The Influence of Traffic Mix on Traffic Efficiency: An In-Depth Examination

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Abstract - *Traffic congestion is a pervasive challenge in megacities worldwide, significantly impacting travel times, economic productivity, and environmental quality. This study explores the impact of increasing the percentage of two-wheelers (2W) and cars on traffic performance at the Munirka Intersection and RK Puram in New Delhi, India. Using VISSIM simulation software, scenarios were simulated with incremental increases in the proportion of 2W and cars. Results show varying effects on traffic performance, with RK Puram experiencing more significant changes compared to the Munirka Intersection. Recommendations include implementing effective traffic management strategies, improving infrastructure, promoting public transportation, and utilizing data-driven decision-making to enhance traffic efficiency in urban intersections. This research provides valuable insights for optimizing traffic flow and developing targeted traffic management approaches in metropolitan regions.*

***Key Words*: Traffic Congestion, VISSIM, Traffic Performance, Traffic Management, Urban intersections, Munirka Intersection, RK Puram**

1. INTRODUCTION

Traffic congestion is a critical problem faced by urban areas worldwide, leading to economic losses, environmental issues, and a decrease in the quality of life[1]. To effectively address this issue and plan for efficient infrastructure, it is essential to understand the factors that influence traffic performance [2], including the composition of vehicles on the road [3]. Different types of vehicles, such as private cars, public transport vehicles, motorcycles, and commercial trucks, interact in unique ways that affect overall traffic dynamics [3]. By analyzing various parameters like density, speed, and volume using the VISSIM simulation software [4], [5], we aim to gain valuable insights into optimizing traffic flow and mitigating congestion [6] in Munirka Intersection, New Delhi.

To conduct this analysis, we will gather comprehensive data on traffic composition in the Munirka Intersection, including different vehicle types such as two-wheelers, four-wheelers, heavy commercial vehicles, and others. Additionally, we will consider factors like traffic volume and signal timings to develop a holistic understanding of traffic performance [7], [8]. Using VISSIM, a sophisticated traffic simulation tool, we will create virtual models that accurately replicate real-world road conditions. By observing and analyzing the behaviour and interactions of different traffic compositions under various scenarios, we can measure key performance indicators such as travel time, average speed, and queue length to assess the correlation between traffic composition and traffic performance.

By utilizing data analysis methods, our goal is to pinpoint particular traffic composition situations that have a substantial influence on traffic efficiency. This examination will offer important perspectives for shaping traffic control approaches and aiding the advancement of effective transportation systems in the Munirka Intersection and comparable urban settings. Ultimately, comprehending the link between traffic makeup and traffic efficiency is essential for addressing congestion, enhancing transportation, and improving the well-being of residents at Munirka Intersection. The objectives of this study are to:

- Examine the influence of traffic makeup on traffic effectiveness in metropolitan regions, specifically focusing on the Munirka Intersection in New Delhi.
- Investigate the relationship between traffic makeup and important performance metrics such as density, speed, and volume.
- Use the PTV VISSIM simulation software to collect detailed information on different vehicle categories, such as private automobiles, public transit vehicles, bikes, and freight trucks [9], [10].
- Consider variables like traffic volume and the configuration of signal timings in the evaluation [11].
- Simulate actual road conditions in VISSIM to evaluate the impact of raising the proportion of 2-wheelers and cars by 5%, 10%, and 15% on traffic performance.
- Examine factors such as density, speed, volume, and other measurable indicators in VISSIM to recognize traffic patterns that have a substantial impact on traffic efficiency [4].

2. STUDY AREA

Munirka Intersection (Fig.2.1), nestled in the vibrant locality of Munirka, stands as a crucial junction in Southwest Delhi, where historical essence intertwines seamlessly with modernity. Known for its rich cultural heritage, Munirka offers a unique blend of connectivity, community, and convenience. Situated between the coordinates 28° 33' 28.29'' N and 77° 10' 23.13'' E, with an altitude of 237 meters, Munirka experiences moderate to high traffic dynamics, reflecting its importance in the urban landscape.

