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Analyzing sustainable city characteristics in Indonesia using ISM-MICMAC: An environmental, social, and economic perspective

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Abstract

The rapid process of urbanization in Indonesia is resulting in increasing environmental, social, and economic pressures in urban areas. The present study identifies and structures the interrelationships among sustainable-city characteristics through a source-identification process that combines five foundational urban-sustainability sources with a cross-check against recent journal literature, Sustainable Development Goal 11, ISO 37120, and Indonesian policy documents. A total of eight academic experts were tasked with validating 32 candidate characteristics. To this end, they employed the item-level Content Validity Index and assessed pairwise relationships for Interpretive Structural Modeling and MICMAC analysis. Eighteen characteristics were retained. The final reachability matrix contained 319 of the 324 possible links (98.5% density), and all factors fell within the linkage quadrant. This concentration reflects dense reciprocal judgments and transitive closure, as opposed to equal causal importance. The identification of integrated waste management, energy-efficient buildings, resource-efficient infrastructure, and the green economic transition as practical entry points for coordinated urban sustainability policy is facilitated by ISM levels and raw driving-dependence scores.

Keywords: ISM-MICMAC; sustainable cities; urban planning; Indonesia; sustainability characteristics

1. Introduction

Rapid process of urbanization has become one of the most significant challenges for urban development worldwide. The proportion of the global urban population has increased substantially since 1950 and is projected to continue rising in the coming decades [1,2]. This phenomenon has intensified pressure on urban land, infrastructure, environmental quality, public services, and economic systems. In numerous developing countries, the expansion of urban areas frequently surpasses the capacity of the cities to provide adequate housing, transportation, sanitation, green open spaces, and employment opportunities. Consequently, urbanization may generate complex problems, including land-use conversion, traffic congestion, air pollution, slum settlements, social inequality, and increasing demand for basic services [3,4].

Indonesia provides an important context for the examination of sustainable urban development, given the ongoing expansion of its population and urban settlements [5,6]. A high population density and interconnected pressures on land, environmental quality, infrastructure, mobility and social welfare are already being experienced by major cities, such as Jakarta, Bandung, Yogyakarta, Semarang, and Surabaya, [7,8]. Similar challenges are increasingly visible in medium-sized cities. Such conditions require planning approaches that can integrate sectoral interventions and identify characteristics exerting influence on a broader systemic scale.

The concept of sustainable cities is predicated on the principle of achieving a balance between environmental protection, social well-being, and economic development without compromising the ability of future generations to meet their own needs [9,10]. It is therefore evident that sustainable urban development incorporates a number of key elements including the efficient utilization of resources, the provision of inclusive services, the accessibility of housing, economic opportunities, the facilitation of community participation, the cultural preservation, and responsible land-use management. It is imperative that assessment encompass not only the presence of individual characteristics but also the structure of relationships among them. In this regard, sustainable city planning requires a comprehensive understanding of the characteristics that influence urban sustainability and the relationships among those characteristics.

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Recent studies and international frameworks have addressed sustainable cities through smart-city strategies, land-use management, urban services, environmental performance, and SDG localization [2,10-15]. Nevertheless, studies that systematically identify and structure the interrelationships among sustainable-city characteristics in the Indonesian context remain limited. In the field of urban intervention, it is a common practice to treat indicators as separate dimensions. However, it should be noted that such interventions routinely generate cross-sector effects. Land-use decisions, for example, influence transport demand, green-space provision, infrastructure costs, and emissions, while economic transition affects employment, consumption, food systems, and resource use. Consequently, conducting a structural analysis of these interdependencies is useful for identifying policy entry points.

The present study analyzes the characteristics of sustainable-city in Indonesia from the perspectives of the environment, society, and economics. The methodology employed in this study involved the development and validation of a candidate set of characteristics, followed by the application of Interpretive Structural Modeling (ISM) and Matrix of Cross-Impact Multiplications Applied to Classification (MICMAC) to examine hierarchical relationships, driving power, and dependence power. The objective of the present study is to provide an expert-based framework for policymakers, urban planners, and related stakeholders to facilitate the prioritization of coordinated sustainable-urban-development strategies.

2. Materials and Methods

This study employed an expert-based mixed-method design comprising four stages: identification of candidate sustainable-city characteristics, content validation, assessment of inter-rater consistency, and structural analysis using ISM-MICMAC. The procedure was designed to combine conceptual coverage from the literature with contextual judgment from Indonesian urban-planning experts.

