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"Analysis on Bangalore Traffic"

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Abstract: Bengaluru faces severe traffic congestion due to rapid urban growth and increasing vehicle numbers. This study analyzes public views on key causes of traffic issues, focusing on factors such as abrupt parking of vehicles, road encroachment, poorly planned roads, peak hours, and mixed-speed vehicle movement and congestion levels. Data was collected from 150 respondents using a Google Form and analyzed through SPSS using Descriptive Statistics, T-test, ANOVA, Chi-square, and Correlation. Our analysis is largely based on **descriptive statistical** tests. Results showed a high mean score (**M = 3.82**) for abrupt parking of vehicles as a cause of traffic problems, indicating strong agreement among respondents.Tests also showed no significant difference across demographic groups, but a significant positive relationship was found between road encroachment and lateness (**p = 0.035**). The study concludes that infrastructure and behavior-based issues, rather than demographics, are the major contributors to Bengaluru traffic problems and require better parking control and road management.

Keywords: Bangalore Traffic, Congestion, Travel time, Abrupt parking, Road Encroachment, Traffic Management, SPSS Analysis.

INTRODUCTION

Bangalore, the technology and innovation hub in India, has witnessed tremendous growth in population and urbanization, thus causing extreme traffic congestion that impacts daily life, productivity, and the environment(Devanathan et al., 2023). Bengaluru is among the most congested cities in the world due to a sharp rise in private automobiles, poor infrastructure of roads, unplanned urban growth, and bottlenecks at major intersections(IBM Commuter Pain Survey, 2011). Even with initiatives such as Namma Metro expansion, upgrading BMTC services, and Intelligent Transport Systems(ITS), the city's mobility network remains under stress because of ever-increasing travel demand and inadequate last-mile connectivity(Tiwari & Jain, 2012; Zhao et al., 2013).

The results show that the challenges include increasing delays in traffic, high travel time, wastage of fuel, and escalating pollution, which all pose serious issues for commuters and policymakers. It becomes imperative that for practical solutions and sustainable urban transportation planning, the causes, trends, and effects of Bengaluru's traffic congestion are comprehensively analyzed.*(Traffic Queuing Analysis on Chord Road V (1), n.d.; Litman, 2020; Button, 2010)*

India's urban traffic problem is not only confined to Bangalore, but also in cities like Mumbai, Delhi, Hyderabad and Chennai faces the same challenges*(Pucher et al., 2007; Wilbur Smith Associates, 2008).*Bengaluru, however, distinguishes itself from other Indian metropolises through its unique temporal congestion profiles, primarily necessitated by the city's distinct concentration of IT industries and the resulting work-hour travel dynamics*(Koushik et al., 2013; Krishnamurthy & Peeta, 2011).* The surge in private vehicle ownership, underpinned by burgeoning disposable incomes within the IT sector, has resulted in traffic congestion that significantly exceeds the carrying capacity of existing public infrastructure*(Srinivasan et al., 2007; Rao & Rao, 2012).*

By gathering primary data from everyday commuters and putting it through rigorous inferential testing this study aims to close the gap between perception-based research and statistical analysis*(Borjesson & Eliasson, 2014; Duranton & Turner, 2011).*By identifying the most statistically significant causes of Bengaluru's traffic crisis the findings seek to inform policy*(Banister, 2008; Cervero & Kockelman, 1997).*

POPULATION GROWTH

"Bangalore (Bengaluru) is Karnataka's capital and largest city. With a metro population of over 8 million and a total population of about 11 million, it is the third most populous city and fifth most populous urban agglomeration in India. Bangalore has an urban area of 709 square kilometers and 8.4 million people, according to the 2011 census. The

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population was anticipated to reach 12 million in 2020 and 12.7 million (1.27 Crore) in 2021. According to the 2001 census, the rising employment opportunities in the IT sector are responsible for Bangalore receiving 0.3 million in-migrants from other states, comprising 4,01,932 people from within the state, 3,53,156 people from other Indian states, and 6,397 people from other countries. Bangalore had a population of 8,443,675 in 2011, according to preliminary Census India figures, with 4,391,723 men and 4,051,952 women. Bangalore has an urban/metropolitan population of 8,520,435 persons, 4,433,855 of whom are men & 4,086,580 of whom are women, despite having a city population of 8,443,675."(Nayak & Mishra, n.d.,2023)

This rapid population growth has placed enormous pressure on the city's road infrastructure,which was largely designed to accommodate a fraction of the current demand(BBMP Master Plan, 2015; Mohan et al., 2004). The compounding effect of natural population growth and in-migration from other states makes Bangalore's congestion challenge especially acute compared to cities that grow primarily from within *(Bettencourt et al., 2007; Glaeser & Gottlieb, 2009).*

VEHICULAR POPULATION

"The overall number of registered motor vehicles (transport and non-transport) climbed to 296 million in 2018–19, registering a CAGR of 9.91 percent, according to the most recent MPRTH Annual Report 2021–22. While 8.8% of all registered vehicles fall under the category of "Transport" vehicles, the remaining 91.2% are Non Transport vehicles. The majority of registered vehicles (74.8%) are two-wheelers, indicating a preference for individualized modes of transportation.

