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Article

Wirosari Bus Terminal Performance Analysis Based on Facility Availability and Optimization Through Internet of Things (IoT) Technology

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A B S T R A C T

Wirosari Bus Terminal, a Type-C terminal located in Grobogan Regency, plays a crucial role in supporting rural mobility. However, underutilization and non-compliance with Indonesia's Minimum Service Standards (SPM) have significantly hampered its performance. This study evaluates the availability and quality of terminal facilities and proposes a technological optimization model based on the Internet of Things (IoT). Using a quantitative research design, 92 respondents including users, operators, and terminal staff were surveyed. The data were analyzed through multiple linear regression to determine the influence of facility availability (X_1) and technology perception (X_2) on terminal performance (Y). Results indicate that perceived facility availability is low (mean = 2.70), while technology acceptance is high (mean = 4.68). The regression model reveals that both variables significantly affect terminal performance ($R^2 = 0.284$, $p < 0.05$). This study concludes that enhancing physical infrastructure combined with IoT-based digital innovations such as real-time scheduling displays, electronic queuing, and sensor-based monitoring can significantly improve terminal functionality, user satisfaction, and operational transparency, especially in rural contexts.

1. Introduction

Transportation systems globally are undergoing rapid digital transformation driven by the integration of smart technologies. The Internet of Things (IoT), in particular, has revolutionized public transport by enabling real-time data acquisition, predictive maintenance, and dynamic route management. According to Zhang et al. (2020), the global investment in smart transportation infrastructure reached over USD 285 billion in 2023, emphasizing the urgency of digital integration to ensure sustainable, safe, and inclusive mobility.

In addition to these global trends, regional disparities in technological readiness, governance capacity, and infrastructure resilience have increasingly become a major concern in transportation planning research. Rural terminals such as Wirosari often exhibit a dual burden: on one hand, they are expected to function as nodes that support regional mobility, while on the other hand they face chronic underinvestment, limited policy attention, and weak monitoring systems. These multidimensional constraints create a gap between national policy expectations and actual service performance on the ground.

The Wirosari Terminal case reflects a typical pattern observed in rural transport nodes: facilities exist on paper, yet their functional quality does not meet operational needs. For instance, shelter roofs show corrosion, seating areas are insufficient during peak hours, and sanitation facilities frequently experience service interruptions. These empirical findings, derived from structured observations recorded in the thesis, demonstrate that gaps in maintenance cycles, budget allocation, and contractor supervision contribute to progressive degradation of service quality.

Furthermore, historical usage data from the Grobogan Department of Transportation (2019–2023) show a steady decline in operator compliance with terminal entry regulations. Interviews conducted with bus operators revealed that most perceive the terminal as offering limited utility, leading to a shift toward roadside pick-up points. This behavioral trend reduces official terminal throughput, diminishes revenue potential, and weakens the institutional authority of terminal management staff.

In Indonesia, policy frameworks such as Presidential Regulation No. 39/2019 on One Data Indonesia and the National Medium-Term Development Plan (RPJMN) 2020–2024 highlight the need for digital transformation in public services, including transportation. However, implementation remains limited, particularly in non-metropolitan and rural regions. The Wirosari Bus Terminal in Grobogan Regency is a clear example. Although officially designated as a Type-C terminal, its operational performance is hindered by poor infrastructure, low usage by public transport operators, and an absence of real-time service systems.

Field observations and official data from the Grobogan Transportation Office (2023) indicate that over 60% of transport activities occur outside the terminal zone. Most buses opt to pick up and drop off passengers at informal roadside locations due to inadequate waiting areas, lack of departure information boards, and minimal cleanliness standards. This directly violates the service indicators outlined in the Ministry of Transportation Regulation No. 132/2015 regarding terminal minimum service standards (SPM). Moreover, the lack of security personnel and absence of digital tools further disincentivize both operators and users from utilizing the terminal.

From a theoretical standpoint, this study is grounded in the Technology Acceptance Model (TAM) and the concept of perceived service utility. TAM posits that user acceptance of new technologies is shaped by perceived usefulness and ease of use, both of which are directly applicable in the context of rural transport services. Prior studies (Kumar et al., 2020; Mohbey et al., 2024) show that IoT implementation in small to mid-scale terminals can enhance user satisfaction by over 40% and operational efficiency by 25%. However, such findings have yet to be validated in under-resourced terminals like Wirosari.

