Enhancing Public Transport Efficiency in Sylhet: Addressing Low Occupancy and Its Economic Toll on Traffic Efficiency

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Abstract— **One of the main concerns in metropolitan areas of developing nations like Bangladesh is the increase in automobiles brought on by a proportionate increase in people and the quick development of contemporary culture. Thus, it is essential to keep an eye on both the amount of traffic and the Level of Service (LOS), which is a measure of the quality of the transportation provision. Traffic congestion can't be solved by simply doubling the width of roads. More space just means more traffic. Thus, mass transport system can be a good solution. In Sylhet city, CNG and cycle rickshaws make up about 75% of the total traffic volume on major roads. Traffic composition of different roads of Sylhet city are analyzed and found that LOS and congestion cost can be improved greatly by replacing these low occupancy vehicles with minibus. The worst condition was found at Lamabazar road, and the current LOS F can be improved to LOS B just by replacing the two target vehicles with minibus. The V/C ratio at Rikabibazar can be improved by 68.33% after the replacement. Replacement of both the low occupancy vehicles brought an overall improvement of 38.81% in congestion cost. However, the available bus service available during this thesis was found unsatisfactory.**

Index Terms— **Passenger Car Unit, Level of Service, Traffic Volume, Intersection.**

1. Introduction

The design and planning of pedestrian environments are frequently guided by performance metrics and standards (1 2 3). Traffic Volume survey plays a significant role to determine the existing condition and to forecast the future condition of traffic volume. One of the more significant metrics employed is pedestrian level-of-service (PLOS) (4). To ascertain how a pedestrian environment may work in terms of a pedestrian's comfort, safety, and amenity, transport engineers, urban designers, and planners have developed and applied PLOS for almost 50 years. Despite the increasing number of vehicles, the road network cannot be extended to meet the demand. As a result, it affects mental health and environmental balance.

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economic growth, etc. Traffic congestion is a matter of contention of this current world. Its effects can be seen in Bangladesh too. The capital city of Bangladesh, Dhaka, is already congested with excessive vehicles on the road. Robert Gallagher, a transport planner and South Asia specialist from Copenhagen Consensus Center did a study named "Cost-Benefit Analysis: Dhaka's Future Urban Transport" which is about Dhaka's future urban transport and found that the average traffic speed in Dhaka is 6.4 kph (5). But if vehicle growth continues at its current pace, without substantial public transport investment the average speed may fall to 4.7 kph by 2035-about as slow as walking. Not only Dhaka but also other cities of this country such as Sylhet, Chittagong etc. are also suffering from this problem and situation is getting worse by day by day. According to Population and Housing Census 2011 – Volume 3: Urban Area Report from BBS '2014, Sylhet is the fifth populous city in Bangladesh. Sylhet is a densely populated major city in northeastern Bangladesh, located on the Surma river. It has a City Corporation, 12 Upazilas, 101 Unions, and covers 8% of Bangladesh's total land area. Over 500,000 people live there.

Traffic congestion is a major problem in Sylhet city due to narrow roads and a high number of vehicles. Major intersections such as Madina Market, Subid Bazar, Amborkhana, Chowhatta, Bandar Bazar, etc. experience severe congestion, causing delays in employment, meetings, and education. If no active steps are taken to address the issue, the traffic system in Sylhet city may become uncontrollable.

2. Literature Review

The level of service (LOS) is an important part for designing a road so that the policy makers or the transport planners can understand the extent of problems that the drivers are facing in their daily life (6). On the other hand, traffic congestion has become one of the plagues of modern life in a big city; time spent ensnarled in traffic is not simply time wasted, for most of us, it is time miserably wasted (7).

A. Terminology

For the analysis context, a variety of concepts and descriptions need to be understood. Those are described below:

B. LOS Concept

It is an established fact that the terms 'capacity' and 'Level of Service (LOS)' will be closely related. Capacity refers to the quantitative measure of road section and LOS represents the qualitative measure of the road section (8). LOS aims to relate the quality of traffic service to a given traffic flow rate. Table 1 and Table 2 suggest LOS for two-lane undivided and divided urban roads, respectively. The data collected by videography or other techniques is used to determine free flow speed. Vehicular level of service is the only consideration in this research paper.

