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Smart Mobility Governance in Surabaya: Digital Innovation Accessibility, and Sustainable Urban Transport

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Abstract

Smart Mobility research often emphasizes digital applications, intelligent transport systems, or low-emission vehicles, but less attention has been given to how accessibility, environmental sustainability, and ICT integration are governed as interdependent public service dimensions in developing-country cities. This study addresses that gap by analyzing Smart Mobility governance in Surabaya, Indonesia, where Suroboyo Bus, Trans Semanggi, Feeder Wara-Wiri, the GOBIS application, cashless payments, and electric buses are being developed within one urban mobility system. Using a qualitative case study design, data were collected through field observation, semi-structured interviews, documentation, and literature-based conceptual review. Informants were selected through purposive sampling and consisted of 15 participants, including local government or transport authority representatives, public transport service personnel, passengers, and users representing accessibility or digital inclusion concerns. Thematic analysis supported by NVivo 15 was used to code and compare patterns related to accessibility, sustainability, ICT integration, and inclusion barriers. The findings show that Surabaya has improved mobility access through route information, bus stops, pedestrian facilities, passenger assistance, and digital travel information, but access remains uneven for wheelchair users, elderly passengers, and residents with weak first-mile and last-mile connections. Electric buses indicate potential operational emission reduction, although their long-term environmental benefit depends on the electricity mix, fleet scale, life-cycle impacts, and modal shift from private vehicles. GOBIS and cashless payments improve service transparency, journey planning, and user convenience, yet digital literacy, internet access, and application reliability remain critical barriers. The study contributes to Smart Mobility and smart governance literature by conceptualizing mobility innovation as an integrated governance process that must align digital systems, inclusive design, low-emission transport policy, and citizen-oriented service delivery.

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INTRODUCTION

Rapid urban growth has increased the need for mobility systems that are efficient, inclusive, and environmentally sustainable. In Smart City scholarship, mobility is not only a sectoral transport issue but also a governance challenge because it determines how residents access jobs, education, health services, and public spaces. The global urban agenda places transport at the center of sustainable development because

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more than half of the world population already lives in cities, and the proportion is projected to approach 70% by 2050 (United Nations Department of Economic and Social Affairs, 2025). In this context, smart city frameworks encourage local governments to integrate digital technology, data-driven governance, and green infrastructure into urban services (Aina et al., 2023; Aljowder et al., 2023; Alvarez et al., 2022; Hoogen et al., 2024; Khalid, 2025; Nursanty et al., 2024; Suter et al., 2024).

Conceptually, Smart Mobility refers to the integration of transport systems, information and communication technology, service innovation, and governance arrangements to make urban movement more efficient, accessible, safe, and sustainable. The smart city framework identifies Smart Mobility as a core dimension alongside smart governance, smart environment, smart people, smart economy, and smart living (Giffinger et al., 2007). However, Smart Mobility should not be reduced to applications, sensors, or electric vehicles; it requires coordination among technology, infrastructure, spatial planning, public value, and citizen needs (Docherty et al., 2018; Papa & Lauwers, 2015). This orientation is consistent with Sustainable Development Goal (SDG) 11, especially Target 11.2, which emphasizes safe, affordable, accessible, and sustainable transport systems for all, with special attention to older persons, persons with disabilities, women, children, and other vulnerable groups (Kolesnichenko et al., 2021; United Nations Department of Economic and Social Affairs, 2025).

This study frames Smart Mobility governance through three mutually dependent dimensions. Accessibility concerns whether residents can physically reach, understand, and use public transport services. Sustainability concerns whether mobility services reduce environmental burdens and dependence on private vehicles. ICT integration concerns whether digital systems improve information, payment, monitoring, and communication between providers and users. These dimensions interact directly: ICT can improve service predictability, but it does not remove physical access barriers; electric buses can reduce operational emissions, but they require modal shift and reliable service integration; and public transport expansion can improve connectivity only when service design responds to diverse user groups. Therefore, Smart Mobility should also be understood as a participatory and sustainable governance arrangement rather than as a purely technical project (Perillo, 2013).

Surabaya provides a relevant and critical case because the city combines several mobility innovations within one urban governance setting, including Suroboyo Bus, Trans Semanggi, Feeder Wara-Wiri, the GOBIS application, cashless payment systems, and electric buses. These initiatives indicate progress in route information, fleet modernization, public transport branding, and digital service access, and they also continue earlier collaborative planning efforts in Surabaya's smart city development (Pribadi et al., 2021). Previous reports and studies also show growing public transport use, including the increase of Suroboyo Bus ridership from 1,611,415 passengers in 2022 to 1,729,758 passengers in 2023 and 1,990,257 passengers in 2024 (Salman, 2025). Nevertheless, the implementation remains constrained by private vehicle dominance, uneven first-mile and last-mile access, disability-friendly facility gaps, elderly passengers' needs, application reliability, and digital literacy barriers. Recent statistical and public reports indicate that Surabaya remains one of the areas with the highest motor-vehicle ownership in East Java, including a Korlantas ERI-based public report that recorded 3,069,562 registered motor vehicles in July 2025 (BPS-Statistics Indonesia Jawa Timur Province, 2026; Palus, 2025), while traffic data recorded an average congestion level of 43.7% in 2025 (TomTom, 2025).

