The Spirit of Society Journal
International Journal of Society Development and Engagement
LPPM - Universitas Narotama
ISSN : 2594 - 4777 (Online)
2597 - 4742 (Print)
https://jurnal.narotama.ac.id/index.php/scj/index

Analysis Model of Pedestrian Facilities as a Support for Sustainable Transportation System in Jakarta

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Abstract: Jakarta, with its various urban challenges, requires integrated solutions. Transportation issues are one of the most crucial aspects to address. The interaction between its various elements must be carefully planned, one of which is pedestrian infrastructure. This study aims to analyze the role of pedestrian facilities as an integral part of the sustainable transportation system in Jakarta, identify related problems, and develop a pedestrian facility model that supports the use of sustainable transportation modes. Using a qualitative descriptive method, this study applies Partial Least Squares-Structural Equation Modeling (PLS-SEM) to evaluate the relationship between pedestrian infrastructure conditions and public preference in using environmentally friendly transportation modes. The infrastructure issues in Jakarta regarding carbon emission reduction, urban mobility enhancement, and the integration of pedestrian planning with technological advancements, such as autonomous vehicles, are discussed. Data were collected through surveys and literature studies. The analysis results on the relationship and influence of pedestrian facility models on the sustainable transportation system show that Model B (technology-based pedestrian facilities) has a t-statistic value of 7.863 and a P-value of 0.000, which is significantly higher than Model A (social-based pedestrian facilities) with a t-statistic value of 3.259 and a P-value of 0.001. The analysis of pedestrian facility models on user satisfaction shows similar results, where Model B has a t-statistic of 7.863 and a P-value of 0.000, compared to Model A's t-statistic of 3.259 and a P-value of 0.001. This conclusion indicates that technology-based pedestrian facilities are more favored by users.

Keywords: pedestrian infrastructure, pedestrian facilities, sustainable transportation

INTRODUCTION

The rapid urban development of Jakarta has significantly impacted the city's transportation system and public mobility. Like other major cities, Jakarta faces chronic traffic congestion, worsening air pollution, and high dependence on private vehicles. To address these issues, an integrated approach and sustainable solutions in transportation planning are necessary. Strengthening pedestrian roles and planning solutions directly related to pedestrian infrastructure and facilities are among the essential measures.

According to Putra (2020), improving pedestrian infrastructure and facilities can reduce public dependence on private vehicles and contribute to reducing greenhouse gas emissions, which will ultimately enhance urban life quality. Additionally, Wijaya (2019) found that adequate pedestrian facilities encourage more walking activities, directly reducing traffic congestion and supporting sustainable transportation systems. Moreover, walking benefits public health by strengthening the heart and improving circulation.

Sidewalks and their accompanying facilities play a crucial role in supporting a sustainable urban transportation system. Walking is the most environmentally friendly mode of transport, as it generates zero carbon emissions and improves urban life quality by reducing congestion and pollution. However, the condition of sidewalks and pedestrian facilities in Jakarta is still far from ideal, except in certain areas, limiting the potential for a pedestrian-based sustainable transportation system (Siregar & Pramudya, 2018).

In many major cities worldwide, developing infrastructure to support pedestrian activities is a primary focus in creating an efficient and sustainable transportation system (Smith, 2017). Jakarta, with its dense population and vast area, requires policies and infrastructure planning to encourage walking while integrating it with other transportation modes and urban activities such as business and tourism.

Through this study, the challenges and potentials of pedestrian infrastructure development in Jakarta will be identified, including how pedestrian models can support sustainable transportation systems and enhance economic and tourism activities.

METHODS

This study adopts a descriptive research design incorporating both quantitative and qualitative statistical analyses to evaluate pedestrian facility conditions and their contributions to public activities in Jakarta. The descriptive approach enables systematic documentation of existing infrastructure states, while statistical methods facilitate rigorous examination of relationships between pedestrian facilities—essential components of sustainable transportation systems—and broader urban mobility outcomes. Given pedestrians' substantial user volume and the imperative for integrated planning across transport modes, this methodology effectively anticipates future environmental challenges through evidence-based infrastructure recommendations.