As per information released by the Karnataka State Transport Department, the total number of vehicles registered in Bangalore as of January 2021 had nearly topped 10 million, despite the epidemic and lockdown. Of these, 6.4 million are two wheelers, while 2.3 million are personal vehicles. Bangalore added approximately 1.1 million new vehicles in 2020-21, more than doubling the annual average of roughly 6,00,000 since 2018 *(Jagali & Kadam, 2021; IARJSET, 2024).*

Both intracity and interstate transportation alternatives are available in Bangalore, including BMTC buses, Namma Metro rail services, taxis, and auto rickshaws. The government run KSRTC, NWKRTC, and KKRTC also operate buses. However, public transport modal share has been declining year by year as private vehicle ownership rises *(Pucher et al., 2007; Siemiatycki, 2006; Barter, 2000).* This decline in public transport usage creates a vicious cycle, fewer users lead to reduced frequencies, which in turn further discourage ridership *(Vuchic, 2005; Cervero, 1998).*

Comparing countries internationally demonstrates that while developing countries tend to have higher two-wheeler penetration, wealthier countries tend to have higher car penetration ratios *(ITDP, 2018; Kenworthy & Laube, 1999).* Bangalore's trajectory currently mirrors the worst aspects of both categories, a two-wheeler dominated urban fabric combined with rapidly rising car ownership, making its congestion problems uniquely severe *(Goel & Tiwari, 2016; Kumar et al., 2021).*

REVIEW OF LITERATURE

Most previous studies have already established that the sudden growth of Bengaluru, especially its IT sector, has led to a severe imbalance between infrastructural growth and demand for transport. (*Vijayalakshmi S and Krishna Raj (2020)*, n.d.) These studies note that insufficient infrastructure, coupled with increasing population, has caused longer travel times and productivity losses, along with economic and ecological deterioration *(Downs, 2004; Arnott & Small, 1994).* These findings strongly align with the present study, in which the majority of respondents rated the problem of traffic congestion as very severe and estimated the frequency of their delays to work or school accordingly, confirming the actual productivity effect as established by previous research *(Weisbrod et al., 2003; Schrank et al., 2019).*

Poor road planning, a lack of proper integration of transport modes, rapid growth in private vehicle ownership, and ineffective traffic management have been identified as the leading causes of traffic congestion in Bengaluru through several studies in the past *(Comprehensive Traffic and Transportation Plan, Karnataka Government, 2011).* Nearly 10 percent of the city's road network is highly prone to congestion due to bottlenecks, lane obstructions, and delays at important junctions and intersections. Complementing these findings, IARJSET (2024) pointed out that poor maintenance of the road network and the mixing of slow and fast-moving vehicles has resulted in a continuous deterioration of the traffic scenario (Levinson & Huang, 2012; Shoup, 2005) . Again, *Koushik et al. (2013)*, through their study along Mysore Road, established that high-density traffic, frequent merging conflicts, and undisciplined lane movement contributed significantly to the formation of bottlenecks at major junctions. These studies are in full agreement with the present findings, wherein respondents confirmed that ill-maintained roads, improper and unplanned streets, encroachments,

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abrupt parking, and the combined movement of fast and slow vehicles cause traffic congestion daily in Bengaluru (Nagel & Barrett, 1997; Helbing & Huberman, 1998).Further, through our study, the statistical tests confirm that these infrastructural and management-related concerns combine to aggravate delays and lead to loss of commuting efficiency.

Bengaluru is one of the fastest-growing metropolitan cities in India, experiencing a rapid rise in its vehicular population, with an average annual growth rate of nearly 10 percent. This rapid growth in the number of vehicles contributes to almost 40 percent of the city's RSPM, thus making traffic congestion a very serious urban and environmental concern.(*The IBM Commuter Pain Survey (2011)*, n.d.), also ranked Bengaluru as one of the most congested cities in the world. Such daily travel conditions have been rated as extremely severe in the present study*(IBM, 2011; Litman, 2020)*, while delays to reach work or school were reported to occur quite frequently. The statistically significant association between perceived severity of traffic and everyday lateness observed in this study clearly confirms that rapid growth in the vehicular population continues to directly influence commuting efficiency and productivity in Bengaluru.

The rapid growth in population and vehicle ownership, coupled with minimal scope for expansion of roads, has made congestion of urban traffic a serious challenge in Bengaluru *(Jagali & Kadam, 2021 n.d.).* Carried out a detail traffic queuing analysis at the Chord Road (Vijayanagar–Attiguppe) intersections using PTV VISSIM software and found that heterogeneous traffic conditions, poor lane discipline, and high volumes of traffic significantly increase queue length, waiting time, and travel delay at signalized intersection (Bain & Polzin, 2013; Wardrop, 1952).Their study showed that two-wheelers and cars form approximately 90% of the total traffic volume. Heavy congestion is created by the mixed-speed movement and improper utilization of the road *(Treiber et al., 2000; Kerner, 1998)*.

