

Integrating Smart City Indicators and Environmental Quality for Sustainable Urban Development in Padang, Indonesia

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Abstract: Smart city development generally focuses on technology utilisation and improving governance, while research integrating smart city indicators, environmental standards, and spatial disparities to support sustainable urban development is limited. The purpose of this study is to integrate these three elements to determine development priorities for Padang City. This study uses a mixed-methods approach that combines smart city analysis, spatial disparity, and environmental quality across 11 districts of Padang city. The results show that Padang Barat (2,80) and Padang Timur (2,95) are included in the low-priority category; Padang Utara (3,25), Nanggalo (3,30), Lubuk Begalung (3,50), Padang Selatan (3,60), and Koto Tengah (3,85) are included in the medium priority category. Meanwhile, Lubuk Kilangan (4,00), Kuranji (4,10), Pauh (4,20), and Bungus Teluk Kabung (4,35) are included in the high-priority category because their implementation remains ineffective. Compared to other regions, this priority area faces a more complex landscape and greater environmental challenges. Research shows that by combining smart city indicators, environmental quality, and spatial disparities, the development direction can be more closely aligned with regional characteristics. This will help make Padang city's development more inclusive, resilient and sustainable.

Keywords: Environmental Quality; Padang City; Smart City; Spatial Disparity; Sustainable Development

Introduction

One approach based on information and communication technology (ICT) is the smart city concept. This concept emerged from the worldwide rise in urbanisation and the growing complexity of urban problems (Jiang et al., 2022). The smart city concept is seen as capable of improving the efficiency of city governance, the quality of public services, and the overall well-being of society (Jiang et al., 2022). The concept of a "smart city" is essentially an effort to integrate existing urban infrastructure with advances in digital technology, enabling cities to operate more responsively, adaptively, and sustainably (Batty et al., 2012). Over time, this concept has evolved into a more strategic approach to supporting environmental sustainability and strengthening accessibility among the

wider community. It is no longer simply the application of technology to services (Bibri, 2021).

Recent environmental studies have shown that sustainable environmental management is closely linked to smart city development. Sustainable management primarily focuses on improving urban environmental quality, resource efficiency, waste management, energy optimisation, and climate change adaptation. Furthermore, the concept of a smart environment has become a crucial component of smart city development, emphasising the use of technology, ecological sustainability, and spatial management to support a sustainable urban ecosystem (Attaran & Kheibari, 2022). The smart city concept is considered to improve environmental monitoring, ecological risk mitigation, and sustainable urban planning with a data-driven approach (Bibri, 2019).

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This approach has previously been implemented in various digital-based development policies and strategies in many countries, including Indonesia (Sulistyaningsih et al., 2023). However, implementation often fails due to various constraints, such as governance, institutional capacity, and the availability of digital infrastructure (Tan & Taeihagh, 2020). Conversely, rapid technological advances can lead to widening social and geographic disparities, particularly in access to technology-based public services (Caragliu & Del Bo, 2023). From an environmental perspective, this mismatch in technological progress can lead to declines in environmental quality, public infrastructure access, ecological resilience, and spatial sustainability in urban areas (Fan et al., 2022).

Various studies have used a multidimensional framework to understand this complexity. This framework divides urban development into six main dimensions: smart economy, smart mobility, smart governance, smart society, smart living, and smart environment (Attaran & Kheibari, 2022). This structure can facilitate systematic analysis, enabling policy performance assessment and identifying elements that can influence the successful implementation of smart cities (Jasso et al., 2006). Smart environments play a strategic role in supporting sustainable urban development by enabling efficient resource use, protecting the environment, managing space, and implementing an environmental monitoring system (Kim et al., 2025). However, most research focuses on comparisons between cities, thus ignoring differences within cities and local environmental conditions (Kim et al., 2025).

Furthermore, numerous studies emphasise the need for a more comprehensive analysis of smart cities, focusing on regional characteristics, spatial disparities, environmental sustainability, and policy effectiveness (Trindade et al., 2017). This is crucial because smart city implementation often has disparate impacts across regions, influenced by socioeconomic conditions, infrastructure capacity, level of digitalisation, and local ecological vulnerabilities (Caragliu & Del Bo, 2023). If not balanced with data-driven planning and an appropriate regional approach, these mismatches can widen spatial disparities.