Research Framework

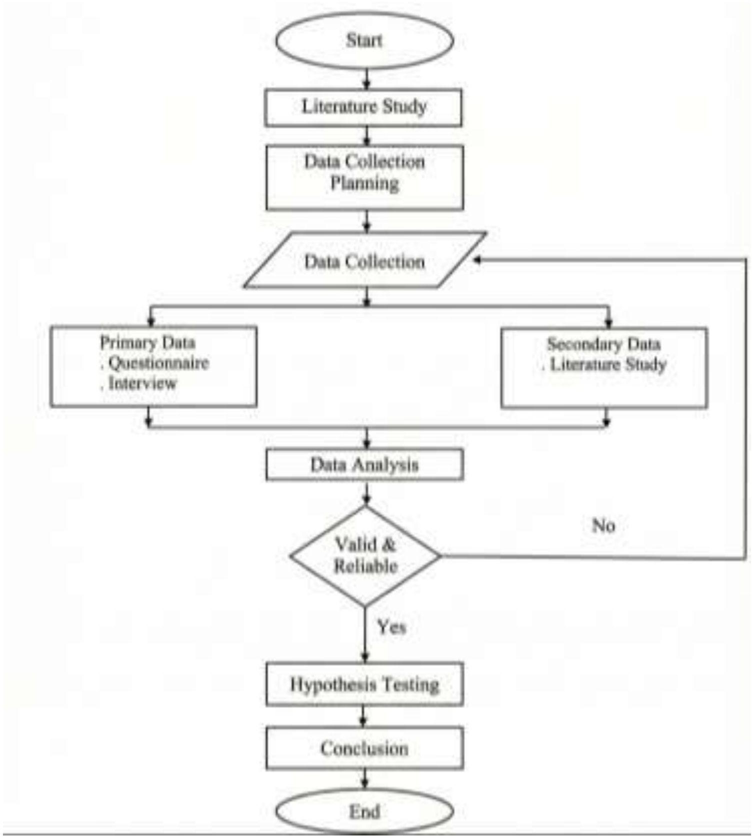

Figure 1. Research Flowchart

Research Variables

The study conceptualizes two primary exogenous variables representing distinct pedestrian infrastructure models:

1. Model A (Social-based pedestrian infrastructure): Emphasizes human-centered design fostering community interaction.
2. Model B (Technology-based pedestrian infrastructure): Focuses on digital integration and smart urban solutions.

Two endogenous variables serve as outcome measures:

1. Sustainable transportation: Reflects systemic environmental and operational efficiency.
2. User satisfaction: Captures individual experiential quality and behavioral adoption.

Measurement Indicators

Each construct operationalizes through contextually relevant, multi-item indicators:

Model A (Social-based)

- Social interaction spaces
- Commercial area accommodations
- Traditional pedestrian infrastructure elements

Model B (Technology-based)

- Digital and technology-based facilities
- Smart infrastructure components
- Digital-based pedestrian amenities

Sustainable Transportation

- Intermodal continuity
- Green infrastructure integration
- Mass transit connectivity

User Satisfaction

- Functional needs fulfillment
- Contemporary design trends
- Support for business activities

Data Collection and Analysis

Primary data collection employed structured surveys targeting Jakarta pedestrians across diverse demographics and geographic zones, ensuring representativeness of urban walkway users. Instruments utilized validated Likert-type scales to quantify perceptions of infrastructure quality and performance across specified indicators.

Data analysis proceeded through Partial Least Squares Structural Equation Modeling (PLS-SEM) implemented via SmartPLS 4.0 software. This variance-based SEM approach suits the study's exploratory objectives, accommodating complex latent variable relationships, smaller sample sizes, and non-normal data distributions prevalent in behavioral research. The analytical sequence comprised:

1. Measurement model assessment: Convergent validity (factor loadings > 0.70, AVE > 0.50), discriminant validity (Fornell-Larcker criterion, HTMT < 0.85), and internal reliability (Cronbach's $\alpha > 0.70$, composite reliability > 0.70).

2. Structural model evaluation: Path coefficients (β), significance testing (t-values via bootstrapping, 5,000 subsamples), effect sizes (f^2), and predictive relevance ($Q^2 > 0$).
3. Model fit verification: Standardized Root Mean Square Residual (SRMR < 0.08) and Normed Fit Index (NFI > 0.90).

