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Assessment of urban traffic flow characteristics using field observations and SUMO simulation: a case study of Oba Adesida Road Akure, Nigeria

Evaluarea caracteristicilor fluxului de trafic urban utilizând observații de teren și simularea SUMO: studiu de caz al drumului Oba Adesida din Akure, Nigeria

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Abstract. The study assesses the characteristics of urban traffic flow along Oba Adesida Road, Akure, Nigeria, using a combination of field data and Simulation of Urban Mobility (SUMO). Physical measurements of the roadway were obtained, and a seven-day traffic count was conducted from 7:00 a.m. to 7:00 p.m. using videographic and manual methods. Vehicle volumes were converted into Passenger Car Units (PCU) using the British standard equivalence method. SUMO simulation was applied to replicate the observed conditions, enabling comparison between field and model outputs. Results indicate that the corridor is dominated by taxis, motorcycles, tricycles, and buses, with peak volumes ranging from 1080 to 2221 PCU/hr and daily totals between 13,908 and 25,788 PCU/day. The simulation closely matched field observations, with a mean deviation of about 10%. The findings highlight significant congestion patterns during morning and evening peaks, providing a basis for improving traffic management strategies in Akure.

Keywords: Urban Traffic Flow, SUMO Simulation, Passenger Car Unit, Traffic Congestion, Akure City

1.0 Introduction

Urban traffic flow analysis is a critical component of transportation engineering and sustainable city planning. As cities expand, understanding the dynamics of vehicular

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movement becomes essential for managing congestion, optimizing road capacity, and improving travel efficiency. Efficient traffic management not only supports economic productivity but also reduces fuel consumption, air pollution, and travel delays that affect the overall quality of urban life [1, 2]. Consequently, the study of traffic flow characteristics provides valuable insights into road performance, driver behavior, and infrastructure needs in rapidly growing urban environments [3]. In developing cities, the challenges of traffic congestion have intensified due to unregulated urbanization, inadequate infrastructure, and the absence of integrated transport systems. Many African cities, including those in Nigeria, experience a rapid rise in motorization without corresponding improvements in road networks and traffic control systems [4, 2]. Traditional methods of traffic analysis relying solely on manual counts and limited observational data are increasingly insufficient for capturing the complexity of modern traffic conditions [5]. Moreover, there remains a significant gap in data-driven modelling approaches that can simulate and predict real-world traffic scenarios with high accuracy [6]. To address these limitations, advanced traffic simulation tools such as the Simulation of Urban Mobility (SUMO) have emerged as effective frameworks for modeling and evaluating urban traffic behavior. SUMO is an open-source, microscopic simulation platform developed by the German Aerospace Center (DLR) that allows researchers to replicate vehicle interactions, assess traffic control strategies, and estimate performance metrics such as flow, delay, and emissions under various conditions [6, 1]. When calibrated with accurate field data, SUMO can provide reliable insights into congestion patterns and system efficiency [5]. Therefore, this study aims to analyze urban traffic flow characteristics using field data and SUMO simulation for Oba Adesida Road, Akure**,** with the goal of understanding prevailing traffic dynamics, validating simulation performance, and proposing data-supported measures for improved mobility management in the city.

Figure 1: Oba Adesida Road, Akure during peak hours

Figure 1 shows Oba Adesida Road, featuring various traffic composition and commercial activities along both directions. The study corridor, extending from Sacred Heart Cathedral Junction to Oba Osupa/Police A-Division Junction, was assessed in terms of drainage, median, carriageway, and length. Serving as a key feeder road to other major routes in Akure, it has experienced a marked increase in vehicular traffic due to growing socioeconomic activities. Analyzing its traffic characteristics is essential for understanding traffic volume, congestion patterns, and for evaluating the road's capacity and level of service.

