

Mitigating Urban Traffic Congestion: A Comprehensive Evaluation of Infrastructure Strategies in Selected Barangays of Daraga, Albay

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ABSTRACT

This study investigated the effectiveness of infrastructure strategies in mitigating urban traffic congestion in Daraga, Albay. Employing a descriptive-correlational research design, the study examined the current traffic conditions, infrastructure improvements, and commuter experiences. A mixed-methods approach, combining quantitative surveys and qualitative interviews, was used to collect data from a representative sample of commuters, business owners, traffic enforcers, and transport operators. Key infrastructure strategies analyzed included road network enhancements, public transit improvements, active transportation facilities, and urban planning policies. The findings revealed that infrastructure strategies, particularly urban planning measures, played a significant role in reducing congestion, with respondents showing high satisfaction with public transit improvements and active transportation options. However, road network expansions were perceived as a temporary solution due to induced demand. The study also identified significant relationships between demographic factors such as sex, marital status, and commuting frequency, which influenced perceptions of congestion. Statistical analyses, including regression and correlation tests, demonstrated that a combination of infrastructure strategies and policy measures was essential for long-term traffic decongestion. The study concluded that comprehensive urban planning, including integrated land-use policies, improved public transportation, and active mobility infrastructure, is crucial in addressing urban traffic congestion. These findings provide actionable recommendations for policymakers and urban planners to develop more sustainable and efficient urban mobility systems.

Keywords: *Active Transportation, Congestion Mitigation, Infrastructure Strategies, Public Transit, Road Network, Urban Planning*

INTRODUCTION

Traffic congestion had become a pressing issue in urban areas, significantly affecting transportation efficiency, economic productivity, and environmental sustainability. According to Mendoza et al. (2021), inadequate road infrastructure and poor traffic management had contributed significantly to congestion. In addition, rapid urbanization and increasing vehicle ownership had exacerbated gridlocks, making daily commutes even more time-consuming (Garcia & Santos, 2022). Sustainable urban transport planning had proven to be essential in alleviating congestion and enhancing mobility. Effective infrastructure strategies were found to improve traffic flow, making urban environments more livable for residents.

Infrastructure development had played a critical role in managing traffic congestion and promoting sustainable urban mobility. Road network enhancements, such as widening roads and improving intersections, had been shown to reduce travel delays (Lopez & Rivera, 2023). Public transit improvements, including the introduction of bus rapid transit and railway expansions, had encouraged

people to shift from private vehicles to public transportation (Hernandez et al., 2021). Additionally, integrating non-motorized transport facilities, such as pedestrian walkways and bike lanes, had fostered a safer and more inclusive transport system (Diaz & Cruz, 2022). These strategies had collectively contributed to reducing urban congestion over time.

The environmental and economic impacts of traffic congestion had been substantial, underscoring the need for immediate policy interventions. Studies had indicated that congestion increased fuel consumption, emissions, and financial losses due to wasted time and productivity (Reyes & Tan, 2020). Congested roads had also affected the reliability of public transportation, making it less attractive to commuters (Villanueva & Torres, 2023). Green infrastructure solutions, such as smart traffic systems and eco-friendly transport modes, had shown promise in mitigating these harmful effects. Policies encouraging carpooling and ride-sharing had further eased congestion pressures (Santos & Mercado, 2021). A multi-faceted approach had been deemed necessary to achieve long-term traffic decongestion.

A comprehensive evaluation of infrastructure strategies had been essential to identifying sustainable solutions for urban traffic congestion. The study aimed to assess the effectiveness of various interventions and their impact on traffic performance, environmental sustainability, and the commuter experience. It sought to provide actionable recommendations for local government units by analyzing urban planning measures and policy frameworks. The findings were expected to contribute to the development of strategic transport policies that could enhance mobility and economic resilience (Ramirez & Gutierrez, 2022). Addressing urban congestion had required coordinated efforts between policymakers, urban planners, and various stakeholders to develop effective, long-lasting solutions.

LITERATURE REVIEW

Traffic congestion has been a persistent issue in urban areas, significantly affecting transportation systems, environmental quality, and economic productivity. Numerous studies have identified a variety of factors contributing to urban traffic congestion. Martinez and Cruz (2021) argue that congestion arises from the imbalance between road capacity and the number of vehicles, which leads to slower travel speeds and delays. This issue has worsened due to rapid urbanization and increasing vehicle ownership, particularly in metropolitan areas where infrastructure development has struggled to keep pace with demand (Gonzalez & Rivera, 2022). Moreover, congestion is compounded by poorly designed road networks and a lack of efficient traffic management systems (Fernandez & Lim, 2020). Hernandez and Diaz (2022) further highlight that inadequate public transportation systems and heavy reliance on private vehicles exacerbate congestion, especially in cities with limited transit alternatives.

In addition to infrastructure shortcomings, environmental and economic costs associated with traffic congestion are substantial. Lopez and Santos (2023) emphasize that congestion leads to reduced fuel efficiency and increased carbon emissions, which contribute to environmental degradation and climate change. Moreover, the economic implications of congestion are severe, as lost work hours due to traffic delays translate into billions of dollars in productivity losses annually (Rodriguez & Brown, 2022). Additionally, prolonged exposure to vehicular emissions has been linked to respiratory and cardiovascular diseases, making congestion a significant public health concern (Smith & Gonzalez, 2022). Thus, mitigating congestion is not only crucial for improving traffic flow but also for addressing the broader health and environmental impacts.

