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Original Article

Traffic Congestion Due to Roadside Activities on Kampu Baru Road, Dili City, Timor-Leste

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Abstract

Urban roads are crucial for mobility and socio-economic activities, yet traffic congestion remains a persistent challenge, especially in rapidly growing cities. This study analyzes traffic congestion on Kampu Baru Road, Dili City, by evaluating traffic volume, lateral obstacles, road geometry, and degree of saturation using the Indonesian Road Capacity Manual (MKJI) framework. Data were collected through field observations during peak hours and analyzed using MKJI-based calculations for road capacity and level of service. The findings reveal that lateral obstacles peak on Saturdays, with up to 2,600 events per hour, mainly due to street vendors and roadside commercial activities, significantly affecting traffic flow. The degree of saturation reached 0.82 during peak hours, corresponding to Level of Service D, indicating near-unstable conditions with low speeds and limited maneuverability. These results highlight the critical role of managing lateral obstacles and optimizing road performance to reduce congestion and improve mobility. The study provides practical insights for traffic management and urban planning in developing cities.

Keywords: Degree of Saturation, Lateral Obstacles, Road Capacity, Traffic Congestion, Urban Road Performance.

1. Introduction

Rapid urban growth in Dili City has led to increased traffic demand, particularly on primary roads serving commercial and residential activities. Kampu Baru Road is a major urban corridor that frequently experiences congestion, especially during peak hours. This condition is largely influenced by high side friction caused by on-street parking, street vendors, pedestrian crossings, and public transport stopping activities (Angkoso, 2022).

Previous studies have highlighted the significant impact of side friction on road capacity and traffic performance, especially in urban areas with limited road width and mixed traffic conditions (Obiri-yeboah et al., 2020). However, most research focuses on large metropolitan cities or arterial roads, while empirical evidence from medium-sized developing cities, such as Dili, remains limited (Zhang et al., 2025). Moreover, studies that quantitatively assess the relationship between side friction intensity and level of service using standardized capacity analysis methods are scarce (Srivastava & Kumar, 2023b).

This study addresses this gap by analyzing traffic congestion on Kampu Baru Road using the Indonesian Highway Capacity Manual (MKJI), a method widely applied in countries with similar traffic characteristics (Directorate General of Highways, 1997). The objective is to evaluate road performance based on traffic volume, side friction, and geometric conditions and to determine the level of service during peak periods. The findings aim to support practical strategies for urban traffic management and congestion mitigation through effective control of roadside activities (Rosyd et al., 2023; Zhang et al., 2025).

2. Literature Review

Traffic congestion is a common problem in urban road networks, particularly in developing cities where rapid growth in vehicle ownership is not matched by adequate road capacity and traffic management. Congestion reduces travel speed, increases delays and fuel consumption, and negatively impacts economic activities. Therefore, a strong theoretical foundation related to congestion, road performance, and previous studies is essential to support the analysis of traffic conditions on Kampu Baru Road, Dili City, Timor Leste (Ayeni & Iyeke, 2024; Diaz et al., 2023; Ginting & Widyaningsih, 2022).

2.1. Traffic Congestion and Road Performance Theory

Traffic congestion occurs when traffic demand exceeds the available road capacity, resulting in unstable traffic flow conditions. According to traffic flow theory, congestion is closely related to the interaction between traffic volume, speed, and density. The performance of an urban road segment can be evaluated using key indicators such as traffic volume, free-flow speed, capacity, degree of saturation, and level of service (Kusumawaty & Hartanto Susilo, 2023; Srivastava & Kumar, 2023).

The Manual Kapasitas Jalan Indonesia (MKJI) provides a systematic framework for analyzing road performance under mixed traffic conditions commonly found in developing cities. High side friction, limited road geometry, and uncontrolled roadside activities significantly reduce road capacity and operational speed, leading to congestion. This theoretical framework forms the basis for evaluating traffic conditions on Kampu Baru Road (Ayeni & Iyeke, 2024; Faradila & Puspito, 2022; Wirdianto et al., 2025).

