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ESTABLISHING A TRAFFIC IMPACT ASSESSMENT MODEL FOR LARGE-SCALE URBAN CONSTRUCTION PROJECTS IN VIETNAM

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ABSTRACT: The accelerated pace of urbanization in Vietnam has led to growing concerns about traffic congestion, especially in areas undergoing large-scale construction. This paper presents a structured and practical framework for conducting Traffic Impact Assessments (TIA) tailored to major urban construction projects. By leveraging both macroscopic and microscopic simulation tools VISUM and VISSIM we provide a robust methodology to forecast, assess, and mitigate traffic impacts from proposed developments. The framework centers on critical peak hours (7- 8 AM and 5- 6 PM) to capture the most severe traffic conditions. Data inputs include socio-economic indicators, base-year traffic volumes, and spatial configurations from major Vietnamese cities like Hanoi. The simulation results highlight the stark contrast in Level of Service (LOS), delay times, and queue lengths across three scenarios: existing conditions, post-development without mitigation, and post-development with interventions. Our findings emphasize the necessity of early-stage traffic modeling in urban planning and advocate for the institutionalization of simulation-based TIA in Vietnamese regulatory practice. This study offers urban planners, policymakers, and traffic engineers a replicable model for integrating transportation considerations into the design and approval process of large-scale developments.

Keywords: Traffic impact assessment, ITS, GIS, VISUM, VISSIM, Hanoi, Traffic simulation, Vietnam planning

1. INTRODUCTION

Vietnam is currently undergoing rapid urban transformation, with cities such as Hanoi and Ho Chi Minh City expanding at unprecedented rates. This growth has brought about increased demands on urban infrastructure, especially the transportation network. Traffic congestion, particularly during peak hours and has become a pressing issue, often exacerbated by ongoing and planned large-scale construction projects such as embassies, mixed-use developments, and high-rise commercial zones [1, 2].

A Traffic Impact Assessment (TIA) serves as a critical tool to understand and manage the consequences of these developments [3]. TIA enables urban planners and policymakers to anticipate potential traffic disruptions, evaluate mitigation strategies, and make informed decisions to ensure sustainable urban mobility. While TIAs have become a standard in many developed countries, their application in Vietnam remains inconsistent and often limited to qualitative assessments or basic traffic counts [4-6].

This paper presents a simulation-based TIA framework, adapted to Vietnam's urban context and validated through a case study of the new U.S. Embassy project in Hanoi's Cau Giay District. The site, covering 32,000 square meters, is expected to generate over 4,000 person-trips daily upon completion. Located at a key intersection, it offers an opportunity to assess construction-induced traffic impacts. Figure 1 shows the study area's location in Cau Giay District.

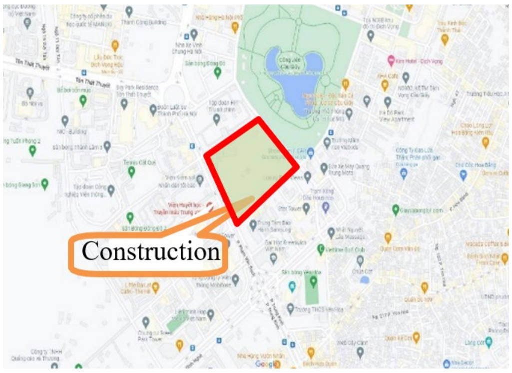


Fig. 1 Location of the U.S. Embassy construction site in Cau Giay District, Hanoi

The paper is structured as follows: Section 2 covers the study area, data sources, and the use of VISUM and VISSIM for traffic assessment. Section 3 presents and compares traffic conditions across scenarios, focusing on key performance indicators. Section 4 summarizes the findings, emphasizing mitigation strategy effectiveness and the need for early-stage TIA. Section 5 discusses the findings' implications and recommends institutionalizing TIA in Vietnam for better traffic management.

2. RESEARCH SIGNIFICANCE

This study introduces an original simulation-based framework for Traffic Impact Assessment (TIA) in rapidly urbanizing Vietnam. By integrating macroscopic (VISUM) and microscopic (VISSIM) models, it captures peak-hour traffic dynamics beyond conventional static methods. The novelty lies in linking socio-economic data, traffic volumes, and spatial patterns to evaluate multi-scenario impacts. The framework offers a replicable tool for policymakers and planners to institutionalize simulation-driven TIA in large-scale urban developments.

