STUDY ON TRAFFIC DELAY AT AKRAN INTERSECTION AND COMPARISON WITH THEORETICAL MODEL

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Certification

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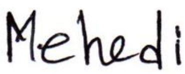

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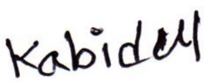

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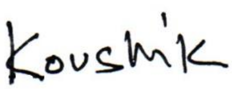

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ABSTRACT

There are both motorized and non-powered vehicles in Bangladesh traffic. In the absence of lane rules and unrestrained mixing of different types of vehicles, the character of the traffic stream becomes heterogeneous. In addition, formulae for forecasting traffic delays and optimizing signal timing, which includes predicting several factors, do not account for non-lane-based traffic circumstances. Although various methods exist for estimating the delays at junction approaches, relatively little study has been undertaken to evaluate their consistency. This research proposes a dependable strategy for estimating Bangladesh's real field delay. At Dhaka city junctions, traffic data were gathered for the purpose of the study. Four video cameras were utilized to collect field data, and the information necessary for the delay estimate was acquired. The research suggests that the theoretical incremental delay (due to random arrival and oversaturated queues) in the HCM 2000 delay model be modified to reflect the field conditions more accurately. The existing delay model exhibits a strong connection with the current example but requires more refinement to be applicable to the whole range of input variables.

CHAPTER 1
INTRODUCTION

1.1 Introduction

A transportation network aims to transport people and things most efficiently and securely. But nowadays, the rapid growth of traffic in the road network of developing countries causes grave concern from the traffic engineer's perspective [1]. Therefore, traffic delay analysis is vital for assessing the level of service (LOS) and road performance. In any metropolitan network, signalized intersections are the primary bottlenecks and a considerable contributor to delay. Consequently, estimating delay is crucial from both a planning and an operational standpoint. Despite the fact that intersections in Bangladesh are not signalized, traffic delay is measured at Akran in Dhaka city for this study. Additionally, sometimes the vehicles do not follow the lane discipline.

A number of theoretical models, notably HCM 2000, are available for estimating intersection delay. However, these processes are optimal for lane disciplined and uniform traffic flow. Therefore, none of these techniques can be implemented directly in Bangladesh. Congestion is recognized as a problem in urban networks as well as inter-urban contexts, and as a result, it plays a significant role in regional, national, and supra-national transport policies bs [2]. In evaluating the operational success of priority intersections, traffic delay is a crucial factor to examine [3]. Delay is factored into the computation of average speeds used to establish different service levels on arterial roadways, either expressly or implicitly [4]. Delay estimates will offer travelers crucial information that will allow them to select an alternate route if one is available. Traffic engineers are able to evaluate the functioning of a traffic system component based on the delay of vehicles at intersections [5]. At an unmanaged crossroads, it is essential to comprehend the amount of potential traffic delay produced by small vehicle interactions. Detailed analysis can determine the convergence of the delay distribution and the steady-state delay for a two-lane intersection under two distinct classes of policies corresponding to two different passing orders [6].

Traffic congestion has increased dramatically over the past two decades, resulting in high environmental costs and productivity losses. As a result, it is crucial to determine the travel time of a traveler and how it is affected by congestion and to comprehend how traffic distributes in a transportation network [7]. Control delay is an essential measure of effectiveness at signalized junctions since it is used to estimate level-of-service (LOS) and to design intersections [4]. Due to the difficulties of field observations, this essential indicator of efficacy at signalized junctions is often evaluated using analytical models. The highway capacity manual (HCM) delay model employs a unique ratio of stopped-to-control delay (Ds/Dc) of 0.76. The unique Ds/Dc ratio utilized in the HCM delay model is not always suitable for precise delay prediction, and a modified model is recommended [8]. The estimated SFRs produced by a model that considers right-turning and traffic interaction, pedestrian-vehicle conflict, and pedestrian behavior is close to the field observed values and significantly more accurate than the findings obtained from the HCM techniques [9].

Intersections are the chokepoints of the road system. The capacity of signalized junctions hinders the efficiency of the road network [10]. Typical intersection performance indicators are delay and saturation flow rate s[11]. The saturation flow assessment must accurately assess service level and capacity [12]. Predicting the saturation flow of an approach to a signalized intersection is crucial for determining the optimal signal settings for reducing delay or increasing capacity [13]. Saturation flow rate (SFR) is considered one of the most important metrics for calculating delay and capacity at signalized junctions. SFR also plays an essential part in signal timing plan design. The highway capacity manual (HCM) defines SFR as the maximum number of vehicles that may travel through a specific lane group within a certain time period [9]. A signalized intersection is a crucial and essential component of the city's traffic network. At signalized intersections, driver behavior has a significant impact on the saturation flow rate, with non-aggressive (conservative) driver behavior increasing the saturation headway and decreasing the saturation flow rate, and aggressive driver behavior decreasing the saturation headway and increasing the saturation flow rate. The saturation flow rate depends on location and is notably impacted by driver conduct [14]. Left-turn capacity is significantly affected by lane width and turn radius [15]. A model for estimating the saturation flow of a junction based on category vehicle count and approach road width can properly evaluate the right-turning effect under heterogeneous traffic conditions and says that saturation flow does not grow linearly with approach width [16]. A model for estimating the saturation flow of a junction based on category vehicle count and approach road width can properly evaluate the right-turning effect under heterogeneous traffic conditions and says that saturation flow does not grow linearly with approach width. [17]. Akran Intersection simultaneously connects Dhaka with various important places around it. Akran Birulia Road, which merges with the road of the embankment. The road connects with Mirpur Gabtoli road. On the other hand, the road connects Uttara, Airport, Tongi, and Gazipur. Akran Savar Road is the fastest connecting road in Savar with different parts of Dhaka. During office hours, the intersection is busy with vehicles, and unprotected intersections lead to severe traffic jams, which cause delays and loss of time and money. Many autorickshaws, private cars, buses, trucks, Motorcycles, and Laguna move day and night.

1.2 Transport System in Bangladesh

According to the Bangladesh Road Transport Authority (BRTA), Bangladesh has 3,1,000,000 registered vehicles, and Dhaka has about 1,000,000. However, another survey reveals that 5 million cars, including registered vehicles, are on the road at any given time. Every day, residents of Dhaka conduct thirty million journeys, of which 47 percent include buses, 32 percent involve rickshaws, 9 percent involve private automobiles, which occupy 76 percent of the road, and 7 percent involve public transportation. If a reliable public transportation system is implemented, the number of private automobiles and other vehicles will drop.

