# ANALYSIS OF TRAFFIC CHARACTERISTICS ON BANGABANDHU SHEIKH MUJIBUR RAHMAN EXPRESSWAY

**Anika Abida Chowdhury*[1], Noman Hasan Fahim[2] and Md. Mizanur Rahman[3]**

*[1] Postgraduate Student, Department of Civil Engineering, Bangladesh University of Engineering and Technology, Bangladesh, e-mail: anikamegha68@gmail.com*
*[2] Postgraduate Student, Department of Civil Engineering, Bangladesh University of Engineering and Technology, Bangladesh, e-mail: nomanhasan647@gmail.com*
*[3] Professor, Department of Civil Engineering, Bangladesh University of Engineering and Technology, Bangladesh, e-mail: mizanrafik@gmail.com*

***Corresponding Author**

## ABSTRACT

The Bangabandhu Sheikh Mujibur Rahman Expressway is the first national expressway of Bangladesh. The serviceability of the expressway has been greatly enhanced by the recent completion of the Padma Bridge. At the same time, the important Bhanga Cloverleaf Interchange operates as a vital convergence point for the Gopalganj(N803), Barisal(N8), and Faridpur(N805) highways. The data has been collected from Road and Highways Department (RHD) and toll complexes, which includes Dhaleshwari toll plaza data from January 2022 to April 2023 and Bhanga toll plaza data from August 2022 to April 2023. In addition, a traffic count survey was conducted within a one-kilometer area of the Bhanga cloverleaf to evaluate the Level of Service (LOS), which also included speed measurement, traffic volume measurement, and considerations of travel speed, traffic characteristics, and congestion patterns. In this study, inflow proceeds to the cloverleaf interchange, whereas outflow comes from the Bhanga cloverleaf. The analysis of traffic patterns shows complex behaviour, with peak PCU/hour of 774 to Barisal and 514 to Faridpur highway. Before the opening of the Padma Bridge, 37% of vehicles were private automobiles and 31% were microbuses/pickups. Four-wheelers, Trailer, Agro, and Rickshaw/Van were in short supply at Dhaleshwari Toll Plaza. Post-bridge, Large Buses, Private Automobiles, and Microbuses constitute approximately 62% and 57% of Dhaleshwari and Bhanga Toll Plazas, respectively. The graphs illustrate the weekend traffic increase in Dhaleshwari. Non-motorized vehicles constitute 19%, 26%, and 21% of Faridpur, Gopalganj, and Barisal routes, respectively, causing bottlenecks such as the Bhanga Cloverleaf Interchange, which connects southern highways. The paper concludes with an overview of the operational dynamics and impact of the Bangabandhu Expressway on the connected road network. The results provide valuable insights into Bangladesh's effective transportation planning, infrastructure development, and congestion mitigation strategies. The future implementation measures include the improvement of Barisal Highway's capacity and the establishment of regional and service roads to mitigate the presence of non-motorized vehicles on the highway, consequently enhancing safety and service standards. The analysis also predicts a forthcoming state of equilibrium in the capacity of the Bangabandhu Sheikh Mujibur Rahman Expressway and Padma Bridge, hence indicating the necessity for supplementary expressways and bridges. The purpose of these recommendations is to offer valuable insights and early prediction calibration to assist and guide future infrastructure initiatives.

**Keywords:** *Interchange, Expressway, Level of Service(LOS), Traffic Characteristics.*

## 1. INTRODUCTION

Bangladesh is a nation with a rapidly growing population and flourishing economy. However, the increase in population has led to a rise in transportation demands, particularly in the densely populated southern region. In response to this challenge, the Bangabandhu Sheikh Mujibur Rahman Expressway (BSMRE) and the Padma Multipurpose Bridge (PMB) have emerged as transformative infrastructure projects that aim to facilitate economic integration and address transportation needs.

The BSMRE, a four-lane and 55-kilometer expressway, connects Dhaka with Bhanga Interchange as well as the southern Bangladesh. The Padma Bridge has played a crucial role in improving Bangladesh's internal connectivity and enhancing South Asia's regional connection through its road and rail infrastructure. Our study has identified the need for significant improvements in the road network after Bhanga Cloverleaf to provide a safe and conducive environment for vehicles. The study has also presented a comprehensive guide to understanding the Padma Bridge's significant effect on local traffic and highlighted the need to strengthen the Mawa-Bhanga Cloverleaf Interchange to optimize vehicle movement and improve transportation experience in the region.

