ASSESSMENT ON VOLUME STUDY OF PUBLIC TRANSPORTATION SYSTEM OF KHULNA- CITY ROAD, BANGLADESH: A CASE STUDY OF BOYRA TO SHIB-BARI MOR MIDBLOCK

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ABSTRACT

Traffic volume is a very important parameter in majority of the transportation planning applications. This paper attempts to gain insights into the traffic volume and its effect on public transport system. For this reason a traffic volume study has been conducted from Boyra to Shib-Bari Mor of Khulna- city road. In this study, volume of the road section has been determined through video analysis method and is represented by Passenger Car Unit (PCU). The collected data is analyzed to identify the congestion phenomenon during peak and off-peak period on weekdays and weekends. The volume to capacity (V/C) ratio identified for the section "Boyra-Joragate" is mor than 0.62, which is found to be the highest comparing with other sections (V/C in between 0.30 to 0.35) during the peak period of weekdays. Finally, the Level of service (LOS) for this road section is also determined along with the formal and informal parking of the road. Proposals like; reduction of conflicting points, provision of off-street parking; would be some potential solutions to increase the efficiency of this section of road.

Keywords: *Volume, Capacity, Level of service, Assessment, Conflict Points*

1. INTRODUCTION

Khulna is one of the divisional cities of Bangladesh with a land area of 45.65 km^2. It has a road network of 1231 km (Hossain et al., 2005) here Khulna- city road is about 106.25km (50 - Roads and Railway Division, 2013). For increasing efficiency of this city road and to provide better means to utilize other roads linked to this city road a traffic volume study was necessary. Morover, a volume study survey can also be helpful in impact analysis of this road and determining need for traffic control system.

The volume study survey was being conducted from Boyra to Shib-bari mor on Khulna-city road in two different spots at 3 peak period and 2 off peak period on both weekday and weekend. It was performed through indirect method in which vehicle movements were captured by camera and counted by categorizing them. It is a permanent method and so the collected data can be used to monitor and evaluate traffic volumes and trends over a long period of time (Traffic Volume Counts). In this study, Passenger Car Unit of different vehicles represents the volume across the road sections and Passenger Car Equivalent Unit represents the road capacity where Dhaka Urban Transport Study is used as standard but in general the design capacity of urban arterial road is 1400 PCU/lane/hour (Sharmeen et al., 2012). Major finding of this study is determining the Level of service (LOS) of the roads through Volume-Capacity ratio (Boarnet et al., 1998). The objective of this study is to assess the existing volume condition of the roads and reducing the number of conflict points and also to increase road life by controlling excessive volume of vehicles.

Due to rapid growth of urbanization there is a major influence on transportation sectors in terms of major traffic characteristics such as increasing volume, city road capacity and level of service etc. Traffic volume is an important measure of magnitude, composition, and time and route distribution of volume. Volume by definition is the total number of vehicles that pass over a given point or section of a lane or roadway during a given time interval (Nuzhat Nueery Haque et al., 2013). One of the main design parameter of road, "average annual daily traffic" can be obtained through dividing summation of daily traffic count in one year by 365 (Roads Department, 2004).

Since roads have certain width with varying lanes, flow is always defined in terms of width, ADT, termed as average daily traffic, implies the road capacity which is considered as a function of traffic and road geometrics. To express city road capacity the Passenger Car Unit (PCU) or Passenger Car Equivalent (PCE) is used which is termed to be the universally adopted unit for measuring traffic volume or capacity (Pothula Sanyasi Naidu, 2015).

Case Study on Development of Passenger Car Unit in NAL STOP, PUNE shows that the PCU value of each vehicle is not a constant but varies with several factors such as proportion of other classes, level of service and volume to capacity (Patil, 2015).

Level of service (LOS) is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience and six LOS which are defined for each type of facility that has analysis procedures available (Singh et al. 1991).

Percentage Speed Reduction (PSR) from Free Flow Speed (FFS) can be identified as a performance measure for LOS assessment on urban arterials which has been analysed from the Case Study on the Assessment of Level of service on Urban Arterials in Kolkata (Subhadip Biswas, 2016).

2. METHODOLOGY

2.1 Study Area

The study area is located in Khulna-Jossore City road and the surveyed area was Boera to Shibbari mor. The total road is almost 2.2 KM. The study area is about 1.2 KM and 1.3 KM from Dakbanglo mor and Sonadanga mor respectively. The land use along the road is residential use (32%) and commercial use (16%). Common traffic control systems, stopping point, roundabout, speed breaker and signal are introduced in the area. There are three major intersection, Boyra mor, Joragate mor and Shibbari mor.