A key strategy for alleviating congestion is improving urban transport planning and integrating public transportation systems with road infrastructure. Studies have shown that cities with robust transport planning, including well-coordinated land-use and transportation policies, experience fewer congestion-related problems (Reyes & Tan, 2021). Furthermore, investments in public transit infrastructure, such as bus rapid transit (BRT) and railway expansions, have proven effective in

reducing congestion by encouraging people to shift from private vehicles to public transportation (Rodriguez & Brown, 2023). Public transport systems also benefit from dedicated lanes and transit-priority measures, which help avoid delays caused by general traffic (Williams & Carter, 2021). The electrification of public transportation fleets, including buses and trams, is another sustainable solution that can reduce traffic-induced emissions and improve air quality (Fernandez & Tanaka, 2023).

Active transportation infrastructure, such as pedestrian walkways and bicycle lanes, also plays a vital role in reducing urban congestion. Research shows that cities investing in cycling networks and pedestrian-friendly infrastructure experience significant reductions in vehicular congestion and improved air quality (Anderson & Becker, 2023). These investments not only promote sustainable mobility but also improve urban livability by reducing car dependency and fostering healthier lifestyles (Rodriguez & Patel, 2023). Moreover, the promotion of bicycle-sharing programs and the integration of cycling infrastructure into public transit systems further support alternative commuting options and help alleviate road congestion (Nguyen & Park, 2023).

In addition to infrastructure improvements, innovative technological solutions, such as intelligent transportation systems (ITS), are increasingly being used to optimize traffic flow and reduce congestion. Real-time traffic monitoring, adaptive signal control, and data analytics are essential tools for identifying congestion hotspots and managing traffic demand (Martinez & Rivera, 2023). Implementing ITS technologies helps improve the efficiency of road networks by adjusting traffic signal timings based on current conditions, thereby reducing congestion and emissions (Li & Thompson, 2023). The integration of digital technologies into traffic management systems is crucial for modernizing transportation infrastructure and ensuring sustainable urban mobility (Nelson & Park, 2021).

Addressing the complex issue of traffic congestion requires coordinated efforts from policymakers, urban planners, and transportation agencies. A multi-faceted approach that combines infrastructure enhancements, technological innovations, and behavioral interventions is essential for achieving long-term congestion mitigation (Rodriguez & Brown, 2023). Policies such as congestion pricing, carpooling incentives, and the promotion of active transportation can help reduce road demand and encourage more sustainable commuting practices (Li & Thompson, 2023). Moreover, comprehensive urban planning that integrates sustainable land-use practices with transport systems is critical for reducing congestion and improving overall urban mobility (Gomez & Patel, 2023). As cities continue to grow, the need for integrated, sustainable solutions to urban congestion will only increase, requiring ongoing research and collaboration to develop effective strategies for the future.

In conclusion, the growing issue of urban traffic congestion requires a comprehensive approach that addresses both immediate traffic management needs and long-term infrastructure development. A combination of improved public transportation, active transportation infrastructure, and technological innovations is essential for creating more sustainable and efficient urban mobility systems. Moreover, policymakers must continue to develop and implement strategies that prioritize both environmental sustainability and economic productivity while improving quality of life for urban residents.

MATERIALS & METHODS

This study employed a descriptive-correlational research design to assess the effectiveness of infrastructure strategies in mitigating urban traffic congestion. The descriptive aspect of the research provided a detailed account of current traffic conditions, infrastructure improvements, and commuter experiences in selected barangays. The correlational design was used to explore the relationships between traffic congestion levels and various infrastructure strategies, allowing the researcher to determine how infrastructure developments influenced urban mobility and congestion. A combination

of quantitative and qualitative methods was utilized to gather comprehensive data. Quantitative data was obtained through survey questionnaires, which were distributed to a randomly selected sample of residents and stakeholders, while qualitative data was gathered through interviews and observations with key figures such as traffic enforcers, transport authorities, and local planners. This mixed-methods approach ensured a well-rounded understanding of the factors contributing to urban congestion and the effectiveness of the strategies in place.

The study was conducted in three barangays in Daraga, Albay: Bagumbayan, Sagpon, and Market Area Poblacion. These areas were selected due to their high population density, significant commercial activities, and ongoing traffic congestion problems. A cross-sectional research approach was used, collecting data at a specific point in time to capture a snapshot of the traffic conditions and infrastructure impacts in these areas. Random sampling was employed to select respondents from each barangay, ensuring equal representation and minimizing bias. The sample size was calculated using the Raosoft Sample Size Calculator, with a 95% confidence level and a 5% margin of error, resulting in 351 respondents from Bagumbayan, 357 from Sagpon, and 342 from Market Area Poblacion. Respondents included commuters, business owners, traffic enforcers, and transport operators, ensuring a diverse perspective on the impact of traffic congestion and infrastructure strategies.

Data collection was conducted through both physical and online surveys, ensuring accessibility for all respondents. The surveys were distributed by trained enumerators who provided necessary clarification to respondents when needed. Prior to full implementation, the research instrument was pilot-tested to assess clarity and reliability. The instrument was adapted from previously validated questionnaires and reviewed by urban transport specialists to ensure its relevance. The data gathered was then analyzed using descriptive and inferential statistical methods. Descriptive statistics provided an overview of traffic conditions and infrastructure satisfaction, while inferential statistics, including Pearson correlation and one-way ANOVA tests, examined the relationships between infrastructure strategies and traffic congestion levels. Multiple regression analysis was also conducted to determine the key factors influencing congestion. The study adhered to ethical guidelines, ensuring informed consent, confidentiality, and voluntary participation from all respondents.

