Social Sustainability of Transit Infrastructure: An Analysis of Factors and Indicators at Jakarta MRT Stations

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Abstract *: The rapid development of transit infrastructure in Jakarta has triggered an increase in community mobility; however, the implementation of social sustainability in station projects has not been optimally integrated with technical workflows. Although various project parameters have been proposed, empirical validation of indicators affecting social sustainability using structural equation modeling within the urban railway context remains limited. This study aims to identify and validate key determining indicators of social sustainability in Jakarta Mass Rapid Transit projects. Data were collected through questionnaire surveys administered to active commuters and professional engineering stakeholders, and subsequently analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results of the analysis confirmed a set of valid indicators representing four main variables: community participation, connected construction, project design, and social sustainability. The findings demonstrate that all three independent variables significantly influence social sustainability. Among these variables, the inclusion of public expectations, digital data synchronization, community quality of life, regional connectivity, and fare affordability were identified as the most representative indicators, yielding the highest outer loading values. This study provides an empirical contribution to social infrastructure indicators and offers practical implications for enhancing the quality of transit services.*

Keywords :*Community Participation, Connected Construction, Project Design, Social Sustainability, MRT Stations.*

Abstrak : Perkembangan pesat infrastruktur transit di Jakarta telah mendorong peningkatan mobilitas masyarakat; namun, penerapan keberlanjutan sosial dalam proyek stasiun belum terintegrasi secara optimal, menyeluruh, dan konsisten dengan alur kerja teknis. Meskipun berbagai parameter proyek telah diusulkan, validasi empiris terhadap indikator yang memengaruhi keberlanjutan sosial menggunakan pemodelan persamaan struktural dalam konteks perkeretaapian perkotaan masih terbatas. Penelitian ini bertujuan mengidentifikasi dan memvalidasi indikator penentu utama keberlanjutan sosial pada proyek Mass Rapid Transit Jakarta. Data dikumpulkan melalui survei kuesioner yang diberikan kepada komuter aktif yang melakukan perjalanan setiap hari dan pemangku kepentingan profesional bidang teknik, kemudian dianalisis secara kuantitatif menggunakan Partial Least Squares Structural Equation Modeling (PLS-SEM). Hasil analisis berdasarkan hasil pengujian model mengonfirmasi seperangkat indikator valid yang mewakili empat variabel utama, yaitu partisipasi masyarakat, konstruksi terhubung, desain proyek, dan keberlanjutan sosial. Temuan menunjukkan bahwa ketiga variabel independen berpengaruh signifikan terhadap keberlanjutan sosial. Di antara variabel tersebut, pemenuhan harapan publik, sinkronisasi data digital, kualitas hidup masyarakat, konektivitas wilayah, dan keterjangkauan tarif teridentifikasi sebagai indikator paling representatif dengan nilai outer loading tertinggi. Penelitian ini memberikan kontribusi empiris terhadap indikator infrastruktur sosial dan menawarkan implikasi praktis untuk meningkatkan kualitas layanan transit dalam pembangunan transportasi perkotaan modern.

Kata kunci: Partisipasi Masyarakat, Konstruksi Terhubung, Desain Proyek, Keberlanjutan Sosial, Stasiun MRT.

INTRODUCTION

The rapid expansion of urban transit infrastructure across Jakarta has significantly accelerated construction activities, shifting focus toward the urgent need for highly responsive public facilities. Yet, in the actual execution of these station projects, weaving social sustainability into the core technical workflows remains a persistent challenge (Gunawan et al., 2025). While previous literature has offered various frameworks for project delivery and public satisfaction, we still face a shortage of empirical proof. Specifically, there is little research validating the exact factor structures and indicators driving social sustainability through structural equation modeling within the mass rapid transit sector (Corsini & Moultrie, 2021). This gap matters because transit stations are far more than concrete structures; they operate as vital public hubs and shared spaces utilized by an incredibly diverse community every single day (Zemp et al., 2011). Consequently, embedding social sustainability into station infrastructure is paramount, directly influencing the quality of life, safety, security, comfort, and universal inclusivity experienced by everyday commuters (Shatta & Myamba, 2024). Driven by this necessity, this study aims to pin down and validate the critical factors and indicators that dictate social sustainability performance across Jakarta's Mass Rapid Transit projects (Choiriyah et al., n.d.).

