International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Characterization of Urban Traffic Flow Patterns around General Santos City Public Market

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Abstract

This study characterizes the traffic flow dynamics of the road network surrounding the General Santos City Public Market, focusing on four key segments: Santiago Boulevard, Acharon Boulevard, Barreras Street, and Magsaysay Avenue. Using continuous video data collection over one week and field-based observations, traffic characteristics such as Hourly Variation, Peak Hour Volume (PHV), Daily Traffic (DT), Average Hourly Traffic (AHT), and Vehicle Composition (VC) were analyzed. Findings reveal that Acharon Boulevard recorded the highest daily traffic volume (55,402 PCU), followed by Santiago Boulevard. Peak congestion occurred between 7:00–11:00 a.m. and 3:00–6:00 p.m.The inner lanes adjacent to the market experience higher traffic volumes than the outer ones. Tricycles constituted the majority of traffic across all segments, averaging 58 percent of total vehicle composition. These results offer essential insights for traffic management strategies and future infrastructure improvements in commercial urban corridors.

Keywords: Daily Traffic, Peak Hour Volume, Traffic Flow, Vehicle Composition

1. Introduction

The movement of people and goods is a fundamental pillar of modern society, and the efficiency of transportation networks directly impacts economic vitality, environmental sustainability, and overall quality of life. As urban populations burgeon and roadway vehicular density intensifies, the challenges of managing traffic flow become increasingly complex [1, 3]. In this context, traffic flow characterization emerges as an indispensable discipline. It provides the foundational data and analytical insights necessary to understand, predict, and ultimately optimize the intricate dynamics of vehicular movement [4]. The importance of this characterization cannot be overstated. Firstly, it forms the empirical bedrock for informed transportation planning and engineering decisions [1, 5]. Without accurate data on existing traffic conditions, any attempt to design new infrastructure, modify existing roadways, or implement traffic management strategies would be based on conjecture rather than evidence. For instance, understanding peak hour volumes and directional splits is crucial for determining the required capacity of a new road or the appropriate lane configurations for an existing one [1]. Similarly, characterizing speed profiles and identifying locations with high-speed variance can highlight safety hazards that require targeted interventions.

Secondly, traffic flow characterization is fundamental to diagnosing and mitigating traffic congestion – one of the most pervasive and costly problems in urban areas worldwide [3]. Congestion leads to increased travel times, fuel consumption, and vehicular emissions, imposing significant economic and environmental burdens [1, 3]. By meticulously characterizing traffic flow, engineers can pinpoint the root causes of congestion, whether they stem from insufficient capacity, poorly timed traffic signals, incidents, or inefficient roadway geometry [2]. This detailed understanding allows for the development and implementation of targeted solutions, such as adaptive signal control systems, incident management programs, or infrastructure upgrades designed to alleviate specific bottlenecks.

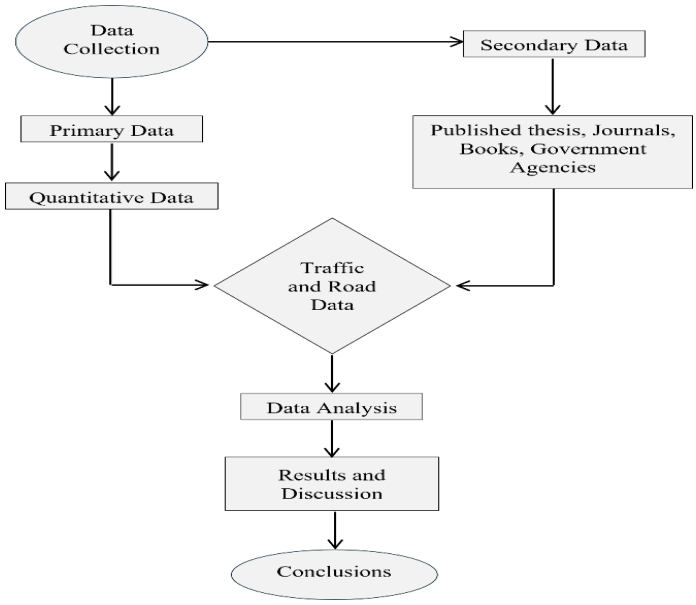
Traffic flow analysis in central business districts is vital for optimizing urban transportation systems. General Santos City, a key economic hub in the southern Philippines, experiences pronounced traffic congestion around its public market. These roadways serve as arteries for commerce and mobility, yet the influx of vehicles during peak hours exacerbates congestion, particularly in the absence of traffic lights and organized loading zones. The current study focuses exclusively on characterizing the traffic flow dynamics within the public market vicinity, with the aim of providing data-driven insights to support congestion mitigation strategies.

2. Methodology

2.1 Research Design

A descriptive research design was used to characterize the traffic flow of the General Santos City Public Market road network. These roads were Santiago Boulevard, Acharon Boulevard, Magsaysay Avenue, and Barreras Street. The study incorporated both primary and secondary data. Primary data encompassed quantitative information, which included (a) traffic survey data such as traffic flow and (b) road data such as segment length, number of lanes, and lane width. Secondary data was gathered from published research, theses, journals, and government agencies, providing valuable inputs to the study. Figure 1 illustrates the flowchart outlining the sequential steps involved in the research methodology.

