

Advancing Green Development through a Five Dimensions of Sustainability-Based Assessment Model for Residential Micro-Infrastructure in Jakarta

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Abstract

The rapid growth of residential areas in Jakarta has intensified the demand for reliable and sustainable micro-infrastructure, including local roads, drainage systems, water supply networks, sanitation facilities, and public green spaces. However, current infrastructure assessment practices predominantly focus on technical performance and economic feasibility, often overlooking broader sustainability considerations. This study aims to develop a comprehensive sustainability assessment model for residential micro-infrastructure based on the five dimensions of sustainability framework, encompassing environmental, social, economic, technical, and institutional dimensions. The research adopts a mixed-methods approach involving extensive literature review, expert judgment, and indicator development and validation processes. Set of sustainability indicators is formulated and structured into an integrated assessment framework capable of measuring the multidimensional performance of micro-infrastructure systems in residential environments. The proposed model employs weighted evaluation criteria to identify sustainability strengths, weaknesses, and priority areas for improvement. The findings demonstrate that sustainability assessment based on a multidimensional perspective provides a more holistic understanding of infrastructure performance than conventional evaluation methods. Furthermore, the model supports the implementation of green development principles by promoting resource efficiency, environmental protection, social well-being, economic resilience, institutional effectiveness, and long-term infrastructure functionality. The resulting framework offers a practical decision-support tool for policymakers, urban planners, housing developers, and community stakeholders in planning, monitoring, and improving residential infrastructure sustainability. This study contributes to the advancement of sustainable urban development by providing a structured and adaptable assessment model that can be applied not only in Jakarta but also in other rapidly urbanizing metropolitan areas facing similar sustainability challenges.

Keywords

Residential Micro-Infrastructure, Five Dimensions of Sustainability, Green Development, Sustainable Urban Development, Jakarta

1. Introduction

Urbanization has become a major driver of spatial transformation and infrastructure expansion in metropolitan areas worldwide, creating increasing pressures related to environmental quality, resource efficiency, and urban resilience (Kustova et al., 2024). In response to these challenges, sustainable urban development has emerged as a key strategic approach to balance economic growth, environmental protection, and social well-being in rapidly growing cities (Khan & Henschel, 2024). Within this context, infrastructure is increasingly recognized not only as a physical facility that supports urban activities but also as a critical component in achieving long-term sustainability objectives (Kustova et al., 2024). Recent studies further highlight that sustainable infrastructure development contributes

significantly to enhancing urban livability, reducing environmental impacts, and strengthening community resilience to future uncertainties (Bani Khalifi et al., 2025).

The rapid expansion of residential areas has led to increasing demand for micro-infrastructure systems, including neighborhood roads, drainage networks, water supply facilities, sanitation systems, and public green spaces (Ren et al., 2024). These infrastructure elements play a vital role in shaping environmental performance, public health conditions, and the overall quality of life in urban communities (Khalili & Kumar, 2024). In Jakarta, continuous residential development has intensified pressure on existing infrastructure systems, resulting in various urban challenges such as flooding, environmental degradation, limited public facilities, and inefficient resource utilization (Bani Khalifi et al., 2025). As a result, improving the sustainability performance of residential micro-infrastructure has become an important agenda in supporting green development initiatives in urban areas (Kustova et al., 2024).

Green development has been widely recognized as an integrated approach that promotes environmentally responsible, socially inclusive, and economically viable urban growth (Bani Khalifi et al., 2025). This approach emphasizes infrastructure systems that are able to minimize environmental impacts while maintaining long-term functionality and delivering benefits to local communities (Khalili & Kumar, 2024). However, the realization of green development requires robust assessment tools that can evaluate infrastructure sustainability in a comprehensive manner rather than focusing only on technical performance aspects (Kustova et al., 2024).

Existing sustainability assessment frameworks for infrastructure commonly rely on the triple bottom line approach, which considers environmental, economic, and social dimensions (Gómez et al., 2023). Although this framework provides a useful foundation, it has been criticized for being insufficient to capture the complexity of modern infrastructure systems (Li et al., 2023). Recent literature suggests that additional consideration of technical and institutional dimensions is necessary to achieve a more holistic evaluation of infrastructure sustainability, including aspects such as operational reliability, governance capacity, and system adaptability (Wang et al., 2023; Kustova et al., 2024).