MRT Jakarta Phase I officially commenced commercial operations on March 24, 2019. This initial phase spans the Lebak Bulus to Bundaran HI route, encompassing 13 stations including the starting terminal (PT MRT Jakarta, 2020). From its inception, the MRT Jakarta system has seen high public adoption, registering a total of 24,621,467 passengers throughout 2019. This equates to an average daily ridership of 89,645 users during its first year of operation (Pambudi & Hidayati, 2020). Recent official data indicates that MRT Jakarta's monthly passenger volume reached 3,534,665 individuals in January 2025 (BPS Provinsi DKI Jakarta, 2025). This figure represents a 12.80% increase compared to January 2024, underscoring the mass rapid transit system's growing and critical role in the daily mobility of Jakarta's population (BPS Provinsi DKI Jakarta, 2025).

In practice, the implementation of social sustainability at MRT Jakarta stations still leaves room for evaluation regarding physical infrastructure and user facility design. Specifically, research by Oktaviani & Sugandi (2021) at Haji Nawi MRT Station revealed that certain amenities for individuals with disabilities such as the absence of guiding blocks on platforms, taxi shelters, and signage at designated parking zones fall short of established accessibility standards, proving that modern facilities do not automatically guarantee equitable access for all. Furthermore, Putra et al., (2024) highlighted missing support structures, including lifts and ramps for wheelchair users, at the Dukuh Atas MRT station area, emphasizing that transit-oriented accessibility remains a critical concern for the mobility of vulnerable groups. Beyond physical access, safety and comfort are paramount to social sustainability; Ceccato et al. (2024) note that passenger safety perceptions are heavily shaped by both social and physical transit attributes, such as facility maintenance, waiting areas, lighting, CCTV coverage, and the surrounding environment leading to the station. Ultimately, because commuters with limited mobility experience unique vulnerabilities, the overall quality of the MRT Jakarta experience is determined not just by the train ride itself, but by an integrated combination of service reliability, perceived value, environmental quality, and robust supporting infrastructure (Choiriyah et al., 2026).

Social sustainability within transportation networks does not exist in a vacuum; it is shaped by a continuous interplay of managerial choices, technological adoption, and physical design (Ben Purvis et al., 1987). Public participation serves as the bedrock here, channeling community expectations straight into the project life cycle via targeted public engagement indicators (Unegbu et al., 2025). This groundwork directly feeds into the success of connected construction, a phase mapped through collaborative digital data synchronization on modern construction management platforms (Utomo et al., 2022). When this integrated data flows smoothly, it refines project design by minimizing errors and allowing engineers to map out optimized station layouts (Leedy & Ormrod, 2016). Once these tangible design elements like barrier-free access and safe transit facilities are properly built, they interact seamlessly with daily passengers to bring true social sustainability to life (Ceccato et al., 2024). Even though these conceptual links are widely accepted in theory, empirical studies evaluating convergent validity, discriminant validity, and the exact outer loadings of these metrics within a unified model are incredibly rare (Huwaida et al., 2020). Most engineering assessments tend to disconnect technical metrics from actual community impacts, leaving a blind spot regarding which indicators truly matter for project success (Choiriyah et al., n.d.). By utilizing a confirmatory factor analysis, this study weeds out indicators falling below statistical thresholds to build a bulletproof measurement model (Henseler et al., 2015). Ultimately, by validating this multi-tiered framework, this paper delivers a fresh empirical foundation for social infrastructure benchmarks while giving transit operators practical strategies to elevate the commuter experience (Velasco Arevalo & Gerike, 2023).

The concept of social sustainability places human beings at the center of development success. Within the construction industry, projects are evaluated not merely by their physical execution, but by how the facilities deliver social benefits, establish equitable access, safeguard safety, and enhance the quality of life for end-users and affected communities (Gurmu et al., 2022). In the context of public transportation infrastructure, such as Mass Rapid Transit (MRT) stations, social sustainability inherently relates to the capacity of transit structures to act as shared spaces that provide safe, comfortable, inclusive, and accessible environments for vulnerable groups, including individuals with disabilities, the elderly, women, and children (Hofstad, 2023).