RESULTS AND DISCUSSION

1. What is the demographic profile of the respondents in terms of:

- 1.1. Age;**
- 1.2. Sex;**
- 1.3. Marital Status;**
- 1.4. Occupation; and**
- 1.5. Frequency of Commuting?**

Table 1 shows the frequency and percentage distribution of the demographic profile of respondents in terms of age. The data reveal that the majority of respondents fall within the age group of 18 to 25 years old (39.4%), followed by those aged 26 to 35 (22.9%) and 36 to 45 (20.6%). The lowest representation comes from individuals aged 56 and above, constituting only 6% of the sample. This indicates that a substantial portion of the commuting public in the area is relatively young and likely to be students or early-career professionals. These findings suggest that younger populations may depend more on commuting, possibly due to school or entry-level employment. Such demographic concentration may influence the formulation of youth-centered urban mobility programs. Transportation planners must consider this age group's commuting frequency and habits when designing routes and transit schedules. According to Nguyen et al. (2022), young adults are highly responsive to public transport enhancements and urban mobility shifts.

Table 1
The Frequency and Percentage Distribution of the Demographic Profile of Respondents in terms of Age

Age	Frequency	Percentage
18 to 25 years old	414	39.4
26 to 35 years old	240	22.9
36 to 45 years old	216	20.6
46 to 55 years old	117	11.1
56 years old and above	63	6.0
Total	1050	100

Table 2 shows the frequency and percentage distribution of the demographic profile of respondents by sex. Most respondents are female (51.4%), followed by male respondents (35.1%), while 13.4% preferred not to disclose their gender. The dominance of female respondents in the commuting population highlights the need for gender-sensitive transportation policies. This could include enhanced safety measures, well-lit waiting areas, and more secure transportation modes. The relatively high number of respondents preferring not to disclose their sex also indicates the importance of inclusive and non-discriminatory transportation environments. Transportation accessibility must be universal, ensuring that all individuals—regardless of gender identification—feel secure. Prior research by Borkowski et al. (2021) emphasized the role of gender-sensitive planning in improving satisfaction with public transit systems. These considerations should influence transport policy to encourage higher ridership.

Table 2
The Frequency and Percentage Distribution of the Demographic Profile of Respondents in terms of Sex

Sex	Frequency	Percentage
Male	369	35.1
Female	540	51.4
Prefer not to say	141	13.4
Total	1050	100

Table 3 presents the frequency and percentage distribution of the demographic profile of respondents by marital status. The data indicate that most respondents are single (52.7%), followed by married individuals (36.1%), with the remaining widowed or separated. The dominance of single respondents implies that many of the commuting population likely have fewer domestic obligations, allowing more flexible commuting hours. Married individuals may exhibit different travel behaviors, possibly involving family-based commuting or carpooling.

Table 3
The Frequency and Percentage Distribution of the Demographic Profile of Respondents in terms of Marital Status

Marital Status	Frequency	Percentage
Single	553	52.7
Married	379	36.1
Widowed	47	4.5
Separated	71	6.8
Total	1050	100

Meanwhile, widowed and separated individuals may require special consideration for mobility and accessibility services. Urban transportation planning must consider the diversity in lifestyle and domestic responsibilities reflected in these profiles. Pojani and Stead (2020) noted that demographic characteristics significantly shape commuting patterns and the responsiveness of transport policy. This further highlights the relevance of segmenting mobility services based on life circumstances.

Table 4 shows the frequency and percentage distribution of the demographic profile of respondents in terms of occupation. Among the 1050 respondents, students represent the largest group (28.7%), followed by government employees (25.4%) and private employees (20.9%). This result reflects a diverse educational, private, and public commuter base. The high student participation underscores the need for affordable and student-friendly transit systems. Meanwhile, the sizable share of government and private employees highlights the importance of timely and reliable public transport services for working individuals. This occupational diversity suggests the need for segmented approaches in transport planning. Tomic and Bego (2021) assert that occupational status significantly influences travel mode choices and commuter satisfaction. These findings emphasize tailoring mobility solutions to varying employment categories.

Table 4
The Frequency and Percentage Distribution of the Demographic Profile of Respondents in terms of Occupation

Occupation	Frequency	Percentage
Student	301	28.7
Private Employee	219	20.9
Government Employee	267	25.4
Self-Employed	176	16.8
Unemployed	86	8.2
Total	1050	100

Table 5 shows the frequency and percentage distribution of the demographic profile of respondents in terms of commuting frequency. Most respondents (38.3%) commute daily, while 27.7% commute occasionally and 20.2% rarely commute. A smaller portion (13.7%) commutes multiple times a day. This commuting pattern suggests that most respondents are engaged in routine activities such as school or work that require consistent transportation access. The presence of daily and multiple-time commuters highlights the urgency for efficient, punctual, and high-frequency transit options. Occasional commuters may also benefit from flexible fare schemes or on-demand services. These findings underscore the varying demands on transport infrastructure. According to Rojas-Rueda et al. (2021), understanding commuting frequency is essential for predicting congestion patterns and optimizing service allocation. Therefore, frequency-based segmentation must be integrated into mobility planning.

