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# Predictive Analysis of Traffic Performance Using Vissim Simulation in Informal Settlement Redevelopment in Kutai Kartanegara Regency

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**Abstract:** Redevelopment of informal settlements frequently induces substantial shifts in local traffic dynamics, driven by increased construction activities and vehicular movement within the affected areas. In Kutai Kartanegara Regency, ongoing infrastructure enhancement programs—including neighborhood road improvements, substandard housing rehabilitation, and drainage system upgrades—aim to elevate residents' living standards. This study applies a microscopic traffic simulation approach using the PTV VISSIM software to model three scenarios: the existing condition, a "do-nothing" projection, and a "do-something" scenario with urban improvement interventions. The simulation covers projections up to 2029 and evaluates key traffic performance indicators, including Level of Service (LOS), volume-to-capacity ratio (V/C), delay times, and queue lengths. Simulation outcomes indicate that, without intervention, traffic conditions are projected to deteriorate into oversaturated states (LOS F). Instead of physical road widening, the interventions explored include optimizing the use of the existing 10-meter-wide roadway—through revised lane markings and functional lane assignments—which resulted in improved network performance. Nonetheless, the Jembatan Teluk Dalam intersection remains a critical congestion point during peak hours, necessitating more nuanced traffic management strategies. These findings underscore the necessity of implementing adaptive, data-driven traffic control measures to ensure sustained mobility and successful informal settlement upgrading initiatives.

**Keywords:** Roadway Performance; Slum Redevelopment; Traffic Forecasting; Traffic Impact Assessment; VISSIM Simulation



## 1. Introduction

In many developing countries, including Indonesia, informal settlement upgrading has become a central focus of infrastructure development policy (UN-Habitat, 2020a). These initiatives aim to improve living conditions, accessibility (Duangputtan & Nobuo, 2024; Promma & Suppakittpaisarn, 2021), and neighborhood connectivity (Cervero & Dai, 2014). However, such physical improvements often trigger significant changes in travel demand and traffic patterns, particularly in rapidly urbanizing areas (Sietchiping et al., 2012).

Kutai Kartanegara Regency is currently undergoing a transformation driven by several redevelopment programs, including neighborhood street improvement, housing rehabilitation, and drainage enhancement. While these programs are expected to yield long-term socio-economic benefits, studies such as UN-Habitat

(2020b) and Litman (2001) have shown that physical changes in residential areas often result in increased community activity and traffic volumes. A similar trend was observed by Promma & Suppakittpaisarn (2021) in Chiang Mai, where slum upgrading efforts led to higher local mobility.

Aligned with Indonesia's national urban development policy, the Strategic Plan of the Directorate General of Human Settlements (2020–2024) emphasizes strengthening basic infrastructure in low-income neighborhoods to reduce regional disparities. Additionally, Law No. 22/2009 on Road Traffic and Transport, and Ministry of Transportation Regulation No. 17 (2021) mandate that any land development activity with potential traffic impacts must be supported by a comprehensive Traffic Impact Analysis (Andalalin) (John et al., 1985; Khisty, 1990).

Without proper traffic planning, physical infrastructure interventions may unintentionally cause congestion, degraded road performance, and longer travel times (Meyer & Miller, 2001; Zhao & Chung, 2001). Conventional traffic studies often focus only on current or short-term conditions and may fail to account for long-term behavioral shifts in travel demand.

Traffic congestion itself is a multifaceted phenomenon. According to the Highway Capacity Manual (1994), it occurs when traffic volume exceeds road capacity (V/C ratio > 1.0). Unsignalized intersections frequently become bottlenecks as traffic volume increases, leading to delays and vehicle queues (Khisty & Lall, 2003). Moreover, improved accessibility can lead to induced demand (Litman, 2001), where previously suppressed or nonexistent trips emerge due to better infrastructure. Therefore, the shifting characteristics of trip generation must be carefully assessed when planning for traffic impacts in redevelopment zones (Ilahi et al., 2015; Verma & Ramanayya, 2015).

This study aims to address these issues by applying PTV VISSIM microscopic traffic simulation to model and compare three future traffic scenarios: the current baseline, a future without intervention (do-nothing), and a future with operational improvements (do-something) (Fellendorf & Vortisch, 2010; Yang et al., 2012). The model projects traffic conditions through 2029 and evaluates several key performance indicators, such as Level of Service (LOS), delay time, queue length, and volume-to-capacity (V/C) ratio.