Table .1. LOS of Two lane Undivided Urban Roads based on Stream speed, V/C Ratio and FFS by Indian Highway Capacity Manual 2017 (9)

Level of Service	Volume/Capacity Ratio	Percentage of Free Flow Speed
LOS A	0.35	89
LOS B	0.36-0.55	88-55
LOS C	0.56-0.70	54-21
LOS C	0.71 -0.85	20-12
LOS E	0.86-1.00	6-Nov
LOS F	> 1.00	<6

Table.2. LOS of Multiline Divided Urban Roads based on Stream Speed, V/C Ratio and FFS by Indian Highway Capacity Manual 2017 (9)

Level of Service	Volume/Capacity Ratio	Percentage of Free Flow Speed
LOSA	≤0.15	≥84
LOSB	0.15-0.45	83-76
LOSC	0.46-0.75	75-59
LOSD	0.76-0.85	58-41
LOSE	0.86-1.00	40-22
LOSF	> 1.00	<22

C. Passenger Car Unit (PCU)

In developing countries like Bangladesh, different types of vehicles such as cars, buses, trucks, bikes, etc. commonly use the same roads without following the lane separation rules. This creates a complex mixed traffic flow, as different vehicles have varying features and driver behavior. To simplify the measurement of traffic, a Passenger Car Unit (PCU) is used as a standard unit of measurement. PCU values are crucial in analyzing mixed traffic flow, including traffic parameters, capacity, signal design, and parking lots (10). Passenger car units are used to represent the effects of varying mixed vehicle types on traffic stream (11). If a specific vehicle class has the same impact as adding one passenger car, then it's considered equivalent to a passenger car with a PCU value of 1.

D. Studies on Level of Service in Bangladesh

Transportation is one of the factors that is closely linked to the development of a country. The development of a city is explicitly interconnected with the transportation system. The low level of service on the Muradpur to Dewanhat Road in Chittagong is due to factors such as geometric design, lack of parking and bus stop, commercial land use, high number of CNG autorickshaws and cars, absence of separate shoulder for non-motorized vehicles, and human behavior (12). Factors such as lane width, shoulders, surface condition, channelization, land use, parking, stoppage concentration, and frictional effects were considered for LOS (13). Five pedestrian level of service (PLOS) was implemented to consider the suitability for use in Dhaka city, Bangladesh (14). Accessibility, attractiveness, and safety are important factors for footpaths, carriageways, and transit facilities (15). Al Kafy analyzed traffic volume and accidents in major intersections of Rajshahi, Bangladesh, estimating the Level of Service using the V/C Method. (16). This study assessed the efficacy of pedestrian walkways in Dhaka city (17). Siddique determined a suitable level of service method to measure service quality of pedestrian walkways in Dhaka city (18). This research paper emphasized pedestrian safety by providing some recommendations.

In the context of abroad, Khisty discusses the need to consider environmental factors over and beyond the quantitative measures of level of service provided by the HCM, and then sets out a methodology for evaluating pedestrian facilities (19). When the number of turning vehicles increases, the result shows a corresponding decrease in the perceived safety to the pedestrian (20). Different assessment methods can lead to multiple LOS ratings for the same sidewalk segment, which limits the confidence in using existing methods for pedestrian LOS estimation in both urban and campus-like environments (21). FREEVAL and Vissim can replicate field conditions with LOS differing by a maximum of one grade. HCM produces higher segment density than Vissim microsimulation (22). Pompigna & Rupi found out the differences between HCM procedures and fundamental diagram calibration for operational level of service assessment on Italian freeways (23). The average travel speed for LOS categories "A," "B," and "C" is higher than HCM values, but for a shorter duration. Probe vehicles traveled more frequently at LOS "D," "E," and "F." (24). The pedestrians' perception of comfort and safety is influenced by both the walking environment and adjacent road and traffic characteristics in Johor Bahru (25). Klodzinski & Al-Deek estimated that the 85th delay percentile graphs from each of the plaza analysis results for LOS values were also observed to be similar (26). Kita presented new model based on driver perception can help evaluate the quality of service of road traffic (27).

E. Traffic Congestion:

Traffic congestion has become one of the plagues of modem life in a big city (7). Public transport plays an important role for mobility in urban areas, particularly with regard to work trips