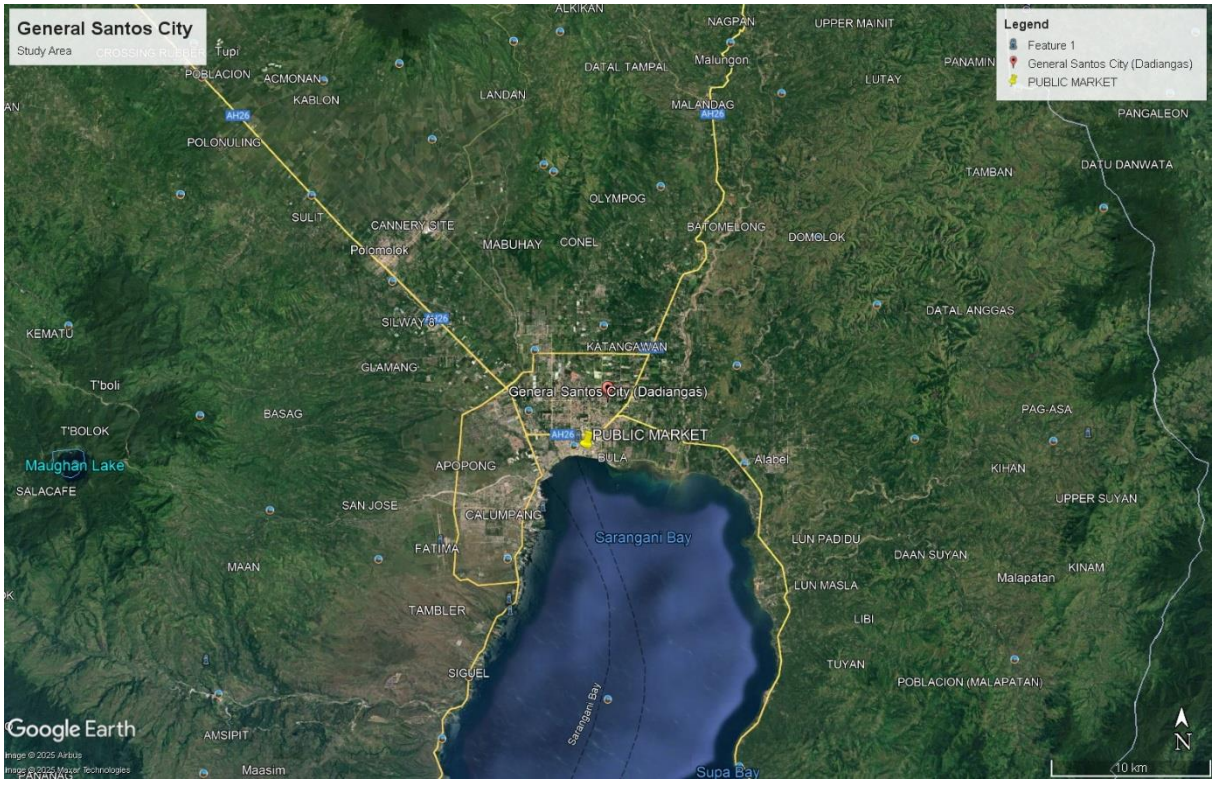
Figure 1: Research Flowchart



2.2 Study Area

General Santos City, located in the southern part of the Philippines at coordinates approximately 6.1164° N latitude and 125.1698° E longitude, is a thriving urban center known as "The Tuna Capital of the Philippines."The study covered four road segments near the General Santos City public market: Santiago Boulevard, Acharon Boulevard, Barreras Street, and Magsaysay Avenue. These roads were selected for their high traffic volumes and proximity to key commercial establishments.

Figure 2: General Santos City Map



2.3 Data Collection

Traffic data were collected continuously over a one-week period, from March 18 to March 23, 2024, using solar-powered 4G-enabled CCTV systems. Although data were captured across all days, Monday's dataset was utilized for detailed peak hour analysis due to its representativeness of typical weekday traffic behavior. Traffic volume was recorded in 15-minute intervals for both directions of each road segment. Vehicle classifications followed Philippine standard Passenger Car Unit (PCU) values. A *trisikad* is a local term for a cycle rickshaw.Figure 4 illustrates the direction of traffic flow (e.g., Mag: E-W denotes the east-to-west direction on Magsaysay Avenue). Figure 5 shows the data collection flowchart.

Primary data were collected from field measurements and video recording. The following data were collected:

1. Traffic data
    i. Traffic volume (in PCU or Passenger Car Unit, as shown in Figure 6)
2. Road Geometric data

i. Carriageway width (12-40m)
ii. Number of lanes (2-6)

Secondary data were collected from Google Earth, published and unpublished journals and research, and government agencies. The following data were collected:

i. Vehicle classification (DPWH D.O. 22, Series of 2013, as shown in Table 1)
ii. Passenger Car Equivalent Factor (DPWH D.O. 22, Series of 2013, as shown in Table 1)
iii. Images (Study area/Vicinity Map) from Google Earth (as shown in Figures 2 to 4)

