STUDY OF TRAFFIC CONGESTION IN BARISHAL CITY

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ABSTRACT

In the southern region of Bangladesh, particularly in Barishal Metropolitan City, traffic congestion has grown to be a very major issue. The city dynamically grew as a result of the city's rising population without any formal planning or management. The newly built Padma Bridge has linked Barishal to the rest of the entire country. Therefore the highways and roads has to manage the massive influx of traffic. Additionally, the Payra Bridge and Payra Seaport have a big impact on Barishal City's transportation infrastructure. This rapid increase of vehicle creates traffic congestion in Barishal City**.** Even though the number of vehicles increases significantly, the road capacity stays the same. In recent years, the issue of traffic congestion has emerged as one of the most problematic issues in many cities throughout the world, both financially and environmentally. Additionally, citizens lose crucial time as a result of this. This study was carried out to measure the level of Barishal City's traffic congestion. Data were collected from the intersections and crowded locations. Sagordi to Rupatoli had the largest traffic flow (4356 PCU/h), and its volume to capacity ratio was 3.66; nevertheless, Chowmatha to Nobogram Road had the lowest traffic volume (840 PCU/h) and its volume to capacity ratio was 0.7. The Roadway Congestion Index (RCI) for the highway was found as 2.45. Additionally, 90 questionnaires for drivers, pedestrians, and passengers were conducted at six busy junctions and other congested areas. The study looked at the popularity of auto-rickshaws, rickshaws, and motorcycles as modes of transportation. The primary and most significant issues are traffic law violations and illegal parking. Therefore, it is advised that the government and relevant agencies should take appropriate measures to reduce the traffic congestion.

Keywords*: Traffic congestion, Barishal City, Passenger Car Unit, Roadway Congestion Index , Congestion area and assessment.*

1. INTRODUCTION

Bangladesh is a developing country. In developing country, divisional cities play an important role in economic growth. According to World Bank, around 80% of GDP growth in developing countries is expected to come from cities. For economic activities, it is mandatory to simplify movements. Transportation system provides the proper way for movements and medium for reaching destinations. Economic activities are being hampered due to inadequate transportation system and create hindrances for development.

The impact of population on the transportation system is profound and multifaceted. As the population increases, it leads to heightened congestion on roads, longer travel times, and decreased efficiency. The demand for transportation infrastructure and services grows, requiring the development and expansion of roads, bridges, and public transit systems. The increased population density often results in greater reliance on public transportation, necessitating expanded routes and improved services.

Traffic congestion can occur on highways, urban streets, and even in suburban areas during peak travel times or due to various factors such as accidents, road construction, or poor road design. This congestion not only leads to wasted time and increased fuel consumption but also contributes to air pollution, carbon emissions, and decreased overall productivity. City planners, transportation engineers, and policymakers continually seek innovative solutions to reduce traffic congestion, such as improving public transportation, implementing smart traffic management systems, and encouraging alternative commuting methods like carpooling and cycling.

Efforts to mitigate traffic congestion not only enhance urban mobility but also promote environmental sustainability and economic prosperity. Alleviating the traffic congestion requires a proper traffic system. Developing an efficient traffic system requires careful planning, implementation, and continuous improvement. It involves analyzing transportation needs, addressing congestion points, and integrating alternative modes of transportation. Efficient traffic management strategies, improved public transportation, and infrastructure for active transportation play a crucial role.

An agent-based simulation model was created as a case study and traffic volume data from one of Dhaka's main arterial routes was collected for this purpose. The results of the simulation experiment show that switching everyday commuters from private cars to public transportation can dramatically reduce traffic congestion (Rahman, 2018).

In Chittagong city, there are 13 key factors that contribute to traffic congestion. The primary factor causing traffic congestion in Chittagong city is unlawful parking. (Ali, 2009) identified the primary or major sources of traffic congestion in Chittagong City and ranked them according to the level of congestion as reported by the city's residents.

(Hossain, 2018) monitoring traffic congestion in Chittagong City's chosen transportation axes. The highest traffic volume was 4088 PCU/h, and the lowest was 2070 PCU/h. According to their observations, the majority of the carriageway width at the chosen intersections is not kept up to the standards set by the UK for urban streets. Nearly all the intersections that were investigated are reached in a forced movement and badly crowded region and are overloaded with the current observed traffic capacity.