The simulation results also indicated that delay and queue length reduction is possible only through improvement in structural facilities such as elevated lanes and improved signal control *(Daganzo, 1994; Lighthill & Whitham, 1955)*. Such findings constitute strong support for the present study's on congestion in Bengaluru traffic, as poor conditions of roads, mixed vehicle movement, encroachments, and weak traffic discipline were also identified by the respondents in the study as major contributors to daily problems with traffic congestion *(Ogden, 1997; May, 1990)*. Thus, both earlier simulation-based evidence and the present survey-based analysis confirm that Bengaluru's congestion problem is primarily driven by infrastructural limitations and unregulated heterogeneous traffic flow.

Apart from its congestion impacts, traffic also causes severe economic losses for daily commuters. Some studies based on the Cost of Illness (COI) approach reported that individuals spend almost ₹4,944 annually on medical treatment, lose around ₹15,520 every year in productivity due to illness-related absenteeism, and have to bear additional preventive costs in the form of toll charges or metro fares amounting to almost ₹31,800 every year. Considering these expenses collectively, an estimated near ₹52,264 per commuter annually-roughly 13 percent of personal income-clearly represents the combined burden of economic and health-related losses *(Verma et al., 2016; Singh, 2015)*. These findings are strongly supported by the current study, with results indicating a statistically significant association between the severity of problems with traffic and frequent lateness to work or school, thus showing that congestion directly impacts daily productivity and contributes to losses in the commuters' income.*(Impact Of Traffic Congestion, June 2020, n.d.)* There are serious health implications of traffic congestion in Bengaluru due to chronic exposure to vehicular air pollution. High levels of emissions like PM10, PM2.5, carbon monoxide, and nitrogen oxides near busy roads and junctions may lead to respiratory problems, asthma, cardiovascular stress, and long-term lung diseases. Indian studies have reported a serious increase in asthma cases and mortality related to pollution in the city *(Banerjee, 2015; Goel & Tiwari, 2016)* . These results are corroborated by the present study, as a large number of respondents reported feeling stressful, tired, and uncomfortable while breathing during daily travel, thus confirming that traffic congestion is not only a transport issue but also a major public health concern. *(Iyer, 2012)*

METHODOLOGY

Problem Statement:

Bengaluru suffers from heavy traffic each day. While the city is growing rapidly, with more people are coming in, and so are more vehicles on the roads. But the road and infrastructure development have not kept pace with it. And for this reason, traffic congestion is a recurring affair.

On top of this, poor designing of roads, less space on the road, and inefficient traffic light functioning aggravate the situation. As a result, people have to waste long hours in traffic jams, fuel consumption goes up, and there is continuous pollution. This does not only harm the city's environment but also reduces productivity and impacts the lives of its residents.

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Objectives of the study:

1) To assess the impact of rapid population growth and increased vehicle ownership on daily traffic congestion in Bengaluru *(Census of India, 2011; Karnataka Transport Department, 2021).*

2) To assess the impact of poor roadway design, limited road expansion, and inefficient signal systems on the city's traffic delays *(IARJSET, 2024; Koushik et al., 2013).*

3) to assess the impact of congestion-related vehicular emissions on the health and productivity of commuters *(Iyer, 2012; Banerjee, 2015; WHO, 2018).*

4) To examine queue lengths, traffic delays, and saturation flow at major junctions using traffic simulation techniques *(Jagali & Kadam, 2021; Daganzo, 1994).*

5) To identify appropriate technological and traffic-management solutions for improving mobility in Bengaluru *(Devanathan et al., 2023; Tiwari & Jain, 2012).*

Need for the Study:

Traffic congestion has become a daily crisis in Bengaluru due to rapid population growth, the dominance of two-wheelers and cars (90%), and insufficient road infrastructure to accommodate them, leading to increased travel times by 3–4 folds compared to a decade ago *(IBM, 2011; BBMP Master Plan, 2015)*. Long queue lengths, high delays, inadequate green times, and poor lane discipline have been revealed by studies at major junctions, since existing signal systems and junction designs are unsuitable for the current volumes. Traffic management has become extremely difficult with bottlenecks exacerbated by flyovers and metro constructions on account of practically no scope for expansion of roads *(Siemiatycki, 2006; Bertaud, 2004).*

Despite the availability of B-TRAC and ITS technologies, traffic congestion continues to rise, indicating an urgent need for upgrading the traffic management strategies and stronger implementation *(Tiwari & Jain, 2012; CPCB, 2019)*. The present study fills a critical gap in the literature by combining both descriptive and inferential statistical methods to understand commuter perceptions and statistically validate the causes of congestion *(Borjesson & Eliasson, 2014; Duranton & Turner, 2011).*

Scope of Study:

The study aims at understanding the process and reasons behind traffic congestion in Bengaluru. It includes major roads, busy junctions, IT corridors, and places with heavy traffic jams *(Comprehensive Traffic and Transportation Plan, 2011)* . The study considers a regular traffic pattern, congestion at peak hours, and delay-causing factors, including road surface, number of vehicles, and access to public means of transport. It also analyzes the movement of vehicles and people based on the existing infrastructure in place—BMTC buses, Namma Metro, flyovers, and traffic signals. The scope includes, collecting traffic data, examining existing reports, and observing live traffic behavior to validate ground realities *(Priya Uteng & Cresswell, 2008; Lucas, 2004)*. The study is primarily limited to the urban limits of Bengaluru city and does not cover national highways outside the city. Based on its analysis, it tries to recommend empirically grounded solutions that are aimed at mitigating congestion and improving citizens' commuting experience *(Verma et al., 2016; Singh, 2015).*