Community participation represents the active engagement of end-users throughout the project life cycle, spanning from the planning and decision-making phases to post-construction evaluation (Boström, 2012). This involvement serves as a mechanism to align public expectations with technical performance on-site, minimize potential conflicts of interest, and reinforce procedural legitimacy (Velasco Arevalo & Gerike, 2023a). Feedback from the public brings forth vital local knowledge regarding real-world requirements in transit environments such as directional clarity (*signage*), adequacy of priority facilities, and pedestrian pathway efficiency which often fail to be optimally accommodated in purely technical engineering designs (Oktaviani, 2021).

Connected construction is a modern paradigm that integrates workflows, data, digital technologies, and stakeholders across the entire project life cycle (Utomo et al., 2022). This approach leverages collaborative platforms, such as Building Information Modeling (BIM) and cloud-based systems, to facilitate seamless communication, knowledge sharing, and real-time data management among project participants (Bashir et al., 2024). In mass transit construction management, connected construction dissolves traditional organizational silos between design management, field contractors, and facility management teams, thereby proactively mitigating operational bottlenecks before asset handover (Astarini et al., 2022).

Project design in civil engineering refers to the process of translating technical constraints and user requirement parameters into an actionable, effective physical blueprint (Rohman, 2017). Modern transit station designs must adopt principles of inclusive and universal design to create a built environment responsive to urban mobility needs (Rohman, 2017). Design performance is judged not merely by the aesthetics of the final product, but by the efficiency of multidisciplinary data integration that minimizes physical layout deviations, reduces engineering drawing errors, and ensures functional reliability regarding passenger circulation, security protection, and commuter comfort (Ceccato et al., 2024).

RESEARCH METHODS

This study utilizes a quantitative approach with primary data to develop and validate the determining indicators of social sustainability in transit infrastructure. The sampling technique employs a non-probability sampling method with a purposive sampling approach. The criteria for respondents require them to be active commuters as well as professional engineering stakeholders from project owners, design consultants, or main contractors involved in the Jakarta Mass Rapid Transit project. The research instrument consists of a questionnaire measured using a five-point Likert scale. The indicators used in this study were identified through a literature review of various previous studies related to public infrastructure performance measurement and digital construction management. Subsequently, all indicators were synthesized and grouped into research variables that represent the main factors in shaping social sustainability. This categorization aims to ensure that each variable reflects relevant operational aspects and can be systematically measured using Partial Least Squares Structural Equation Modeling (PLS-SEM)(Hair et al., 2017). Overall, this research utilizes a set of valid indicators grouped into four main research variables for analytical purposes, as presented in Table 1.

Table 1. Research Factor and Indicator

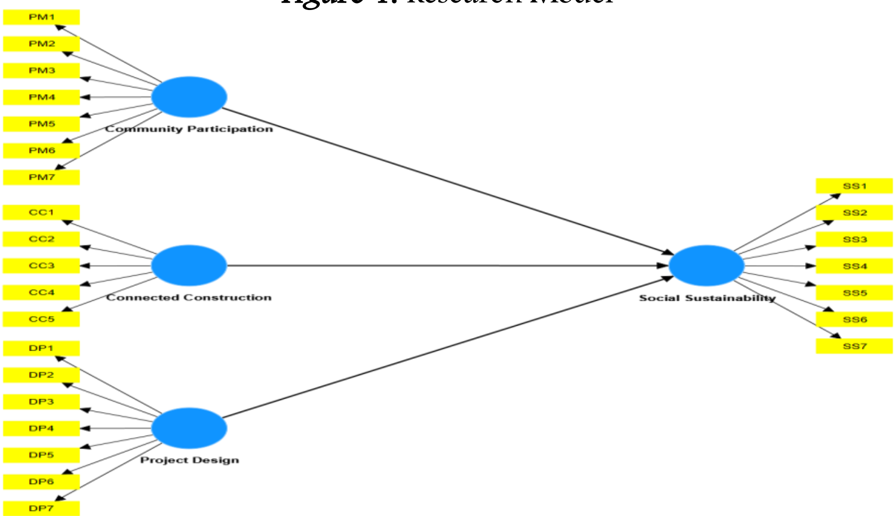
Code	Indicator	Operational Definition	References
PM1	Input/complaint channels	Availability and accessibility of official channels for the community to submit feedback, complaints, or aspirations regarding MRT services and facilities.	(Utsunomiya et al., 2023); (Ismael & Duleba, 2021)
PM2	Participation in planning	The level of community involvement in planning or decision-making processes related to public transportation services and facilities.	(Unegbu et al., 2025); (Fasya, 2025.)
PM3	Influence of community input	The extent to which community input is considered in decision-making regarding the development of MRT services or facilities.	(Xiahou et al., 2022a); (Rohman, 2017)
PM4	Information transparency	The level of openness regarding information about MRT services, policies, changes, and facility developments for the community.	(Velasco Arevalo & Gerike, 2023)
PM5	Access to latest information	The ease with which the community can obtain updated information regarding MRT services, facility changes, schedules, or service policies.	(Fasya, 2025.); (Choiriyah et al., 2026)
PM6	Service evaluation	Community involvement in providing assessments, evaluations, or monitoring of MRT services after they have been implemented.	(Maddaloni & Sabini, 2022); (Unegbu et al., 2025)
PM7	Influence on local policy	The impact of community participation on adjustments to local policies or decisions related to public transportation.	(Xiahou et al., 2022b); (Velasco Arevalo & Gerike, 2023)