The growth of transportation in the Dhaka metropolitan area was thoroughly studied, with a focus on the creation and administration of the road network. Additionally, it discussed the research area's physical characteristics, including construction costs, vehicle lifespans, and the capacity of various means of transportation (Cox, 1979). In addition, it recommended giving rickshaws extra design consideration while building roads. (Alam, 1992) conducted a model-based analysis on the city of Dhaka. Using the traffic assignment model, the choices for traffic optimization was examined.

A few of the issues were highlighted with the issues of Metropolitan Dhaka's bus system. Although there was a constant need for buses, he claimed that the fleet did not grow at a rate that kept up with the population growth (Firdos, 1984).

The importance of having a reliable and economical public transit system was highlighted. It was emphasized the necessity for route network and fleet size expansion for the current public transit system. Additionally, It was suggested to enhance the quality of services, stop and terminal layouts, maintenance facilities, and the creation of more sophisticated transportation infrastructure, such as fast transit systems (Ahsan, 1990).

A well-functioning traffic system is crucial for the safety, efficiency, and overall quality of life in a community. It ensures smooth transportation, minimizes accidents, and reduces congestion. By supporting economic growth, reducing environmental impact, and enabling easy access to essential services, a reliable traffic system plays a vital role in enhancing the well-being of individuals and the development of cities.

2. METHODOLOGY

The study has been conducted by the Department of Civil Engineering, Barishal Engineering College, Barishal for assessing the existing traffic condition in Barishal City Corporation (BCC) area . Figure 1 showing the stages of the research work.