2.2. Side Friction and Road Geometry

Side friction refers to activities along the roadside that interfere with traffic flow, such as pedestrians, parked vehicles, vehicles entering and exiting access points, and slow-moving vehicles. High levels of side friction are common in urban areas with commercial activities and significantly affect road capacity and speed (Hidayati et al., 2019; Patel et al., 2017; Salini et al., 2016; Srivastava & Kumar, 2023). MKJI classifies side friction into different levels based on the frequency and type of roadside activities (Fuad, 2017; Patel et al., 2017).

Road geometry, including lane width, number of lanes, shoulder conditions, and median presence, also plays a key role in determining road performance. Inadequate geometric conditions combined with high side friction can accelerate congestion, particularly during peak hours. Understanding the influence of side friction and geometric characteristics is crucial for analyzing urban road congestion (Arianta & Widyatami, 2025; Dharmawan et al., 2019).

2.3. Previous Research

Several studies have examined congestion and urban road performance. Kusumawaty and Susilo (2023) analyzed traffic congestion on Jalan M.H. Thamrin, Tangerang City, using direct observations during morning and evening peak hours. They employed descriptive methods and the 1997 MKJI to assess traffic flow, obstacles, and density, recommending road widening and vehicle management to reduce congestion.

Faradila and Puspito (2022) evaluated urban road performance on Jalan Sawangan Raya, Depok City, using the 1997 MKJI. Field surveys during peak hours measured vehicle volume and speed. The study concluded that road performance can be improved through side obstacle management and road widening, using linear regression analysis to project traffic growth. Widodo et al. (2024) conducted a capacity analysis on the Diponegoro Road section in Bondowoso Regency using the 1997 MKJI and the updated 2023 PKJI methods. Data were collected to compare road capacity, free-flow speed, and adjustment factors such as lateral resistance, lane width, and lane separators. Results showed differences between the two methods, reflecting updated methodology and parameters.

Other studies highlight that unmanaged roadside activities and side friction directly reduce traffic flow and road capacity in developing cities, emphasizing the importance of roadside management, vehicle regulation, and infrastructure improvements to mitigate congestion (Hasyim et al., 2021; Hidayati et al., 2019; Wirdianto et al., 2025).

3. Methods

This study was conducted on Kampu Baru Road, Dili City, to identify factors causing traffic congestion. The research combined direct field observation, geometric measurements, and traffic surveys. Key variables included road geometry, traffic volume, vehicle types, traffic management, and surrounding environmental conditions (Dharmawan et al., 2019; Rosyd et al., 2023).

3.1. Data Collection

Data were collected from both primary and secondary sources. Primary data were obtained through direct field observations, recording vehicle counts, vehicle types, and traffic flow patterns. Secondary data were obtained from official reports, government documents, and relevant publications. Traffic counts were conducted manually at strategic points during peak hours (7:00-9:00 AM, 12:00-2:00 PM, 4:00-6:00 PM). Vehicles were classified into four categories: Light Vehicles (LV) including passenger cars and small trucks; Heavy Vehicles (HV) including buses and large trucks; Motorcycles (MC) including motorcycles and three-wheelers; and Non-motorized vehicles (UM) such as bicycles and pedicabs (Angkoso, 2022; Hidayati et al., 2019).

3.2. Road Geometry and Environment

The road geometry and surrounding environment significantly influence traffic flow and congestion levels. Measurements focused on the number of lanes, lane widths, shoulder widths, and parking conditions, which affect vehicle capacity, lane-changing behavior, and overall traffic performance. Environmental observations considered roadside activities such as commercial operations, pedestrian movements, and other external factors that could impact vehicle speed and traffic dynamics. The north and east sections of Kampu Baru Road each consist of 2 lanes with a lane width of 3 meters, providing insight into traffic capacity and potential constraints (Arianta & Widyatami, 2025).

3.3. Data Analysis

Collected data were analyzed using Microsoft Excel and the Indonesian Road Capacity Manual (MKJI, 1997) to calculate traffic flows, delays, and congestion levels. This analysis facilitated the identification of congestion causes and the evaluation of potential mitigation strategies (Faradila & Puspito, 2022; Kusumawaty & Susilo, 2023).

4. Results and Discussion

4.1. Research Results

Kampu Baru Road is located in Comoro, Dom Aleixo District, Dili City, Timor-Leste. It is a major urban corridor with heavy daily traffic, passing through commercial and residential areas, which significantly influence traffic flow. The road is classified as 2/2 UD (2 lanes - 2 directions) with 1 m shoulders on both sides, and a functional road width of 6 m, although some sections are used for parking and local activities.