1.3 Problem statement

Akran Bazar Intersection is a heavily congested intersection located far from Dhaka city. It is mainly located in a mixed township. Akran Intersection connects Savar and surrounding areas with Dhaka for various activities, including education and commerce. Commercial and private transport, including university students and teacher's buses, pass through this intersection daily. It is basically an unprotected intersection. The vehicles traveling here rush through the intersection without ignoring the rules of signals to cross the intersection, and the vehicles suddenly enter the unprotected intersection and cause more and more severe traffic jams. Sometimes the guards of private companies try to restore order on the road to relieve the long traffic jams. He basically controls the movement of vehicles in the traditional way, which is not very useful in relieving heavy traffic. Due to the traffic drivers crossing this intersection not obeying the signal, extreme disrespect is observed among them, and sometimes it takes the form of verbal altercations. Very annoying and uncomfortable.

1.4 Objectives

The main objective of this study is to estimate and analyze the actual delay of the traffic system at akran intersection. For this purpose, the objectives are:

- To collect real-time experimental data from the intersection area.
- To estimate and calculate the delay of the traffic network to provide an effective traffic system.
- To compare the proposed delay estimation approach with the theoretical model.

CHAPTER 2
LITERATURE REVIEW

Travel time and delay are the quintessential levels of service measures for any transportation network, and several studies were reported on the estimation of these variables. Travel time estimation methods are classified into two types: (i) Planning oriented approach and (ii) Operation oriented approach. Planning-oriented approaches are generally based on historical data and rely on queueing theory [18] and shockwave analysis [19]. Operation-oriented techniques depend on real-time observations of traffic characteristics and information on signal phase to estimate delay. Conventionally, operation-oriented techniques obtain data via location-based sensors such as loop detectors. The input-output technique is one of the easiest ways to estimate the queue from these detector data by using individual cars' arrival and departure counts. [20]. The issue with the input output method is that the initial number of vehicles in the section should be known, which is often difficult to obtain [21]. A hybrid version of the input-output method uses a manual approach to determine the number of vehicles initially present in the study stretch [22]. They used cumulative curves for different traffic conditions. The study of [23] explained a methodology called Cumulative plots and Probe Integration for travel time estimation (CUPRITE), which used analytical modeling to integrate cumulative plots with probe vehicle data to estimate average travel time accurately. Probe vehicles equipped with communication devices can be used to monitor travel times as they perform their regular travel. Communication devices such as the Global Positioning System (GPS), Bluetooth, or electronic toll collection RFID tags, can be considered as ITS probe vehicles for travel time data collection [24]. The proposed methodology estimates control delay components with the help of second-by-second vehicle speed profiles extracted from GPS-fitted probe vehicles [25]. They showed that the accuracy of probe vehicle-based delay estimation methods is highly dependent on the penetration of probe vehicles. Quite several studies also used cellular phones as probes to estimate travel time and delay [26][27][28][29]. They demonstrated several practice-ready methodologies for automatic vehicle identification (AVI) data collection systems. These include Bluetooth, GPS, etc. Various combinations of AVIs are also used for delay estimation. Abbas et al. [30] presented several models for calculating control delay based on synchronized Bluetooth and GPS probe vehicle data. The study of [31] evaluated the effect of vehicle identification using Bluetooth signatures for travel time estimation along a section of freeway. Bhaskar and Chung [23] formulated a multilayer simulation model called Traffic and Communication Simulation (TCS). TCS was used to model the theoretical properties of the Bluetooth Media Access Control Scanner (BMS) data, and the accuracy and reliability of travel time estimation using the BMS data were analyzed.

Though very cost-effective and readily available, the major problem with Bluetooth-based approaches is the low penetration of Bluetooth, resulting in a very small sample size. The penetration rates have decreased because of stricter privacy settings in smartphones and other Bluetooth devices. An alternative AVI method is to use Wi-Fi instead of Bluetooth. This has been an emerging area for the last few years.

Moreover, it can be noticed that all the studies discussed above were from homogeneous and lane disciplined traffic conditions. Estimating delay near signalized intersections under mixed traffic conditions, with different vehicle types moving without any lane discipline, is a more challenging and complex task and has not been reported much. This study compares delay estimation using three different approaches under mixed traffic conditions. The approaches are - (i) Based on location-based data collected using graphic video technique and applying cumulative count curves, (ii) Delay measurement using Wi-Fi sensors, and (iii) Using a simulation environment (VISSIM) by generating and calibrating the field network and then measuring the delays. "

2.1 TRAFFIC CAPACITY, FLOW, AND SPEED AT WORK ZONES

The values of traffic capacity, vehicle speed, and flow rate at the intersection are essential for estimating traffic delays. These traffic estimates were previously calculated for four-lane divided highway interchange areas.

The types of work zones are shown as follows:

1. Single-Lane Closure (or Partial Closure) - When one lane in one way is closed, with minimal or no impact on traffic in the opposing direction.

2. Crossover (or two-lane two-way traffic operations) - when one highway is blocked, and the traffic that would usually use that route is diverted over the median, while two-way traffic is maintained on the other roadway.

A partial closure work zone impacts traffic flow in only one direction, but a crossover work zone affects traffic flow in both directions (the median crossover direction and the opposite direction). On the other hand, a crossover work zone allows the construction crew to operate on two lanes and provides a safer workspace because it is segregated from traffic. The closed lane may be the left or right lane in a work zone with a partial lane closure, depending on the construction requirements. In a work zone with a median crossover, the work zone affects traffic flows in the opposite and median crossover directions. The necessary traffic measurements were for four work zone layouts: partial closure with the right lane closed, partial closure with the left lane closed, crossover in the opposite direction, and crossover in the crossover direction attained. Appropriate values of work zone capacity, traffic flow rate, and speed must be employed to predict traffic delays in work zones effectively.

It was noticed that the move from uncongested to congested traffic conditions in Indiana interstate construction zones was usually accompanied by a significant decrease in speed. This research defines work zone capacity as "the traffic flow rate right before a sudden speed drop followed by a protracted period of low vehicle speed and varying traffic flow rate". To express work zone capacity in passenger cars per hour, the traffic flow rate was converted to hourly volume, and correction factors from the 1994 Highway Capacity Manual were applied to convert trucks and buses to passenger car equivalents. When traffic is congested in a work zone, the average vehicle speed remains below the uncongested speed, and the average traffic flow rate remains below the work zone capacity. During congestion, the traffic flow rate in a work zone is referred to as the queue-discharge rate of the work zone since it represents the pace at which cars are being released from the work zone's wait.