Figure 3: Public Market Roadblock and Location of CCTV

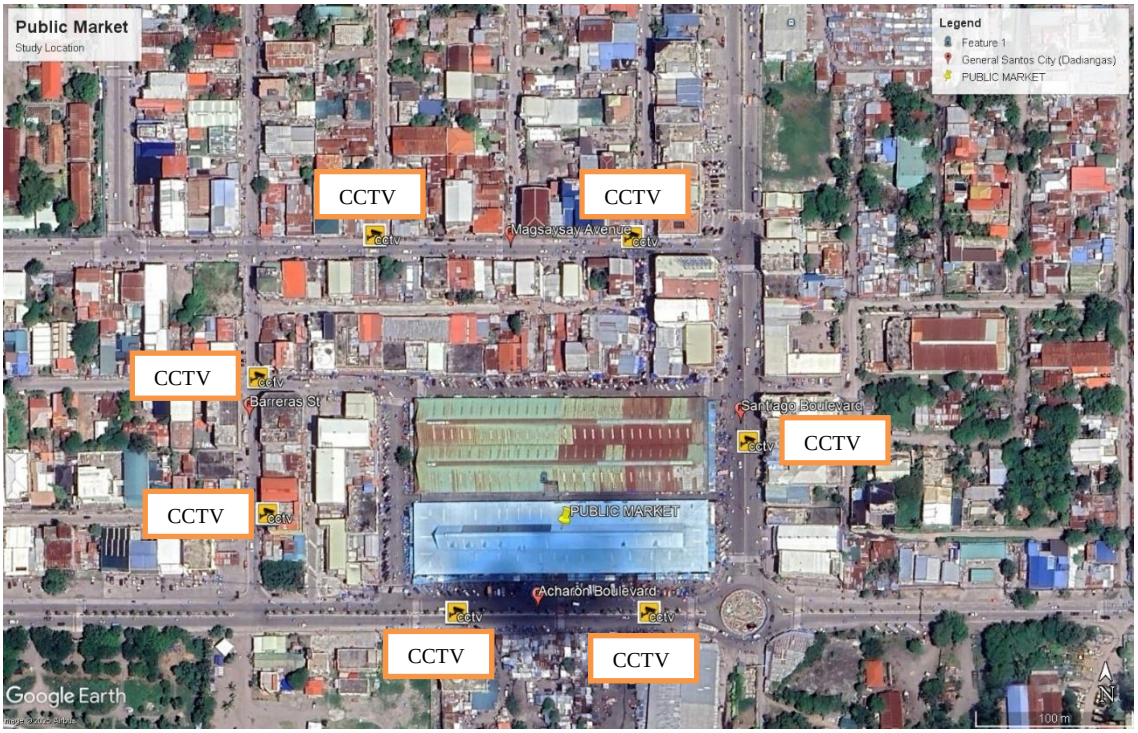


Figure 4. Data Collection Flowchart

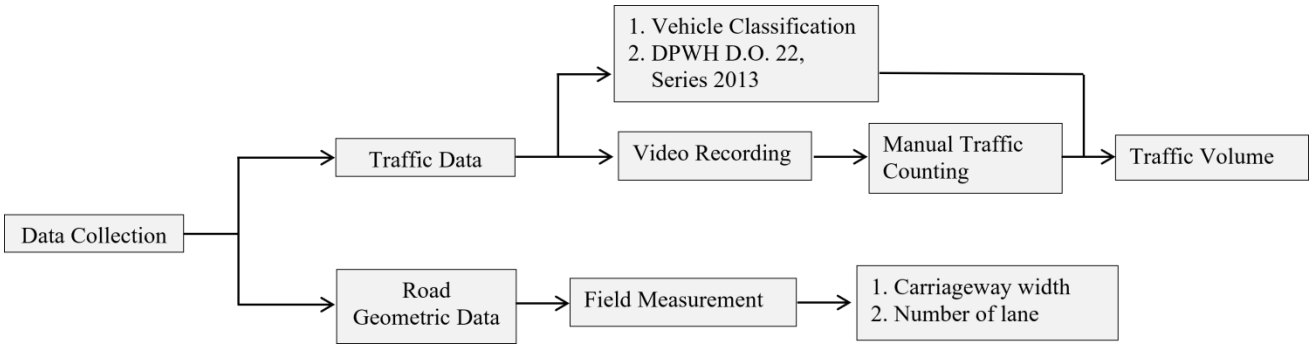


Figure 5: Direction of Traffic Flow

Vehicle classification with their corresponding Passenger Car Equivalent Factor (PCEF) is shown in Table 1.

Table 1. Passenger Car Equivalent Factor (PCEF)

No	Vehicle Classification	PCEF
1	PC (Passenger car)	1
2	Taxi	1
3	PUJ (Public Utility Jeepney)	1.5
4	EJ (Electric Jeepney)	1.5
5	GU (Goods Utility)	1.5
6	SB (Small Bus)	1.5
7	EB (Electric Bus)	1.5

8	LB (Large Bus)	2.0
9	MC (Multicab)	1.5
10	Van	1.5
11	Tricycle	2.5
12	Trisikad	2.5
13	Motorcycle	0.75
14	Bicycle	0.50
15	Rigid truck, 2 axles	2.5
16	Rigid truck, 3+ axles	2.5
17	Truck semi-trailer, 3 and 4 axles	2.5
18	Truck semi-trailer, 5+ axles	2.5
19	Truck trailers, 4 axles	2.5
20	Truck trailers, 5+ axles	2.5

2.4 Analytical Measures

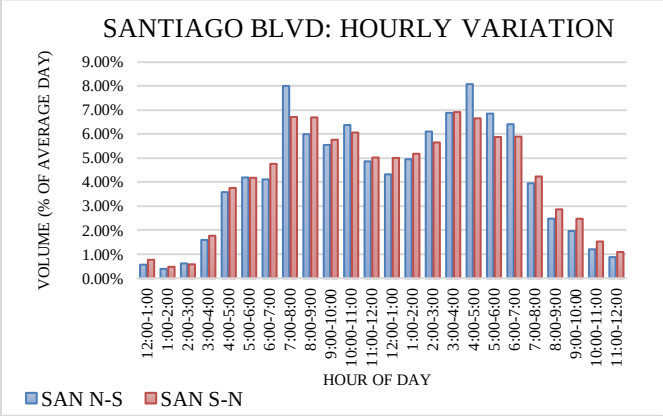
The following traffic flow characteristics [2]as were calculated and will be analyzed descriptively:

- Hourly Variation: Observed fluctuations in volume throughout the day.
- Peak Hour Volume (PHV): Highest observed traffic volume in a one-hour period.
- Daily Traffic (DT): Sum of 24-hour traffic counts.
- Average Hourly Traffic (AHT): DT divided by 24.
- Vehicle Composition (VC): Percentage distribution by vehicle type.

3. Results and Discussions

3.1 Hourly Variation

Figure 6.1 Traffic Flow Hourly Variation (Santiago Boulevard)



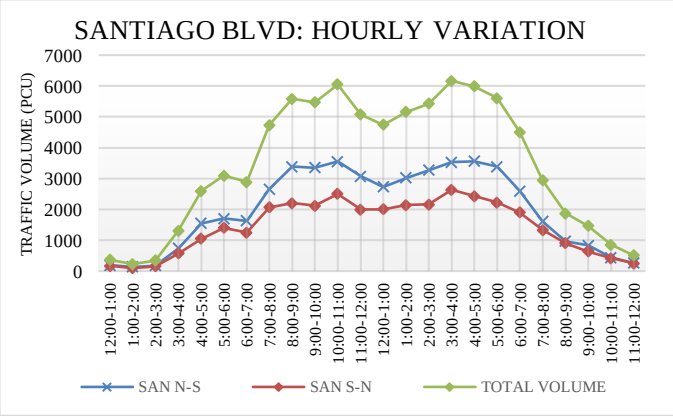
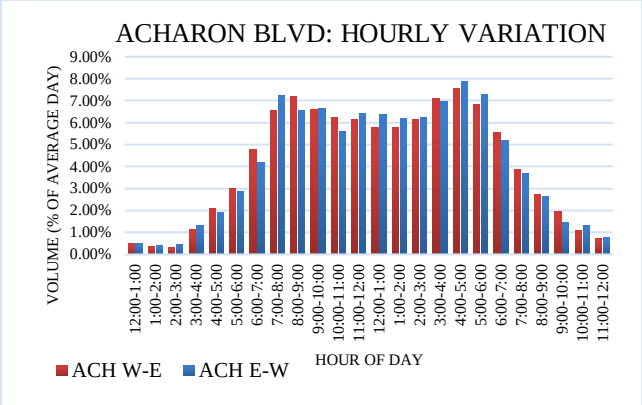


Figure 6.2 Traffic Flow Hourly Variation (Acharon Boulevard)