3. RESEARCH METHODOLOGY

3.1. Genereal

This study uses a structured methodology with macroscopic and microscopic simulations to assess traffic impacts from large urban developments, tailored for Vietnam's high-density environments. Figure 2 shows the framework, linking traffic demand, network capacity, and mitigation measures across planning scenarios.

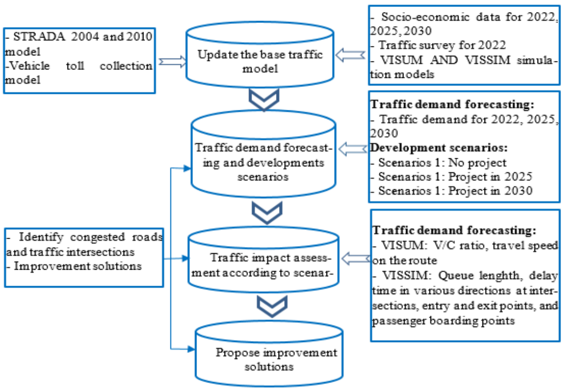


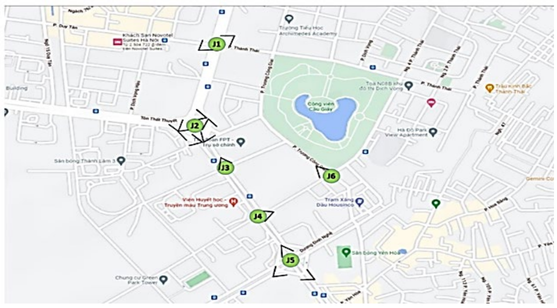
Fig. 2 The simulation-based framework for traffic impact assessment integrating macroscopic and microscopic modeling tools

The first stage defines the study area, key development characteristics, access points, intersections, and land-use data. Trip generation estimates are based on land-use types and projected populations. The second stage involves collecting data and calibrating the model. Traffic surveys were conducted during the morning (7- 8 AM) and evening (5- 6 PM) peak hours, and socio-economic, land-use, and transportation data were gathered. The VISUM model was calibrated with real traffic counts and speed data to reflect existing conditions.

In the third stage, future traffic demand is forecasted using a four-step model, with projections for 2025 and 2030. Three scenarios are defined: baseline (no development), development without mitigation, and development with interventions.

The fourth stage involves macroscopic and microscopic simulations. The VISUM model analyzes network-level indicators, while VISSIM assesses traffic behavior at critical intersections, including queue lengths, delays, and LOS. These outputs enable a comparative analysis of development impacts and mitigation effectiveness.

This methodology offers a rigorous, context-sensitive approach to traffic impact assessment, applicable to other urban projects in Vietnam. It provides insights for planners to improve mobility and support infrastructure growth. Figure 2 illustrates the framework, linking traffic demand, capacity, and mitigation measures to guide future policy and planning. The study area covers major intersections and corridors in Cau Giay District, Hanoi, including Pham Van Bach, Duy Tan, and Tran Thai Tong, which serve residential and institutional areas. The assessment focuses on a 500- 800 meter radius around the development site, covering critical access points and junctions likely to experience significant traffic changes. Special attention was given to key intersections such as Tran Thai Tong- Duy Tan, Ton That Thuyet- Pham Van Bach, and Duong Dinh Nghe- Trung Kinh. These nodes are characterized by heavy traffic volumes and strategic importance within Hanoi's broader urban road network.



(a)

(b)

Fig. 3 Spatial overview of survey locations and affected road network: (a) Traffic count locations used for model calibration; (b) Geographical extent of project-induced traffic impact in Cau Giay District, Hanoi.

Survey locations were selected based on field observations and historical data, focusing on typical and peak-hour conditions. Sites were observed during rush hours to capture high-demand periods, with the survey grid shaped by surrounding land-use, including residential, commercial, and public areas.

Figure 3 shows the traffic survey locations and the influence zone around the U.S. Embassy site. Subfigure 3a highlights key survey points, while 3b outlines impacted corridors and intersections. These visuals informed model calibration, ensuring accurate representation of local and regional traffic dynamics.

Figure 3's spatial data defined the study area boundaries and selected key intersections for data collection. Combining survey points (3a) and the influence zone (3b) ensured contextual relevance and guided the base model configuration and calibration.