2.1. Identification of sustainable city characteristics

The candidate pool was developed through a two-step scoping process. Firstly, five foundational sources on sustainable urban management, infrastructure systems, equitable urban design, city-scale sustainability practice, and the dimensions of sustainable cities were purposively selected [16-20]. The utilization of these sources was predicated on their capacity to furnish comprehensive, city-level concepts across the environmental, social, and economic domains, as opposed to a mere list of single-sector indicator. Candidate characteristics were extracted, coded by dimension, and consolidated when labels described substantially overlapping concepts. Secondly, the consolidated list was cross-checked against a range of recent peer-reviewed studies [2,10,12,13], the targets of SDG 11 [14], ISO 37120 indicators for city services and quality of life [15], and Indonesian policy instruments on the national SDG agenda and spatial planning [21,22]. The cross-check was utilized to verify contemporary relevance and policy fit, rather than to adopt every framework indicator mechanically. The retention of an item was dependent upon its representation of a city-level condition or capability, its applicability across different Indonesian city types, and its capacity to plausibly interact with other sustainability characteristics. The process produced 32 initial characteristics: 17 environmental, 11 social, and 4 economic.

2.2. Expert selection and questionnaire design

Purposive sampling was utilized to recruit eight experts in urban and regional planning with relevant academic and professional experience. The collective expertise of, the panel encompassed a wide range of disciplines, including urban and regional planning, environmental planning, land-use management, urban infrastructure and transportation, and sustainable urban development. All experts had more than five years of teaching, research, and/or professional planning experience and were affiliated with Indonesian universities located in, or in close proximity to, the highly urbanized regions of Jakarta, Bandung, and Yogyakarta. The panel composition was conducive to the validation and structural judgment. However, given that all participants were academics, perspectives on implementation from municipal government, private operators, and community organizations were not represented directly.

The questionnaire was prepared in Indonesian to ensure clarity and to reduce the possibility of misunderstanding among respondents. A five-point Likert scale was utilized to evaluate the relevance of each characteristic, where a higher score indicated a higher level of relevance. The distribution of questionnaire was conducted online via Google Forms. The initial validation process was conducted from November to December 2024.

2.3. Content validity analysis

The item-level Content Validity Index (I-CVI) was utilized to evaluate the relevance of each characteristic. This approach is considered appropriate for content validation by a relatively small expert panel [23-26]. Ratings of 3, 4, or 5 were designated as relevant, whereas ratings of 1 or 2 were categorized as not relevant. The I-CVI was calculated as the proportion of experts rating an item as relevant. In accordance with the established criteria for panels of this size, an item was retained when I-CVI was a minimum of 0.79 [26].

2.4. Reliability analysis

The inter-rater consistency of the data was examined using the intraclass correlation coefficient (ICC) and the Kendall's coefficient of concordance (Kendall's W). The interpretation of ICC values is as follows: values below 0.50 are considered poor, 0.50-0.75 as moderate, 0.75-0.90 are good, and above 0.90 are excellent [27]. Kendall's W ranges from 0 to 1, with higher values indicating stronger concordance among experts [28]. The analysis was conducted using SPSS.

2.5. ISM-MICMAC analysis

Following validation, the experts independently assessed the contextual relationship for each of the 153 unordered pairs among the 18 retained characteristics. The Structural Self-Interaction Matrix (SSIM) utilized four directional symbols: V denotes the influence of characteristic i on j; A denotes the influence of characteristic i is on j; X denotes a reciprocal influence; and O denotes the absence of a direct relationship. Due to the nature of SSIM symbols as nominal directional categories, the eight judgments for each pair were aggregated using the modal symbol rather than an arithmetic average. The retained research record contained one final symbol for each pair, and that recorded symbol was entered into the final SSIM. However, the records available for the present revision did not preserve a separate audit trail showing how tied frequencies or contested interpretations, if any, were resolved. Consequently, a consensus procedure is not retrospectively reconstructed. This documentation gap limits reproducibility for disputed pairs and is treated as a methodological limitation. It is recommended that future studies predefine a tie-breaking rule, such as a second-round Delphi confirmation using the same operational definitions.