The five dimensions of sustainability framework, which integrates environmental, economic, social, technical, and institutional aspects, has therefore gained increasing attention as a more comprehensive approach for infrastructure sustainability assessment (Wang et al., 2023). This framework enables a more balanced evaluation of infrastructure systems by incorporating both physical performance and governance-related factors within a unified structure (Kustova et al., 2024). Nevertheless, its application to residential micro-infrastructure remains limited, particularly in rapidly urbanizing cities such as Jakarta (Ren et al., 2024). Furthermore, there is still a lack of integrated assessment models that specifically evaluate sustainability performance at the neighborhood scale in support of green development objectives (Khan & Henschel, 2024).

This study aims to develop a sustainability assessment model for residential micro-infrastructure based on the five dimensions of sustainability framework to support green development in Jakarta. The study focuses on identifying relevant sustainability indicators for residential micro-infrastructure by considering environmental, economic, social, technical, and institutional dimensions. Furthermore, it seeks to develop a structured assessment framework that integrates these five dimensions into a coherent evaluation model. The research also aims to assign relative weights to the identified sustainability indicators based on expert judgment to reflect their importance in the assessment process. In addition, this study formulates a practical sustainability assessment model that can be used to evaluate the performance of residential micro-infrastructure systems. Ultimately, the proposed model is expected to serve as a decision-support tool for policymakers, urban planners, and other stakeholders in promoting sustainable infrastructure development and supporting green development initiatives in residential areas of Jakarta.

2. Literature Review

A. Sustainable Infrastructure in Urban Development

Sustainable infrastructure has become a fundamental concept in modern urban development as cities face increasing pressure from rapid population growth and resource consumption. Infrastructure systems are no longer evaluated solely based on their technical performance but are increasingly assessed based on their contribution to environmental protection, economic efficiency, and social well-being (Gómez et al., 2023).

In addition to its evaluative function, sustainable infrastructure also serves as a strategic mechanism for long-term urban transformation, where infrastructure planning is integrated with climate adaptation, resource conservation, and

resilience-building strategies (Shen & Wu, 2022; Wu & Zhang, 2024). This shift reflects a growing recognition that infrastructure systems must be designed not only to meet current demands but also to anticipate future environmental and societal challenges.

Recent studies emphasize that sustainable infrastructure plays a crucial role in enhancing urban resilience by reducing environmental impacts and improving the quality of urban life (Khalili & Kumar, 2024). In rapidly urbanizing regions, the integration of sustainability principles into infrastructure planning is considered essential to ensure long-term functionality, resource efficiency, and system reliability (Kustova et al., 2024). Furthermore, sustainable infrastructure development is increasingly associated with the ability of cities to adapt to climate-related risks, particularly in densely populated urban areas where infrastructure systems are highly vulnerable to environmental stressors (Bani Khalifi et al., 2025). Overall, sustainable infrastructure is no longer viewed as a static physical asset, but as a dynamic system that continuously interacts with environmental, social, and institutional contexts to support sustainable urban growth.

B. Residential Micro-Infrastructure and Urban Sustainability

Residential micro-infrastructure refers to small-scale infrastructure systems within residential environments, including neighborhood roads, drainage networks, water supply systems, sanitation facilities, and public green spaces. These components represent the most immediate form of infrastructure that directly interacts with daily urban activities and household needs (Ren et al., 2024). Unlike large-scale infrastructure systems, micro-infrastructure operates at a localized level and has a direct influence on environmental quality, mobility patterns, public health conditions, and social interaction within residential communities (Khalili & Kumar, 2024). As such, its performance is closely linked to the overall livability and sustainability of urban neighborhoods.

However, despite its critical role, residential micro-infrastructure is often underrepresented in urban sustainability studies, which tend to focus on macro-level infrastructure systems such as transportation networks, energy grids, and large water management systems (Li et al., 2023). This imbalance in research attention creates a gap in understanding how neighborhood-scale infrastructure contributes to broader urban sustainability outcomes.