2.2 Average Daily Traffic

The capacity of traffic passing is a point on a roadway in both directions on an average day less than one year after the point was constructed (or design year). It is the average 24-hour traffic volume in a certain area during a period shorter than one year (a month, a week, or some days). It was determined by dividing the traffic count acquired during a certain spell by the number of days.

2.3 Annual Average Daily Traffic

AADT is the average daily traffic volume at a specified place over a period of 365 days. The total amount of traffic passing a roadside observation station over the course of a calendar year, divided by the number of days in that year, is the most prevalent approach employed by agencies (365 or 366 days).

2.4 Vehicle speed

Accidents on the road are increasingly a typical occurrence in Bangladesh. Automobile accidents are caused by excessive speed. Several places, such as schools, colleges, hospitals, highways, and construction zones, should regulate vehicle speed. A wireless forewarning system will aid in vehicle speed management. The systems consist of a transmitting unit and a receiving unit. When a vehicle reaches the transmission range, the RF receiver is activated. A vehicle-mounted LCD monitor will show the information upon reception of the signal. In Bangladesh's rural areas, the majority of roads are unpaved; the driver of a vehicle must be equipped to navigate these roads. Use a low speed to avoid an automobile collision. The following speed restrictions are typical in Bangladesh: 25 km/h in urban areas. Thirty kilometres per hour on rural and major routes. 80 km/h on highways and freeways. In Bangladesh, the instrument used to assess speed is a speed gun.

2.5 Materials and Methods

This study focuses on techniques for estimating and analyzing real delay. Numerous theoretical models' measurable delays are addressed here. Following a brief discussion of the current state of Dhaka, the research region is described in-depth and analyzed in depth. Bangladesh has a greater demand for flyovers than any other country in the world. Because the volume of traffic in this nation is so great, it is the most critical factor for reducing traffic congestion and increasing vehicle throughput. Flyovers are utilized to enhance the traffic flow of a country's arterial roads and decrease the travel time for the remaining at-grade traffic. This road layout is intended to connect two places in crowded regions: roadways and crossroads. In addition, it provides amenities that allow passing over a barrier without obstructing the way below, which is more time-consuming for travellers.

CHAPTER 3
DATA COLLECTION

In order to collect our thesis data at the akran intersection, the group members discussed among themselves the time, date and time of the video to be decided. We recorded a demo video of the situation at the point and checked to see if everything was ok. Then we collect video data at different times of the week. For example, 15/04/2022 from 9:50 am to 10:00 am. In this way, we all started collecting different videos together at different times and on different days of the week. We recorded videos for 10 minutes. At the end of the video recording, we analyzed the video data and made a list of the vehicles moving at that time. We looked at the list of moving vehicles and calculated the number of vehicles that had gone. Besides, we determined the speed of the moving vehicles. After watching the video, the delays in moving vehicles have been noted. After crossing the intersection, the information about the time wasted and how long the traffic congestion was due to the delays has been collected. And finally, we have tried to identify the problems caused by the delay.

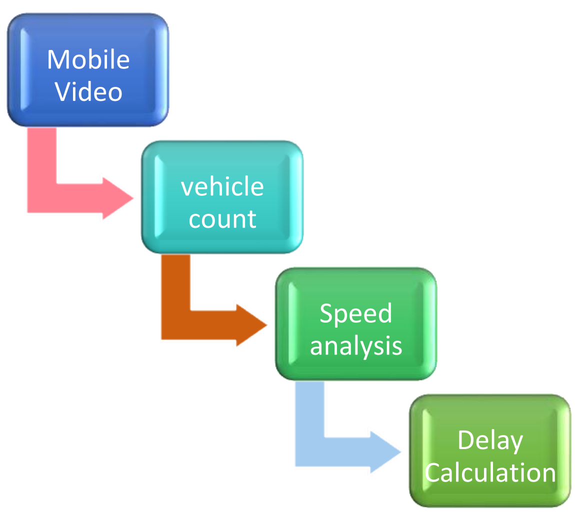


Figure 1 Data analysis process

Shows the intersection of the akran Bazar. The road has been designed using the AutoCAD software.