Table 5
The Frequency and Percentage Distribution of the Demographic Profile of Respondents in terms of Frequency of Commuting

Frequency of Commuting	Frequency	Percentage
Rarely (1 to 2 times a week)	212	20.2
Occasionally (3 to 4 times a week)	291	27.7
Daily (5 to 7 times a week)	402	38.3
Multiple times a day	144	13.7
Total	1050	100

2. How do different infrastructure strategies contribute to urban traffic congestion, particularly in terms of:

- 2.1. Road network enhancements;**
- 2.2. Public transit infrastructure improvements;**
- 2.3. Active transportation facilities; and**
- 2.4. Urban planning and policy measures?**

Table 6 presents the different infrastructure strategies that contributed to urban traffic congestion in terms of road network enhancements. The overall mean of 3.32 and standard deviation of 0.73 indicate that respondents strongly agree and are very satisfied with the contribution of road network enhancements to mitigating traffic congestion. This suggests that the public acknowledges the relevance of expanding and maintaining roads in easing urban mobility. The consistency in perception, as shown by the standard deviation, implies broad-based satisfaction. These results reinforce the importance of strategic road expansion in traffic management plans. Infrastructure strategies should thus focus on improving not just quantity but also the quality of road networks. According to Givoni and Macmillen (2020), road capacity improvements can delay but not completely solve congestion without complementary transport policies.

The indicator “Traffic congestion worsens due to poor road maintenance” received the highest mean of 3.40 with a standard deviation of 0.74, showing strong agreement and high satisfaction. Respondents view maintenance as a vital element in managing congestion. Poor road upkeep may lead to bottlenecks, vehicle damage, and increased travel time. This finding underlines that enhancing infrastructure is not solely about expansion but also ensuring longevity and functionality. Regular maintenance thus directly correlates with congestion relief. Ghafouri et al. (2022) emphasize that a lack of road maintenance deteriorates driving conditions, leading to systemic congestion over time.

The lowest mean was recorded under “Expanding roads and highways effectively reduces congestion,” with a mean of 3.25 and a standard deviation of 0.75. While still rated as “Agree,” this suggests slight skepticism among respondents about the long-term effect of road expansion. It reflects growing awareness that road widening might induce more vehicle use over time, leading to induced demand. Respondents may perceive it as a temporary fix rather than a sustainable strategy. This insight can guide urban planners to integrate road expansion with complementary policies like congestion pricing. Duranton and Turner (2021) confirmed that new road space often leads to proportional increases in traffic, known as the “Fundamental Law of Road Congestion.”

Table 6
The Different Infrastructure Strategies Contributed to Urban Traffic Congestion in terms of Road Network Enhancements

Indicators	Mean	Std. Deviation	Response	Interpretation
Expanding roads and highways effectively reduces congestion.	3.25	0.75	Agree	Satisfied
Road widening projects improve traffic flow in urban areas.	3.29	0.71	Strongly Agree	Very Satisfied
The construction of new roads leads to long-term traffic relief.	3.34	0.70	Strongly Agree	Very Satisfied
Traffic congestion worsens due to poor road maintenance.	3.40	0.74	Strongly Agree	Very Satisfied
Road expansions encourage higher vehicle use, increasing congestion in the long run.	3.31	0.76	Strongly Agree	Very Satisfied
Overall	3.32	0.73	Strongly Agree	Very Satisfied

Legend: 1.00-1.75 Strongly Disagree(Dissatisfied), 1.76-2.50 Disagree(Neutral), 2.51-3.25 Agree(Satisfied), and 3.26-4.00 Strongly Agree(Very Satisfied)

Table 7 presents the different infrastructure strategies that contributed to urban traffic congestion in terms of public transit infrastructure improvements. The overall mean of 3.32 and standard deviation of 0.73 suggest strong agreement and high satisfaction regarding the importance of public transit infrastructure improvements. Respondents believe investing in reliable and integrated public transit networks helps mitigate traffic congestion. The uniformity in responses signifies a consensus on the effectiveness of these improvements. Efficient public transit provides alternatives to private vehicle use, easing pressure on road networks. This finding supports policy directions that prioritize mass transportation. Ewing and Hamidi (2021) state that robust public transit correlates with lower urban congestion and enhanced mobility outcomes.

The highest-rated item, “Poor integration of different transit systems worsens congestion,” received a mean of 3.41 and a standard deviation of 0.69. This strong agreement highlights the critical need for synchronized operations among different modes of public transport. Fragmented systems reduce accessibility and convenience, forcing people to use private vehicles. Integrating buses, trains, and BRT can significantly increase efficiency and user satisfaction. It also ensures optimized routes and schedules. Guo et al. (2020) argue that multimodal integration enhances urban mobility by reducing transfer times and boosting public transport reliability.

The lowest mean value was “Investing in public transportation reduces private vehicle dependence,” with a mean of 3.19 and a standard deviation of 0.75. Though respondents agreed, the lower score suggests moderate uncertainty or slower perceived results. This may reflect limitations in current public transit investments or gaps in last-mile connectivity. While investment is crucial, it must be complemented by behavior change campaigns and incentives. The relatively higher standard deviation points to a variance in user experiences. As Abdullah et al. (2021) pointed out, without affordability and accessibility, public transport investments may not lead to immediate shifts in vehicle dependency.

Table 7

The Different Infrastructure Strategies Contributed to Urban Traffic Congestion in terms of Public Transit Infrastructure Improvements

Indicators	Mean	Std. Deviation	Response	Interpretation
Investing in public transportation reduces private vehicle dependence.	3.19	0.75	Agree	Satisfied
The availability of efficient bus and train systems lessens congestion.	3.35	0.74	Strongly Agree	Very Satisfied
Limited public transport options contribute to increased urban traffic.	3.33	0.76	Strongly Agree	Very Satisfied
Bus rapid transit (BRT) systems improve city-wide mobility.	3.33	0.72	Strongly Agree	Very Satisfied
Poor integration of different transit systems worsens congestion.	3.41	0.69	Strongly Agree	Very Satisfied
Overall	3.32	0.73	Strongly Agree	Very Satisfied