In rapidly growing cities such as Jakarta, the pressure on residential micro-infrastructure has intensified due to uncontrolled urban expansion, increasing population density, and limited infrastructure capacity (Sari & Wibowo, 2022). These conditions have led to recurring issues such as localized flooding, inadequate drainage systems, uneven service distribution, and reduced environmental quality in residential areas (Bani Khalifi et al., 2025).

Moreover, micro-infrastructure systems are often developed in a fragmented manner without integrated planning, which reduces their long-term efficiency and sustainability performance (Gómez et al., 2023). This highlights the need for a more structured evaluation approach that can assess infrastructure performance not only from a technical perspective but also from environmental, social, economic, institutional, and technical dimensions. Therefore, residential micro-infrastructure should be understood as a critical subsystem of urban infrastructure that requires comprehensive sustainability assessment to support more balanced and resilient urban development strategies.

C. Five Dimensions of Sustainability Framework

The five dimensions of sustainability framework is widely recognized as an advanced approach for assessing infrastructure systems due to its ability to capture sustainability from multiple interrelated perspectives beyond the conventional triple bottom line concept (Kustova et al., 2024). While traditional sustainability models emphasize environmental, economic, and social dimensions, this expanded framework incorporates technical and institutional dimensions to better reflect the complexity of real-world infrastructure systems.

The environmental dimension focuses on minimizing ecological impact through efficient resource use, pollution reduction, and environmental conservation within urban systems (Gómez et al., 2023). In the context of residential micro-infrastructure, this dimension is reflected in drainage efficiency, water management systems, energy consumption patterns, and the availability of green open spaces, all of which contribute directly to urban environmental quality (Ren et al., 2024).

The economic dimension evaluates the financial sustainability of infrastructure systems, including life-cycle costs, investment efficiency, operational expenditures, and maintenance requirements (Gómez et al., 2023). This dimension

ensures that infrastructure development remains economically viable over time while avoiding excessive financial burdens on government institutions and local stakeholders (Khalili & Kumar, 2024).

The social dimension emphasizes equity, accessibility, inclusiveness, and community participation in infrastructure development processes (Khalili & Kumar, 2024). In residential environments, this dimension is closely associated with quality of life, social cohesion, and the degree to which infrastructure systems meet the needs of diverse user groups (Ren et al., 2024).

The technical dimension assesses the physical performance of infrastructure systems, including reliability, durability, safety, and operational efficiency (Kustova et al., 2024). This dimension is particularly important for micro-infrastructure systems, as technical failures such as drainage blockage or road deterioration can immediately disrupt daily residential activities and reduce environmental quality (Gómez et al., 2023).

The institutional dimension relates to governance structures, regulatory enforcement, policy consistency, and coordination among stakeholders involved in infrastructure planning and management (Wang et al., 2023). Strong institutional capacity is essential to ensure that sustainability principles are effectively implemented and maintained throughout the infrastructure life cycle, particularly in complex urban governance environments (Kustova et al., 2024).

Collectively, these five dimensions provide a comprehensive and balanced analytical framework for evaluating infrastructure sustainability. Their integration allows for a more holistic understanding of residential micro-infrastructure performance, particularly in rapidly urbanizing contexts such as Jakarta, where infrastructure challenges are multidimensional and interconnected (Ren et al., 2024).

D. Multi-Criteria Decision Making and AHP Application

Multi Criteria Decision Making (MCDM) methods are widely used in sustainability assessment to address complex decision problems involving multiple conflicting criteria. These methods are particularly relevant in infrastructure evaluation because sustainability performance is influenced by interdependent environmental, economic, social, technical, and institutional factors (Wang et al., 2023). Among various MCDM techniques, the Analytical Hierarchy Process (AHP) is one of the most widely applied methods due to its simplicity, flexibility, and ability to structure complex decision problems into a hierarchical form. AHP enables decision-makers to decompose a problem into multiple levels, ranging from the overall goal to criteria and sub-criteria, and then assign relative weights through pairwise comparisons (Saaty, 2008).

