

ASSESSING THE POTENTIAL OF MODAL SHIFT FROM ELECTRIC THREE-WHEELERS TO MINIBUSES USING COMMUTER SURVEYS AND MICROSIMULATION TECHNIQUE TO ALLEVIATE URBAN CONGESTION

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ABSTRACT

Urban roads in Bangladesh face increasing congestion, largely due to the high number of electric three-wheelers (E3Ws) with limited passenger capacity. Shifting these trips to higher-capacity vehicles such as minibuses may help reduce traffic congestion. However, studies that combine commuter willingness to shift with traffic performance analysis are limited in the local context. This study evaluates commuter intention, drivers' aggressive behaviors, and the traffic impacts of replacing E3Ws with minibuses at the Shibbari intersection. A commuter survey was conducted to assess willingness to shift from E3Ws to minibuses, while a questionnaire survey of three-wheeler drivers was used to identify operational challenges. Traffic volume, vehicle composition, occupancy levels, and routing patterns were collected through field surveys, and vehicle dynamics were recorded using a GPS logger application. A microscopic simulation model in PTV VISSIM 2025 was also developed to replicate existing mixed-traffic conditions and test modal shift scenarios, where E3Ws were substituted with minibuses. The model was then calibrated with the collected data and validated using a holdout sample. Survey results indicate that approximately 68% of commuters view electric three-wheelers as a key source of delay, while 69% of E3W users are willing to switch modes, depending on socio-demographic, trip, and accessibility factors. The drivers' behavior questionnaire revealed that more than half of the E3W drivers engage in high speed, aggressive overtaking, and risky car-following approaches. Also, nearly 50% of the drivers are unsafe and directly contribute to congestion. Field surveys showed that E3Ws account for 62% of stoppages and hold 63.9% share of the total vehicle composition, indicating their major role in congestion generation. Simulation findings indicate that the modal shift scenario outperforms the base scenario by reducing delays, increasing speeds, and removing a large share of vehicles from the roadway. Shifting toward minibuses can reduce vehicle delays by up to 82.43%, and most importantly, this intervention significantly removes nearly half (49.22% on average) of the vehicles from the road network. These findings suggest that commuter-supported modal shift strategies can substantially improve roadway performance and provide a strong basis for future policy interventions.

Keywords: *Electric three-wheelers, modal shift, microsimulation, minibuses, urban congestion.*

1. INTRODUCTION

Bangladesh, a developing country has generated unusual travel demand due to uncontrolled rapid urban growth which in result created significant negative impact on her city networks (Cervero & Golub, 2011). In this country, roadways carry high volume of mixed traffic including trucks, buses, cars, non-motorized vehicles and most importantly auto-rickshaws. These heterogeneous traffic in Bangladesh travels without maintaining proper lane discipline (M. K. Hossain et al., 2019). This scenario poses safety challenges with high risk of vehicle, pedestrian collisions. All this strongly demonstrates how urban traffic congestion has become one of the greatest challenge in rapidly growing cities of Bangladesh. A field study carried in Dhaka show that the average travel speed has dropped to 6.1 km/h during peak periods, dictating poor outcomes if compared to global urban standard (Mashrur, 2018).

In a road network, the most critical point i.e., the intersection often experiences severe operational challenges and delays due to the presence of mixed traffic streams. In Gazipur, intersections with severe traffic congestions have become a regular phenomenon and Shibbari intersection is one of these. Although this intersection is the corridor of industrial and residential areas in Gazipur, its traffic performance degrades highly due to poor operational performance. Mixed traffic with fast moving cars, buses, trucks and specially E3Ws make the intersection most critical in terms of congestion during peak hours. Among all vehicles, the dominance of E3Ws has further reduced the efficiency of the intersection. These small three-wheeled vehicles are very common in Gazipur for short-distance travel.

In urban regions, the lack of formal public transport system introduces the informal intermediate public transport (IPT). Pramanik et al. (2023) showed that IPT plays an important role in meeting daily mobility needs (Pramanik et al., 2023). A notable IPT mode is the electric three-wheelers, locally called an “easy bike,” first introduced around 2004 and fully marketed by 2008 (Awal et al., 2019). These battery powered auto rickshaws have become widespread due to their lower operating costs, zero tailpipe emissions, and passenger friendly service. Present estimates suggest that roughly one million such vehicles operate across Bangladesh, serving as a vital last-mile transport mode for low and middle-income residents (Awal et al., 2019).