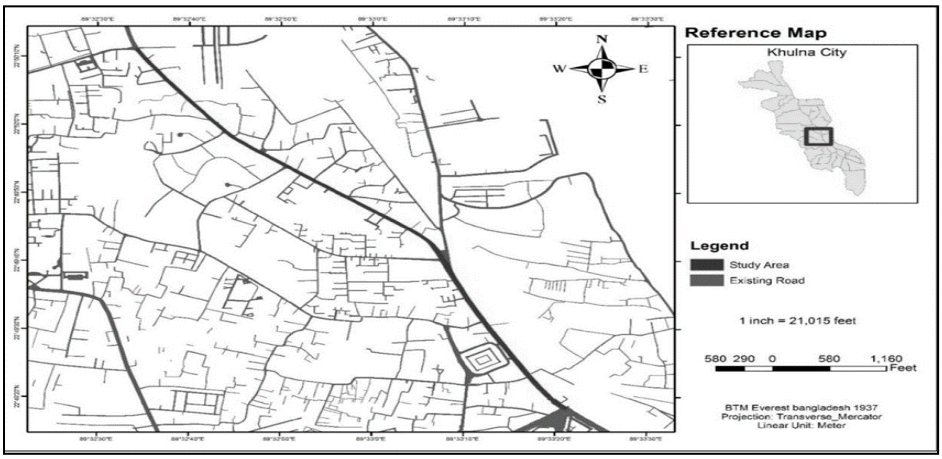

Figure 1: Study Area Map

2.2 Methods

A theoretical framework was developed from the understanding of operational features of the selected study area, relevant volume and speed studies. In the operational features of the study area, considered elements were: right of way, carriage way, median, lane numbers, footpaths, and driveways. Volume, speed and delay studies along with road capacity and LOS have considerable influence on theoretical assessment of public transport.

After conceptualization, the survey strategy was developed. The survey covered questionnaires of different user groups, checklist of existing roadway facilities and user rating survey. Three (3) questioner survey forms were developed addressing general users, drivers and traffic policies.

Additional data was collected from both primary and secondary sources. Primary data focused on physical features of roadway, vehicle speed and volume data. Directional vehicle volume data was collected by using video camera at selected nodes. The selected nodes were in front of Passport Office near Boyra mor and near Joragate mor. Speed data was collected using different test vehicles at a specified roadway segment. Vehicle speed of peak and off-peak hours were calculated and compared. The survey was conducted on two weekdays at 5 different times (3 peak times and 2 off-peak times). Secondary data covered technical sources which were basically the standards of Rajdhani Unnayan Kartripakkha (RAJUK), Khulna Development Authority (KDA), and Khulna City Corporation (KCC).

The primary data was used to calculate LOS which may be helpful to plan to reduce the conflict points and secondary data was used to compare those results with the national standards so that mor facilities can be added to increase road life.