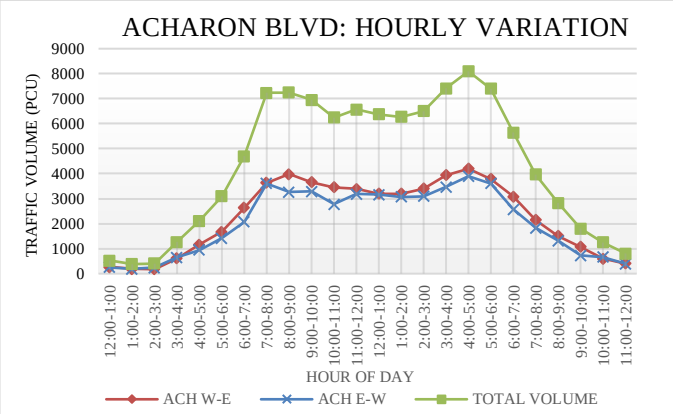
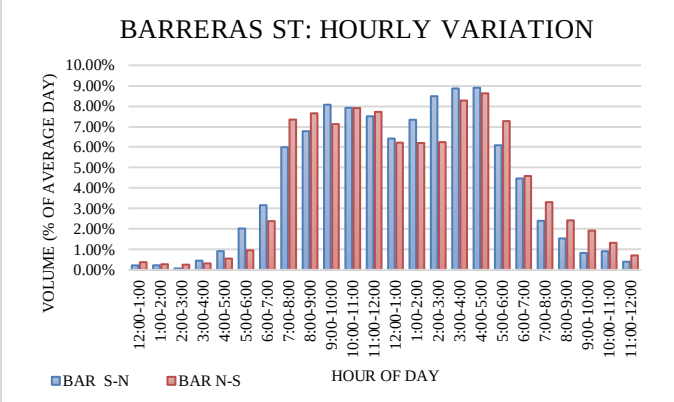


Figure 6.3 Traffic Flow Hourly Variation (Barreras Street)



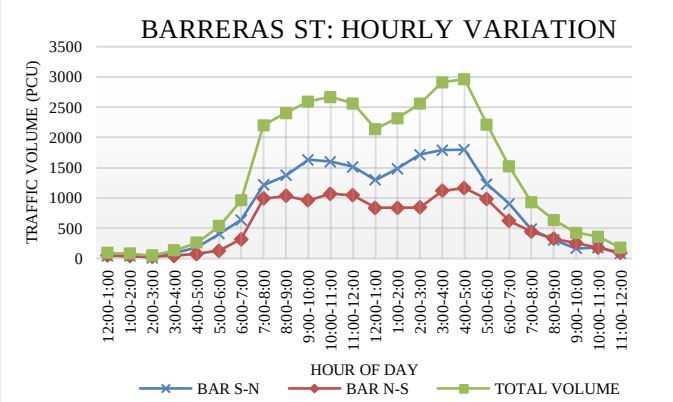
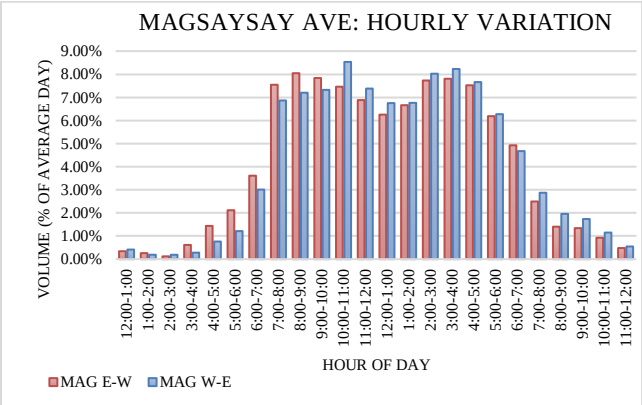


Figure 6.4 Traffic Flow Hourly Variation (Magsaysay Avenue)



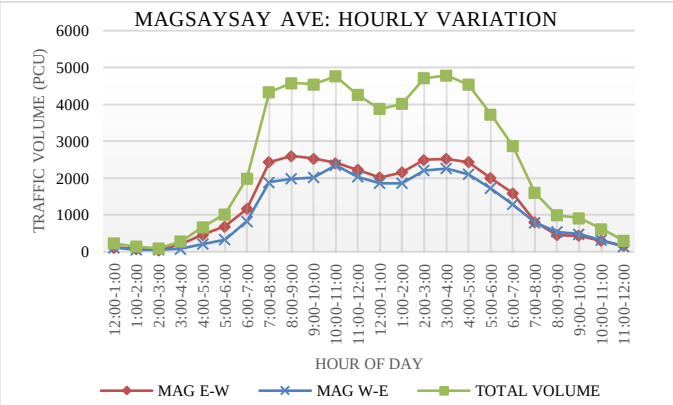
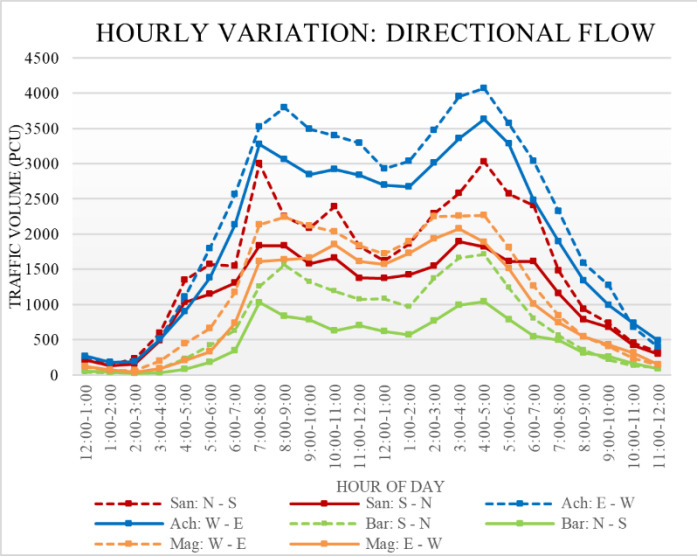
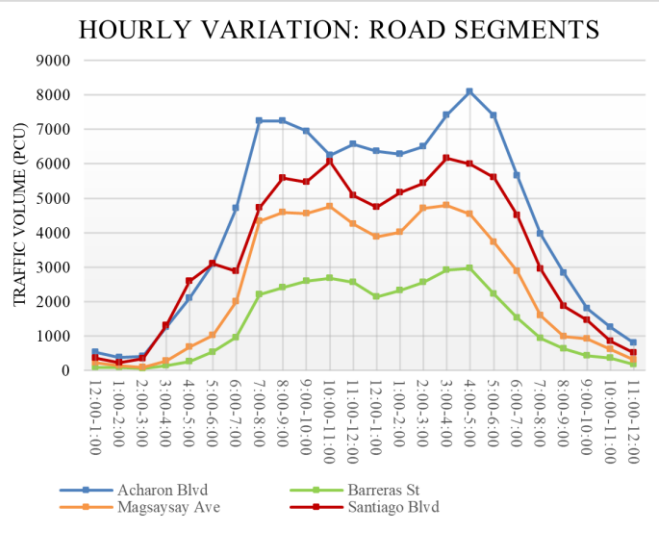


Figure 6.5 Traffic Flow Hourly Variation (Consolidated)





Based on Figures 6.1 to 6.4, fluctuations in traffic volume were observed throughout the day. Peak traffic periods were consistently observed from 7:00 AM to 11:00 AM and again from 3:00 PM to 6:00 PM across all segments. Acharon Boulevard generally exhibited higher traffic volumes compared to other roads, with pronounced peaks during the morning and afternoon rush hours. Santiago Boulevard also showed significant traffic, particularly during peak times. Barreras Street and Magsaysay Avenue had comparatively lower traffic volumes but still followed similar diurnal patterns with morning and afternoon peaks.