Strategically positioned at the confluence of South Delhi and affluent areas like Vasant Vihar, R.K. Puram, and Hauz Khas, Munirka enjoys superb connectivity to prominent commercial hubs, educational institutions, healthcare facilities, and recreational amenities. The area boasts an extensive network of roads, including the Outer Ring Road, Nelson Mandela Marg, and the Munirka-Dhaula Kuan Flyover, facilitating smooth transit for residents and commuters alike. Adding to its accessibility, the Munirka Metro Station links the area to other parts of Delhi and the National Capital Region, enhancing its allure as a residential and commercial hub [12].

Munirka thrives as a diverse community, with professionals, students, and families. Renowned educational institutions like JNU and IIT Delhi enrich the vibrant student culture. Residents enjoy various recreational activities with parks and cultural centres nearby. The area boasts excellent social infrastructure, including hospitals and shopping complexes. Despite premier shopping destinations nearby, traffic at the Munirka intersection remains complex.

In Munirka, the weather ranges from scorching summers, with temperatures hitting 45°C, to chilly winters at 3-4°C. Monsoon rains often flood the streets, creating challenges for commuters. Recent downpours submerged roads, particularly affecting low-lying areas and poorly drained regions. The Outer Ring Road near Munirka is severely affected, with vehicles struggling to navigate through the flooded streets, causing significant inconvenience.

Fig. 2.1: Munirka Intersection

3. DATA USED

Traffic volume data collection at the Munirka intersection in New Delhi was conducted using video-based surveys, the approach would involve the following steps:

3.1 Survey Setup:

• Identify suitable vantage points: Select locations at the Munirka intersection that provide a clear view of the traffic movements.
• Camera placement: Install video cameras at the chosen vantage points to capture the traffic flow.

3.2 Video Data Collection:

- Video recording: Record video footage of the traffic at the Munirka intersection (Fig. 3.1) for a specific duration. This period should be representative of the traffic patterns and variations throughout the time of the survey.

Fig. 3.1: Recorder placed on the roadside

- Annotation and counting: Analyze the recorded videos and manually count the vehicles of each class separately for each 5-minute Time interval.
- Traffic volume calculation (Fig. 3.2 & Fig. 3.3): Summaries the vehicle counts from each five-minute time interval to determine the total traffic volume at the traffic stream in both directions [7], [8], [11].

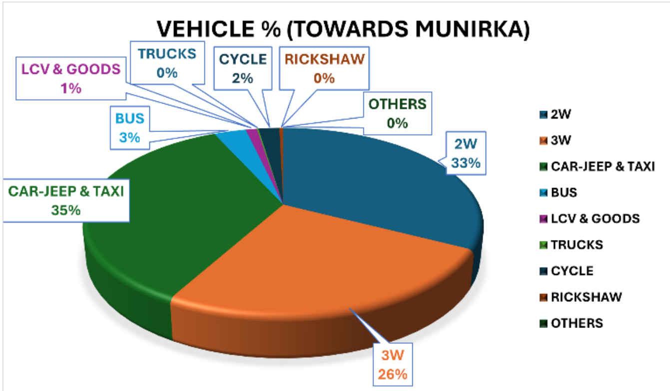

Fig. 3.2: Vehicle Percentage towards Munirka

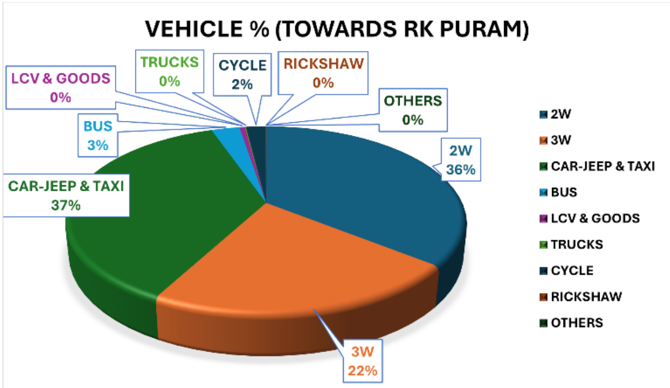

Fig. 3.3: Vehicle Percentage towards RK Puram

3.3 Calculate Average Speed:

- Set up the 30-meter road section by using the roadometer (Fig. 3.4) and traffic cones (Fig. 3.5) placed at its boundaries to mark the start and end points.
- Ensure that the selected road section is visible in the video camera and there are no obstacles or hazards.
- By using the HCM software to find the average speed for each class of vehicle in the given traffic stream [13].
- Take 5 samples of each vehicle class for every 5-minute interval.
- Find out the speed of each sample and take the average of all samples to get the final value of average speed. This should be done for each vehicle class separately [14].

