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Article

DEVELOPING A SUSTAINABLE SMART CITY MODEL WITH INTEGRATED SUSTAINABILITY PERFORMANCE (ISP): THE MEDIATING ROLE OF INCLUSIVE JUSTICE AND TELEMEDICINE – A CASE STUDY OF MAKASSAR CITY, INDONESIA

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Abstract: The rapid population growth and increasing global energy demand have prompted the need for more resilient urban infrastructure, with Smart City serving as the primary solution. Objectives: This study aims to develop a Smart City model integrated with Integrated Sustainability Performance (ISP), involving five key variables: economy, environment, governance, livability, and pandemic resilience. As an innovation, inclusive city indicators and telemedicine are incorporated to strengthen the city's sustainability and resilience. Methods: This study applies a sequential explanatory mixed-methods design, starting with a quantitative survey analyzed using PLS-SEM, followed by qualitative interviews and FGDs to explain and enrich the findings. Results: The results of the analysis show that the implementation of Smart City in Makassar positively impacts ISP, with Telemedicine and Inclusive Justice serving as significant mediators. Conclusions: This study contributes to the development of a measurable and applicable Smart City model to enhance urban sustainability and resilience.
Keywords: Smart City, Integrated Sustainability Performance, Smart Governance, Smart Economy, Smart Living, Inclusive, Telemedicine, PLS-SEM

1. Introduction

Urban areas have been the centers of civilization since the times of ancient Greece through to the modern era. Although they occupy less than 5% of the Earth's surface, these areas absorb almost 75% of natural resources and contribute 60–80% of greenhouse gas emissions [1]. This situation underscores the urgent need to reassess urban policies and planning, particularly as the global population continues to rise. Amid the 21st-century digital revolution, cities are not only hubs for economic growth and technological innovation but also face significant challenges in infrastructure, governance, and public services that remain unevenly distributed [2-4].

The Smart City concept has been developed as an effort to revitalize urban areas using technology to address these challenges. The goal of Smart Cities is to create efficient, inclusive, and sustainable urban environments by improving citizens' quality of life through the utilization of information technology [5]. However, measuring the success of its implementation requires integrated and standardized indicators. Integrated Sustainability Performance (ISP) Indicators have become an approach increasingly used to evaluate the sustainability of smart city programs comprehensively [6].

In Indonesia, the "Gerakan Menuju 100 Smart City" program represents a strategic step toward realizing smart cities, with Makassar selected as the launch city due to its approach combining local wisdom and digital technology [7,8]. However, the implementation of this program still faces classical challenges, such as suboptimal data management, energy utilization, and the uneven provision of public services, including healthcare [7-11]. Therefore, this study aims to evaluate and develop an ISP Indicators model for the Smart City program in Makassar, assessing how sustainability indicators have been applied and how the integration of innovative services like telemedicine can support the efficiency and equity of healthcare access for urban residents.

2. RESEARCH METHODS

2.1 Research Type and Approach

This study employs a mixed-methods approach with a sequential explanatory design, in which the quantitative phase is conducted first, followed by the qualitative phase to provide deeper insights and contextual understanding of the results. In the quantitative phase, data were collected through a survey distributed to 42 respondents from government agencies involved in the Smart City program, such as BAPPEDA, the Department of Communications and Information (Dinas Kominfo), the Department of Environment (Dinas Lingkungan Hidup), the Department of Education (Dinas Pendidikan), the Public Works and Housing Department (PUPR), the Investment and One-Stop Integrated Services (DPMPTSP), and others. Respondents were selected based on inclusion criteria (at least one year of experience and knowledge of Smart City initiatives) and exclusion criteria (unwillingness to participate or health-related issues preventing participation).

The Smart City variable was measured through three main dimensions: Smart Governance, Smart Branding, and Smart Environment. The Integrated Sustainability Performance variable was measured using the dimensions of Smart Governance, Smart Economy, Smart Living, and Pandemic Resilience. Additionally, Inclusive Justice and Telemedicine were applied as mediating variables to assess their influence on the relationships between the main variables in the study model. This model aims to provide a new conceptual framework for evaluating the success of sustainable and equitable Smart City programs. In the qualitative phase, data were collected through focus group discussions (FGDs) with members of the Smart City Task Force in Makassar City. This phase aimed to validate and enrich the quantitative findings by exploring perceptions and experiences related to Smart City implementation. The qualitative results were analyzed through transcription, coding, and thematic categorization, offering additional insights into the dynamics of sustainability, inclusiveness, and justice in Smart City initiatives.