Traffic volume on Santiago Boulevard, particularly in the northbound direction (San: N-S), begins to increase as early as 3:00 a.m. due to the early commencement of economic activities along this road. This is due to the early commencement of economic activities in this road. Conversely, traffic volume begins to intensify near Acharon Boulevard's Ach: E - W and Ach: W - E, as well as Santiago Boulevard's San: S-N, around 4:00 a.m. This is due to the presence of vehicles such as tricycles and cargo trucks that transport goods. Starting around 6:00am, there is a significant rise in traffic on the remaining road stretch, namely Magsaysay Avenue and Barreras Street

Figure 6.4 shows a significant increase in traffic flow in all directions at 6:00 a.m., which continues to rise until it reaches its peak in the morning. During this period, individuals such as students, employees, and shoppers started their daily routines by attending school, going to work, and visiting the market. The highest traffic volume for Acharon Boulevard's Ach: E - W occurred in the morning between 8:00 and 9:00 am, whereas for Ach: W - E it occurred between 7:00 and 8:00 am. The traffic congestion on Santiago Boulevard and Magsaysay Avenue occurs from 7:00 to 8:00 am. On Barreras Street, the congestion is observed from 7:00 to 8:00 am for Bar: N - S and from 8:00 to 9:00 am for Bar: S - N. Following the morning peak, traffic flow progressively declined in all directions, with a significant drop observed between 11:00 a.m. and 2:00 p.m.

Table 2: Summary of Traffic Volume per Direction of Flow

Direction of Flow	Traffic Volume	Percentage of Traffic Volume	Rank	Road Segment
SAN: N-S	48,367	16.31%	3rd	Santiago Blvd.
SAN: S-N	34,619	11.78%	4th	Santiago Blvd.
ACH: E - W	55,402	20.87%	1st	Acharon Blvd.
ACH: W - E	49,653	18.38%	2nd	Acharon Blvd.
BAR: S - N	20,207	7.28%	7th	Barreras St.
BAR: N - S	13,506	4.73%	8th	Barreras St.
MAG: W - E	32,317	11.59%	5th	Magsaysay Avenue
MAG: E - W	23,847	9.06%	6th	Barreras St.

Table 2 summarizes the ranking of direction of flow in terms of traffic volume. According to the information provided in Table 2, Acharon Boulevard's Ach: E - W and Ach: W - E had the largest traffic volumes, accounting for 20.87% and 18.38% of the total, respectively. Santiago Boulevard has a traffic volume proportion of 16.31% for San: N-S and 11.78% for San: S-N. Acharon and Santiago Boulevards have a wider carriageway than Magsaysay Avenue and Barreras Street, which explains why they rank higher in traffic volume than the latter roads (ranked 5th-8th). Based on the data presented in Table 4.21, it is evident that San: N-S, Ach: E - W, Bar: S - N, and Mag: W - E have higher traffic volumes compared to their corresponding lanes (San: S-N, Ach: W - E, Bar: N - S, and Mag: E - W).

This indicates that the lane next to the public market experiences a higher level of traffic and is the busiest section, regardless of the presence of establishments and business buildings on the other side, such as Unitop, Dadiangas Sun Trading, and Yap Marketing, among others.

3.2 Daily Traffic (DT), Peak Hour Volume (PHV), and Average Hourly Traffic (AHT)

As presented below in Table 3, Acharon Boulevard recorded the highest daily traffic volume, followed by Santiago Boulevard, Magsaysay Avenue, and Barreras Street. For instance, Acharon Boulevard (East-West) had a daily traffic of 55,402 PCU, and Santiago Boulevard (North-South) had 48,367 PCU.

Peak Hour Volume (PHV) analysis showed two distinct peak periods. The morning peak hours were typically between 7:00 AM and 11:00 AM, while the afternoon peak hours were between 3:00 PM and 5:00 PM. Acharon Boulevard consistently showed the highest PHVs, reaching 3,983 PCU (East-West) in the morning and 4,197 PCU (East-West) in the afternoon. Average Hourly Traffic (AHT) also reflected these trends, with Acharon Boulevard having the highest AHT values, indicating sustained high traffic throughout the operational hours.

Table 3: Traffic Volume Characteristics (DT, PHV, and AHT)

Volume Characteristics	Acharon Boulevard		Barreras Street		Magsaysay Avenue		Santiago Boulevard	
	Ach: E	Ach:	Bar: S	Bar: N	Mag:	Mag: E	San: N-	San: S-

	- W	W - E	- N	- S	W - E	- W	S	N
Daily Traffic (PCU)	55,402	49,653	20,201	13,506	32,317	27,517	48,367	34,619
(a.m) Peak-Hour Volume (PHV)	3,983	3,604	1,632	1,068	2,600	2,348	3,553	2,498
Time	8:00-9:00	7:00-8:00	9:00-10:00	8:00-9:00	8:00-9:00	10:00-11:00	10:00 – 11:00	10:00 – 11:00
(p.m.) Peak-Hour Volume (PHV)	4,197	3,899	1,799	1,165	2,522	2,264	3,557	2,636
Time	4:00-5:00	4:00-5:00	4:00-5:00	4:00-5:00	3:00-4:00	3:00-4:00	4:00-5:00	4:00-5:00
Average Hourly Traffic (AHT)	2,308	2,069	842	563	1,347	1,147	2,015	1,443