Related research shows a significant reduction in travel time between the southwestern region and Dhaka, with trucks saving more than ten hours and autos saving two hours. Ali et al. (2022) addressed that the Padma Multipurpose Bridge has replaced the clumsy ferry system and become a critical catalyst in enhancing connectivity and mobility between Dhaka and the southern regions of Bangladesh. According to the feasibility assessment completed by the Japan International Cooperation Agency, the bridge is projected to reduce daily gasoline consumption by approximately 681,600 gallons. Sistuk, V., & Onastyrskyi, Y. (2019). have mentioned that the speeds are above the predicted values, which prompts inquiries on the evaluation of service levels on rural two-lane highways. In Ukraine, simulations are being used to manage traffic flow by assessing intersections and suggesting alternate options such as adjusting traffic signals. When examining metropolitan environments, Salam, F. M. (2022). focused on the complex flow of vehicles on multi-lane highways, carefully analyzing their capacity and service levels to gain a comprehensive understanding of these different transportation routes.

Researchers are developing new methods to evaluate service levels on high-speed roads where vehicles surpass typical models at dizzying speeds, pushing the boundaries of what is possible. Morrall, J. F., & Werner, A. (1982) provide a wide-ranging view of the continuous effort to control and manage the constantly changing challenge of traffic, encompassing many environments from rural areas to metropolitan settings, and use techniques ranging from simulations to complex mathematical calculations. Also, Robertson, J., Fitzpatrick, K., Park, E. S., & Iragavarapu, V. (2014) discussed the transformation of our road infrastructure and enhanced technological instruments, it is possible that in the future, traveling on any highway will become a seamless, productive, and potentially pleasurable experience.

This study systematically analyses traffic dynamics by studying the movement of vehicles towards the southern region. We have conducted a comparative examination of vehicle counts across various categories throughout weekdays, weekends and public or national holidays by obtaining data from Dhaleshwari and Bhanga Toll Plaza, both before and after the bridge's inauguration. Furthermore, the highway speed has been measured to evaluate the level of service of expressway and highways. At the Bhanga Cloverleaf interchange, a detailed assessment has been performed of the Level of Service performance and traffic flow.

The study provides valuable insights into the impact of key infrastructure projects on transportation dynamics. By comparing traffic counts at different locations or time intervals, we can identify areas facing congestion, gain a deeper understanding of traffic patterns and trends, and develop approaches to enhance traffic flow in the region. We believe that continued investment in transportation infrastructure is essential to support Bangladesh's economic growth and development.

## 2. METHODOLOGY

The study is based on the data collected from the study area by field survey and from the Toll booths of the Roads and Highways Department (RHD). The study of the level of service (LOS), operating speed, and traffic characteristics analysis is the main component of this study.

### 2.1 Study Area

The study is conducted on the approach roads of Bhanga Cloverleaf, located in the District of Faridpur under the Division Dhaka. The total area covered by cloverleaf is approximately 187,698.39m$^2$ (2020368.69 sq ft). The study area has been addressed in Figure 1.

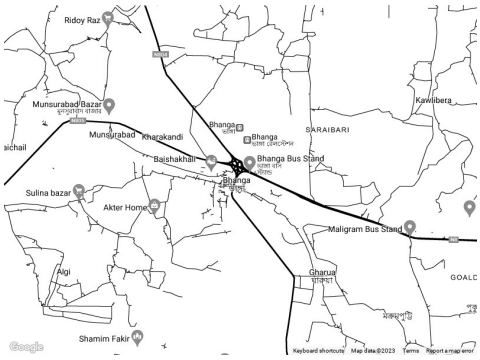



Figure 1: Study Area (Bhanga)

A traffic count survey has been conducted on three approaches, in national highways at the Bhanga Cloverleaf interchange. Both directional flows of traffic have been measured. The survey was done at 4 locations on these highways. The volume count of the expressway was also done by collecting data from Bhanga and Dhaleshwari Toll Plaza through the Roads and Highways Department (RHD).

### 2.2 Data Collection

At the Bhanga Cloverleaf interchange, a traffic count survey has been carried out on three approaches. Both the inflow and outflow of classified traffic have been measured according to Geometric Design Standard Manual (Revised) 2005. The survey was done at 4 locations. Data were collected for 2 hours from 11.03 AM to 1.03 PM on March 05, 2023(Weekday). In this study, the manual count method has been opted for. This technique entails utilizing a tally sheet, clicker, and other counting tools to manually count the number of vehicles that pass through a certain location. In the speed survey, the distance between the two points is taken 100 m. At least 5 numbers of each vehicle's speed were measured from the survey field by manual speed study survey. The secondary Data source: six months of traffic flow data of Dhaleshwari Toll Plaza before the opening of Padma Multipurpose Bridge, nine months of traffic flow data of Dhaleshwari Toll Plaza and Bhanga Toll Plaza after the inaguration of Padma Multipurpose Bridge were obtained from Roads and Highways Department.

### 2.3 Related Manuals

For the calculation of the level of service, The Geometric Design Standard Manual of RHD (Revised) 2005, Govt of the People's Republic of Bangladesh Ministry of Communication, Roads and Highway Division has been followed. The AHS (Average Highway Speed), Lane factor, and Shoulder factor had been taken from (HCM)-1994 (USA). The PCE factor derived from Geometric Design Standards for Roads & Highways Department, Draft version-4, October 2004, Page-4.