The final SSIM was converted into an Initial Reachability Matrix (IRM) using the standard binary rules: V became 1 for i to j and 0 for j to i; A became 0 for i to j and 1 for j to i; X became 1 in both directions; and O became 0 in both directions. The Final Reachability Matrix (FRM) was then obtained by applying transitivity. Therefore, when i influenced j and j influenced k, i was treated as indirectly influencing k [29-31].

The calculation of driving power was performed as the row sum of the FRM, while the dependence power was determined as the column sum. The values were plotted in the MICMAC plane and classified as autonomous, dependent, linkage, or independent factors [32,33]. The conventional midpoint utilized in the analysis separated low and high scores at a cut line of 10 on the 1-18 scale. It is acknowledged that quadrant placement can become compressed when the FRM is dense; therefore the raw scores and ISM hierarchy were retained as complementary evidence for prioritization.

Level partitioning was performed by identifying the reachability set, antecedent set, and their intersection for each characteristic. The current upper level was assigned a characteristic when its reachability set equaled its intersection set. The assigned characteristics were then removed iteratively until all items were placed. The resulting hierarchy represents structural position rather than a simple ranking of substantive importance [29,32].

3. Results and Discussion

3.1. Validity and reliability of sustainable city characteristics

Eighteen of the 32 candidate characteristics met the I-CVI threshold. The final set comprised 12 environmental, 3 social, and 3 economic characteristics. The environmental characteristics encompassed ecosystem integrity, urban water, air quality, waste, natural resources, land use, transport, green space, emissions, buildings, infrastructure, and urbanization dynamics. The social characteristics included access to health services and public safety, sustainable lifestyles, and urban-growth management. The economic characteristics encompassed green employment, local food systems, and the green economic transition.

The larger number of environmental items indicates that the panel viewed biophysical conditions and urban-service systems as particularly salient in the Indonesian context. This distribution should not be interpreted as a normative weighting of the three sustainability dimensions. Furthermore, it is evident that the composition of the expert panel has been considered as well as the more extensive environmental coverage of several foundational sources. The finding indicate that environmental performance depends on public welfare, behavior, employment, food resilience, and economic restructuring.

Table 1. Validated sustainable city characteristics

Dimension	Code	Characteristic	I-CVI
Environmental	L1	Ecosystems and natural habitats	1.000
Environmental	L2	Water management	1.000
Environmental	L3	Improved air quality	0.875
Environmental	L4	Waste management	1.000
Environmental	L5	Conservation of natural resources	1.000
Environmental	L6	Good land management	1.000
Environmental	L7	Environmentally-friendly transportation system	1.000
Environmental	L8	Green open spaces and recreation areas	1.000
Environmental	L10	Greenhouse gas emissions	0.875
Environmental	L11	Energy-saving buildings	0.875
Environmental	L12	Efficient infrastructure system	1.000
Environmental	L16	Urbanization and global spread	1.000
Social	S5	Access to health services and public safety	0.875
Social	S9	Sustainable lifestyle	1.000
Social	S11	Growth management or urban sprawl	1.000
Economic	E1	Green jobs	0.875
Economic	E2	Local food system	1.000
Economic	E4	Green economy	1.000

3.2. Operational definitions of the validated characteristics

L1 (ecosystem integrity and natural-habitat protection) refers to the protection and restoration of biodiversity, ecological functions, and habitats in urban and peri-urban areas. L2 (integrated urban water management) refers to the coordinated management of water supply, conservation, drainage, wastewater, water quality, and flood risk. L3 (urban air-quality improvement) refers to the monitoring and reduction of ambient air pollutants through source control and cleaner urban systems.

L4 (integrated solid-waste management) refers to waste prevention, segregation, collection, reuse, recycling, treatment, and environmentally safe disposal. L5 (natural-resource conservation) is defined as the efficient use and long-term protection of water, soil, energy, minerals, and biological resources. L6 (sustainable land-use management) is utilized to denote a method of allocating and controlling urban land that is both compact, and coordinated, whilst also being risk-sensitive.

L7 (low-emission and accessible urban transport) refers to integrated public transport, active travel, and low-emission mobility that is both affordable and accessible. L8 (accessible green open and recreational spaces) is defined as the equitable provision of connected, safe, and usable green and recreational areas. L10 (greenhouse-gas emission reduction) refers to the measurement and reduction of greenhouse-gas emissions across major sectors on a citywide scale.