2.0 Materials and Methods

Akure is a city in southwestern Nigeria and the capital of Ondo State. , it is located between latitudes 7^0 15^1 and 7^0 17^1 north of the Equator and between longitudes 5^0 14^1 and 5^0 15^1 east of the Greenwich Meridian. It is about 204 km east of Ibadan, capital of Oyo state; 168 km west of Benin City, capital of Edo state; 311 km north-east of Lagos; and 323 km south-west of Abuja, the Federal Capital Territory of Nigeria. Akure city spreads over an area of about 15,500 km^2 in about 370 m above the sea level. Akure is divided into two local government areas: Akure South and Akure North LGA. Notably, Oba Adesida Road falls within the jurisdiction of Akure South Local Government Area. Figure 2 depicts a map outlining the boundaries of the two local governments within Akure city.

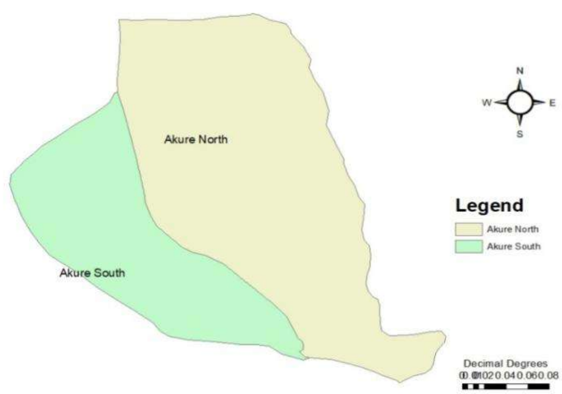

Figure 2: Akure South and Akure North LGA Map

2.1 Methods of Data Collection

Data collection for this study was primarily conducted through direct field surveys, including traffic counts, road measurements, and observational assessments, following procedures recommended in recent traffic studies [11, 12]. The study was carried out over a seven-day period from Monday, 25th September to Sunday, 1st October 2023, under clear and dry weather conditions to minimize variability in traffic patterns. Road parameters, including carriageway width, median, and drainage, were measured using a measuring tape for each lane, consistent with standard field survey techniques [11]. Traffic characteristics were surveyed using a combination of manual counting and video-graphic techniques, capturing traffic flow in both directions from 07:00 am to 7:00 pm daily. Data quality was ensured through error checking, cross-validation between manual and video counts, and handling of missing data via interpolation methods where necessary, as recommended in previous studies using mixed manual/video field surveys [12, 13]. The Passenger Car Unit (PCU) technique was applied to standardize vehicle flow, converting heterogeneous traffic into equivalent passenger car volumes. PCU factors were based on IRC: 106–1990 and the British Standard (UK Transport Research Laboratory) for each vehicle classification, in line with the approaches used in recent research [11, 12]. For simulation analysis, the study employed Simulation of Urban Mobility (SUMO) v1.18 (DLR, 2023). Field traffic data were used to generate road networks, define vehicle types, and configure simulation parameters including step size, car-following models, and route assignments, following methodologies described in SUMO simulation studies [13, 14].

Table 1

Vehicular Traffic Classifications with its equivalent PCU Factors

S/N	1	2	3	4	5	6	7
Vehicle Classifications	Motorcycle/ Tricycle	Car	Bus	2-Axle Truck	3-Axle Truck	4-Axle Truck	5-Axle Truck
PCU Factors	0.75	1.0	2.0	2.0	3.0	4.0	4.0

Source: [15]

Table 1 presents the classification of vehicular traffic along with the corresponding Passenger Car Unit (PCU) factors for each vehicle type. Tricycles and motorcycles have a PCU factor of 0.75, while a 5-axle truck is assigned a factor of 4.0. Cars and buses have PCU factors of 1.0 and 2.0, respectively. Trucks with two to four axles are assigned PCU factors ranging from 2.0 to 4.0**.**

3.0 Results and Discussion

The carriageway width of Oba Adesida Road, as well as its length includes measurements for both the shoulder and lateral clearance. The total width of 14.6 meters and length of 1800 meters, encompassing the right-of-way components, conforms to the provisions of the Code of Practice for Road Geometric Design [16]. Adequate lane width is critical for safe and efficient traffic operation. It was noted that lanes that are too narrow can increase collision risks and hinder vehicle maneuverability, while excessively wide lanes may encourage over speeding and reduce driver vigilance. Similarly, insufficient shoulder width limits space for emergency stops, heightening accident risk. The measured lane width on Oba Adesida Road strikes an appropriate balance, being neither overly narrow nor excessively wide. Furthermore, the median, walkway, and drainage dimensions of 1.2, 2.4 and 0.6 meters respectively are all within the required standards, ensuring compliance with roadway safety and design specifications.