3.2 Data Collection and Calibration

To ensure the accuracy and reliability of the simulation framework, an extensive data collection process was undertaken. Traffic volume counts were carried out at strategically selected intersections during two critical peak periods: 7:00- 8:00 AM and 5:00- 6:00 PM. These time windows correspond to the highest demand intervals identified from prior traffic studies and empirical observations in Hanoi. Manual and video-based counting methods were employed simultaneously to enhance data fidelity, especially at locations with high vehicle throughput or multimodal complexity.

Table 1. Classified traffic volumes at J6 intersection (vehicles/hour) at Truong Cong Giai Street - Street No. 2, Cau Giay District intersection during peak hours.

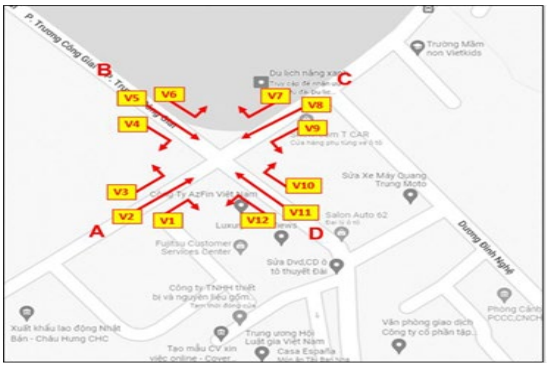
Time	Direction	Bicycle	Motorbike	Car, Taxi	2-Axle Truck	3-Axle Truck	Bus	Container	Total
7:00–8:00	A	15	654	174	2	0	6	0	851
	B	22	987	219	1	1	22	0	1252
	C	82	1622	471	2	1	20	0	2198
	D	34	1931	489	1	1	21	0	2454
17:00–18:00	A	30	836	205	1	0	10	0	1082
	B	40	1665	296	5	2	24	0	2032
	C	37	2161	381	6	1	27	0	2613
	D	13	1863	353	13	1	14	0	2256
TOTAL									14604

In addition to volume data, turning movement counts (TMCs) were recorded at all signalized junctions within the study area. These counts were essential for configuring turning ratios and intersection-specific signal timings in the microscopic simulation. Traffic composition namely the share of motorcycles, cars, buses, and heavy vehicles was also documented to reflect the modal structure typical of urban Vietnamese corridors [7].

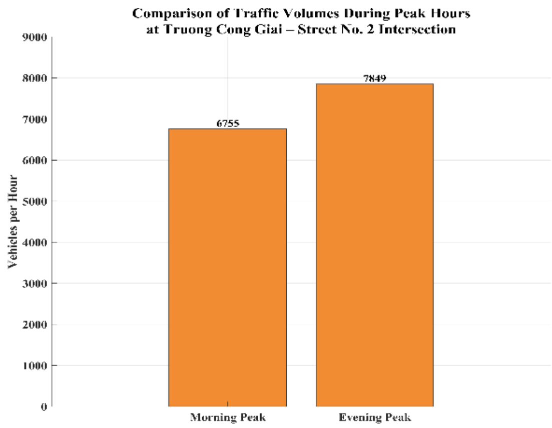
Table 1 summarizes the classified traffic volumes at one of the major intersections within the study area (J6: Truong Cong Giai - Street No. 2). The data include disaggregated vehicle counts by type during both morning and evening peak hours and were used to validate and calibrate the simulation models (VISUM and VISSIM).

Figure 4 provides a visual overview of the traffic survey at J6 intersection. Subfigure (a) shows the geometric layout and directional flows recorded through coded observation points (V1- V15), while subfigure (b) presents the total volume comparison between morning and evening peak hours. These visual data help contextualize the traffic composition summarized in Table 1 and support the calibration of the simulation models.

Socio-economic and demographic data were gathered from publicly available sources, including Hanoi's Department of Planning and Investment. These datasets were used to inform trip generation parameters, land-use functions, and network demand inputs. Land use maps and zoning plans provided insight into future development densities and helped validate the plausibility of projected traffic growth scenarios.



(a)



(b)

Fig. 4 (a) Traffic observation layout and (b) peak-hour volume comparison at J6 intersection (Truong Cong Giai - Street No. 2).