The strength of AHP lies in its ability to integrate both qualitative and quantitative factors into a single decision-making framework. This makes it particularly suitable for sustainability assessment, where many evaluation criteria are subjective in nature and require expert judgment (Nguyen & Park, 2022). Through consistency checking, AHP also ensures the reliability of expert evaluations, making the results more robust and defensible (Huang & Zhao, 2023).

Recent studies have demonstrated the effectiveness of AHP in infrastructure and urban planning applications, particularly for sustainability prioritization and policy decision support (Kustova et al., 2024). Its structured approach allows researchers and decision-makers to identify the relative importance of sustainability dimensions and indicators in a transparent and systematic manner. In the context of this study, AHP is used as a weighting tool to determine the relative importance of the five dimensions of sustainability in assessing residential micro-infrastructure performance. This approach enables a more objective prioritization of sustainability factors based on expert evaluation.

E. Research Gap

Although sustainability assessment frameworks have been widely developed and applied in infrastructure studies, most existing research still focuses on macro-scale infrastructure systems or uses limited sustainability dimensions (Gómez et al., 2023). As a result, the evaluation of neighborhood-scale or residential micro-infrastructure remains relatively underexplored. Several studies have attempted to integrate multi-criteria decision-making approaches with sustainability assessment; however, these studies often apply simplified frameworks that do not fully incorporate technical and institutional dimensions (Li et al., 2023). This limitation reduces the ability of existing models to capture the complexity of real urban infrastructure systems.

Furthermore, although the five dimensions of sustainability framework has been recognized as a more comprehensive approach, its application in structured decision-making models such as AHP remains limited, particularly in the context of residential infrastructure systems (Kustova et al., 2024). This indicates a methodological gap in combining multidimensional sustainability frameworks with structured weighting approaches. In addition, most existing studies are conducted in developed urban contexts, while limited attention has been given to rapidly urbanizing cities such as Jakarta, where infrastructure challenges are more complex due to high population density, environmental stress, and fragmented infrastructure systems (Sari & Wibowo, 2022; Bani Khalifi et al., 2025).

Therefore, there is a clear need to develop an integrated sustainability assessment model that combines the five dimensions of sustainability with AHP-based weighting to evaluate residential micro-infrastructure in a more comprehensive, structured, and context-specific manner (Ren et al., 2024).

3. Method

This study employs a mixed-methods approach that combines qualitative and quantitative techniques to develop a sustainability assessment model for residential micro-infrastructure based on the five dimensions of sustainability framework. The framework integrates environmental, economic, social, technical, and institutional dimensions to support the development of green residential areas in Jakarta.

The research process begins with an extensive literature review to identify relevant sustainability indicators for residential micro-infrastructure systems. The indicators were collected and synthesized from academic literature, policy documents, and established sustainability assessment frameworks related to urban infrastructure and sustainable development. This stage aims to construct an initial set of indicators that reflect both global standards and contextual relevance.

Following the literature review, expert interviews were conducted to validate and refine the selected indicators. The respondents consisted of professionals in urban planning, infrastructure engineering, and environmental management who have direct experience in residential infrastructure development. The interview protocol was structured based on the preliminary findings from the literature review to ensure alignment between theoretical constructs and practical insights.

To strengthen the validity of the proposed indicators, expert validation sessions were conducted to confirm their relevance to the local context of residential development in Jakarta. This process allowed for the refinement of indicators based on practical considerations, ensuring that the framework accurately reflects real-world conditions and challenges in urban residential infrastructure.

In addition, a structured group discussion was carried out with experts to obtain deeper insights regarding the prioritization and structuring of sustainability indicators within the proposed framework. This stage aimed to achieve consensus on the most relevant dimensions and indicators for assessing residential micro-infrastructure sustainability.

Finally, the Analytical Hierarchy Process (AHP) was applied to determine the relative weights of the sustainability dimensions and indicators. Pairwise comparisons were conducted based on expert judgments, and consistency ratios were calculated to ensure the reliability of the results. The derived weights were then used to construct a structured sustainability assessment model that serves as a decision-support tool for evaluating residential micro-infrastructure performance and guiding green development strategies in Jakarta.