Fig. 3.4: Roadometer

Fig. 3.5: Traffic Cone

4. METHODOLOGY

Fig. 4.0 explains the flow chart of the methodology followed to achieve the objectives.

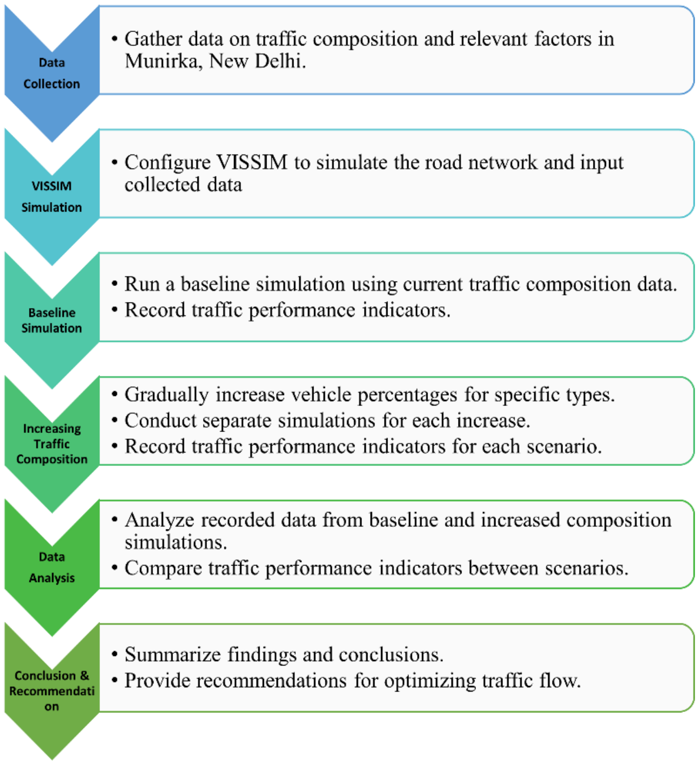

Fig. 4.0: The flow chart of the methodology

4.1 VISSIM Simulation Setup:

4.1.1 Network Design:

- The road network of the Munirka intersection was accurately modelled in PTV Vissim. This involved creating lanes and connecting road segments according to the actual layout of the intersection in New Delhi [4], [9], [10].

- Enter the number of lanes, lane width and name of the road.

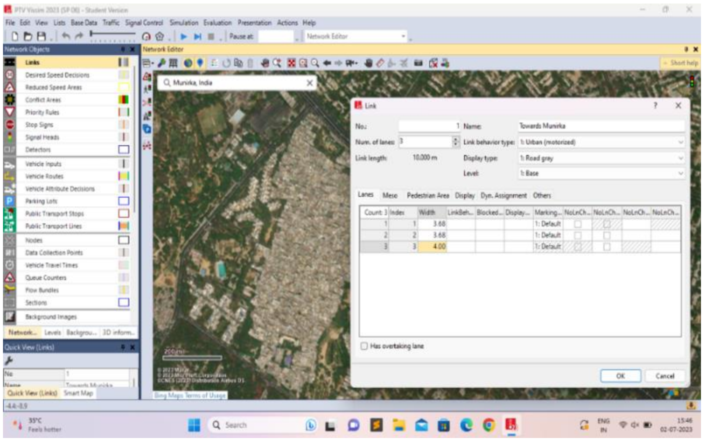

Fig. 4.1

- Add Vehicle: Add the vehicle by selecting "Vehicle Input" from the "Network Objects" menu. Enter the input volume in Veh/hr for each Link.