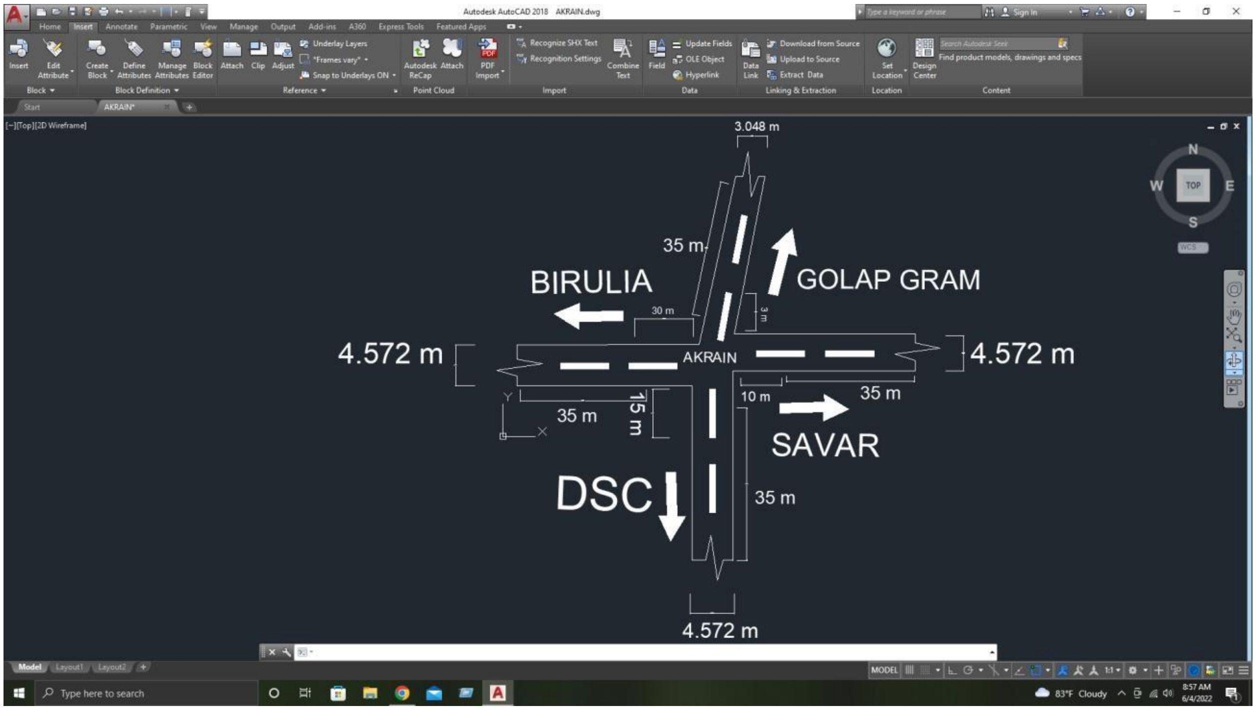


Figure 2 Akran Intersection Geometry

3.1 Delay computation from cumulative count curves using field video data

This method of delay estimate necessitates the accumulation of vehicle arrivals and departures at a signalized intersection approach. Input for constructing a pair of cumulative count curves is the volume of traffic entering and exiting the approach and stop line. A video graphic method was used to capture traffic volume data on an approach using four fixed cameras. A hand-held camera was used to record vehicle arrivals at the mid-block stretch of the ECR approach to the intersection, and a camera was used to record vehicle departures at the stop line of the intersection, which is 350m from the entrance point. Videos were captured for 180 minutes during the peak hours of two working days from 6:35 to 7:45 pm. At both sites, traffic volumes and vehicle timestamps were extracted to generate a map of the cumulative number of vehicle arrivals and departures with respect to time. The timestamped vehicle count data taken from the films at the two locations generated cumulative count curves for arrival and departure.

A cumulative count curve indicates the number of cars that have traversed a stretch at any given moment. For each given vehicle number on the y-axis, the difference between the x-coordinates of the departure and arrival curves represents that vehicle's trip time. The journey time is then calculated as the area between the vehicle arrival and departure curves.

3.2 Present Condition of Akran Bazar:

In this study, we have estimated and calculated the akran bazaar's traffic delay. Nowadays this road has become more densely because of the heavy traffic. Besides, several model towns are developing in this area. With the rapid growth of technology and heavy vehicles, it is very difficult to maintain a good traffic system on this road. Several factories also the fact of heavy traffic. Recently, some university campuses also shifted in this area. Due to these several reasons, primarily we have focused on working in the akran Bazar road. Firstly, we have collected realtime traffic data from the akran Bazar to observe and calculate the traffic delay in this area. For the data collection, we used a video camera. Four video cameras are used to collect real-time data of the four intersecting are of this road. Figure 2 shows the map of the akran Bazar road.

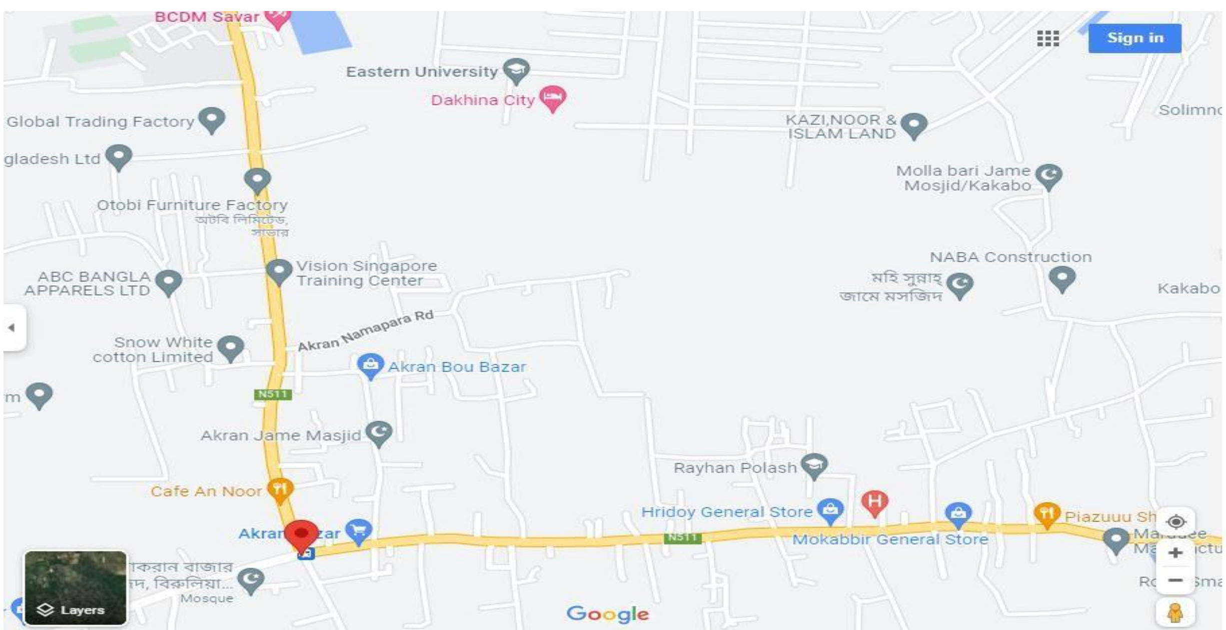


Figure 3 Google map

3.3 Data Analysis

The Akran Bazar road has an intersection that has 1 lane 2 way. We collected and calculated the four different roads connected with intersection data during the data collection. These roads are Akran to biruliya road, akran to khagan, road, akran to savar road and Akran to Golap Gram Among the wide range of vehicles, this study only focuses on such vehicles (bus, autorickshaw, motorcycle, car, truck, leguna, CNG), which appeared on this road more frequently than other vehicles. During the data collection from the four different roads, we collected the datasheet in three different time slots; each slot is 10 minutes long. The datasheet has been captured using mobile video cameras. After collecting the data from each slot, we have taken a total of 1-minute rest. For the data collection, we have calculated 35 meters distance based on the intersection of this road. Figure 4 illustrates the overall data acquisition procedure of this study.