Table 2

Traffic Volume Capacity Per Hour With PCUE (First Day)

Time Interval		In-Coming Vehicles		Out-Going Vehicles		Average	
From	To	Field Values	PCUE Values	Field Values	PCUE Values	Field Values	PCU Values
7:00am	8:00am	2195	1958	1946	1774	2071	1866
8:00am	9:00am	2431	2165	2051	1884	2241	2025
9:00am	10:0am	2198	1970	1950	1775	2074	1873
10:0am	11:0am	2092	1855	1916	1730	2004	1793
11:0am	12:0pm	1818	1645	1849	1677	1834	1661
12:0pm	1:00pm	1819	1642	1789	1620	1804	1631
1:00pm	2:00pm	1866	1676	1811	1642	1839	1659
2:00pm	3:00pm	1986	1778	1884	1706	1935	1742
3:00pm	4:00pm	2036	1817	1889	1688	1963	1753
4:00pm	5:00pm	2195	1946	1994	1806	2095	1876
5:00pm	6:00pm	2273	2027	2043	1852	2158	1940
6:00pm	7:00pm	2173	1915	1931	1741	2044	1828
Total		**25082**	**22394**	**23053**	**20895**	**24068**	**21645**

Field Survey, 2023

It was observed from Table 2 that the highest traffic volumes on Monday, the first survey day were recorded between 8:00 a.m. and 9:00 a.m.**,** with average field and PCU values of 2,241 veh/hr and 2,025 PCU/hr, respectively, in both directions. The lowest traffic volumes occurred between 12:00 noon and 1:00 p.m.**,** registering 1,804 veh/hr (field count) and 1,631 PCU/hr**.** Overall, the total daily averages for Monday were 24,068 vehicles/day and 21,645 PCU/day for both directions combined.

Table 3

Differences between Field and PCU Using Simulation of Urban Mobility (SUMO) Technique

Category	Field Total	PCU Total	Difference	%Difference (PCU vs Field)
Incoming	25, 082	22, 394	- 2, 688	- 10.7%
Outgoing	23, 053	20, 895	- 2, 158	- 9.4%
Average	24, 068	21, 645	- 2, 423	- 10.1%

From table 3, the SUMO PCU results underestimate field traffic counts by roughly 9–11**%**, which is reasonable depending on simulation calibration, detector precision, or conversion factors.

Table 4

Difference Patterns (Hourly Deviation)

Time	% Difference (Avg)	Comment
7–8 am	–9.9%	Early buildup
8–9 am	–9.6%	Morning peak underestimated
9–10 am	–9.7%	Stable
10–11 am	–10.5%	Midday drop starts
11–12 pm	–9.4%	Consistent
12–1 pm	–9.6%	Lunch off-peak
1–2 pm	–9.8%	Lowest period
2–3 pm	–10.0%	Gradual recovery
3–4 pm	–10.7%	Afternoon buildup
4–5 pm	–10.5%	Evening rise begins
5–6 pm	–10.1%	Evening peak
6–7 pm	–10.6%	Post-peak decline

From Table 4 and Figure 3 the PCU simulation shows strong correlation in pattern (timing of peaks matches field data), but an underestimation in magnitude by about 10%. This may be due to default car-following parameters (e.g., gaps or speed distributions slightly conservative). It can also be as a result of simplified vehicle composition mix (car-heavy versus mixed fleet). However, A 10% difference is within acceptable limits for many urban simulation calibrations (typically ±15% is acceptable). Between 7: 00 am and 12: 00 noon are early build up traffic, stable and consistent. There was off peak hour before traffic began to rise to the peak between the hours of 1: 00 pm and 7:00 pm. Figure 3 shows this fall (off peak hour) and rise (Peak hour) of the traffic graphically. The traffic volume comparison between the field values and PCU (SUMO) can be seen clearly as presented in figure 3. Observations from figure 4 shows that GEH Statistics reveals that all hourly GEH values are below 5, indicating very good calibration (standard threshold: GEH < 5 for $\geq 85\%$ of intervals). This implies that the SUMO model is highly reliable, with strong temporal alignment and minor systematic bias. Coefficient of determination (R^2) is 0.995, indicating excellent correlation between field and SUMO PCU data. An average percentage difference of about –10%, shows consistent underestimation.