Calibration of the base traffic model in VISUM was conducted iteratively. Observed traffic counts were compared against simulated outputs, with model parameters adjusted to minimize error margins. Calibration metrics such as the Root Mean Square Error (RMSE) and the GEH statistic were used to evaluate model accuracy. Intersections and links showing significant deviations were re-examined to identify data inconsistencies, potential network coding errors, or unusual local conditions (e.g., construction detours or signal malfunctions during survey periods). Once the macroscopic model achieved satisfactory calibration, its outputs were used to configure the microscopic simulation in VISSIM. Traffic geometry, signal phasing, lane configuration, and traffic behavior parameters were customized for each intersection, with traffic geometry data sourced from the Geographic Information System (GIS) platform. This two-tier calibration process ensured consistency between network-wide traffic flows and local-level dynamics, enhancing overall robustness of TIA framework.

Traffic performance indicators were collected during the morning and evening peak periods and include vehicle volume, travel speed, density, link capacity, average delay, and intersection waiting time. Among these, control delay is one of the most widely recognized metrics for evaluating intersection performance. Based on this, the Level of Service (LOS) classification provides a standardized framework to assess operational efficiency at both signalized and unsignalized intersections.

LOS is typically expressed in six categories, from A (free flow) to F (oversaturation), and reflects user experience through measurable delays. These thresholds are especially useful for comparative evaluations across scenarios and for quantifying the benefits of mitigation strategies. Table 2 presents the LOS classification criteria adopted in this study, based on guidelines from the Highway Capacity Manual (HCM) and related international standards.

Table 2. Level of Service (LOS) classification criteria for signalized and unsignalized intersections. [8, 9]

No.	Level of Service (LOS)	Delay Time (seconds) - Signalized Intersection	Delay Time (seconds) - Unsignalized Intersection
1	A	≤ 10	≤ 10
2	B	10 - 20	10 - 15
3	C	20 - 25	15 - 25
4	D	25 - 55	25 - 35
5	E	55 - 80	35 - 50
6	F	≥ 80	≥ 50

a. Integrated Simulation Framework

To analyze the traffic implications of the proposed development, this study employed a two-tier simulation framework using VISUM and VISSIM two industry-standard tools developed by PTV Group. VISUM, a macroscopic traffic modeling software, was utilized to construct a comprehensive network-level model of Hanoi's transport system. This platform allowed for the estimation of traffic flows, travel speeds, and capacity utilization across arterial roads, and served as the foundation for evaluating regional traffic redistribution under different development scenarios.

Complementing this, VISSIM a microscopic simulation tool was used to model vehicle interactions and operational conditions at key intersections within the study area. VISSIM enables a detailed replication of lane behavior, signal timing, and individual vehicle dynamics, thereby providing accurate insights into local-level congestion patterns, queue formation, and intersection delays. This bottom-up approach is especially valuable for quantifying user experience metrics such as average delay per vehicle and Level of Service (LOS).

The integration of VISUM and VISSIM enables multi-scale analysis: VISUM captures system-wide changes due to network reloading or land-use shifts, while VISSIM focuses on the performance of critical nodes under localized stress. Together, these tools were used to simulate three development scenarios up to the year 2030, factoring in baseline conditions, projected demand growth, and mitigation strategies. The modeling framework illustrated in Figure 2 encapsulates the logical workflow of this integrated approach.

b. Traffic Impact Scenario Development

To comprehensively evaluate the effects of the proposed development, three distinct traffic scenarios were established:

Scenario 1: The existing traffic condition in the absence of new construction projects.

Scenario 2: The traffic condition after the introduction of large-scale construction projects without any mitigation measures.

Scenario 3: The traffic condition with the implementation of proposed mitigation strategies, including additional roadways, optimized traffic signals, and increased public transportation options.

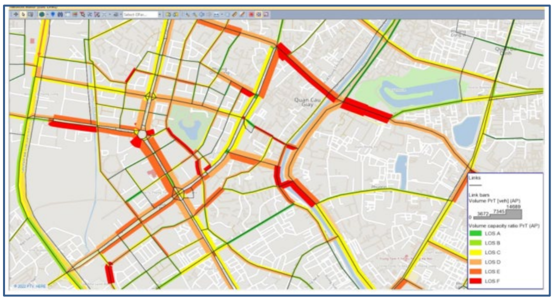
Each scenario was modeled using VISUM for network-level assignment and VISSIM for localized impact assessment. By comparing baseline and future conditions, both with and without the development, the modeling allows for clear attribution of congestion impacts and the identification of mitigation needs.

Traffic flow distribution for each scenario was visualized using VISUM. As illustrated in Figure 5, Figure 6 and Figure 7, Scenario 2 and Scenario 3 demonstrate significant shifts in volume and congestion concentration, particularly around high-demand corridors and intersections. These heatmap-based visuals help validate model outputs and communicate congestion risks in a spatially intuitive manner, forming the visual basis for the comparative performance analysis discussed in Section 3.