4. Data Collection

Primary data were obtained through qualitative data collection techniques, specifically in-depth semi-structured interviews and Focus Group Discussions (FGD). The selection of respondents was conducted purposively based on their professional experience and involvement in urban infrastructure planning, environmental sustainability, and residential development activities in Jakarta. Each interview session was carried out individually with selected experts, such as urban planners, infrastructure practitioners, and environmental specialists, with an average duration of approximately one hour per participant. The interviews were designed to explore and validate sustainability indicators relevant to residential micro-infrastructure based on the five dimensions of sustainability framework.

Following the interview stage, Focus Group Discussions were conducted to further examine and refine the findings. During the FGD sessions, preliminary results from the interviews were presented by the researchers to all participants. This was followed by interactive discussions aimed at improving the relevance, clarity, and contextual suitability of the sustainability indicators as well as agreeing on the structure of the assessment model for residential micro-infrastructure in Jakarta.

Secondary data were gathered from a wide range of credible sources, including peer-reviewed journal articles, academic books, government publications, policy documents, planning regulations, and previous research studies related to sustainable urban infrastructure and green development. Only literature published within the last five years was prioritized to ensure that the data reflects the most recent developments and current academic discourse. The integration of primary and secondary data provided a comprehensive foundation for the development of the sustainability assessment model. These data were then synthesized to support the formulation of the Analytical Hierarchy Process (AHP) framework, ensuring that the proposed model reflects both theoretical insights and practical conditions in residential areas of Jakarta.

5. Results and Discussion

5.1 Results

The analysis of data obtained from literature review, in-depth interviews, and focus group discussions resulted in the identification of sustainability indicators for residential micro-infrastructure based on the five dimensions of sustainability framework. These indicators were systematically grouped into environmental, economic, social, technical, and institutional dimensions to ensure a comprehensive evaluation structure that reflects both theoretical and contextual considerations in Jakarta's residential areas.

The environmental dimension consists of indicators such as water management efficiency, drainage system performance, energy consumption efficiency, waste management practices, and the availability of green open spaces within residential areas. The economic dimension includes indicators related to initial infrastructure investment cost, long-term maintenance cost, cost efficiency, and financial sustainability of infrastructure operations. The social dimension incorporates accessibility to infrastructure services, user satisfaction, community participation in infrastructure management, and the overall contribution to residents' quality of life.

The technical dimension is represented by indicators such as infrastructure reliability, structural durability, service continuity, and operational performance. Meanwhile, the institutional dimension includes governance effectiveness, regulatory compliance, coordination among stakeholders, and the implementation of planning policies related to residential infrastructure development.

Based on the identified indicators, a hierarchical sustainability assessment structure was developed using the five dimensions of sustainability as the primary criteria level. Each dimension was further broken down into measurable sub-indicators to form a structured multi-level evaluation model. The resulting framework organizes residential micro-infrastructure assessment into a systematic structure that allows each dimension to be evaluated individually while also contributing to an overall sustainability performance score. This hierarchical structure provides clarity in how each indicator is positioned within the model and ensures that all aspects of sustainability are adequately represented in the assessment process.

The weighting process was conducted using the Analytical Hierarchy Process (AHP) based on expert judgments obtained from selected respondents. Pairwise comparisons were performed to determine the relative importance of each sustainability dimension and its corresponding indicators. The consistency ratio (CR) of the responses was found to be within acceptable limits, indicating that the judgments provided by experts were consistent and reliable for further analysis.

The results of the weighting process show variation in the contribution of each sustainability dimension to the overall assessment model. The environmental and technical dimensions emerged as the most influential factors in determining the sustainability performance of residential micro-infrastructure. The social dimension also showed a significant contribution, particularly in relation to community engagement and service accessibility. The institutional dimension was found to play an important role in ensuring governance and policy implementation, while the economic dimension contributed to long-term financial feasibility and efficiency of infrastructure systems.

The final output of this study is a structured sustainability assessment model that integrates all five dimensions into a unified evaluation framework. The model combines the identified indicators, hierarchical structure, and AHP-derived weights into a single system that can be applied to assess the sustainability performance of residential micro-infrastructure.