The main contribution of this research lies in its provision of long-term data-driven projections within the context of slum upgrading initiatives led by local governments. The approach is intended to inform traffic planning efforts in fast-growing urban regions and ensure sustainable mobility outcomes.

## 2. Materials and Methods

This research applies a quantitative approach using microscopic traffic simulation. The study area is located in Tenggarong Seberang District, Kutai Kartanegara Regency, designated as a priority zone in the local government's slum upgrading program.

Primary data were collected through traffic volume surveys during peak hours, geometric measurements of roads and intersections, and field observations of traffic behavior. Secondary data were obtained from relevant agencies, including official Andalalin (Traffic Impact Analysis) documents, spatial planning records, and traffic growth projections.

Simulations were conducted using the PTV VISSIM software, which enables detailed modeling of vehicle movements within complex road networks. The study examined three simulation scenarios:

1. Baseline (existing conditions);
2. Do-nothing (future projection without intervention);
3. Do-something (future projection with operational adjustments).

The traffic performance indicators analyzed included:

1. Level of Service (LOS);
2. Average vehicle delay (in seconds);
3. Vehicle queue length (in meters);
4. Volume-to-capacity ratio (V/C).

The planning horizon extends to the year 2029, providing long-range projections of road network performance under each scenario. Simulation outputs served as the basis for recommending long-term traffic management strategies aimed at maintaining functional roadway conditions amid urban improvements.

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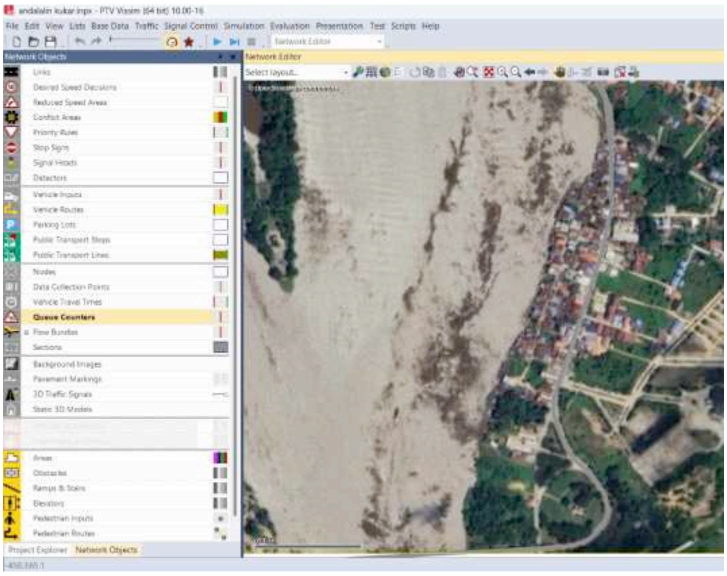

**Figure 1.** VISSIM Simulation Layout View in the Study Area

## 3. Results

This section presents the analysis results of road segment performance and unsignalized intersections within the study area, based on PTV VISSIM simulations projected through the year 2029. The analysis includes a comparison between existing conditions and future projections, as well as an evaluation of vehicle queue lengths and traffic management scenarios during the construction period.

### 3.1. Road Segment Analysis

Simulation results for the existing conditions (Table 1) reveal that most road segments within the study area are operating at Level of Service (LOS) E during peak periods. The volume-to-capacity (V/C) ratios range between 0.77 and 0.89, indicating that traffic demand is approaching or exceeding critical thresholds, particularly on Friday and Sunday evenings. Such conditions reflect a near-saturation state, in which even minor increases in vehicle volume, such as during public events or seasonal travel could severely impact traffic flow.