Previous studies on Surabaya provide important but still partial insights. Sulistyowati & Muazansyah (2019), Anityasari et al. (2023), Rhamdani and Widyastuti (2023), and Fikri (2024) examine the potential and service quality of Suroboyo Bus, but their emphasis is mainly on service performance rather than the governance relationship among accessibility, ICT, and sustainability. Larasati & Handayeni (2021) analyze factors influencing bus use, while Gerika et al. (2025) discuss Suroboyo Bus operating costs; however, these studies do not fully explain how digital tools and inclusive design shape mobility access for vulnerable groups. Rahmanti et al. (2019) focus on integrated information systems, focus on integrated information systems, and other recent studies discuss Feeder Wara-Wiri implementation, MaaS-based inclusiveness, and public participation in bus transit policymaking (Handayeni & Romadhon, 2025; Nalle et al., 2023; Soetikno & Tukiman, 2024), but the analysis of environmental transition and social inclusion remains fragmented. Studies on digital participation and citizen-centered smart city development are valuable for understanding governance and participation (Hansen & Dahiya, 2025; Landa Oregi et al., 2025; Munoz & Bolivar, 2021; Oikonomaki et al., 2024; Suter et al., 2024), yet they do not specifically explain how public transport accessibility, low-emission mobility, and ICT integration operate together in a developing-country urban transport system.

The research gap therefore lies in the limited empirical and conceptual understanding of Smart Mobility as an integrated governance process. Existing research tends to examine service quality, public transport use, digital systems, participation, or environmental transition separately. This separation is problematic because Smart Mobility can fail to generate public value when digital innovation is detached from inclusive access and environmental policy. A bus tracking application may improve journey planning, but it does not automatically solve inaccessible stops. Electric buses may reduce direct operational emissions, but their benefits depend on energy sources, route integration, and user adoption. Public transport expansion may improve network coverage, but it requires governance mechanisms that respond to users with different mobility and digital capacities while also addressing power relations and inclusion challenges in smart-city development (Delgado-Baena & Sianes, 2024; Praharaj, 2021).

This study therefore analyzes how Surabaya implements Smart Mobility through the interaction of accessibility, sustainability, and ICT integration. It also identifies the governance and inclusion challenges that shape Smart Mobility as a smart society initiative. The novelty of this study lies in its integrated governance perspective: unlike previous Surabaya studies that examine public transport quality, digital information systems, or bus usage separately, this research conceptualizes Smart Mobility as a public service governance arrangement that aligns digital systems, inclusive physical access, low-emission transport policy, and citizen-oriented service delivery. The contribution is theoretical and empirical: theoretically, it extends Smart Mobility literature beyond technology-centered approaches; empirically, it provides evidence from a large Indonesian city where digital and low-emission mobility initiatives are being implemented under uneven access and inclusion conditions.

METHOD

This research used a qualitative case study design to analyze the implementation of Smart Mobility governance in Surabaya. A qualitative approach was selected because the study examines policy implementation, public service innovation, and interactions among digital technology, transport infrastructure, environmental transition, and urban governance. Surabaya was treated as a critical case because it brings together three forms of mobility innovation in one municipal setting: public transport network expansion through Suroboyo Bus, Trans Semanggi, and Feeder Wara-Wiri; digital service integration through GOBIS and cashless payment; and low-emission transition through electric buses. This combination makes Surabaya analytically useful for examining how smart city initiatives move from technological adoption toward integrated public service governance.

The research was conducted in Surabaya, Indonesia, with attention to Suroboyo Bus corridors, selected public transport stops, feeder points, pedestrian facilities, bus stop areas, and GOBIS-related services. Field observations and stakeholder interviews were conducted from January to November 2025. Documentation covered transport facilities and operational records reported in 2024-2025, including electric bus mileage records from November 2024 to March 2025. Interview data were obtained from stakeholders with direct roles in service provision and use, including government actors, service personnel, passengers, and users who could explain accessibility or digital inclusion issues. The study did not aim to statistically represent all transport users in Surabaya; instead, it sought to obtain in-depth information from actors who directly experienced or managed Smart Mobility implementation.

Informants were selected using purposive sampling because the study required participants with direct knowledge of Smart Mobility implementation and use in Surabaya. This study involved 15 informants, comprising three representatives of local government or transport authorities, four public transport service personnel, five passengers of Suroboyo Bus and feeder services, and three users representing accessibility or digital inclusion concerns. Informants were selected based on their direct involvement in service provision, regular interaction with public transport services, experience using the GOBIS application, familiarity with cashless payment systems, and ability to explain access or inclusion barriers. The number of 15 informants was considered sufficient for a qualitative case study because the objective was analytical depth rather than statistical generalization. Data collection was continued until recurring themes appeared across informant groups, and thematic saturation was indicated when additional interviews no longer produced substantially new codes related to accessibility, sustainability, ICT integration, and inclusion challenges.

Empirical data were collected through field observation, semi-structured interviews, and documentation, while the literature review was used to build the conceptual framework and support interpretation. Observations followed a structured protocol that examined stop location, pedestrian access, crossing facilities, route information, shelter and seating conditions, disability-related facilities, feeder connectivity, vehicle access, and the availability of digital or non-digital travel information. Semi-structured interviews lasted approximately 30-60 minutes and used guiding questions on service access, route planning, GOBIS use, cashless payment, waiting time, passenger assistance, physical barriers, digital literacy, application reliability, and expectations for service improvement. Interview information was recorded through field notes and, when permitted, audio records; all informant identities were anonymized. Documentation included public transport data, GOBIS-related information, field photographs, and operational records relevant to Suroboyo Bus, Trans Semanggi, Feeder Wara-Wiri, and electric bus mileage.