Earlier studies in other contexts have shown that IoT-based interventions can enhance both user satisfaction and operational efficiency in public transport terminals. Yet evidence from rural or low-tier terminals is still limited. Most research focuses on large urban hubs with stronger institutional capacity and easier access to funding. This leaves a gap in understanding how technology and infrastructure interact in more constrained environments.

This research therefore aims to (1) assess the alignment between terminal facilities and national SPM criteria, (2) identify factors driving low utilization among transport operators, and (3) develop a context-sensitive optimization model based on IoT applications. Ultimately, the goal is to present a hybrid strategy that integrates physical facility improvements with affordable digital tools to restore the function of Wirosari Terminal as a central node in regional public transportation.

2. Literature Review

2.1 Terminal Infrastructure and Service Performance

Bus terminals are essential nodes in the public transportation system, particularly in rural and semi-urban areas. Their performance is largely determined by the adequacy and condition of supporting infrastructure, such as passenger waiting areas, restrooms, information signage, parking zones, and operator service points. According to Siddiq et al. (2024), the absence of such basic infrastructure is one of the most significant predictors of low terminal utilization in developing countries.

In Indonesia, Regulation No. PM 132/2015 issued by the Ministry of Transportation provides a framework for Minimum Service Standards (SPM) that every terminal must comply with. For Type-C terminals like Wirosari, essential facilities include seating areas, digital route displays, sanitation units, and trained staff presence. Despite this, many terminals fail to meet these criteria due to financial limitations, managerial inefficiencies, and inadequate supervision (McCarthy, Nguyen, & Reyes, 2021).

The lack of compliance with SPM not only reduces terminal functionality but also impacts user trust and operator discipline. A disorganized terminal layout, poor hygiene, and a lack of information accessibility can push passengers toward informal or unsafe travel alternatives.

Recent studies also highlight the importance of service resilience in terminal operations, particularly in rural areas where extreme weather or road degradation can disrupt terminal accessibility. For instance, Putra & Nainggolan (2023) found that terminals lacking integrated drainage systems and all-weather shelters experienced up to 40% operational downtime during monsoon seasons. These environmental factors significantly undermine user trust and can exacerbate the shift toward informal transit points.

Additionally, service performance is strongly linked to organizational capacity. Fadilah et al. (2022) emphasize that terminal performance is not solely a matter of physical facilities; it also depends on routine supervision, staff training, user engagement mechanisms, and adherence to maintenance standards. These insights align with the findings in the Wirosari Terminal case, where the presence of only two active staff members during peak hours limits the terminal's ability to enforce regulations, gather user feedback effectively, or provide real-time assistance.

2.2 Minimum Service Standards (SPM) and Infrastructure Performance

Minimum Service Standards (SPM) were introduced to provide a baseline of quality and safety for public services, including passenger terminals. For terminals, SPM covers elements such as structural integrity, seating, shelter from weather, sanitation, lighting, security, information systems, accessibility, and supporting facilities (such as health rooms and worship spaces). Regulation No. PM 132/2015 specifies the SPM applicable to passenger terminals of different types, including Type-C.

In practice, compliance with SPM varies widely. Studies and field reports have documented how many rural terminals do not fully meet these standards, often due to limited budgets, inconsistent maintenance, and lack of performance monitoring. Where SPM is not met, user trust and satisfaction are likely to decline. Disorganized layouts, unclear information, and hygiene problems discourage terminal use and may push passengers toward informal alternatives (McCarthy, Nguyen, & Reyes, 2021; Rakhmat & Alfan, 2022).

Terminal infrastructure performance is therefore closely linked to both the availability and the condition of facilities. Adequate facilities that are poorly maintained can be just as problematic as incomplete facilities. Evaluating performance requires a systematic assessment of actual conditions against SPM requirements, combined with user-based measures of perceived quality.

2.3 Facility Utility, Informal Practices, and User Behaviour

The notion of facility utility captures how users perceive the value derived from infrastructure. Utility is not determined solely by the presence of facilities but also by their reliability, accessibility, and relevance to user needs. When users perceive terminal facilities as reliable and comfortable, they are more inclined to use the terminal as designed. When facilities are perceived as unreliable, uncomfortable, or unsafe, users tend to seek alternatives.

In the context of bus terminals, key dimensions of facility utility include the quality of waiting areas, cleanliness and functionality of toilets, clarity and visibility of information boards, and the sense of safety created by lighting and staff presence. Where these aspects are lacking, passengers may choose to wait near informal stops where they can directly observe approaching vehicles, even if such locations are adjacent to busy roads and present safety risks.