Previous studies have also found that the transformation towards smart cities has the potential to create an unequal distribution of benefits, both in environmental quality and in access to technology-based public services (Martinez et al., 2026). This situation suggests that spatial equality does not always correlate with urban modernisation. (Malaker & Meng, 2024). Therefore, the development of regional typologies and spatial analysis is an important tool for prioritising

interventions that align with the local needs and potential of each region (Malaker & Meng, 2024).

In a local context, such as Padang, Indonesia, efforts toward smart city transformation continue to be driven by various policies and initiatives regarding the development of smart city-based urban structures (Putera & Putri, 2025). However, due to urbanisation, Padang City faces various environmental issues, including uneven infrastructure development, environmental vulnerability, spatial disparities, and differences in access to public services across sub-districts (Haoxing & System, n.d.). To understand the effectiveness of smart cities in sustainable urban development, a more in-depth empirical evaluation is needed (Gil-Garcia et al., 2023). Furthermore, there has been no comprehensive research on the geographic differences and contextual factors that influence the success of smart city implementation across regions. However, it has long been recognised that social, economic, and environmental conditions influence sustainable urban development outcomes (Gil-Garcia et al., 2023).

In the process of developing smart cities, approaches such as spatial analysis, composite indices, and regional typologies help us view cities more holistically and realistically, not just as data, but as living spaces with varying conditions across regions. From coastal areas to lowlands and hills, each sub-district in Padang has distinct physical characteristics and environmental challenges. (Addea Islami et al., 2024). These differences suggest that development policies cannot be generalized; instead, they must be designed more adaptively, taking into account real-world conditions to ensure that smart city development is more targeted, equitable, and sustainable across the region.

Method

This research uses a mixed-methods approach, combining quantitative and qualitative methods within a single study, to gain a more comprehensive understanding (Josephine Oranga, 2025). The main characteristic of mixed methods is the integration of quantitative and qualitative data across the collection, analysis, and interpretation stages. By integrating data, research can produce a more in-depth understanding and greater validity, resulting in more robust research outcomes (Östlund et al., 2011).

Location and Duration of Research

Conducted across all sub-districts of Padang City, this study reflects the overall local conditions. The study was conducted from December 8, 2025, to April 6, 2026.

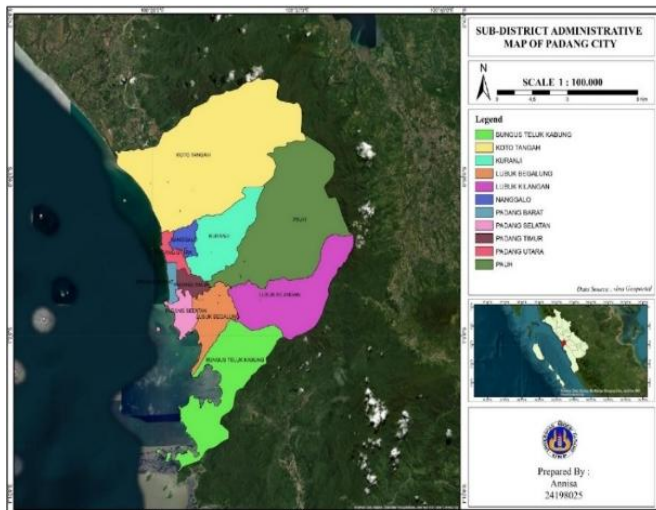


Figure 1. Peta Administrative map of Padang 2026

Table 1. Research Variables

Problem Formulation	Research Variables	Key Indicators	Measuring Scale
Effectiveness of smart city implementation	Institutional Policy (KK)	Coordination and Regulation	Likert scale (1-5)
	Program and Activities (PK)	Program Implementation	Likert scale (1-5)
	Infrastructure (IP)	Digital Networks and System	Likert scale (1-5)
	Human Resource and Governance	Competence and Management	Likert scale (1-5)
	Utilization (PM)	Benefits for Society	Likert scale (1-5)
Integration Effectiveness, Regional Characteristics, And Regional Typology	Smart city effectiveness	Index result from the first problem formulation	Likert scale (1-5)
	Regional Characteristics	Socio-economics, demographics, and infrastructure	Index (0-100)
	Spatial disparity	Variation between regions	Index (0-100)
	Regional typology	Integration of effectiveness, characteristics, and levels of spatial disparity of regions	Score (1-5)
	Priority development directions	Level of need for smart city policy intervention	Priority classification

Data Collection Methods

In this study, the unit of analysis covers all sub-districts in Padang city. All sub-districts were used as objects of analysis without using a regional census method. Furthermore, informants were selected through purposive sampling, meaning they had the knowledge and understanding necessary for smart city implementation. (Tajik et al., 2024). Regional Apparatus Organisations (ODP), specifically the Environmental Agency, provided this information.