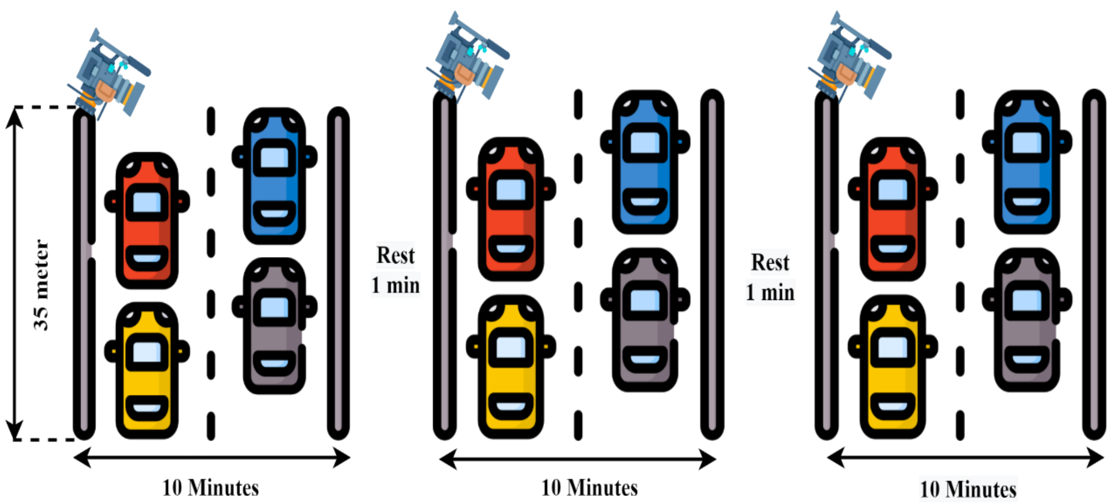
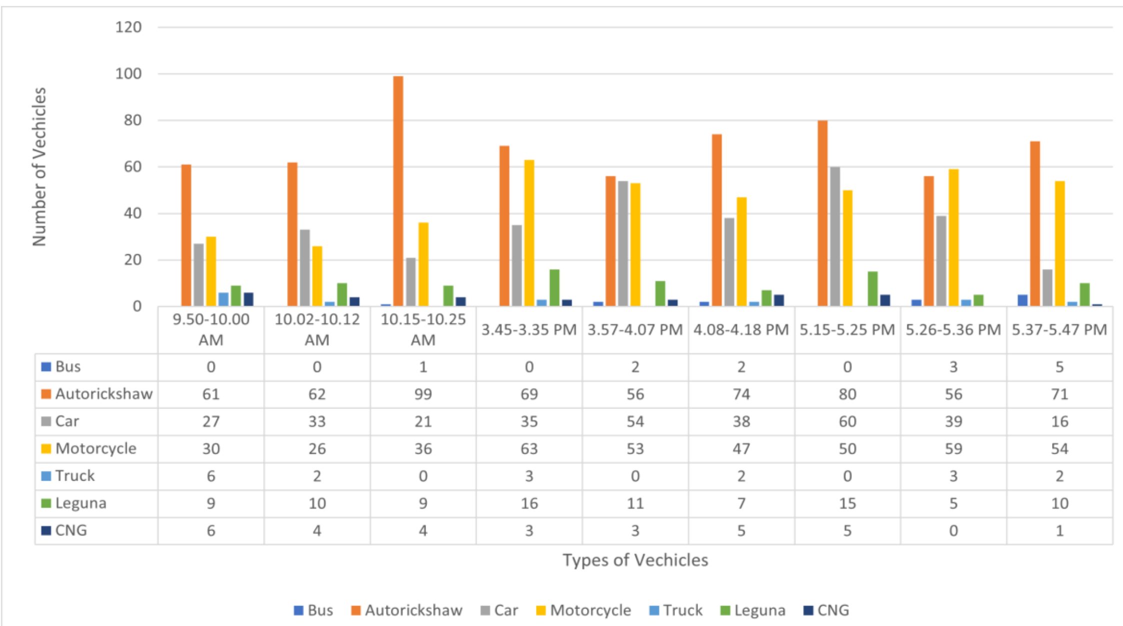


Figure 4 Video analysis process

3.4 Biruliya road to Akran road

During the data collection, the traffic data from the Biruliya road to Akran road was collected. We have collected the data in three different time durations on this road. Figure 5, Figure 6, Figure 7, and Figure 8 shows how many vehicles appeared in this road during the three different time periods. The Biruliya road to Akran road has high traffic most of the time. On 15/4/2022, 13 buses, 628 autorickshaws, 92 laguna, 18 trucks, 418 motorcycles, and 31 CNG appeared.



	9.50-10.00 AM	10.02-10.12 AM	10.15-10.25 AM	3.45-3.35 PM	3.57-4.07 PM	4.08-4.18 PM	5.15-5.25 PM	5.26-5.36 PM	5.37-5.47 PM
Bus	0	0	1	0	2	2	0	3	5
Autorickshaw	61	62	99	69	56	74	80	56	71
Car	27	33	21	35	54	38	60	39	16
Motorcycle	30	26	36	63	53	47	50	59	54
Truck	6	2	0	3	0	2	0	3	2
Leguna	9	10	9	16	11	7	15	5	10
CNG	6	4	4	3	3	5	5	0	1

Figure 5 Calculation Flow chart at biruliya road

Figure 6 illustrates the pie chart of the traffic Biruliya road to Akran road on 15/4/2022. From the pie chart, we can observe a maximum of percent31% of motorcycle,29% of autorickshaws and have arrived. Besides, 3% buses, 2% trucks, 4% leguna, 29% cars, and 2% CNG arrived during the data collection period.