Code	Indicator	Operational Definition	References
CC1	Coordination technology	The use of digital technology to support coordination, communication, and information exchange among MRT project stakeholders.	Utomo et al. (2022); (Astarini et al., 2022)
CC2	Digital information systems	The utilization of digital information systems that enable fast and real-time access to MRT project or service data.	Utomo et al. (2022); (Haryanti et al., 2024)
CC3	Stakeholder collaboration	The level of collaboration between MRT management, contractors, consultants, the government, and the community in supporting project or service quality.	Utomo et al. (2022); (de Almeida Vittori Ferreira et al., 2024); (Xiahou et al., 2022a)
CC4	Real-time data management	The management of MRT project or service data digitally, in real-time, and easily accessible to relevant stakeholders.	Utomo et al. (2022); Astarini et al. (2022)
CC5	Technological transparency	The use of technology to increase transparency in decision-making and MRT project management.	Utomo et al. (2022); (de Almeida Vittori Ferreira et al., 2024)
DP1	Accessibility of design	The ease of access to MRT facilities for all users, including people with disabilities, the elderly, children, and other vulnerable groups.	(Corsini & Moultrie, 2021); Velasco Arevalo & Gerike (2023)
DP2	Design innovation	The application of design innovations that support efficiency, ease of use, and the improvement of MRT service quality.	(Chen et al., 2024); Astarini et al. (2022)
DP3	Eco-friendly design	Design consideration toward environmental sustainability through energy efficiency, the use of eco-friendly materials, and environmental impact reduction.	(Zhang et al., 2025); Velasco Arevalo & Gerike (2023)
DP4	Needs of vulnerable groups	The ability of MRT design to accommodate the needs of vulnerable groups, such as people with disabilities, the elderly, pregnant women, and users with limited mobility.	(Oktaviani, 2021); (Gui et al., 2025)
DP5	Safety and comfort	The ability of MRT facility design to provide a sense of safety, comfort, orderliness, and decency for users.	Ceccato et al. (2024); (Q. Yang et al., 2025)
DP6	Inclusive design	The ability of MRT design to consider the needs of various social groups so that facilities can be used equally.	Velasco Arevalo & Gerike (2023); (Alves et al., 2025)
DP7	Participation in design	The involvement of the community or users in providing input on MRT facility design decisions.	Unegbu et al. (2024); Rohman (2017)
SS1	Safe and comfortable facilities	The provision of MRT facilities capable of offering safety, comfort, and baseline usability for the community.	Ceccato et al. (2024); Choiriyah et al. (2026)
SS2	Travel time efficiency	The contribution of the MRT in reducing community travel time compared to other modes of transportation.	Xiahou et al. (2022); Velasco Arevalo & Gerike (2023)
SS3	Ease of regional access	The ability of the MRT to improve community access to areas that were previously difficult to reach.	Xiahou et al. (2022); Yang et al. (2024)