Data Analysis Methods

The results of interviews and questionnaires distributed to stakeholders involved in smart city implementation in Padang City (Hamamurad et al., 2022) helped establish priorities for the Smart City development. The data were then processed in Microsoft Excel to generate average values for each indicator and analysed descriptively (Divisi et al., 2017) in quantitative research. This approach is widely used because it can

Population and Sample Size

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Research Variables

The objectives of this research include assessing implementation effectiveness, analysing spatial disparities, and determining policy priorities for targeted smart city development. Based on these objectives, the research variables were formulated.

simplify data into a more understandable form using measures of central tendency such as the mean. This can facilitate interpretation and decision-making in research (Sudaryono, 2019).

This participatory approach is considered essential to support a more inclusive, targeted, and sustainable urban planning process. This method enables further identification of the needs, potential, and challenges in developing a smart city process, thereby ensuring that development directions are better aligned with local needs and conditions (Mahdad et al., 2024).

Then, in determining development priorities that can support sustainable development, the results of the smart city indicator analysis are combined with the condition of the urban environmental quality (Fauzan & Syaodih, 2022). Subdistricts with relatively low capacity to implement smart city initiatives and that are still facing many environmental problems should receive greater attention in development planning (Bibri et al., 2023). This method is based on the understanding that

smart cities are not only about the use of digital technology; they also help improve environmental quality, optimise resource use, and ensure equitable development across regions. (Shao & Min, 2025). As a result, the priorities established are expected to help transform Padang into a smarter, more competitive, and environmentally sustainable city. The following are the score results, which will then be classified as follows:

Table 2. Priority Direction for Smart City Policy Development

Interval	Category
≤2,50	Low priority
2,51 – 3,25	Medium priority
> 3,25	High priority

The average score for each research indicator is used to determine development priority categories. These scores are then categorised into low, medium, and high priority using a class interval approach (Febrian et al., n.d.). This is done to facilitate the interpretation of the results and the formulation of development policy directions. Minimum intervals, such as 2,50 and 3,25, are set based on score distribution and analysis needs (Sundoro et al., 2022). This is intended to provide a clearer picture of the importance of each region in smart city development.

Result and Discussion

Smart City Development Strategy to Improve Urban Environmental Sustainability

In this study, priority directions for smart city development are formulated by considering the level of smart city implementation and development disparities between sub-districts (Rahman & Szabó, 2022) in Padang city. The goal of this approach is to identify areas requiring greater attention to ensure equitable and sustainable development (Trindade et al., 2017).

Padang city still faces various urban environmental challenges, such as flood risk (Rusnani et al., 2021), poor waste management (Nabila et al., 2024), and limited green space (Akbar et al., 2023). These conditions demonstrate that urban development requires an approach that integrates technological advancements with environmental sustainability (Gil-Garcia et al., 2023). The smart city concept has been widely used to improve governance and public services (Mora et al., 2023). However, previous studies have tended to focus on the administrative and technological aspects of urban development, with little attention paid to its relationship to environmental issues and spatial inequality (Georgiadis et al., 2022).

This research demonstrates that few studies integrate analysis of smart city implementation, regional

disparities, and environmental issues into a single framework (Valencia-Arias et al., 2021). Therefore, the novelty of this research lies in the creation of a smart city priority model that combines the level of implementation, spatial disparities between sub-districts, and urban environmental challenges to develop more inclusive, adaptive, and sustainable development policies for Padang City. The following table shows the classification results of smart city development priorities in Padang city:

Table 3. Priority directions for smart city development

Subdistrict	Characteristics	Final score	priority
Padang Barat	High effectiveness, low disparity	2,80	Low
Padang Timur	High effectiveness, low moderate disparity	2,95	Low
Padang Utara	Moderate effectiveness, moderate disparity	3,25	Currently
Padang Selatan	Moderate effectiveness, high disparity	3,60	Currently
Nanggalo	Moderate effectiveness, moderate disparity	3,30	Currently
Lubuk Begalung	Moderate effectiveness, moderate-high disparity	3,50	Currently
Koto Tengah	Low-medium effectiveness, high disparity	3,85	Currently
Kuranji	Low effectiveness, high disparity	4,10	High
Lubuk Kilangan	Low effectiveness, high disparity	4,00	High
Bungus Teluk Kabung	Low effectiveness, very high disparity	4,35	High
Pauh	Low effectiveness, high disparity	4,20	High

The table above shows that the level of intervention needs varies across sub-districts based on the priority direction of smart city development in Padang city. The results indicate that several areas are given high priority, including Kuranji, Pauh, Lubuk Kilangan, and Bungus

Teluk Kabung. Medium-priority areas include North Padang, South Padang, Nanggalo, Lubuk Begalung, and Koto Tangah. Low-priority areas include West Padang, East Padang, and Koto Tangah. The following provides additional explanations in the form of a policy map of the priority direction of smart city development.

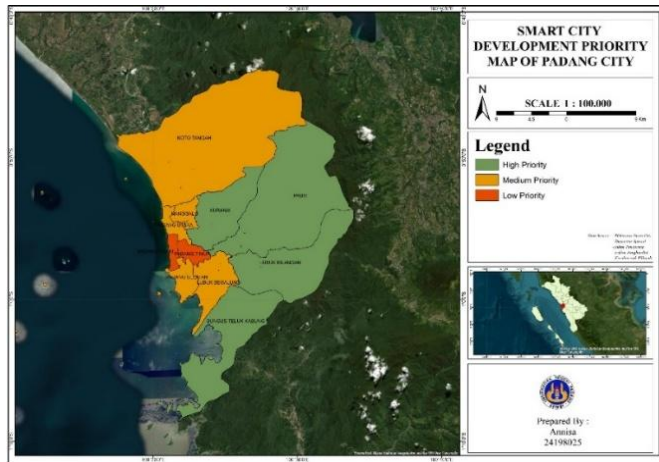


Figure 2. Map of priority directions for smart city development

The analysis results show that, to create policies more aligned with the needs of each sub-district and support sustainable development, the priority direction for smart city development in Padang city must consider both the level of implementation effectiveness and disparities between regions (Wang et al., 2024). This method aligns with the concept of a sustainable smart city, which views technology as a tool to improve public services and sustain the urban environment (Trindade et al., 2017).

Compared to other regions, Padang Barat and Padang Timur districts have demonstrated relatively high levels of success in smart city implementation, with low regional disparities. This indicates that various supporting components of smart cities, such as digital infrastructure, governance, and technology-based public services (Pereira et al., 2017), have developed quite well compared to other regions. Therefore, these two districts are included in the low-priority group.

Therefore, a more appropriate development direction for these two sub-districts is to concentrate on improving the existing system, increasing data integration between agencies, and enhancing public service innovation to make city management more efficient and effective (Sania & Sri Nugroho, 2025). To support city sustainability, a real-time environmental quality monitoring system, a technology-based waste management system, and increased energy efficiency can help achieve these goals (Bibri & Krogstie, 2020).

The medium priority group, consisting of the district of Padang Utara, Padang Selatan, Nanggalo, Lubuk

Begalung, and Koto Tangah, requires greater attention to reduce regional disparities in smart city implementation. This goal can be achieved through increased access to technology, improved public services, and strengthened local institutional capacity (Aditya et al., 2023).

This step is crucial because the region exhibits varying levels of implementation effectiveness, which can impact the overall success of urban development (Jaiswal, 2024). From an environmental perspective, Padang city is a coastal area with high vulnerability to flooding, landslides, and various hydrometeorological disasters, and is in dire need of improved environmental information systems (Zambrano Nájera et al., 2024). This technology can be used to manage urban drainage and develop early warning systems for disasters (Bacco et al., 2017).