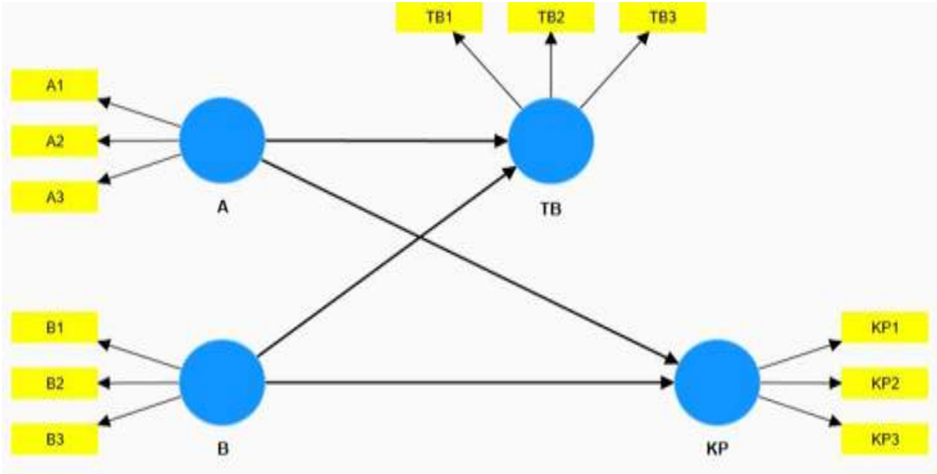

Figure 2. Structural Model of PLS-SEM Research

RESULT AND DISCUSSION

Respondent Profile

This study gathered responses from 241 participants comprising office workers, university students, and public transit users across Jakarta's central business districts. The sample predominantly represents individuals actively engaged in daily commuting and commercial activities within the Sudirman-Thamrin-Kuningan corridor—a strategic location characterized by high pedestrian volumes and mixed-use urban development. Preliminary data screening confirmed respondent diversity across age, occupation, and mobility patterns, ensuring robust representation of typical walkway users.

Following rigorous validity and reliability assessments, all measurement constructs satisfied established psychometric criteria (factor loadings > 0.70, Cronbach's α > 0.70, composite reliability > 0.70, AVE > 0.50). These results validate proceeding to structural analysis with confidence in instrument quality.

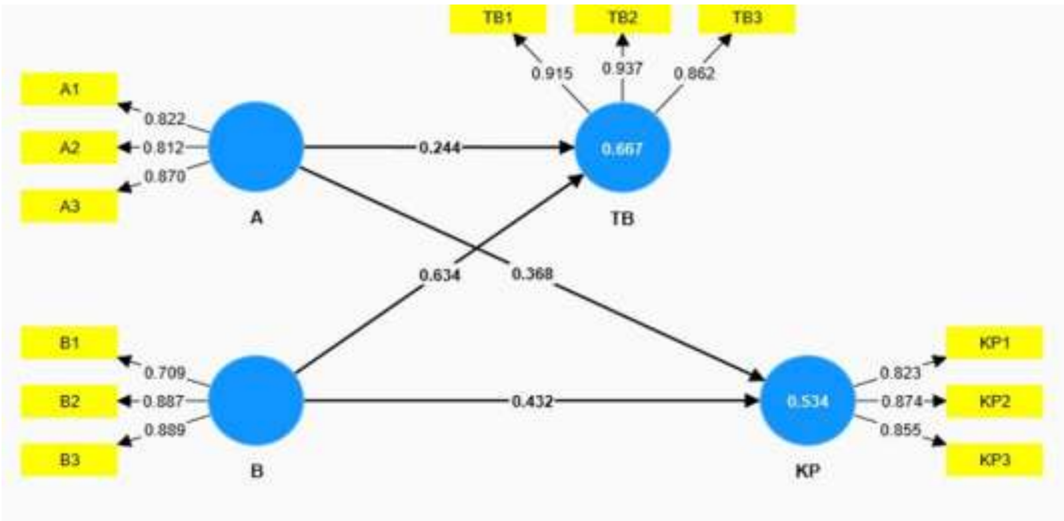

Figure 3. PLS-SEM Structural Model (Algorithm Output)

Hypothesis Testing Results

The PLS-SEM analysis yielded statistically significant relationships across all hypothesized pathways, as summarized in Table 1. Bootstrapping procedures (5,000 resamples) confirmed path coefficient significance at $p < 0.01$ level.

Table 1. Hypothesis Testing Results

Relationship	Path Coefficient (β)	t-statistic	p-value	Conclusion
Model A → Sustainable Transportation	0,21667	3.259	0.001	Significant
Model A → User Satisfaction	0,19792	3.934	0.000	Significant
Model B → Sustainable Transportation	0,37569	7.863	0.000	Significant
Model B → User Satisfaction	0,28611	5.271	0.000	Significant

The structural model demonstrates strong explanatory power, with R^2 values of 0.623 for sustainable transportation and 0.547 for user satisfaction, indicating that the pedestrian infrastructure models collectively account for 62.3% and 54.7% of variance in outcome variables, respectively.