Code	Indicator	Operational Definition	References
SS4	Quality of life of the community	The contribution of the MRT to improving the community's quality of life through ease of mobility, access to services, and urban connectivity.	(Rostamnezhad & Thaheem, 2022); Velasco Arevalo & Gerike (2023)
SS5	Fare affordability	The suitability of MRT fares with the purchasing power of the community, especially middle-to-lower-income groups.	Velasco Arevalo & Gerike (2023); (Fatourehchi & Zarghami, 2020)
SS6	Regional connectivity	The ability of the MRT to improve inter-regional connectivity and support public transportation integration.	(W. Yang et al., 2024); Chen et al. (2025)
SS7	Local job opportunities	The contribution of MRT construction or operations in creating job opportunities and economic benefits for the local community.	Rostamnezhad & Thaheem (2022); Xiahou et al. (2022)

Source: Processed by the author, 2026.

Figure 1. Research Model



Source: Processed by the author, 2026.

Data analysis was performed using PLS-SEM with a primary focus on evaluating the measurement model. The testing procedures encompass convergent validity via outer loading values using a strict threshold cut-off of 0.70, where indicators with loadings below 0.70 are removed to ensure robust measurement model properties. Discriminant validity was evaluated utilizing cross-loadings, the Fornell-Larcker criterion, and the heterotrait-monotrait (HTMT) ratio, along with reliability tests including Cronbach's alpha, composite reliability, and average variance extracted (AVE). This approach is employed to ensure that the developed indicators possess adequate levels of reliability and validity in representing the social sustainability performance of MRT station infrastructure (Hair et al., 2017).

RESULT AND DISCUSSION

The research findings are structured into three distinct stages: questionnaire response evaluation, research data evaluation (validity and reliability), and measurement model evaluation. The respondents for the primary questionnaire comprise active commuters as well as professional engineering stakeholders involved with the MRT stations. Analysis of the complete questionnaire dataset from respondents meeting the inclusion criteria reveals that participants tend to agree or strongly agree with each measurement indicator across the research variables.

Table 2. Indicator Validity of the Measurement Model

Variable	Code	Outer Loading	Description
Community Participation (X1)	PM1	0,921	Valid
	PM2	0,835	Valid
	PM3	0,728	Valid
	PM 4	0,941	Valid
	PM5	0,767	Valid
	PM6	0,787	Valid
	PM7	0,739	Valid
Connected Construction (X2)	CC1	0,741	Valid
	CC2	0,697	Invalid
	CC3	0,662	Invalid
	CC4	0,778	Valid
	CC5	0,702	Valid
Project Design (X3)	DP1	0,661	Invalid
	DP2	0,685	Invalid
	DP3	0,745	Valid
	DP4	0,729	Valid
	DP5	0,877	Valid
	DP6	0,757	Valid
	DP7	0,634	Invalid
Social Sustainability (Y)	SS1	0,894	Valid
	SS2	0,904	Valid
	SS3	0,854	Valid
	SS4	0,927	Valid
	SS5	0,912	Valid
	SS6	0,913	Valid
	SS7	0,907	Valid

Source: Processed by the author, 2026.

Based on the data analysis results, the community participation variable is represented by seven indicators, all of which were declared valid. PM4 (0.941) and PM1 (0.921) yielded the highest outer loading values, indicating that the active inclusion of public expectations since the early planning phase is the most dominant element in attracting community social support for transit infrastructure projects.

The connected construction variable is represented by three valid indicators after eliminating indicators CC2 (0.697) and CC3 (0.662). Indicator CC4 exhibited the highest outer loading value of 0.778, proving that the aspect of collaborative digital data synchronization plays the most powerful role in aligning technical workflows on-site. The project design variable is represented by four valid indicators, whereas indicators DP1 (0.661), DP2 (0.685), and DP7 (0.634) were removed from the model due to failing to meet the eligibility threshold. Indicator DP5 recorded the highest outer loading value of 0.877, confirming that the safety and comfort (Safety and Comfort) aspects of MRT facility design represent the most critical physical design elements in shaping user perceptions. The social sustainability variable is represented by seven indicators, all of which possess exceptionally high loading values and were declared valid. Indicator SS4 (Quality of life) achieved the highest outer loading value of 0.927, followed closely by SS6 (Regional connectivity-0.913) and SS5 (Fare affordability-0.912), reflecting that enhancing community quality of life, improving inter-regional connectivity, and maintaining affordable fares serve as the primary determining parameters for successful social sustainability performance at Jakarta MRT stations.