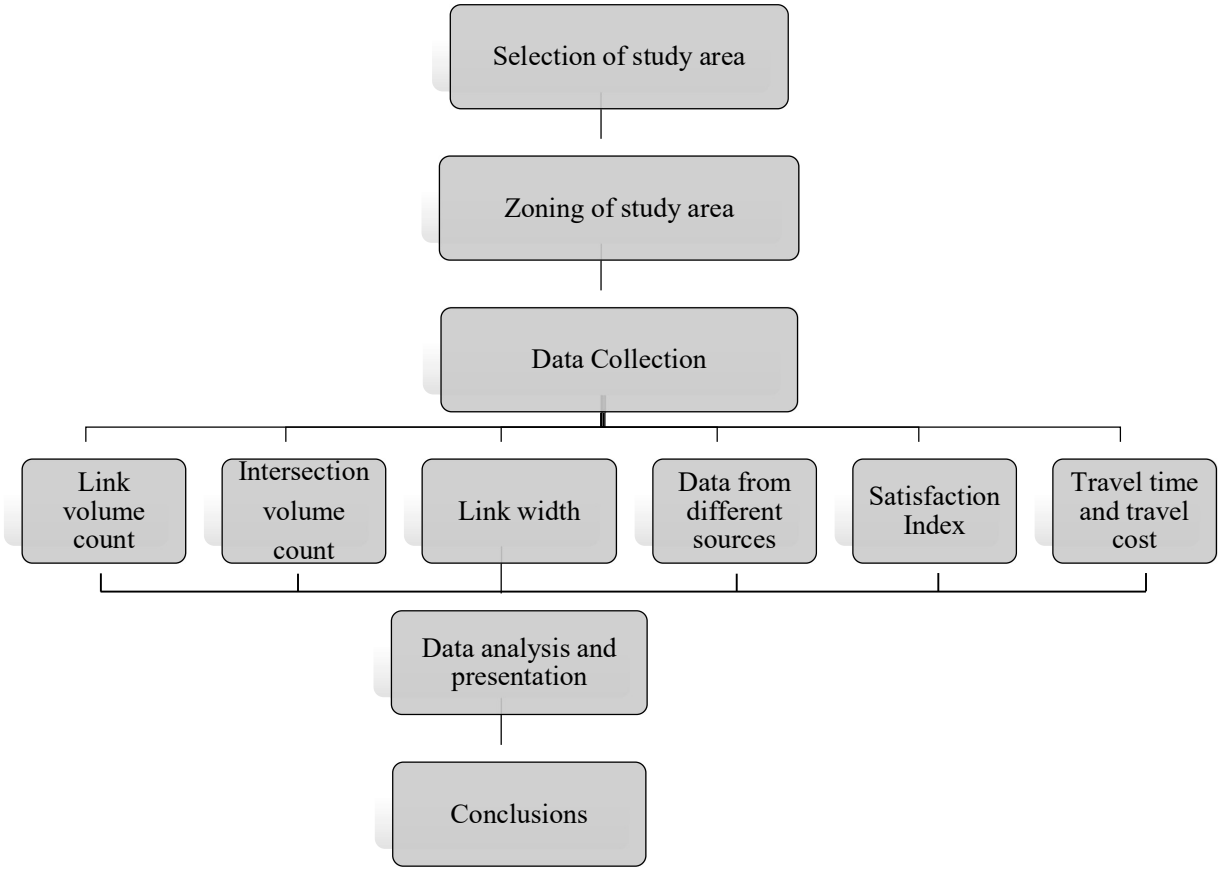

Figure 1: Flow chart showing the stages of the research.

2.1 Study Area

Barishal, a newly born City Corporation, is situated at the northeast portion of the country with latitude of 22.710^0N and longitude of 90.363^0E. Barishal City Corporation, a self-governing municipal body in Bangladesh, is in charge of managing and supervising the upkeep and development of the city of Barishal. Over five million people live in the Barishal district, where The Corporation covers an area of over 58 square kilometers (https://www.wikipedia.org, n.d.).

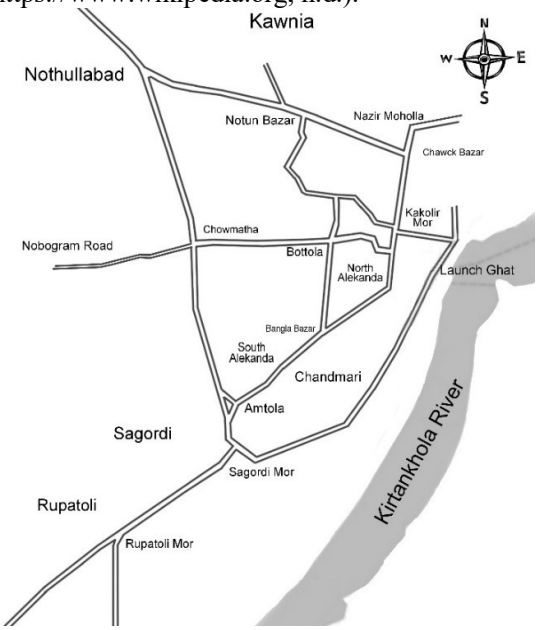

Figure 2: Important Road networks in Barishal City Corporation

The study area is belonged to BCC. For the analysis of regional transportation activities, the study area is divided into five broad sub-regions or Specified Zones (SPZ) which is designated as Zone-1, Zone-2, Zone-3, Zone-4, and Zone-5 as shown in Figure 2. BCC has total 30 wards.

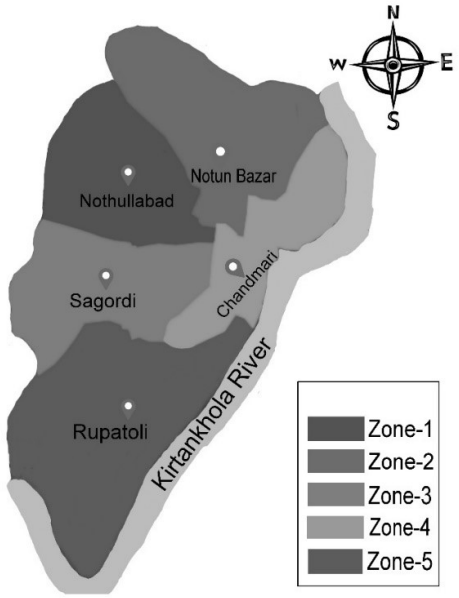

Figure 3: Map of Barishal City showing different zones.

Table 1 shows ward wise zoning of BCC area.