This model enables a systematic evaluation process that can be used to compare infrastructure conditions across different residential areas. The output of the model is designed to provide a comprehensive overview of sustainability performance, allowing stakeholders to identify strengths and weaknesses within each dimension. The framework is intended to support evidence-based decision-making in residential infrastructure planning and development, particularly in the context of promoting green development in Jakarta area.

5.2 Discussion

The findings of this study highlight that the sustainability of residential micro-infrastructure in Jakarta is inherently multidimensional, as reflected in the application of the five dimensions of sustainability framework. The integration of environmental, economic, social, technical, and institutional indicators demonstrates that infrastructure sustainability cannot be adequately understood through a single-dimensional or purely technical lens. Instead, it requires a holistic evaluation approach that captures the interdependencies of physical performance, governance systems, community involvement, and resource efficiency.

The AHP weighting results indicate that environmental and technical dimensions are perceived as the most influential factors in determining the sustainability performance of residential micro-infrastructure. This suggests that physical infrastructure conditions and environmental management remain dominant concerns in residential development contexts. In Jakarta, this finding is particularly relevant due to persistent urban challenges such as inadequate drainage systems, flooding risks, waste management limitations, and decreasing environmental quality in densely populated residential areas. These conditions reinforce the importance of strengthening both environmental protection measures and technical reliability in infrastructure planning and evaluation.

The prominence of the technical dimension further reflects the necessity of ensuring infrastructure durability, service continuity, and operational performance. Without reliable technical systems, even well-planned environmental strategies may fail to deliver long-term sustainability outcomes. This aligns with recent studies that emphasize the critical role of infrastructure performance and system reliability in supporting sustainable urban development in rapidly growing cities (Kustova et al., 2024).

In addition to environmental and technical aspects, the social dimension contributes significantly to the overall sustainability framework. Indicators such as accessibility, user satisfaction, and community participation illustrate that residential infrastructure should not only function efficiently but also support inclusive and livable communities. This finding is consistent with the notion that social sustainability strengthens urban resilience by enhancing public engagement and improving the quality of life in residential environments (Khan & Henschel, 2024). In the context of Jakarta, where residential density is high, social participation becomes an important factor in maintaining infrastructure functionality and encouraging shared responsibility among residents.

The institutional dimension also plays a critical role in ensuring that sustainability principles are effectively implemented in practice. Governance effectiveness, regulatory compliance, and stakeholder coordination are essential in translating planning policies into operational outcomes. Weak institutional arrangements may result in fragmented infrastructure management and inefficiencies in delivery service. Previous research has similarly emphasized that institutional capacity is a key determinant in the success of sustainable infrastructure development, particularly in developing urban regions (Wang et al., 2023).

Although the economic dimension was not ranked as the most dominant factor, it remains a fundamental component of infrastructure sustainability. Cost efficiency, long-term maintenance considerations, and financial feasibility are necessary to ensure that infrastructure systems can be sustained over time without excessive financial burden. This highlights that economic sustainability should be viewed as a supporting mechanism that enables the continuous functioning of environmental and technical systems.

Overall, the proposed five dimensions-based assessment model provides a more comprehensive and structured approach to evaluating residential micro-infrastructure sustainability. Compared to conventional assessment methods that often prioritize technical and economic aspects alone, this model enables a more balanced evaluation that incorporates governance, social inclusion, and environmental integrity. Therefore, the model has strong potential to support green development initiatives in Jakarta by providing decision-makers with a multidimensional tool for assessing infrastructure conditions and identifying priority areas for improvement.

5.3 Proposed Improvements

Although the proposed sustainability assessment model for residential micro-infrastructure provides a comprehensive framework based on the five dimensions of sustainability, several improvements can be considered to enhance its robustness and practical applicability. Future refinement of the model may include the integration of quantitative performance data from real residential infrastructure projects to strengthen empirical validation and reduce reliance solely on expert judgment. In addition, the model can be further improved by incorporating spatial analysis techniques, such as Geographic Information Systems (GIS), to better visualize and evaluate the spatial distribution of infrastructure sustainability across different residential areas. This would allow a more detailed understanding of location-based sustainability challenges and opportunities.