Table.3.
A summary of some alternate definitions of congestion

	Definition	Author
Demand Capacity related	Traffic congestion occurs when travel demand exceeds the existing road system capacity	*(32)*
	Congestion is a condition in which the number of vehicles attempting to use a roadway at any time exceeds the ability of the roadway to carry the load at generally acceptable service levels.	*(33)*
	Congestion is a condition that arises because more people wish to travel at a given time than the transportation system can accommodate: a simple case of demand exceeding supply	*(34)*
	When vehicular volume on a transportation facility (street or highway) exceeds the capacity of that facility, the result is a state of congestion.	*(35)*
	Congestion is the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity	*(36)*
	Congestion may be defined as state of traffic flow on a transportation facility characterized by high densities and low speeds, relative to some chosen reference state (with low density and high speed)	*(37)*
Delay-travel time related	Congestion is an imbalance between traffic flow and capacity that causes increased travel time, cost, and modification of behavior	Pisaraski 1990 cited in *(34)*
	Traffic congestion is travel time or delay in excess of that normally incurred under light or free-flow travel conditions	*(38)*
	Traffic congestion is a condition of traffic delay (when the flow od traffic is slowed blow reasonable speeds) because the number of vehicles trying to use the road exceeds the traffic network capacity to handle them	*(39)*
	Congestion is the presence of delays along a physical pathway due to presence of other users	*(40)*
	Congestion can be def9ined as the situation when traffic is moving at speeds below the designed capacity of a roadway	*(31)*
	In the transportation realm, congestion usually relates to an excess of vehicles on a portion of roadway at a particular time resulting in speeds that are slower – sometimes much slower than normal or "free flow" speeds	*(41)*

and trips to central areas (28, 29, 30). Traffic congestion is a major issue that hinders smooth traffic flow in urban areas. Physical construction alone cannot solve the problem. Transportation management technology is essential to regulate traffic. Downs identified three broad categories of traffic congestion: demand capacity related, delay-travel time related, and cost related (31). A summary of some alternate definitions of congestion are shown in table.3.

Congestion can occur due to reduction of road capacity or increase in the number of vehicles. According to USDT-FHA, there are seven root causes of congestion, such as traffic incidents, work zones, weather fluctuations, special events, traffic control devices, and physical bottlenecks. Economic cost of traffic congestion is one of the most debatable issues in an economy (42). In conditions where the use of a transport system approaches its capacity congestion is defined as the impedance which vehicles impose on each other due to the speed-flow relationship (43).

F. Travel Time Cost (TIC):

The cost of travel time is a crucial component of the total expenses for road users. It's the time spent in traveling that has an opportunity cost. The cost can vary from place to place and time to time. The economic travel time cost of autorickshaws and tempos in 2016-17 is almost three times that of the 2004-05 report by the Roads and Highways Department of Bangladesh.

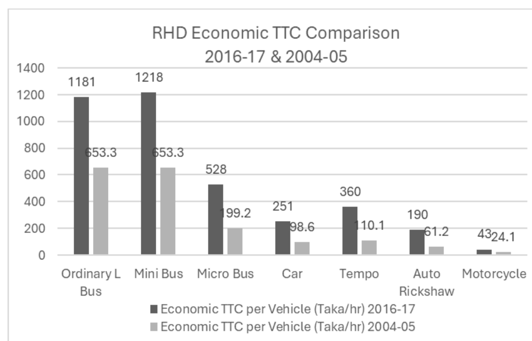

Fig.1. RHD Economic TTC Comparison

Saha worked on the application of traffic management plan and a sustainable solution of traffic congestions in Pabna city, Bangladesh which provided vast proposals to reduce traffic congestion (44). Khan & Mcips studied the economic impact of traffic congestion in Dhaka city (45). Shamsher & Abdullah identified that traffic congestion in Chittagong Metropolitan City, Bangladesh can be mitigated through the implementation of a proper traffic management system and adherence to traffic rules (46). Wider lane will reduce waiting expectancy and increase travel length, yet improve mental health of drivers (47). Traffic congestion in Dhaka city causes an economic loss of around 12.561 billion USD, which is about 7% of the country's GDP (48). Research on traffic congestion and sustainable development in Dhaka city found that allowing a small lane for bicycles can contribute to a better urban transport system (49).

3. Methodology

The main objective of this research is to find the level of service in three conditions and to find the congestion costs of the designated points in current situation and after replacing the low occupancy vehicles. Many data have been analyzed to fulfil the research work. Some mathematical models were taken from chapter 5 (Urban Roads) of Indian Highway Capacity Manual 2017 (9). Data were collected by analyzing the video and the CCTV footage of the study areas and some field data were also collected to get the delay time for congestion cost calculation.

A. Route Section

Focus was drawn to cover the busiest and the most important points while selecting the route to get the best results. Traffic data were collected between every two main points, as per the suggestion of Indo-HCM urban roads condition. For LOS determination, the followed route is: SUST Gate - Madina Market - Subidbazar - Ambarkhana - Chowhatta - Rikabibazar - Lamabazar - Jitu Mia's Point - Taltola - Bandar. The route map is shown in Figure 2 and Figure 3.