**Table 1.** Road Segment Performance (Existing Condition)

| Condition | Capacity (smp/h) | Flow (smp/h) | V/C Ratio | Speed (km/h) | LOS |
|---|---|---|---|---|---|
| Friday Morning | 1,772 | 1,368 | 0.77 | 22 | E |
| Friday Evening | 1,829 | 1,537 | 0.84 | 20 | E |
| Sunday Morning | 1,885 | 852 | 0.45 | 26 | E |
| Sunday Evening | 1,829 | 1,636 | 0.89 | 20 | E |

Projections for the year 2029 (Table 2) suggest a significant decline in road performance along Teluk Dalam Street. During Friday and Sunday evening peaks, V/C ratios are projected to exceed 1.0, corresponding to LOS F. This condition signals the onset of severe congestion, characterized by average speeds below 15 km/h, prolonged delays, and extensive queuing, especially during high-demand periods.

**Table 2.** Road Segment Performance (Year 2029 Projection)

| Condition | Capacity (smp/h) | Flow (smp/h) | V/C Ratio | Speed (km/h) | LOS |
|---|---|---|---|---|---|
| Friday Morning | 1,772 | 1,830 | 1.03 | <16 | F |
| Friday Evening | 1,829 | 2,057 | 1.12 | <15 | F |
| Sunday Morning | 1,885 | 1,140 | 0.60 | 24 | E |
| Sunday Evening | 1,829 | 2,189 | 1.20 | <15 | F |

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These findings highlight the urgency of implementing operational improvements, even in the absence of physical expansion. Without intervention, the road network is likely to experience substantial delays, degraded service levels, and increased travel costs for local commuters.

## 3.2. Unsignalized Intersection Performance

The performance of unsignalized intersections under current conditions (Table 3) indicates stable traffic operations. All intersections function at Level of Service (LOS) B, with V/C ratios ranging between 0.18 and 0.67 and delays generally under 12 seconds. These values suggest that traffic flows remain within acceptable thresholds, with minimal queuing and manageable delays during peak hours.

**Table 3.** Unsignalized Intersection Performance (Existing Condition)

| Intersection | Condition | Capacity (smp/h) | Volume (smp/h) | V/C Ratio | Delay (s) | LOS |
|---|---|---|---|---|---|---|
| AP Mangkunegara – Perjiwa | Friday Morning | 3,063 | 803 | 0.26 | 7 | B |
| | Friday Evening | 3,250 | 1,284 | 0.40 | 9 | B |
| | Sunday Morning | 2,874 | 508 | 0.18 | 7 | B |
| | Sunday Evening | 3,137 | 1,441 | 0.46 | 9 | B |
| Kereta Gantung – Teluk Dalam | Friday Morning | 2,538 | 1,337 | 0.53 | 10 | B |
| | Friday Evening | 2,991 | 1,713 | 0.57 | 10 | B |
| | Sunday Morning | 2,860 | 860 | 0.30 | 8 | B |
| | Sunday Evening | 2,863 | 1,636 | 0.57 | 10 | B |
| PKM 4 – Teluk Dalam | Friday Morning | 2,319 | 1,309 | 0.56 | 10 | B |
| | Friday Evening | 2,318 | 1,498 | 0.65 | 11 | B |
| | Sunday Morning | 2,299 | 816 | 0.35 | 8 | B |
| | Sunday Evening | 2,323 | 1,545 | 0.67 | 11 | B |
| Jembatan – Teluk Dalam | Friday Morning | 3,416 | 1,780 | 0.52 | 10 | B |
| | Friday Evening | 3,218 | 2,138 | 0.66 | 12 | B |
| | Sunday Morning | 3,613 | 1,024 | 0.28 | 8 | B |
| | Sunday Evening | 3,269 | 1,992 | 0.61 | 11 | B |

Projections for 2029 (Table 4) suggest that two intersections, PKM 4. Teluk Dalam and Jembatan Teluk Dalam, will experience growing pressure during peak times. The V/C ratios at these locations are expected to approach 0.90, and vehicle delay may reach up to 15 seconds. While still operating at LOS B, these intersections are trending toward saturation, with increased risk of turning conflicts and queuing.