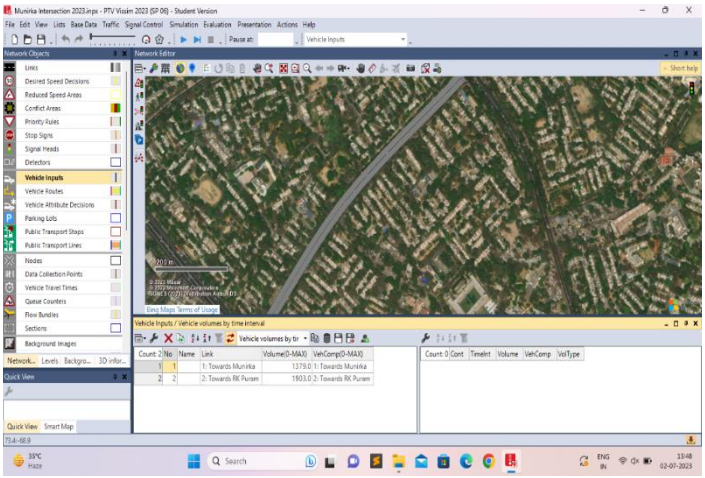

Fig. 4.2

- After that click on the vehicle route and define the vehicle path.

4.1.2 Define Vehicle Composition:

Add different vehicle types to represent the various categories of vehicles in your simulation. Vehicle types can be defined based on parameters such as size and speed.

4.1.3 Vehicle Composition Distribution:

After defining the vehicle types, we need to specify the distribution of these vehicle types within the traffic flow. Such as the proportion of each vehicle type in the traffic stream.

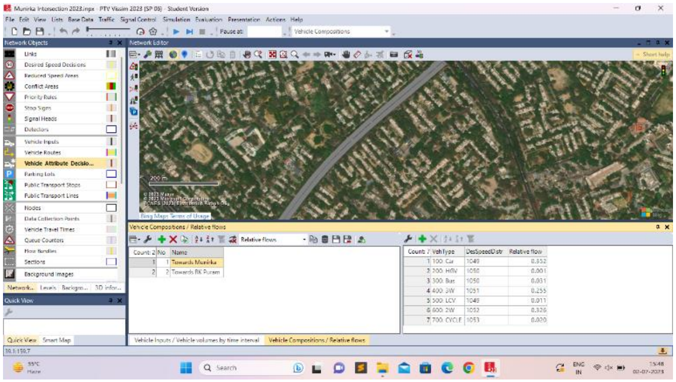

Fig. 4.3

4.1.4 Place Data Collection Point:

Position the data collection object at the desired location within the road network where you want to collect data. This can be done by clicking on the appropriate location in the PTV Vissim workspace.

4.1.5 Specify Data Collection Parameters:

Once the data collection object is placed, you can specify the parameters for data collection. This includes selecting the type of data you want to collect, such as vehicle counts, travel times, speeds, delay, or other relevant metrics.

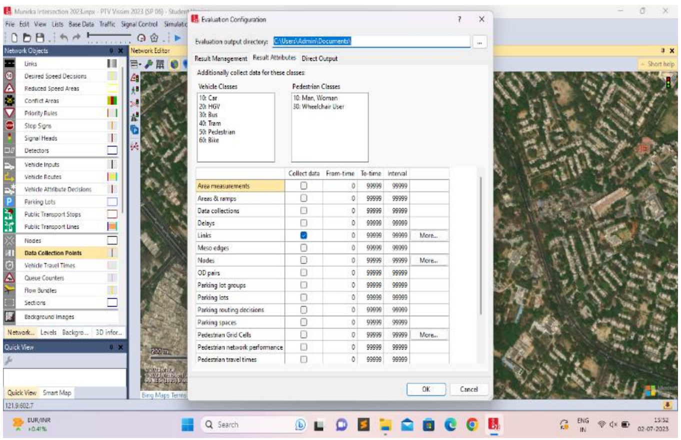

Fig. 4.4

4.1.6 Add Driving Behavior Parameter sets as Per India:

To effectively design traffic flow models and advanced driver assistance systems, understanding driver behaviour in a specific region is crucial [15], [16]. These tables (Table 1 & 2) present typical values for various driving behaviour parameters in India, including factors like following distances, reaction times, and braking capabilities. The values are further categorized for both minor and major roads [17], [18].

