

Operational Challenges of Electric Three-Wheeler Vehicles at Urban Intersection: A Case Study on Traffic Behavior and Congestion Factors

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Abstract

Electric three-wheelers (ETW) in Gazipur city are widely used for short trips and have been linked to increased congestion at key junctions. Understanding driver behavior and operational challenges can improve traffic flow, but research on the Shibbari intersection is limited. This study aims to assess operational challenges, evaluate drivers' behavior, and examine willingness to follow rules at the Shibbari intersection. A mixed-methods approach was used, combining a reconnaissance survey, stoppage counts, over 40 stakeholder interviews, and a questionnaire of 141 drivers on their demographics, careers, habits, and aggressive behavior. ETW accounted for about 62% of stoppages in peak hours, primarily due to random roadside halts and poor lane discipline. About 73% drivers had no formal training. Over 46% completed 20+ trips daily and often stopped on active lanes. Through statistical analysis, it has been seen that more than 47% drivers are increasing congestion rates based on their aggressive behavior. Drivers with other professional skills, stand registration, and non-smoking status were found to be the safest. Police and residents reported illegal parking as the most common violation; 68% of commuters identified three-wheelers as a major cause of delay with highlighting a modal shift towards minibuses. Certified training, stand registration, designated pickup zones, and controlling the smoking habit of drivers could substantially reduce congestion at Shibbari.

Keywords: Electric three wheelers; Intersection congestion; Driver behavior; Stoppages; Pickup zones.

1 Introduction

The rapid pace of urban growth in developing countries such as Bangladesh has generated unusual travel demand, creating significant pressure on city road networks (Cervero and Golub, 2007). Roadways in Bangladesh carry a highly mixed traffic stream, including buses, trucks, cars, auto-rickshaws, and non-motorized vehicles, often without strict lane segregation (Hossain et al., 2019). In many urban areas, the formal public transport system is limited, and informal paratransit often referred to as intermediate public transport (IPT) plays an essential role in meeting daily mobility needs (Pramanik et al., 2023). A notable IPT mode is the electric three-wheeler, locally called an "easy bike," first introduced around 2004 and fully marketed by 2008 (Awal et al., 2023). These battery powered auto rickshaws have become widespread due to their lower operating costs, zero tailpipe emissions, and passenger friendly service (Hossain et al., 2023; Rahman et al., 2023). 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., 2023).

Gazipur City, located just north of Dhaka, faces severe traffic congestion (Siraj et al., 2023). Key intersections, such as the Chowrasta and Shibbari, experience prolonged delays; for instance, surveys at Chowrasta indicate that about 54% of commuters lose 4–5 hours daily due to traffic blockages (Siraj et al., 2023). Electric three-wheelers contribute significantly to this problem, frequently stopping in active lanes for passenger boarding or parking, which disrupts traffic flow. Underlying driver practices intensify the issue: 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 recent years, concerns over accident rates have led policymakers to consider strict regulations, including potential bans on battery powered three-wheelers (Nurunnahar et al., 2022).

Similar challenges have been documented across South Asia. Tharamasinghe et al. (2021) identified three-wheelers as a major contributor to congestion in Sri Lanka and proposed solutions such as formal driver training and designated parking zones (Tharamasinghe et al., 2021). Hossain et al. (2023) likewise reported that current electric three-wheeler designs are prone to accidents and frequently cause traffic disruption (Hossain et al., 2023). In Bangladesh, studies on Gazipur intersections (Hossain et al., 2020; Siraj et al., 2023) have mainly

examined traffic composition and volume rather than the specific operational and behavioral aspects of electric three-wheeler drivers. While recommendations such as licensing, stand registration, and formal boarding points have been discussed (Tharamasinghe et al., 2021), empirical evaluation in actual intersection environments remains scarce.

This research addresses that gap by focusing on the Shibbari intersection in Gazipur. Specifically, it examines how driver demographics, training backgrounds, and behavioral tendencies influence congestion and traffic, as well as drivers' willingness to comply with regulatory measures. The objectives are to:

1. Assess operational issues of electric three-wheelers at Shibbari, including mid-lane stops, lane discipline, and their impact on congestion.
2. Evaluate driver characteristics and aggressive behaviors affecting traffic flow.
3. Explore willingness to adopt regulated practices such as formal training/licensing and designated pickup/drop-off zones.