For LOS determination a total of 8 stations were selected for data collection. They are,

- Surma residential area Gate. (SUST Gate to Madina Market traffic direction.)
- Pathantula. (Madina Market to Subidbazar traffic direction.)
- Amberkhana. (Subidbazar to Amberkhana directional traffic.)
- Chowhatta. (Amberkhana to Chowhatta, both directional traffic.)
- Rikabibazar. (Chowhatta to Rikabibazar traffic direction)
- Lamabazar. (Rikabibazar to Lamabazar, both directional traffic.)
- Jitu Miah`s Point to Taltola Road (both directional traffic.)
- Taltola to Bandar Road (both directional traffic)

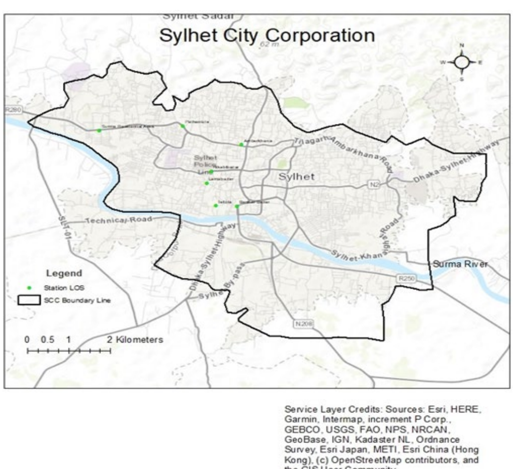

Fig.2. Route Map and Stations for LOS Determination

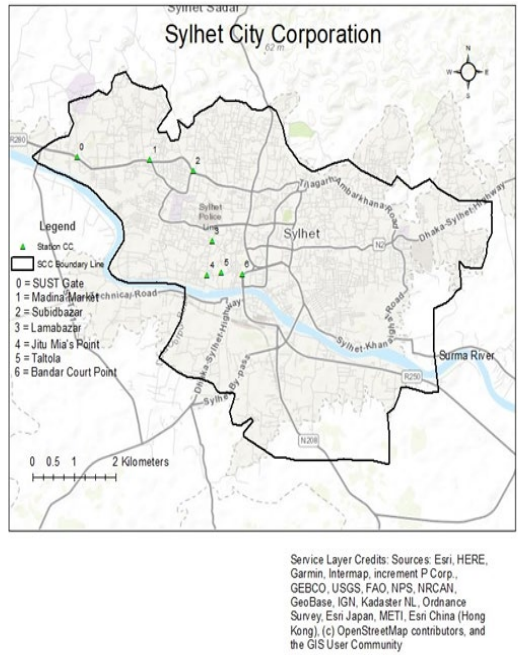

Fig.3. Route Map and Control Points for Congestion Cost Determination

B. Delay Calculation

Speed and delay studies can be carried out via different methods. This study was conducted in Bangladesh using the manual delay study method, which is the most economical. It requires a test vehicle, driver, observer, two stopwatches or one with double sweep, and a distance measuring instrument. Data is collected using a field form containing three runs and one area. The first stopwatch records the time, and the second stopwatch records the delay data for speeds lower than 5 mph. The delay is recorded in seconds and causes, and the stop delay is obtained from the data table. The time taken for each run from the starting point to the ending point was recorded from the first stopwatch while the second stopwatch gave the delay between the control points.

The vehicle operating delay can easily be calculated by subtracting Free Flow Time and Stop Delay from Peak Hour Time.

$$Operating\ delay = (Peak\ Hour\ Time - Free\ Flow\ Time) - Stop\ delay \quad \ldots\ldots\ldots (1)$$

C. Input Data Requirement

To determine the level of service, some equations from authentic research papers were used in this study. The saturation flow was derived from width by Indian Road Council- SP41 *(50)*. The equation is,

$$S = 525w \quad \ldots\ldots\ldots (2)$$

Where, S = saturation flow (pcu/hr)

w = width (m)

Capacity was calculated using saturation flow, green time, and cycle length. The equation was taken from HCM-2010 *(51)*.

c=Sg/C…………………………………………………(3)

Where, c = capacity (pcu/hr)
S = Saturation flow (pcu/hr)
g = Green Time (sec)
C = Cycle length (sec)

From the volume and capacity ratio, the level of service is determined according to Indo- HCM 2017. Different types of vehicles have different PCU values. From the video footage, vehicles were counted first. Then, the amount was converted to l-hour period and multiplied by their respective PCU values. The summation of all these PCU/hr values is the volume of traffic termed here.