S.NO.	Parameters Considered	Default Value	Calibrated Value	
			Major Road	Minor Road
1	Average Stand Still Distance	2	0.3	0.2
2	Additive part of safety Distance	2	0.2	0.2
3	Multiplicative part of safety Distance	3	0.2	0.2
4	Look ahead Distance			
	Minimum	0	30	30
	Maximum	250	150	150
5	Observed Vehicles	4	4	4
6	Look back Distance			
	Minimum	0	25	25

Table 1

	Maximum	150	150	150
7	Maximum Deceleration			
	Own	4	3	3
	Trailing	3	2	2.5
8	Accepted Deceleration			
	Own	1	1	1
	Trailing	1	0.5	1
9	Waiting time before diffusion	60	30	30
10	Minimum Headway	0.5	0.3	0.3
11	Safety Distance Reduction factor	0.6	0.5	0.6
12	Maximum Deceleration for cooperative braking	3	3	3
13	Minimum Lateral Distance			
	0 Km/h	0.2	0.1	0.1
	50 Km/h	1	0.2	0.2

Table 2

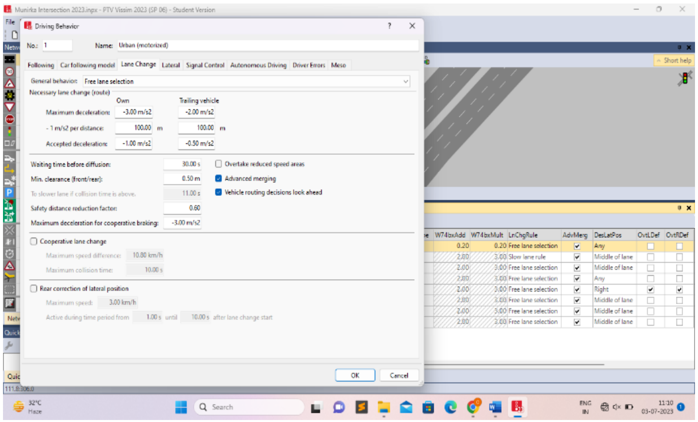

Fig. 4.5

4.1.7 Parameters and Assumptions:

- The simulation assumed that vehicles follow traffic rules and regulations, including lane discipline, speed limits, and traffic signal compliance.
- Vehicle interactions and behaviour were modelled based on general traffic flow principles, considering acceleration, deceleration, lane changing, and gap acceptance.
- The breakdown scenario assumed that the disabled vehicle occupies one lane, creating a bottleneck in traffic flow.

By utilizing PTV Vissim and following this methodology, the impact of vehicle breakdowns on traffic flow, including factors such as volume, speed, and delay, can be accurately analysed and evaluated. This information is crucial for understanding the consequences of breakdown incidents and developing effective strategies for traffic management and congestion mitigation.

4.2 SPEED DATA

Calculated speed data is presented in Tables 3 & 4 below.

DIRECTION	TOWARDS MUNIRKA
VEHICLE TYPE	AVERAGE SPEED (KM/H)
2W	49.86562199
3W	40.47680028
CAR	56.54487127
BUS	35.3495979
CYCLE	10.46826319

Table 3

DIRECTION	TOWARDS RK PURAM
VEHICLE TYPE	AVERAGE SPEED (KM/H)
2W	49.2218036
3W	43.3944804
CAR	45.8021699
BUS	33.71844619
CYCLE	17.43709115

Table 4

4.3 BASELINE SIMULATION:

- Run a baseline simulation using the current traffic composition data in VISSIM. This will serve as the reference scenario for comparison.
- Monitor and record various traffic performance indicators during the simulation, including density, speed, volume, and queue length. These indicators will provide insights into the existing traffic performance in Munirka.

5.0 RESULTS AND RECOMMENDATIONS:

Traffic congestion is a pervasive challenge in megacities worldwide, significantly impacting travel times, economic productivity, and environmental quality [1]. Beyond just volume, the composition of traffic flow, specifically the mix of vehicles like two-wheelers (2W) and cars, can influence performance at intersections [3]. This study explores the impact of increasing the percentage of 2W and cars on traffic performance at two intersections in New Delhi, India. Utilizing a VISSIM traffic simulation model, we systematically increased the proportions of 2W and cars for specific vehicle types. The corresponding traffic performance indicators, including average speed, density, relative delay, and volume, were recorded for each simulation scenario. Our findings aim to contribute to a deeper understanding of how traffic composition interacts with intersection performance, aiding in the development of targeted traffic management strategies.

- We gradually increased the percentage of 2W and Car by 5%, 10%, and 15% for specific vehicle types (two-wheelers, four-wheelers, heavy commercial vehicles, etc.) in the VISSIM simulation.
- For each increased percentage, we conducted a separate simulation and recorded the corresponding traffic performance indicators mentioned earlier.

