Impact of a Dedicated Bicycle Lane at a Selected Intersection

Anika Tahsin, Ahmed Ferdous Nafis, and Nasir Uddin Ahmed

Abstract This study aims to evaluate the impact of a separated bicycle lane in Gulshan, an upscale district in Dhaka city, to alleviate traffic congestion during peak hours. The demand for vehicular transportation in Gulshan is high due to its multiple foreign embassies, corporate offices and high-end commerce, resulting in a traffic capacity that often surpasses peak-hour traffic. With a modal share of 9%, bicycles were considered as a viable transportation mode. Using VISSIM model, the existing roadway configuration was compared with a roadway section that includes a separated bicycle lane, considering the level of service (LOS), travel time, queue length and greenhouse gas emissions. The introduction of a separated bicycle lane resulted in a reduced volume-to-capacity ratio (*V/C*), thus improving the LOS of the roadway section. The overall LOS of the roadway section was upgraded from E to C and queue length and greenhouse gas emissions were also reduced. The stop delay was reduced by 71% due to the removal of all non-motorized vehicles from the motorized vehicle lane, making the traffic more homogenous. Thus, the study suggests that the implementation of a dedicated bicycle lane in a busy area like Gulshan can help improve the overall traffic condition.

Keywords Bicycle lane · Traffic congestion · Volume-to-capacity ratio (*V/C*) VISSIM model · Level of service · Modal share · Queue length · Stop delay · Bicycle facility

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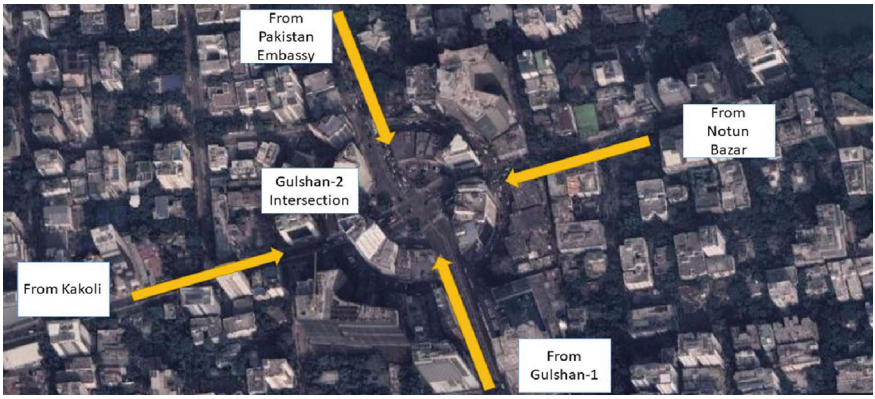

Fig. 1 Four legs of Gulshan-2 intersection

1 Introduction

Bicycles offer efficient and sustainable transportation in congested cities like Dhaka, mitigating issues such as congestion, pollution and accidents [1]. Previous studies emphasize the importance of bicycles in urban transportation, especially for the underprivileged [2]. Introduction of dedicated bicycle lane influences modal shift. Reducing private car usage by 36% can significantly decrease fuel consumption and emissions [3]. The study aims to evaluate the impact of a dedicated bicycle lane on traffic conditions at the Gulshan-2 intersection, a crucial connection in Dhaka's upscale business hub [4]. The research focuses on traffic capacity changes, flow improvement, and the volume-to-capacity ratio (*V/C*) using traffic simulation and considers a 10-year traffic forecast. The study area serves as a connection between Kakoli, Notun Bazar, Pakistan Embassy and Gulshan-1 (Fig. 1).

2 Research Methodology

This study is developed based on the following methodologies (Fig. 2). The comparison was done by determining *V/C* ratio and results from VISSIM simulation. Two models, Model 1 (with existing road condition and traffic composition) and Model 2 (with dedicated bicycle lane and modified traffic composition) were developed.