Observations were conducted from Monday, August 4, 2025, to Saturday, August 9, 2025, by eight trained surveyors. Data collected included vehicle volume, lateral obstacles, and vehicle speed. Surveys were carried out during three time periods: morning (07:00-09:00), midday (12:00-14:00), and evening (16:00-18:00). The collected data were analyzed to calculate traffic volume, road capacity, degree of saturation, lateral resistance class, speed, and level of service (LOS), based on MKJI 1997 (Angkoso, 2022; Rosyd et al., 2023).

4.1.1. Traffic Volume

Traffic volume represents the number of vehicles passing a specific point during a specified time interval and is expressed in passenger car units per hour (PCU/hour). The traffic volume survey on Kampu Baru Road included motorcycles (MC), light vehicles (LV), and heavy vehicles (HV) recorded in both directions. The results of the total traffic volume analysis are presented in Table 1.

Table 1. Total Traffic Volume (smp/hour) at Kampu Baru

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
07.00-08.00	1,280.9	1,334.8	1,335.95	1,346	1,369.4	1,391.2
08.00-09.00	1,435.85	1,469	1,476.65	1,492.85	1,517.7	1,539.35
12.00-13.00	1,307.4	1,325.55	1,334.55	1,349.65	1,372.45	1,395.2
13.00-14.00	1,078.45	1,142.55	1,146.85	1,153.65	1,170.3	1,191.6
16.00-17.00	1,612.45	1,629.85	1,633.15	1,626.1	1,650.85	1,671.2
17.00-18.00	1,378.5	1,480.85	1,470.5	1,494.7	1,513.95	1,535.75

The highest traffic volume occurred on Saturday from 16:00-17:00, with 1,671.2 PCU/hour, due to increased commercial activities and returning commuters (Wirdianto et al., 2025).

4.1.2. Lateral Obstacles

Lateral obstacles include parked vehicles, street vendors, pedestrians crossing the road, and other objects that impede traffic flow.

Table 2. Total Lateral Obstacles per 100 m per Hour

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
07.00-08.00	1,891	2,030	2,150	2,220	2,350	2,430
08.00-09.00	2,100	2,200	2,280	2,350	2,470	2,520
12.00-13.00	1,020	1,150	1,250	1,180	1,250	1,360
13.00-14.00	1,220	1,350	1,300	1,420	1,480	1,500
17.00-18.00	2,310	2,450	2,400	2,430	2,510	2,600
18.00-19.00	1,950	1,800	2,150	1,900	2,050	1,850

The results indicate that commercial and pedestrian activities significantly impact traffic flow, particularly during afternoon peak hours (Hidayati et al., 2019; Rosyd et al., 2023).

4.1.3. Free Flow Speed

The free flow speed (FFS) for light vehicles was calculated based on MKJI 1997 adjustment factors for lane width, lateral obstacles, and urban conditions. The resulting FFS was 33.3 km/h, reflecting the influence of roadside resistance and mixed traffic composition (Angkoso, 2022).

4.1.4. Roadway Capacity

The roadway capacity of the Kampu Baru section was determined using the MKJI 1997 methodology for urban roads. The calculation involved multiplying the base capacity (C_o = 2900 pcu/hour) by several adjustment factors to account for specific roadway conditions: lane width factor (FCW = 0.87), lateral clearance factor ($FCSP$ = 0.94), driver population factor ($FCSF$ = 0.95), and composition factor ($FCCS$ = 0.90). By applying these factors, the effective capacity of the road was calculated as C = 2028 smp/h, reflecting the combined influence of geometric, environmental, and traffic composition characteristics on the maximum sustainable flow of vehicles (Dharmawan et al., 2019; Lalenoh et al., 2015).

4.1.5. Degree of Saturation

The degree of saturation (DS) represents the ratio of the actual traffic volume (Q) to the road's capacity (C), calculated as $DS = Q/C$. For the Kampu Baru section, the highest degree of saturation was observed on Saturday afternoon, with DS = 1,671.2 / 2,028 ≈ 0.82. This value indicates that the road is approaching high saturation during peak hours, suggesting that traffic flow is nearing the road's maximum operational capacity and that congestion is likely to occur if volumes increase further (Hidayati et al., 2019).