2W-%	AVG. SPEED(KM/HR)	AVG. DENSITY (VEH/KM)	AVG. RELATIVE DELAY	AVG. VOLUME (VEH/HR)
No Increase	46.28	28.60	2.67	1304
5% Increase	45.77	29.01	2.96	1330
10% Increase	45.86	29.46	3.03	1349
15% Increase	45.59	29.53	3.39	1366

Table 5: 2W-Average of parameters (towards Munirka)

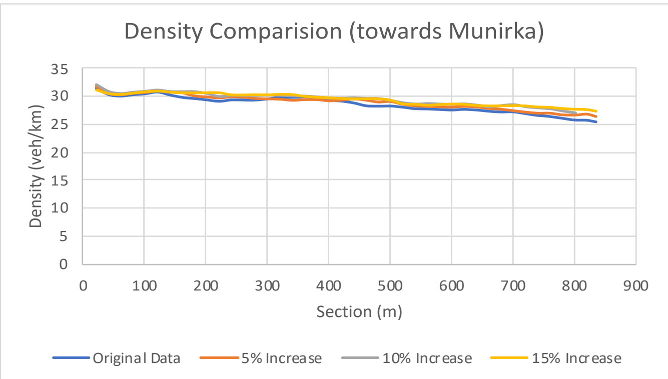

Fig. 5.1: 2W-Graph showing density comparison (towards Munirka)

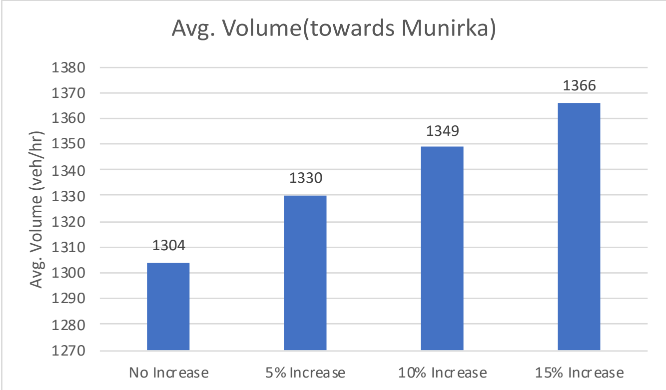

Fig. 5.2: 2W-Graph showing volume comparison (towards Munirka)

CAR-%	AVG. SPEED(KM/HR)	AVG. DENSITY (VEH/KM)	AVG. RELATIVE DELAY	AVG. VOLUME (VEH/HR)
No Increase	45.88	28.60	2.99	1303
5% Increase	45.81	29.01	3.12	1330
10% Increase	45.78	29.48	3.34	1350
15% Increase	45.58	29.90	3.39	1367

Table 6: Car-Average of parameters (towards Munirka)

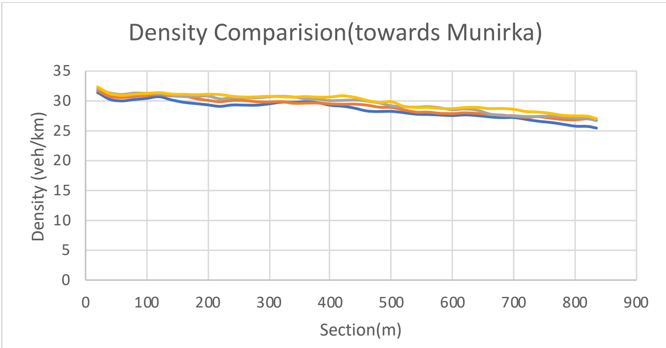

Fig. 5.3: Car-Graph showing density comparison (towards Munirka)

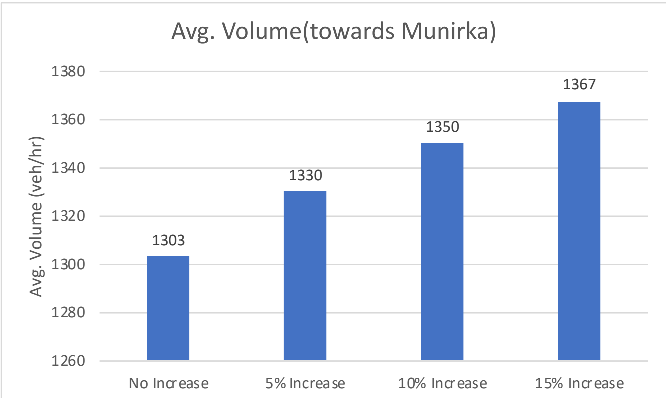

Fig. 5.4: Car-Graph showing volume comparison (towards Munirka)