To determine the congestion cost, after calculating the delay times for different vehicles, recommended economic Travel Time Cost (TTC) for FY 2016-2017 by RHD was used. From Average Consumption Rate (ACR) of fuel of different vehicles the amount of extra burnt fuel is also calculated and added to the congestion cost value. Amount of CNG consumption (m3) can be found by multiplying total delay by the number of vehicles and Average Consumption Rates. Then total fuel cost can be found by multiplying consumption of fuel by unit price of fuel. The calculation is done using the market value of 1m3 CNG of 43 taka. Table.4 shows the recommended Travel Time Cost values for 2016-17 financial year which is taken from Road User Cost (RUC) final report 2017, published by the Department of Roads and Highways (RHD), People's Republic of Bangladesh (52). Table.5 presents the RHD recommended TIC for non-motorized vehicles for the financial year 2004-05 (53). TIC for non-motorized vehicles recommended by Local Government Engineering Department (LGED) is shown in Table.6 (54). In table.7, the Average consumption rate (ACR) of fuel by different vehicles are shown (55).

Table.4. Recommended TTC for FY 2016-17 by RHD

Vehicle Category	Economic	TTC per Passenger (Taka/hr)
Ordinary L Bus	33	1181
Minibus	35	1218
Micro Bus	66	5218
Car	84	251
Tempo	40	360
Auto Rickshaw	38	190
Motorcycle	43	43

Table.5. TTC for Non-motorized Vehicle for FY 2004-2005 by RHD

Vehicle Category	Occupancy	Economic	TTC per Passenger (Taka/hr)
Cycle Rickshaw	2	4.1	8.2
Bicycle	1	10.5	10.5

Table.6. TTC for Non-Motorized Vehicles from LGED RUC Final Report-2009

Division	Vehicle	Occupancy	Economic	TTC per Passenger (Taka/hr)
Sylhet	Cycle Rickshaw	2	4.3	8.4
	Bicycle	1	10.7	107

Table.7. Average Consumption Rate (ACR) of Fuel by Different Vehicles

Vehicle Type	Petrol (L/min)	Diesel (L/min)	CNG (m^3/min)
Car	0.025		0.031
Bus	0.033		0.078
CNG Auto Rickshaw			0.015
Motorcycle	0015		
Truck		0.079	

4. Analysis And Result

A. General

The analysis task for this study can mainly be divided into two parts, one is to determine LOS and the other is to calculate congestion cost. Surveyed traffic data are first analyzed, and hourly traffic volumes are calculated. Then road capacity was measured. From these data, LOS was determined. Congestion costs are determined after finishing delay data study. The results of this study are also presented in this chapter. The goal of this study is to observe the change in LOS and traffic congestion cost if we replace the low occupancy vehicles by minibuses. Changes in these two traffic parameters are presented numerically.

B. Level of Service (LOS)

The collected data using mobile camera and drone were analyzed for traffic volume determination. Some CCTV footage which has been collected from Sylhet Metropolitan Police was also analyzed for traffic volume determination. Before data collection, a short survey was done to determine the peak hours. And the busiest traffic condition was found between 10:00AM to 11:30AM in the morning and 04:30PM to 06:00PM in the evening. Traffic data were collected between these peak-hour times accordingly.

C. Vehicle Type

1) Traffic Volume

Traffic volume survey is necessary for both LOS and congestion cost calculation.

The traffic volume data were accumulated by analyzing recorded videos from smartphones and drones; some CCTV footage was also analyzed. Traffic data were collected for three or five minutes depending on the cycle length of the signal. These three- or five-minutes data were converted and multiplied by PCU values and hourly volume of traffic was found in PCU per hour unit.

Average hourly traffic volume data are presented in figure.4.

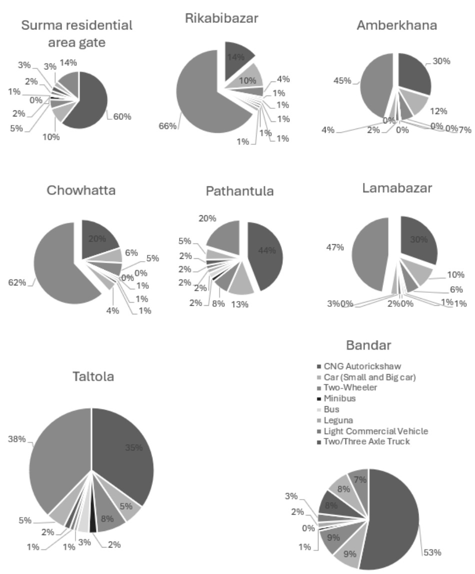

Fig.4. Average hourly traffic volume data.

D. Roadway Capacity

For the first station, roadway width was measured at the point which is in front of Surma Residential Area Gate. Using this width, the capacity of SUST Gate to Modina Market directional traffic flow was calculated. Similarly, for the second station, roadway capacity was measured at Pathantula point which indicates the traffic flow of Modina Market to Subidbazar direction. Similarly, capacity for all other stations were measured.