Four analytical categories guided the study and were derived from Smart Mobility, sustainable urban mobility, transport equity, and digital governance literature. Accessibility refers to the ease with which residents can reach, understand, and use public transport services through routes, stops, pedestrian access, passenger assistance, and travel information; this category is linked to transport equity and mobility justice because unequal access may produce unequal opportunities (Karner et al., 2025; Martens, 2017). Sustainability refers to the contribution of mobility services to lower emissions, cleaner operations, and reduced dependence on private vehicles, and it also requires community-oriented transition planning (Li & Lange, 2023). ICT integration refers to the use of digital systems for route information, real-time vehicle tracking, payment, monitoring, and communication between service providers and users. Inclusion challenges refer to barriers faced by elderly passengers, persons with disabilities, users with limited internet access, and passengers with low digital literacy. These categories are consistent with the view that Smart Mobility must connect transport and ICT infrastructure with environmental and social objectives, including the use of inclusive technologies for broader smart-city transformation (Docherty et al., 2018; Kameni & Tekouabou Koumetio, 2023; Giffinger et al., 2007; Papa & Lauwers, 2015).

The data were analyzed through thematic analysis following the logic of Braun & Clarke (2006). The process began with familiarization through repeated reading of interview notes, observation records, documentation, and relevant literature. Initial coding was then conducted by labeling statements and observations related to service access, route information, stop facilities, passenger assistance, electric bus operation, digital application use, payment systems, and inclusion barriers. These codes were grouped into candidate themes and reviewed against the four analytical categories. NVivo 15 was used not merely as a storage tool but as an analytical aid to organize data sources, compare codes across informant groups, identify co-occurrence among themes, generate relationship maps, and examine matrix coding patterns. Researcher interpretation remained central: the NVivo outputs were used to support systematic comparison and transparency, while final themes were refined through repeated code review, cross-source comparison, and discussion among researchers to resolve overlapping or inconsistent interpretations. Figure 1 summarizes how the study moved from problem identification and conceptual framing to empirical data collection, thematic coding, interpretation, and policy implications.

Figure 1. Research process flowchart
Source: Prepared by the researchers, 2025

Data credibility was strengthened through triangulation across interviews, observations, documents, and literature. Cross-checking was used to compare information from different sources, while member clarification was applied when informant statements required confirmation. Analytical reliability was enhanced through repeated reading, code refinement, comparison of evidence across informant groups, and review of theme consistency with the conceptual framework. Ethical considerations included voluntary participation, responsible use of field data, anonymization of informant statements, and use of documentation only for academic analysis. These procedures were applied to improve transparency, credibility, and reproducibility in the qualitative case study design.

RESULTS AND DISCUSSION

The passenger trend provides an empirical entry point for the findings because it shows that public transport use must be interpreted together with service accessibility, user convenience, and governance capacity. Figure 2 is therefore discussed in this section as evidence of service adoption within Surabaya's Smart Mobility implementation.

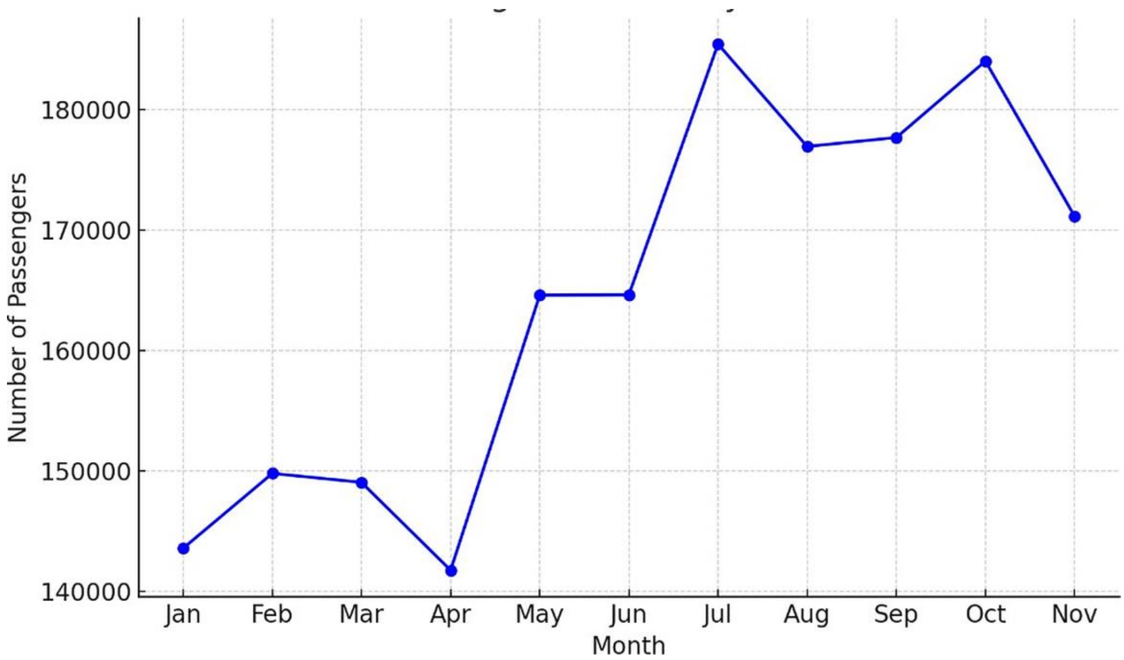

Figure 2. Suroboyo Bus passenger data in 2025
Source: Surabaya City Transportation Department, 2025

Accessibility and inclusive public transport

Accessibility emerged as the most visible test of Smart Mobility governance in Surabaya because digital information and public transport expansion only generate public value when residents can physically reach, understand, and use the service. The findings show that Suroboyo Bus, Trans Semanggi, and Feeder Wara-Wiri have expanded the public transport network, while GOBIS provides route information, vehicle location, and estimated arrival information. These features reduce uncertainty and make public transport easier to plan, but their benefits remain uneven across user groups and locations.