Fig. 5 Simulated traffic conditions in the study area of Scenario 1 (Existing conditions).

4. RESULTS AND PERFORMANCE EVALUATION

The LOS analysis for each scenario is summarized in Table 2. In Scenario 2 (2030 without the project), delay times at intersections increased by 30- 40% compared to the baseline condition, with waiting times exceeding 80 seconds at several critical junctions. This degradation reflects the compounded effects of urban growth and the absence of mitigation interventions. However, under Scenario 3 (2030 with the project and proposed mitigation measures), delay times were reduced by 20- 25%, with average waiting times returning to acceptable operational thresholds.



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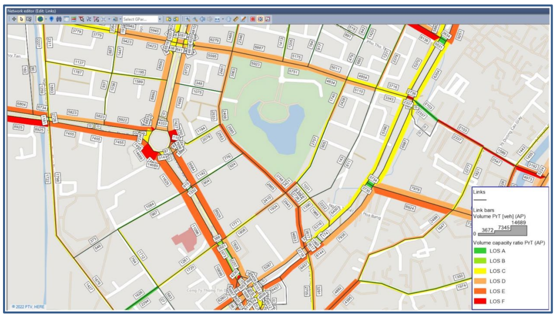
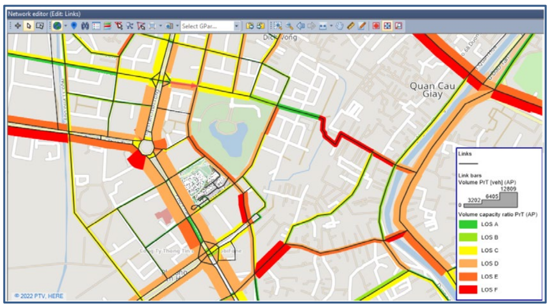


(b)

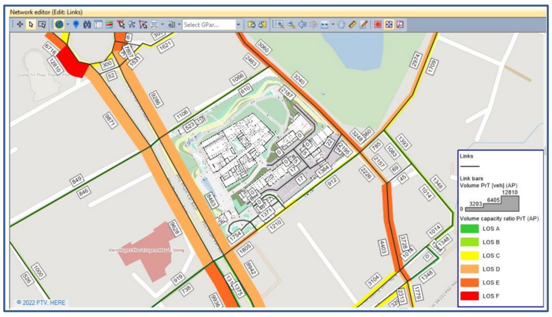
Fig. 6 VISUM-based simulated traffic volume distribution under Scenario 2 (2030 without project implementation). (a) Central Hanoi network overview. (b) Local congestion near the proposed project site.

The intersection-level results for Scenario 3 are presented in Table 3, which outlines key traffic performance indicators including average vehicle delay (VEH_DELAY), queue lengths (Q_LENGTH and Q_LENMAX), operating speeds, and corresponding LOS grades. including average vehicle delay (VEH_DELAY), queue lengths (Q_LENGTH and Q_LENMAX), operating speeds, and corresponding LOS grades. Notably, most turning movements maintain LOS levels of C or better, while left-turn and through movements at high-volume intersections generally operate at LOS D. Only a limited number of approaches, such as Trung Kinh Go Straight, operate at LOS E, indicating localized oversaturation. Table 3. Traffic Performance Indicators at Intersections for Scenario 3 (2030).

This would provide a more nuanced understanding of how individual mitigation strategies contribute to overall network performance and user experience.



(a)



(b)

Fig. 7 VISUM-based simulated traffic volume distribution under Scenario 3 (2030 with project implementation). (a) Central network impact zone. (b) Localized volume shifts and bottlenecks around the site.

These results collectively validate the effectiveness of the mitigation strategies, which include optimized signal timing, modified turning lanes, and traffic rechanneling. Furthermore, quantitative comparisons across scenarios could be strengthened by introducing performance indices the anticipated operational improvements.