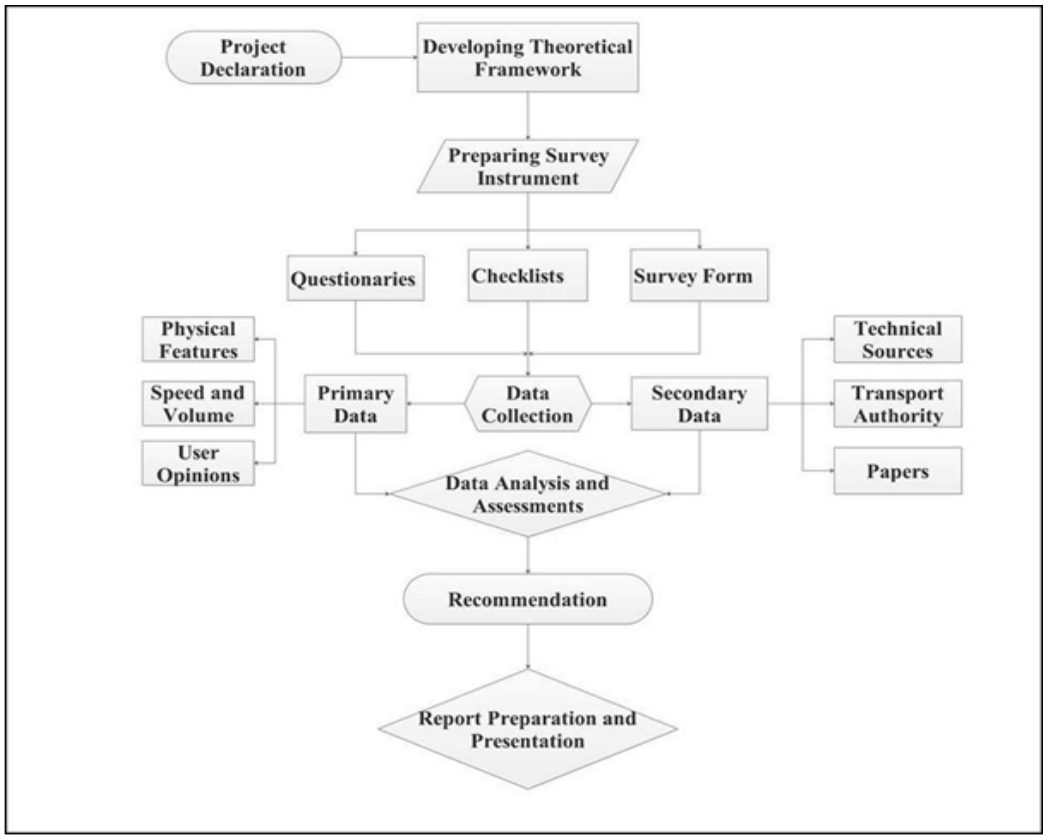

Figure 2: Methodology for Flow Chart

3. ANALYSIS

3.1 Volume:

Table 1: Vehicles according to direction in Weekdays

Vehicles	Baira-Joragate		Joragate-Boyra		Joragate-Shibbari		Shibbari-Joragate	
	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Truck	4.2	9.3	4.9	9.4	3.2	7.3	6.6	8.7
Bus	5.0	5.2	6.2	4.6	5.5	4.8	4.8	4.1
Mini-Truck	3.1	7.3	3.9	7.4	5.6	8.0	1.3	7.7
Car	8.9	5.0	11.1	3.8	15.1	6.7	17.6	4.1
Mahendra	41.5	24.1	29.6	33.0	24.8	27.6	23.7	27.9
Easy bike	14.6	23.6	20.4	20.5	17.3	24.6	16.1	26.0
CNG	2.5	3.5	3.7	3.0	9.8	3.5	6.1	2.8
Bike	11.1	11.4	8.6	11.2	8.1	7.2	11.1	10.9
Rickshaw	3.1	3.9	5.0	3.1	5.2	3.8	5.9	3.5
Cycle	3.7	3.9	3.5	2.8	2.5	3.2	4.7	2.9
Van	2.2	2.8	3.0	1.1	2.9	3.2	2.1	1.2

Table 1 and Table 2 show that the volume of the study area varied on the weekdays and weekends and even in the day long. The volume study was surveyed in two different spot at 3 peak periods and 2 off peak periods on both weekdays and weekends. In Boyra College Mor to Joragate section, Mahendra occupied 41.5% of volume moving towards Joragate and 29.6% towards Boyra College Mor in peak during weekdays. The number of Motorbike and Easybike were highest after the number of Mahendra. Mahendra had the highest Passenger Car Unit of the particular section in both directions. Percentage of PCU for van was 2.2 % which is the lowest among all type of vehicles. The volume of the area towards Joragate was approximately 1145 PCU/hr and toward Boyra College Mor was almost 1000 PCU/hr.
On the other hand, on off peak period, Mahendra and Easybike generated the highest volume towards Joragate Mor which was 24.1% and 23.6% respectively. The volume of Mahendra was the highest (33%) towards Boyra College Mor. In weekend, the volume was lower compared to weekdays which is clear from the Table 2 below.

Table 2: Vehicles according to direction in Weekends

Vehicles	Baira-Joragate		Joragate-Boyra		Joragate-Shibbari		Shibbari-Joragate	
	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Truck	7.8	8.9	6.4	7.2	2.6	4.9	2.5	5.5
Bus	4.1	1.7	2.5	2.5	3.4	2.4	4.4	4.7
Mini-Truck	2.4	2.1	1.5	2.9	9.3	6.9	3.1	4.6
Car	6.7	11.0	10.6	6.4	15.5	8.3	19.2	9.5
Mahendra	31.0	26.9	32.5	34.4	29.3	24.7	29.6	26.2
Easy bike	21.1	19.7	21.0	16.5	12.0	26.9	15.5	25.3
CNG	5.8	11.1	3.4	8.2	11.1	3.9	7.4	3.9
Bike	10.2	10.1	9.3	9.7	6.3	10.9	6.8	9.9
Rickshaw	4.3	2.8	6.0	5.1	6.2	5.8	6.1	5.6
Cycle	2.9	2.1	3.0	2.6	2.1	2.0	2.8	2.1
Van	3.6	3.5	3.8	4.4	2.3	3.2	2.7	2.7

In the Joragate-Shibbari section, the nature of occupied volume was the same as the Boyra College mor to Joragate section. In both section, the number and volume of mahendra was highest in both direction. Van and in some cases bicycle occupied the lowest volume of total volume.

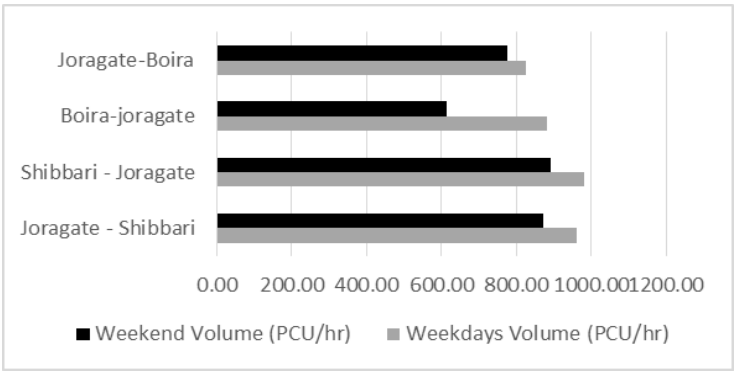

Figure 2: Peak Period Volume Variation in Weekdays and Weekends

Figure 3 implies that peak period volume of vehicles in weekdays was greater than the volume in weekends. There are two residential area near the road within 3 KM which generates the flow of public vehicles.