Table 1: Zoning of BCC

Zone No.	Zone Name	Consisting of Wards
1	Nothullabad	1,20,21,27,28,29
2	Notun Bazar	2,3,4,7,19
3	Chandmari	5,6,8,9,11,12
4	Sagordi	14,15,17,18,22,23
5	Rupatoli	24,25,26

2.2 Data Collection

Traffic volume data were collected from different arterial and sub-arterial roads and intersections in Barishal City. A field survey was conducted on weekdays from 9:00 am to 11:00 am, morning peak hours, and 1:00 pm to 3:00 pm, afternoon peak hours, and 6:00 pm to 8:00 pm, evening peak hours under sunny weather conditions. The study area is approximately 25 square kilometers. The network includes 4 three-way intersections and 2 four-way intersections. Video recording, as well as manual data collection, were conducted at all the 15 intersections to capture the traffic flow data at different directions. Later, the recorded video recordings were played on a computer screen to count the number of each type of vehicles. Eight types of vehicles were identified: Rickshaw, Auto rickshaw, Motor-Cycle, Bicycle, CNG, Private Car, Bus, Truck shows the hourly volume distribution of these eight types of vehicles during morning, afternoon and evening peak hours.

2.3 Road Geometry and Flow Capacity

Road geometry data of 15 link roads were surveyed, and traffic flow capacity of those roads was calculated and expressed as PCU/h according to Indian Roads Congress (IRC). These theoretical traffic volumes are compared with the actual traffic volume and the ratio of volume to capacity is assessed.

2.4 Quantifying Congestion

Due to lack of sufficient data only the Roadway Congestion Index (RCI) was selected to quantify congestion for this study. RCI can be calculated by the following equation.

$$\text{RCI} = \frac{\sum \frac{(Vehicle\ per\ Peak\ Hour)}{(Link\ Capacity)} * (Vehicle\ per\ Peak\ Hour * Link\ Length)}{\sum (Vehicle\ per\ peak\ Hour * Link\ Length)}$$

Here the RCI stands as the network weighted average volume to capacity ratio.

2.5 Travel Time Survey

Different kinds of vehicles traveling through five zone centroids were questioned as part of a journey time survey. This was done for the four main forms of transportation used in Barishal, including the rickshaw, auto-rickshaw, motorcycle, and CNG. Nothullabad, Notun Bazar, Chandmari, Sagordi, and Rupatoli were chosen as the zone centroids for Zones 1, 2, 3, 4, and 5, respectively.

2.6 Satisfaction Index

The following satisfaction index, created by Hall et al. (1975), was chosen for determining the respondents' limit of satisfaction and dissatisfaction with the causes of traffic congestion causes.

$$Is = \frac{fs - f}{N}$$

Here,
Is = Satisfaction Index.
fs = Number of Satisfied Respondents.
fd = Number of Dissatisfied Respondents.
N = Total Number of Respondents.
The above satisfaction index has been used by Ali (2009) and Hasan (1999) to determine the satisfaction index.

3. ILLUSTRATIONS

Traffic congestion is a common problem in many urban areas around the world and can involve various types of vehicles, including cars, trucks, motorcycles, bicycles, and public transportation. In Barishal city, congestion mainly depends on heterogeneous (Rickshaw, Auto rickshaw, Motor-Cycle) transportation network system. Road unfairness has been evolved due to topography of the city.

3.1 Traffic Volumes and Composition

It's essential to collect data during this peak hour to ensure the highest possible volume of traffic. For identifying peak hours, it is important to collect the 12-hour volume count at different major intersections. By averaging all the data, it was found the peak hour, as shown in the curve chart.