The districts of Kuranji, Lubuk Kilangan, Bungus Teluk Kabung, and Pauh should be prioritized because research shows relatively low implementation effectiveness and significant regional disparities. This situation highlights unequal access to digital infrastructure, technology-dependent public services, and communities' ability to use technology. Therefore, these regions urgently need stronger interventions through digital infrastructure development, increased regional connectivity, enhanced digital literacy, and expansion of more inclusive e-Governance services (Kruhlov & Dvorak, 2025). These interventions are expected to reduce spatial disparities, which have been a major obstacle to the implementation of smart cities in developing regions (Caragliu & Del Bo, 2023).

From an environmental perspective, high-priority areas are crucial for biodiversity in Padang city. Most of these areas encompass buffer zones, such as ecological zones, watersheds, hilly areas, and coastal areas, which are vulnerable to development pressures and natural disaster risks (Driptufany et al., 2021). For example, the Bungus Teluk Kabung regency requires technology to maintain coastal environmental conditions and facilitate data-driven disaster mitigation (Ramadhan, 2021), while Pauh and Lubuk Kilangan regencies serve as conservation areas and water catchment areas (Dahlan & Omo Rusdiana, 2014), requiring the implementation of smarter environmental management systems (Nahib et al., 2025). Therefore, smart city development in these areas aims not only to improve the quality of public services but also to enhance environmental adaptability, maintain the region's ecological functions, and increase resilience to natural disasters and climate change (Lopez & Castro, 2021).

Overall, the findings of this study indicate that smart city development in Padang city must be carried out with an integrated approach that combines environmental sustainability, spatial disparities, and

implementation effectiveness (Gil-Garcia et al., 2023). This method allows the local government to create policies tailored to each sub-district's characteristics, resulting in a more efficient allocation of development resources. This smart city development strategy not only focuses on technology but also helps build Padang city into a more inclusive, resilient, and sustainable city (Sugandha et al., 2022).

Conclusion

In this study, smart city development in Padang city has not been evenly distributed across the region. Due to differences in implementation effectiveness and between sub-districts, development priorities vary. Padang Barat and Padang Timur were given low priority; Padang Utara, Padang Selatan, Nanggalo, Lubuk Begalung, and Koto Tangah were given medium priority; and Kuranji, Lubuk Kilangan, Bungus Teluk Kabung, and Pauh must be prioritized. These results demonstrate that developing Padang into a smart city requires an approach tailored to each region's characteristics and needs. According to environmental science, this research suggests that smart city development must be combined with environmental management and disaster risk reduction efforts, particularly in areas that serve as important ecological buffers for living organisms and areas with high levels of environmental vulnerability. Therefore, the most strategic step to building a better Padang city is to integrate smart city development to reduce spatial disparities and ensure environmental sustainability.

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Author Contributions

For research articles with multiple authors, a short paragraph outlining their individual contributions must be included. The following statements should be used: "Conceptualization, Annisa and Febriandi; methodology, Annisa and Febriandi; software, Annisa; validation, Febriandi; formal analysis, Annisa and Febriandi; investigation, Febriandi; resources, Annisa; data curation, Febriandi; writing—original draft preparation, Annisa; writing—review and editing, Annisa and Febriandi; visualization, Annisa; supervision, Febriandi; project administration, Annisa; funding acquisition, Annisa and Febriandi. All authors have read and agreed to the published version of the manuscript." Please turn to the term

explanation. Authorship must be limited to those who have contributed substantially to the work reported.

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Conflict of Interest

The authors state that there are no known personal relationships or financial interests that could be perceived as influencing the research discussed in this paper.