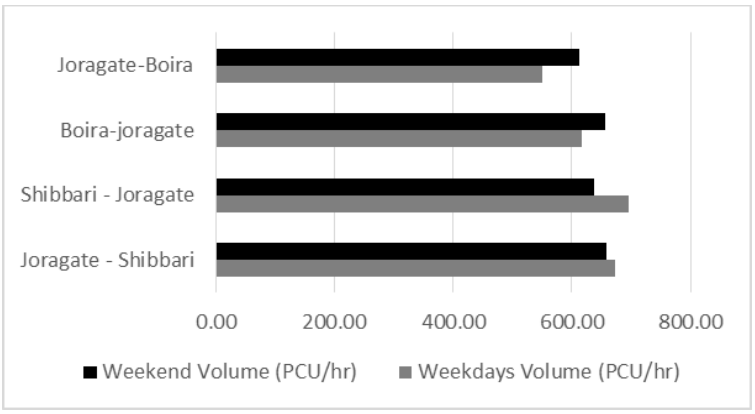

Figure 3: Off Peak Period Volume Variation in Weekdays and Weekends

From figure 4 it is clear that in off peak period, the volume of vehicles in weekend was greater than the volume of weekdays in the Joragate to Boyra College Mor section and the volume of vehicles in weekend is lower than the volume in weekdays in the Shibbari to Joragate section. The volume from two residential area added with the volume in Joragate intersection.

3.2 Volume Capacity Ratio

To identify the level of service it was needed to calculate the volume capacity ratio. Figure 5 refers that in peak period the volume capacity ratio of Boyra College Mor to Joragate direction is 0.63 in weekdays. All the directions having the ratio lower than 0.60 indicated LOS A as LOS can be measured through speed range or volume capacity ratio. Such as if the speed is >=80kph or the volume capacity ratio is <=.60 then the required LOS will be LOAS A. These road had free flow in both direction.

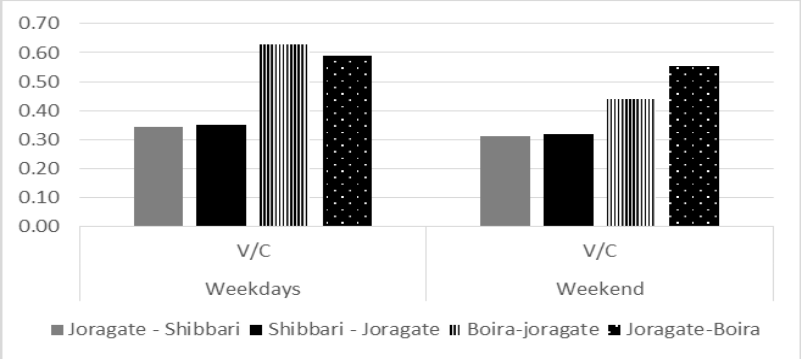

Figure 4: Peak Period Volume Capacity Ratio in Different Section.

The Level of service in Boyra College Mor to Joragate direction in weekdays was LOS B and reasonably free flow in that specific direction.

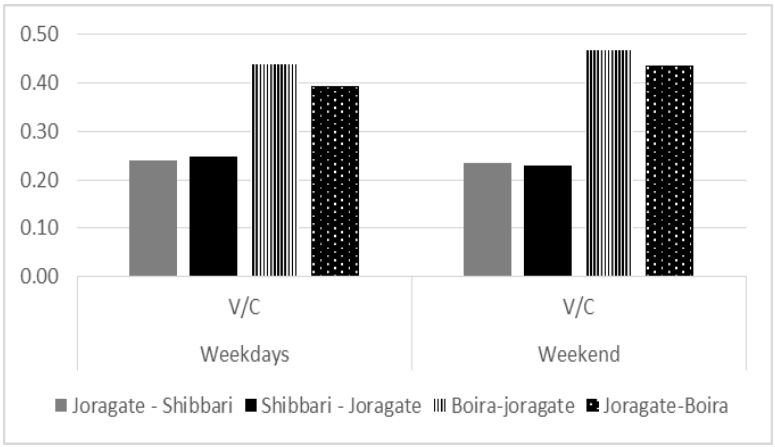

Figure 5: Off Peak Period Volume Capacity Ratio in Different Section.

Figure 6 shows that in off peak period the result shows that the Volume Capacity Ratio is less than 0.60 which indicates that the section had LOS A and they had free flow in all directions. Volume capacity ratio and spot speed ratio was used to determine the level of service of the road section.

3.3 Capacity and Level of service

It is observed that Shibbari mor to Joragate and Boyra College mor to Joragate respectively consist of two lane and one lane. The capacity of each lane is 1400 PCU/hr/lane according to Dhaka Integrated Transport Study, 1994.

Table 3: Volume and Level of service according to direction in Peak Period

Direction	Weekdays				Weekend			
	Volume (PCU/hr)	Capacity (PCU/hr/lane)	V/C	LOS	Volume (PCU/hr)	Capacity (PCU/hr/lane)	V/C	LOS
Joragate - Shibbari	959.58	2800	0.34	A	870.23	2800	0.31	A
Shibbari - Joragate	979.63	2800	0.35	A	890.70	2800	0.32	A
Boyra-joragate	881.82	1400	0.63	B	613.73	1400	0.44	A
Joragate-Boyra	824.75	1400	0.59	A	774.47	1400	0.55	A

The volume capacity ratio of all direction except the Boyra College mor to Joragate mor direction are lower than 0.60. This indicates that all the directional flow have level of service A which represents free flow conditions. Only the geometric design features of the city road may limit the speed of the car. Comfort and convenience levels for road users are very high as vehicles have almost complete freedom to maneuver. Only the Boyra College mor to Joragate direction have level of service B. This represents reasonable free-flow conditions. Comfort and convenience levels for road users are still relatively high as vehicles have only slightly reduced freedom to maneuver.