## 3. RESULT AND DISCUSSION

The analysis is divided into two main parts. Calculating the Level of Service involves flow, operating speed, passing sight distance, Level of Service (LOS) and evaluating traffic characteristics in the

Bangabandhu Expressway including vehicle mode user variation, flow and a comparative analysis using graphs and charts.

### 3.1 Analysis of Data for Calculation Level of Service

#### 3.1.1 PCU per hour

Traffic flow of 2 hours with 20-minute intervals in both outflow (away from Bhanga Cloverleaf Interchange) and inflow (towards Bhanga Cloverleaf Interchange) direction was measured in each connecting route. The Traffic Volume Study at Bhanga has been addressed in Table 1.

Table 1 - Traffic Volume Study at Bhanga Cloverleaf Interchange

| Traffic Volume Study at Bhanga Cloverleaf | | | |
|---|---|---|---|
| Location | Flow Direction | PCU/hr. | Average PCU/hr. in both directions |
| Faridpur | Inflow | 486 | 551 |
| Faridpur | Outflow | 616 | |
| Gopalganj | Inflow | 674 | 675 |
| Gopalganj | Outflow | 676 | |
| Barisal | Inflow | 774 | 774 |
| Barisal | Outflow | 774 | |

#### 3.1.2 Operating speed:

Following the RHD method calculating operating speed, using each vehicle's speed and PCU of three connecting routes. The highest operating speed is found in the Faridpur route. The operating speeds of the Gopalganj and Barisal routes are almost the same. The operating speed at Bhanga Cloverleaf Interchange has been addressed in Table 2.

Table 2 - The operating speed at Bhanga Cloverleaf Interchange

| Speed Calculation at Bhanga Cloverleaf | | | |
|---|---|---|---|
| **Location** | **Faridpur** | **Gopalganj** | **Barisal** |
| Operating Speed (inflow) in km/hr. | 45.3 | 40.48 | 43.16 |
| Operating Speed (outflow) in km/hr. | 43.1 | 41.17 | 39.14 |
| Average Operating Speed in km/hr. | 44.2 | 40.82 | 41.15 |
| Average Operating Speed in mph | 27.5 | 25.37 | 25.57 |

The Passing Sight Distance of connected routes is found on average 1300 ft for Level of Service calculation.

#### 3.1.3 Level of service (LOS):

Using percentage passing sight distance, road width, shoulder width, capacity per lane, and the related factors for measuring LOS. The Level of Service has been mentioned in Table 3.

Table 3 - Level of service at the approaches of Bhanga Cloverleaf Interchange

| Location | LOS |
|---|---|
| Expressway | A |
| Gopalganj | C |

| | |
|---|---|
| Faridpur | E |
| Barisal | F |

The construction of the Bangabandhu Expressway was completed in March 2020, and Padma Bridge was opened in June 2022. The Expressway got a higher level of service "A" from Dhaka to Bhanga; but after the Bhanga interchange, it was diverged into three routes - Faridpur, Gopalganj, and Barisal. But the Capacity and Level of Service of the Bangabandhu expressway are higher than the other three routes and this breaks the uniformity which makes the road users uncomfortable and they start facing congestion due to bottlenecks and other related problems, like – narrow road, non-motorized vehicle access on the main highway, etc.

### 3.2 Mode choice variation

#### 3.2.1 Comparison of Modal Share

From Figure 2, it can be identified that before the opening of the Padma Multipurpose Bridge, private cars, microbuses, and large buses were used at a higher amount in the route traveling from Dhaka to Mawa Ferry Terminal. Usually, Private cars, Large buses, and Microbus are dominating in the percentage after the opening of the Padma Multipurpose Bridge.