Table 3. Simulated intersection performance measures under scenario 3 (2030)

Inter-section	Directions	Movements	Q_Length(m)	Q_LENMAX (m)	VEH_DELAY (s)	Speed km/h	LOS
Tran Thai Tong -Duy Tan	Tran Thai Tong (1)	Go Straight	54.30	72.45	45.14	23.95	D
		Turn Left	61.35	81.84	50.99	22.99	D
		Turn Right	15.73	20.98	13.07	30.28	B
	Duy Tan	Turn Right	20.23	26.99	10.84	32.42	B
		Go Straight	48.94	65.29	40.68	25.96	D
		Turn Left	53.69	71.63	44.63	23.32	D
	Tran Thai Tong (2)	Turn Right	21.23	28.32	6.66	33.30	A
		Go Straight	63.30	84.44	52.61	24.01	D
		Turn Left	59.61	79.52	49.54	23.87	D
	Thanh Thai	Turn Right	11.52	15.37	9.58	32.88	A
		Go Straight	34.02	45.38	28.27	30.24	C
		Turn Left	39.11	52.18	32.51	25.17	C
Ton That Thuyet -Tran Thai Tong	Tran Thai Tong	Go Straight	53.89	71.90	44.79	23.95	D
		Turn Left	59.79	79.77	49.70	23.77	D
		Turn Right	27.92	37.25	23.21	31.18	B
	Ton That Thuyet	Turn Right	20.23	26.99	23.26	31.05	B
		Go Straight	58.31	77.80	48.47	23.81	D
		Turn Left	46.52	62.06	38.66	26.04	D
	Pham Van Bach	Turn Right	21.23	28.32	25.47	32.09	C
		Go Straight	57.28	76.41	47.61	23.32	D
		Turn Left	61.32	81.80	50.96	23.12	D
	Truong Cong Giai	Turn Right	7.97	10.63	6.63	33.29	A
		Go Straight	42.00	56.04	34.91	25.77	C
		Turn Left	45.92	61.26	38.17	24.81	D
Duong Dinh Nghe -Trung Kinh	Pham Van Bach	Go Straight	64.36	85.87	53.50	23.14	D
		Turn Left	65.96	88.00	54.83	24.15	D
		Turn Right	27.60	36.82	22.94	30.60	B
	Duong Dinh Nghe (1)	Turn Right	20.23	26.99	20.56	31.29	B
		Go Straight	57.25	76.37	47.58	23.86	D
		Turn Left	53.98	72.02	44.87	23.76	D
	Trung Kinh	Turn Right	21.23	28.32	25.47	30.51	C
		Go Straight	73.65	98.25	61.21	24.45	E
		Turn Left	69.52	92.74	57.78	24.03	E
	Duong Dinh Nghe (2)	Turn Right	15.64	20.86	13.00	32.22	B
		Go Straight	41.94	55.96	34.86	24.82	C
		Turn Left	36.06	48.11	29.97	31.54	C
Pham Van Bach - Street No. 1	Pham Van Bach (from Duy Tan)	Go Straight	45.38	60.55	37.72	32.06	D
		Turn Left	55.43	73.94	46.07	33.01	D
		Turn Right	15.20	20.28	12.63	36.87	B
	Street No. 1 (from Project)	Turn Right	20.23	26.99	9.63	37.47	A
		Go Straight	35.94	47.95	29.87	34.82	C
		Turn Left	29.01	38.70	24.11	35.06	B
	Pham Van Bach (from Trung Kinh)	Turn Right	21.23	28.32	15.11	35.73	B
		Go Straight	47.23	63.01	39.26	33.33	D
		Turn Left	53.74	71.69	44.66	33.02	D
	Street No. 1 (from Viettel HQ)	Turn Right	18.24	24.33	15.16	35.99	B
		Go Straight	48.92	65.26	40.66	32.97	D
		Turn Left	42.06	56.11	34.96	33.29	C
Pham Van Bach - Street No. 2	Pham Van Bach (from Duy Tan)	Go Straight	48.62	64.86	40.41	31.42	D
		Turn Left	58.06	77.45	48.25	32.35	D
		Turn Right	21.62	28.84	17.97	36.14	B
	Street No. 2 (from Pro-ject)	Turn Right	20.23	26.99	15.11	36.72	B
		Go Straight	47.23	63.01	39.26	34.12	D
		Turn Left	35.78	47.74	29.74	34.36	C
	Pham Van Bach (from Trung Kinh)	Turn Right	21.23	28.32	18.51	35.01	B
		Go Straight	54.06	72.12	44.93	32.67	D
		Turn Left	58.04	77.43	48.24	32.36	D
	Street No. 2 (from Alley 7 TTT)	Turn Right	20.39	27.20	16.95	35.27	B
		Go Straight	54.13	72.21	44.99	32.31	D
		Turn Left	47.16	62.92	39.20	32.62	D
Truong Cong Giai - Street No. 2	Truong Cong Giai (from Thanh Thai)	Go Straight	41.35	55.16	34.37	32.24	C
		Turn Left	32.92	43.92	27.36	35.09	C
		Turn Right	15.16	20.23	12.60	38.82	B
	Street No. 2	Turn Right	20.23	26.99	18.34	36.61	B
		Go Straight	41.28	55.07	34.31	33.42	C
		Turn Left	35.87	47.86	29.82	34.68	C
	Truong Cong Giai (from Duong Dinh Nghe)	Turn Right	21.23	28.32	21.22	34.18	B
		Go Straight	53.79	71.76	44.71	31.15	D
		Turn Left	46.98	62.68	39.05	31.92	D
	Perime-ter Road	Turn Right	20.00	26.68	16.62	35.15	B
		Go Straight	43.60	58.17	36.24	33.86	D
		Turn Left	41.61	55.52	34.59	34.15	C
Thanh Thai - Truong Cong Giai	Truong Cong Giai (from Cau Giay)	Go Straight	53.77	71.74	44.69	32.10	D
		Turn Left	46.95	62.63	39.02	33.15	D
		Turn Right	23.91	31.90	19.87	36.09	B
	Thanh Thai (from Duy Tan))	Turn Right	20.23	26.99	24.50	35.24	B
		Go Straight	48.62	64.86	40.41	33.24	D
		Turn Left	53.52	71.41	44.49	32.10	D
	Truong Cong Giai (from Pro-ject)	Turn Right	21.23	28.32	24.27	35.59	B
		Go Straight	54.00	72.05	44.89	32.44	D
		Turn Left	47.52	63.39	39.49	33.47	D
	Thanh Thai (from Park)	Turn Right	18.24	24.33	15.16	36.51	B
		Go Straight	48.92	65.26	40.66	33.68	D
		Turn Left	42.06	56.11	34.96	34.79	C