The NVivo relationship map was interpreted to examine how accessibility was connected with other implementation factors, rather than simply to visualize coding results. Figure 3 presents the relationship between accessibility, service provision, facilities, government support, and user benefits. The pattern indicates that accessibility is produced through coordination among operational service quality, physical infrastructure, digital information, and public-sector support.

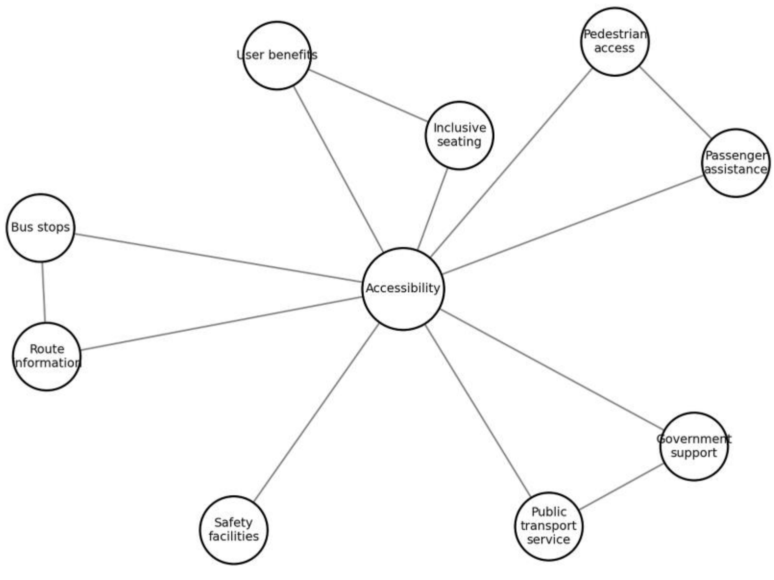

Figure 3. Accessibility relationship map from NVivo 15
Source: Processed by the researchers using NVivo 15, 2025

The map shows that accessibility depends on the alignment of service quality, supporting facilities, and government coordination. This finding extends studies on public transport use in Surabaya by showing that service availability alone is not enough; users also need reliable information, safe access to stops, and assistance when using the system (Larasati & Handayeni, 2021; Rhamdani & Widyastuti, 2023). From a governance perspective, accessibility is therefore not a single infrastructure output but a multi-actor coordination process involving route planning, facility provision, passenger assistance, digital information, and maintenance. To compare the relative emphasis of accessibility indicators across data sources, the matrix coding result is shown in Figure 4.

	A: UPTD Head	B: Community	C: Driver
Funding	1	3	1
Transport	5	4	2
Energy	2	3	1
Innovation	2	0	2
Health	4	1	3
Service	7	7	4
Education	4	2	0
Safety	4	1	4
Affordability	3	1	1
Users	2	1	2

Figure 4. Matrix coding of accessibility indicators and informants
Source: Processed by the researchers using NVivo 15, 2025

The matrix indicates that service quality receives the strongest emphasis. This factor became dominant because passengers experience Smart Mobility primarily through everyday service conditions: whether the route is understandable, whether the bus arrives within a reasonable waiting time, whether the stop is safe and comfortable, and whether officers can assist users who face physical or digital barriers. This means that digital platforms do not replace basic service quality; they amplify it when the service is reliable and expose its weaknesses when the service is inconsistent. For example, passenger informants noted that route information in GOBIS was helpful for planning trips, but assistance from officers remained important when users were unfamiliar with routes, payment systems, or application features. From a governance perspective, digital platforms only become meaningful when they strengthen these basic service conditions.

One passenger interview illustrates this relationship between digital information and everyday service quality: "Through this application, I am greatly helped to check where the bus is, so I do not have to wait too long at the bus stop. I usually go to the stop when the bus is already close. However, during peak hours, such as morning work trips, evening commutes, or holidays, the queue can be long. Sometimes the arrival time is not accurate, and some stops are uncomfortable in hot weather or rain because water can spill onto waiting passengers. I use the application every day and almost every time I take Suroboyo Bus, so it is very useful" (Interview with Passenger Informant 1, 2025).

This statement confirms that GOBIS improves journey planning and reduces unnecessary waiting, but it also shows that digital information must be supported by reliable arrival data, adequate capacity during peak periods, and comfortable stop facilities. Field observations further show that physical access remains uneven across locations. Figures 5 and 6 illustrate examples of public transport stops and bus stop facilities observed in Surabaya.