Table 4: Volume and Level of service according to direction in Off-Peak Period

Direction	**Weekdays**				**Weekend**			
	Volume (PCU/hr)	Capacity (PCU/hr/lane)	V/C	LOS	Volume (PCU/hr)	Capacity (PCU/hr/lane)	V/C	LOS
Joragate - Shibbari	673.33	2800	0.24	A	657.60	2800	0.23	A
Shibbari - Joragate	695.60	2800	0.25	A	638.40	2800	0.23	A
Boyra-joragate	615.87	1400	0.44	A	656.40	1400	0.47	A
Joragate-Boyra	550.97	1400	0.39	A	611.83	1400	0.44	A

In off-peak period, all the directional flow shows that the level of service is A. This represents free flow conditions where traffic flow is virtually zero. Only the geometric design features of the city road may limit the speed of the car. Comfort and convenience levels for road users are very high as vehicles have almost complete freedom to maneuver.

3.4 Parking

The informal on street parking are seen in various places of the study area. The left of the starting of the boyar bazar road is informally used for Easybike parking. Morover there is a driveway in front of Newmarket where car, Rickshaw and various other vehicles are being parked. At Shib-bari mor the opposite road lane of KDA Building is used as on street parking space in some extent.

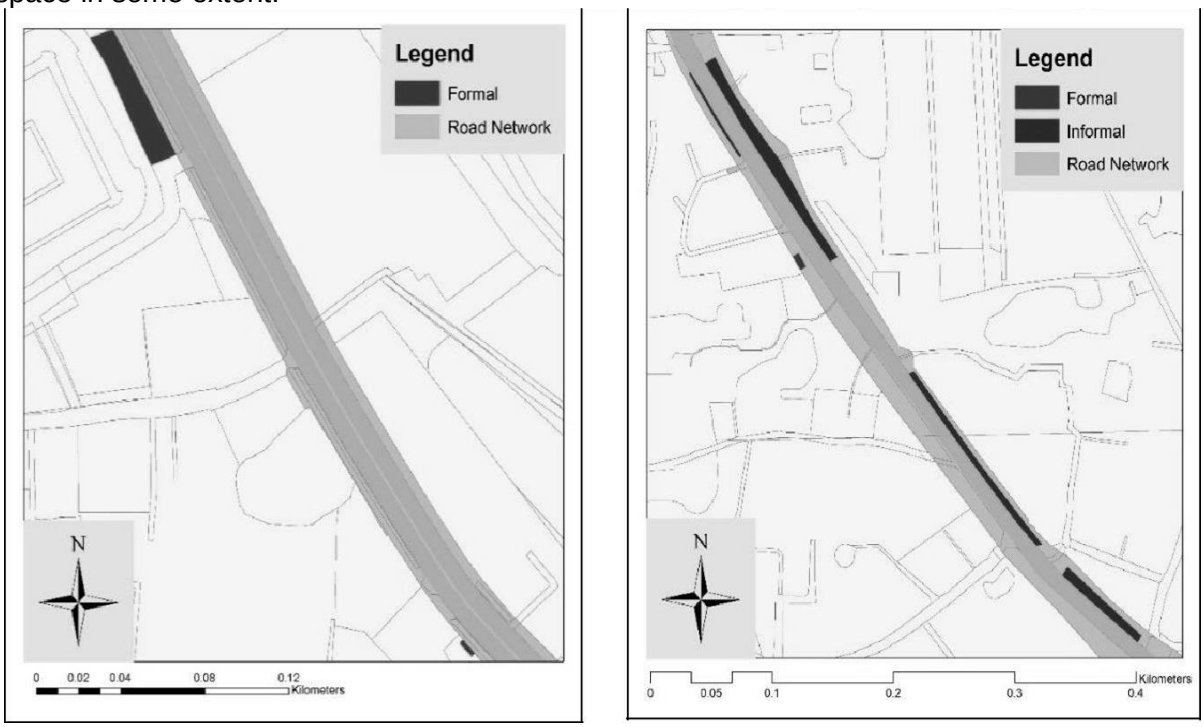

Figure 6: Parking facilities in Khulna Jessore City road

3.4.1 Conflicts point at intersection

The road intersections are a most significant component of a road where different type of vehicles merge into or diverge from the major road to minor road. This merging and diverging causes conflict at the intersections and sometimes it causes accidents. So it is a vital issue to maintain the traffic movement at these intersection points manually or in a signalized way.