L11 (energy-efficient buildings) refers to building design and operation that minimize energy demand while maintaining safety and comfort. L12 (resource-efficient urban infrastructure) refers to reliable infrastructure services that minimize energy, water, material, and land requirements over their life cycle. L16 (urbanization dynamics and global interconnectedness) refers to the pace and spatial pattern of urbanization and the cross-boundary flows that shape urban demand, opportunity, and risk.

S5 (access to health services and public safety) refers to equitable access to health, emergency, and safety services as well as to secure public environments. S9 (resource-efficient and low-carbon lifestyles) refers to daily mobility, energy, consumption, and waste management practices that are designed to minimize resource consumption and reduce emissions. S11 (urban-growth management and sprawl control) refers to planning and regulatory measures that guide expansion, density, infill, and peripheral development.

E1 (green employment opportunities) refers to decent work that preserves or restores the environment or improves resource efficiency. E2 (resilient local food systems) refers to urban-regional food production, distribution, access, and recovery systems that support local producers and reduce vulnerability. E4 (green economic transition) refers to a shift in investment, production, and consumption patterns, favoring low-carbon, circular, resource-efficient, and inclusive activities.

The ICC was 0.918, indicating excellent inter-rater reliability [27]. Kendall's W was 0.732, indicating strong concordance among the experts [28]. Collectively, these results support the utilization of the validation ratings and pairwise judgments in the subsequent ISM-MICMAC analysis, while not eliminating the substantive limitations associated with the panel's academic composition.

3.3. ISM analysis and hierarchical structure

Following the transitivity check, the SSIM was converted into the IRM and then the FRM. Level partitioning produced a two-level structure (see Fig. 1). The high level of connectivity observed in the FRM indicates that the validated characteristics operate as an integrated system rather than as isolated policy domains.

Level 1 comprised 14 characteristics: L1, L2, L3, L5, L6, L7, L8, L10, L16, S5, S9, S11, E1, and E2. These characteristics occupy the upper level because their reachability sets were resolved after the lower-level elements and because they are strongly conditioned by relationships elsewhere in the system. Level 2 comprised L4, L11, L12, and E4, which function as structural support and intervention-entry characteristics within the elicited model.

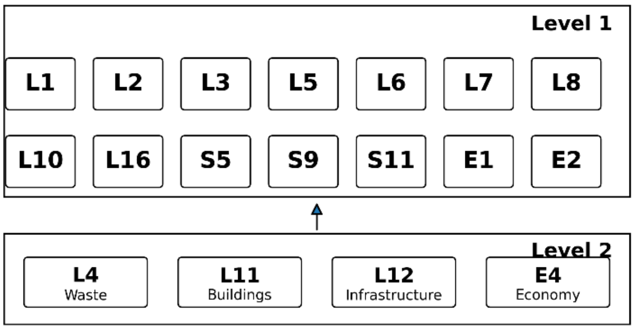

Fig. 1. ISM hierarchy of validated sustainable-city characteristics in Indonesia

The Level 2 position of integrated solid-waste management (L4), energy-efficient buildings (L11), resource-efficient urban infrastructure (L12), and the green economic transition (E4) indicates their broad enabling role. The policy pertaining to the management of waste has the capacity to influence a number of key areas, including environmental quality, public health, behavior, and circular economic activity. The efficient buildings and infrastructure has been demonstrated to influence resource demand, service performance, and emissions. A green economic transition supports investment, production, employment, and consumption patterns that have the potential to reinforce the remaining characteristics.

3.4. MICMAC classification

MICMAC analysis placed all 18 characteristics in the linkage quadrant, indicating that each had both high driving power and high dependence power (Fig. 2; Table 2). Linkage factors are sensitive to feedback, i.e. a change in one factor can propagate through the system and return through other paths [34]. This result therefore signals a need for coordinated interventions as opposed to independent sector programs.