However, E3Ws carry few passengers and often move slowly. Although each E3W is small and can maneuver in tight spaces, having so many of them actually lowers the road’s effective capacity. Several E3Ws might carry the same number of passengers as a couple of public transport such as minibuses, yet these E3Ws take up much more space on the roadway collectively. A study conducted on Chowrasta intersection (one of the key intersection of Gazipur City) indicates that over 54% of commuters in Chowrasta lose 4–5 hours daily because of roadway blocking by these E3Ws, where E3Ws were identified as a key cause of delay (Siraj et al., 2023). Similarly, another study on Gazipur Chowrasta confirmed that congestion was severe due to heterogeneous traffic and land use pattern, with buses, trucks, cars, rickshaws, and E3Ws competing for limited road space (M. K. Hossain et al., 2019). Electric three-wheelers, frequently stopping in active lanes for passenger boarding or parking, which disrupts traffic flow. This is intensified by the drivers characteristics: a large proportion have no formal training, and aggressive driving is common in the pursuit of higher trip numbers. This was reported by a study in the South Asian region, along with the information that only 18.7% of three-wheeler drivers were trained by certified instructors (Tharamasinghe et al., 2021). Such behaviors not only increase congestion but also elevate road safety risks.

In a Bangladesh study, Nurunnahar et al. (2022) found that concerns over accident rates have led policymakers to consider strict regulations, including potential bans on battery powered three-wheelers. The authors added that electric three-wheelers, though free from tailpipe emissions, indirectly worsen air quality by intensifying congestion, which increases delay time and pollutant emissions compared to other vehicles (Nurunnahar et al., 2022). Another Bangladesh study revealed that current E3Ws designs are prone to accidents and frequently cause traffic congestion (Hossain et al., 2023).

In the above context, the Shibbari intersection in Gazipur is a prime example where E3Ws dominate the traffic composition, reducing roadway capacity and safety and creating environmental and operational challenges. Considering the problems discussed earlier, this research suggests a solution through modal shift from E3Ws to Minibuses to ease traffic flow at the aforementioned intersection. Modal shift refers to changing travel from one mode of transport to another in this context, from low-occupancy vehicles to high-occupancy transport modes. This shifting towards higher-capacity vehicles offers multiple benefits such as it reduces the number of vehicles on the road, minimizes congestion, and improves overall roadway efficiency. For example, a study on Dhaka found that moving even 20–40% of car commuters to public buses could increase average traffic speeds by about 10–21% while significantly cutting travel delays (Rahman et al., 2020).

However, modal shifting scenario in developing countries like Bangladesh is very hard to achieve and corresponds significant challenges. In Dhaka, Aktar et al. (2024) found that due to poor bus reliability, comfort and safety, many commuters abandon public transport in favor of motorbikes and paratransit such as E3Ws causing bus ridership to fall sharply (Aktar et al., 2024). Therefore, it is very important to ensure the safety, comfort of passengers in high occupancy vehicles to make them shift towards minibuses from E3Ws. Successful modal shift therefore requires not only introducing high-occupancy vehicles but also implementing supportive infrastructure and policies, along with efforts to change commuter behavior. Studies indicate that passengers are indeed willing to shift if such conditions are met. For example, about 75% of surveyed travelers in Dhaka said they would consider using a new mass transit option if it is comfortable, timely, and reasonably priced (Aktar et al., 2024).