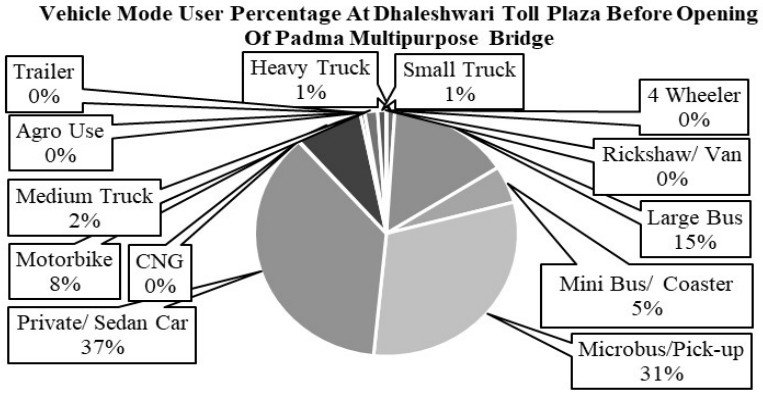



Figure 2: Types of Vehicles in Dhaleshwari Toll Plaza before the opening of PMB

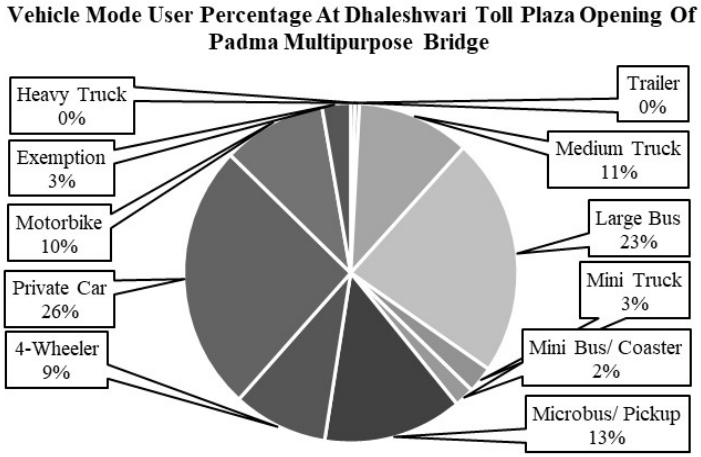



Figure 3: Types of Vehicles in Dhaleshwari Toll Plaza after the opening of PMB

After the opening of the Padma Multipurpose Bridge, the mostly observed mode here is the large bus. Due to the lengthy ferry system, people avoided this route for a long time and used the Aricha terminal. But after PMB, the bus routes of the southern part of Bangladesh developed and people started using this route. The Percentage of Different Types of Vehicles has been shown in Figure 3 and Figure 4.

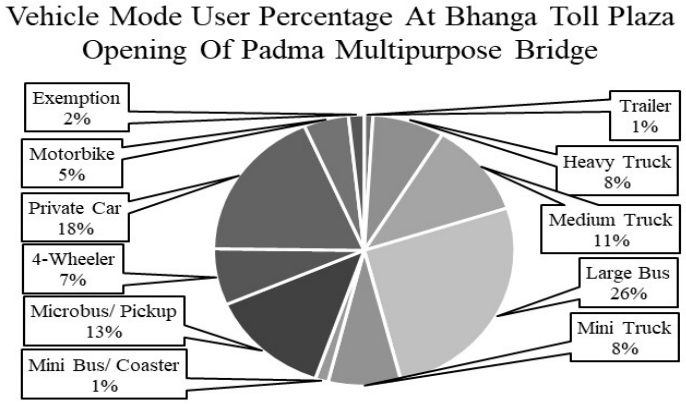



Figure 4: Types of Vehicles in Bhanga Toll Plaza after the opening of PMB

### 3.2.2 Mode Split based on Time (Dhaleshwari)

A higher number of medium and large trucks have used the expressway from January 2023 to March 2023 because of the construction purposes of the Padma Bridge Rail Link Project. The scenario has been addressed in Figure 5 and Figure 6.

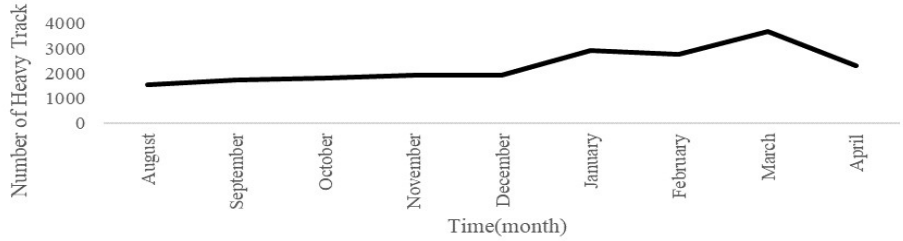



Figure 5 - Heavy Truck vs Time(month) at Dhaleshwari Toll Plaza after the opening of PMB

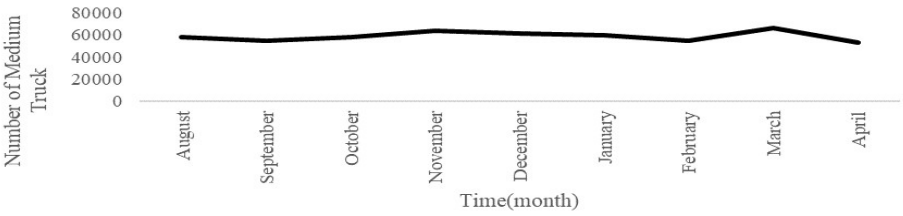



Figure 6 –Medium Truck vs Time(month) at Dhaleshwari Toll Plaza after the opening of PMB

New routes have been introduced by different Bus (Figure 7) Operators for better transportation facilities to ensure the fastest communication and so the number of large buses were increasing.