Table.8 Roadway Capacity in pcu/hour Unit

Road	Capacity (PCU/hr)
Surma Residential Area Gate (SUST Gate to Modina Market direction)	3517.5
Pathantula (Modina Market to Subidbazar direction)	3517.5
Ambarkhana (Subidbazar to Ambarkhana, both direction)	3465
Chowhatta (Ambarkhana to Chowhatta, both direction)	4500
Rikabibazar (Chowhatta to Rikabibazar direction)	4500
Lamabazar (Rikabibazar to Lamabazar, both direction)	3656.25
Sheikhghat-Kazibazar Road (Jitu Mia's point to Taltola, both direction)	6300
Bandar (Taltola to Bandar Road, both direction)	7087.5

E. Occupancy Conversion

Vehicular occupancy is the average number of passengers that any vehicle serves at a time. Average occupancy was measured for three target vehicles during this study and they are presented in table.9 These values show that one single minibus can serve the same number of passengers served by total seven CNG autorickshaws. While the total number of passengers served by twenty-two cycle rickshaws can be served by only one minibus. Minibus surveyed for this study are the 36-seater ones.

Table.9. Average Occupancy Values

Vehicle category	Avg. Occupancy
CNG Autorickshaw	4.20
Cycle Rickshaws	1.33
Minibus	29.4

F. Level of Service (LOS) Results

LOS is first measured for the current condition. Then the expected LOS was measured by replacing CNG autorickshaws first, then replacing cycle rickshaws and finally replacing them both by minibuses. LOS is determined based on Indo-HCM 2017 guidelines for urban roads.

The concept of mass transport system is not any new theory and it clearly indicates that introducing mass transport system can improve the LOS. In this study, LOS values for different stations have also improved by different margins depending upon the proportion of vehicular volumes. However, changes are not same for all the cases. Replacement of CNG autorickshaws shows better result sometimes and replacement of cycle rickshaws gives better LOS at some stations. It is observed that, replacement of any vehicle which currently occupies most of the road capacity gives the highest improvement for that place. While replacement of both the low occupancy vehicles always give the best results. A comparison of improved LOS is presented in the figure 4. The improvement in V/C ratios are drawn in the comparison. In the Rikabibazar station, 60.83% of V/C ratio was improved only by replacing cycle rickshaws. While 68.33% of improvement in V/C ratio has achieved for the station after replacing both the CNG autorickshaws and cycle rickshaws. For the first two stations, those are Surma residential area gate and Pathantula, the improvement is higher for CNG autorickshaws replacement. At these two stations, the most prevailing vehicle is the CNG autorickshaws. Thus, replacement of them gave better results for those two stations.

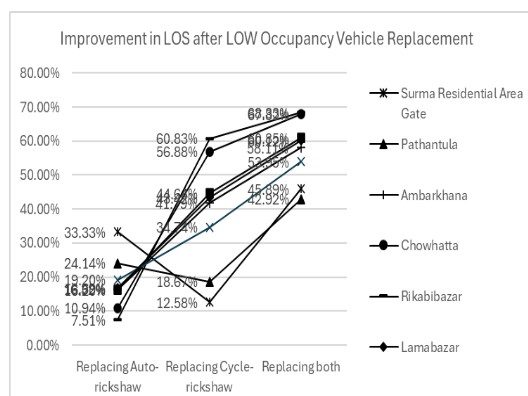

Fig.5. Improvement in LOS after Replacing Low Occupancy Vehicle

G. Congestion Cost

To determine the congestion cost, delay time was measured first. Then congestion cost was calculated using the RHD Travel Time Cost (TTC) data. Congestion cost was measured for travel time cost and fuel burning cost. TTC data for motorized vehicles are used same as provided in the Road User Cost (RUC) 2016-17 report. But there is no recent TTC data available for non-motorized vehicles. Thus, TTC for cycle rickshaw was calculated analyzing the growth rate of TTC value of low occupancy motorized vehicles.

It was found that TTC of autorickshaws and tempos in 2016-17 report are almost three times of that of TTC in 2004-05 report, that has been presented in the chapter two of this thesis. As autorickshaws and tempos are both low occupancy vehicles, an assumption is made and TTC of cycle rickshaws is taken as three times the value of the TTC in the 2004-05 report. In 2004-05 report, TTC for cycle rickshaws was 8.2 Taka/hr per vehicle and in this study the TTC for cycle rickshaws is taken as 24.6 Taka/hr. per vehicle.

H. Delay Data

Delay time was calculated for one route. Delay time was converted into per hour value and it shows that minibuses have more delay time than CNG autorickshaws for most of the times. Here delay time is highest in the Subidbazar-Lamabazar link and which is quite visible to naked eyes in regular traffic congestion scenario in this link. Calculated delay time results are presented in table.10 and table.11 in terms of seconds and hours, respectively.