such as:

- Network Delay Index (NDI) [10, 11]:

$$\mathrm{NDI}=\frac{\Sigma D_i}{\Sigma T_I} \quad (3.1)$$

Where D_i is the delay and T_i is the theoretical free-flow time.

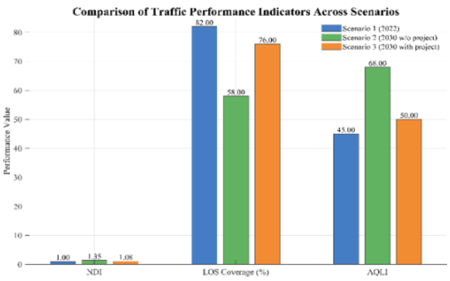
- LOS Coverage Ratio: Percentage of intersection movements operating at LOS C or better [10, 12] .
- Average Queue Length Index (AQLI) [13, 14]:

$$\mathrm{AQLI}=\frac{\Sigma Q_i}{n} \quad (3.2)$$

Where Q_i the average queue per movement.

Such indicators could be presented in future studies using comparative bar charts or radar plots to visualize multi-dimensional improvements.

The combined analysis from Figure 8a and 8b reinforces the robustness of the model calibration and the reliability of the proposed mitigation strategies. The consistency in performance gains across both visualizations particularly the improved LOS Coverage and lower NDI in Scenario 3 demonstrates that the validated model effectively captures This alignment between quantitative metrics and visual interpretation provides confidence in the model's predictive accuracy and its applicability for supporting real-world decision-making in urban traffic planning. Building upon this validation, the internal site layout and traffic simulation shown in Figure 9 (subfigures 9a and 9b) offer additional assurance regarding the spatial and operational feasibility of the proposed development. The visualizations highlight smooth internal circulation patterns and absence of major queue spillbacks within the site boundaries, even under peak-hour demand. This confirms that the mitigation strategies not only improve network-wide performance but also maintain internal accessibility and safety. Together, these layers of analysis validate the proposed framework as a reliable tool for traffic impact forecasting and infrastructure planning.