Data Collection And Sampling Techniques

This research on traffic congestion in Bengaluru was carried out by collecting data through a structured questionnaire which was administered to commuters of different city areas. Primary data is used and has been collected through Google Forms and direct responses from daily commuters. The sampling technique used is the non-probability convenience sampling method, considering that respondents can be reached easily and are the ones facing the issue of traffic problems on a daily basis *(Creswell, 2014; Saunders et al., 2019)*.. Besides, purposive sampling was also considered to ensure the inclusion of specific groups such as students, working professionals, and regular road users, who can offer relevant insights. The sample is a mix of demographics to capture the perceptual aspects of responses regarding pedestrian behavior, road condition, intensity of congestion, and traffic management. These data have been analyzed using the inferential statistical tools of t-test, ANOVA, Chi-square test, and correlation to bring out the significant patterns and relationships between variables for comprehensive and valid findings on causes and impacts of traffic congestion in Bengaluru**.**

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Data Analysis

1)Descriptive Statistics

Variable - Whimsical Movement of Pedestrians are solely responsible for increasing rate of traffic management problems

Interpretation:
For the variable "Whimsical movements of pedestrians are solely responsible for the increasing rate of traffic management problems," responses were recorded using a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5).The SPSS output shows a mean score of **3.14,** indicating that respondents generally selected options between Neutral (3) and Agree (4), with responses leaning slightly closer to Neutral. The standard deviation of **1.081** reflects a moderate spread in responses, showing that participants differed in their opinions.When the standard deviation is subtracted from the mean, the resulting value is **2.059**, which is close to **2** (Disagree). This further supports that the most typical or common perception among the respondents is Disagree, suggesting that the majority neither strongly agree nor disagree that pedestrian movement alone is responsible for traffic management issues.Overall, the responses indicate a generally neutral perception, suggesting that most participants do not strongly attribute traffic management problems solely to pedestrians' whimsical movements.

2)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Poorly maintained roads sometimes generate traffic management problems	150	628	4.19	1.013
Valid N (listwise)	150			

Variable- Poorly maintained roads sometimes generate traffic management

Interpretation:
For the variable "Poorly maintained roads sometimes generate traffic management ," responses were recorded using a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5).The SPSS output shows a mean score of **4.19**, indicating that respondents generally selected options between Agree (4) and Strongly Agree (5), with responses leaning slightly closer to Agree. The standard deviation of **1.013** reflects a moderate spread in responses, showing that participants differed in their opinions.When the standard deviation is subtracted from the mean, the resulting value is **3.177**, which is close to **3** (Neutral). This further supports that the most typical or common perception among the respondents is Neutral.The actual mean value (4.19) clearly indicates that respondents largely agree that poorly maintained roads contribute to traffic management problems . Most respondents agree that poorly maintained roads significantly contribute to traffic management problems.

3)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Certain hours of a day are significantly related to certain typical traffic problem	150	612	4.08	.901
Valid N (listwise)	150			

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Variable- Certain hours of a day are significantly related to certain typical traffic problem

Interpretation

The variable "Certain hours of a day are significantly related to certain typical traffic problems" was measured using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The mean score of **4.08** indicates that respondents generally agree with this statement, showing a strong perception that specific hours of the day are associated with typical traffic issues. The standard deviation of **0.901** suggests a moderate level of variation in responses, meaning that while most people lean toward agreement, some respondents expressed differing views.The value obtained by subtracting the standard deviation from the mean (**4.08 – 0.901 = 3.179**) falls close to the neutral point, indicating that the *central tendency range* still covers neutral to agreement. However, the actual mean clearly remains well above **4,** confirming that the overall perception strongly aligns with agreement. Therefore, the results show that respondents largely believe that traffic problems are significantly linked to particular hours of the day.

4)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Simultaneous movement of speedy and slow moving vehicles often generates traffic management problems	150	564	3.76	.925
Valid N (listwise)	150			

Variable-Simultaneous movement of speedy and slow moving vehicles often generates traffic management problems

Interpretation

The variable "Simultaneous movement of speedy and slow moving vehicles often generates traffic management problems" was assessed using a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree.The mean score of **3.76** indicates that respondents generally lean toward agreeing with the statement, though the agreement is moderate rather than strong. This suggests that most participants believe that the mix of fast and slow vehicles contributes to traffic management problems, but the level of agreement is not extremely high.The standard deviation of **0.925** shows a moderate spread in responses, meaning that while a majority tend to agree, there is some noticeable variation some respondents were neutral or less convinced.The findings indicate that respondents moderately agree that the simultaneous movement of both fast and slow vehicles is a contributing factor to traffic management issues.