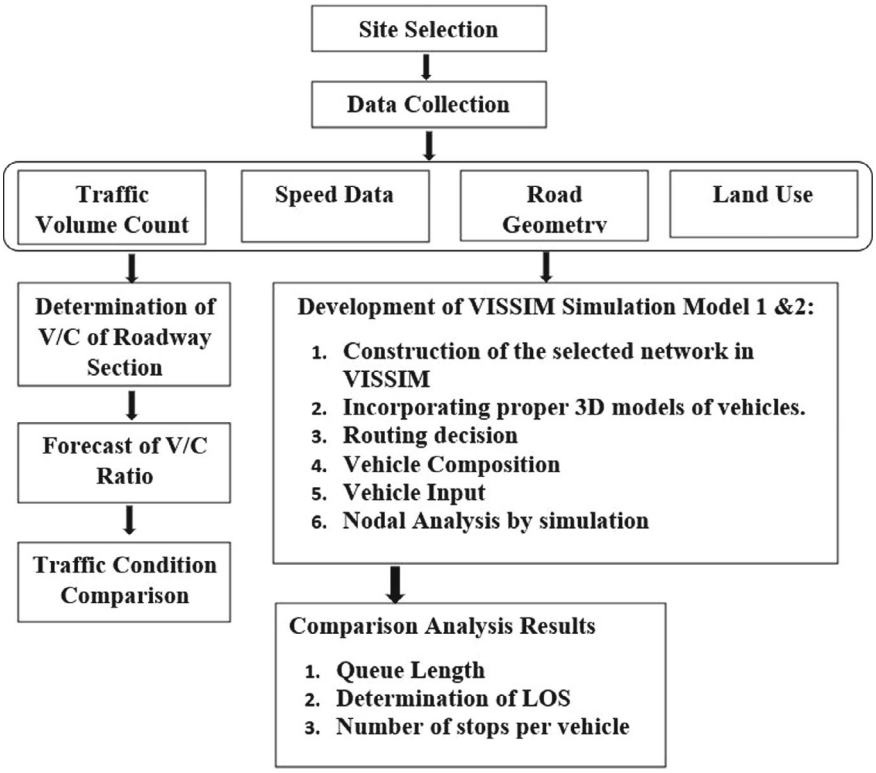

Fig. 2 Study approach

3 Data Collection

3.1 Classified Traffic Volume Data

Traffic volume data for 12 directions and 4 U-turns at the Gulshan-2 intersection were collected over a 14-h period and converted into passenger car units (PCU) with corresponding PCU values sourced from the geometric design standards manual [5]. The data included seven vehicle types, such as private vehicles (car, SUV, microbus), motorcycles, medium trucks, standard buses, bicycles, autorickshaws and rickshaws. High-definition IP-based video cameras were installed for data collection and specific camera positions were chosen to monitor traffic flow directions shown in Fig. 3. Currently, bicycles account for 9% of all modes of transportation at the Gulshan-2 intersection, as determined from the classified traffic volume data.

The overall peak hour for the study area was selected from 0900 to 1000 h according to the volume data. Microsimulation models were created using this