I. Delay Data Comparison

Because of the heterogeneous traffic condition, the delay data tradeline for all the six stations is not exactly linear. The first three road segments showed somewhat nearly results for CNG autorickshaw and minibus. In the fourth segment, which is marked as control point 3-4, the delay time of minibus is almost double as the delay time of CNG autorickshaw. While in the last two segments, the delay time of CNG autorickshaws are far better than that of minibuses.

J. Predicted Delay Data of the Post Replacement Condition

Future delay time was predicted depending upon the current V/C ratio, current delay time and the expected V/C ratio after the replacement of targeted low occupancy vehicles. Predicted delay times were measured after replacing CNG autorickshaws, after replacing cycle-rickshaws, and replacing both the low occupancy vehicles successively. Then the post replacement congestion costs were calculated from these three different sets of delay time values. The predicted delay times are presented in the tables.10, and table.11. The predicted delay time (DT) was calculated using a simple relation, that is,

Table.10
Delay Time Result (in sec)

Vehicle	CNG autorickshaw Average Delay (in Sec)		Cycle-rickshaw Average Delay (in Sec)		Minibus Average Delay (in Sec)	
Control Point	Stop Delay	Operating Delay	Stop Delay	Operating Delay	Stop Delay	Operating Delay
0-1	65.33	85.67	18.67	149.83	55	58.5
1-2	56.67	115.83	13.37	72.83	21.5	161.5
2-3	97	111	54.94	128.83	71.5	174.5
3-4	22	60	9.67	40.83	32.5	115.5
4-5	03	5	06	46.5	3.5	74.5
5-6	11	7	19	45	24.5	72.5
Total	258	384.5	121.68	483.82	208.5	657

Table.11
Total Delay Time Result (in hours) at different Control Points

Control Point	CNG autorickshaw (hour)	Cycle-rickshaw (hour)	Minibus(hour)	Total(hour)
0-1	0.042	0.047	0.032	0.121
1-2	0.048	0.024	0.051	0.123
2-3	0.058	0.051	0.068	0.177
3-4	0.023	0.014	0.041	0.078
4-5	0.003	0.015	0.022	0.04
5-6	0.005	0.018	0.027	0.05
Total	0.179	0.169	0.241	0.589

Control Points indication: 0 = SUST Gate, 1 = Modina Market, 2= Subid Bazar
3= Lamabazar Point, 4= Jitu miah`s Point, 5= Taltola, 6= Bandar Court Point

$$Predicted\ DT = \frac{Present\ DT * Past\ replacement\ \frac{V}{C}\ ratio}{Present\ \frac{V}{c}\ ratio} \dots\dots\dots\dots (4)$$

K. Comparison of Congestion Cost

Results of congestion cost show that, after replacing CNG autorickshaws and cycle rickshaws by minibuses, the congestion cost gets a significant improvement from the current situation. However, the changing scenario is not always the same for all different road segments. For the first three road segments, the replacement of CNG autorickshaws shows a great improvement over the present condition (see figure.6.). But, for the last two road segments, replacement of CNG autorickshaws did not bring out any improvement. This is because of the very smaller delay time of CNG autorickshaws at those two points. suitable road condition for the buses to operate smoothly and efficiently. This will improve the quality of life for citizens and enhance the city's reputation as a modern and well-connected hub.

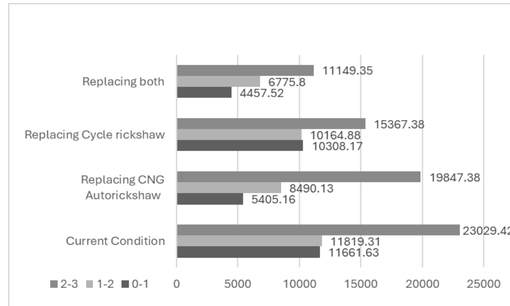

Fig.6. Comparison of Congestion Cost for Road Segment 0-1-2-3

Table.12
Predicted DT after Replacing CNG Autorickshaws

Expected future Condition – Replacing CNG Autorickshaws				
Segment	V/C Ratio	CNG Autorickshaw DT (hr)	Cycle rickshaw DT (hr)	Minibus DT (hr)
0 to 1	0.2606	0.028	0.031333333	0.021333333
1 to 2	0.3513	0.036412006	0.018206003	0.038687756
2 to 3	0.8352	0.048315978	0.04248474	0.05664632
4 to 5	0.3311	0.002423865	0.012119327	0.017775012
5 to 6	0.6359	0.004189617	0.01508262	0.022623929