5)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
what type of roads best describes the section where you experience the most congestion	148	390	2.64	1.224
Valid N (listwise)	148			

Variable-Which type of road best describes the section where you experience the most congestion

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Interpretation:

The variable “Which type of road best describes the section where you experience the most congestion” was measured on a five-point scale. The mean score of **2.64** indicates that responses are generally close to the neutral point, leaning slightly toward the lower side of the scale. This suggests that no strong consensus exists about a particular road type being the main source of congestion, and respondents show only a mild inclination toward the listed option.The standard deviation of **1.224** reflects a high level of variation, meaning respondents’ experiences differ widely some strongly agree, some disagree, and others remain neutral. This spread indicates that congestion is not consistently associated with one specific road type across the sample.Respondents show no strong consensus on which road type causes the most congestion, with opinions varying widely.

6)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Streets and lanes of the City are not properly planned and built up to accommodate the fast growing traffic movements of recent years	150	588	3.92	.848
Valid N (listwise)	150			

Variable

Streets and Lanes of the city are not properly planned and built up to accommodate the fast growing traffic movement of recent years

Interpretation

The variable *“Streets and lanes of the City are not properly planned and built up to accommodate the fast growing traffic movements of recent years”* was measured using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The mean score of **3.92** indicates that respondents generally agree with this statement, reflecting a strong perception that the city’s streets and lanes are inadequately planned to handle the increasing traffic flow in recent years.The standard deviation of **0.848** suggests a moderate level of variability in responses, meaning that while most respondents lean toward agreement, a few hold neutral or differing views. The value obtained by subtracting the standard deviation from the mean (**3.92 – 0.848 = 3.072**) remains above the neutral point, indicating that the overall response pattern ranges from neutral to agreement. However, the mean being close to **4** clearly shows that respondents predominantly agree that the city’s road infrastructure is insufficient to meet the demands of rapid traffic growth.The results reveal that respondents largely believe that improper road planning and inadequate street design significantly contribute to current traffic challenges.

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7)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Existence of tram makes the Bengaluru traffic management more difficult	150	486	3.24	1.015
Valid N (listwise)	150			

Variable

Existence of Tram makes the Bengaluru traffic management more difficult

Interpretation

The variable *"Existence of tram makes the Bengaluru traffic management more difficult"* was assessed using a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The mean score of **3.24** indicates that respondents show a mild inclination toward agreement, but the level of agreement is not strong. This suggests that while some participants believe trams add to traffic management challenges, many remain neutral or uncertain.The standard deviation of **1.015** reflects a fairly high variation in responses, meaning that opinions differ significantly across respondents—some agree, some disagree, and others hold neutral views**.**The findings indicate that respondents show only a moderate and mixed perception regarding whether the existence of trams makes Bengaluru's traffic management more difficult.

8)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Encroachment of road by unauthorised garbaging generates traffic management problems	150	579	3.86	.811
Valid N (listwise)	150			

Variables

Encroachment of road by unauthorised garbaging generates traffic management problems

Interpretation

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The variable *"*Encroachment of road by unauthorised garbage generates traffic management problems*"* was assessed using a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The mean score of **3.86** indicates that respondents generally agree with this statement, suggesting that most participants believe that unauthorized dumping or garbaging on roads contributes significantly to traffic management issues. The level of agreement is fairly strong, leaning clearly toward the "Agree" category.The standard deviation of **0.811** shows a moderate variation in responses, meaning that although most respondents agree, a few maintain neutral or differing views.The findings indicate that respondents largely believe that unauthorized road encroachment through garbaging contributes significantly to traffic management problems.

9)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Abrupt parking of vehicles generates traffic management problems	150	608	4.05	1.028
Valid N (listwise)	150			

Variables -

Abrupt parking of vehicles generates traffic management problems

The variable **"**Abrupt parking of vehicles generates traffic management problems**"** was assessed using a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The mean score of **4.05** indicates that respondents generally agree with this statement, suggesting that most participants perceive abrupt or haphazard vehicle parking as a significant contributor to traffic management issues. The level of agreement is strong, leaning clearly toward the "Agree" category and approaching "Strongly Agree."The standard deviation of **1.028** shows a moderate to high variation in responses, implying that while a majority of respondents agree, there is a noticeable spread in opinions, with some respondents expressing neutral or opposing views.The findings suggest that respondents predominantly believe abrupt vehicle parking is a major factor in traffic management problems, although the presence of varied responses indicates that the issue may be context-dependent or perceived differently across locations or experiences.

10)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
How severe do you think the overall traffic problem in Bangalore is?	150	624	4.16	.977
Valid N (listwise)	150			

Variables - *How severe do you think the overall traffic problem in Bangalore is*

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The variable "How severe do you think the overall traffic problem in Bangalore is?" was assessed using a five-point Likert scale ranging from 1 = Not Severe to 5 = Very Severe. The mean score of **4.16** indicates that respondents generally perceive the traffic problem in Bangalore as highly severe. This suggests that most participants view traffic congestion and related issues as a major urban challenge. The level of concern is strong, leaning clearly toward the "Very Severe" category.The standard deviation of **0.977** shows a moderate variation in responses, meaning that while the majority of respondents rated the problem as severe, there are some who perceive it as less intense or moderately concerning.The findings reveal that respondents overwhelmingly consider traffic problems in Bangalore to be severe, highlighting a widespread public concern that may warrant urgent attention from urban planners and policymakers.