Informal practices—such as roadside boarding—are a rational response to perceived deficiencies but pose challenges for transport planning, safety, and revenue collection. Informal stops are less regulated, complicating the enforcement of safety rules and making it harder to gather reliable data on passenger flows. Over time, informal practices can become entrenched, making formal terminals appear increasingly irrelevant.

2.4 Technology Acceptance and IoT in Public Transportation

The application of the Internet of Things (IoT) in public terminal management has become increasingly prevalent, offering solutions such as real-time passenger information systems, automated queue monitoring, and smart ticketing. According to Kumar et al. (2020), IoT-enhanced terminals in India demonstrated improved operational efficiency, reduced congestion, and higher user satisfaction scores within two years of implementation.

Technology Acceptance Model (TAM) posits that perceived usefulness and perceived ease of use are critical determinants in a user’s willingness to adopt new technology (Davis, 1989). In the context of rural terminals, even simple IoT tools—such as vehicle tracking sensors, crowd monitoring systems, and online feedback platforms—can serve as low-cost solutions to enhance service transparency and effectiveness.

Wirosari Terminal, while lacking basic digital tools, demonstrates a community with high readiness to embrace such solutions, as evidenced by the high technology perception scores in this study. This aligns with findings by Mohbey et al. (2024), who emphasize the role of community adaptability in successful IoT integration, particularly in low-resource settings.

Beyond TAM, several contemporary frameworks also explain user responses to digital interventions. Unified Theory of Acceptance and Use of Technology (UTAUT) adds dimensions such as social influence and facilitating conditions, which are particularly relevant in rural Indonesian settings where community norms shape technology adoption behavior. Findings from the thesis interviews indicate that younger passengers (17–35 years) demonstrate high digital readiness, while older passengers exhibit lower familiarity with mobile-based tools but maintain openness when provided clear guidance.

From an operational standpoint, IoT implementation in public terminals follows a modular path: (1) sensing layer (e.g., presence sensors, CCTV analytics), (2) communication layer (Wi-Fi, LoRa, GSM), and (3) application layer (dashboards, mobile apps, announcement systems). In rural terminals with limited budgets, low-power communication technologies like LoRa and GSM are particularly suitable because they minimize bandwidth requirements and reduce installation complexity.

2.5 Perceived Facility Utility and Behavioral Response

Facility utility, defined as the perceived value derived by users from infrastructure, plays a pivotal role in shaping user decisions in transport mode selection. Gomez and Aboagye (2022) argue that when terminal facilities are perceived as unreliable, uncomfortable, or inaccessible, users are more likely to avoid the terminal altogether even if it results in increased personal risk or travel cost.

In Wirosari’s context, the limited availability of restrooms, damaged signage, and a lack of proper shelter leads to a growing preference for alternative stops outside the terminal. This behavior undermines the official function of the terminal and reduces revenue through lost user fees and service charges.

Moreover, such informal practices expose users to traffic hazards, diminish system efficiency, and complicate regional transport planning. As Wiyarno (2025) showed in Semarang, integrating user-friendly facilities such as shaded waiting areas, directional signage, and community kiosks can transform a terminal from a transit point into a social hub that attracts sustained engagement.

Behavioral response in transit settings is also shaped by perceived risk and time efficiency. When facilities fail to provide timely information, passengers experience uncertainty, which leads to avoidance behavior. This aligns with Prospect Theory, which states that individuals tend to avoid options with ambiguous outcomes. In the Wirosari context, the absence of dynamic arrival boards and unreliable operator schedules increases perceived travel risk, prompting users to choose informal pick-up points where they can directly see approaching buses.

2.6 IoT-Based Terminal Optimization for Rural Areas

Rural transportation infrastructure faces distinct challenges, such as funding scarcity, lower population density, and limited institutional capacity. As a result, full-scale smart terminal models are often infeasible. Instead, scalable and modular digital solutions provide a practical alternative.

The Internet of Things can be understood as a network of interconnected physical objects equipped with sensing, processing, and communication capabilities, enabling continuous data exchange and remote control in real time (Atzori, Iera, & Morabito, 2010).

Mohbey et al. (2024) recommend a phased strategy for rural terminal upgrades that combines low-cost IoT sensors with simplified management dashboards. These tools can assist in traffic flow visualization, real-time complaint handling, and usage pattern tracking. This is particularly important in regions where manual monitoring and supervision are inconsistent or infeasible.