A microsimulation model will be used to test how modal shift scenario influence overall traffic performance. Microsimulation is a powerful tool to model heterogeneous traffic conditions where analytical methods fail. PTV VISSIM is one of the most widely used software in Bangladesh, applied in intersection modelling, bus lane scheme studies, and interchange feasibility evaluation (Mashrur, 2018) (Chowdhury, 2019). Many authors emphasize adjusting Wiedemann parameters in drivers behavior such as CC0 (standstill distance) and CC1 (headway time) to reflect short headways and aggressive maneuvers for proper calibrations (Sadat et al., 2024). On one hand, poor calibration can lead to 30% misestimation of delays, on the other hand well-calibrated models reproduce observed queue lengths and travel speeds with high reliability (Acharya et al., 2023). The author also added that, empirical validations show that with proper calibration, VISSIM can replicate field delays, queues, and speeds with high accuracy, often achieving acceptable GEH statistics for turning volumes (Acharya et al., 2023). Therefore, proper calibration is a must for microsimulation study and hence in this study the model of Shibbari intersection is well calibrated with Florida Department of Transportation (FDOT) guidelines. Studies with VISSIM in Bangladesh demonstrate that interventions such as bus-priority schemes and grade separated interchanges reduce delays by 20–40% in simulation environments (Akter, 2019) (Mashrur, 2018). These outcomes confirm that microsimulation provides a reliable platform for evaluating operational improvements in mixed traffic conditions. Key findings from the literature can be summarized as (i) E3Ws are a dominant contributor to congestion, lowering speeds, and increasing delays (ii) Modal shift improves traffic flow, reduces delays, and lowers emissions (iii) Microsimulation, especially VISSIM, is an effective tool for evaluating such interventions under heterogeneous conditions.

With having several microsimulation studies conducted over Bangladesh, studies on modal shift specially in Gazipur context remain limited. Modal shifting scenario evaluation through commuters, drivers questionnaire survey and the outcomes are justified through microsimulation modelling is scarce in Bangladesh. So, this study addresses that gap by modeling the Shibbari intersection with integrated approach of questionnaire survey and calibrated microsimulation model evaluation. The objectives of this study are

1. To explore commuter willingness to adopt minibuses in lieu of E3Ws for better traffic flow.
2. To identify E3Ws drivers behavioral impact on traffic congestion.
3. To test the modal shift scenario outcomes on traffic flow through microsimulation modeling.

2. METHODOLOGY

In this study, the overall research methodology consists of several structured steps. At the very first stage, the objectives of the study were defined. Then, field data including road geometry, traffic volume, E3W occupancy, and GPS-based speed data were collected. Questionnaire surveys were also carried out to explore commuter needs and driver behavioral impacts. Next, a microsimulation model was developed and calibrated in PTV VISSIM to represent real traffic conditions. Modal shift scenario was created and tested to find out the justification of the intervention.

2.1 Study Area

The study was carried out at the Shibbari intersection in Gazipur city, Bangladesh. The Gazipur district located approximately between 23°53'–24°21' N latitude and 90°09'–92°39' E longitude, placing it near the center of Bangladesh (M. K. Hossain et al., 2019). Shibbari intersection is about 37 km north of central Dhaka City. This location connects industrial-residential zones and contributes to high traffic volumes, making it a relevant case for congestion analysis. The geographic location has been showed in the Figure 1.



Figure 1: Birds eye view of the study area: Shibbari Intersection

2.2 Data Collection

Data collection in this study was definitely a challenging task as Traffic volume was taken manually. Alongside traffic volume, vehicle composition, road geometry, E3W occupancy for all type of auto rickshaws (6 persons, 4 persons and 2 persons capacity type vehicles) were taken into consideration. Traffic volume was taken during morning (8:00 AM–10:00 AM) and evening (4:00 PM–6:00 PM) peak hours (M. K. Hossain et al., 2019). Intersection layout and segment lengths were measured using basic instruments like measuring tapes. Additionally, GPS-based logger data was used to find desired speed distribution of several vehicles. These collected data played a vital role in developing the VISSIM model that represents existing traffic conditions realistically. Further discussion of the data collection, is presented in below.

2.2.1 Road Geometry and Vehicle size measurements

Geometric features of the study area such as road width, number of lanes and lane width were measured directly from the field. These measurements provided essential inputs for developing the microscopic simulation model. The collected intersection approach details are summarized in Table 1.

Table 1: Geometric Features collected from field

Features	Towards							
	Shimultoli			Railgate		Chowrasta		
Road width (ft)	22	22	32	24	32	22	22	30
Lane width (ft)	*L-10	*L-10	16	12	16	11	11	15
	*R-12	*R-12						
No of Lanes	2	2	2	2 (BRT)	2	2	2 (BRT)	2

*L = Left Lane, R= Right Lane

Different vehicles that pass through the intersection were also examined to note their dimensions. This procedure included all types of vehicles that travels through the study area. Table 2 shows the outcomes of this process.