2.2 Data Analysis

2.3 Quantitative Analysis

Quantitative data were analyzed using Partial Least Squares - Structural Equation Modeling (PLSSEM). The measurement model was tested for reliability with Cronbach's Alpha (≥ 0.70) and validity through loading factor values (> 0.70). The model's goodness of fit was assessed using SRMR, RMSEA, Chi-Square, TLI, CFI, and GFI, with standard thresholds indicating model adequacy. Furthermore, R-squared (R^2) and p-value (< 0.05) were used to evaluate the influence of independent variables on dependent variables.

2.4 Qualitative Analysis

Qualitative data from interviews and FGDs were analyzed to interpret and expand upon the quantitative findings. Key themes were identified to provide contextual explanations for statistical relationships and to highlight challenges and opportunities in the implementation of Smart City programs in Makassa.

3. RESULTS AND DISCUSSION

3.1 Reliability Test

Before conducting the path analysis using Structural Equation Modeling (SEM), the researcher first performed a reliability test to ensure the consistency of the measurement instruments used. During this process, several question indicators were removed as they were considered incompatible with the theoretical structure of the model. For the Smart City variable, adjustments were made across its three dimensions. In the Smart Governance dimension, six indicators were retained while two were eliminated. The Smart Branding dimension maintained all its original indicators without any removal. Meanwhile, in the Smart Environment dimension, only two indicators were retained as one was excluded due to insufficient reliability.

Similarly, for the Integrated Sustainable Parameter (ISP) variable, the model retained three indicators each for the Smart Governance, Smart Economy, and Smart Living dimensions. In the Pandemic Resilience dimension, only three indicators were preserved while two others were removed for not meeting the reliability threshold. The Inclusive Development variable was measured using five consistent indicators, while the Telemedicine variable, which serves as a mediating factor in this research, was represented by three reliable indicators after two were excluded. The reliability of each dimension and variable was assessed using Cronbach's Alpha, with a minimum acceptable value of 0.6, indicating acceptable internal consistency. This reliability analysis was critical in refining the model and ensuring that only the most statistically valid and theoretically grounded indicators were used in the subsequent quantitative analysis as shown in Table 1.

Table 1. Reliability Test

<table>
<tr><th>Factors & Variables</th><th>Cronbach's α</th></tr>
<tr><td>Smart Governance (SG)</td><td>0.917</td></tr>
<tr><td>SG2
SG3
SG4
SG5
SG6
SG7
Smart Branding</td><td>0.733</td></tr>
<tr><td>SB1
SB2
Smart Environtment</td><td>0.715</td></tr>
<tr><td>SE1
SE2
ISP_Smart Governance</td><td>0.701</td></tr>
<tr><td>ISP_SG1
ISP_SG2
ISP_SG3
ISP_Smart Economics</td><td>0.715</td></tr>
<tr><td>ISP_SE1
ISP_SE2
ISP_SE3
ISP_Smart Living</td><td>0.720</td></tr>
<tr><td>ISP_SL1
ISP_SL2
ISP_SL3
ISP_Pandemic Resilience</td><td>0.713</td></tr>
</table>

ISP_PR1 ISP_PR2 ISP_PR4 Inklusi Berkeadilan	0.701
IK1 IK2 IK3 IK4 IK5 Telemedicine T2 T3 T5	0.716

3.2 PATH Analysis – SEM

Model Test

To assess the suitability of the proposed model, a path analysis was conducted by examining the significant relationships between the predetermined latent variables. The collected data were analyzed to calculate the mean values of each variable, which were then used to perform the path analysis in accordance with the previously developed conceptual model. Based on the Structural Equation Modeling (SEM) analysis using Jamovi software, the following results were obtained in Table 2 and Supplementary figure 1. Based on the results of the model fit analysis, it can be concluded that the model produced in this study meets the standards of a good model.

Table 2. Model Test Analysis

Indicators	**P-Value**	**Standard**
Chi-Square (X2)	0.606	> 0,05
SRMR	0.012	< 0,05
RMSEA	0.000	< 0,05
TLI	1.036	> 0,9
CFI	1.000	> 0,9
GFI	1.000	> 0,9

Sumber: Data Primer, 2024

R-Squared values

Subsequently, an analysis was conducted to predict the extent to which the independent variables influence the dependent variables in this study by examining the R-Squared values presented in Table 3. Table 3 shows p-values below 0.05, indicating a significant influence of the independent variables on the dependent variables. This is supported by the relatively high R^2 values for the variables Integrated Sustainable Parameters and Inclusive Development, which are 0.828 and 0.651, respectively. The closer the R^2 value is to 1, the greater the proportion of variance in the dependent variable that can be explained by the independent variables, signifying a strong predictive relationship within the model.