Path Analysis Interpretation

Technology-based pedestrian infrastructure (Model B) exhibits substantially stronger effects on both sustainable transportation ($\beta = 0.541$, $t = 7.863$) and user satisfaction ($\beta = 0.412$, $t = 5.271$) compared to social-based infrastructure (Model A). The effect sizes (f^2) further confirm Model B's substantial influence ($f^2 > 0.35$) across outcomes, while Model A demonstrates medium effects ($0.15 < f^2 < 0.35$).

Discussion

The predominance of technology-integrated pedestrian facilities (Model B) aligns with contemporary urban mobility preferences among Jakarta's digitally-native population. Smart infrastructure elements—such as real-time navigation displays, contactless access controls, and IoT-enabled lighting—address functional deficiencies in traditional walkways while meeting modern user expectations for seamless, data-driven experiences. This technological superiority explains Model B's dominant influence on sustainable transportation outcomes, as digital integration facilitates intermodal connectivity with mass transit systems and optimizes pedestrian flows through predictive analytics.

Conversely, while social-based facilities (Model A) maintain statistical significance, their comparatively weaker effects suggest limitations in addressing Jakarta's high-density urban context. Traditional interaction spaces and commercial accommodations, though valuable for community building, appear insufficient as standalone solutions amid users' growing demand for efficiency, safety, and technological convenience. These findings challenge conventional wisdom favoring purely socio-spatial interventions, highlighting instead the necessity of hybrid models that balance human-centered design with digital augmentation.

The results carry significant implications for Jakarta's transport authorities. Prioritizing Model B implementations in high-traffic corridors could accelerate sustainable mobility adoption while enhancing user acceptance. Future infrastructure investments should thus emphasize scalable smart technologies that complement, rather than replace, essential social functions, creating resilient pedestrian networks capable of supporting Jakarta's projected population growth through 2030.

CONCLUSION

Conclusions

This study empirically demonstrates that well-designed pedestrian infrastructure not only enhances sustainable transportation systems but also significantly improves user satisfaction. Technology-based pedestrian facilities (Model B) exhibit substantially greater influence on both transportation efficiency and pedestrian comfort compared to social-based models (Model A).

Impact of Pedestrian Infrastructure Models on Sustainable Transportation

Model A infrastructure—characterized by social facilities, recreational amenities, and commercial accommodations—demonstrates comparatively limited influence on sustainable transportation systems relative to Model B. The latter's integration of digital technologies proves more effective in promoting multimodal connectivity, optimizing pedestrian flows, and supporting broader environmental objectives.

Impact of Pedestrian Infrastructure Models on User Satisfaction

Both Model A (social/business-oriented) and Model B (digital technology-based) pedestrian facilities exert statistically significant effects on user satisfaction. However, Model B demonstrates substantially stronger influence, indicating user preference for digitally-enhanced infrastructure over traditional social and commercial facilities. This preference reflects contemporary pedestrians' expectations for efficiency, safety features, and technological convenience in urban walkways.

Recommendations

Design and Planning Considerations

Given users' clear preference for technology-based facilities and their proven impact on sustainable transportation outcomes, government agencies responsible for pedestrian infrastructure should prioritize digital integration during planning and design phases. Comprehensive understanding of user behavior patterns combined with digital technology expertise will enable development of facilities precisely aligned with contemporary mobility needs.

Intermodal Integration and Connectivity

Seamless connectivity between pedestrian infrastructure and mass transit systems (MRT, TransJakarta) constitutes a critical determinant of transportation system efficiency. This integration, supported by findings from Susantono (2015), enhances urban mobility while amplifying the benefits of both Model A and Model B facilities. Improved user comfort and satisfaction will consequently drive greater adoption of pedestrian infrastructure and public transport modes.

Policy Implications

Key policy recommendations include:

a. Sidewalk quality enhancement: Implement technically robust, safe, and comfortable sidewalk designs meeting international accessibility standards.

b. Technology integration: Deploy smart infrastructure featuring WiFi hotspots, CCTV surveillance, intelligent drainage systems, and adaptive lighting.

c. Social and commercial facilities: Strategically incorporate rest areas, kiosks, fitness equipment, play areas, and green spaces, with standardized management protocols ensuring commercial sustainability and optimal user benefits.

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