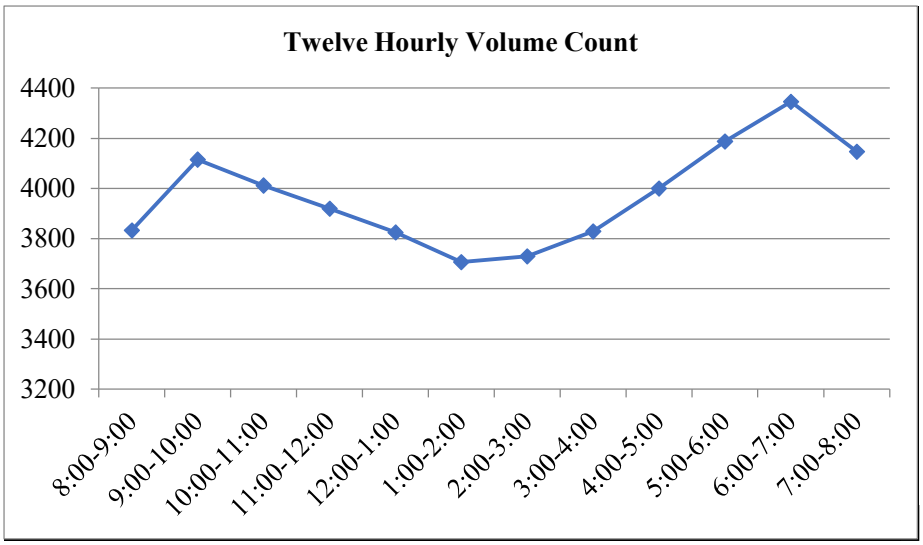

Figure 4: Relative values of twelve hourly traffic volumes with respect to average

Figure 4 shows the comparison between the average value and the twelve-hourly traffic volumes at five different study locations. According to this data, there were often two separate peak flows: one between 9:00 and 10:00 am, which was 4115.3 to the average flow, and another between 6:00 and 7:00 pm, which was 4345.8 to the average flow. Office, business, and educational visits accounted for the majority of the first peak (9:00 to 10:00 am). The second one (from 6:00 to 7:00 pm) was primarily caused by work, travel, and shopping excursions. But throughout the day, the pace of traffic remained essentially constant.

3.1.1 Traffic Volume in Intersections

Traffic volumes were also counted at 6 intersections in the period of peak flows (9:00 am to 10:00 am and 6:00 pm to 7:00) as shown in Table 2. The maximum traffic volume was found at Sagordi (5532 vehicle/hr). The lowest value was found in Kakolir Mor (3356 vehicle/hr).

Table 2: Traffic volume in different intersections

Name of Intersection	Type	Approach				Total Vehicle/hr
		North	South	East	West	
Bottola	4-legged	1346	759	1144	1458	4707
Kakolir Mor	3-legged	1386	1069	901	0	3356
Chowmatha	4-legged	1393	1338	1216	551	4498
Nothullabad	3-legged	1216	1611	1456	0	4283
Sagordi	3-legged	2218	1511	1803	0	5532
Rupatoli	3-legged	0	1149	2218	655	4022
Total		7559	7437	8738	2664	26398