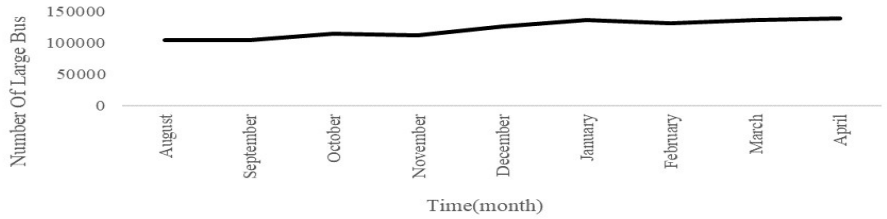



Figure 7- Large Bus VS Time(month) at Dhaleshwari Toll Plaza after the opening of PMB

There was a sudden change in number of motorbikes in Dhaleshwari toll plaza on April 2023. After the opening of the Padma Bridge on 25 June 2022, bikes were prohibited from the Padma Multipurpose Bridge from 27 June 2022 due to reckless driving and accidents. So the government did not allowed the bikes in the PMB in the earlier months. But from April 20, 2023, the bikes got permitted in the bridge and there was a sudden increase in Motorbikes (Figure 8) in the Dhaleshwari toll plaza.

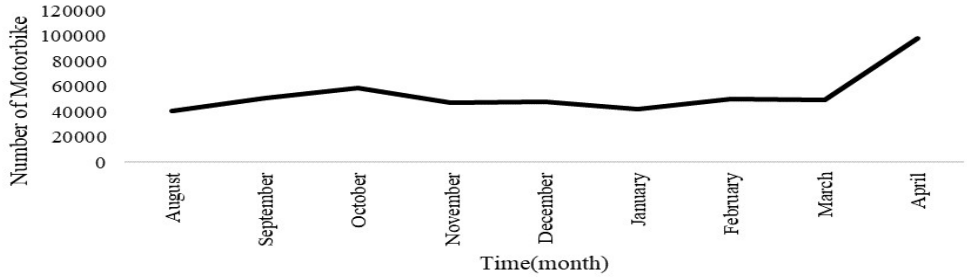



Figure 8 - Motorbikes vs Time(month) at Dhaleshwari Toll Plaza after the opening of PMB

The Exemption vehicles are the maintenance and other project-related vehicles and these types of vehicle were decreasing after the opening of Padma Bridge. When the bridge was opened, the construction works were not fully completed. So relative working procedures were still going on in the bridge and the number was reducing along with the completion of the project. This scenario has been addressed on Figure 9.

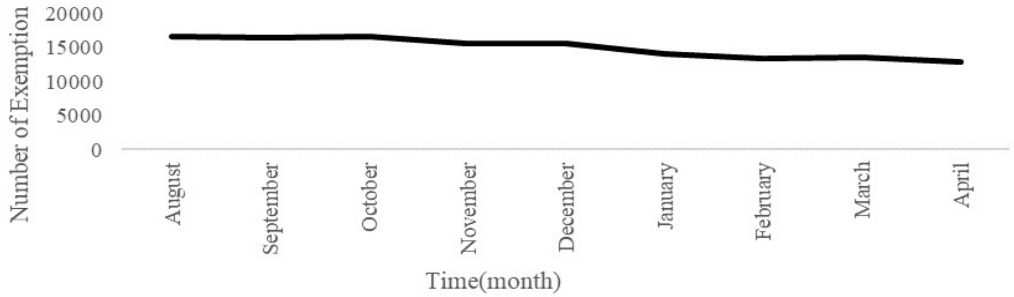



Figure 9 - Exemption VS Time(month) at Dhaleshwari Toll Plaza after the opening of PMB

### 3.2.3 Mode Split Based on Time (Bhanga)

There was some construction problem with carpeting in the roadway of PMB within the liability period and the constructor was liable to repair the faulty carpeting from October to December of 2022. Due to the carpeting, there were some changes in traffic in this period which does not represent the homogenous behavior. The Number of Private Cars vs Time (month) at Bhanga Toll Plaza after the opening of Padma Multipurpose Bridge and Number of Exemption vs Time(month) at Bhanga Toll Plaza after opening of Padma Multipurpose Bridge have been addressed in Figure 10 and Figure 11 respectively.