Table.13
Predicted DT after Replacing Cycle rickshaws

Expected future Condition – Replacing CNG Autorickshaws				
Segment	V/C Ratio	CNG Autorickshaw DT (hr)	Cycle rickshaw DT (hr)	Minibus DT (hr)
0 to 1	0.3417	0.036713738	0.041084421	0.027972371
1 to 2	0.3766	0.0390.4334	0.019517167	0.04147398
2 to 3	0.5672	0.032812288	0.028852184	0.038469579
4 to 5	0.2674	0.00195754	0.009787701	0.014355295
5 to 6	0.4201	0.002767822	0.009964159	0.014946238

Table.14
Predicted DT after Replacing Cycle rickshaws.

Expected future Condition – Replacing CNG Autorickshaws				
Segment	V/C Ratio	CNG Autorickshaw DT (hr)	Cycle rickshaw DT (hr)	Minibus DT (hr)
0 to 1	0.2115	0.022724482	0.025429777	0.01313891
1 to 2	0.2643	0.027394515	0.013697258	0.029106672
2 to 3	0.3998	0.02328267	0.020336924	0.027115899
4 to 5	0.1887	0.001381406	0.006907028	0.010130307
5 to 6	0.2971	0.001957438	0.007046778	0.010570167

Control Points indication: 0 = SUST Gate, 1 = Modina Market, 2= Subid Bazar
3= Lamabazar Point, 4= Jitu miah`s Point, 5= Taltola, 6= Bandar Court Point

However, replacement of both the low occupancy vehicles brought an improvement of 38.81% overall.

Sylhet city's public transport is struggling to provide efficient service. The intercity bus transport service introduced by Sylhet City Corporation in December 2019 is insufficient, causing buses to move slowly on narrow roads and spend a lot of time searching for passengers. The absence of fixed stopping points and illegal parking add to the chaos. The current operating condition of the bus transport service in Sylhet city is inadequate and fails to provide a proper service to citizens. The Sylhet city authority must take immediate action to ensure a

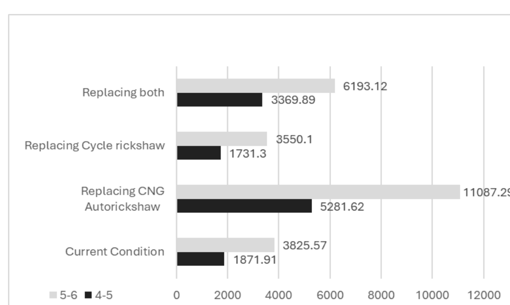

Fig.7. Comparison of Congestion Cost for Road Segment 4-5-6

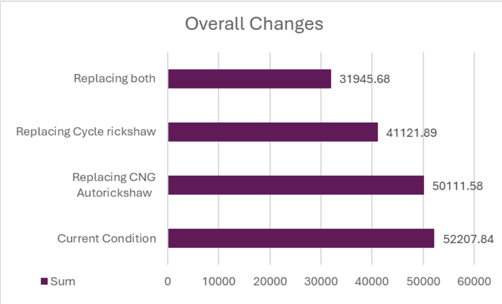

Fig.8. Comparison of overall Congestion Cost Changes

L. Summary

Changes in LOS mainly occurred depending upon the vehicle category and the PCU/hour amount of that vehicle in total traffic volume. However, changes in congestion cost occurred according to the delay times and delay time of minibus is not always the best among the three target vehicles. This chapter shows all the results acquired from the study with some brief descriptions. Result shows that, elimination of CNG autorickshaws and cycle rickshaws can bring lots of improvement in LOS and congestion cost.

5. Conclusion

Cities in Bangladesh are facing traffic congestion due to increased traffic volume. Simply increasing road width is not a viable solution, as congestion will occupy any new space. Mass transport systems could help, but they are difficult to implement city-wide. Low-occupancy vehicles are a large part of the cause of traffic congestion in Sylhet city.

CNG autorickshaws and cycle rickshaws combined occupy an average of 75% of the total traffic volume of different roads in Sylhet City. Replacement of CNG autorickshaws and cycle rickshaws gives a far better LOS than that of the current condition. Even in some cases, it is found that the road, which is currently serving an LOS F, upgrades to an LOS B after the replacement of these low occupancy vehicles by minibuses. Delay time for buses is presently higher than that of CNG autorickshaws. Therefore, the currently available bus service needs to serve its potential. Congestion costs will decrease significantly if CNG autorickshaws and cycle rickshaws are replaced with minibuses. Replacement of both the low occupancy vehicles reduced 38.81% of the current congestion cost.

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