Table 2: Vehicle's physical dimension collected from field

Vehicle Type	Length (m)	Width (m)
Rickshaw	2	1.2
CNG	2	1.5
Leguna	3.5	1.5
Bicycle	1.8-2	0.5
Bike	1.45-1.8	0.5
Car	4.11-4.88	1.8
Truck	6.31-10.21	1.5
Bus	11.54	2
E3W two persons capacity	2.5	1
E3W four persons capacity	2.3	1.2
E3W six persons capacity	2.8	1.2

2.2.2 Traffic Volume and Composition Data

During the identified peak hours of the day, traffic volume was recorded manually as mentioned earlier in section 2.2. Observations were made for both morning (8:00–10:00 AM) and evening (4:00–6:00 PM) peaks to ensure a realistic understanding of existing operating conditions. For vehicle composition, it was found that total eleven types of vehicles run through Shibbari intersection. The share percentage of these vehicles will be discussed in the result section.

2.2.3 Passenger Occupancy Analysis for Modal Shift

For all types of E3Ws approaching the Shibbari intersection, the commuter occupancy analysis was carried out. The required sample size was calculated using the formula simplified by the NIST/SEMATECH e-Handbook (2023) to ensure statistical reliability, where the population standard deviation (σ) is known (NIST/SEMATECH, 2023):

$$N = \left(\frac{Z_{1-\alpha/2} \times \sigma}{E} \right)^2$$

Using a 98% confidence level ($Z = 2.33$), an assumed standard deviation (σ) of 0.40, and a margin of error (E) of 0.05, the calculation gives:

$$N = \left(\frac{2.33 \times 0.40}{0.05} \right)^2 = 347.50 \approx 350$$

Therefore, a minimum 350 E3Ws per category must be taken for maintaining the statistical reliability requirement. In this study around 360 E3Ws were taken into consideration. This analysis provided the

basis for estimating the average occupancy factors used in modal shift evaluation. Table 3 represents the occupancy factors for each individual E3Ws types as per their field occupancy analysis.

Table 3: Occupancy factors identified for different E3Ws

Direction	Occupancy Factor		
	E3W (6 persons)	E3W (4 persons)	E3W (2 persons)
From Shimultoli	0.24	0.22	0.4
From Railgate	0.65	0.61	0.492
From Chowrasta	0.42	0.393	0.38

Once the occupancy factor identified, the authors determined the modal shift pattern. For this, an average minibus occupancy of nine passengers (50% of its total 18-seat capacity) was assumed. The main theory applied in this study for modal shift is that the total number of passengers currently carried by all types of E3Ws should be equivalently accommodated by minibuses. Hence:

$$\text{Total passengers in all E3Ws} = \text{Total passengers in minibuses}$$

The required number of minibuses replacing E3Ws was determined using the following formula:

$$\text{No. of minibuses} = \frac{(\text{Occupancy of E3W} \times \text{Capacity of E3W} \times \text{No. of E3Ws})}{(\text{Minibus occupancy} \times \text{Minibus capacity})}$$

2.2.4 Dynamic Parameters

GPS Logger application was used to determine the desired speed distribution of vehicles. For proper calibration of real scenario into VISSIM, these speed distribution curves impact highly. Using this software, the authors recorded real-time data on speed for all types of E3Ws and minibuses operating at the study area illustrated on Figure 2. The desired speed distributions for the remaining vehicle categories were adopted from a previous study conducted on Bangladesh (Mashrur, 2018).

A summary table (Table 3) of collected field data and simulated model outputs is presented below for better understanding.

Table 3: Summary of Data Collection

Major Category	Data Type
Network Data	1. Roadway width
	2. Lane numbers
	3. Connectors between links to model turning movements.
Traffic Volume Data	1. Through and turning traffic volume counts.
	2. Vehicle composition.
	3. Vehicle length.
Speed Data	1. Desired speed (Through GPS logger)
	2. Operating Speed
Occupancy Data	1. E3W 6 persons occupancy
	2. E3W 4 persons occupancy
	3. E3W 2 persons occupancy
Vehicle Stoppage Data	E3Ws Stoppages in the intersection
	1. Queue Delay
Model Data	2. Average Speed (Arithmetic and Harmonic)
	3. Vehicle Delay and Stop Delay
	4. Level of Service (LOS)