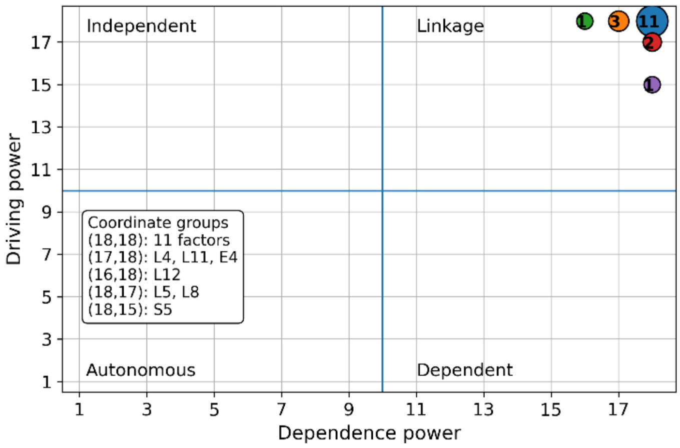

Fig. 2 MICMAC classification based on driving power and dependence power

The raw scores continue to differentiate relative structural positions. Fifteen characteristics had a driving-power score of 18, : L1, L2, L3, L4, L6, L7, L10, L11, L12, L16, S9, S11, E1, E2, and E4. L5 and L8 scored 17, whereas S5 scored 15. Nevertheless S5 demonstrated a dependence power of 18, suggesting that equitable access to health services and public safety is significantly influenced by infrastructure, environmental quality, land management, mobility, and economic capacity. It is important to interpret these score differences in conjunction with the two-level ISM structure as opposed to considering them as a stand-alone ranking. The all-linkage classification serves to emphasize the systemic nature of sustainable-city development. The sustainable land-use management has the capacity to influence transport demand, ecosystem integrity, green space, infrastructure efficiency, and emissions. Conversely, the green economic transition can influence green employment, local food systems, sustainable lifestyles, and resource conservation. Consequently, interventions should be packaged to anticipate feedback, implementation sequencing, and cross-agency effects.

Table 2 Driving power, dependence power, and MICMAC classification

Code	Characteristic	Driving power	Dependence power	MICMAC category
L1	Ecosystems and natural habitats	18	18	Linkage
L2	Water management	18	18	Linkage
L3	Improved air quality	18	18	Linkage
L4	Waste management	18	17	Linkage
L5	Conservation of natural resources	17	18	Linkage
L6	Good land management	18	18	Linkage
L7	Environmentally friendly transportation system	18	18	Linkage
L8	Green open spaces and recreation areas	17	18	Linkage
L10	Greenhouse gas emissions	18	18	Linkage
L11	Energy-saving buildings	18	17	Linkage
L12	Efficient infrastructure system	18	16	Linkage
L16	Urbanization and global spread	18	18	Linkage
S5	Access to health services and public safety	15	18	Linkage
S9	Sustainable lifestyle	18	18	Linkage
S11	Growth management or urban sprawl	18	18	Linkage
E1	Green jobs	18	18	Linkage
E2	Local food system	18	18	Linkage
E4	Green economy	18	17	Linkage

3.5. Policy implications for sustainable urban development in Indonesia

Firstly, it is imperative that environmental management remains central to urban policy given that the validated environmental characteristics exhibit a combination of high driving and dependence power. The integration of urban water management, waste management, sustainable land use, air-quality improvement, emission reduction, and accessible green space has been demonstrated to have a direct impact on health, service reliability, economic activity, and resilience.

Secondly, the Level 2 position on energy-efficient buildings and resource-efficient urban infrastructure identifies the built environment as an enabling platform. The implementation of building standards, infrastructure investment, and climate-sensitive design is able to reduce energy and material demand while enhancing service performance [35, 36]. Policy coordination is imperative to ensure that decisions pertaining to building, transport, water, sanitation, energy, and land-use decisions reinforce one another.

Thirdly, integrated solid-waste management should be treated as a cross-dimensional priority. The Kang Pisman program in Bandung illustrates that the waste outcomes depend not solely on collection and treatment technology but also on institutional capacity, public participation, behavioral change, and local governance [37]. The improvements in prevention, segregation, recycling, and safe disposal can produce co-benefits for public health, resource efficiency, sustainable lifestyles, and green economic activity. Fourthly, green employment, resilient local food systems, and the green economic transition should be embedded in city strategies rather than being treated as secondary outcomes. These characteristics have the potential to support livelihoods, reduce resource chains, enhance urban-regional resilience, and align investment and consumption with environmental objectives. The high dependence scores of the subject in question demonstrate that economic transition requires supportive infrastructure, land-use policy, institutional capacity, and public behavior.