4.1.6. Instant Velocity Survey

Instantaneous vehicle speeds affected by lateral obstacles are presented in Tables 3-5. Morning speeds ranged 19.23-26.32 km/hour, midday 16.13-25.64 km/hour, and evening 16.13-23.81 km/hour, with lowest speeds on weekdays due to higher pedestrian and vehicle interactions. Average daily speeds were 18.84-24.75 km/hour, indicating that lateral obstacles significantly reduce vehicle performance. These findings emphasize the impact of roadside and environmental factors on overall traffic flow efficiency (Angkoso, 2022; Hidayati et al., 2019).

Table 3. Instantaneous Vehicle Speed Affected by Lateral Obstacles During Morning Peak Hours

Day	Distance (Km)	Time Taken (Hour)			Vehicle Speed (Km/hour)			Average (Km/hour)
		I	II	III	I	II	III	
Monday	0.10	0.00400	0.00450	0.00520	25.00	22.22	19.23	22.82
Tuesday	0.10	0.00390	0.00410	0.00450	25.64	24.39	22.22	24.75
Wednesday	0.10	0.00450	0.00500	0.00480	22.22	20.00	20.83	21.68
Thursday	0.10	0.00430	0.00470	0.00460	23.26	21.28	21.74	22.09
Friday	0.10	0.00520	0.00450	0.00390	19.23	22.22	25.64	22.36
Saturday	0.10	0.00380	0.00440	0.00500	26.32	22.73	20.00	23.68

Table 4. Instantaneous Vehicle Speed Affected by Lateral Obstacles During Midday Peak Hours

Day	Distance (Km)	Time Taken (Hour)			Vehicle Speed (Km/hour)			Average (Km/hour)
		I	II	III	I	II	III	
Monday	0.10	0.00550	0.00420	0.00620	18.18	23.81	16.13	19.37
Tuesday	0.10	0.00450	0.00460	0.00470	22.22	21.74	21.28	21.75
Wednesday	0.10	0.00410	0.00450	0.00430	24.39	22.22	23.26	23.29
Thursday	0.10	0.00570	0.00580	0.00460	17.54	17.24	21.74	18.84
Friday	0.10	0.00420	0.00390	0.00490	23.81	25.64	20.41	23.29
Saturday	0.10	0.00490	0.00470	0.00460	20.41	21.28	21.74	21.14

Table 5. Daily Vehicle Speed and Travel Time Measurements on Kampu Baru Road, Dili City

Day	Distance (Km)	Time Taken (Hour)			Vehicle Speed (Km/hour)			Average (Km/hour)
		I	II	III	I	II	III	
Monday	0.10	0.00480	0.00620	0.00460	20.83	16.13	21.74	19.57
Tuesday	0.10	0.00600	0.00470	0.00520	16.67	21.28	19.23	19.06
Wednesday	0.10	0.00450	0.00440	0.00460	22.22	22.73	21.74	22.23
Thursday	0.10	0.00540	0.00420	0.00490	18.52	23.81	20.41	20.91
Friday	0.10	0.00460	0.00470	0.00510	21.74	21.28	19.61	20.88
Saturday	0.10	0.00470	0.00440	0.00480	21.28	22.73	20.83	21.61

4.2. Discussion

The results of this study demonstrate that traffic performance on Kampu Baru Road is strongly governed by the interaction between traffic demand, lateral obstacles, and roadway geometry, consistent with the theoretical framework of the MKJI 1997 method. Peak traffic volume was recorded on Saturday afternoon (16:00-17:00), reaching 1,671.2 PCU/hour, a pattern attributable to the convergence of weekend commercial activity and homeward commuter flows. This peak coincided closely with the highest recorded level of lateral obstacles, at 2,600 events per 100 m per hour, indicating a direct temporal relationship between roadside commercial intensity and traffic loading rather than two independent phenomena. This finding aligns with earlier observations that roadside vendor activity and public transport stopping behavior tend to intensify during weekend peak periods, thereby compounding congestion beyond what traffic volume alone would predict (Wirdianto et al., 2025).