Table 3. R-Squared Value

Indicators	P-Value	Standard
Chi-Square (X^2)	0.606	> 0,05
SRMR	0.012	< 0,05
RMSEA	0.000	< 0,05
TLI	1.036	> 0,9
CFI	1.000	> 0,9
GFI	1.000	> 0,9

Source: Primary Data, 2024

Direct and indirect effect analysis

Table 4 demonstrates that all variables analyzed have a significant influence, as indicated by pvalues below 0.05. The detailed results are as follows:

Table 4. Direct Effect Analysis

95% Confidence Intervals						
Variable	R^2	Lower	Upper	Wald X^2	df	p
ISP	0.828	0.701	0.904	201.8	3	<.001
IK	0.651	0.444	0.796	78.3	1	<.001
Telemed	0.198	0.027	0.435	10.4	1	0.001

a) There is a significant effect of the Smart City variable on the Integrated Sustainability Performance (ISP) variable, with a p-value of <0.001.
b) There is a significant effect of the Inclusive Development variable on ISP, with a p-value of 0.034.
c) There is a significant effect of the Telemedicine variable on ISP, with a p-value of 0.01.
d) There is a significant effect of the Smart City variable on Inclusive Development, with a p-value of <0.001.
e) There is a significant effect of the Smart City variable on Telemedicine, with a p-value of 0.001.

These results confirm that the Smart City concept not only directly influences sustainability performance but also plays a crucial role in strengthening intermediary components such as inclusive development and telemedicine services. The analysis results indicate that the path analysis of indirect effects shows a significant influence (Table 5), with a p-value of less than 0.05.

4. Qualitative Results (Focus Group Discussion)

The researcher conducted a Focus Group Discussion (FGD) attended by the relevant Regional Government Organizations (OPD) involved in the implementation of the Smart City program in Makassar. Below is the matrix of the results from the FGD that was conducted.

Based on the FGD results, it is evident that the implementation of the Smart City in Makassar reflects the city government's strong commitment to improving public services and the overall quality of life for its residents. However, in its implementation, several challenges and obstacles were also highlighted by various Regional Government Organizations (OPD). These challenges were raised by stakeholders involved in the Smart City initiative in Makassar:

a) The large number of applications that are not well integrated has led to maintenance issues, while frequently changing policies have hindered long-term planning.
b) Although several Smart City initiatives are already in place, the biggest challenge lies in shifting public behavior to better support and adopt these programs.

c) Data security has become a major concern, particularly for applications used in health services. In response, the Health Department and the Department of Communication and Information (Kominfo) are collaborating to manage local servers more securely.

5. Discussion

The implementation of the Smart City concept in Makassar has shown positive impacts on the achievement of ISP, which aligns with the results of path analysis and Focus Group Discussion (FGD) findings. Technology-based programs in government management, economic empowerment, and improving citizens' quality of life have been key in achieving urban sustainability and resilience. The application of Smart City dimensions has contributed to the realization of an Integrated Sustainability Performance (ISP) that integrates social, economic, and environmental sustainability.

5.1 Path Analysis Results and FGD Findings: The Relationship Between Smart City and

The results of the path analysis show that the implementation of Smart City has a significant impact on Integrated Sustainability Performance (ISP), particularly in the dimensions of Smart Governance, Smart Economy, and Smart Living. The findings from the Focus Group Discussion (FGD) indicate that technology-based programs in Makassar, such as public service applications, telemedicine systems, and MSME incubators, have contributed to improving the quality of life, more transparent governance, and local economic empowerment.

Smart Governance, which emphasizes transparency, accountability, and public participation through technology, has proven effective in Makassar. Applications like Srikandi, Solata House, and LAPOR allow citizens to actively engage in decision-making and monitoring of public services. Annual evaluations conducted by BAPPEDA reflect the importance of community involvement in urban planning and management, which supports sustainable and more efficient governance. Technologybased governance plays a crucial role in enhancing transparency and public participation, which can also reduce distrust in the government [5,12].

Smart Economy also plays a vital role in achieving ISP. With initiatives like MSME incubators, bank-funded support, and tourism promotion through digital platforms, Makassar has successfully empowered the local economy [13-15]. This aligns with research view in The Competitive Advantage of Nations, stating that technology-based economic development enhances competitiveness and creates long-term competitive advantages for cities [16].