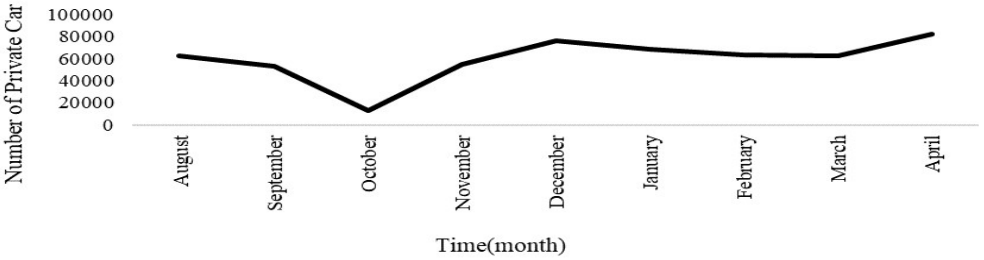



Figure 10 - Private Cars vs Time(month) at Bhanga Toll Plaza after the opening of PMB

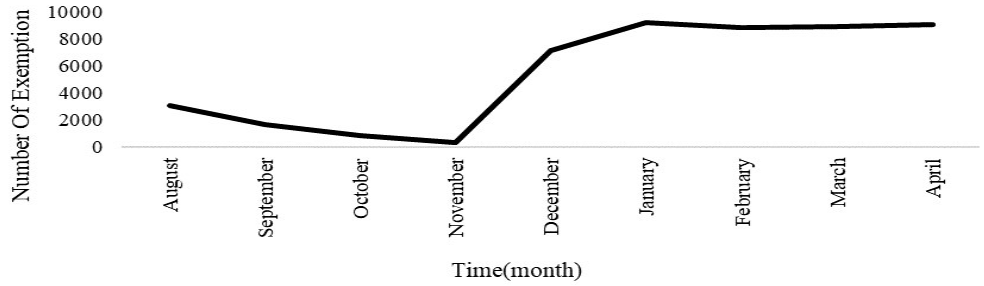



Figure 11 - Exemption VS Time(month) at Bhanga Toll Plaza after opening of PMB

### 3.2.4 Traffic Flow Pattern

Repetition of the curve represents that, people using the Expressway mostly on the weekends for both going home and recreational visit purposes. Flow vs Time(month) at Dhaleshwari Toll Plaza in September 2022 has been addressed in Figure 12.

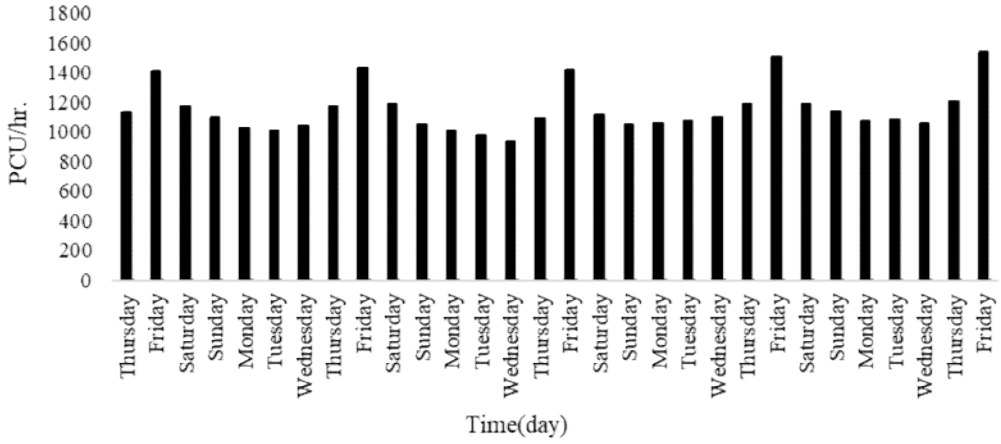



Figure 12 – Flow vs Time(month) at Dhaleshwari Toll Plaza in September 2022

There was higher traffic density in the second half of April 2023, because of the national and the religious Holiday of Bangladesh, the Eid-ul-Fitr. Because of this occasion, the Passenger Car unit per hour on this Expressway increased. The highest value of the flow was over 2000 PCU/hr., and this caused the LOS of the Expressway from LOS A to LOS C. Flow vs Time(month) at Dhaleshwari Toll Plaza in April 2023 has been addressed in Figure 13.