11)Descriptive Statistics

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
How often does traffic make you late to work/school?	150	588	3.92	.832
Valid N (listwise)	150			

Variable- How often does traffic make you late to work/school

Interpretation

The variable "*How often does traffic make you late to work/school*?" was assessed using a five-point Likert scale ranging from 1 = Never to 5 = Very Often. The mean score of **3.92** indicates that respondents generally experience frequent delays due to traffic, suggesting that most participants are regularly affected by congestion when commuting. The level of frequency is notably high, leaning toward the "Often" category.The standard deviation of **0.832** shows a moderate variation in responses, meaning that while many respondents report frequent lateness, there are some who experience it less often or occasionally.The findings suggest that traffic congestion significantly impacts punctuality for a majority of respondents, reinforcing the perception that traffic delays are a common and disruptive part of daily life in the region.

Interpretation

The results of the descriptive statistics across all variables indicate that, overall, respondents view traffic problems in Bengaluru to be severe, with multiple causes rather than a single cause. Whimsical pedestrian movements generated a neutral response, with a mean of 3.14, indicating most respondents do not strongly attribute traffic issues to pedestrians alone. However, poorly maintained roads generated the highest response for any variable, with a mean of 4.19, followed closely by those respondents who attributed traffic problems to certain peak hours with a mean of 4.08, and then by those who attributed them to the simultaneous movement of slow and fast vehicles at 3.76. Differences of opinion as to which type of road experiences the most congestion generated a low response with a high standard deviation of responses, or mean 2.64, indicating no consensus of opinion. Strong agreement on other items included not planning the roads properly, mean of 3.92; unauthorized encroachment of the roads by garbage, mean 3.86; and abrupt parking of vehicles, mean 4.05. There was mixed opinion on whether trams complicate the traffic problem, mean 3.24, indicating uncertainty or divided opinion. Overall, respondents viewed the traffic problem of Bengaluru to be highly severe at a mean of 4.16 and reported being delayed by traffic frequently, mean 3.92. These findings collectively lead to the identification that traffic challenges emerge from a mix of infrastructural flaws, behavioral factors, and peak time pressures. This places pressure on the need for comprehensive multi-dimensional traffic management strategies.

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Sl.No	Hypothesis	Test	P-Value	Significant value	Verification results
1	There is no significant difference between whimsical movement of pedestrians and gender	T-Test	0.937	0.05	Accept H_0
2	There is no significant difference between certain hours of high traffic and gender	T-Test	0.533	0.05	Accept H_0
3	There is no significant difference between poorly maintained roads and gender	T-Test	0.785	0.05	Accept H_0
4	There is no significant difference between Simultaneous movement of speedy and slow moving vehicles	ANOVA	0.561	0.05	Accept H_0
5	There is no significant difference between type of roads and gender	ANOVA	0.393	0.05	Accept H_0
6	There is no significant difference between streets and lanes are not properly planned to accommodate increasing traffic and gender	ANOVA	0.431	0.05	Accept H_0
7	There is no significant difference between existence of trams and gender	ANOVA	0.288	0.05	Accept H_0
8	There is no significant difference between Encroachment of road by unauthorized garbaging and gender	ANOVA	0.147	0.05	Accept H_0
9	There is no significant association between severity of traffic problems and the frequency and makes people late to work/school	Chi-square	0.000	0.05	Reject H_0
10	There is no significant association between profession and how often traffic makes individuals late to work/school.	Chi-Square	0.280	0.05	Accept H_0
11	There is no significant correlation between road encroachment due to unauthorized garbage and traffic makes individuals late to work/school.	Correlation	0.035	0.05	Reject H_0

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12	There is no significant correlation between Streets and lanes of the City are not properly planned and Whimsical movements of pedestrians	Correlation	0.000	0.05	Reject H_0
13	There is no significant correlation Simultaneous movement of speedy and slow moving vehicles and Poorly maintained roads	Correlation	0.000	0.05	Reject H_0
14	There is no significant correlation between peak hours causing traffic issues and the existence of trams.	Correlation	0.176	0.05	Accept H_0

Interpretation:

From the results of all statistical tests, we came to know that most of the factors, such as whimsical pedestrian movement, poorly maintained roads, type of road, existence of trams, and road encroachment, do not vary between genders, as their p-values are greater than 0.05, which implies that traffic problems in Bengaluru are being faced identically by males and females. On the other hand, some relationships of importance were observed to be significant. Chi-square testing revealed that the magnitude of traffic problems is highly associated with getting late to work or schools, which is very common in Bengaluru, especially during peak hours *(IBM, 2011; Schrank et al., 2019)*. The correlation results also stated that unauthorized garbage encroachment, unplanned streets and lanes, and co-movement of slow and fast vehicles together have a significant influence on traffic congestion.

The acceptance of H_0 for the relationship between peak hours and tram existence($p=0.176$) confirms that these two variables are not significantly correlated, supporting the view that peak hour congestion is primarily driven by the volume and behaviour of private motor vehicles rather than public transport infrastructure*(Vuchic, 2005; Cervero, 1998)*. This finding has important policy implications, suggesting that tram-like mass transit systems would not by themselves solve Bangalore's peak hour problem without accompanying demand management measures. These reflect the exact real-life problems in Bengaluru, where narrow, unplanned roads, mixing of vehicle speeds, and road-side encroachments add to traffic congestion. Overall, the results have helped me understand that though everybody faces the problem similarly, its major causes are structural and environmental factors rather than demographic differences.