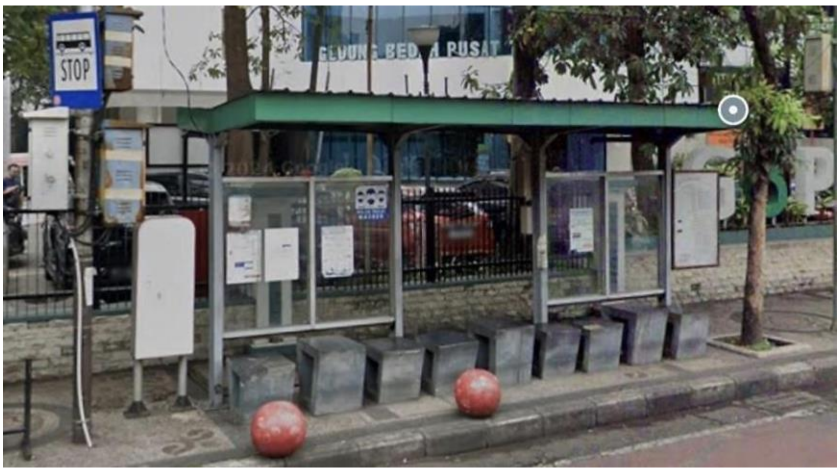

Figure 5. Public transport stop in Surabaya
Source: Research team documentation, 2024

Figure 6. Bus stop facility
Source: Research team documentation, 2025

Several service points are supported by pedestrian facilities such as zebra crossings, pedestrian bridges, sidewalks, and, in some locations, lifts for persons with disabilities. These facilities support intermodal movement and improve access to public transport. However, not all crossing facilities have activation buttons, and not all stops provide equal comfort, shelter, or safety. Field observations also indicated that some feeder points were marked only by signs, making them less visible and less comfortable for waiting passengers. This condition shows that accessibility is still spatially uneven and raises issues of transport equity because users in poorly connected locations may receive lower access to the same public service. It also indicates that Smart Mobility requires stronger integration between public transport nodes, feeder services, and transit-oriented planning institutions (Pham & Duong, 2025).

Accessibility also depends on the design of vehicles and passenger support inside the service. Figure 7 shows the classification of passenger seats in Suroboyo Bus, which supports priority seating and passenger comfort.

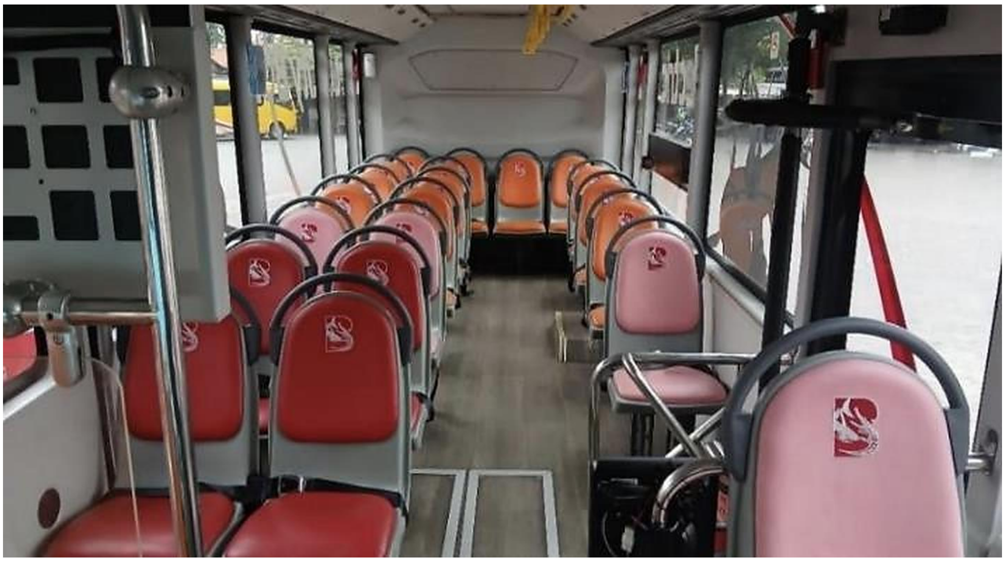

Figure 7. Classification of Suroboyo Bus passenger seats
Source: Processed by the researchers, 2025

Priority seating, handrails, passenger helpers, audio-visual information, and payment assistance improve the usability of public transport. Nevertheless, several buses are not yet low-deck vehicles, which limits access for wheelchair users and passengers with mobility constraints. Users representing accessibility concerns emphasized that assistance from officers could reduce difficulties, but assistance cannot substitute for universal vehicle and stop design. These findings differ from earlier service-quality studies by showing that accessibility is produced by the interaction between physical infrastructure, digital information, human assistance, and governance standards, rather than by service availability alone. They also connect Smart Mobility with mobility justice because users with disabilities, elderly passengers, and residents in weak first-mile and last-mile areas may experience unequal access to urban opportunities (Karner et al., 2025; Martens, 2017). The policy implication is clear: Surabaya's Smart Mobility agenda should prioritize universal design standards for vehicles, stops, pedestrian crossings, and digital information. It should also provide offline route information and on-site assistance for users who cannot rely fully on digital applications.

An interview with a wheelchair user further shows the relationship between digital assistance and physical accessibility: "As a wheelchair user, the service is quite helpful. Although the stop does not yet have adequate wheelchair facilities, the waiting area is sufficient. The officers are responsive in helping me board the bus. Through the application, I can also send a note requesting disability service, so the officers are ready before the bus arrives at the stop to help me enter the bus. More adequate disability facilities need to be provided in the future" (Interview with Accessibility Informant 1, 2025). This account shows that human assistance and digital service notes can improve accessibility, but they cannot replace the need for universal design in stops, boarding areas, and vehicle access.

Sustainability and low-emission mobility

Sustainability in Surabaya's Smart Mobility agenda is not merely a matter of replacing conventional buses with electric buses. It depends on how low-emission vehicles are integrated with reliable service frequency, route planning, electricity sources, supporting facilities, and policies that encourage modal shift from private vehicles to public transport. The city has introduced electric buses and promoted public transport as an alternative to private vehicles. This initiative supports the transition to lower-emission urban mobility, but its impact depends on service reliability, fleet scale, electricity sources, and the ability to attract users away from private vehicles. The sustainability relationship map in Figure 8 shows how the sustainability theme is connected with innovation, renewable energy, health, cleanliness, and service facilities.