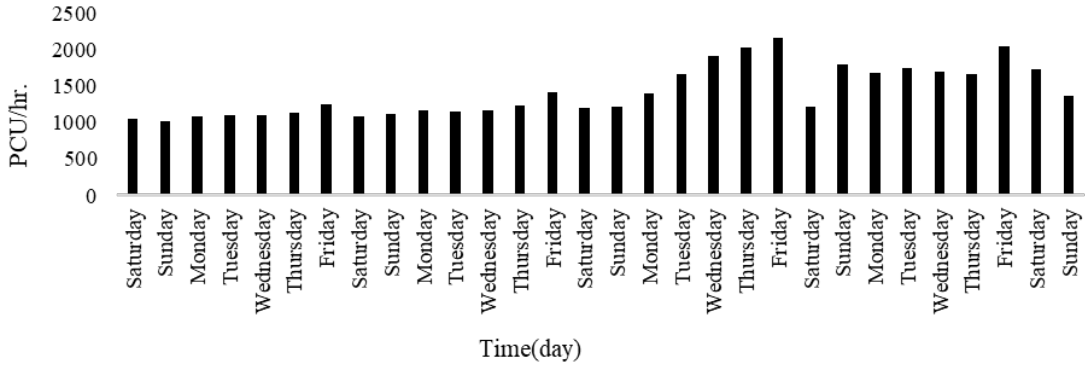



Figure 13 - Flow Time(month) at Dhaleshwari Toll Plaza in April 2023

### 3.3 Comparative Analysis:

The number of private cars and large buses decreases by almost 30-50% because people used to go to the Padma multipurpose bridge and Mawa ferry terminal for recreational purposes, especially on holidays. Vehicle Number vs Different Types of Vehicles of Dhaleshwari and Bhanga Toll Plaza after the opening of Padma Multipurpose Bridge has been addressed in Figure 14. The difference represents the number of recreational vehicles from the capital, Dhaka city.

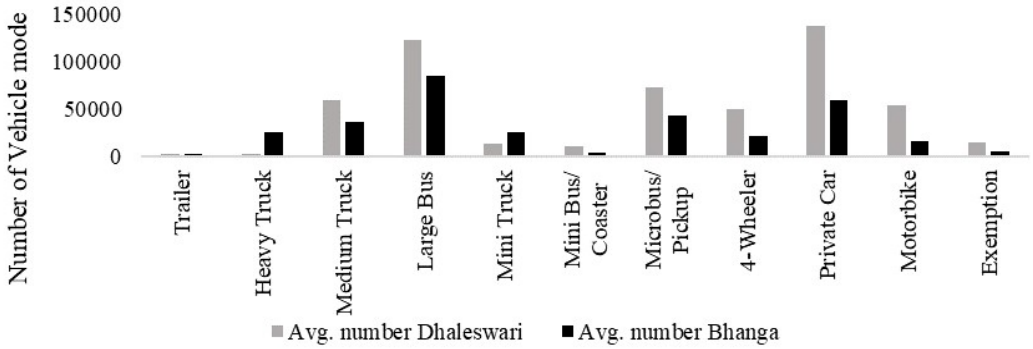



Figure 14 – Difference in vehicles of Dhaleshwari and Bhanga Toll Plaza after the opening of PMB

There was a variation in the Bangabandhu Expressway toll count at Dhaleshwari and the Bhanga toll count. The observed reason was, from the capital city, Dhaka, people enter on the expressway but only used to go to Munshiganj, Shariatpur, Madaripur, etc. and usage other exits; and so this number of vehicles does not pass the Bhanga toll booth. As a result, there is always a lower traffic volume at Bhanga toll plaza relative to Dhaleshwari toll plaza. Flow vs Time(month) of Dhaleshwari and Bhanga Toll Plaza has been addressed in Figure 15.

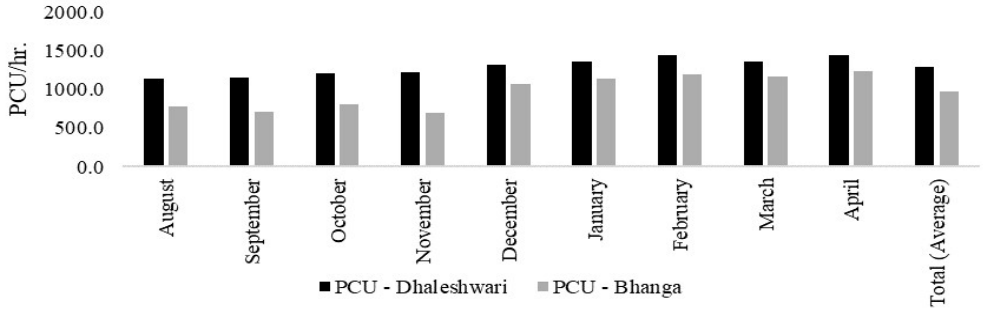
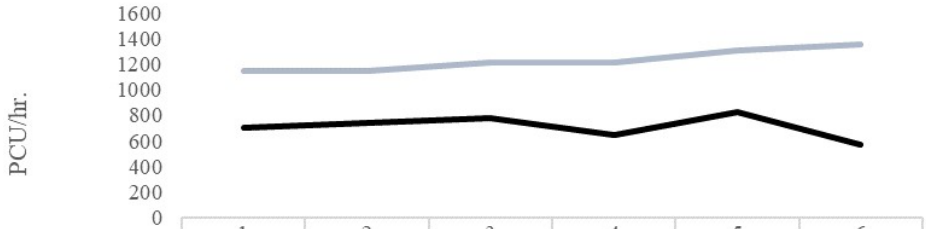



Figure 15 - PCU/hr. VS Time(month) of Dhaleshwari and Bhanga Toll Plaza

This is a clear representation (Figure 16) of the increase in overall traffic volume in the expressway after the opening of Padma Bridge.




| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Avg PCU/hr(before) | 708 | 740 | 780 | 644 | 823 | 568 |
| Avg PCU/hr(after) | 1144 | 1150 | 1210 | 1214 | 1312 | 1359 |

Figure 16 – Flow vs Time(month) of Dhaleshwari Toll Plaza before and after the opening of PMB

Usually in holidays, people use Padma Bridge for visiting and recreational purposes. So, the average flow is higher on holidays. The comparison has been shown in Figure 17.