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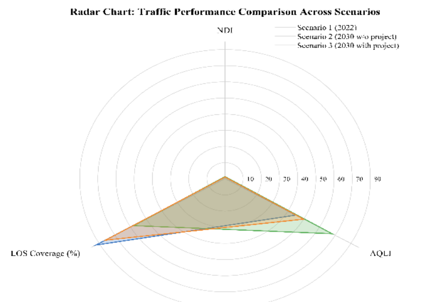

(b)

Fig. 8 Comparative visualization of traffic performance metrics across scenarios. (a) Bar chart of NDI, LOS Coverage, and AQLI indicators. (b) Radar chart showing multi-dimensional distribution

In summary, the multi-layered results presented across macroscopic, microscopic, and spatial simulation levels illustrate a coherent and effective assessment framework. The alignment of quantitative outputs with visual interpretations confirms the internal consistency and practical relevance of the proposed model. These findings set the stage for actionable policy recommendations and form a robust basis for concluding the study.

Beyond the technical results, the successful application of the proposed Transport Impact Assessment (TIA) framework in Vietnam will depend on overcoming long-standing institutional fragmentation. Urban planning has often suffered from poor coordination between the Ministry of Construction (MoC), Ministry of Planning and Investment (MPI), municipal Departments of Transport and Construction, and provincial People's Committees. Early and continuous coordination among these stakeholders is essential to ensure synchronized project implementation and to support the adoption of TIA as a standard planning requirement.

(a)

(b)

Fig.9. Internal circulation simulation of the project site (a) 2D layout-based traffic assignment; (b) 3D visual simulation of peak-hour vehicle flow

5. CONCLUSIONS

This study presents a comprehensive traffic impact assessment (TIA) framework tailored for large-scale urban construction projects in Vietnam. By integrating both macroscopic (VISUM) and microscopic (VISSIM) simulation tools, the framework offers a robust methodology for evaluating traffic conditions, identifying critical intersections, and validating the effectiveness of mitigation measures. The simulation results emphasize that, without proper mitigation, urban construction projects can severely worsen traffic performance particularly in high-density cities like Hanoi leading to significant delays, congestion, and deteriorated commuter experience. However, the application of targeted strategies such as road widening, signal timing optimization, and traffic flow rechanneling proved effective in restoring acceptable traffic conditions, as demonstrated in Scenario 3. These findings reinforce the necessity of incorporating TIA studies at the earliest stages of urban development. A proactive approach where traffic planners and urban developers collaborate from the outset will better anticipate demand pressures and ensure infrastructure readiness. Moreover, the use of advanced modeling tools enables not only forecasting but also scenario testing, helping policymakers prioritize investment in high-impact interventions.

Despite its strengths, this study acknowledges limitations inherent in simulation-based research. The accuracy of traffic forecasts is highly dependent on input assumptions, including population growth rates and modal shifts in transportation behavior. Real-world deviations such as policy changes or unexpected economic developments may affect outcomes. Future research should consider integrating environmental metrics such as emission levels and air quality degradation under congestion scenarios. Additionally, linking real-time traffic monitoring data with dynamic simulation models could improve the responsiveness and precision of future TIA evaluations. The validated TIA model developed in this study serves as a reliable tool for both strategic planning and operational decision-making, offering a scalable approach for sustainable traffic management in Vietnam's rapidly urbanizing context. Finally, for long-term institutionalization, TIA should be mandated during the regulatory planning stage and fully integrated into existing (and often outdated) urban master plans, ensuring that traffic impacts are addressed before project approval and construction permits are granted.

6. DISCUSSION

This study proposes a simulation-based Transport Impact Assessment (TIA) framework for Vietnam, but its successful implementation requires institutional, legal, and social considerations. First, the framework should align with the Urban Planning Law and Transport Development Strategy, with statutory guidelines making TIA a compulsory step in project approval, especially in the context of Vietnam's high motorcycle share and mixed traffic conditions. Second, TIA results should be formally integrated into regulatory planning documents submitted to the Ministry of Construction (MoC) and Ministry of Planning and Investment (MPI) to enhance enforceability and support early consideration of transport impacts. Third, the framework should rely on localized socio-economic, vehicle ownership, and travel behavior data from Hanoi to improve forecast accuracy. Fourth, the study applies multi-scenario simulation (baseline, post-development without mitigation, and post-development with mitigation) using VISUM and VISSIM to compare alternatives and identify effective mitigation strategies. Fifth, implementing TIA at scale will require clear enforcement mechanisms, inter-agency coordination, and public participation. Sixth, establishing a national TIA steering committee could help develop technical guidelines, monitor compliance, and facilitate communication among government agencies, consultants, and local communities. Finally, the framework should follow a clear end-to-end process from scoping, data collection, modeling, and mitigation to approval and post-occupancy monitoring with legal approval conditions tied to TIA findings and measurable compliance thresholds such as Level of Service, queue length, and delay.

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