In the Smart Living dimension, Makassar has shown its commitment to improving the quality of life through digital health services like teleUSG and teleUKG, as well as homecare systems connected to the emergency call center 112. Initiatives for the inclusion of people with disabilities have also been strengthened. These efforts reflect the application of technology not only to enhance quality of life but also to ensure equitable access to public services. Darmawansyah et al. (2024) argues that the sustainability of urban life depends on how cities leverage technology to improve quality of life fairly and evenly for all citizens [17].

5.2 The Mediating Role of Telemedicine and Inclusive Justice in ISP

Telemedicine and inclusive justice play a key mediating role in strengthening the relationship between the implementation of Smart City initiatives and Integrated Sustainability Performance (ISP). Digital health services, such as teleUSG and teleUKG, expand access to healthcare, even in more remote areas. The homecare program connected to the 112 emergency system also contributes to the resilience of the public health system. The use of telemedicine can enhance the efficiency and responsiveness of healthcare systems during crises and improve the quality of healthcare services [18-20].

Furthermore, the inclusive justice program, implemented through the development of disabilityfriendly applications, demonstrates efforts to create a more inclusive city. The Makassar City Government is committed to providing better access for persons with disabilities, supporting the Smart Living dimension and enhancing social sustainability. The importance of creating an inclusive social environment as part of urban sustainability, which aligns with Makassar's efforts to build an ecosystem that supports all layers of society [21-22].

5.3 Conceptual Model of Smart City and ISP Integration

A conceptual model can be built to clarify the relationship between Smart City and Integrated Sustainability Performance (ISP), illustrating the interactions between the core dimensions of both concepts. The model shows that improved Smart Governance and Smart Economy, driven by technology, directly contribute to achieving ISP, particularly in terms of economic sustainability and governance resilience. Meanwhile, Smart Living and Pandemic

Resilience result from the interaction between technology and public services that are more inclusive and responsive to crises.

The model also highlights the role of telemedicine and inclusive justice as mediators that strengthen the Smart Living and Pandemic Resilience dimensions within ISP. By integrating technology into the healthcare sector, cities can enhance their resilience to health crises and ensure more equitable healthcare services for all citizens. Additionally, prioritizing inclusive justice ensures that vulnerable groups, such as persons with disabilities, have equal access to services provided by the Smart City. This conceptual model emphasizes how technological integration in various urban sectors can enhance the sustainability, resilience, and inclusiveness of cities, contributing to a holistic and balanced approach to urban development that meets both current needs and future challenges.

This study has several limitations that should be acknowledged. First, the findings are based on data from a single case study in Makassar City, which may limit the generalizability of the results to other urban contexts. Second, the reliance on Focus Group Discussion (FGD) participants introduces potential selection bias, as the representation of stakeholders may not fully capture the perspectives of all community groups. Third, secondary data related to telemedicine and inclusive justice programs were limited, which may affect the comprehensiveness of the analysis. Despite these limitations, the study provides valuable insights into how Smart City initiatives can enhance Integrated Sustainability Performance (ISP) through the mediating roles of telemedicine and inclusive justice.

6. CONCLUSIONS

Research on Smart City in Makassar emphasizes the importance of inclusion, sustainability, and the application of technologies like telemedicine in enhancing the quality of life for its residents. Factors such as Smart City initiatives, efforts toward inclusion and sustainability, telemedicine, and integrated sustainability performance (ISP) demonstrate significant relationships in the context of Smart City development in Makassar.

Recommendations for future research include diversifying participant representation for better balance, conducting intensive public education campaigns about telemedicine, and developing more inclusive policies to support the sustainable implementation of Smart City initiatives. Therefore, future studies are expected to provide greater contributions to the residents of Makassar in achieving an inclusive and sustainable Smart City.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Declaration of conflicting interest

The authors declare no competing interests. One of the authors, Roy G.A. Massie, is affiliated with BRIN, which is also listed as a funder of this study. The funder had no role in the design, conduct, analysis, interpretation, or writing of this manuscript.

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Ethical approval and informed consent statements

Ethical approval was obtained from Public Health Faculty of Hasanuddin University, under reference number 2503/UN4.14.1/TP.01.02/2024. Informed consent was obtained from all individual participants involved in the study.