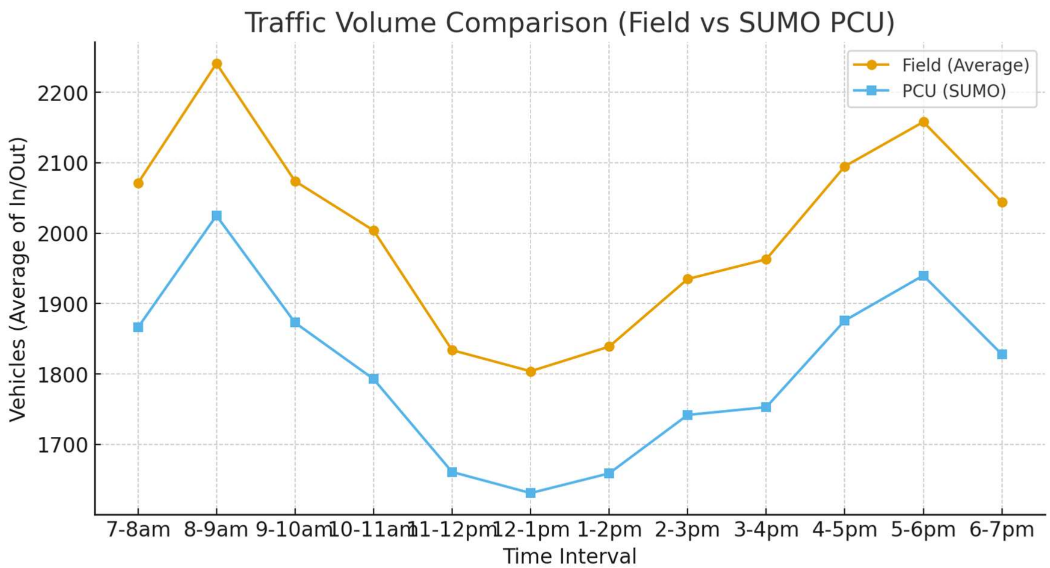

Figure 3: Showing Traffic Comparison between Field Values and SUMO PCU

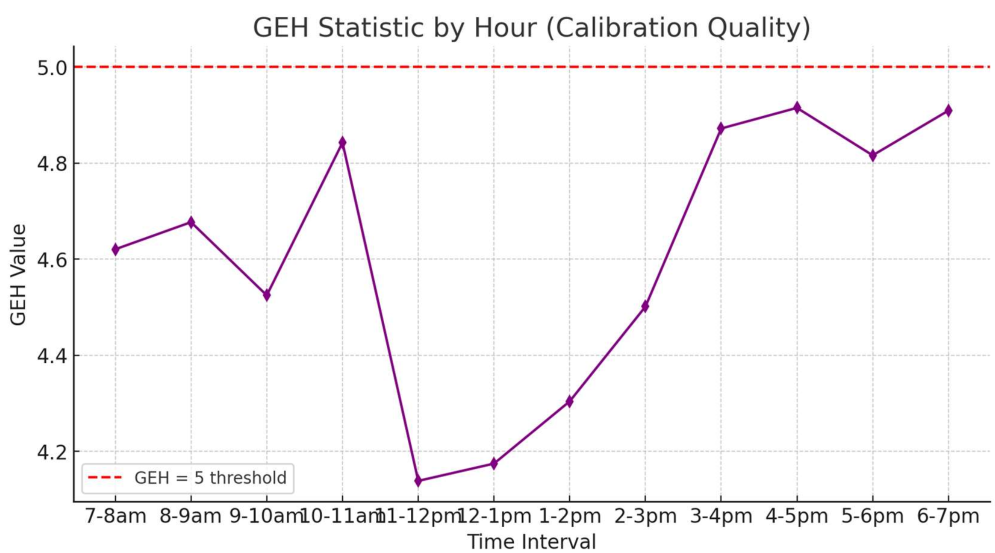

Figure 4: Showing Calibration Quality of SUMO by GEH Statistics per hour

Table 5

Traffic Volume Classifications per day with PCU Equivalent (First day)

Vehicles	PCU Factors	In-Coming Vehicle Classifications Field Values	PCUE Values	Out-going Vehicle Classifications Field Values	PCUE Values	Total Average Field Values	Total Average Average
Passenger car	1.00	12170	12170	12089	12089	12130	12130
Motorcycles/ Tricycles	0.75	12526	9395	10571	7928	11549	8662
Bus	2.00	329	658	313	626	321	610
2-Axle Truck	2.00	19	38	23	46	33	42
3-Axle Truck	3.00	20	60	23	69	22	65
4-Axle Truck	4.00	14	56	23	92	19	74
5-Axle Truck	4.00	04	16	11	44	08	30
TOTAL	**25082**	**22393**	**23053**	**20894**	**24068**	**21644**	

Field Survey, 2023

Table 5 shows that the traffic composition of Oba Adesida Road is characterized by a diverse mix of vehicles, including motorcycles, tricycles, taxis, buses, and trucks. The trucks are subcategorized based on the number of axles, namely 2-axle, 3axle, 4-axle, and 5-axle trucks. However, upon evaluation, the traffic composition of this road predominantly consists of taxis, motorcycles (Okadas), tricycles and buses. From tables 5 and 6, the passenger car categories for both directions was observed took the lead with average values of 12130pcu per day while 5-Axle truck settled for the least volume of 8 and 30 for field and PCU equivalent respectively.