3.3 Vehicle Classification

Table 4: Vehicle Type Classification per Direction

Volume Characteristics	Acharon Boule-vard		Barreras Street		Magsaysay Ave-nue		Santiago Boule-vard	
Vehicle Type	**Ach: E - W**	**Ach: W - E**	**Bar: S - N**	**Bar: N - S**	**Mag: W - E**	**Mag: E - W**	**San: N-S**	**San: S-N**
Tricycle	16,580	13,727	6,497	4,083	10,758	8,888	15,631	10,069
Motorcycle	6,880	7,677	1,880	1,562	2,486	2,632	3,239	3,286
Passenger Car	3,195	3,679	1,035	950	1,654	1,549	2,304	2,380
Trisikad	1,181	1,194	366	251	407	321	983	960
Others	1,583	1,750	334	330	571	628	1,330	1,397

Figure 7.1: Vehicle Composition (Santiago Boulevard)

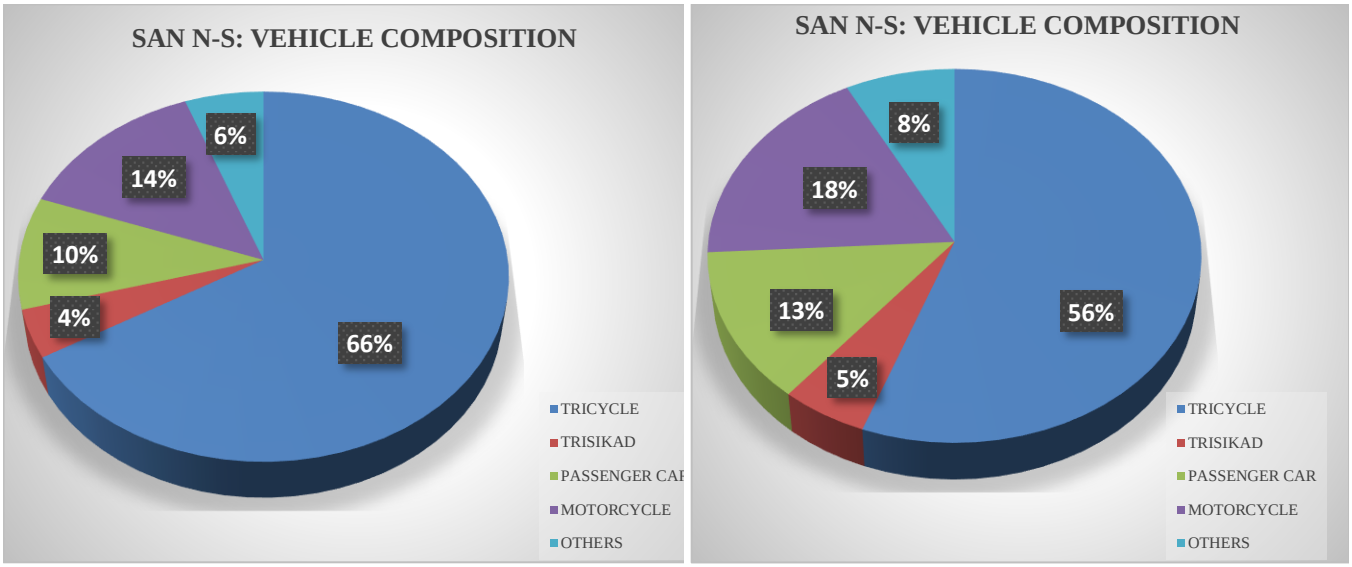


Figure 7.2: Vehicle Composition (Acharon Boulevard)

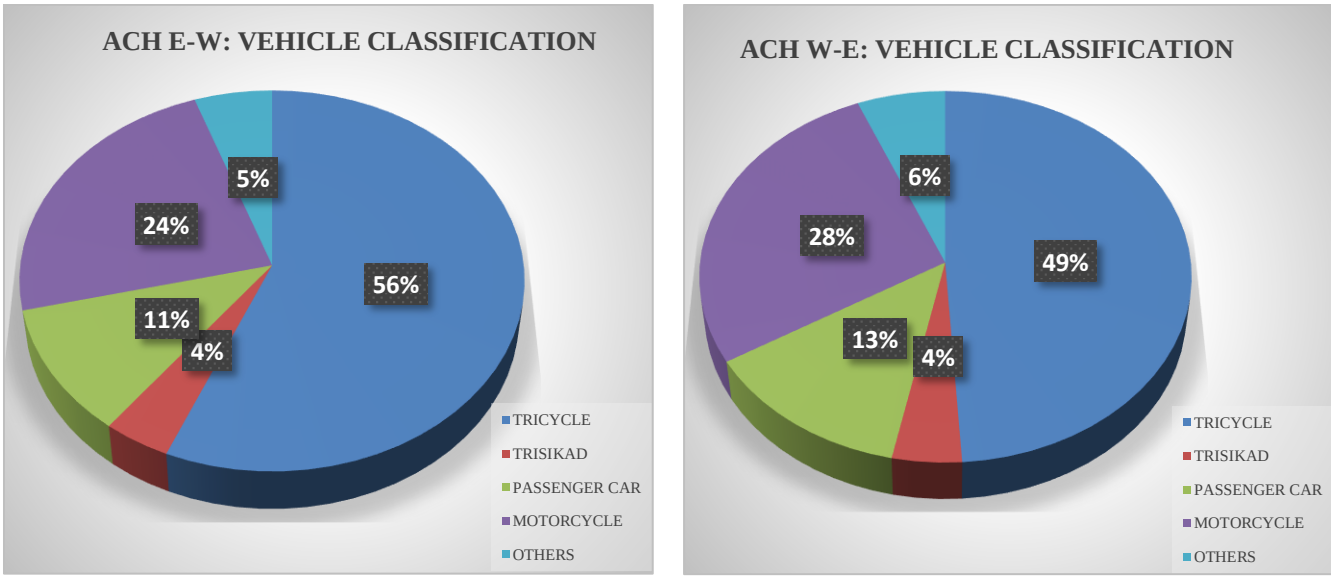


Figure 7.3: Vehicle Composition (Magsaysay Avenue)