References

- Addea Islami, R., Edial, H., & Syarief, A. (2024). Flood Identification by Utilizing Remote Sensing and Spatial Analysis Techniques in Padang City. *International Remote Sensing Applied*, 5(1), 17. <https://www.indonesia-geospasial.com/2020/01/download-peta-rbi->
- Aditya, T., Ningrum, S., Nurasa, H., & Irawati, I. (2023). Community needs for the digital divide on the smart city policy. *Heliyon*, 9(8), e18932. <https://doi.org/10.1016/j.heliyon.2023.e18932>
- Akbar, H. H., Army, I., Arini, D., & Driptufany, D. M. (2023). Spatial Analysis of Green Open Space Based on Oxygen Needs in Padang City Center. 1(1), 1–9.
- Attaran, H., & Kheibari, N. (2022). Toward integrated smart city : a new model for implementation and design challenges. *GeoJournal*, 87(s4), 511–526. <https://doi.org/10.1007/s10708-021-10560-w>
- Bacco, M., Delmastro, F., Ferro, E., & Gotta, A. (2017). Environmental Monitoring for Smart Cities. *IEEE Sensors Journal*, 17(23), 7767–7774. <https://doi.org/10.1109/JSEN.2017.2722819>
- Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., Ouzounis, G., & Portugali, Y. (2012). Smart cities of the future. *European Physical Journal: Special Topics*, 214(1), 481–518. <https://doi.org/10.1140/epjst/e2012-01703-3>
- Bibri, S. E. (2019). The anatomy of the data-driven smart sustainable city: instrumentation, datafication, computerization and related applications. In *Journal of Big Data* (Vol. 6, Number 1). Springer International Publishing. <https://doi.org/10.1186/s40537-019-0221-4>
- Bibri, S. E. (2021). The core academic and scientific disciplines underlying data-driven smart sustainable urbanism: an interdisciplinary and transdisciplinary framework. *Computational Urban Science*, 1(1), 1–32. <https://doi.org/10.1007/s43762-021-00001-2>
- Bibri, S. E., Alexandre, A., Sharifi, A., & Krogstie, J. (2023). Environmentally sustainable smart cities and their converging AI, IoT, and big data technologies and solutions: an integrated approach