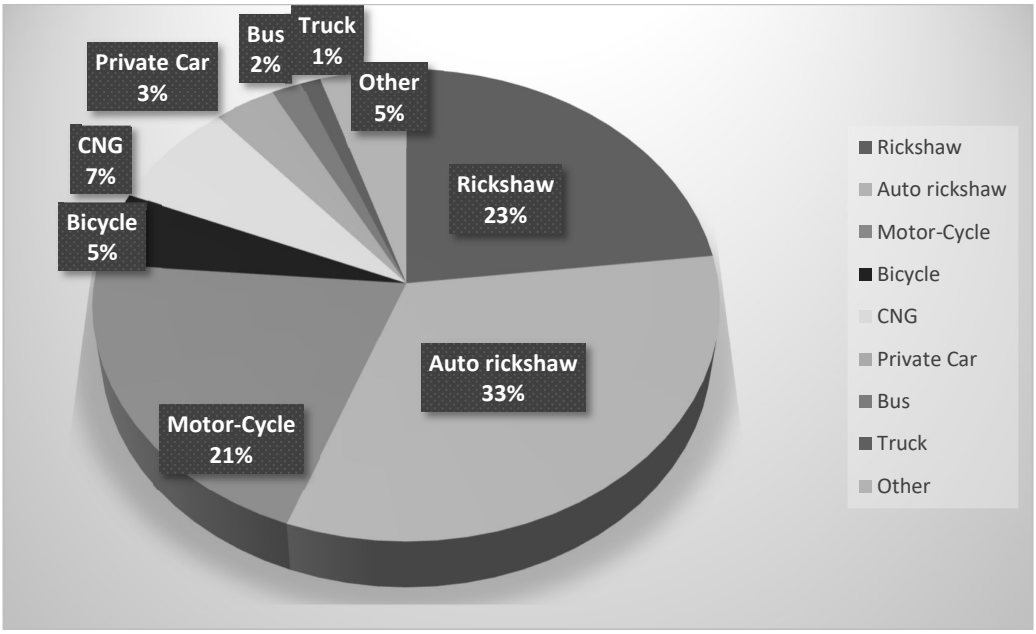

Figure 5: Percentage of vehicles at different links

Figure 5 shows the total number of different types of vehicles that are crossing the intersections. In Barishal City, the highest number of vehicles is found as "auto rickshaws" among those intersections, which is 33%. The 2nd highest number of traffic is "Rickshaw" which is 23%, and the 3rd is 21%, which is "Motor-Cycle". As we know, Barishal is a river-based city, so the transportation medium is also river-based. That's why the number of buses, trucks, and private cars is less than it should be. The percentage of buses, trucks, private cars, CNG, and bicycles is 2, 1, 3, 7, and 5, respectively.

3.1.2 Traffic Volume in Links

15 links had their traffic volume counted during peak hours (9:00 am to 10:00 am and 6:00 pm to 7:00 pm) and the results were compared to the links' actual carrying capacities. Table 3 show the volume/capacity ratio at various links and the hourly average traffic volume expressed as PCU/h, respectively. The Sagordi Mor to Rupatoli link had the highest traffic (4386 PCU/h), while the Chowmatha to Nobogram Road link had the lowest (840 PCU/h). However, the Sagordi Mor to Rupatoli link had the highest volume/capacity ratio 3.66, while the Chowmatha to Nobogram Road link had the lowest 0.7.

Table 3: Comparison of Actual Volume to the Link Capacity

Station	Location	Link Type	Road Width (ft)	Actual Volume (PCU/hr)	Capacity (PCU/hr)	Volume / Capacity Ratio
Near Nagar Bhabon	Launch Ghat To Kakolir Mor	Arterial	32	2019	1200	1.68
Near BibirPukur	Kakolir Mor to Jailkhanar Mor	Arterial	22.3	3804	1200	3.17
In front of Amrita Lal Dey College	Jailkhanar Mor to Notun Bazar	Arterial	26.3	3235	1200	2.7
In front of BM College	Notun Bazar to Nothullabad	Arterial	31.2	3581	1200	2.98
In front of University of Global Village	Nothullabad to Chowmatha	Arterial	39.4	4174	2100	1.99
Near Syed Govt. Hatem Ali College	Chowmatha to Bottola	Arterial	33.5	3519	1200	2.93
In front of Rupali Bank Limited	Bottola to Kakolir Mor	Arterial	32	2836	1200	2.36
Near Oxford Mission High School	Bottola to Notun Bazar	Sub-arterial	26.2	3285	1200	2.74
In front of Alekanda Police Fari	Bottola to Bangla Bazar	Sub-arterial	21.3	1697	1200	1.41
In front of Directorate of Animal Resources	Chowmatha to Nobogram Road	Sub-arterial	26.2	840	1200	0.70
In front of Barishal Metropolitan College	Chowmatha to Sagordi Mor	Arterial	25	3941	1200	3.28
Near Sagordi Bridge	Sagordi Mor to Rupatoli	Arterial	24.6	4386	1200	3.66
Near Sher E Bangla Medical College Hospital	Sagordi Mor to Chandmari Mor	Arterial	37.4	2422	2100	1.15
In front of Bells Park	Chandmari Mor to Launch Ghat	Arterial	37.4	2384	2100	1.13
In Front of BU	Rupatoli to Hiron Point	Arterial	28	2745	1200	2.28

