Schulze, C. Zong, M. Vollmer, B. Schroeter, and W. Lang, "A holistic analysis of sustainability metrics at an urban district scale," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1196, no. 1, 2023, doi: 10.1088/1755-1315/1196/1/012071.

[22] M. and Y. Augustine, "A new decade for social changes," *Tech. Soc. Sci. J.*, vol. 7, pp. 312–320, 2020, [Online]. Available: https://techniumscience.com/index.php/socialsciences/article/view/332/124

[23] L. Mangifera and W. Mawardi, "Digital Transformation and Its Impact on Financial Performance: in the Food and Beverage Small Business Sector," *Int. Conf. …*, pp. 49–61, 2022, [Online]. Available: https://ojsicobuss.stiesia.ac.id/index.php/icobuss1st/article/view/148%0Ahttps://ojsicobuss.stiesia.ac.id/index.php/icobuss1st/article/view/148/216

[24] O. Jakonen, "People-Centric and Inclusive Approach to Planning of Smart Cities," *CSID J. Infrastruct. Dev.*, vol. 6, no. 1, 2023, doi: 10.7454/jid.v6.i1.1087.

[25] H. Chourabi *et al.*, "Understanding smart cities: An integrative framework," *Proc. Annu. Hawaii Int. Conf. Syst. Sci.*, no. July 2014, pp. 2289–2297, 2012, doi: 10.1109/HICSS.2012.615.

[26] S. A. Rye, "Exploring the gap of the digital divide: Conditions of connectivity and higher education participation," *GeoJournal*, vol. 71, no. 2–3, pp. 171–184, 2008, doi: 10.1007/s10708-008-9154-8.

[27] F. Filgueiras and B. Silva, "Designing data policy and governance for smart cities: theoretical essay using the IAD framework to analyze data-driven policy," *Rev. Adm. Publica*, vol. 56, no. 4, pp. 508–528, 2022, doi: 10.1590/0034-761220220078x.

[28] G. Trencher, "Towards the smart city 2.0: Empirical evidence of using smartness as a tool for tackling social challenges," *Technol. Forecast. Soc. Change*, vol. 142, no. July, pp. 117–128, 2019, doi: 10.1016/j.techfore.2018.07.033.

[29] J. R. Gil-Garcia, T. Chen, and M. Gasco-Hernandez, "Smart City Results and Sustainability: Current Progress and Emergent Opportunities for Future Research," *Sustain.*, vol. 15, no. 10, pp. 1–17, 2023, doi: 10.3390/su15108082.

[30] N. Micozzi and T. Yigitcanlar, "Understanding Smart City Policy: Insights from the Strategy Documents of 52 Local Governments," *Sustain.*, vol. 14, no. 16, 2022, doi: 10.3390/su141610164.

[31] I. Mutambik, "The Global Whitewashing of Smart Cities: Citizens' Perspectives," *Sustain.*, vol. 15, no. 10, 2023, doi: 10.3390/su15108100.

[32] A. Sharifi, "A global dataset on tools, frameworks, and indicator sets for smart city assessment," *Data Br.*, vol. 29, 2020, doi: 10.1016/j.dib.2020.105364.

[33] J. J. Lacson *et al.*, "Smart City Assessment in Developing Economies: A Scoping Review," *Smart Cities*, vol. 6, no. 4, pp. 1744–1764, 2023, doi: 10.3390/smartcities6040081.

[34] C. Sharma, S. K. Sharma, and D. Gill, "Reassessing smart city components: An overview of the dynamic nature of smart city concept," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1186, no. 1, 2023, doi: 10.1088/1755-1315/1186/1/012017.

[35] D. Correia, J. L. Marques, and L. Teixeira, "The State-of-the-Art of Smart Cities in the European Union," *Smart Cities*, vol. 5, no. 4, pp. 1776–1810, 2022, doi: 10.3390/smartcities5040089.

[36] E. Hodson *et al.*, "Evaluating Social Impact of Smart City Technologies and Services: Methods, Challenges, Future Directions," *Multimodal Technol. Interact.*, vol. 7, no. 3, 2023, doi: 10.3390/mti7030033.

[37] I. Marotta, F. Guarino, S. Longo, and M. Cellura, "Environmental sustainability approaches and positive energy districts: A literature review," *Sustain.*, vol. 13, no. 23, pp. 1–45, 2021, doi: 10.3390/su132313063.

[38] A. R. Haliza, "Belia Malaysia dan Kelestarian Alam Sekitar: Satu Ulasan," *Perspekt. J. Sains Sos. dan Kemanus.*, vol. 12, no. 2, pp. 43–54, 2020.
[39] J. Červek, "SUSTAINABILITY APPROACHES TO URBAN PLANNING: RE-CYCLING URBANISM," pp. 12–19, 2020.
[40] M. P. Amado, A. J. Pinto, C. V. Santos, and A. Cruz, "Methods in sustainable urban process," *Port. SB 2007 - Sustain. Constr. Mater. Pract. Chall. Ind. New Millenn.*, pp. 694–701, 2007.
[41] R. Blums, J. Zvirgzdins, and I. Geipele, "Sustainable Development Strategy Options in Urban Environment," *Eng. Rural Dev.*, vol. 21, pp. 560–566, 2022, doi: 10.22616/ERDev.2022.21.TF188.
[42] N. Islam and J. Winkel, "Climate change and social inequality: The health and social costs of global warming," *Clim. Chang. Soc. Inequal. Heal. Soc. Costs Glob. Warm.*, no. 152, pp. 1–247, 2017, doi: 10.4324/9781315103358.
[43] E. C. Figueroa-García, J. J. García-Machado, and D. C. P. B. Yábar, "Modeling the social factors that determine sustainable consumption behavior in the community of Madrid," *Sustain.*, vol. 10, no. 8, 2018, doi: 10.3390/su10082811.
[44] F. Z. Azzahro, B. I. Norra, and C. A. Achmad, "The Relationship of Digital Literacy Ability With Students' Cognitive Learning Outcomes," *J. BIOEDUIN Progr. Stud. Pendidik. Biol.*, vol. 13, no. 1, pp. 28–35, 2023, doi: 10.15575/bioeduin.v13i1.24364.