Figure 8. Sustainability relationship map from NVivo 15
Source: Processed by the researchers using NVivo 15, 2025

The map suggests that sustainability is understood not only as emission reduction but also as a broader public service agenda. Clean vehicles, healthier urban air, comfortable facilities, and service innovation are mutually connected. This relationship is significant because passengers and service actors tend to interpret sustainable mobility through visible and usable improvements, such as cleaner buses, better stops, and more reliable operations. This finding is consistent with sustainable urban mobility and green-transition literature, which emphasizes that environmental benefits require integrated transport planning and broader urban innovation rather than isolated technological upgrades (Chojnacka & Widera, 2025; Suryawan et al., 2023; Wicaksono et al., 2024; Zhong et al., 2024). The matrix coding result in Figure 9 provides additional evidence of how sustainability indicators appeared across informant groups and data sources.

	A: UPTD Head	B: Community	C: Driver
Sustainability	8	4	3

Figure 9. Matrix coding of sustainability indicators and informants
Source: Processed by the researchers using NVivo 15, 2025

The coding pattern shows that innovation and service facilities are important in shaping perceptions of sustainable mobility. This means that residents are more likely to experience sustainability through practical service improvements, such as cleaner buses, better stops, and more reliable operations, than through abstract emission targets. Service personnel also indicated that the visibility of electric buses and charging facilities helped communicate the city's low-emission commitment, but passengers still assessed the service mainly through waiting time, comfort, and route usefulness. Figure 10 presents the charging process of the Suroboyo Electric Bus as one of the visible indicators of the low-emission transition.

Figure 10. Suroboyo Electric Bus charging process
Source: Processed by the researchers, 2025

The Suroboyo Electric Bus produces no direct tailpipe emissions during operation. Compared with fossil-fuel buses, electric buses can reduce local air pollution and support cleaner urban transport. However, the environmental benefit should not be interpreted as absolute zero emissions because electricity generation may still depend partly on fossil energy sources and because battery production, vehicle manufacturing, charging infrastructure, and maintenance also create environmental impacts. Recent electric bus life-cycle studies emphasize that electrification produces stronger climate benefits when it is combined with cleaner electricity mixes and full life-cycle assessment (Brambilla & Girardi, 2025). The operational basis for the emission comparison is presented in Table 1. The table reports the recorded mileage of the Suroboyo Electric Bus from November 2024 to March 2025.

Table 1. Suroboyo Electric Bus mileage achievement

Month	Kilometer achievement
November 2024	10,565 km
December 2024	73,679 km
January 2025	92,400 km
February 2025	82,285 km
March 2025	92,092 km
Total	351,021 km

Source: Processed by the researchers, 2025

Table 1 shows that the cumulative mileage reached 351,021 km. This operational distance provides the activity data for estimating the difference between a conventional bus scenario and an electric bus scenario. The calculation used the following screening formula: estimated operational emissions = total vehicle-kilometers x operational emission intensity. Because detailed fuel consumption, electricity consumption, charging efficiency, and grid emission-factor records were not available in the dataset, the study used implied operational emission intensities derived from the available emission estimates. The conventional-bus scenario applies an implied diesel-bus operational emission intensity of approximately 1.48 kg $CO2$/km, derived from 0.52 Gg $CO2$ divided by 351,021 km. The electric-bus scenario applies an implied electricity-based operational emission intensity of approximately 0.43 kg $CO2$/km, derived from 0.15 Gg $CO2$ divided by 351,021 km. The estimate only covers operational emissions and does not include vehicle manufacturing, battery production, charging infrastructure, maintenance, end-of-life treatment, or full life-cycle impacts. Table 2 presents the estimated greenhouse gas emission reduction.

Table 2. Greenhouse gas emission reduction

Total kilometer achievement	Estimated conventional bus GHG emissions	Estimated electric bus GHG emissions
351,021 km	0.52 Gg CO2	0.15 Gg CO2
Estimated GHG emission reduction		0.37 Gg CO2

Source: Processed by the researchers, 2025

Based on Table 2, the estimated emissions would reach 0.52 Gg CO2 if the service were operated using conventional buses, while the estimated emissions from electric buses are 0.15 Gg CO2 under the stated operational assumptions. The difference indicates an estimated reduction of 0.37 Gg CO2, or approximately 71.15%, over the recorded operational distance. This figure should be interpreted cautiously as an indicative operational reduction, not as a comprehensive carbon footprint estimate. Its policy significance lies in showing that fleet electrification can support Surabaya's low-emission transport agenda, but the magnitude of benefit depends on verified energy consumption, grid emission factors, fleet scale, passenger-kilometer performance, and the extent to which electric buses shift users from private vehicles to public transport. Future studies should refine the calculation by using verified energy consumption records, local grid emission factors, battery life-cycle data, and passenger-kilometer indicators.

The policy implication is that electric buses can support low-emission mobility, but technology substitution is not sufficient. Surabaya needs reliable service frequency, stronger intermodal integration, convenient access to stops, transparent emission monitoring, and demand-management policies that make public transport more attractive than private vehicles. Without modal shift and cleaner electricity supply, the environmental benefit of electric buses will remain limited. Sustainability should therefore be governed as a combined agenda of fleet electrification, service integration, energy transition, and behavioral change.