2 Methodology

2.1 Study Area

The study was carried out at the Shibbari Intersection in Gazipur City, Bangladesh. Gazipur is an industrial hub located north of Dhaka, hosting numerous factories, offices (both government and private), and educational institutions. The Gazipur district spans approximately 23°53'–24°21' N and 90°09'–92°39' E, placing it near the center of Bangladesh (Hossain et al., 2019). Shibbari Intersection is about 37 km north of central Dhaka. This strategic urban location connects major highways and contributes to high traffic volumes, making it a relevant case for congestion analysis. The geographic location has been showed in the Figure 1.

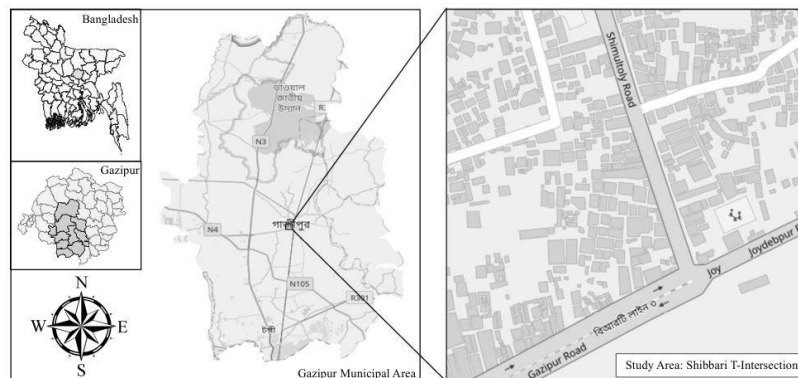


Figure 1. Shibbari Intersection as the study area.

2.2 Reconnaissance Survey and Data Collection

A reconnaissance (field observation) survey was first conducted to understand traffic patterns and problematic behaviors at the intersection. Observers visited the site during two daily peak periods (8:00–10:00 AM and 5:00–7:00 PM) to record vehicle stoppage counts and identify issues related to congestion due to three-wheelers. A “stoppage” was defined as a vehicle halting to pick up or drop off passengers, waiting informally, or obstructing an active travel lane near the intersection. At each approach of the intersection, all vehicles (buses, trucks, cars, three-wheelers, etc.) were counted in terms of stoppages during the visit, and instances of stoppages were manually recorded. These vehicle stoppage counts were made using standard manual counting techniques. The counted data allow quantification of how often different vehicles interrupt flow due to passenger loading or waiting on the roadway.

2.3 Questionnaire survey and Statistical Analysis

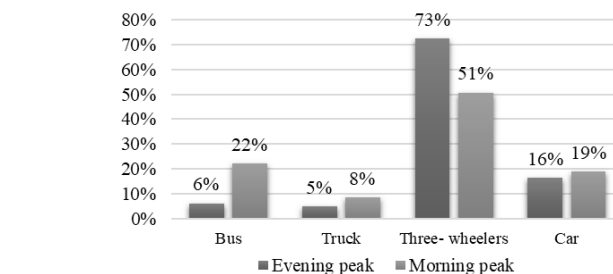
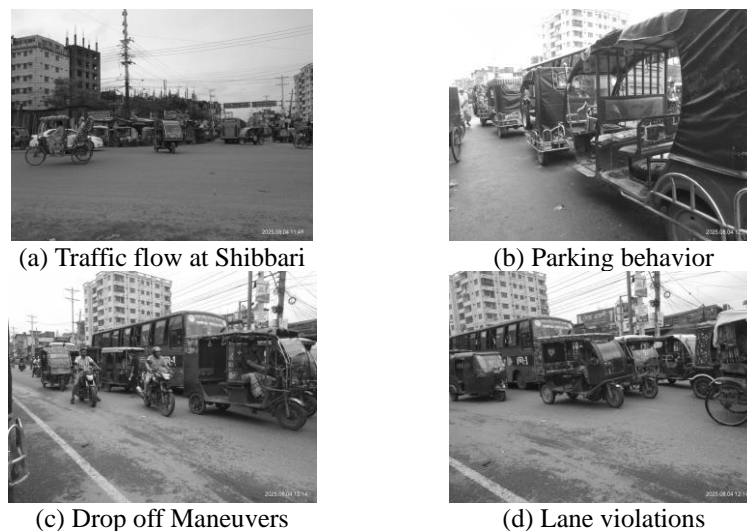
In parallel with field counts, a structured questionnaire survey was administered to gather perceptions from stakeholders and driver behavior data. Three groups of stakeholders were interviewed: local traffic police, commuters and nearby residents (to learn about congestion causes and complaints). Stakeholder interviews covered topics such as causes of congestion by three-wheelers, instances of illegal parking and erratic driving, and opinions on possible interventions (e.g. clearer signage, designated pickup/drop-off zones, driver education, or stricter law enforcement). The driver questionnaire collected each driver's demographic and career information (age, experience, training, etc.), personal habits, and self-reported frequency of six aggressive-driving behaviors. These behaviors were rated on a four-point scale (“never” to “always”), with scores 1–4 assigned respectively. This approach follows prior 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.” These drive-mode categories formed an ordinal dependent variable in the statistical analysis. All analyses were performed in IBM SPSS (v.27). First, descriptive statistics were compiled, and then a stepwise ordinal logistic regression (OLR) was run with drive-mode as the outcome variable. Other driver attributes (age, smoking habit, support training, etc.) were used as independent predictors. Insignificant predictors were removed sequentially, retaining only variables significant at the 95% confidence level.