Table 6

Traffic Composition Analysis with SUMO (Avg. of incoming and outgoing Vehicles)

Vehicle	Avg Field (veh)	Avg PCU (PCU)	Share of Field (%)	Share of PCU (%)
Passenger car	12,129.5	12,129.5	50.4%	56.0%
Motorcycle/Tricycle	11,548.5	8,661.5	48.0%	40.0%
Bus	321.0	642.0	1.33%	2.97%
2-Axle Truck	21.0	42.0	0.09%	0.19%
3-Axle Truck	21.5	64.5	0.09%	0.30%
4-Axle Truck	18.5	74.0	0.08%	0.34%
5-Axle Truck	7.5	30.0	0.03%	0.14%

In Table 6, the PCU of the passenger cars share rises from approximately 50% for field value to 56% because motorcycles are down-weighted by 0.75 PCU while heavy vehicles are up-weighted. Since PCU inflates the effective occupancy of lanes for heavy vehicles, junction performance indices (delay, queue, and throughput) will be sensitive to those vehicle classes.

Table 7

Traffic Volume Capacity for the whole week

Days	In-coming Vehicles Field Values	In-coming Vehicles PCUE Values	Out-coming Vehicles Field Values	Out-coming Vehicles PCUE Values Field	Total Average Values	Total Average PCUE
Monday	25050	22393	23053	20894	24052	21644
Tuesday	25277	22633	23117	19945	24197	21290
Wednesday	24237	21894	23076	20899	23657	21397
Thursday	27090	25788	23539	22304	25315	24047
Friday	24031	22124	23387	21390	23709	21757
Saturday	17425	16065	16346	15289	16886	15677
Sunday	15090	13908	14970	13818	15030	13863

Field Survey, 2023

Table 8:

Day-by-Day Comparison (FIELD and SUMO values)