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**Table 4.** Unsignalized Intersection Performance (Year 2029 Projection)

| Intersection | Condition | Capacity (smp/h) | Volume (smp/h) | V/C Ratio | Delay (s) | LOS |
|---|---|---|---|---|---|---|
| AP Mangkunegara – Perjiwa | Friday Morning | 3,215 | 1,046 | 0.33 | 8 | B |
| | Friday Evening | 3,384 | 1,502 | 0.44 | 9 | B |
| | Sunday Morning | 2,874 | 680 | 0.24 | 7 | B |
| | Sunday Evening | 4,137 | 1,928 | 0.61 | 12 | B |
| Kereta Gantung – Teluk Dalam | Friday Morning | 2,538 | 1,292 | 0.51 | 10 | B |
| | Friday Evening | 2,991 | 2,292 | 0.77 | 13 | B |
| | Sunday Morning | 2,876 | 1,140 | 0.40 | 9 | B |
| | Sunday Evening | 2,863 | 2,189 | 0.76 | 13 | B |
| PKM 4 – Teluk Dalam | Friday Morning | 2,319 | 2,004 | 0.86 | 12 | B |
| | Friday Evening | 2,318 | 2,094 | 0.90 | 13 | B |
| | Sunday Morning | 2,299 | 1,092 | 0.47 | 9 | B |
| | Sunday Evening | 2,323 | 2,068 | 0.89 | 13 | B |
| Jembatan – Teluk Dalam | Friday Morning | 3,416 | 2,282 | 0.67 | 12 | B |
| | Friday Evening | 3,218 | 2,861 | 0.89 | 15 | B |
| | Sunday Morning | 3,613 | 1,204 | 0.33 | 8 | B |
| | Sunday Evening | 3,269 | 2,666 | 0.82 | 14 | B |

### 3.3. Queue Length Simulation Output

Simulation results regarding vehicle queuing are presented in Tables 5 and 6. Along Teluk Dalam Road, maximum queue lengths in the direction toward Perjiwa reached over 250 meters, while the opposing direction toward the bridge exhibited queues extending beyond 175 meters. Under such conditions, drivers may experience waiting times of 5 to 10 minutes during peak periods.

**Table 5.** Unsignalized Intersection Performance (Existing Condition)

| Queue Direction | Average QLEN (m) | Max QLEN (m) | QSTOPS | Note |
|---|---|---|---|---|
| To Perjiwa | 47.97 | 258.49 | 1287 | AVG |
| To Bridge | 24.34 | 175.76 | 619 | AVG |
| To Perjiwa | 51.71 | 253.3 | 1324 | MAX |
| To Bridge | 23.35 | 161.27 | 587 | MAX |
| To Perjiwa | 5.36 | 7.06 | 45 | MIN |
| To Bridge | 2.55 | 2.94 | 9 | MIN |

At the three-way Jembatan intersection (Table 6), maximum queues from the bridge direction exceeded 140 meters. This level of congestion poses the risk of upstream spillback, potentially reaching previous intersections and escalating flow conflicts.

**Table 6.** Queue Length Output from VISSIM Simulation – Simpang 3 Jembatan

| Queue Source | Average QLEN (m) | Max QLEN (m) | QSTOPS | Note |
|---|---|---|---|---|
| Teluk Dalam | 1.5 | 34.19 | 128 | MIN |
| Bridge | 15.95 | 144.12 | 859 | MIN |
| Jongkang | 2.35 | 87.43 | 307 | MIN |
| Teluk Dalam | 1.93 | 40.93 | 151 | AVG |
| Bridge | 4.18 | 92.61 | 383 | AVG |
| Jongkang | 4.51 | 67.51 | 282 | AVG |
| Teluk Dalam | 3.63 | 154.93 | 371 | MAX |
| Bridge | 16.82 | 144.12 | 859 | MAX |
| Jongkang | 4.83 | 73.01 | 307 | MAX |

These patterns underscore the importance of queue management strategies in high-conflict zones. Without active control, queuing may escalate and compromise the efficiency of the broader network.

## 3.4. Scenario-Based Road Performance

Table 7 presents the simulation results of traffic performance on Jalan Teluk Dalam under the Do-Something scenario for the year 2029. Although the road capacity has been increased through physical improvements, the volume-to-capacity (V/C) ratio remains relatively high at 0.94, with a Level of Service (LOS) E. This indicates that the roadway is nearing saturation and is still unable to optimally accommodate peak-hour traffic loads..

**Table 7.** Road Performance in Do Something Scenario – Year 2029

| Road Segment | Condition | Capacity (smp/h) | Flow (smp/h) | V/C Ratio | LOS |
|---|---|---|---|---|---|
| Teluk Dalam | Sunday Evening | 2,322 | 2,189 | 0.94 | E |

The construction of a sidewalk on the landward side has improved pedestrian comfort. However, the existing road width of approximately 10 meters remains insufficient to handle potential long-term congestion. Without additional widening and effective traffic management strategies, this segment is likely to remain a major bottleneck in the corridor.