- to an extensive literature review. *Energy Informatics*, 6(1). <https://doi.org/10.1186/s42162-023-00259-2>
- Bibri, S. E., & Krogstie, J. (2020). Environmentally data-driven smart sustainable cities: applied innovative solutions for energy efficiency, pollution reduction, and urban metabolism. *Energy Informatics*, 3(1). <https://doi.org/10.1186/s42162-020-00130-8>
- Caragliu, A., & Del Bo, C. F. (2023). Smart cities and the urban digital divide. *Npj Urban Sustainability*, 3(1), 1–11. <https://doi.org/10.1038/s42949-023-00117-w>
- Dahlan, E. N., & Omo Rusdiana. (2014). PEMANFAATAN SUMBER DAYA AIR DI SUB DAS LUBUK PARAKU SUMATERA BARAT Water Resources. *Media Konservasi*, 19(1), 30–40.
- Divisi, D., di Leonardo, G., Zaccagna, G., & Crisci, R. (2017). Basic statistics with Microsoft Excel: A review. *Journal of Thoracic Disease*, 9(6), 1734–1740. <https://doi.org/10.21037/jtd.2017.05.81>
- Driptufany, D. M., Guvil, Q., Syafriani, D., Arini, D., & Author, C. (2021). FLOOD MANAGEMENT BASED ON THE POTENTIAL URBAN. 5(1), 49–54.
- Fan, C., Jiang, X., Lee, R., & Mostafavi, A. (2022). Equality of access and resilience in urban population-facility networks. *Npj Urban Sustainability*, 2(1), 1–12. <https://doi.org/10.1038/s42949-022-00051-3>
- Fauzan, F., & Syaodih, E. (2022). Kajian Implementasi Smart Environment di Kota Bandung. *Jurnal Riset Perencanaan Wilayah Dan Kota*, 1(2), 167–174. <https://doi.org/10.29313/jrpk.v1i2.481>
- Febrian, S., Irawan, M. D., Informasi, P. S., Teknologi, S. D., Islam, U., & Sumatera, N. (n.d.). Implementasi ahp dan topsis untuk menentukan prioritas pembangunan wilayah kota tebing tinggi 12. 8(1), 160–173.
- Georgiadis, C., Patias, P., Verde, N., Tsioukas, V., Kaimaris, D., Georgoula, O., Kocman, D., Athanasopoulou, E., Speyer, O., Raudner, A., Karl, M., & Gerasopoulos, E. (2022). State-of-play in addressing urban environmental pressures: Mind the gaps. *Environmental Science and Policy*, 132(March 2021), 308–322. <https://doi.org/10.1016/j.envsci.2022.02.030>
- Gil-Garcia, J. R., Chen, T., & Gasco-Hernandez, M. (2023). Smart City Results and Sustainability: Current Progress and Emergent Opportunities for Future Research. *Sustainability (Switzerland)*, 15(10), 1–17. <https://doi.org/10.3390/su15108082>
- Hamamurad, Q. H., Jusoh, N. M., & Ujang, U. (2022). Factors Affecting Stakeholder Acceptance of a Malaysian Smart City. *Smart Cities*, 5(4), 1508–1535. <https://doi.org/10.3390/smartcities5040077>
- Haoning, Z., & System, C. (n.d.). No 主観的健康感を中心とした在宅高齢者における健康関連指標に関する共分散構造分析Title.
- Jaiswal, A. (2024). the Regional Divide in Smart Cities Implementation a South-East Comparative Analysis. *International Journal of Research - GRANTHAALAYAH*, 12(12), 202–217. <https://doi.org/10.29121/granthaalayah.v12.i12.2024.6528>
- Jasso, H., Fountain, T., Baru, C., Hodgkiss, W., Reich, D., & Warner, K. (2006). Spatiotemporal analysis of 9-1-1 call stream data. *ACM International Conference Proceeding Series*, 151, 21–22. <https://doi.org/10.1145/1146598.1146608>
- Jiang, H., Geertman, S., & Witte, P. (2022). Smart urban governance: an alternative to technocratic “smartness”. *GeoJournal*, 87(3), 1639–1655. <https://doi.org/10.1007/s10708-020-10326-w>
- Josephine Oranga. (2025). Mixed Methods Research: Merits, Applications and Challenges. *International Journal of Social Science*, 5(2), 233–238. <https://doi.org/10.53625/ijss.v5i2.11034>
- Kim, J., Lee, D., Hwang, J., & Lee, J. (2025). What makes smart cities inclusive? The spillover effects of the intra-city digital divide on inter-city digital inequality. *Sustainable Cities and Society*, 135(October), 106939. <https://doi.org/10.1016/j.scs.2025.106939>
- Kruhlov, V., & Dvorak, J. (2025). Social Inclusivity in the Smart City Governance: Overcoming the Digital Divide. *Sustainability (Switzerland)*, 17(13), 1–20. <https://doi.org/10.3390/su17135735>
- Lopez, L. J. R., & Castro, A. I. G. (2021). Sustainability and resilience in smart city planning: A review. *Sustainability (Switzerland)*, 13(1), 1–25. <https://doi.org/10.3390/su13010181>
- Mahdad, M., Minh, T. T., Dinh, T. T., & Vanhaverbeke, W. (2024). Open strategizing for developing smart city food system: Stakeholder inclusion in practice. *Technology in Society*, 77(March), 102516. <https://doi.org/10.1016/j.techsoc.2024.102516>
- Malaker, T., & Meng, Q. (2024). Urban Disparity Analytics Using GIS: A Systematic Review. *Sustainability (Switzerland)*, 16(14). <https://doi.org/10.3390/su16145956>
- Martinez, J., Sánchez-vaquerizo, J. A., & Mahajan, S. (2026). Not your mean green : beyond averages in mapping socio-spatial inequities in urban greenery for smart cities.
- Mora, L., Gerli, P., Ardito, L., & Messeni, A. (2023). Technovation Smart city governance from an innovation management perspective : Theoretical framing , review of current practices , and future