3.6. Methodological interpretation of the MICMAC result

The concentration of every characteristic in the linkage quadrant requires methodological caution. The FRM contained 319 ones out of 324 possible cells, equivalent to a density of 98.5%. A total of five cells remained zero. This near-saturated matrix resulted in the compression of variation in both row and column sums, thereby rendering the separation of these sums into different MICMAC quadrants unlikely. Two mechanisms plausibly produced this pattern. Firstly, frequent reciprocal X judgments increased both driving and dependence power. Secondly, transitive closure added resulted in the identification of indirect paths to relationships already assessed as direct. This process led to the connection of initially distinct chains within the FRM. The result is therefore best understood as a property of a densely reciprocal, transitivity-amplified network, rather than as evidence that every characteristic has identical causal importance. The raw driving-dependence scores and the ISM levels provide the remaining basis for further differentiation.

This interpretation does not invalidate the model, but it limits the discriminating power of the four-quadrant MICMAC classification. It is recommended that future research be conducted to ascertain the stability of the classification against the direct-relation matrix prior to the implementation of transitivity, alternative quadrant thresholds, and the removal of individual experts or contested relationships. The employment of comparative models for metropolitan, medium-sized, and rapidly expanding cities would also indicate whether the dense structure is general or context-specific.

4. Conclusion

The present study identified and structured the interrelationships among sustainable city characteristics in Indonesia using an environmental, social, and economic approach. A two-step process for the source identification was undertaken whoch resulted in the production of 32 candidate characteristics. Through a process of expert content validation, 18 of these characteristics were retained. ISM-MICMAC analysis demonstrated a highly connected system in which all retained characteristics occupied the linkage quadrant.

The all-linkage result should not be interpreted as equal importance. The 98.5% density of the FRM indicates that reciprocal judgments and transitivity compressed the variation in driving and dependence power. The combination of the raw scores with the ISM hierarchy identifies integrated solid-waste management, energy-efficient buildings, resource-efficient urban infrastructure, and the green economic transition as practical entry points with broad systemic reach.

The findings support integrated urban strategies that connect environmental management, infrastructure investment, public welfare, behavior, and economic transformation. Policies developed in isolation have the potential to generate unintended feedback or to shift burdens across sectors. The translation of the model into city-level action is therefore dependent upon coordinated planning, shared performance indicators, and staged implementation.

The study is limited by the small panel and its concentration in academia and in selected highly urbanized regions. Government officials, infrastructure operators, private-sector actors, and community representatives may assign different directions or strengths to the relationships. Future studies should include a wider range of stakeholder representation, encompass a comparison of different city types, and conduct sensitivity analyses on the SSIM, the direct-relation matrix, transitivity assumptions, and MICMAC thresholds.