As a follow-up, a technical analysis was conducted to determine the geometric widening requirements. The study recommends an additional width of approximately 1.5 meters on the right-hand side of the road (facing the bridge), which borders the river, as the opposite side is no longer feasible for expansion. A 1.38-meter sidewalk is also proposed to match the existing one on the other side. With these adjustments, the ideal total carriageway width becomes 11.5 meters, including emergency or side-parking space. When pedestrian facilities on both sides are included, the total space requirement increases to approximately 14.26 meters.

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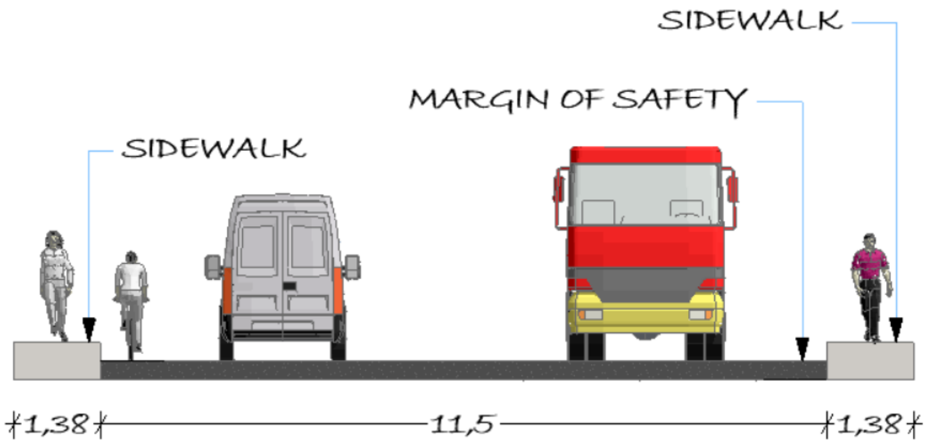


**Figure 2.** Cross-Section Design of Teluk Dalam Road – Proposed (2029)

To address the high V/C ratio (0.94) and LOS E, a re-simulation was conducted using the proposed geometric configuration. With an effective road width of 11.5 meters and two sidewalks of 1.38 meters each, the projected road capacity increases to approximately 2,560 smp/h. At a peak volume of 2,189 smp/h, the V/C ratio decreases to 0.86, and the LOS improves to D. These results demonstrate that physical widening significantly enhances traffic performance.

**Table 8.** Road Performance after Cross-Section Redesign – Year 2029

| Road Segment | Condition | Capacity (smp/h) | Flow (smp/h) | V/C Ratio | LOS |
|---|---|---|---|---|---|
| Teluk Dalam | Sunday Evening | 2,560 | 2,189 | 0.86 | D |

## 3.5. Traffic Simulation During Construction Phase

During the infrastructure development phase, increased construction vehicle activity is expected to affect traffic flow, particularly where roadworks intersect with active lanes. These disruptions include partial lane closures, especially at drainage crossing points along Teluk Dalam Road.


**Figure 3.** Crossing Drainage Work Location of Teluk Dalam Road (-0.4398317)


**Figure 4.** Traffic Diversion Lane from Samarinda for 2-Wheeled and 4-Wheeled Vehicles

To address these disruptions, a temporary traffic management plan was implemented. This plan included a controlled opening and closing of one lane on Teluk Dalam Road and the diversion of light vehicles via PKM Street, while heavy vehicles were rerouted through Jongkang Road as an alternative corridor.

Simulations using PTV VISSIM indicate that the diversion strategy effectively mitigated congestion and minimized queuing during the construction period. With proper coordination, construction activities were able to proceed without causing significant disruption to daily commuter traffic.

## 4. Discussion

A comparison between the Do-Something condition and the widening scenario demonstrates a significant improvement in road performance. The reduction in the V/C ratio from 0.94 to 0.86 indicates that the additional capacity effectively reduces congestion levels. However, LOS D still reflects the potential for traffic delays if not accompanied by proper parking regulations, speed enforcement, and adequate pedestrian facilities.