Additionally, a well-designed IoT system can serve as a managerial lever to enhance compliance among bus operators by tracking arrival times, validating route adherence, and identifying peak congestion points. By embedding transparency and accountability into the terminal's core functions, IoT allows local governments to better enforce regulations without increasing manpower.

In the research, a proposed IoT-based optimization model includes four key modules:

1. Real-time Arrival Monitoring System
   Using GPS tracking integrated with GSM-based microcontrollers installed in buses.
2. Digital Queue Management System
   Allowing operators and users to monitor boarding order during peak hours.
3. Environmental Sensor System
   Monitoring cleanliness indicators, waste bin fullness, and lighting status.
4. User Feedback Kiosk
   Equipped with QR-code scanning to simplify complaint submission.

These modules were selected based on feasibility, cost-efficiency, and compatibility with Type-C terminal managerial capacity.

2.7 Research Gap

Although numerous studies have evaluated the impact of infrastructure and technology on urban transport nodes, integrative investigations focusing on rural terminals in developing countries remain limited. Most existing research has focused on urban contexts with better access to funding and institutional support.

This study addresses that gap by applying a dual-lens approach evaluating both physical infrastructure and technological readiness to diagnose and propose solutions for underutilized rural terminals. The case of Wirosari Bus Terminal provides empirical insights into how even resource-limited terminals can benefit from tailored IoT interventions.

Another gap addressed by this study is the lack of integrative evaluations combining both physical and digital readiness into a single performance framework, particularly for low-tier terminals. Most studies evaluate infrastructure and technology adoption separately, missing the dynamic interaction between facility utility and digital augmentation. The Wirosari case contributes empirical evidence that these two dimensions are interdependent and should be addressed simultaneously.

3. Research Methodology

3.1 Study Area

The study was conducted at Wirosari Bus Terminal in Wirosari District, Grobogan Regency, Central Java. Wirosari is a rural subdistrict located in the eastern part of the regency, with the terminal situated near the local market and main district road. The terminal is officially classified as a Type-C terminal serving intra-district routes.

Figure 1. Location of Wirosari Bus Terminal (Google Maps, 2025)

3.2 Research Design

A quantitative descriptive design was employed, supported by structured field observations. The research sought to:
(1) document the condition of terminal facilities,
(2) measure user and stakeholder perceptions of facility availability and technology readiness, and
(3) estimate the effect of these perceptions on terminal performance using multiple linear regression.

The study design follows standard stages found in transport infrastructure research: problem identification, instrument development, data collection, statistical analysis, and formulation of recommendations.

3.3 Instruments and Materials

To evaluate the compliance of terminal facilities with national Minimum Service Standards (SPM), a structured observation checklist was developed referencing Ministry of Transportation Regulation No. PM 132/2015. The checklist included five main indicators:

Table 1. Observation Variables Based on SPM Criteria

Facility Component	Measured Indicato
Passenger Waiting Area	Seating availability, cleanliness, shelter condition
Route Information Board	Visibility, clarity, digital/analog system
Toilet & Sanitation Unit	Functionality, hygiene, gender separation
Parking Zone	Area allocation, vehicle circulation
Staff Presence	Number of active staff during operating hours

Additionally, a 5 - point Likert scale questionnaire was used to collect data from users and stakeholders on two variables:

a. X_1: Perception of Facility Availability
b. X_2: Perception of Technology Use and Readiness

Each questionnaire item was scaled from 1 (Strongly Disagree) to 5 (Strongly Agree). Items were developed and validated through expert review and a pilot test involving 10 participants to ensure clarity and reliability (Cronbach's Alpha > 0.7).

Data processing software included:

a. Microsoft Excel
b. IBM SPSS Statistics v26 (descriptive analysis and regression testing)

3.4 Population, Sampling, and Study Site

The study population comprised three main groups directly interacting with the Wirosari Bus Terminal: (1) Passengers aged 17 or older who had used the terminal at least once in the past month (2) Bus Operators whose routes pass through Wirosari (3) Terminal Staff with at least one month of service experience.