2.3 Questionnaire Design and Evaluation of Driver Attributes

In parallel with field data collection process, questionnaire surveys were applied to gather perspectives of commuters and driver behavior data. Commuter interviews covered topics such as

causes of congestion by E3Ws, instances of illegal parking and erratic driving, and opinions on possible interventions (e.g. Policy improvement, stricter law enforcement, driver characteristics and perceptions on modal shifting scenario). Each driver’s self-reported frequency of six aggressive-driving behaviors have been collected through a structured questionnaire survey. These behaviors were rated on a four-point scale (“never” to “always”), with scores 1–4 assigned respectively. This method follows previous studies that surveyed three-wheeler drivers for demographic and behavioral information (Tharamasinghe et al., 2021). After data collection, each driver’s responses to the six behavior questions were summed and converted to a percentage of the maximum possible score, yielding a “drive-mode” score for that driver (Tharamasinghe et al., 2021). This score reflects the driver’s overall contribution to congestion (higher scores indicate more frequent aggressive behaviors). Drivers were then classified into categories: Unsafe (score $\geq 60\%$), Ordinary Safe (45–60%), and Safe ($< 45\%$) (Tharamasinghe et al., 2021). Drivers with incomplete answers were labeled “undefined.” This approach was adopted to find how many drivers are prone to congestion with respect to their behavioral impacts.

2.4 Development of Simulation Model in VISSIM

After collecting the required field data, a microscopic model of the study area was coded using PTV VISSIM (Thesis) 2025 (SP 10), to represent the traffic and driving behaviors at the intersection and evaluate the performance of the proposed modal shift intervention. To evaluate traffic performance for the Shibbari intersection, two simulation scenarios were developed such as existing traffic (base condition), and modal shift to minibuses senario and analyzed. Before developing and analyzing the modal shift scenario, the base model was calibrated and validated with field data to represent real conditions.

3. RESULTS

The outcomes are analyzed and discussed with connection to the objectives of this research most importantly the impacts of modal shift from electric three-wheelers to minibuses. Questionnaire outcomes on commuter perceptions and drivers’ behavior will be discussed in this section with a relation to the research’s main goal. Several performance indicators such as mean speed, queue length, vehicle delay and stopped delay have been compared for the efficiency evaluation of modal shift intervention. This results section will also provide a detailed interpretation of outcomes, highlighting how modal shift scenario influences traffic flow improvement under mixed-traffic conditions.

3.1 Stakeholders’ Interview Results

The questionnaire survey on commuters revealed that only 20% of the respondents feel safe riding in E3Ws. However, 45% of the commuters have to use these vehicles on a daily basis.

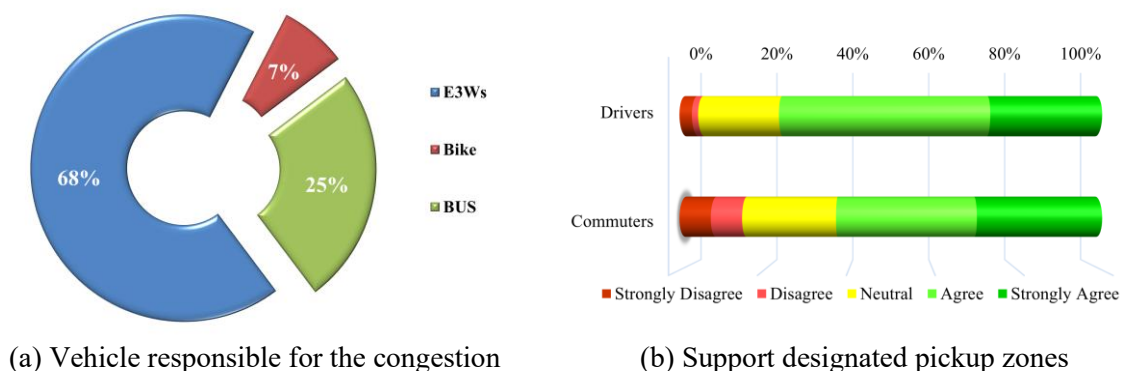


Figure 3: Stakeholders’ responses and recommendations

Approximately 68% commuters identified E3Ws as the main vehicle for causing delay at the study area with respect to Bus and Bikes. Figure 3(a) illustrates vehicles responsible for the congestion at Shibbari. For survey, the authors have used three types of vehicles due to the fact that these vehicles are highly available at the study area. For policy improvement strategy, the commuters recommended to incorporate designated pickup zones and strict law enforcement at about 60% and 80% respectively Figure 3(b). Commuters, when asked for modal shifting approach, most of them favored minibuses replacing E3Ws over buses, CNGs, or bikes, by roughly 69%. A majority of the commuters also reported that E3Ws drivers rarely comply with traffic rules, reinforcing the link between driver behavior and congestion.