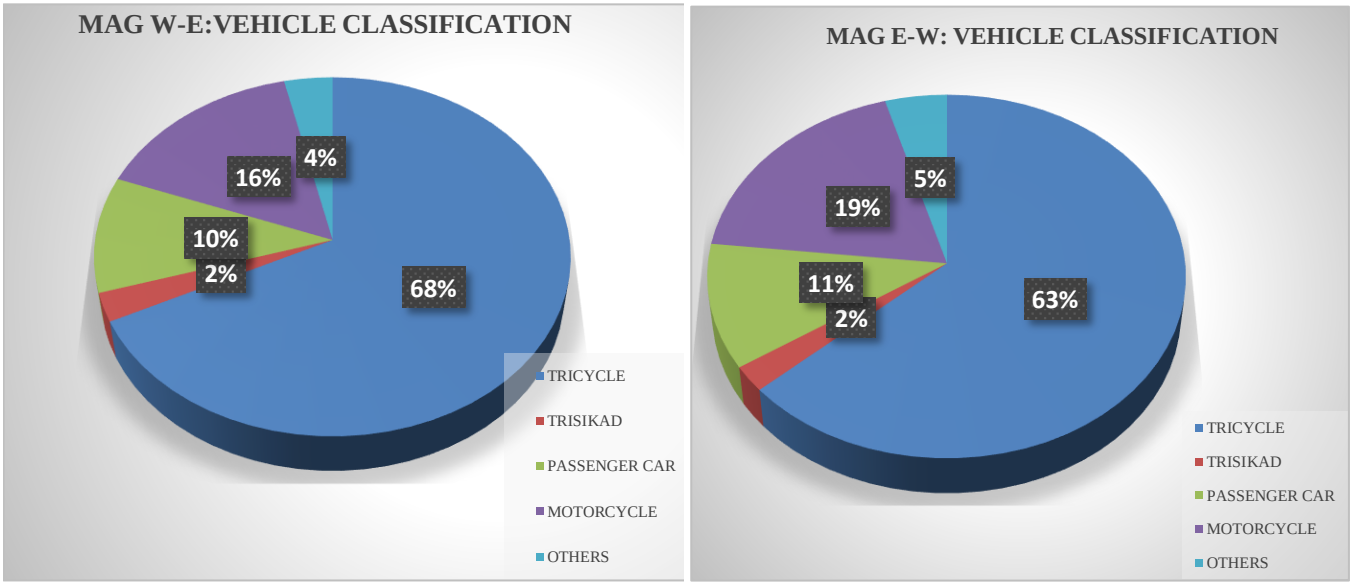


Figure 7.4: Vehicle Composition (Barreras Street)

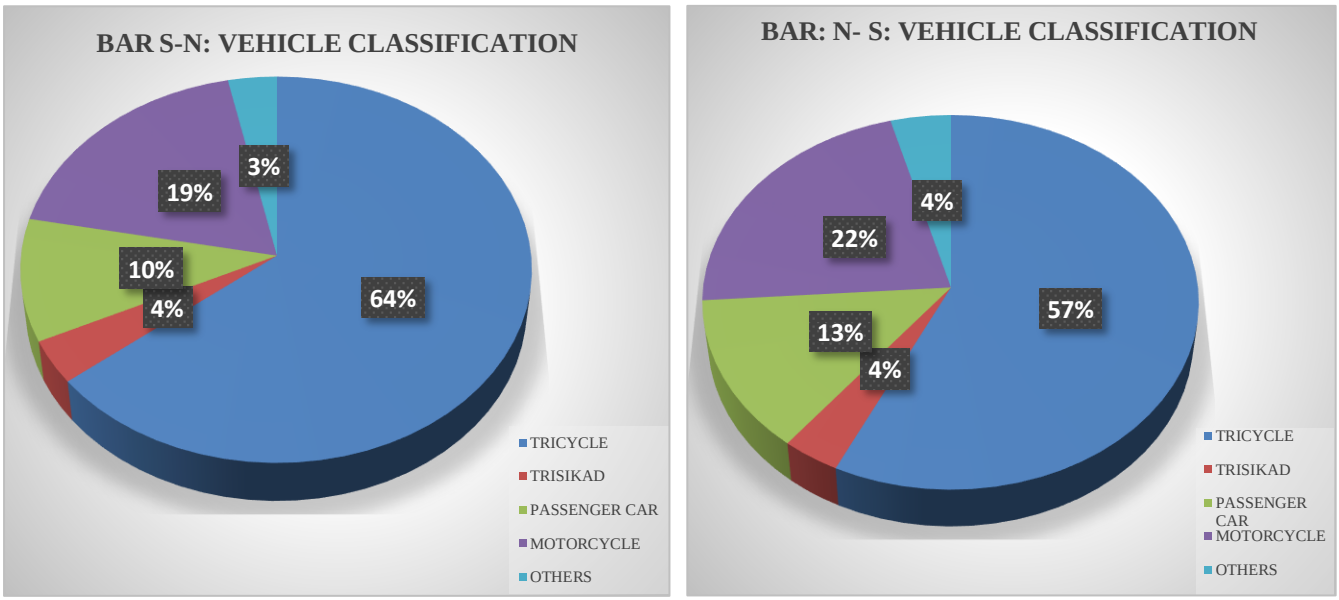
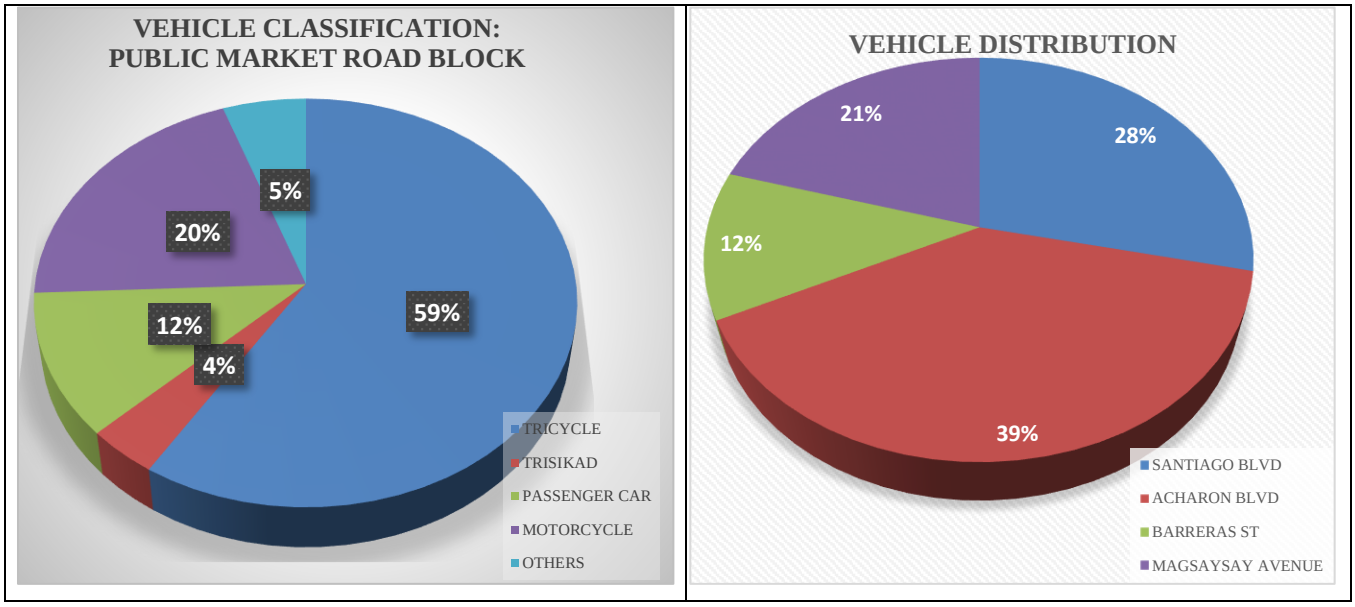