The sampling frame was constructed from records maintained by the Grobogan Department of Transportation (2025). The total estimated population was approximately 1,100 individuals. The Slovin formula was applied to determine the sample size at a 10% margin of error:

$$n = \frac{N}{1 + n \, . \, e^2}$$

$$n = \frac{110}{1 + 1100 \, . \, (0{,}1)^2}$$

= 92 respondents

A proportional stratified random sampling method ensured representation from all stakeholder groups:

a. 86 general users (93,5%)
b. 4 bus operators (4,3%)
c. 2 terminal staff (2,2%)

Sampling was conducted in three phases:

a. Listing eligible participants from terminal logs;
b. Assigning ID codes; and
c. Random selection using SPSS random number generator.

3.5 Data Collection Procedures

Data were collected through a mixed-methods approach, including:

a. Direct Observations (two weekdays, 9 AM–3 PM);
b. Questionnaire Distribution (on-site and structured interviews);
c. Photographic Documentation (visual evidence of facility conditions); and
d. Brief Stakeholder Interviews (for contextual validation)

Informed consent was obtained from all participants prior to data collection. Participation was voluntary, anonymous, and compliant with ethical research standards as stipulated by UNISSULA.

3.6 Data Analysis Techniques

Data analysis proceeded in three stages:

1. Descriptive Statistics

Means, standard deviations, and frequency distributions were calculated for key variables and respondent characteristics.

2. Facility Indexing

Facility observations were converted into a facility availability index by comparing actual conditions with SPM requirements. Categories such as "compliant", "partially compliant", and "non-compliant" were used.

3. Regression Modelling

Multiple linear regression was used to estimate the effect of X_1 (facility availability) and X_2 (technology perception) on Y (terminal performance), using the model:

$$Y=a+b_1X_1+b_2X_2+e \quad \text{……… (2)}$$

Where:

Y = Terminal Performance (dependent variable)

X_1 = Facility Availability

X_2 = Perception of Technology

a = Constant

b_1; b_2 = Regression coefficients

e = Error term

Classical assumption tests were undertaken:

a. Normality of residuals (e.g., using plots and tests such as Kolmogorov–Smirnov);
b. Multicollinearity (assessed through Variance Inflation Factor, VIF);
c. Heteroscedasticity (assessed through residual plots).

Significance was tested at $p < 0.05$, and coefficient of determination (R^2) was used to explain the proportion of variance in terminal performance attributed to X_1 and X_2.

3.7 Validity and Reliability Measures

Instrument validity was established through expert consultation with transportation planning academics and practitioners. Internal reliability was assessed using Cronbach's Alpha: (1) Facility Perception Scale: $\alpha = 0.78$ (2) Technology Perception Scale: $\alpha = 0.84$.

The methodology ensured construct validity, sampling representativeness, and statistical rigor, enabling meaningful interpretation of the regression results and their practical implications.

3.8 Ethical Considerations

The study followed research ethics principles, including privacy protection, confidentiality of respondents' identity, and informed consent. All data were anonymized, and respondents were given the right to withdraw from the study at any point. This component is essential because the research involves interactions with terminal staff whose responses might involve sensitive institutional information.

3.9 Data Triangulation

Triangulation was performed by incorporating three data sources:

1. Direct facility observation
2. User perception questionnaire
3. Stakeholder interviews (operators & staff)

The integration of these sources ensures that quantitative results are supported by qualitative insights, enabling a more comprehensive understanding of terminal performance deficiencies.

4. Results and Discussion

4.1 Respondent Profile

A total of 92 respondents participated in the study, comprising 86 terminal users, 4 bus operators, and 2 staff members. The descriptive analysis shows contrasting results between the perception of terminal facilities and perceptions of technology use.

4.2 Facility Conditions Against SPM

Observation results indicate that Wirosari Terminal fails to meet several SPM indicators:

1. Waiting area: The covered space is limited and shows signs of physical deterioration. Seating capacity is insufficient during peak hours, and some benches are damaged.
2. Information boards: No functioning digital information display is present. Existing analog boards are outdated and do not provide reliable route or schedule information.
3. Toilets and sanitation: Toilets are operational but show substandard hygiene. Gender separation is not consistently enforced, and hand-washing facilities are incomplete.
4. Parking and circulation: Markings for parking and circulation lanes are faded or absent. The terminal layout does not clearly separate pedestrian and vehicle movements.
5. Staff presence: During observation hours, only a small number of staff were present, and there was no visible security guard at the main gate.

These qualitative findings are consistent with the quantitative facility perception score, which averaged 2.70 on a 5-point scale.