- research agenda. *Technovation*, 123(January), 102717.
<https://doi.org/10.1016/j.technovation.2023.102717>
- Nabila, A., Aziz, R., & Indah, S. (2024). Investigasi Pengelolaan Sampah Berbasis Masyarakat Melalui Bank Sampah di Kota Padang. *Serambi Engineering*, 9(1), 8408–8416.
- Nahib, I., Wahyudin, Y., Ambarwulan, W., Pranoto, B., Ramadhani, F., Cahyana, D., Nugroho, N. P., Suwedi, N., Suryanta, J., Karolinoerita, V., Darmawan, M., Rudiastuti, A. W., Cahya, D. L., Winarno, B., Pianto, T. A., & Akbar, H. I. (2025). Spatial Analysis of Water Conservation and Its Driving Factors in an Urban Citarum Tropical Watershed: Geospatial Approach. *Resources*, 14(5), 1–23.
<https://doi.org/10.3390/resources14050077>
- Östlund, U., Kidd, L., Wengström, Y., & Rowa-Dewar, N. (2011). Combining qualitative and quantitative research within mixed method research designs: A methodological review. *International Journal of Nursing Studies*, 48(3), 369–383.
<https://doi.org/10.1016/j.ijnurstu.2010.10.005>
- Pereira, G. V., Macadar, M. A., Luciano, E. M., & Testa, M. G. (2017). Delivering public value through open government data initiatives in a Smart City context. *Information Systems Frontiers*, 19(2), 213–229. <https://doi.org/10.1007/s10796-016-9673-7>
- Putera, R. E., & Putri, I. A. (2025). Digital Transformation of Public Services in Padang City , West Sumatra Province Through Smart City Policy. (3), 710–734.
<https://doi.org/10.18502/kss.v10i18.19496>
- Rahman, M. M., & Szabó, G. (2022). Sustainable Urban Land-Use Optimization Using GIS-Based Multicriteria Decision-Making (GIS-MCDM) Approach. *ISPRS International Journal of Geo-Information*, 11(5).
<https://doi.org/10.3390/ijgi11050313>
- Ramadhan, D. (2021). 14022-40822-1-Pb. 1(1).
- Rusnani, Enita, Tukidi, & Haryanto, E. (2021). Journal of scientech research and development. *Journal of Scientech Research and Development*, 3(1), 24–32.
<https://idm.or.id/JSCR/index.php/JSCR/article/view/14>
- Sania, & Sri Nugroho, H. (2025). Efektivitas Interoperabilitas Data Pelayanan “LAPOR” Sleman Sebagai Perwujudan Smart Governance. *Jurnal Pemerintahan Dan Politik*, 10(3), 618–636.
- Shao, J., & Min, B. (2025). Sustainable development strategies for Smart Cities: Review and development framework. *Cities*, 158(March 2024), 105663.
<https://doi.org/10.1016/j.cities.2024.105663>
- Sudaryono. (2019). METODOLOGI PENELITIAN: Kuantitatif, Kualitatif, dan Mix Method (Edisi Kedu). Kharisma Putra Utama Offset.
- Sugandha, Freestone, R., & Favaro, P. (2022). The social sustainability of smart cities: A conceptual framework. *City, Culture and Society*, 29(October 2021), 100460.
<https://doi.org/10.1016/j.ccs.2022.100460>
- Sulistyaningsih, T., Purnama, R. A., & Kulsum, U. (2023). Smart City Policy: Strategy and Implementation to Realize Smart Urban Governance in Indonesia. *Journal of Governance and Public Policy*, 10(2), 105–117.
<https://doi.org/10.18196/jgpp.v10i1.13840>
- Sundoro, T., Utomo, S. H. T., Mulyono, A. T., & Muthohar, I. (2022). Penentuan Prioritas Program Penanganan Jalan Kabupaten Menggunakan Metode Multikriteria Di Kabupaten Kulon Progo. *Jurnal HPJI*, 7(1), 43–52.
<https://doi.org/10.26593/jhpji.v7i1.4552.43-52>
- Tajik, O., Golzar, J., & Noor, S. (2024). Purposive Sampling. 2(November), 1–9.
- Tan, S. Y., & Taeihagh, A. (2020). Smart city governance in developing countries: A systematic literature review. *Sustainability (Switzerland)*, 12(3).
<https://doi.org/10.3390/su12030899>
- Trindade, E. P., Hinnig, M. P. F., da Costa, E. M., Marques, J. S., Bastos, R. C., & Yigitcanlar, T. (2017). Sustainable development of smart cities: A systematic review of the literature. *Journal of Open Innovation: Technology, Market, and Complexity*, 3(3). <https://doi.org/10.1186/s40852-017-0063-2>
- Valencia-Arias, A., Urrego-Marín, M. L., & Bran-Piedrahita, L. (2021). A methodological model to evaluate smart city sustainability. *Sustainability (Switzerland)*, 13(20), 1–17.
<https://doi.org/10.3390/su132011214>
- Wang, C., Zhu, C., & Du, M. (2024). Spatial Development and Coupling Coordination of Society – Physics – Informational Smart Cities: A Case Study on Thirty Capitals in China.
- Zambrano Nájera, J., Luna, C. C., & Vélez Upegui, J. J. (2024). Performance assessment of indicators of a multi-hazards early warning system in an urban mountain region. *International Journal of Disaster Risk Reduction*, 112(August), 104767.
<https://doi.org/10.1016/j.ijdr.2024.104767>