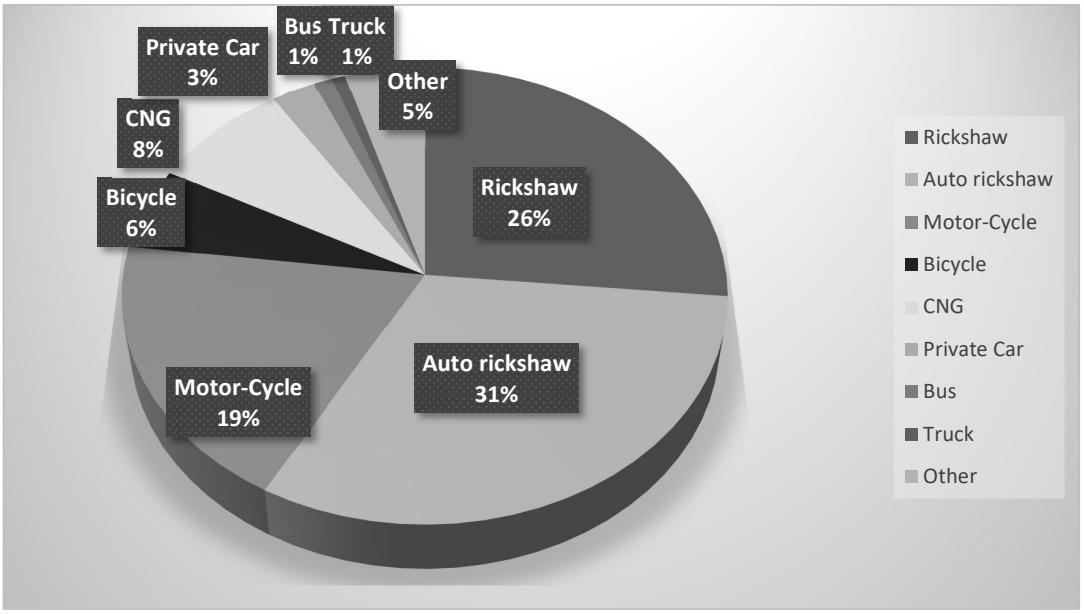

Figure 6: Percentage of vehicles at different links

The above graph represents the percentage of traffic vehicles on different link roads in Barishal City. "Auto Rickshaw" is the most common vehicle among those links, like at an intersection. The percentage is 31. The 2nd most is "Rickshaw," which is 26%, and the 3rd is "Motor-Cycle. The fourth one is "CNG," which is 8%. At an intersection, the number of other vehicles, such as buses, trucks, and so on, is limited. Bicycle, private car, bus, and truck are 6%, 3%, 1%, and 1%, respectively.

3.2 Roadway Congestion Index (RCI)

The density of vehicle traffic on the main roadways in a metropolitan region is measured by the Roadway Congestion Index (RCI). When the RCI is more than 1.0, there is generally more traffic than desired on the major arterial street networks and freeways during peak hours. The RCI value in our analysis was 2.45, indicating an excessive level of traffic congestion. The level of traffic flow is reflected in the traffic congestion index. In order to plan and organize road traffic for traffic managers, to assess the operation status of roads, and to help travelers make appropriate travel decisions, traffic congestion index detection and analysis are useful tools.

Table 4: Calculation For RCI

Col-A	Col-B	Col-C	Col-D	Col-E	Col-F	Col-G	Col-H	Col-I
Link Name	Actual Volume (PCU/hr)	Capacity (PCU/hr)	Link Length (km)	Width (m)	(Col-B * Col-D)	(Col-B/ Col-D)	(Col-F * Col-G)	RCI=(ΣCol_H/ ΣCol_F)
Launch Ghat to Kakolir Mor	2019	1200	0.55	9.75	1110.45	1.68	1865.6	2.45
Kakolir Mor to Jailkhanar Mor	3804	1200	0.65	6.8	2472.6	3.17	7838.1	
Jaikhanar Mor to Notun Bazar	3235	1200	1.1	8	3558.5	2.7	9608	
Notun Bazar to Nothullabad	3581	1200	1.3	9.5	4655.3	2.98	13872.8	
Nothullabad to Chowmatha	4174	2100	1.6	12	6678.4	1.99	13290	
Chowmatha to Bottola	3519	1200	1.2	10.2	4222.8	2.93	12372.8	
Bottola to Kakolir Mor	2836	1200	0.78	9.75	2212.08	2.36	5220.5	
Bottola to Notun Bazar	3285	1200	1.4	8	4599	2.74	12601.3	
Bottola to Bangla Bazar	1697	1200	1.1	6.5	1866.7	1.41	2632.1	
Chowmatha to Nobogram Road	840	1200	2.8	8	2352	0.7	1646.4	
Chowmatha to Sagordi Mor	3941	1200	1.8	7.6	7093.8	3.28	23267.7	
Sagordi Mor to Rupatoli	4386	1200	1.2	7.5	5263.2	3.66	19263.3	
Sagordi Mor to Chandmari Mor	2422	1200	1.4	11.4	3390.8	1.15	3899.4	
Chandmari Mor to Launch Ghat	2384	2100	1.5	11.4	3576	1.13	4040.9	
Rupatoli to Hiron Point	2745	2100	3.8	8.54	10431	2.28	23782.7	