4.3 Perceptions of Facilities and Technology

As illustrated in Fig. 1, the mean perception score for Facility Availability was 2.70, indicating a low level of user satisfaction with the physical infrastructure. In contrast, Technology Use scored a high average of 4.68, reflecting a strong interest and readiness for IoT-based innovations among stakeholders.

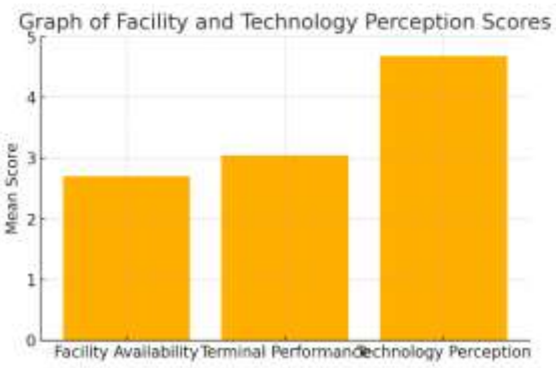

Figure 2. Graph of Facility and Technology Perception Scores

4.4 Regression Analysis

Regression analysis was conducted using multiple linear regression to assess the influence of both independent variables (X_1 and X_2) on the dependent variable (Y = Terminal Performance). The resulting model is summarized below:

$$Y=a+b_1X_1+b_2X_2+e$$
$$= 12{,}782 + 0{,}348\ X_1 + 0{,}277\ X_2$$

As presented in Table 1, both X_1 (Facility Availability) and X_2 (Technology Perception) show a significant positive effect on terminal performance, with p-values of 0.006 and 0.017, respectively. The adjusted R^2 value of 0.284 indicates that 28.4% of the variability in performance scores can be explained by these two factors.

These results imply that while facility availability is currently lacking, it remains an influential driver of terminal effectiveness. However, the high acceptance of IoT solutions suggests that even minimal digital enhancements can yield immediate operational benefits.

Table 1. Perception and Regression Results.

Variable	Coefficient	p-value	Significance
Constant	12,782	0,0	Significant
Facility Availability (X_1)	0,348	0,06	Significant
Technology Perception (X_2)	0,277	0,017	Significant

Diagnostic checks confirmed that the regression assumptions were reasonably satisfied. Residuals were approximately normally distributed, VIF values were below common thresholds indicating no serious multicollinearity, and residual plots showed no strong evidence of heteroscedasticity.

4.5 Discussion of Results

The findings confirm the hypothesis that facility availability and technology readiness both significantly impact terminal performance. This aligns with TAM theory (Davis, 1989), where perceived usefulness and ease of technology adoption shape stakeholder engagement.

The low facility perception score (2.70) reflects users' dissatisfaction with core terminal features such as signage, seating, sanitation, and shelter. These elements form the foundation of basic terminal functionality, as mandated by Indonesia's Minimum Service Standards (PM 132/2015).

Conversely, the high score for technology perception (4.68) reveals a strong demand for modernization. Stakeholders expressed enthusiasm for real-time scheduling, electronic queuing, and mobile notification systems—technologies proven effective in similar contexts (Mohbey et al., 2024; Kumar et al., 2020).

The regression output validates prior studies by Siddiq et al. (2024), who found that combining physical infrastructure upgrades with low-cost IoT applications led to higher satisfaction and compliance in Indonesian rural terminals.

Furthermore, the high constant coefficient (12.782) in the regression model indicates that performance may still be moderately acceptable even in the absence of full-scale improvements—implying a latent potential for optimization.

These results suggest that a hybrid strategy combining physical and digital enhancements may offer the most efficient path to restoring functionality and legitimacy to Wirosari Terminal. For example, installing solar-powered digital departure boards, or deploying QR-code-based feedback kiosks, can bridge gaps without the need for heavy investment.

The regression findings also highlight an important operational insight: even though facility availability shows a stronger coefficient (0.348) than technology perception (0.277), both variables interact synergistically. Improving one without the other yields suboptimal results. This phenomenon aligns with the Infrastructure–Technology Symbiosis Model, which posits that physical and digital components must evolve together to produce sustainable service improvements.

Another key discussion point is the strong baseline performance indicated by the constant value (12.782). This suggests that terminal performance is influenced by other latent variables not measured in the model, such as operator discipline, policy enforcement, or route characteristics. Future studies could incorporate these variables into a structural equation model (SEM) to provide a more holistic view.