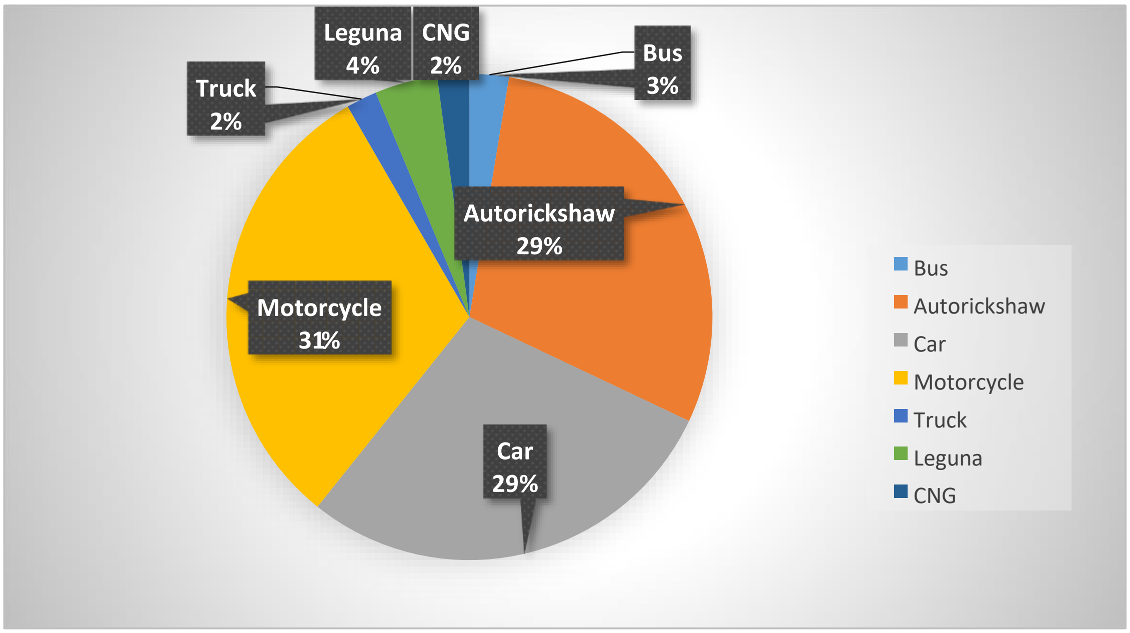
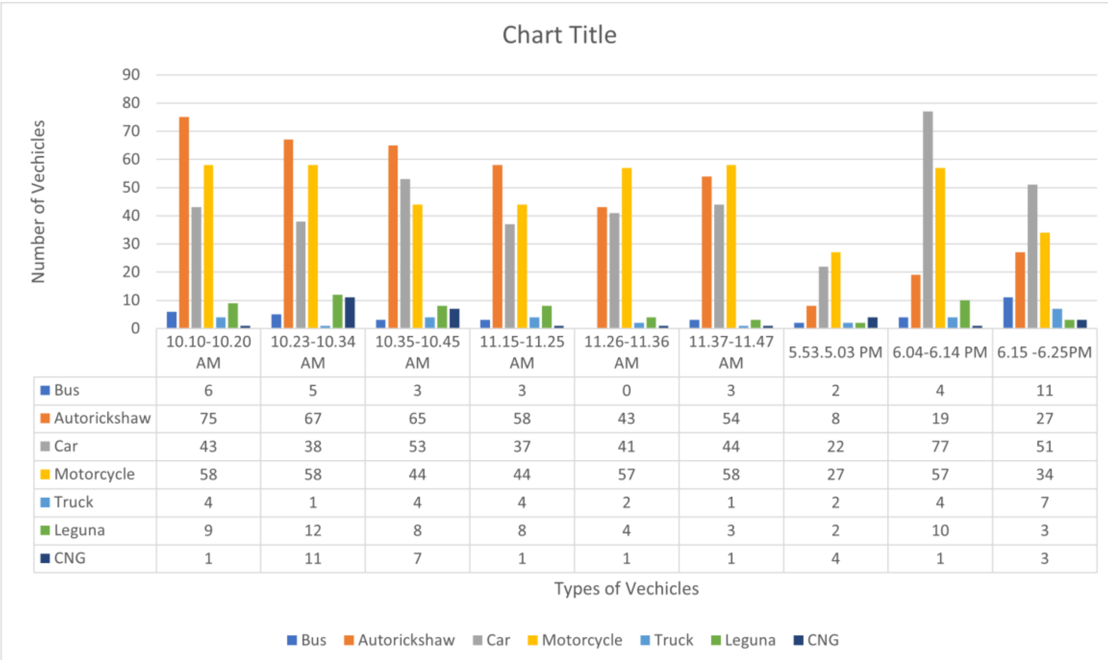


Figure 6 Percentage of pie chart

On 16/04/2022, a total of 90 minutes of traffic data was collected. During the period, a total of 416 autorickshaw, 438 motorcycles, 29 trucks, 59 leguna, and 30 CNG,37 buses were observed (shown in Figure7).



	10.10-10.20 AM	10.23-10.34 AM	10.35-10.45 AM	11.15-11.25 AM	11.26-11.36 AM	11.37-11.47 AM	5.53.5.03 PM	6.04-6.14 PM	6.15 -6.25PM
Bus	6	5	3	3	0	3	2	4	11
Autorickshaw	75	67	65	58	43	54	8	19	27
Car	43	38	53	37	41	44	22	77	51
Motorcycle	58	58	44	44	57	58	27	57	34
Truck	4	1	4	4	2	1	2	4	7
Leguna	9	12	8	8	4	3	2	10	3
CNG	1	11	7	1	1	1	4	1	3

Figure 7 Calculation Flow chart at biruliya road

Figure 8 illustrates the pie chart of the traffic from Biruliya road to Akran road on 16/4/2022. From the pie chart, we can observe a maximum of 29% percent autorickshaws and 31% of motorcycle have arrived. Besides, 3% buses, 2% trucks, 4% leguna, 29% cars, and 2% CNG arrived during the data collection period.