3.3 Travel Time Survey

The travel time and travel cost survey were used to forecast the amount of time and money needed for inter-zonal mobility. The average trip time for moving from one zone to another was calculated by taking the weighted average of the journey times of various vehicles at various locations (zone centroids), as shown in Table 5.

Table 5: Zone-to-Zone Travel Time (Minutes)

Origin Zone	Reference Point	Destination Zone				
		1	2	3	4	5
1	Nothullabad Mor	0	6	14	20	18
2	Notun Bazar Mor	6	0	17	14	21
3	Sagordi Mor	14	17	0	12	4
4	Launch Ghat	20	14	12	0	16
5	Rupatoli Mor	18	21	4	16	0

3.4 Satisfaction Index

It is a measure of how satisfied people are with a specific product or service. In our study, the satisfaction index mainly refers to the opinions of different classes of people about traffic congestion. Satisfaction index +1, meaning highest satisfaction level, and -1, meaning highest dissatisfaction level. 90 questionnaires for drivers, pedestrians, and passengers were conducted at six busy junctions and other congested areas.

From the survey, the number of satisfied respondents was 19, and the number of dissatisfied respondents was 69. From the satisfaction index formula, it was found that the satisfaction index is -0.56, which means a huge number of people in Barishal city are dissatisfied with the congestion.

3.4.1 Nature of the Respondent

Three categories of respondents make up the current study: drivers (30%), pedestrians (46.67%), and passengers (23.33%). According to the age distribution of the respondents, 34.44% of them are young (15–30 age group) and 51.11% are middle-aged (31–49 age group); in contrast, 14.44% of the respondents are old (46–60 age group). Of all the responders, 62.22% completed their SSC and HSC, 26.67% graduated with a master's degree, and 11.11% completed their grades 1–5.

4. CONCLUSIONS

This study mainly helps to know about the present traffic condition of the road network, which gives an idea about optimizing traffic flow. By measuring congestion, authorities can identify bottlenecks, intersections, or road segments where traffic flow is impeded. Understanding congestion helps city planners and transportation authorities identify areas with high traffic volumes and congestion. It also helps city dwellers to know about congested road networks, and they can save their time. Congestion often leads to increased fuel consumption and emissions due to stop-and-go traffic patterns. Measuring congestion helps in evaluating the environmental impact of traffic, and addressing congestion can contribute to reducing air pollution and greenhouse gas emissions.

The study helps the authorities to take actual action on all the city roads according to the RCI value. An RCI exceeding 1.0 indicates an undesirable congestion level, on average, on the freeways and principal arterial street systems during the peak period. Roadway Congestion Index (RCI) was found 2.45 for the entire network as shown in Table 5. This study helps to reduce accidents, which are caused by the excessive number of vehicles that the roads can inhibit. Also, from this study, the authorities can understand the actual condition of the roadways of that particular city at the present time and can predict the future condition of the city according to the present statistics. The educational outings of students

and teachers, as well as the multi-action offices, were correlated with the morning peak of 9–10 AM, while the past meridian is high of 6–7 PM, suggesting the busy scenario of traveling around the city and the city's shopping pattern. The busiest route in Barishal City, Sagordi Mor to Rupatoli, as well as Sher-E-Bangla Medical College, had the most traffic, which culminated at the Sagordi crossroads in the center of the city. The level of traffic congestion in Barishal City was measured by the roadway congestion index, which was 3.66.

It should make use of the expertise of traffic engineers and the participation of professionals, experts, and interested academicians. It will result in both a short-term and long-term solution for Barishal city's effective traffic management. A study about traffic congestion was performed in Dhaka City in 2002 2002 (Habib, 2002) , where the RCI value was found 2.95, and another study was completed in Sylhet City in 2009 (Bijit Kumar Banik, 2009), where the RCI value was found 2.36.

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