ICT integration and digital governance

ICT integration functions as the governance interface between transport providers and users in Surabaya's Smart Mobility system. Its effectiveness depends not only on application availability, but also on data accuracy, application reliability, digital literacy, internet access, and the availability of non-digital alternatives. In urban transport, ICT supports journey planning, real-time information, payment efficiency, data-driven monitoring, and communication between service providers and users. GOBIS functions as a digital platform that helps passengers identify routes, check vehicle positions, and estimate arrival times.

Figure 11 illustrates the route-connectivity function of GOBIS and is discussed in the ICT integration section because it provides empirical evidence of how digital information mediates mobility planning and public service interaction.

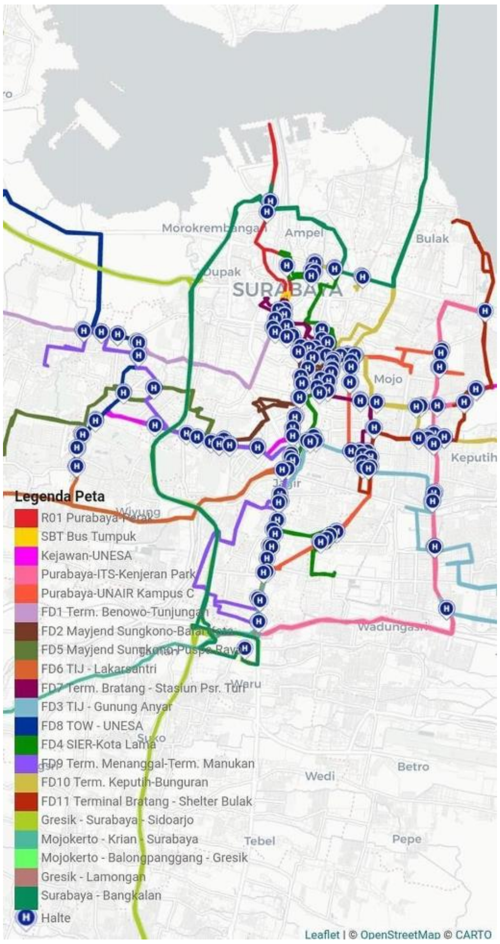

Figure 11. Integrated travel route map in the GOBIS application
Source: Processed from the GOBIS Suroboyo application, 2025

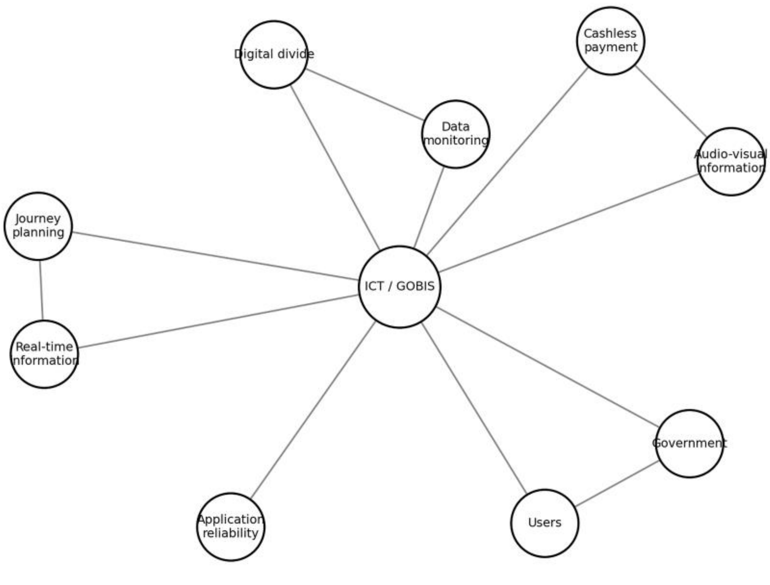

Figure 12. presents the NVivo relationship map for ICT integration. The map connects application use, users, government initiatives, and service obstacles.
Source: Processed by the researchers using NVivo 15, 2025

The map shows that ICT is not only a technical instrument. It is part of digital governance because it mediates the relationship between local government, service operators, and residents. When the application works well, it improves transparency and reduces uncertainty. When it is unreliable or difficult to use, it can weaken user trust and reproduce exclusion. The relationship map therefore indicates that ICT integration requires institutional capacity to maintain data accuracy, respond to user complaints, coordinate operators, and provide assistance for users who are not fully digitally connected. The user-facing dimension of ICT integration is illustrated in Figure 13, which shows the main display of the GOBIS application.

Figure 13. GOBIS main display
Source: Processed by the researchers, 2025

ICT adoption is also visible in the use of non-cash payments through QRIS and e-money. These systems improve transaction speed, reduce physical contact, and strengthen accountability in public transport service delivery. Audio and visual information systems in vehicle units can also support passengers with visual or hearing impairments when implemented consistently. However, these systems require governance routines for technical maintenance, staff assistance, data updating, and coordination between digital payment providers, transport operators, and local government. Such routines are important because smart digital systems can strengthen accountability and public-sector supervision only when supported by reliable institutional processes (Restrepo-Carmona et al., 2024).

However, digitalization does not automatically create inclusive mobility. Elderly passengers, users with limited digital literacy, passengers with unstable internet access, and persons with disabilities may experience difficulties using digital applications. Interview evidence indicated that some passengers benefited from GOBIS for route planning, but others still depended on officers or fellow passengers to interpret routes, check vehicle positions, or complete cashless payments. Service personnel also noted that application errors or inaccurate arrival information could lead to complaints and reduce user trust. These empirical examples show that digital barriers are not merely individual skill problems; they reflect the need for accessible interface design, reliable data infrastructure, and non-digital support channels. These challenges are consistent with studies showing that smart city systems must consider digitally disadvantaged groups and social inclusion (Chu et al., 2024; Santos et al., 2025).