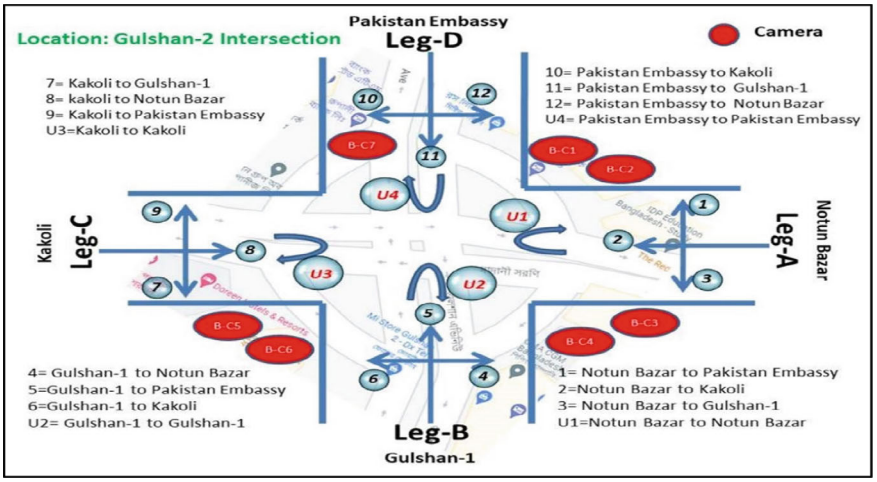

Fig. 3 Direction of traffic flow and camera positions at the intersection

Table 1 Collected volume data for each direction of the Gulshan-2 intersection

Vehicle type	PCU value	Direction 2	Direction 5	Direction 8	Direction 11
Medium truck	3	29	22	7	8
Bus	3	38	11	38	13
Microbus/car/SUV	1	243	451	141	465
Motorcycle	0.75	261	220	206	326
Autorickshaw	0.75	59	94	77	58
Rickshaw	2	22	7	10	14
Bicycle	0.5	167	28	72	97

volume data for through movement of the intersection. Table 1 provides the classified traffic volume data of the through movements for in directions 2, 5, 8 and 11 in Fig. 3.

3.2 Speed Data, Road Geometry & Land Use

Spot speed of freely moving vehicles were measured with speed gun. A sample size of 50–100 vehicles is recommended [6]. Average speeds were: car—40 m/s, medium truck—25 m/s, bus—30 m/s, motorcycle—40 m/s, autorickshaw—30 m/s, rickshaw—12 m/s and bicycle—15 m/s. Measurements of lane width, number of lanes and width of side roads were obtained through a survey. The study identified road bottlenecks occurring 350 m from the intersection on Kakoli side and

400 m before the crossing on Notun Bazar side. These observations, combined with surveyed data and analysis of the surrounding land use patterns, guided the VISSIM model.

4 Data Analysis and Results

4.1 Conversion and Forecast of Vehicle Counts to PCU/h for Both Conditions

The traffic volumes collected were forecasted using RHD recommended growth factor $(1 + r^n)$. Seven percent (7%) growth was taken for regional roads of Bangladesh [5]. Predictions were made for five and ten years following 2027 and 2032. Table 2 presents the predicted traffic volumes in PCU/h for both the existing condition and after the introduction of the bicycle lane. The results show that the traffic volume doubles in the year 2032 in both cases.

Consideration of Modal Shift: Research has shown that the implementation of dedicated bicycle lanes leads to a significant modal shift. In Albuquerque, New Mexico, over one-third of current cyclists would cease cycling without these facilities, with 33% choosing not to cycle and 26% opting for cars [7]. Despite a high percentage of Dhaka commuters (85%) knowing how to ride a bicycle, poor infrastructure and limited cycling opportunities deter their usage. Encouraging measures such as free parking and separate lanes can promote cycling [8]. This paper evaluates the overall performance of Gulshan-2 intersection with and without a dedicated cycle lane, considering mode switching. Studies indicate that the motorized to cycling modal shift is often above 20%, such as in Stockholm, where shift figures range from 31.6% to 48.7% depending on commuting time [9]. In this study, a minimum modal shift of 20% is assumed based on previous research indicating that after the implementation of bicycle lanes, 20% of private vehicles are expected to shift to bicycles (15%) and buses (5%).

Table 2 Forecasted traffic volume for existing condition and with bicycle lane

Leg	2022 PCU/h		2027 PCU/h		2032 PCU/h	
	Existing condition	With bicycle lane	Existing condition	With bicycle lane	Existing condition	With bicycle lane
Notun Bazar	1162	849	1630	1190	2286	1669
Gulshan-1	1926	1529	2702	2145	3790	3008
Kakoli	1850	1444	2595	2025	3640	2840
Pakistan Embassy	1230	839	1725	1177	2420	1651

4.2 Effect of Bicycle Lane on V/C Ratio & Traffic Condition

Geometric design standards of the roads and highways department is used to determine traffic capacity, where each side of the carriageway has a width of 9.14 m (30 ft). For 14.6 m carriageway, the maximum traffic volume is 4500 PCU/h. Thus, maximum capacity of 9.14 m width road is 2817.12 PCU/h. As the bicycle lane width is 1.52 m, motorized lane width will be (9.14–1.52) m or 7.62 m on each side. For 7.62 m, the maximum traffic volume or capacity would be 2348.63 PCU/h [5]. To have minimal impact, rickshaws and other slow-moving vehicles will be restricted to side roads dedicating cycling lane to bicycles, resulting in a modal shift of 20%.