References

1. U. N. Publications, *World urbanization prospects: the 2018 revision,* UN, 2019.
2. S. Chen, et al., *Navigating urban human settlement sustainability: a multi-indicator assessment based on sustainable development goal 11,* J. Clean. Prod. 472 (2024) 143509.
3. V. Cheng, *Understanding density and high density,* in: Designing High-Density Cities for Social and Environmental Sustainability, 2010, pp. 3–17.
4. I. Manisalidis, et al., *Environmental and health impacts of air pollution: a review,* Front. Public Health 8 (2020).
5. S. Indonesia, *Mid year population (thousand people), 2022–2024,* (2024).
6. E. Dyah, *52% penduduk ada di perkotaan, Bamsoet dorong tingkatkan pembangunan desa,* (2024).
7. S. Indonesia, *Population density by province (person/sq.km), 2021,* (2023).
8. R. Prihatin, *Alih fungsi lahan di perkotaan (studi kasus di Kota Bandung dan Yogyakarta),* J. Aspirasi 6 (2016) 105–118.
9. U. N. H. S. P. (UN-Habitat), *Planning sustainable cities: global report on human settlements 2009,* 1st ed., 2009.
10. S. Bibri and J. Krogstie, *Smart sustainable cities of the future: an extensive interdisciplinary literature review,* Sustain. Cities Soc. 31 (2017).
11. M. Batty, et al., *Smart cities of the future,* Eur. Phys. J. Spec. Top. 214 (2012) 481–518.
12. C. O'Driscoll, et al., *Land-use mixing in Irish cities: implications for sustainable development,* Land Use Policy 128 (2023) 106615.
13. J. Clement, B. Ruysschaert and N. Crutzen, *Smart city strategies – a driver for the localization of the sustainable development goals?,* Ecol. Econ. 213 (2023) 107941.
14. S. Kufeoglu, *SDG-11: Sustainable Cities and Communities,* (2022) 385–408.
15. T. Spiri-Ferreira, et al., *Sustainable cities in the light of ISO 37120 and 37101 standards: a systematic review and the contribution of a theoretical framework,* Urban Sci. 9 (2025) 368.
16. G. N. L. Stowers, *Managing the Sustainable City,* 1st ed., Routledge, 2017.
17. Pollalis, *Planning Sustainable Cities: An infrastructure-based approach,* 1st ed., Routledge, 2016.
18. M. Fragoso, *Reimagining sustainable cities: strategies for designing greener, healthier, more equitable communities, por Stephen M. Wheeler e Christina D. Rosan,* Finisterra (2024) 125–129.
19. R. Smardon, *Worldwatch Institute: can a city be sustainable?,* J. Environ. Stud. Sci. 6 (2016).
20. M. Jenks and C. Jones, *Dimensions of the Sustainable City,* (2010).
21. R. o. Indonesia, *Presidential Regulation No. 111 of 2022 on the Implementation of the Achievement of the Sustainable Development Goals,* (2022).
22. R. o. Indonesia, *Government Regulation No. 21 of 2021 on the Implementation of Spatial Planning,* (2021).
23. J. Smith, et al., *Content validity index for the readiness for hospital discharge scale in the skilled nursing facility setting,* Geriatr. Nurs. 59 (2024) 346–350.
24. S. Tsang, C. F. Royse and A. S. Terkawi, *Guidelines for developing, translating, and validating a questionnaire in perioperative and pain medicine,* Saudi J. Anaesth. 11 (2017) S80–S89.
25. M. S. B. Yusoff, *ABC of Content Validation and Content Validity Index Calculation,* Educ. Med. J. 11 (2019) 49–54.
26. V. Zamanzadeh, et al., *Design and Implementation Content Validity Study: Development of an instrument for measuring Patient-Centered Communication,* J. Caring Sci. 4 (2015) 165–178.
27. T. K. Koo and M. Y. Li, *A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research,* J. Chiropr. Med. 15 (2016) 155–163.
28. T. J. Atchley, et al., *Hannover Classification of Vestibular Schwannomas: A Reliability Study,* World Neurosurg. 158 (2022) e179–e183.
29. R. Attri, N. Dev and V. Sharma, *Interpretive Structural Modelling (ISM) approach: An Overview,* (2013).
30. M. Bouzon, K. Govindan and C. M. T. Rodriguez, *Reducing the extraction of minerals: Reverse logistics in the machinery manufacturing*

industry sector in Brazil using ISM approach, Resour. Policy 46 (2015) 27–36.

31. R. Sindhwani and V. Malhotra, *An integrated approach for implementation of agile manufacturing system in an Indian manufacturing industry,* Benchmarking Int. J. 25 (2018) 1106–1120.
32. X. Gan, et al., *Barriers to the transition towards off-site construction in China: An Interpretive structural modeling approach,* J. Clean. Prod. (2018).
33. V. Rangasamy and J.-B. Yang, *Interpreting Crucial Barriers to Advancing Prefabricated Construction: An Empirical Study in Taiwan Using ISM-MICMAC Approach,* J. Clean. Prod. 489 (2025) 144702.
34. J.-K. Chen, *An extension of importance-performance analysis method: integrated with fuzzy MICMAC,* Int. J. Serv. Oper. Informatics 9 (2018) 83.
35. F. Fingki, T. Sundari and H. Silva, *Implementasi Konsep Hemat Energi Pada Bangunan City Hotel Di Kota Dumai,* J. Tek. 13 (2020) 145–152.
36. F. Tahmasbi, et al., *Energy-Efficient Building Façades: A Comprehensive Review of Innovative Technologies and Sustainable Strategies,* J. Build. Eng. 99 (2024) 111643.
37. A. Sumaryana, S. Komara and R. Pancasilawan, *Organizational Capacity in Implementing the "Kang Pisman" Program: A Case Study of Waste Management in Bandung City,* J. Ecohumanism 4 (2025).