DISCUSSION

The present study identifies that congestion in Bengaluru is not confined to any particular demographic but affects the entire urban commuting population alike *(Downs, 2004; Button, 2010)*. Tests of significance show no significant variation in perception across gender, age, or profession, which means one and all face similar challenges. It is mainly linked with poor road planning, poor maintenance of roads, and mixed-speed vehicle movements. The perceived severity of traffic congestion correlates very strongly with frequent lateness to work or school on a day-to-day basis, given that this directly impacts productivity. The correlation results further identify how issues related to pedestrian movement, encroachment of roads, and unequal road surface all together disturb flow. These findings are in tune with previous studies, which quoted rapid growth in population and escalating vehicle ownership as major contributors. Limited expansion of roads further aggravates bottlenecks at major junctions. Public transportation and traffic management systems do exist but are grossly inadequate in relation to demand. Therefore, it implies that congestion in Bengaluru is multidimensional rather than being caused by one single factor. In summary, sustainable improvement needs proper infrastructure planning, strict enforcement, and strong integration of public transport.

CONCLUSION

Descriptive and inferential statistical analyses were conducted to empirically establish the various causes of traffic congestion in Bengaluru. The findings all point to the fact that congestion is essentially caused by infrastructural shortfalls, accelerated urban growth, and irregular road-use behavior. High mean scores recorded in variables relating to sudden parking, poor road maintenance, road encroachment, and unplanned street designs confirm that the general public

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recognizes infrastructure-related limitations as the leading cause of congestion.The findings are further bolstered by the inferential analyses. The T-tests and ANOVA analyses do not indicate any statistically significant difference in perception among the demographic categories, further reiterating that the congestion burden cuts across the urban population. On the other hand, Chi-square and correlation analyses reveal significant associations between traffic severity and commuter punctuality, and between road encroachment, pedestrian irregularities, and heterogeneous traffic flow. These results affirm that congestion reflects not only infrastructural limitations but also manifests in tangible consequences on the productivity of commuters and efficiency in mobility.Together, they indicate that the traffic congestion in Bengaluru is systemic rather than episodic, influenced by the interaction between structural inadequacies and behavioral externalities. The findings underscore the need for integrated, long-term transportation planning that considers road design, maintenance regimes, and rigorous enforcement against road encroachments, together with mass transit systems expansion. Moreover, the alignment of these results with prior literature further validates the argument that unless infrastructural expansion and mobility management evolve in proportion with urban growth, congestion will continue to adversely influence socio-economic and environmental outcomes.In conclusion, the study highlights that comprehensive mobility governance is urgently needed, together with technologically supported traffic management and sustainable urban transport interventions, to mitigate the increasing congestion challenges in Bengaluru.

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Appendix

T-Test

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Whimsical movements of pedestrians are solely responsible for increasing rate of traffic management problems	Male	82	3.15	1.112	.123
	Female	68	3.13	1.050	.127

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Whimsical movements of pedestrians are solely responsible for increasing rate of traffic management problems	Equal variances assumed	.482	.489	.079	148	.937	.014	.178	-.337	.365
	Equal variances not assumed			.079	145.519	.937	.014	.177	-.336	.364

T-Test

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Whimsical movements of pedestrians are solely responsible for increasing rate of traffic management problems	Male	82	3.15	1.112	.123
	Female	68	3.13	1.050	.127
Certain hours of a day are significantly related to certain typical traffic problem	Male	82	4.12	.852	.094
	Female	68	4.03	.962	.117
Poorly maintained roads sometimes generate traffic management problems	Male	82	4.21	1.063	.117
	Female	68	4.16	.956	.116

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Whimsical movements of pedestrians are solely responsible for increasing rate of traffic management problems	Equal variances assumed	.482	.489	.079	148	.937	.014	.178	-.337	.365
	Equal variances not assumed			.079	145.519	.937	.014	.177	-.336	.364
Certain hours of a day are significantly related to certain typical traffic problem	Equal variances assumed	.205	.651	.625	148	.533	.093	.148	-.200	.385
	Equal variances not assumed			.618	135.222	.538	.093	.150	-.204	.389
Poorly maintained roads sometimes generate traffic management problems	Equal variances assumed	.500	.480	.273	148	.785	.046	.167	-.284	.375
	Equal variances not assumed			.276	146.996	.783	.046	.165	-.280	.372

Anova test

Simultaneous movement of speedy and slow moving vehicles often generates traffic management problems	Between Groups	2.574	4	.643	.748	.561
	Within Groups	124.786	145	.861		
	Total	127.360	149			

Anova test

what type of roads best describes the section where you experience the most congestion	Between Groups	6.175	4	1.544	1.031	.393
	Within Groups	214.122	143	1.497		
	Total	220.297	147			

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Anova test

Streets and lanes of the City are not properly planned and built up to accommodate the fast growing traffic movements of recent years	Between Groups	2.766	4	.692	.962	.431
	Within Groups	104.274	145	.719		
	Total	107.040	149			