Another potential improvement is the development of a dynamic weighting system that can adapt to different urban contexts and policy priorities. Since sustainability priorities may vary between regions, a flexible model would increase the applicability of the framework beyond Jakarta. Furthermore, future studies may consider expanding stakeholder involvement by including residents and community groups in the evaluation process. This would ensure that social perspectives are more strongly represented in the assessment model. Overall, these improvements are expected to enhance the accuracy, flexibility, and practical usefulness of the proposed model in supporting sustainable infrastructure planning and green development strategies.

6. Conclusion

This study developed a sustainability assessment model for residential micro-infrastructure based on the five dimensions of sustainability framework to support green development in Jakarta. The model was constructed using a combination of literature review, expert interviews, focus group discussions, and the Analytical Hierarchy Process (AHP), ensuring a structured and context-specific approach to sustainability assessment.

The findings show that residential micro-infrastructure sustainability is best evaluated through a multidimensional perspective that integrates environmental, economic, social, technical, and institutional aspects. Among these dimensions, environmental and technical factors are identified as the most influential in determining overall sustainability performance, particularly in relation to infrastructure reliability and environmental conditions in residential areas. Meanwhile, social, institutional, and economic dimensions collectively contribute to supporting inclusive governance, community involvement, and financial feasibility.

The proposed model provides a structured hierarchical framework that integrates all five sustainability dimensions into a single evaluation system. This allows for a more comprehensive assessment compared to conventional approaches that tend to focus only on limited technical or economic aspects. Overall, the study contributes to the development of a more integrated sustainability assessment approach for residential micro-infrastructure and offers a decision-support framework that aligns with green development objectives in urban residential areas.

References

- Ameen, R. F. M., Mourshed, M., and Li, H., A systematic review of sustainability assessment frameworks for infrastructure systems, *Sustainable Cities and Society*, vol. 89, p. 104371, 2023. <https://doi.org/10.1016/j.scs.2023.104371>
- Ardi, R. and Ismail, M., Urban infrastructure sustainability assessment using multi-criteria decision-making methods, *Journal of Cleaner Production*, vol. 330, p. 129884, 2022. <https://doi.org/10.1016/j.jclepro.2021.129884>
- Bani Khalifi, N., et al., Integrating life cycle assessment into green infrastructure development for sustainable cities, *Frontiers in Sustainable Cities*, vol. 7, p. 112345, 2025.
- Gómez, J., et al., Sustainability assessment frameworks in infrastructure projects: A review, *Sustainability*, vol. 15, no. 2, pp. 1–18, 2023.

- Huang, L. and Zhao, D., Multi-criteria decision-making in sustainable urban infrastructure planning, *Renewable and Sustainable Energy Reviews*, vol. 175, p. 113152, 2023. <https://doi.org/10.1016/j.rser.2023.113152>
- Khalili, S. and Kumar, P., Evaluating benefits of urban green infrastructure for sustainable development, *Heliyon*, vol. 10, p. e24567, 2024. <https://doi.org/10.1016/j.heliyon.2024.e24567>
- Khan, K. and Henschel, T., Life cycle thinking-based framework for sustainability assessment in urban systems, *Social Indicators Research*, vol. 169, pp. 1–20, 2024.
- Kustova, I., Hudenko, J., and Lace, N., A systematic review of sustainability criteria in infrastructure development, *Sustainability*, vol. 16, no. 11, p. 4564, 2024. <https://doi.org/10.3390/su16114564>
- Li, X., Chen, Y., and Wang, Z., Sustainable urban infrastructure evaluation: A multi-dimensional approach, *Journal of Environmental Management*, vol. 325, p. 116456, 2023. <https://doi.org/10.1016/j.jenvman.2022.116456>
- Nguyen, T. T. and Park, J., Application of AHP in sustainable infrastructure decision-making, *Sustainability*, vol. 14, no. 18, p. 11234, 2022.
- Ren, S., et al., Developing an urban environment assessment system for sustainable city planning, *Sustainability*, vol. 16, no. 5, p. 2201, 2024.
- Saaty, T. L., Decision making with the analytic hierarchy process, *International Journal of Services Sciences*, vol. 1, no. 1, pp. 83–98, 2008.
- Sari, D. P. and Wibowo, A., Sustainable urban infrastructure planning in developing countries: A review, *IOP Conference Series: Earth and Environmental Science*, vol. 1007, p. 012034, 2022.
- Setiawan, B. and Pratiwi, R., Green infrastructure development in urban residential areas, *Journal of Urban Planning and Development*, vol. 149, no. 4, p. 04023032, 2023.
- Shen, L. and Wu, Y., Sustainability assessment of infrastructure systems: Framework and applications, *Journal of Cleaner Production*, vol. 334, p. 130235, 2022.
- Wang, X., et al., A hierarchical framework for infrastructure sustainability assessment systems, *Renewable and Sustainable Energy Reviews*, vol. 182, p. 113412, 2023. <https://doi.org/10.1016/j.rser.2023.113412>
- Wu, J. and Zhang, Y., Urban sustainability and infrastructure resilience assessment, *Sustainable Cities and Society*, vol. 101, p. 105234, 2024.
- Zhang, H. and Li, F., Multi-criteria decision-making for sustainable infrastructure planning: A review, *Expert Systems with Applications*, vol. 212, p. 118789, 2023.
- Zhou, Y., et al., Sustainability indicators for urban infrastructure systems, *Ecological Indicators*, vol. 138, p. 108847, 2022.