3 Results and Discussion

3.1 Field observations and Stoppage counts

At the study site, several congestion factors were noted, including informal stops, illegal parking, improper drop-off maneuvers, and inconsistent lane use. A large presence of three-wheelers was evident at Shibbari intersection. Figure 2(a) illustrates that three-wheelers dominate the vehicle mix at this junction. Figure 2(b) shows electric three-wheelers parked on the curb lanes (left lane in both directions), a pattern attributable to the absence of designated parking areas and weak regulatory enforcement. Poor passenger drop-off practices were frequently observed among three-wheeler drivers (Figure 2(c)).



(e) Stoppages count for all types of vehicles

Figure 2. Identified traffic congestion related issues due to three-wheelers. Numerous lane-violation incidents also occurred at the intersection (Figure 2(d)). Such lane-violating behavior is likely linked to driver characteristics and operating incentives. The stoppage count survey revealed that three-wheelers accounted for an average of 62% of all recorded stoppages (Figure 2(e)). 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.

3.2 Stakeholders' Interview Results

The commuter survey indicated that only 20% of respondents feel safe riding in three-wheelers, despite 45% using them daily. Approximately 68% of commuters identified electric three-wheelers as a principal cause of delay, primarily attributing this to random passenger pickups and lane violations (Figure 3(b)). Regulatory responses designated pickup zones and strict law enforcement received strong support, at about 60% and 80% respectively (Figure 3(a)). When asked for mode alternatives, most commuters favored minibuses over buses, CNGs, or bikes, with minibuses chosen by roughly 69%. A majority also reported that three-wheeler drivers rarely comply with traffic rules, reinforcing the link between driver behavior and congestion. Interviews with traffic police and local residents corroborated commuter concerns: over 85% reported that three-wheelers frequently cause congestion, and more than 75% observed illegal parking as a recurring problem. Close to 70% of local stakeholders endorsed designated pickup zones as the most effective intervention. Strong backing for stricter enforcement was also expressed, aligning with the study objectives to regulate driver behavior and enhance traffic flow at Shibbari.

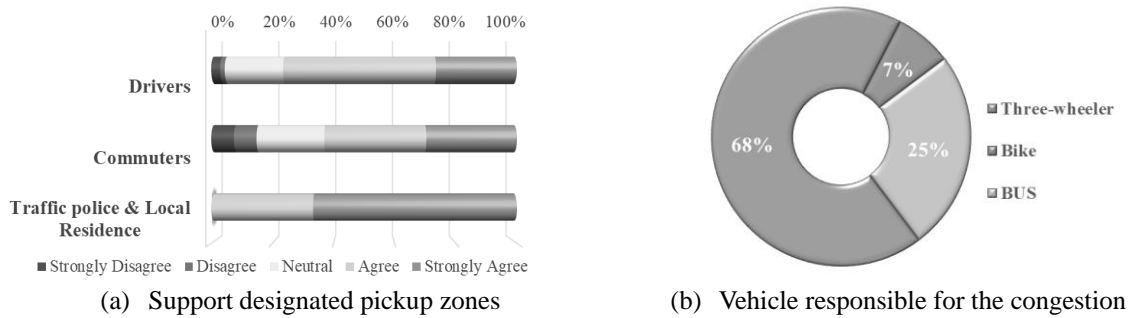


Figure 3. Stakeholders' responses and recommendations

3.3 Effect of three-wheeler drivers' behavior

Driver demographic data show that most operators are over 30 years old and have educational attainment below the Secondary School Certificate (SSC) level. Daily earnings commonly range from 500–1500 BDT, and more than 84% of drivers support five or more family members; consequently, many must operate their vehicle daily to meet household needs. Over 69% reported no alternative professional skills (e.g., plumbing, electrical work). Regarding career and ownership, only 36.69% of drivers own the electric three-wheelers they operate. Formal training is scarce: around 73% had no certified instruction, and 46% complete more than 20 trips per day, a high trip frequency likely driven by income targets. Personal habit assessment showed that smoking is widespread and troublingly, over 27% admitted to smoking while driving.