2W-%	AVG. SPEED(KM/HR)	AVG. DENSITY (VEH/KM)	AVG. RELATIVE DELAY	AVG. VOLUME (VEH/HR)
No Increase	42.54	42.58	2.28	1777
5% Increase	42.34	43.66	2.63	1809
10% Increase	41.72	43.27	4.06	1840
15% Increase	41.42	44.20	4.64	1871

Table 7: 2W- Average of parameters (towards RK Puram)

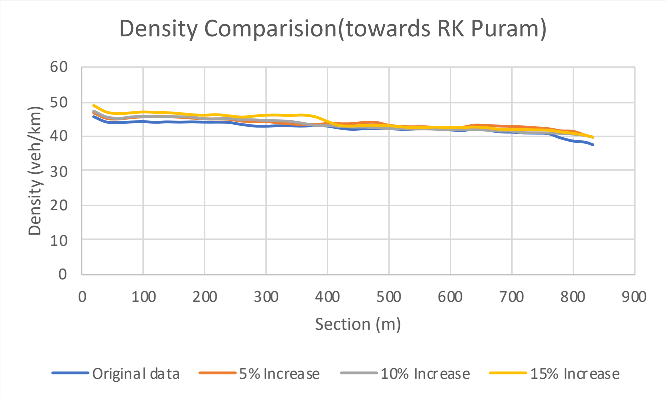

Fig. 5.5: 2W-Graph showing density comparison (towards RK Puram)

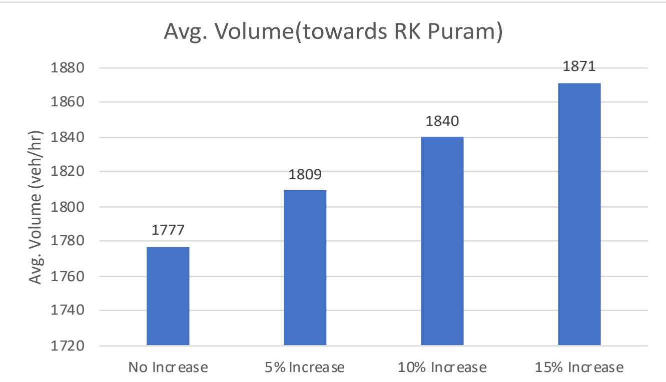

Fig. 5.6: 2W-Graph showing volume comparison (towards RK Puram)

CAR-%	AVG. SPEED(KM/HR)	AVG. DENSITY (VEH/KM)	AVG. RELATIVE DELAY	AVG. VOLUME (VEH/HR)
No Increase	45.88	42.58	2.99	1777
5% Increase	45.81	42.69	3.12	1810
10% Increase	45.78	43.40	3.34	1841
15% Increase	45.58	44.58	3.39	1878

Table 8: Car- Average of parameters (towards RK Puram)

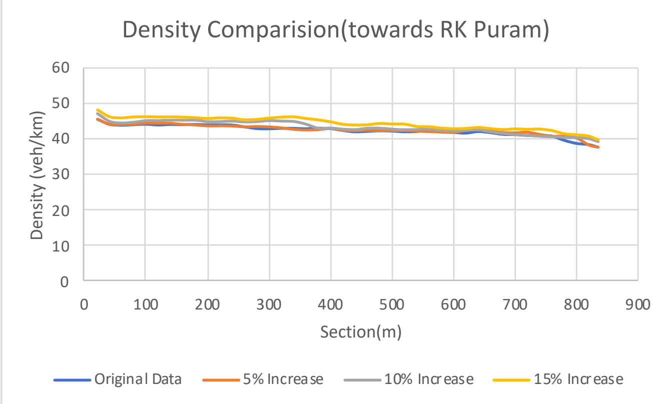

Fig. 5.7: Car-Graph showing density comparison (towards RK Puram)