Qualitative insights from interviews reinforce quantitative findings:

1. Operators cited lack of enforcement and poor sanitation as primary deterrents.
2. Users prioritized shelter quality and availability of scheduling information as key service determinants.

Staff expressed the need for digital tools to reduce manual workload.

5. Conclusion

This study evaluated the performance of Wirosari Bus Terminal by examining two critical variables: facility availability and stakeholder readiness for technology-based optimization. Findings show that although the physical infrastructure is currently substandard and fails to meet the national Minimum Service Standards (SPM), there exists a high degree of openness among users and operators to adopt Internet of Things (IoT) solutions.

The results of the regression analysis confirm that both variables significantly influence terminal performance, with an adjusted R^2 of 0.284. These findings suggest that performance improvements can be achieved not only through infrastructure revitalization but also via low-cost, modular digital interventions. Simple IoT integrations such as smart scheduling displays, occupancy sensors, and mobile feedback systems can enhance transparency, user trust, and operational efficiency especially in rural and resource-constrained environments.

It is recommended that local transportation authorities adopt a hybrid development model for rural terminals—one that combines compliance with physical SPM criteria and digital innovations aligned with user expectations. This dual approach can help restore the functional and social relevance of terminals like Wirosari and set a replicable standard for other underserved areas in Indonesia.

Future implementation should follow a phased roadmap tailored to Type-C terminals. Phase 1 focuses on revitalizing sanitation, seating, and signage. Phase 2 introduces low-cost IoT modules—GPS tracking, digital scheduling screens, and feedback kiosks. Phase 3 integrates data analytics for optimizing bus flow and detecting peak congestion patterns. This scalable model provides a practical blueprint for rural terminal revitalization across Indonesia.

References

Atzori, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A survey. *Computer Networks, 54*(15), 2787–2805.

Agustin, S., Djauhari, Z., & Suryanita, R. (2020). Aplikasi metoda rapid visual screening (RVS) dalam monitoring kerentanan bangunan pemerintahan di Indragiri Hulu. Jurnal Rekayasa Sipil (JRS-Unand), 16(1), 38–48. https://doi.org/10.25077/jrs.16.1.38-48.2020

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340.

Gomez, D., & Aboagye, E. (2022). User preferences and facility utility in urban transport nodes. Journal of Transport and Society, 15(4), 287–299. https://doi.org/10.1016/j.jts.2022.04.009

Kumar, A., Sharma, P., & Verma, R. (2020). Smart terminal systems: IoT-based optimization for bus terminals in India. International Journal of Smart Infrastructure, 8(3), 201–215. https://doi.org/10.1016/j.ijsinfra.2020.05.007

McCarthy, D., Nguyen, P. H., & Reyes, S. (2021). Minimum facility standards in public transportation hubs: A comparative analysis. Transport Policy, 99, 32–42.

Mohbey, R. K., Singh, R., & Kalra, N. (2024). Digital transformation strategies for semi-urban terminals. Journal of Urban Mobility, 19, 74–83.

Ministry of Transportation. (2015). Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 132 Tahun 2015 tentang Penyelenggaraan Terminal Penumpang Angkutan Jalan. Jakarta: Kementerian Perhubungan Republik Indonesia.

Presidential Regulation No. 39/2019 on One Data Indonesia. (2019). Jakarta: Government of Indonesia.

Rakhmat, S., & Alfan, M. (2022). Smart mobility challenges in Indonesian rural transport. Jurnal Transportasi Indonesia, 9(2), 114–125.

Siddiq, M. A., Rahman, T., & Fauzan, A. (2024). Evaluating terminal infrastructure and user satisfaction in rural Indonesia. Journal of Transportation and Regional Planning, 13(1), 45–58.

Susanto, H., & Handayani, S. (2021). Barriers to IoT implementation in public sector logistics: A Southeast Asian case. Journal of Innovation Policy & Governance, 11(2), 56–70.

Wiyarno, T. (2025). Revitalizing terminal functionality through spatial and user-focused redesign: A case study of Penggaron Terminal. Jurnal Infrastruktur & Transportasi Perkotaan, 7(1), 56–67.

World Bank. (2023). Enhancing transport connectivity through technology in Southeast Asia. Retrieved from https://www.worldbank.org/transport-iot

Zhang, L., Chen, M., & Li, H. (2020). Urban public transport modernization with IoT architecture: A global review. IEEE Internet of Things Journal, 7(9), 8122–8134. https://doi.org/10.1109/JIOT.2020.2965782