This issue was also reflected in a passenger interview: "GOBIS is useful when the information is accurate, but when the bus position does not update properly, I become unsure whether I should wait or use another transport mode" (Interview with Passenger Informant 2, 2025). This quote indicates that application reliability is not a minor technical issue; it directly affects user trust, waiting decisions, and willingness to continue using public transport.

The policy implication is that Surabaya should treat GOBIS as part of a wider public service ecosystem rather than as a stand-alone application. Improvements should include accessible interface design, accurate real-time information, physical route maps at stops, offline information alternatives, on-site assistance, and responsive complaint channels. These measures can reduce the risk that digital mobility innovation excludes the very groups that inclusive public transport should serve. They also require a feedback mechanism through which user complaints, application data, and field observations inform route evaluation, stop improvement, and service planning.

The three dimensions should not be treated as separate programs. Accessibility determines whether residents can reach and use public transport. Sustainability determines whether the system contributes to lower-emission urban mobility. ICT determines whether services become more transparent, predictable, and responsive. Smart Mobility becomes effective only when these dimensions are governed as an integrated system. The governance challenge in Surabaya therefore lies not in the absence of innovation, but in the uneven coordination among digital platforms, transport infrastructure, operational management, inclusive service standards, and environmental policy.

The Surabaya case shows that digital innovation can strengthen public transport, but it also depends on physical access, social inclusion, and environmental policy. GOBIS improves route information, but users still need safe stops and reliable first-mile and last-mile access. Electric buses reduce estimated operational emissions, but the benefit depends on fleet expansion, electricity sources, service reliability, and user adoption. Passenger assistance improves inclusion, but it must be supported by universal design and accessible digital tools. Compared with previous studies that mainly confirm the importance of service quality or technology adoption, this study explains the contextual governance conditions under which these innovations become socially inclusive and environmentally meaningful.

This study therefore enriches the Smart Mobility and Smart Society framework by showing that mobility innovation in developing-country cities is not only a matter of adopting technology. It is a governance process that aligns digital platforms, inclusive transport infrastructure, low-emission transition, and citizen-oriented service delivery. The theoretical contribution is to shift the analytical focus from technology-centered Smart Mobility toward integrated Smart Mobility governance, where accessibility, sustainability, and ICT integration are mutually dependent conditions for producing public value.

LIMITATION

This study has several limitations. First, it focuses on Surabaya as a single case, so the findings should be generalized to other cities with caution. Second, the study uses qualitative data to analyze implementation and governance issues; it does not provide a statistical measurement of public readiness, satisfaction, or user adoption. Third, the governance analysis is based on interviews, observations, and available documentation, and it does not fully examine internal coordination documents, budget processes, or contractual arrangements among institutions. Fourth, interview data may contain response bias because informants were discussing public services that involve government and operational actors. Fifth, the representation of digitally disadvantaged users, elderly passengers, and persons with disabilities remains limited and may not capture the full diversity of inclusion barriers. Sixth, the emission comparison is based on available operational data and implied emission intensities; it does not provide a full life-cycle assessment of vehicles, batteries, charging infrastructure, electricity mix, and end-of-life impacts. Finally, the study does not directly compare users and non-users of public transport or compare Surabaya with other Indonesian smart city initiatives. Future research should include surveys, behavioral modeling, comparative city analysis, verified energy data, and broader participation from vulnerable and digitally disadvantaged groups to assess public readiness, modal shift, and digital inclusion more systematically.

CONCLUSION

Smart Mobility in Surabaya shows that accessibility, sustainability, and ICT integration have begun to develop together, but their integration remains uneven. The main finding is that digital applications, electric buses, cashless payments, passenger assistance, and transport infrastructure only produce public value when they are governed as a connected service system. Accessibility remains constrained by uneven physical facilities, weak first-mile and last-mile connections, and limited universal design. Sustainability is strengthened by electric bus operation, but its long-term benefit depends on fleet scale, electricity sources, verified emission monitoring, and modal shift from private vehicles. ICT improves service transparency and journey planning, but digital literacy gaps, internet access, application reliability, and the absence of non-digital alternatives can limit inclusion. Theoretically, this study advances Smart Mobility literature by shifting the focus from technology adoption to integrated governance. It shows that accessibility, sustainability, and ICT integration should not be treated as separate dimensions, but as mutually dependent governance conditions for producing inclusive and sustainable urban mobility in a developing-country city. Policy development should prioritize universal design, offline and online information integration, reliable data systems, fleet and route coordination, transparent emission assessment, and continuous user feedback. Future studies should examine public readiness, willingness to shift from private vehicles to public transport, and the inclusion of digitally disadvantaged groups using mixed methods and broader user data.

AUTHOR CONTRIBUTIONS

DFE contributed to conceptualization, research design, project administration, supervision, funding acquisition, data interpretation, and writing of the original draft. YEKS contributed to conceptual framework development, literature review, validation, and manuscript review and editing. GWP contributed to methodology refinement, field data organization, formal analysis, NVivo coding, visualization, and interpretation of findings. AJ contributed to field observation, stakeholder interviews, documentation, and data curation. RAF contributed to data verification, source triangulation, discussion development, and manuscript review. RU contributed to literature enrichment, reference management, figure and table checking, language editing, and final manuscript preparation. All authors read, revised, and approved the final manuscript.

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