Physical widening yields positive impacts, including a lower V/C ratio and a reduction in queue length by up to ±30%, based on the VISSIM simulation results. Nevertheless, technical challenges, such as the need for approximately 1.5 meters of land acquisition on one side of the road, utility relocation, and potential social conflicts must be carefully considered.

If full widening is not feasible, adaptive traffic management strategies become essential. Measures such as dynamic traffic flow regulation, parking restrictions, and installation of interactive signage in the tourist pier area may serve as viable alternatives.

The simulation reveals that the slum upgrading program in Kutai Kartanegara Regency has directly contributed to increased travel volumes. This aligns with the concept of induced traffic demand (Litman, 2001), where improvements in environmental quality and public facilities stimulate greater trip generation.

The congestion phenomena observed, particularly along Teluk Dalam and the Jembatan Teluk Dalam intersection can be explained using the bottleneck concept (Khisty & Lall, 2003). Unsignalized intersections operating at high volumes tend to become conflict points, increasing delays and vehicle queuing.

PTV VISSIM-based simulation has proven effective for assessing the impacts of roadway development (Fellendorf & Vortisch, 2010; Li & Yu, 2022), and for supporting data-driven decision-making. While widening has demonstrably improved network performance, projections to 2029 indicate that the Jembatan Teluk Dalam intersection will still face a high risk of saturation and significant delays, necessitating long-term solutions.

One potential strategy is the implementation of adaptive traffic signals based on VISSIM modeling, as explored in studies by Cao (2024) and Suthanaya (2023). A comprehensive traffic management approach, including dynamic flow regulation, real-time monitoring, and public education also constitutes a critical component (Paredes, 2025).

From a policy perspective, Government Regulation No. 30 of 2021 and Minister of Transportation Regulation No. 14 of 2006 offer technical guidelines for implementing traffic management and engineering in densely populated areas. Based on analysis, the Jembatan Teluk Dalam intersection is projected to reach a V/C ratio ≥ 0.85 during peak hours, which according to the Highway Capacity Manual (John et al., 1985), warrants signal control.

However, further evaluation suggests that the installation of traffic signals at this location is not recommended. The potential for queuing toward the bridge poses a risk of vehicle buildup on the bridge structure, which is technically and psychologically sensitive due to the collective trauma from the previous bridge collapse. Additionally, the downhill geometry approaching the bridge increases accident risk in the event of sudden queues caused by signal stops.

As an alternative, more appropriate strategies include speed management, warning signage installation, and clear pavement markings and directional signs to guide driver behavior safely without overloading the bridge's capacity.

Moving forward, the integration of data-based traffic simulation tools like PTV VISSIM into transport planning processes must be enhanced to support sustainable area development and ensure smooth urban mobility.

## 5. Conclusions

The road design with a total width of 14.26 meters has been shown to significantly increase capacity and reduce traffic saturation levels. However, this physical intervention must be supported by data-driven traffic management strategies to mitigate the risk of future congestion.

Widening the road to 11.5 meters is recommended as a medium-term solution to alleviate traffic density. This effort should be accompanied by a Road Safety Audit, proper lane marking, and a participatory planning approach to avoid negative impacts on the surrounding densely populated residential areas.

This study highlights the importance of a simulation-based approach in planning traffic management within developing slum areas. Using PTV VISSIM, it becomes evident that without adequate control strategies, the study area is at risk of experiencing increased congestion and declining network performance over the long term.

One critical point is the Jembatan Teluk Dalam intersection, which is projected to face rising traffic flow conflicts. However, the installation of traffic signals at this location is not recommended due to the potential for vehicle queuing on the bridge and public concerns regarding structural safety following a previous collapse incident. As an alternative, strategies such as speed management, warning signs, and well-designed lane markings and signage are considered safer and more effective.

These findings reinforce the need for a comprehensive and adaptive traffic management strategy, as well as the integration of data-based monitoring systems in decision-making processes. Such an approach is essential to ensure that area development aligns with the goals of safe and efficient mobility for local residents.

A limitation of this study lies in its focus on scenarios projected only through the 2029 planning horizon. Future research should explore a wider range of long-term development scenarios and the potential application of intelligent traffic management technologies to enhance the resilience of urban transportation systems.

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