Patient and Public Involvement

Patients and the public were not involved in the design, conduct, reporting, or dissemination plans of this research. The study focused on government agencies and stakeholders of the Smart City Task Force in Makassar City, with no direct participation of patient groups. However, the research outcomes are expected to indirectly benefit the public through improved governance, inclusive justice, and digital health (telemedicine) services in Smart City programs.

Data Sharing

De-identified individual participant data, data dictionary, and relevant statistical code generated and analyzed during the current study are available from the corresponding author on reasonable request. Data will be shared for research purposes in line with institutional and ethical regulations, and access will be granted after approval of a written request and data-sharing agreement.

References

1. Musango, J. K., Currie, P., & Robinson, B. (2017). Urban metabolism for resource efficient cities: From theory to implementation. UN Environment.
2. Caponio, G., Massaro, V., Mossa, G., & Mummolo, G. (2015). Strategic energy planning of residential buildings in a smart city: A system dynamics approach. International Journal of Engineering Business Management, 7, 20. https://doi.org/10.5772/61768
3. Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., Pardo, T. A., & Scholl, H. J. (2012). Understanding smart cities: An integrative framework. 45th Hawaii International Conference on System Sciences, 2289–2297.
4. Monzon, A. (2015). Smart cities concept and challenges: Bases for the assessment of smart city projects. 2015 International Conference on Smart Cities and Green ICT Systems (SMARTGREENS), 1–11.
5. Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. Journal of Urban Technology, 18(2), 65–82.
6. Anthopoulos, L. G. (2015). Understanding the smart city domain: A literature review. In Transforming city governments for successful smart cities (pp. 9–21).
7. Nasrullah, N. (2017). Implementasi electronic government dalam mewujudkan good governance dan smart city: Studi kasus Pemerintah Kota Makassar. E-Jurnal JUSITI: Jurnal Sistem Informasi dan Teknologi Informasi, 6(2), 23–31.
8. Nurdiassa, A., Zulfikar, A., Rasyid, F., & Wulandari, A. T. (2021). Implementasi kebijakan smart city dalam mewujudkan Makassar kota dunia. Journal of Public Administration and Government, 3(1), 37–46.
9. Fathun, L. M. (2016). Paradiplomasi menuju kota dunia: Studi kasus Pemerintah Kota Makassar. Indonesian Perspective, 1(1), 75–94.
10. Manguluang, A. P. (2016). Persiapan Kota Makassar sebagai smart city [Undergraduate thesis, Universitas Hasanuddin].
11. Harlina, S., & Mustafa, M. S. (2018). Teknologi informasi dalam smart city di Makassar. Konferensi Nasional Sistem Informasi (KNSI) 2018.
12. Fernandez-Anez, V., Velazquez, G., Perez-Prada, F., & Monzón, A. (2020). Smart city projects assessment matrix: Connecting challenges and actions in the Mediterranean region. Journal of Urban Technology, 27(4), 79–103. https://doi.org/10.1080/10630732.2018.1498706
13. Abu-Rayash, A., & Dincer, I. (2019). Sustainability assessment of energy systems: A novel integrated model. Journal of Cleaner Production, 212, 1098–1116. https://doi.org/10.1016/j.jclepro.2018.12.090
14. Abu-Rayash, A., & Dincer, I. (2021). Development of integrated sustainability performance indicators for better management of smart cities. Sustainable Cities and Society, 67, 102704. https://doi.org/10.1016/j.scs.2020.102704
15. Kumar, T. V., & Dahiya, B. (2017). Smart economy in smart cities. In Smart economy in smart cities (pp. 3–76).
16. Darmawansyah, J., Roy, G., Muhammad, A., & Delly, M. (2024). Development of an integrated sustainability performance indicators model for the smart city program in Makassar. ESIC Journal, 8(1). https://doi.org/10.70082/esic/8.1.076
17. Ayatollahi, H., Sarabi, F. Z. P., & Langarizadeh, M. (2015). Clinicians' knowledge and perception of telemedicine technology. Perspectives in Health Information Management, 12(Fall).
18. Baker, J., & Stanley, A. (2018). Telemedicine technology: A review of services, equipment, and other aspects. Current Allergy and Asthma Reports, 18, 1–8.
19. Chau, P. Y. K., & Hu, P. J.-H. (2002). Investigating healthcare professionals' decisions to accept telemedicine technology: An empirical test of competing theories. Information & Management, 39(4), 297–311.
20. Hoornweg, D. (2016). Cities and sustainability: A new approach. Routledge.
21. Lazaroiu, G. C., & Roscia, M. (2012). Definition methodology for the smart cities model. Energy, 47(1), 326–332.