Table 3. Construct and Indicator Reliability Evaluation

Variable	Cronbach Alpha	Composite Reliability	Average Variance Extracted (AVE)	Description
Community Participation (X1)	0,912	0,930	0,654	Reliabel
Connected Construction (X2)	0,785	0,814	0,598	Reliabel
Project Design (X3)	0,824	0,852	0,591	Reliabel
Social Sustainability (Y)	0,954	0,962	0,784	Reliabel

Source: Processed by the author, 2026.

Based on the statistical data analysis results presented in Table 3, it is revealed that the community participation variable yields a Cronbach's alpha value of 0.912 and a composite reliability value of 0.930. Both parameters sit well above the required minimum threshold, thereby declaring the community participation construct to possess exceptionally high reliability. Furthermore, the obtained Average Variance Extracted (AVE) value is 0.654, signifying that approximately 65.4% of the variance across all measurement indicators can be explained by this latent variable. This finding confirms that the indicators capturing the inclusion of public expectations and the absorption of community aspirations serve as consistent instruments for measuring public contribution throughout the project life cycle (Unegbu et al., 2025).

For the connected construction variable, the test results demonstrate a Cronbach's alpha value of 0.785 and a composite reliability value of 0.814. Although the reliability of this construct is lower compared to the other variables, these figures still adequately satisfy the minimum statistical thresholds. The recorded Average Variance Extracted (AVE) value of 0.598 indicates that the measurement dimension successfully fulfills the standard criteria for convergent validity. This characteristic proves that the indicators representing collaborative digital data synchronization and technology platform-based information integration are capable of stably evaluating the level of communication connectivity among stakeholders within a transit project environment (Utomo et al., 2022).

The project design variable registers a Cronbach's alpha value of 0.824 and a composite reliability value of 0.852, confirming that all indicators retained in the model possess strong internal consistency. The achieved Average Variance Extracted (AVE) value of 0.591 further reinforces the eligibility of the measurement model for this dimension. The robust reliability of the project design variable reflects that the measurement instruments which focus on design blueprint accuracy and the minimization of layout errors are highly capable of predicting the quality of physical station designs that are responsive to both technical and operational requirements (Zhang et al., 2025).

Lastly, the social sustainability variable, serving as the primary dependent construct in this study, exhibits the highest reliability performance, with a Cronbach's alpha reaching 0.954 and a composite reliability value of 0.962. The obtained Average Variance Extracted (AVE) value is also remarkably high at 0.784, confirming that the measurement instrument possesses an extraordinary capability to explain the latent variance of social sustainability. This figure provides highly robust empirical confirmation that the set of indicators encompassing community quality of life (SS4), regional connectivity (SS6), and fare affordability (SS5) serves as valid quantitative parameters to measure the success level of social sustainability performance in Jakarta Mass Rapid Transit station projects (Ceccato et al., 2024).

CONCLUSION AND SUGGESTIONS

This study has successfully developed and validated a set of indicators and factors to measure social sustainability performance in Jakarta Mass Rapid Transit station infrastructure projects. The evaluation results of the measurement model demonstrate that all indicators retained within the framework meet the criteria for convergent validity, discriminant validity, and internal consistency reliability exceptionally well, thereby adequately representing the latent variables. The research findings identify that the community participation, connected construction, and project design variables make vital contributions to shaping the social performance of urban transit stations. Specifically, the dominant indicators influencing social sustainability performance within each respective factor group encompass the inclusion of public expectations, collaborative digital data synchronization, and the accuracy of design blueprints to minimize building layout errors. Furthermore, the improvement of community quality of life, regional connectivity, and fare affordability are validated as the most reliable quantitative indicators for assessing the effectiveness of social sustainability practices on-site. Overall, this study contributes a validated and relevant framework of indicators within the context of urban public transportation, which can be utilized as a baseline for performance evaluation and policy development in similar infrastructure construction contexts.

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