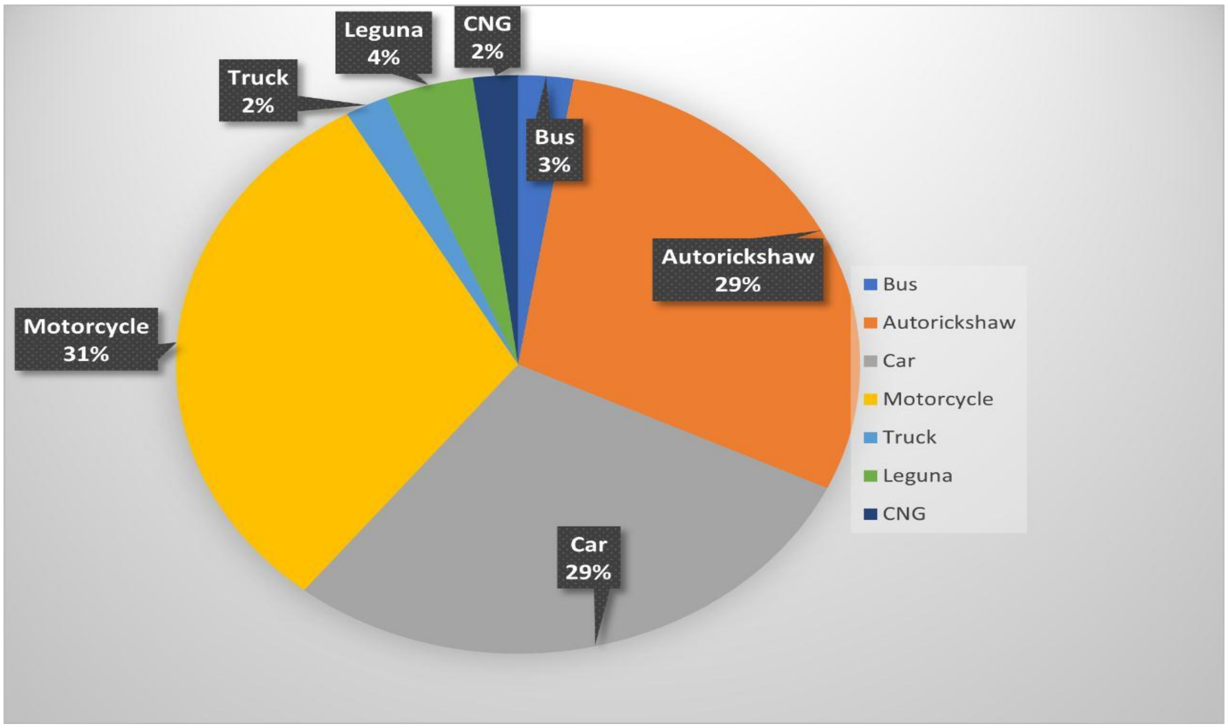
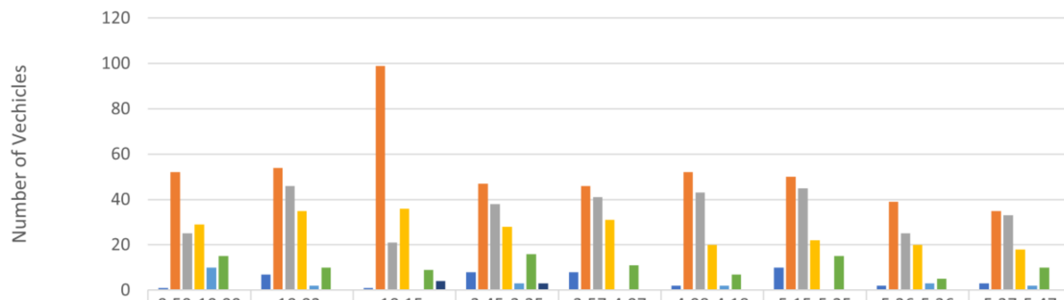


Figure 8 Percentage of pie chart

The overall Biruliya road to Akran road has also been calculated. A total of 180 minutes of data has been collected to estimate the traffic of the Biruliya road to Akran road. A total of 50 buses, 1044 autorickshaws, 729 cars, 855 motorcycles, 57 trucks, 151 laguna, and 61 CNG appeared during data collection time periods.

3.5 Khagan road to Akran road

The traffic data from Khagan road to Akran road was collected during the data collection. We have collected the data in three different time durations on this road. Figure 9, Figure 10, Figure 11, and Figure 12 show how many vehicles appeared on this road during the three different time periods. The Khagan road to Akran road has high traffic most of the time. On 15/4/2022, 42 buses, 474 autorickshaws, 317 cars, 239 motorcycles, 22 trucks, 98 legunas, and 7 CNG appeared on this road.



	9.50-10.00 AM	10.02-10.12 AM	10.15-10.25 AM	3.45-3.35 PM	3.57-4.07 PM	4.08-4.18 PM	5.15-5.25 PM	5.26-5.36 PM	5.37-5.47 PM
Bus	1	7	1	8	8	2	10	2	3
Autorickshaw	52	54	99	47	46	52	50	39	35
Car	25	46	21	38	41	43	45	25	33
Motorcycle	29	35	36	28	31	20	22	20	18
Truck	10	2	0	3	0	2	0	3	2
Leguna	15	10	9	16	11	7	15	5	10
CNG	0	0	4	3	0	0	0	0	0

Types of Vechicles

Bus Autorickshaw Car Motorcycle Truck Leguna CNG

Figure 9 Calculation Flow chart at khagan road

Figure 10 illustrates the pie chart of the traffic from Khagan road to Akran road on 15/4/2022. From the pie chart, we can observe a maximum of 40% autorickshaws, 26% cars, 20% motorcycle, 2% trucks, 8% legunas, 1% CNG, and 3% buses have arrived during the data collection time period.