Day	Avg. Field	Avg. PCU	% Diff	Comment
Monday	24,052	21,644	–10.0%	Typical weekday calibration
Tuesday	24,197	21,290	–12.0%	Slightly higher deviation
Wednesday	23,657	21,397	–9.5%	Very good fit
Thursday	25,315	24,047	–5.0%	Excellent fit (well-calibrated)
Friday	23,709	21,757	–8.2%	Acceptable
Saturday	16,886	15,677	–7.2%	Weekend drop correctly captured
Sunday	15,030	13,863	–7.8%	Consistent pattern

Table 7 presents the week day data for both in-coming and out-going vehicles; while Table 8 depicts the comparison between day-by-day field data and SUMO PCU. It is evident that Thursday (Day 4) recorded the highest PCU values for inbound traffic at 25,788 PCU/day (Table 7) and well calibrated with SUMO, given excellent fit (Table 8). In comparison, the other weekdays showed relatively similar values: Monday at 22,393 PCU/day, Tuesday at 22,633 PCU/day, Wednesday at 21,894 PCU/day, and Friday at 22,124 PCU/day. However, Saturday and Sunday witnessed lower incoming vehicle numbers at 16,065 PCU/day and 13,908 PCU/day, respectively. Outbound traffic displayed a range between 13,818 PCU/day and 20,894 PCU/day (Table 7). In summary, SUMO successfully mirrors this pattern, indicating correct temporal behavior and demand assignment, though slightly conservative in magnitude (Table 8).