Anova test

Existence of tram makes the Bengaluru traffic management more difficult	Between Groups	5.153	4	1.288	1.260	.288
	Within Groups	148.207	145	1.022		
	Total	153.360	149			

Anova test

Encroachment of road by unauthorised garbaging generates traffic management problems	Between Groups	4.457	4	1.114	1.726	.147
	Within Groups	93.603	145	.646		
	Total	98.060	149			

Chi-Square

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
How severe do you think the overall traffic problem in Bangalore is? * How often does traffic make you late to work/school?	150	100.0%	0	0.0%	150	100.0%

How severe do you think the overall traffic problem in Bangalore is? * How often does traffic make you late to work/school? Crosstabulation

Count

		How often does traffic make you late to work/school?					
		never	rarely	sometimes	often	always	Total
How severe do you think the overall traffic problem in Bangalore is?	not severe	0	0	2	0	1	3
	slightly severe	0	4	2	0	1	7
	moderately severe	1	0	10	11	0	22
	very severe	0	0	12	28	9	49
	extremely severe	0	1	11	30	27	69
Total		1	5	37	69	38	150

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.801	.000
	Cramer's V	.400	.000
N of Valid Cases		150	

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Chi-Square

Profession * How often does traffic make you late to work/school? Crosstabulation

Count

		How often does traffic make you late to work/school?					
		never	rarely	sometimes	often	always	Total
Profession	Studying	1	3	24	44	17	89
	Working	0	2	13	25	21	61
Total		1	5	37	69	38	150

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.073[a]	4	.280
Likelihood Ratio	5.372	4	.251
N of Valid Cases	150		

a. 4 cells (40.0%) have expected count less than 5. The minimum expected count is .41.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.184	.280
	Cramer's V	.184	.280
N of Valid Cases		150	

Correlation

Correlations

Correlations

		Encroachment of road by unauthorised garbaging generates traffic management problems	How often does traffic make you late to work/school?
Encroachment of road by unauthorised garbaging generates traffic management problems	Pearson Correlation	1	.172*
	Sig. (2-tailed)		.035
	N	150	150
How often does traffic make you late to work/school?	Pearson Correlation	.172*	1
	Sig. (2-tailed)	.035	
	N	150	150

*. Correlation is significant at the 0.05 level (2-tailed).

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Correlations

Correlations

		Streets and lanes of the City are not properly planned and built up to accommodate the fast growing traffic movements of recent years	Whimsical movements of pedestrians are solely responsible for increasing rate of traffic management problems
Streets and lanes of the City are not properly planned and built up to accommodate the fast growing traffic movements of recent years	Pearson Correlation	1	.291**
	Sig. (2-tailed)		.000
	N	150	150
Whimsical movements of pedestrians are solely responsible for increasing rate of traffic management problems	Pearson Correlation	.291**	1
	Sig. (2-tailed)	.000	
	N	150	150

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

Correlations

		Simultaneous movement of speedy and slow moving vehicles often generates traffic management problems	Poorly maintained roads sometimes generate traffic management problems
Simultaneous movement of speedy and slow moving vehicles often generates traffic management problems	Pearson Correlation	1	.557**
	Sig. (2-tailed)		.000
	N	150	150
Poorly maintained roads sometimes generate traffic management problems	Pearson Correlation	.557**	1
	Sig. (2-tailed)	.000	
	N	150	150

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation

Correlations

Correlations

		Certain hours of a day are significantly related to certain typical traffic problem	Existence of tram makes the Bengaluru traffic management more difficult
Certain hours of a day are significantly related to certain typical traffic problem	Pearson Correlation	1	.111
	Sig. (2-tailed)		.176
	N	150	150
Existence of tram makes the Bengaluru traffic management more difficult	Pearson Correlation	.111	1
	Sig. (2-tailed)	.176	
	N	150	150

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Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Poorly maintained roads sometimes generate traffic management problems	150	628	4.19	1.013
Valid N (listwise)	150			

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Certain hours of a day are significantly related to certain typical traffic problem	150	612	4.08	.901
Valid N (listwise)	150			

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Simultaneous movement of speedy and slow moving vehicles often generates traffic management problems	150	564	3.76	.925
Valid N (listwise)	150			

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Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
what type of roads best describes the section where you experience the most congestion	148	390	2.64	1.224
Valid N (listwise)	148			

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Streets and lanes of the City are not properly planned and built up to accommodate the fast growing traffic movements of recent years	150	588	3.92	.848
Valid N (listwise)	150			

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Existence of tram makes the Bengaluru traffic management more difficult	150	486	3.24	1.015
Valid N (listwise)	150			

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Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Encroachment of road by unauthorised garbaging generates traffic management problems	150	579	3.86	.811
Valid N (listwise)	150			

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
Abrupt parking of vehicles generates traffic management problems	150	608	4.05	1.028
Valid N (listwise)	150			

Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
How severe do you think the overall traffic problem in Bangalore is?	150	624	4.16	.977
Valid N (listwise)	150			

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Descriptives

Descriptive Statistics

	N	Sum	Mean	Std. Deviation
How often does traffic make you late to work/school?	150	588	3.92	.832
Valid N (listwise)	150			

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