There is three major intersection in study area (Boyra to Shibbari mor) which are:

- A T shape intersection at Boyra which connects another major road heading towards Boyra to Shonadanga.
- A Y shape or skewed intersection at Joragate which connects Khalishpur residential are road to this major area.
- Intersection at Shibbari mor links 3 road which is connected to Moylapota, Shonadanga and Dakbanglo road.

Here, all three are very important intersection where a huge no. of vehicles diverges and merges into the Khulna-city road and affect the traffic behavior of this road.

3.4.1.1 Conflict points at Boyra road intersection and Joragate road intersection

Boyra intersection is the lowest merge diverging point overall. Basically mahendra and easy bikes are observed mosty in this point. There are 9 conflicting points overall among them 3 are merging and 3 are diverging points which describes the accident potential for this intersection.

Next is Joragate Road intersection which is a skewed intersection and a very complex intersection point. There is a fuel station which causes frequent divergence in vehicular movement which is directed to south. Among 9 conflicting points 3 are diverging and 3 are merging points. Accident potential is similar to Boyra point in respect of the number of conflict points. As it is not signalized intersection “Inappropriate intersection traffic control, vehicle conflicts with non-motorists, misjudgement of gaps in traffics” occur daily.

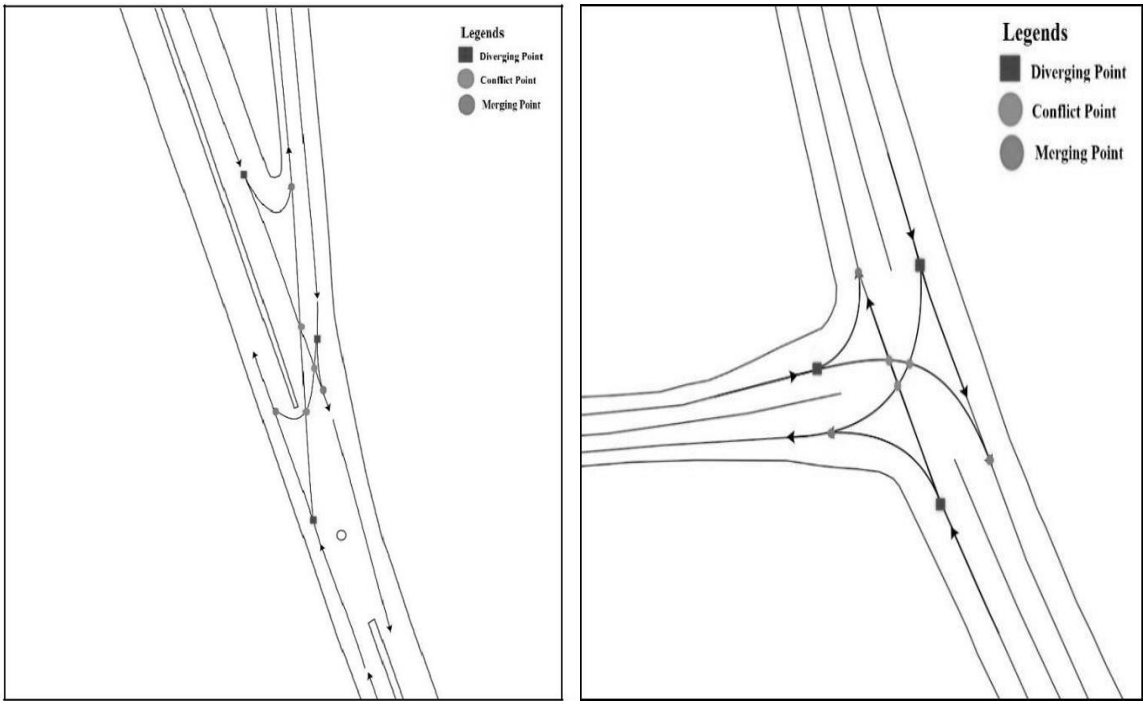

Figure 8: Conflict points at Joragate and Boyra intersection

3.4.1.2 Conflict points at Shibbari mor Intersection

Due to the location of many commercial, institutional activities and road pattern it can be categorized complex intersection. Highest number of vehicle among all these three intersections runs through this section. There are 7 diverging points and 8 merging points whereas total conflict points are 31. These large number of conflict points provide drivers complicated driving situation which lead to make them mor mistakes and even to accidents. Morover Lack of signal system, informal parking increases the congestion risk, provides inadequate guidance for motorist, lead to poor operational performance.