The *V/C* ratio (in this case, V = PCU/h) shows the level of congestion on a highway by dividing the traffic volume by roadway's capacity. Traffic state and condition can be understood by *V/C* ratio. Volume-to-capacity (*V/C*) ratio ranging from 0 to 0.60 represents free-flowing traffic and from 0.61 to 0.70 indicates stable flow with unaffected speed. *V/C* ratio ranging from 0.71 to 0.80 signifies stable flow but with a decrease in speed, where ranging from 0.81 to 0.90 represents high-density stable flow. The ranges from 0.91 to 1.00 corresponds to traffic volume near or at capacity level, resulting in low speeds. Breakdown flow occurs where the *V/C* ratio exceeds 1.00 [10].

A comparison of traffic volume and *V/C* ratio of existing conditions and forecasted for the years 2027 and 2032 with that of bicycle lane in all directions of the intersection is shown in the following Table 3. In all cases, the traffic volume and *V/C* ratio considerably decrease.

Table 3 Traffic volume and *V/C* ratio of existing condition and with bike lane

Analyzed data	Notun bazar		Gulshan-1		Kakoli		Pakistan Embassy	
	Existing	Bike lane	Existing	Bike lane	Existing	Bike lane	Existing	Bike lane
PCU/h in 2022	1162	848	1926	1529	1850	1444	1230	839
V/C in 2022	0.41	0.36	0.68	0.65	0.66	0.61	0.44	0.36
PCU/h in 2027	1630	1190	2702	2145	2595	2025	1725	1177
V/C in 2027	0.58	0.51	0.96	0.91	0.92	0.86	0.61	0.51
PCU/h in 2032	2286	1669	3790	3008	3640	2840	2420	1651
V/C in 2032	0.81	0.71	1.34	1.28	1.29	1.21	0.86	0.71

4.3 *Development of the VISSIM Microscopic Simulation Model*

VISSIM was used to simulate the Gulshan-2 intersection, incorporating the left-hand traffic system of Bangladesh. The road geometry was modified to include a bicycle lane, adhering to the minimum width recommendation of 1.5 m (5 ft) according to the AASHTO Guide for the Development of Bicycle Facilities [11]. In this study, the bicycle lane width was set at 1.52 m, while the remaining two motorized vehicle lanes were 3.81 m each.

Model 1 (Fig. 4) in VISSIM is developed using geometric and vehicle data, incorporating volume and composition calculations based on collected traffic data (Table 4). The existing lane width at the intersection is 3.04 m (10 ft).

Model 2 (Fig. 5) introduces a bicycle lane, resulting in a modal shift and changes in vehicle composition and volume. Rickshaws are banned from using the roadways, and bicycles are redirected to the dedicated lane. Five types of vehicles remain in the motorized lanes, with their new volume count converted into percentages to create a new vehicle composition (Table 5).

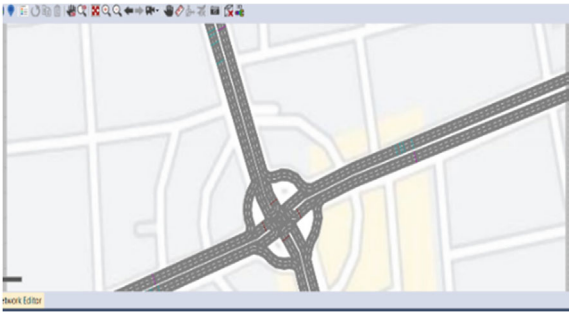

Fig. 4 Model 1 without bicycle lane

Table 4 Total volume and vehicle composition (%) of Model 1

Vehicle types	Kakoli (Model 1)	Pak. Embassy (Model 1)	Gulshan-1 (Model 1)	Notun bazar (Model 1)
Total volume (%)	1949	1336	1195	2020
Car	54.8	30.2	53.6	34.6
Medium truck	0.8	0.7	2.3	3.3
Bus	3.2	0.8	0.9	4.1
Bicycle	10.7	39.4	3.5	18.4
Autorickshaw	5.3	7.3	13.6	6.6
Motorbike	24.5	18.8	25.5	30.2
Rickshaw	0.8	2.8	0.5	2.8