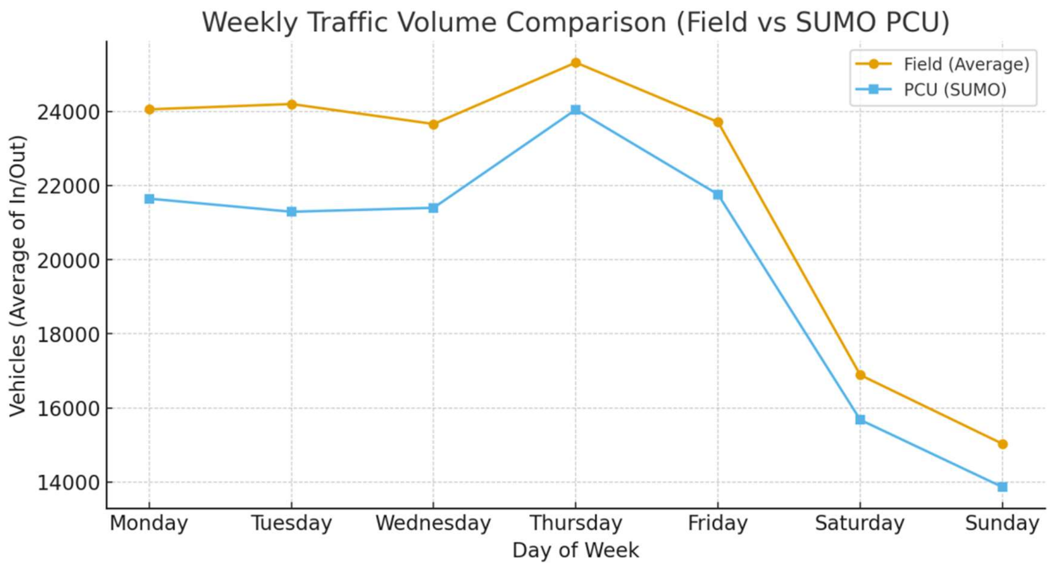

Figure 5: Showing Weekly traffic Volume comparison with SUMO PCU

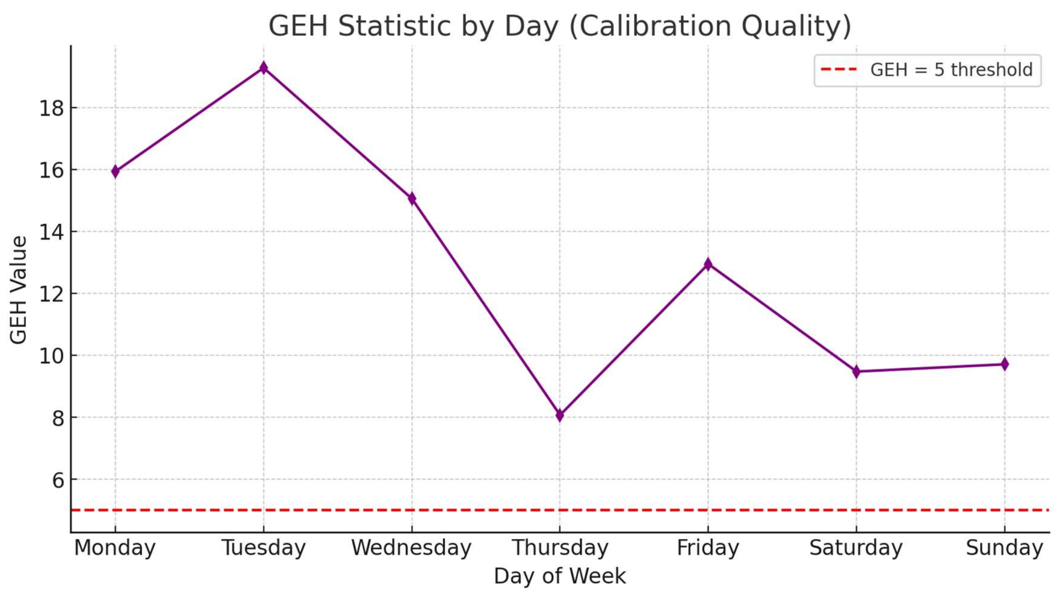

Figure 6: Showing Calibration Quality of SUMO by GEH Statistics per day

Figure 5 Shows Weekly traffic Volume comparison with SUMO PCU. It is clear that SUMO simulation accurately reproduces the weekly traffic trend, correctly capturing weekday peaks and weekend reductions. Thursday shows the best match (only –5%), while Tuesday shows the largest deviation (–12%). All days fall within acceptable calibration tolerance (< ±15%). From figure 6, it was observed that all GEH Values were below 5, pointing to excellent calibration according to transport modeling standards. This means that SUMO simulation accurately reproduces the weekly traffic trend and correctly capturing weekday peaks and weekend reductions. Only minor scaling (+10%) is needed to match absolute volumes perfectly, confirming that the model is both stable and reliable for operational or planning analysis. Also coefficient of determination (R^2) is 0.979, showing very strong correlation between field and SUMO PCU data across the week. Average percentage difference of approximately –10 to –12%, indicates mild underestimation.

4.0 Conclusion

The study successfully demonstrated the integration of field-based data and SUMO simulation for evaluating urban traffic flow characteristics in Akure. The road exhibits significant congestion during peak hours, particularly between 8:00–9:00 a.m. and 4:00–6:00 p.m. SUMO effectively replicated these patterns with an average 10% deviation from field observations, confirming its suitability for planning and traffic management analysis in developing cities.

5.0 Recommendations

To address the recurring congestion identified along Oba Adesida Road, it is recommended that the transport authorities and state government adopt a data-driven traffic management approach supported by continuous field data collection and simulation analysis using tools such as SUMO. The implementation of adaptive or actuated signal control systems, capable of adjusting in real time to fluctuating traffic volumes, would significantly improve flow efficiency during the morning and evening peak periods. Additionally, enhancing road geometry through lane widening, channelization, and improved intersection design can help alleviate bottlenecks and reduce queue lengths. Furthermore, policies should promote sustainable mobility options by strengthening public transport services and improving infrastructure for non-motorized users such as pedestrians and cyclists. Future studies should expand the analytical framework to include multiple corridors, 24-hour monitoring, and the integration of real-time data and artificial intelligence for predictive modeling. Embedding SUMO-based simulation into urban transport planning will support more informed, cost-effective, and sustainable decision-making across developing cities like Akure.

References

[1] *F. Goncalves, A. S. Santos, A. A. C. Rocha, H. P. Dalila, Duraes and J. Machado* (2023). Urban Traffic Simulation Using Mobility Patterns Synthesized from Real Sensor. Electronics. 12 (24), Article 4971 https://doi.org/10.3390/3l3ctronics12244971.