Legend: 1.00-1.75 Strongly Disagree(Dissatisfied), 1.76-2.50 Disagree(Neutral), 2.51-3.25 Agree(Satisfied), and 3.26-4.00 Strongly Agree(Very Satisfied)

Table 8 presents the different infrastructure strategies that contributed to urban traffic congestion in terms of active transportation in facilities. The overall mean of 3.30 and standard deviation of 0.73 show that respondents strongly agree and are very satisfied with the impact of active transportation facilities on reducing congestion. This means that infrastructures such as sidewalks and bike lanes are seen as valuable alternatives to vehicle usage. The consistent standard deviation indicates general agreement across the population. These results support the promotion of walkability and bikeability as essential components of sustainable urban planning. Prioritizing active transport not only alleviates

traffic but also promotes public health. According to Rojas-Rueda et al. (2021), cities with improved walking and cycling infrastructure report reduced congestion and enhanced urban livability.

The indicator “Safe and accessible active transportation options ease congestion in urban areas” had the highest mean of 3.46 and a low standard deviation of 0.64. This shows strong support and uniform agreement that secure and user-friendly infrastructure is pivotal in encouraging alternative travel modes. Accessibility drives adoption, particularly for vulnerable groups such as children and the elderly. This affirms that providing physical safety and comfort directly correlates with reducing car dependency. City governments should thus prioritize well-maintained and inclusive pedestrian and cycling networks. As Pojani and Stead (2020) explain, urban areas with complete active transport systems experience lower congestion and higher public satisfaction.

The lowest mean was seen in “Dedicated bike lanes encourage people to use bicycles instead of cars,” with a mean of 3.08 and a standard deviation of 0.80. Although respondents agree, the relatively low score suggests that bike lane infrastructure may still be insufficient or underutilized. This might be due to concerns about safety, connectivity, or social norms around cycling. The higher standard deviation reveals mixed experiences and opinions among respondents. This emphasizes the need for comprehensive bike lane networks that are connected, protected, and convenient. Zhang et al. (2022) noted that perceived safety is a key factor influencing whether people switch from cars to bicycles.

Table 8
The Different Infrastructure Strategies Contributed to Urban Traffic Congestion in terms of Active Transportation Facilities

Indicators	Mean	Std. Deviation	Response	Interpretation
Dedicated bike lanes encourage people to use bicycles instead of cars.	3.08	0.80	Agree	Satisfied
Sidewalk improvements and pedestrian-friendly zones reduce vehicle traffic.	3.32	0.73	Strongly Agree	Very Satisfied
Limited walkability forces people to rely on private vehicles.	3.30	0.77	Strongly Agree	Very Satisfied
Poorly maintained pedestrian and cycling infrastructure discourages alternative transportation.	3.33	0.70	Strongly Agree	Very Satisfied
Safe and accessible active transportation options ease congestion in urban areas.	3.46	0.64	Strongly Agree	Very Satisfied
Overall	3.30	0.73	Strongly Agree	Very Satisfied

Legend: 1.00-1.75 Strongly Disagree(Dissatisfied), 1.76-2.50 Disagree(Neutral), 2.51-3.25 Agree(Satisfied), and 3.26-4.00 Strongly Agree(Very Satisfied)

Table 9 presents the different infrastructure strategies that contributed to urban traffic congestion in terms of urban planning and policy measures. The overall mean of 3.38 and standard deviation of 0.70 indicate strong agreement and high satisfaction among respondents regarding the role of planning and policy measures. This highlights the value of integrated zoning, enforcement, and strategic urban development in alleviating traffic issues. Consistency in responses reflects a collective belief that policy reforms can yield substantial improvements in congestion management. Respondents may recognize systemic interventions' long-term benefits rather than isolated fixes. Urban planning efforts should, therefore, prioritize mobility alongside land use. Lucas and Jones (2021) state that successful congestion mitigation requires coordination between infrastructure development and policy frameworks.

The indicator “Poorly planned commercial and residential zoning contributes to congestion” recorded the highest mean at 3.46 with a standard deviation of 0.65. Respondents strongly agree that haphazard development contributes to increased traffic flow. The narrow spread of responses indicates consistent

perceptions. This suggests a demand for better coordination in urban land use, such as locating residential areas near employment centers. Planners should integrate transportation impact assessments in zoning decisions. According to Tiznado-Aitken et al. (2021), ineffective land-use planning often results in extended travel distances and intensified road congestion.

The lowest scoring indicator was “Effective traffic management policies improve road efficiency” with a mean of 3.28 and a standard deviation of 0.71. While still within the strong agreement category, this relatively lower rating may indicate partial implementation or weak enforcement. Respondents may be skeptical about whether policies are being effectively carried out. It signals a gap between policy design and real-world impact. Addressing this may require not just creating policies but ensuring institutional accountability. Zhang and Guhathakurta (2020) emphasized that traffic policies may fall short of their intended outcomes without consistent monitoring.