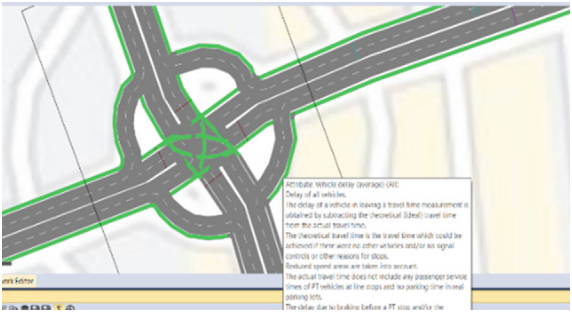

Fig. 5 Model 2 with bicycle lane

Table 5 Total volume and vehicle composition (%) of Model 2

Vehicle types	Kakoli	Pak Embassy	Gulshan-1	Notun bazar
Total volume	1700	1014	1765	900
Total Volume of bike lane	154	212	123	280
Car (%)	62.0	54.5	55.0	46.0
HGV (%)	1.0	1.0	2.0	4.0
Bus (%)	3.5	1.0	1.0	5.0
Autorickshaw (%)	6.0	9.5	14.0	8.0
Motorbike (%)	27.5	34	28.0	37.0

4.4 Comparison of Traffic Capacity Parameters Through VISSIM Model

The study compared the effects of bicycle lanes by analyzing two VISSIM model outputs: level of service (LOS), queue length and number of stops encountered, focusing solely on the through movement direction for simplicity in data representation.

LOS, queue length and no. of stops of the directional movement improves from E to C as the motorized lane becomes fully separate.

Figures 6 and 7 present a comparison of changes in queue length and number of stops obtained from the nodal analysis of the two models (existing and with bike lanes), respectively, providing a clear visualization of the impact of the bicycle lane on the intersection in terms of queue length and number of stops.

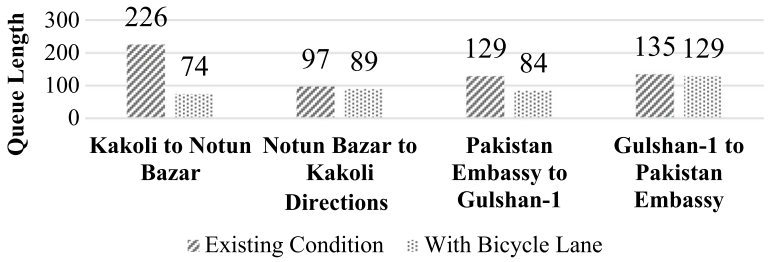

Fig. 6 Comparison of queue length

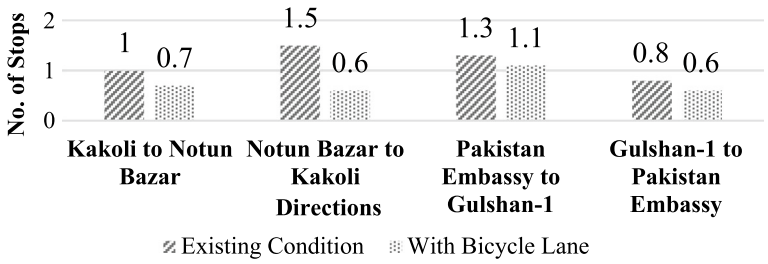

Fig. 7 Comparison of no. of stops

5 Conclusion

The study concludes that implementing a dedicated bicycle lane in Gulshan, Dhaka can effectively alleviate traffic congestion during peak hours. By utilizing the VISSIM model and considering factors such as level of service, queue length, and number of stops, the study observed significant improvements in the overall traffic condition. The installation of bicycle lanes resulted in a decrease in the volume-to-capacity ratio at the intersection and improved the environment and general traffic situation in the study area. The level of service improved from E to C, while the queue length and number of stops decreased. These findings highlight the positive impact of dedicated bicycle lanes in busy urban areas, promoting sustainable transportation options and enhancing traffic flow.

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