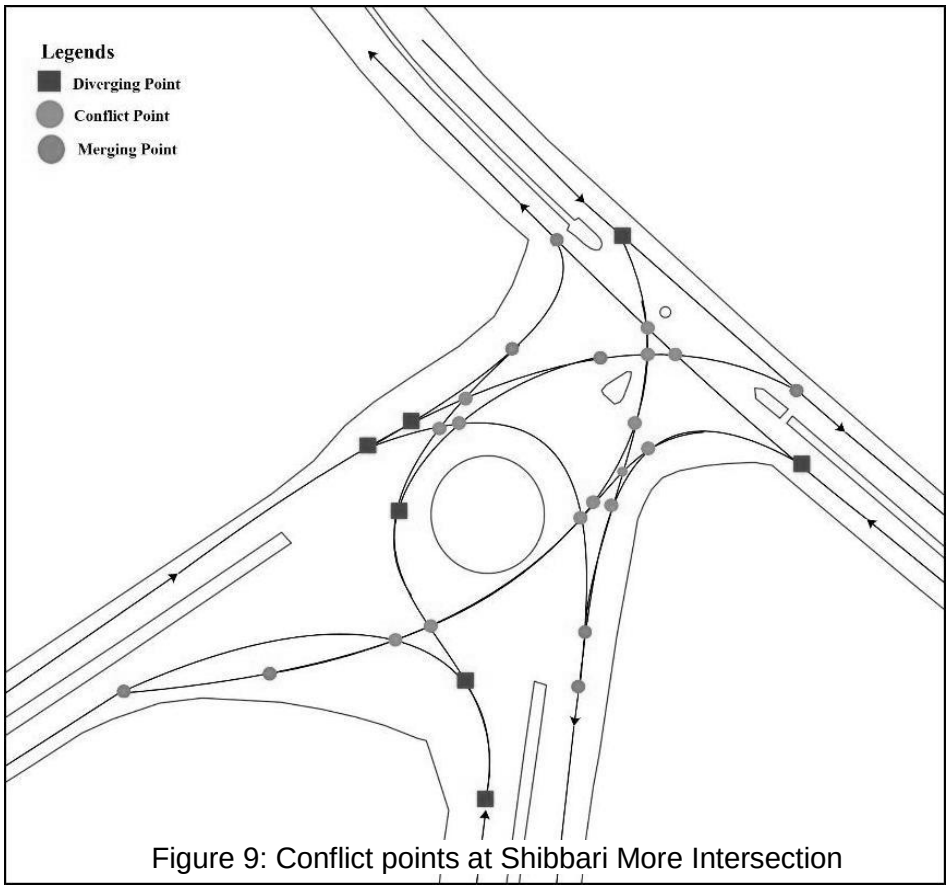

Figure 9: Conflict points at Shibbari More Intersection

3.5 Recommendation

All the solution and proposals will be provided through this section.

3.5.1 Reduction of conflict points at Boyra mor Intersection

In the Boyra College mor, the intersection was a three-leg intersection. From the field survey it was observed that through vehicles and right turning vehicles were not high in that Intersection. If it is required in the future to reduce the right turn conflicts, two U-turn can be constructed along the Boyra-Newmarket road. From field survey, space required to do so was found available. All the vehicles coming from Daulatpur can take a U-turn at 450 feet ahead from the intersection. The vehicles from Boyra direction will also be forced to go through and after 450 feet there will be a U-turn for the vehicles taking right turns to Khulna. On the both U-turn, yield sign should be used to reduce the speed of vehicles to diverge and merge the vehicles with upstream and downstream flow.

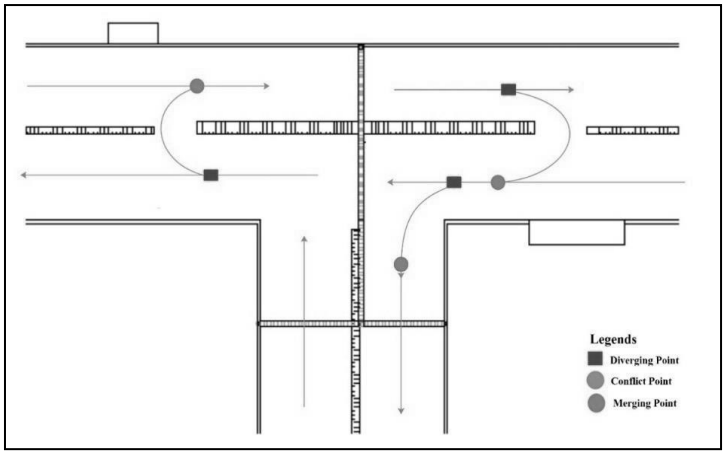

Figure 10: Reduction of Conflict Points at Boyra Mor

3.5.2 Reduction of conflict points at Joragate mor Intersection

In Joragete, the intersection is skewed Y shape. The vehicles from Shibbari mor toward Khalishpur will take a U-turn at 450 feet ahead from the intersection. There will be a channelized island which separate the flow from Boyra College Mor into two different direction. A median is proposed to prevent the vehicles to take right turn in the intersection. Number of conflict points has been reduced from 9 to 4 which is very effective to reduce accident rate in this intersection and to ensure safety.