Table 9
The Different Infrastructure Strategies Contributed to Urban Traffic Congestion in terms of Urban Planning and Policy Measures

Indicators	Mean	Std. Deviation	Response	Interpretation
Effective traffic management policies improve road efficiency.	3.28	0.71	Strongly Agree	Very Satisfied
Poorly planned commercial and residential zoning contributes to congestion.	3.46	0.65	Strongly Agree	Very Satisfied
Coordinated land use planning reduces excessive traffic buildup.	3.41	0.69	Strongly Agree	Very Satisfied
Strict enforcement of traffic laws minimizes congestion issues.	3.36	0.77	Strongly Agree	Very Satisfied
The lack of urban mobility policies worsens congestion problems.	3.40	0.68	Strongly Agree	Very Satisfied
Overall	3.38	0.70	Strongly Agree	Very Satisfied

Legend: 1.00-1.75 Strongly Disagree(Dissatisfied), 1.76-2.50 Disagree(Neutral), 2.51-3.25 Agree(Satisfied), and 3.26-4.00 Strongly Agree(Very Satisfied)

3. What are the key indicators of urban traffic congestion based on:

- 3.1. Traffic performance metrics;**
- 3.2. Environmental and economic impact metrics; and**
- 3.3. User experience and reliability metrics?**

Table 10 presents the key indicators of urban traffic congestion based on traffic performance metrics. The overall mean of 3.31 and standard deviation of 0.69 show that respondents strongly agree and view performance metrics as highly reliable indicators of traffic congestion. Travel time, vehicle volume, and road capacity were significant measures for assessing congestion levels. The agreement reflects widespread awareness of these metrics when evaluating urban traffic. Their application provides planners and engineers with objective data to address congestion. The consistent responses suggest a shared understanding of the practical indicators for traffic efficiency. Wang and Zhang (2021) emphasized that performance-based metrics are foundational for traffic modeling and congestion reduction strategies.

The highest mean was 3.36 for “Road capacity is insufficient to handle peak-hour traffic,” with a standard deviation of 0.66. Respondents strongly agree that existing roads are overwhelmed during peak times. This indicates a clear call for congestion management during rush hours. It may also signal that road infrastructure has not kept pace with population and vehicle growth. Solutions may include intelligent transport systems and flexible work hours. Javid et al. (2022) confirmed that inadequate road capacity during peak periods remains a persistent challenge in growing urban centers.

The lowest-rated indicator was “Travel time and average speed are reliable indicators of traffic congestion,” with a mean of 3.23 and a standard deviation of 0.67. While respondents agreed, the slightly lower mean suggests limited public understanding or exposure to these technical measures. This may imply the need for public education about traffic indicators and their relevance. It also points to the potential for improving data transparency in congestion reporting. Local governments could enhance information-sharing platforms for real-time traffic updates. Sabouri et al. (2020) outlined that accurate and accessible travel time data enhances congestion management and public trust.

Table 10
The Key Indicators of Urban Traffic Congestion based on Traffic Performance Metrics

Indicators	Mean	Std. Deviation	Response	Interpretation
Travel time and average speed are reliable indicators of traffic congestion.	3.23	0.67	Agree	High
High vehicle volume leads to frequent road congestion.	3.30	0.68	Strongly Agree	Very High
Traffic signal timing and coordination affect road efficiency.	3.32	0.70	Strongly Agree	Very High
Road capacity is insufficient to handle peak-hour traffic.	3.36	0.66	Strongly Agree	Very High
The availability of alternative routes affects traffic congestion levels.	3.34	0.73	Strongly Agree	Very High
Overall	3.31	0.69	Strongly Agree	Very High

Legend: 1.00-1.75 Strongly Disagree(Very Low), 1.76-2.50 Disagree(Low), 2.51-3.25 Agree(High), and 3.26-4.00 Strongly Agree(Very High)

Table 11 presents the key indicators of urban traffic congestion based on environmental and economic impact metrics. The overall mean of 3.36 and standard deviation of 0.72 reflect strong agreement and high perception among respondents regarding the environmental and financial consequences of traffic congestion. The findings indicate widespread recognition that congestion affects mobility and imposes serious costs on air quality, fuel usage, and productivity. The standard deviation suggests uniform responses across participants. These indicators highlight the interconnectedness of traffic problems with sustainability and economic well-being. Urban policy must, therefore, integrate congestion mitigation with environmental and economic policies. According to Yao et al. (2022), the environmental congestion costs in developing cities have risen significantly, demanding holistic urban transport solutions.

The highest mean of 3.42 was shared by three indicators: “Air pollution levels rise due to prolonged vehicle idling in congested areas,” “Traffic congestion negatively impacts local businesses and economic productivity,” and “Noise pollution is a growing issue in high-traffic areas.” These results highlight a collective concern over traffic build-up's indirect yet significant consequences. High noise and air pollution levels affect public health and quality of life, while business productivity suffers due to delays. The convergence of perceptions across these dimensions reflects a systemic understanding of congestion’s ripple effects. Policymakers should explore congestion pricing and emission-based regulation. Li and Zhao (2021) state that congestion-induced pollution and economic losses reinforce the need for low-emission zones and strategic urban transport planning.

The lowest-rated item was “Increased fuel consumption is a direct result of urban traffic congestion” with a mean of 3.16 and a standard deviation of 0.76. Although still agreed upon, this slightly lower score may reflect less personal awareness or direct experience regarding fuel-related costs. Respondents may prioritize visible impacts like pollution or stress over economic loss via fuel. The higher variability in response may indicate that fuel consumption is viewed differently across income levels or commuting frequency. This insight emphasizes the need for energy efficiency education and

transport alternatives like hybrid or electric public vehicles. Rupp et al. (2020) found that vehicle idling in traffic contributes to significant fuel wastage and carbon emissions in metropolitan settings.