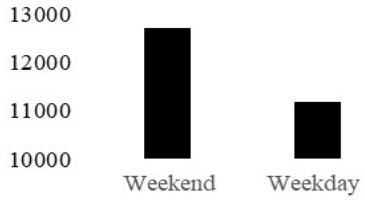



Figure 17 - Comparison of flow on weekends and weekdays at Dhaleshwari Toll Plaza

The different scenario has been seen in Bhanga Toll Plaza but in December 2022 and April 2023. The scenario was different due to the national holiday and the Eid-ul-Fitr. The comparison of average flow on weekends and weekdays of April 2023 have been addressed in Figure 18. With respect to the previous discussion, the average flow is much lower due to the absence of recreational vehicle in the southern side of Padma Bridge.

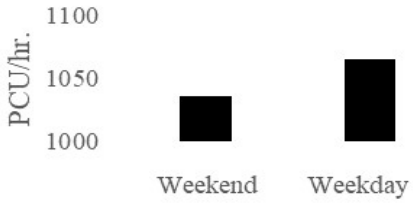



Figure 18 - Comparison of flow on weekends and weekdays at Bhanga in December 2022

Due to Non-motorized vehicles on the connected roads in Bhanga Cloverleaf Interchange, there is a bottleneck in the connecting points. For this, the operating speed of motorized vehicles at these points decreases to a lower level and creates conflicts in those area. The percentage of non-motorized vehicles and motorized vehicles are shown in the Figure 19.

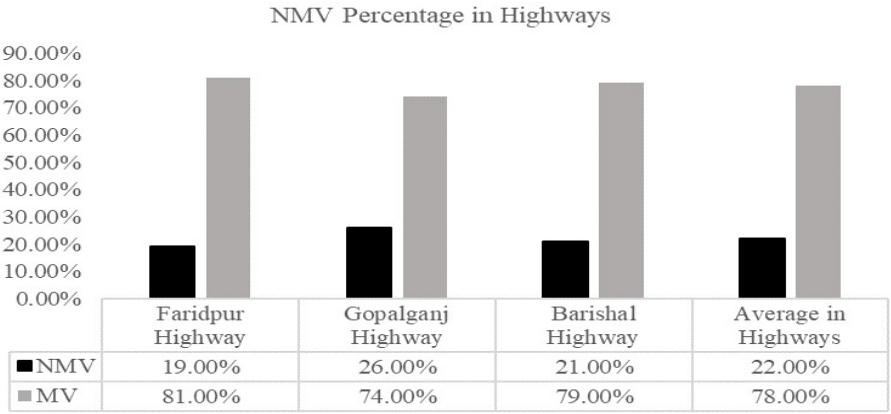



Figure 19 – Non-Motorized Vehicle Composition on the approaches of Bhanga Intersection.

## 4. CONCLUSIONS

The Padma Multipurpose Bridge has been a game-changer for transportation in Bangladesh, revolutionizing the Bangabandhu Expressway and other connected highways. As we delve into the pre- and post-bridge scenarios in this study, we offer vital insights for future infrastructure development. The new connection to Dhaka via the Bangabandhu Expressway has empowered various vehicles, including trailer trucks, agricultural vehicles, rickshaws, and vans, to transport goods and services more efficiently. This shift highlights the bridge's critical role in bridging the urban-rural divide and unlocking economic potential. Our study presents a set of crucial recommendations for optimizing traffic flow and maximizing the bridge's impact. We propose upgrading the Barisal highway, improving regional roads for non-motorized vehicles, and anticipating future infrastructure needs for expressways and bridges. Our analysis has identified a bottleneck at the Bhanga cloverleaf interchange, where highways branch towards Faridpur, Gopalganj, and Barisal, with a significant number of non-motorized vehicles contributing to congestion challenges. Addressing this critical issue requires strategic solutions. Comparing the Dhaleshwari toll plaza to Bhanga, we have noted a wider variety of vehicle users earlier, which can be attributed to economic and technological disparities between the two regions. By recognizing these nuanced changes and addressing emerging challenges, Bangladesh can optimize its infrastructure and unlock the full potential of the Padma Bridge and the Bangabandhu Expressway. Our study serves as a valuable compass for navigating the evolving transportation landscape and ensuring a seamless connection across the nation. Let us work together to make these recommendations a reality and build a stronger, more connected Bangladesh.

## ACKNOWLEDGMENTS

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