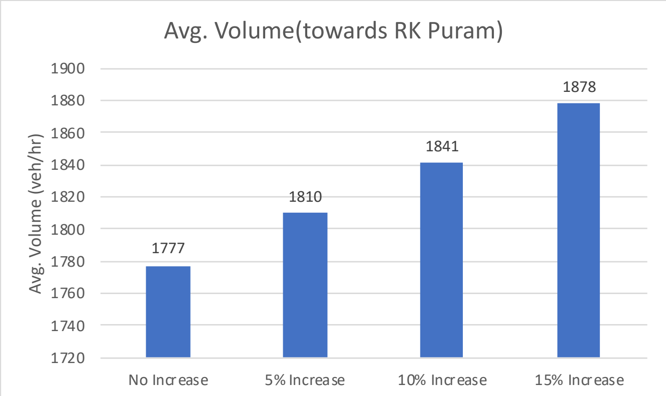

Fig. 5.8: Car-Graph showing volume comparison (towards RK Puram)

Towards Munirka Intersection:

- Increasing the percentage of 2W (two-wheelers) by 5%, 10%, and 15% resulted in a slight decrease of 0.5 Km/hr,0.42 Km/hr and 0.70 Km/hr in average speed respectively, with a minimal impact on average density and relative delay.
- Increasing the percentage of cars by 5%, 10%, and 15% also showed a minor decrease in average speed, 0.07 Km/hr,0.1 Km/hr and 0.3 Km/hr with slightly higher average density and relative delay compared to the no increase scenario.
- Overall, the impact of increasing traffic composition on traffic performance towards the Munirka Intersection was relatively minimal, with small changes observed in average speed, density, relative delay, and volume.

Towards RK Puram:

- Increasing the percentage of 2W (two-wheelers) by 5%, 10%, and 15% resulted in a decrease of 0.52 Km/hr,0.46 Km/hr and 0.73 Km/hr in average speed respectively, an increase in average density, and a significant increase in relative delay.

- Increasing the percentage of cars by 5%, 10%, and 15% showed a similar pattern, with a decline of 0.09 Km/hr,0.13 Km/hr and 0.36 Km/hr in average speed, higher average density, and a notable increase in relative delay.

Here are some recommendations derived from this study:

- The impact of increasing traffic composition on traffic performance towards RK Puram was more significant compared to the Munirka Intersection, with noticeable changes in average speed, density, relative delay, and volume.
- Traffic Management: Implement effective traffic management strategies to mitigate congestion and reduce relative delay. This could include optimizing traffic signal timings, implementing traffic flow control measures, and considering capacity expansion where necessary.
- Infrastructure Improvement: Assess the road infrastructure in areas experiencing high density and relative delay. Identify potential bottlenecks and consider infrastructure enhancements such as widening roads, adding lanes, or improving intersections to improve traffic flow.
- Public Transportation: Promote the use of public transportation as an alternative to individual vehicles to reduce the overall volume of vehicles on the road and alleviate congestion.
- Data-Driven Decision Making: Continuously monitor and analyze traffic data to make informed decisions regarding traffic management, infrastructure planning, and policymaking. Use data-driven approaches to identify problem areas and prioritize interventions.

7. CONCLUSION:

1. ***Density:***

- Generally, as the percentage increase in density occurs, the density of vehicles per kilometre tends to increase across all time intervals and sections.
- The increase in density may indicate a higher concentration of vehicles, which can lead to increased traffic congestion and reduced traffic flow.

2. ***Relative Delay:***

- With the increase in density, there is a corresponding increase in relative delay in most cases.
- Higher density results in slower traffic movement and increased travel time, leading to higher relative delay.
- The relative delay is influenced by factors such as road capacity, traffic management, and infrastructure.

3. ***Speed:***

- As density increases, the average speed tends to decrease across various time intervals and sections.
- Higher density leads to traffic congestion, which results in reduced speeds and slower traffic flow.
- Lower speeds can impact the overall efficiency and effectiveness of transportation systems.

4. ***Volume:***

- The volume of vehicles per hour shows variations depending on the specific time interval, section, and percentage increase.
- In some cases, the volume increases as the density increases, indicating a higher number of vehicles passing through a particular area.
- It is essential to consider volume along with other factors like speed and density to assess the overall traffic conditions accurately.

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