Table 11
The Key Indicators of Urban Traffic Congestion based on Environmental and Economic Impact Metrics

Indicators	Mean	Std. Deviation	Response	Interpretation
Increased fuel consumption is a direct result of urban traffic congestion.	3.16	0.76	Agree	High
Air pollution levels rise due to prolonged vehicle idling in congested areas.	3.42	0.70	Strongly Agree	Very High
Traffic congestion negatively impacts local businesses and economic productivity.	3.42	0.70	Strongly Agree	Very High
The cost of commuting increases due to longer travel times.	3.41	0.70	Strongly Agree	Very High
Noise pollution is a growing issue in high-traffic areas.	3.42	0.72	Strongly Agree	Very High
Overall	3.36	0.72	Strongly Agree	Very High

Legend: 1.00-1.75 Strongly Disagree(Very Low), 1.76-2.50 Disagree(Low), 2.51-3.25 Agree(High), and 3.26-4.00 Strongly Agree(Very High)

Table 12 presents the key indicators of urban traffic congestion based on user experience and readability metrics. The overall mean of 3.38 and standard deviation of 0.72 indicate strong agreement among respondents that congestion directly affects their knowledge and perceptions of reliability. User satisfaction is significantly impacted by how predictable, safe, and manageable their daily commutes are. This result implies that the human experience of commuting plays a major role in evaluating congestion beyond infrastructure. Urban traffic solutions should, therefore, aim to improve efficiency and psychological comfort. These findings align with service-oriented approaches in transport planning. According to Friman et al. (2021), commuter satisfaction is a key predictor of perceived traffic performance and long-term behavioral adaptation.

The indicator “Road congestion affects the reliability of travel schedules” received the highest mean of 3.47 with a standard deviation of 0.66. Respondents strongly agree that congestion results in unpredictable travel times, which disrupt daily routines and commitments. This finding underlines the need for consistent transport services and intelligent systems to manage variability. Commuters’ growing concern over reliability may influence their shift toward flexible or hybrid work setups. Public transportation systems must improve time adherence to maintain trust. According to Ye and Titheridge (2020), travel reliability is central to mode choice and travel satisfaction across urban populations.

Table 12
The Key Indicators of Urban Traffic Congestion based on User Experience and Reliability Metrics

Indicators	Mean	Std. Deviation	Response	Interpretation
Traffic congestion increases commuter stress and frustration.	3.31	0.74	Strongly Agree	Very High
Public transportation delays are common in congested areas.	3.42	0.67	Strongly Agree	Very High
Road congestion affects the reliability of travel schedules.	3.47	0.66	Strongly Agree	Very High
The availability of ride-sharing and carpooling options influences traffic congestion.	3.32	0.72	Strongly Agree	Very High
Commuters frequently adjust their schedules to avoid peak-hour congestion.	3.39	0.82	Strongly Agree	Very High
Overall	3.38	0.72	Strongly Agree	Very High

Legend: 1.00-1.75 Strongly Disagree(Very Low), 1.76-2.50 Disagree(Low), 2.51-3.25 Agree(High), and 3.26-4.00 Strongly Agree(Very High)

The lowest-rated indicator, “Traffic congestion increases commuter stress and frustration,” had a mean of 3.31 and a standard deviation of 0.74. While still strongly agreed upon, the marginally lower rating could suggest habituation—where commuters have adjusted their expectations to accept stress as usual. The slightly wider deviation indicates varied stress levels based on commute distance, mode, or exposure. Traffic stress has psychological and physiological consequences, calling for interventions such as better communication, route information, and travel apps. Addressing these needs can improve commuter well-being and productivity. As highlighted by Novak and Ayalon (2021), traffic-related stress is a growing concern, especially in urban workforces with high daily exposure to congestion.

4. Is there a significant relationship between the demographic profile of respondents and their perception of traffic congestion?

Table 13 depicts the test of a significant relationship between respondents' demographic profiles and their perceptions of traffic congestion. The data reveal that several demographic variables have a significant relationship with perceptions of traffic congestion, particularly *sex*, *marital status*, and *frequency of commuting*. Significant correlations were found between sex and all four infrastructure-related dimensions: road network enhancements, public transit improvements, active transportation, and urban planning. This suggests that males and females experience traffic congestion and the effectiveness of urban strategies differently. The frequency of commuting was also significantly associated with road network and active transport perceptions, showing that those who commute more often are more likely to be impacted by congestion patterns. Marital status showed significance about transit infrastructure and urban planning, implying that lifestyle roles influence how people interact with transportation systems. On the other hand, age and occupation showed limited or no significant relationships with the variables tested. These findings affirm that personal background and life circumstances shape how people perceive and are affected by urban traffic issues. According to Zhang and Zhao (2021), commuter perceptions and experiences are shaped by personal attributes and commuting frequency, reinforcing the need for differentiated urban mobility strategies.

Table 13
Test of Significant Relationship between the Demographic Profile of Respondents and their Perception of Traffic Congestion

Demographic Profile	Traffic Congestion											
	Road Network Enhancements			Public Transit Infrastructure Improvements			Active Transportation Facilities			Urban Planning and Policy Measures		
	r	p-value	Ho	r	p-value	Ho	r	p-value	Ho	r	p-value	Ho
Age	-.018	.553	NS	-.070*	.024	S	.013	.667	NS	-.055	.076	NS
Sex	.082**	.008	S	.099**	.001	S	.149**	.000	S	..101**	.001	S
Marital Status	-.049	.114	NS	-.087**	.005	S	-.004	.893	NS	-.096**	.002	S
Occupation	-.011	.729	NS	-.027	.379	NS	.028	.358	NS	-.013	.681	NS
Frequency of Commuting	-.169**	.000	S	-.013	.677	NS	-.129**	.000	S	.031	.323	NS

Significant if p-value < 0.05

Legend: Ho is rejected if Significant

Ho is failed to reject if Not Significant

The implications of these findings are vital for developing inclusive and responsive urban transportation policies. Planners must consider how different demographic groups experience mobility challenges in their day-to-day lives. Since gender, relationship status, and commuting habits influence congestion perceptions, city governments should tailor interventions accordingly. For instance, policies that improve safety and convenience for female commuters or flexible transportation options

for daily travelers may enhance effectiveness. Demographic-sensitive infrastructure planning helps avoid one-size-fits-all approaches that often fail to address the needs of diverse populations. These insights are crucial for improving transport equity and reducing congestion burdens across sectors. As Lucas et al. (2022) discussed, transport justice demands that urban planning decisions consider users' differentiated experiences to achieve sustainable and equitable mobility outcomes.