Figure 7.5: Vehicle Composition (Figure 7.5a left side, Figure 7.5b right side)



As presented in Figures 7.1 to 7.4, tricycles were found to be the dominant vehicle type across all studied road segments, making up the largest percentage of the traffic composition. For example, tricycles accounted for 66% of the traffic on Santiago Boulevard (North-South) and 56% on Acharon Boulevard (East-West). Motorcycles were the second most common vehicle type, followed by passenger cars, trisikads, and other vehicle types. This high proportion of tricycles contributes significantly to congestion, given their high passenger car equivalent factor (PCEF) of 2.5.

As seen in Figure 7.5a, the tricycle maintains the highest percentage of daily traffic of any vehicle in the public market road block, accounting for an average of 59%. Subsequently, the breakdown consists of motorcycles (20%), passenger cars (12%), trisikads (4%), and other vehicles (5%). Additional categories of vehicles comprise vans, multicabs, public utility jeeps, e-buses, e-jeeps, bicycles, and trucks. Also in Figure 7.5b, it can be seen in the vehicle distribution Acharon Boulevard has the highest number of vehicles followed by Santiago Boulevard, next Magsaysay Avenue, and lastly Barreras Street.

4. Conclusions

- Traffic flow characteristics around the Public Market vary significantly across different road segments, with inner lanes adjacent to the market experiencing higher traffic volumes compared to outer lanes.
- Traffic volumes begin to rise at different times due to variations in economic activity patterns: Santiago Boulevard (San: N-S): Traffic starts increasing at 3:00 a.m. For Acharon Boulevard (Ach: E-W, Ach: W-E) and Santiago Boulevard (San: S-N), traffic begins to rise around 4:00 a.m.; and Magsaysay Avenue and Barreras Street traffic volumes start increasing at approximately 6:00 a.m.
- The public market road network has an average daily traffic (ADT) of 264,950 Passenger Car Units (PCU), equivalent to 138,088 vehicles.. Acharon Boulevard has the highest average hourly traffic (AHT), followed by Santiago Boulevard, Magsaysay Avenue, and Barreras Street.

- Traffic decreases for all segments around 8:00 p.m. Acharon Boulevard has the highest average daily traffic volume, accounting for 39% of the total, followed by Santiago Boulevard (28%), Magsaysay Avenue (21%), and Barreras Street (12%).
- Peak traffic times at the Public Market are from 8:00 to 9:00 a.m. (6.99% of ADT) and from 4:00 to 5:00 p.m. (7.57% of ADT). The overall busiest periods are from 7:00 to 11:00 a.m. and 3:00 to 6:00 p.m.
- Tricycles constitute the highest proportion of daily traffic at 58%, followed by motorcycles (21%), passenger cars (11%), Trisikad (4%), and other vehicles (6%). Acharon Boulevard has the highest proportion of all vehicle types passing through.

5. Recommendations

5.1 Policy and Infrastructure Recommendations

- Lane Reconfiguration and Functional Zoning

Designate inner lanes adjacent to the public market for loading/unloading and tricycle access during peak hours (7:00–11:00 a.m., 3:00–6:00 p.m.). Maintain outer lanes as continuous through-traffic corridors to reduce intersection interference and vehicle weaving.

- Staggered Scheduling of Economic Activities

Encourage early deliveries (2:00–5:00 a.m.) on Santiago and Acharon Boulevards to prevent overlap with commuter peaks. Schedule deliveries for Magsaysay Avenue and Barreras Street after 6:00 a.m., aligning with their later traffic increase.

- Peak Hour Demand Management

Implement time-based entry restrictions for high-impact vehicle types (e.g., delivery trucks) during the 8:00–9:00 a.m. and 4:00–5:00 p.m. peak hours. Introduce tricycle rotation or quota systems to reduce lane saturation near market entrances.

- Modal Segregation and Geometric Enhancements

Establish tricycle-priority corridors or designated lanes on Acharon Boulevard to improve flow and reduce modal conflicts. Upgrade major intersections with roundabouts or adaptive signals on Santiago and Acharon corridors.

- Intelligent Transport Systems (ITS)

Install real-time traffic counters and CCTV-based analytics to monitor live congestion levels and guide rerouting. Integrate GIS dashboards for LGU decision-making and predictive traffic management.

- Support for Active and Last-Mile Mobility

Improve sidewalks, signage, and crossings, particularly on Magsaysay Avenue and Barreras Street, to support pedestrians and trisikad users. Encourage park-and-ride systems or micro-mobility solutions to reduce inner-core traffic load.

- Long-Term Infrastructure Investment

Widen and improve key segments of Acharon Boulevard to accommodate its 39% traffic share. Establish centralized loading terminals within 250–300 meters of the market to reduce roadside friction.

5.2 Future Research Directions

- Traffic Congestion Indexing and Level of Service (LOS) Evaluation

Future research should quantify traffic congestion severity using indices such as Volume-to-Capacity Ratio (V/C), Travel Time Index (TTI), and Delay Cost Estimation to provide more actionable congestion metrics for each segment.

- Traffic Flow Modelling and Simulation

Researchers are encouraged to use simulation software (e.g., VISSIM, SIDRA, SUMO) to model existing traffic dynamics and test interventions such as lane additions, signal controls, or one-way conversions. Simulations can help anticipate impacts under varying traffic growth scenarios.

- Road User Perception Surveys

Conduct structured surveys among drivers, commuters, and business owners to gather insights on perceived congestion causes, mobility challenges, and openness to potential solutions such as pedestrianization, time-based restrictions, or fare reform. Such qualitative data complements technical metrics with social perspectives.

- Weekend and Seasonal Flow Characterization

Since the present study is limited to weekday data, additional studies should focus on weekend and holiday traffic to account for market-related variability and leisure travel surges.

- Environmental Impact Assessment

Assess the impact of traffic congestion on air quality, noise pollution, and emissions in the market vicinity, especially given the high density of low-emission but slow-moving tricycles and motorcycles.

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