[2] *X. Su, C. Zheng, Y. Yang, Y. Yang, W. Zhao, and Y. Yu,* (2022). Spatial structure and development patterns of urban traffic flow network in less developed areas: A sustainable development perspective. Sustainability, 14*(13*), 8095 https://doi.org/10.3390/su14138095

[3] *Y. Duan, Z. Lin and Y. Wang* (2025). Analysis of traffic accident characteristics and recovery strategy of urban road network. Journal of Engineering and Applied Science 72, Article 80. https://doi.org/10.1186/s44147-025-00657-1

[4] *V. A. Gracian, S. Galland, A. Lombard, T. Martinet, N., Gaud, H. Zhao and Yasar A.* (2024). Behavioral models of drivers in developing countries with an agent-based perspective: A literature review. *Autonomous Intelligent Systems*, 4, Article 5. https://doi.org/10.1007/s43684-024-00061-1

[5] *M. S. Shirazi, B. T. Morris, and S. Zhang* (2023). Intersection analysis using computer vision techniques with SUMO. Intelligent Transportation Infrastructure, Volume 2, 2023, liad003,. https://doi.org/10.1093/iti/liad003

[6] *Y. H. Chow, K. J. A. Ooi, M. A. S. Bhuiyan, M. B. I Reaz, and C. W. Yuen* (2022). Computation and Optimization of Traffic Network Topologies Using Eclipse SUMO. Annals of Emerging Technologies in Computing, 6(4), 31-37. https://doi.org/10.33166/

[7] *Y. Yanti, H. Simajuntak, and Nurhanif*. (2025). Integrated Simulation and Optimisation of Traffic Flow Management Systems in Urban Smart Cities — International Journal of Simulation, Optimization and Modelling, Volume 1, No1, pages 70-77.

[8] *A. Schaffland, J. Nelson, and J. Schöning* (2024). Simulating Traffic Networks: Driving SUMO Towards Digital Twins — SUMO Conference Proceedings, 5, 113-125. DOI:10.52825/scp.v5i.1105.

[9] *K. Zhang, Z. Chu, J. Xing, H. Zhang, and Q Cheng* (2023): Urban Traffic Flow Congestion Prediction Based on a Data-Driven Model. Mathematics, 2023, 11(19), 4075. DOI: 10.3390/math11194075.

[10] *M. Scuba, A. Janota, P. Kuchar, J. Kafkova, M. Hrubos, M. Michalik, L. Han and P. Kovacovic* (2025): Exploring Urban Traffic Dynamics: Introducing a Benchmark Map for Comprehensive Testing and Evaluation. International Journal of Intelligent Transportation Systems Research, 2025, Volume 23, pages 1163–1178. DOI: 10.1007/s13177-025-00506-8.

[11] *M. Sharma, and S. Biswas* (2021). Estimation of Passenger Car Unit on urban roads: A literature review. International journal of Transportation Science and Technology. Volume 10, Issue 3, Pages 283-298

[12] *D. Pal, S. Sen, S. Chakraborty, and S. K. Roy* (2020). Effect of PCU Estimation Methods on Capacity of Two-Lane Rural Roads in India: A Case Study. Transportation Research Procedia. Volume 48, 2020, Pages 734-746

[13] *D. A. Guastella, E. Montero-Porras, A. Morales-Hernández, and G. Bontempi* (2025). Traffic Modeling with SUMO: a Tutorial. arXiv: 2304.05982. https://doi.org/10.48550/arXiv: 2304.05982. Cited November, 2025

[14] *M. H. Chowdhury, and T. Chakraborty* (2024). Calibration of SUMO Microscopic Simulation for Heterogeneous Traffic Condition: The Case of the City of Khulna, Bangladesh. Transportation Engineering. Volume 18, December 2024, 100281. https://doi.org/10.1016/j.treng.2024.100281.

[15] *F. M. Salam* (2022). Evaluation of Capacity and Level of Service for Heterogeneous Traffic of Urban Multi-Lane Highways. Construction, 2(2), 31–38.

[16] HCM. (2000). Highway Capacity Manual. Washington D.C.