Table 4 summarizes six aggressive behaviors associated with drivers. Notably, more than half of the respondents reported often or always engaging in high speed, aggressive overtaking, and dangerously close following. These aggressive driving patterns are important contributors to intersection congestion and safety risk, as documented in regional studies of three-wheeler operations (Tharamasinghe et al., 2021). Together, the socioeconomic pressures, limited training, and habitual risky behaviors form a behavioral profile that helps explain the operational disruptions observed at Shibbari. Overall, these aggressive behaviors are key factors for generating congestions (Kazi and Mohammadreza, 2020).

Table 4: Aggressive behaviors of electric three-wheeler drivers

Factors	Never(%)	Seldom(%)	Often(%)	Always(%)
Use horn aggressively	18	48.20	23.02	10.07
Following another vehicle too closely	12.23	35.25	34.53	16.55
Improper Lane change	13.67	42.45	29.50	13.67
Aggressive overtaking	20.14	28.78	30.22	20.14
High Speed	8.63	33.09	38.13	18
Shouting at others	28.78	25.18	35.25	10.79

Table 5 presents the driving conditions of drivers determined from their response of aggressive behaviors questionnaire. Statistical analysis revealed that only 13.95% of drivers can be classified as safe and less likely to contribute to congestion. In contrast, the majority of drivers exhibit aggressive behaviors observed at the Shibbari intersection, indicating a higher tendency to generate congestion.

Table 5: Frequency and percentage of drivers as per their driving condition

Driving Condition	Frequency	Percentage(%)
Safe	18	13.95
Ordinary safe	50	38.76
Unsafe	61	47.29
Undefined	12	8.51

3.2 Field observations and Stoppage counts

The overall vehicle composition of the study area combining all approaches has been illustrated in a pie chart in Figure 4. Results indicates that E3Ws are the most dominant vehicle mode, more than half of the total traffic. In this context, E3Ws two-person capacity vehicles are the most found vehicle with 24.9% in the study area. E3Ws four person and six-person capacity vehicles are found at 15% and 24% respectively. In Shibbari, Motorcycles also dominates other vehicles with 12.2% of the total vehicle composition. But, heavy vehicles such as trucks and Bus occupy only small shares. This vehicle composition setup highly dictates the strong presence of the low-capacity based mixed traffic which contributes to the degradation of the overall traffic performance of the intersection.

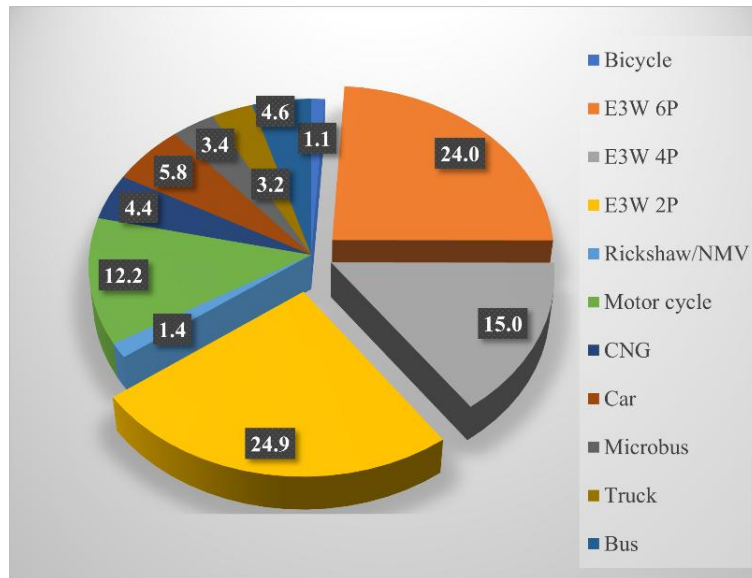


Figure 4: Vehicle composition of Shibbari intersection

The stoppage count survey revealed that three-wheelers accounted for an average of 62% of all recorded stoppages (Figure 5). This dominance can be attributed to the fact that electric three-wheelers serve as the most affordable and readily available option for last-mile and short-distance travel in the Shibbari area.