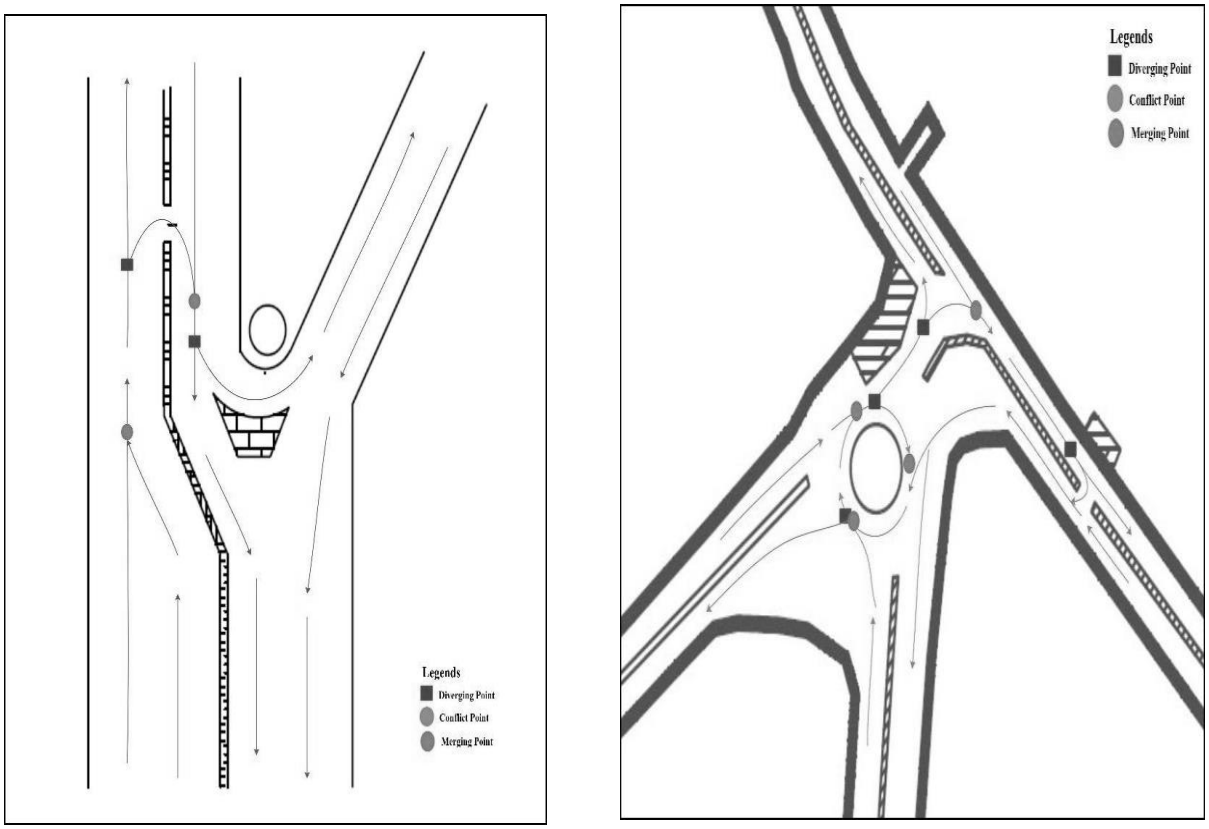

Figure 11: Reduction of Conflict Points at Joragate Mor and Shib-Bari Mor

3.5.3 Reduction of conflict points at Shibbari mor Intersection

Shibbari mor is required as the most congested junction of the study area due to informal parking. To reduce conflict points at this mor traffic flow has been channelized directed towards roundabout coming from Dakbanglo mor through extending the median which is clear from the image below. Furthermor a “U” turn is provided to avoid confliction between the flows coming from Moylapota to Dakbanglo and flows coming from Dakbanglo to moylapota. Previously number of conflict points were 31 which has been reduced to points through changing the pattern of median and providing median.

3.5.4 Providing median between two way roads

In the study area from Boyra to Joragate intersection there are no medians. In most of the cases accidents occur due to head to head collision. So in order to reduce the accidents medians should be provided in the area

3.5.5 Introducing digital traffic signals

The major intersection in this road are free flow driveways. The overall traffic management system is informal in type. To start a formal traffic management system signalized traffic system is needed. Though some signalized traffic are seen at the town side but most of them are not operational. So two way auto signalized traffic system needs to be installed at every intersection. Improving the quality of road markings. In the study area very few road markings were found. Among the present road markings most of the road markings were not visible clearly.

3.5.6 Establishing mor road signs

In the study area the amount of road sings were insufficient. For the convenience of both drivers and pedestrians the road sings should be newly established at necessary intervals.

3.5.7 Providing off street parking

Off-street parking bays must be introduced specially for the public transports in order to reduce the amount of on-street parking and thus reduce the congestion of the road.

3.5.8 Separating lanes for motorized and non-motorized vehicles

In order to increase the regular speed of motorized vehicles in the study area the lanes for motorized and non-motorized vehicles should be separated.

3.5.9 Providing regular monitoring

Regular monitoring includes, checking driving license regularly, banning wrong way traffic flow and assigning traffic police in regular intervals.

4. CONCLUSIONS

The main objective of the paper was to assess the operational features of public transport and volume study of different types of vehicles in Khulna-city road. The paper contains different information’s about volume study of the study area from Boyra to Shibbari mor. The main finding of the paper was that the volume capacity ratio of all direction except the Boira College mor to Joragate mor direction are lower than 0.60. This indicates that all the directional flow have level of service A which represents free flow conditions. From the analysis of the data and information it was found that the present condition was not satisfactory. The number of conflicting points were mor and as a result of which the free flowing movement of vehicles were hampered. Some important recommendations were mentioned in order to solve the current problems and provide the pedestrians and drivers with improved facilities.

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