Table 1 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 1. 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

Based on the methodology of this study, the dummy variable “drive mode” was determined for each three-wheeler driver, as presented in Table 2. 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.

Subsequent analysis using SPSS was conducted to correlate driver behavior with the drive mode through Ordinal Logistic Regression (OLR). A stepwise logistic regression approach was applied, and statistically insignificant

variables were excluded from the model. A variable was considered statistically significant when its sig.-value was less than 0.1 (sig. < 0.1).

Table 2. Frequency and percentage of drivers as per their drive mode

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

When multiple variables belonged to the same parameter category, the one with statistical significance (sig. < 0.1) was retained in the model (Chowdhury et al., 2018). In this study, the OLR procedure identified six variables as statistically significant; the results are summarized in Table 3. In the table, Estimate denotes the log-odds change associated with a one-unit increase in the explanatory (independent) variable, while Exp (log odds) gives the corresponding odds ratio. The odds ratio therefore indicates the multiplicative change in the odds for a one unit increase in the predictor, holding all other variables constant.

Table 3. Parameter estimation results from SPSS analysis identifying driver habits associated with congestion.

SL No	Independent Variable	Values from SPSS			Comment
		Estimate (log odds)	Exp(log odds)	Sig.	
1	Professional Skill				
	Yes	-0.826	0.44	0.024	Significant
No	0 ^a				
2	Registered at stand				
	Yes	-0.946	0.39	0.037	Significant
No	0 ^a				
3	Driving Experience				
	Less than one year	-0.694	0.50	0.283	Significant
	One year	-0.796	0.45	0.052	
	4-7 years	-0.792	0.45	0.112	
More than 7 years	0 ^a				
4	Driving after having Alcohol				
	Never	0.204	1.23	0.795	Significant
	Seldom	0.570	1.77	0.529	
	Often	2.434	11.41	0.066	
Always	0 ^a				
5	Smoking				
	Never	-1.603	0.20	0.005	Significant
	Seldom	-1.002	0.37	0.044	
	Often	-0.368	0.69	0.494	Significant
Always	0 ^a				
6	Willingness for Training				
	Strongly Disagree	-1.154	0.32	0.543	Significant
	Disagree	0.284	1.33	0.717	
	Neutral	-1.154	0.32	0.036	
	Agree	-0.261	0.77	0.532	
Strongly Agree	0 ^a				

From the summarized table (Table 3), it is evident that drivers possessing other professional skills exhibit lower odds ratios, indicating they are less likely to fall into higher drive modes (progressing from safe to ordinary safe to unsafe). This tendency may result from vocational or related skills that enhance decision-making and vehicle control, thereby minimizing risky maneuvers that contribute to congestion.

Similarly, drivers with stand registration are less inclined toward higher drive modes, as statistical analysis revealed that 61% of them are less likely to be unsafe compared to those without registration. This suggests that registration fosters a sense of responsibility and accountability in their driving behavior. Furthermore, non-smokers were significantly less likely to be unsafe (Exp(log odds) = 0.20, sig. = 0.005), and seldom-smokers also demonstrated lower odds (Exp(log odds) = 0.37, sig. = 0.044). Smoking appears to be associated with other risk-taking tendencies or distractions, making smoking status a potential behavioral indicator of unsafe driving.

4 Conclusions

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

- a) Electric three-wheelers showed high stoppage rates and are widely reported as a major source of congestion by most of the stakeholders. This particularly addresses the factor of three-wheeler being a congestion generating vehicle at this intersection. Designated pick-up/drop-off zones and strict law enforcement can solve this.
- b) Lack of proper parking leads to curbside parking. This negatively impacts roadway capacity and traffic flow. Therefore, dedicated parking facilities are needed.
- c) Key congestion-related driver factors include professional skills, stand registration, and smoking habits are identified.
- d) Most stakeholders support certified training, stand registration, law enforcement, and designated pick-up zones to improve traffic flow.
- e) Overall, the findings indicate that electric three-wheelers significantly contribute to congestion at urban intersections, compounded by drivers' habitual behaviors and maneuvers. This study recommends certified training, stand registration, designated pickup zones, and regulation of drivers' smoking habits to mitigate congestion at Shibbari. Future research should consider vehicle parking methods and traffic volume analysis.

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