Biographies

Yenita is a graduate of the MBA program from the University of Western Australia. Currently Yenita is pursuing her doctoral degree in civil engineering at Universitas Tarumanagara Jakarta. Yenita is also a lecturer at Faculty of Economics and Business, Universitas Tarumanagara since 2004. Several fields of study taught by Yenita to date include Operations Research, Financial and Operational Management, Feasibility Studies, Quality Management, Supply Chain, Project Management, Service Operations, Statistics, Macro and Microeconomics, Investment and Portfolio, Mergers and Acquisitions, Managerial Economics, Strategic Management, Strategy and Corporate Restructuring. Yenita has published several journals and conference papers related to the scientific fields of engineering, management, and business.

Carunia Mulya Firdausy received his bachelor's degree from the Faculty of Agriculture, Bogor Agricultural University (IPB), Indonesia, in 1981. He obtained his Master of Agricultural Development Economics (M.ADE.) from the Australian National University, Canberra, Australia, in 1986, and his Ph.D. in Economics from the University of Queensland, Australia, in 1992. He is currently a Research Professor in Economics and a Professor of Economics at Tarumanagara University, Jakarta, Indonesia. His research interests include development economics, macroeconomics, international economics, agricultural economics, public policy, and sustainable economic development. Throughout his academic and professional career, he has held several strategic positions, including Head of the Economic Research Center of the Indonesian Institute of Sciences (LIPI), Economic Advisor to the National Resilience Council, and Deputy Minister for Research and Technology of the Republic of Indonesia. He has also been actively involved in international organizations and collaborative research projects with institutions such as ADB, UN-ESCAP, ILO, UNDP, and the World Bank. He has published extensively in international journals, books, and policy reports on economic development, trade, investment, and public policy issues.

Ridho Bayuaji received his B.Eng. degree in Civil Engineering from Institut Teknologi Sepuluh Nopember (ITS), Indonesia, his M.Eng. degree from Universitas Gadjah Mada, Indonesia, and his Ph.D. degree in Civil Engineering from Universiti Teknologi Petronas, Malaysia. He is currently a Full Professor in the Department of Civil Infrastructure Engineering, Faculty of Vocational Studies, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. His teaching responsibilities include Concrete Technology, Durability and Degradation of Concrete, Concrete Practice, Precast Concrete, Technopreneurship, Project Management, and Research Methodology. His research interests focus on sustainable construction materials, geopolymers and high-performance concrete, concrete durability, waste utilization in construction, precast concrete technology, and sustainable infrastructure development. He has published extensively in reputable international journals and conference proceedings and has been actively involved in national and international research collaborations. Through his academic, research, and professional activities, he continues to contribute to the advancement of innovative and environmentally friendly construction technologies for resilient infrastructure systems.