5. Is there a significant impact on the infrastructure strategies to urban traffic congestion?

Table 14 depicts the test of the significant impact of infrastructure strategies on urban traffic congestion. The regression results demonstrate that all four infrastructure strategies—road network enhancements, public transit infrastructure improvements, active transportation facilities, and urban planning and policy measures—significantly impact urban traffic congestion. Among them, urban planning and policy measures ($\beta = .281, p = .000$) had the most substantial impact, followed by public transit improvements ($\beta = .170, p = .000$), road network enhancements ($\beta = .136, p = .000$), and active transportation ($\beta = .074, p = .020$). The model yielded an adjusted R² of .283, indicating that these infrastructure strategies collectively explain about 28.3% of the variance in traffic congestion perception. This suggests that while these four strategies are influential, other contextual and behavioral variables may also play important roles. Nevertheless, the statistical significance of each factor reinforces the importance of adopting a multi-pronged infrastructure approach to congestion mitigation. These results highlight that no intervention suffices in isolation; instead, coordinated planning across multiple domains yields the strongest outcomes. According to Buehler and Pucher (2021), integrated transport systems that combine infrastructure, policy, and transit planning result in greater efficiency and lower congestion levels.

The implications of these findings are crucial for future infrastructure development and transportation policy. Given the significant influence of urban planning, local governments should emphasize land-use coordination, zoning regulations, and enforcement of traffic policies. Investments in public transportation systems must be sustained and expanded, with attention to interconnectivity, reliability, and accessibility. Moreover, the impact of road network enhancements should be balanced with measures to prevent induced demand, such as congestion pricing and carpool incentives. While having the smallest beta value, active transportation still plays a meaningful role and should not be overlooked—especially for short-distance urban travel. The combined effect of these variables suggests that traffic congestion is a systemic issue, requiring inter-agency coordination and data-driven planning. Litman (2022) asserts that effective congestion management relies on multimodal strategies beyond infrastructure expansion to include behavior change and institutional integration.

Table 14
Test of Significant Impact on the Infrastructure Strategies to Urban Traffic Congestion

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.135	.115		9.851	.000
Road Network Enhancements	.140	.033	.136	4.281	.000
Public Transit Infrastructure Improvements	.166	.033	.170	5.030	.000
Active Transportation Facilities	.075	.032	.074	2.331	.020
Urban Planning and Policy Measures	.293	.036	.281	8.261	.000

Note: Adjusted r²= .283 ANOVA for Regression F= 29.195, p=.000

CONCLUSION

The study concludes that traffic congestion is a complex issue shaped by infrastructure conditions, public policy, and individual commuter characteristics. Respondents acknowledged the effectiveness of infrastructure strategies, especially urban planning measures, in addressing congestion. Furthermore, multiple indicators—from technical metrics to user experience—were essential in understanding congestion levels. Significant relationships between demographic factors and congestion perception revealed the need for targeted transport solutions. The study also demonstrated that no single strategy could solve congestion alone, but a combination of infrastructure, policy, and planning yields more significant results. The findings provide a data-driven foundation for creating responsive and sustainable mobility solutions.

Urban transportation systems must be planned holistically, focusing on people-centered outcomes. Coordinated investments in public transit, road networks, and pedestrian facilities are crucial for long-term impact. Policies must align with commuter behavior and urban growth patterns to be effective. Equally important is considering equity—ensuring that all groups, regardless of age, gender, or status, have access to safe and efficient mobility. Inter-agency collaboration, backed by real-time data and inclusive governance, will be key to implementing reforms. The results of this study thus serve as a roadmap for multi-sectoral planning and innovation in urban traffic management.

Recommendations

Based on the findings and conclusions, here are the recommendations:

1. **Local Government Units.** Must design and implement integrated land-use and transport policies that address zoning inefficiencies, commuter flow, and congestion hotspots with data-driven solutions.
2. **Business Owners.** Should consider adopting flexible work schedules and supporting commuter subsidy programs to reduce peak-hour traffic volume and improve employee mobility.
3. **Commuters.** Are encouraged to shift toward sustainable modes of transport such as carpooling, public transit, walking, or cycling, especially for short urban trips.
4. **Urban Planners.** Must prioritize inclusive and resilient infrastructure plans that combine road, transit, and active transport elements with equitable policy enforcement.
5. **Transport Authorities.** Transport authorities should modernize and integrate all transportation systems with real-time data applications to ensure accessibility across demographic sectors.
6. **Environmental Advocates.** Must promote policy measures like low-emission zones, clean transit investment, and awareness programs on pollution from urban congestion.
7. **Residents.** Are urged to support and engage in local mobility programs and adopt commuting habits that contribute to reduced traffic and emissions.
8. **Traffic Enforcement Agencies.** Should enhance coordination with urban planners and strictly implement rules concerning road use, congestion zones, and peak-time management.
9. **Educational Institutions.** Transport education and sustainability awareness must be included in their curricula to foster early adoption of eco-friendly commuting habits.
10. **Future Researchers.** Should explore longitudinal impacts of traffic policies, commuter behavior trends, and technological innovations in congestion mitigation.

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