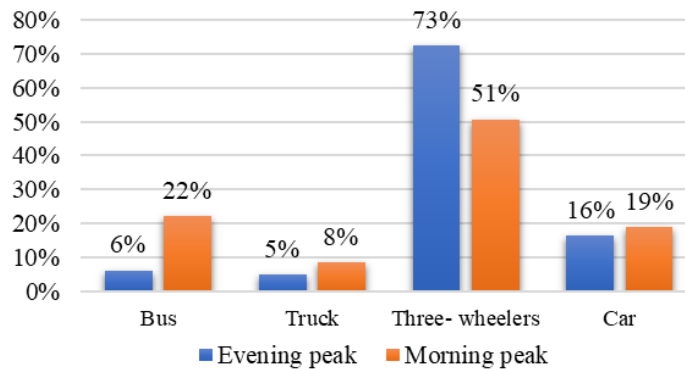


Figure 5: Stoppages count for all types of vehicles

3.3 Simulation Results for Existing Conditions

Table 4 represents the simulation results for the existing traffic conditions at the Shibbari area. From the software outcome, it is evident that the intersection faces severe congestion. Queue delay analysis at the intersection dictates that the vehicles moving from Shibbari towards Chowrasta experiences largest queue delays of 32.54 seconds. All approaches experience large queue delay while exiting the intersection as compared to entering the intersection. Average Speed (arithmetic) of the vehicles are similar (ranging from 17.23 km/h to 18.65 km/h) except vehicles coming from Shimultoli to Shibbari. These vehicles have average speed of 14.1 km/h only. For harmonic average speed, the approaches followed previous trend like arithmetic mean. However, the harmonic average speed range is well below the range of arithmetic average speed. Link occupancy rate analysis revealed that vehicles coming from Shimultoli occupy almost half (47.31%) of the roadway. This high traffic pressure may be due to the drop off and pick up maneuvers near the intersection. Other than vehicles coming from Shimultoli, all other directions remain less dense if compared to the road of Shimultoli to Shibbari. These numerical indicators collectively suggest that the existing layout is operating under constrained

conditions and is experiencing measurable congestion indicating that the current intersection layout become increasingly inadequate under traffic demand and require operational improvements.

Table 4: Simulation Results for Existing Conditions.

Roadway	Queue delay (all) sec	Speed avg arith. (all) km/h	Speed avg harm. (all) km/h	Occup. rate (all)
From Shimultoli	4.22	14.1	10.79	47.31%
To Shimultoli	25.84	20.08	18.4	6.92%
From Railgate	0.31	17.23	15.8	17.82%
To Railgate	18.35	18.65	17.64	11.06%
From Chowrasta	0.19	17.11	16.22	15.74%
To Chowrasta	32.54	17.40	15.86	22.37%

3.4 Simulation Results for Modal Shift Scenario

Intervention simulation results in this research dictates that queue delay is substantially decreased from the base condition. No approach showed delay more than 14 seconds and in modal shift intervention the highest possible queue delay is 13.76 seconds for vehicles moving towards chowrasta from Shibbari. Vehicle average speed (both arithmetic and harmonic) also improved as compared to base condition. The lowest possible speed of vehicles in the intersection found 21.26 km/h which is larger than the highest possible speed of base condition. Occupancy rates of the roadways reduced significantly in the modal shift scenario where the chowrasta roadways crossed two digits of number. The overall simulation outcome of modal shift scenario has been represented in Table 5.

Table 5: Simulation Results for Modal Shift Scenario

Roadway	Queue delay (all) sec	Speed avg arith. (all) km/h	Speed avg harm. (all) km/h	Occup. rate (all)
From Shimultoli	0	22.16	21.26	9.56%
To Shimultoli	4.31	28.82	26.38	5.11%
From Railgate	0.03	24.79	23.11	7.02%
To Railgate	5.38	26.77	25.55	6.86%
From Chowrasta	0	25.01	23.34	12.47%
To Chowrasta	13.76	26.12	23.81	12.64%

3.5 Comparative Analysis of Scenarios

Two of the scenarios have been compared with respect to delays (Vehicle delay and Stopped delay). The comparison has been represented on a bar diagram Figure 6 (a) below. From the software output, it is seen that, vehicle delay has been reduced by 82.43% (121.58 sec to 21.36 sec) by incorporating modal shift intervention. A similar improvement observed for stop delay. Stop delay was 71.65 seconds for base conditions but it reduced to only 8.07 seconds if minibuses being incorporated at Shibbari. These reductions indicate a major improvement in overall traffic performance. The significant drop in both vehicle delay and stop delay confirms that shifting to an E3W-based minibus system effectively supports the objective of reducing congestion by improving traffic flow efficiency and lowering intersection delays.