The calculated degree of saturation of 0.82, corresponding to Level of Service (LOS) D, confirms that the road segment operates close to its practical capacity during peak hours. According to MKJI 1997 classification, LOS D reflects unstable flow characterized by restricted vehicle maneuverability, frequent speed fluctuations, and low tolerance for any additional volume increase, conditions that were directly observed in the field through reduced average speeds (18.84-24.75 km/h) across all survey days. Notably, the lowest instantaneous speeds were recorded on weekdays rather than Saturday, suggesting that although Saturday generates the highest absolute traffic volume, the cumulative friction from daily commuting patterns, school-related trips, and continuous roadside activity throughout the work week exerts a comparably disruptive effect on speed performance. This distinction between volume-driven and friction-driven congestion is an important nuance that a single-day observation would likely have missed.

The strong association between lateral obstacles and reduced travel speed corroborates findings from previous studies on urban arterials in developing cities, where uncontrolled roadside activity, including on-street parking, informal vending, and pedestrian crossings—has consistently been shown to reduce effective road capacity by narrowing usable carriageway width and increasing driver hesitation (Hidayati et al., 2019; Salini et al., 2016; Wirdianto et al., 2025). The adjustment factors applied in this study, particularly the lateral clearance factor (FCSP = 0.94) and side friction classification, quantitatively reflect this reduction, and the resulting effective capacity of 2,028 PCU/hour, well below the base capacity of 2,900 PCU/hour, illustrates the tangible cost that unmanaged side friction imposes on road performance.

These findings are also consistent with broader patterns identified in similar MKJI-based studies conducted in Indonesian cities of comparable scale, such as Tangerang (Kusumawaty & Susilo, 2023) and Depok (Faradila & Puspito, 2022), both of which identified side friction management and geometric improvement as the primary levers for congestion mitigation rather than large-scale road widening alone. This suggests that the congestion pattern observed on Kampu Baru Road is not an isolated case but reflects a broader structural challenge common to medium-sized, rapidly urbanizing cities where commercial land use directly abuts constrained road corridors (Obiri-yeboah et al., 2020; Zhang et al., 2025).

Taken together, these results indicate that congestion on Kampu Baru Road is driven less by an absolute deficiency in road capacity and more by the compounding effect of high-frequency roadside interference on an already geometrically constrained corridor (6 m functional width, 2/2 UD configuration). This distinction is critical for policy: interventions focused solely on capacity expansion (e.g., road widening) may yield limited benefit if lateral obstacles remain unmanaged, whereas targeted side-friction control—relocating vendors, enforcing parking restrictions, and formalizing pedestrian crossings—could meaningfully shift the degree of saturation below the LOS D threshold without requiring costly infrastructure expansion.

5. Conclusion

This study evaluated traffic conditions on Kampu Baru Road, Dili City, using the MKJI 1997 method. The findings show that peak traffic volume occurred on Saturday between 16:00 and 17:00, reaching 1,671.2 PCU/hour, coinciding with the highest recorded level of lateral obstacles at 2,600 incidences per 100 meters during the same period. The calculated road capacity was 2,028 PCU/hour, yielding a degree of saturation of 0.82, which corresponds to Level of Service (LOS) D, indicating unstable traffic flow and a high potential for congestion. Roadside activities and commercial interactions were found to significantly reduce vehicle speeds, with averages ranging from 18.84 to 24.75 km/h, further contributing to congestion along the road.

Based on these findings, several measures are recommended to improve traffic performance on Kampu Baru Road. First, side friction should be actively managed by relocating or regulating roadside vendors, parked vehicles, and other obstructions that narrow effective road width and disrupt traffic flow. Second, stricter traffic regulation and enforcement are needed, particularly during peak hours such as Saturday afternoons, to maintain smoother vehicle movement and reduce the risk of congestion. Third, the provision of adequate pedestrian infrastructure, such as designated footpaths and crossing points, is essential to separate pedestrian activity from vehicular traffic, thereby minimizing conflicts that contribute to reduced speeds and side friction. Finally, future studies could explore the long-term effectiveness of these interventions, including their impact on degree of saturation and level of service, to ensure sustainable improvements in road capacity and traffic performance on Kampu Baru Road.

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5.2. Competing interests

The authors declare that there are no competing interests related to this research.

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