Furthermore, the graph presented in Figure 6(b), clearly shows that replacing E3Ws with minibuses at the Shibbari intersection results in a significant reduction in overall traffic volume entering the critical approaches.

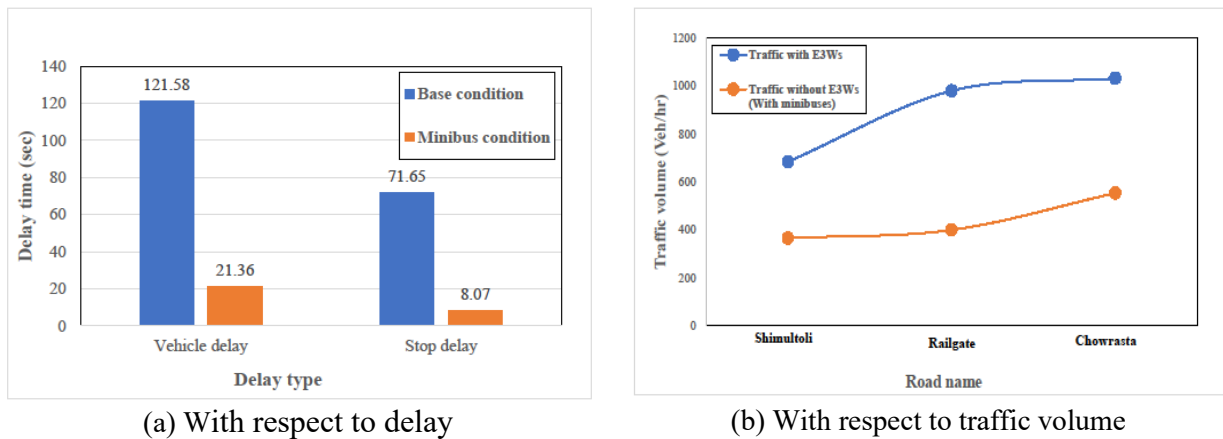


Figure 6: Comparative Analysis of Scenarios

At Shimultoli, traffic volume decreases from 684 veh/hr under the E3W condition to 365 veh/hr when minibuses are introduced. A similar reduction is observed at Railgate, where the volume drops from 980 veh/hr to 399 veh/hr, and at Chowrasta, where it decreases from 1032 veh/hr to 553 veh/hr. Therefore, the intervention of modal shift from E3Ws to minibuses significantly reduces traffic from Shibbari intersection and smoothen the traffic flow.

4. CONCLUSIONS

Based on the study's findings, the following conclusions and recommendations have been drawn:

- Commuters interview results suggest that E3Ws are unsafe and congestion prone vehicle and they recommended policy improvement strategy, strict law enforcement and modal shifting to minibuses.
- Drivers' questionnaire revealed that more than half of the E3W drivers are engaging in high speed, aggressive overtaking and risky car following approaches. Also, nearly 50% of the drivers are unsafe and contributing directly to congestion.
- Field observation showed that E3Ws have the most share of the total vehicle types available at Shibbari and these have high stoppage rates. This particularly addresses the factor of E3W being a congestion generating vehicle at this intersection.
- Simulation results dictates that modal shifting scenario overtake base scenario by reducing delay, increasing speed and removing large share of vehicles from the roadway appreciably.
- Overall, the findings indicate that E3Ws significantly contribute to congestion at urban intersections, compounded by drivers' aggressive behaviours and manoeuvres. This study recommends modal shifting from E3Ws to Minibuses and improving the policy guidelines to mitigate congestion at Shibbari. Future research should consider other intervention such as grade separated interchange and signal optimization approach at this intersection to alleviate congestion.

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DECLARATION OF USE OF AI

The authors declare that no artificial intelligence (AI) tools were used in the preparation of this manuscript, including the research methodology, technical analysis, logical reasoning, or writing.

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