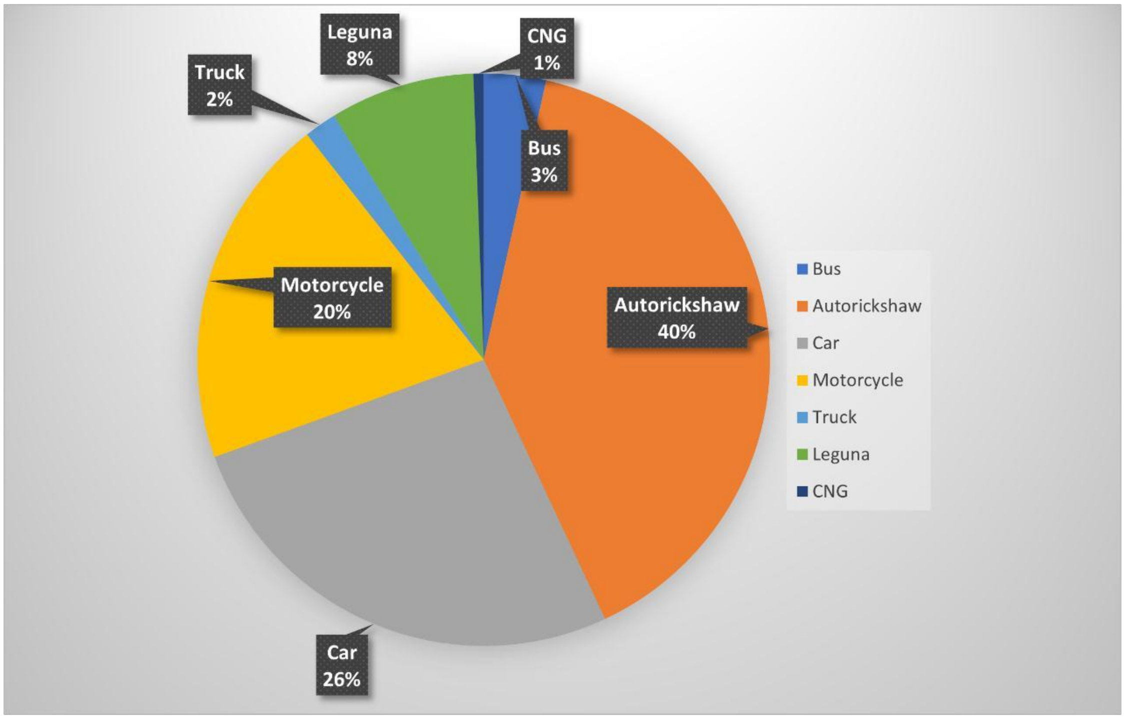
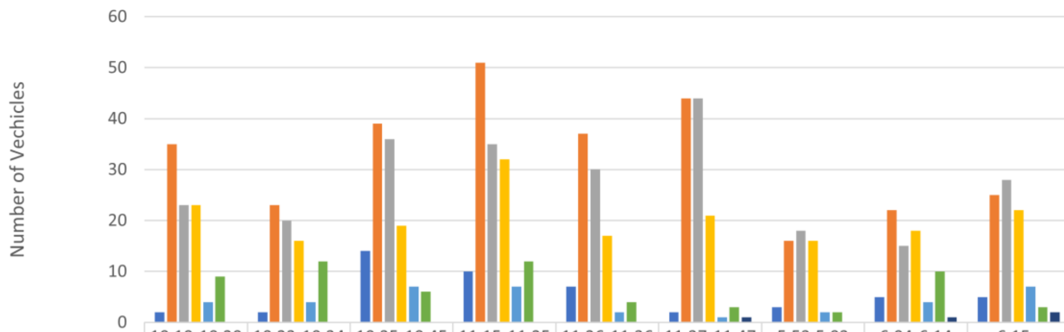


Figure 10 Percentage of pie chart

On 16/04/2022, a total of 90 minutes of traffic data was collected. During the time period, 50 buses, 249 cars, 292 autorickshaws, 184 motorcycles, 38 trucks, 61 leguna, and 4 CNG appeared in Figure 11.



	10.10-10.20 AM	10.23-10.34 AM	10.35-10.45 AM	11.15-11.25 AM	11.26-11.36 AM	11.37-11.47 AM	5.53.5.03 PM	6.04-6.14 PM	6.15 - 6.25PM
Bus	2	2	14	10	7	2	3	5	5
Autorickshaw	35	23	39	51	37	44	16	22	25
Car	23	20	36	35	30	44	18	15	28
Motorcycle	23	16	19	32	17	21	16	18	22
Truck	4	4	7	7	2	1	2	4	7
Leguna	9	12	6	12	4	3	2	10	3
CNG	0	0	0	0	0	1	0	1	2

Types of Vechicles

Bus Autorickshaw Car Motorcycle Truck Leguna CNG

Figure 11 Calculation Flow chart at khagan road

Figure 12 illustrates the pie chart of the traffic from Khagan road to Akran road on 16/4/2022. From the pie chart, we can observe that a maximum of 33% autorickshaws, 28% cars, and 21% motorcycles have arrived. Besides, 6% buses, 4% trucks, 7% leguna, and 1% CNG arrived during the data collection period.

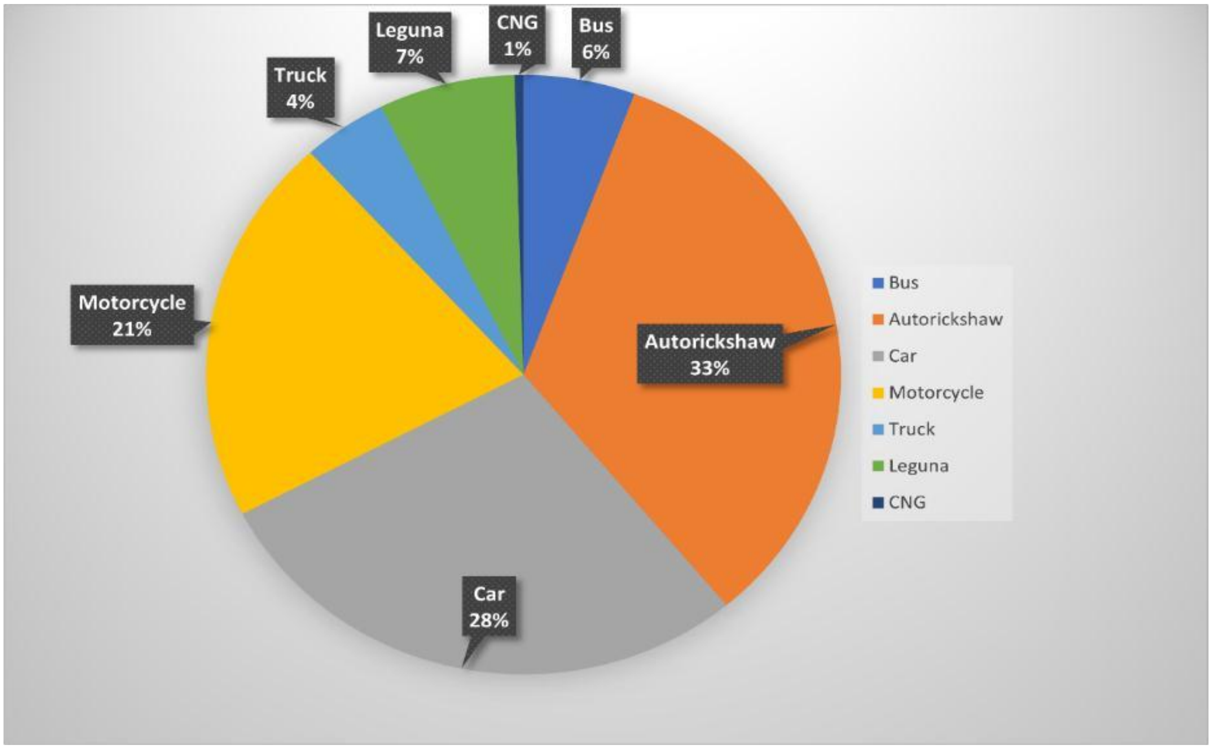
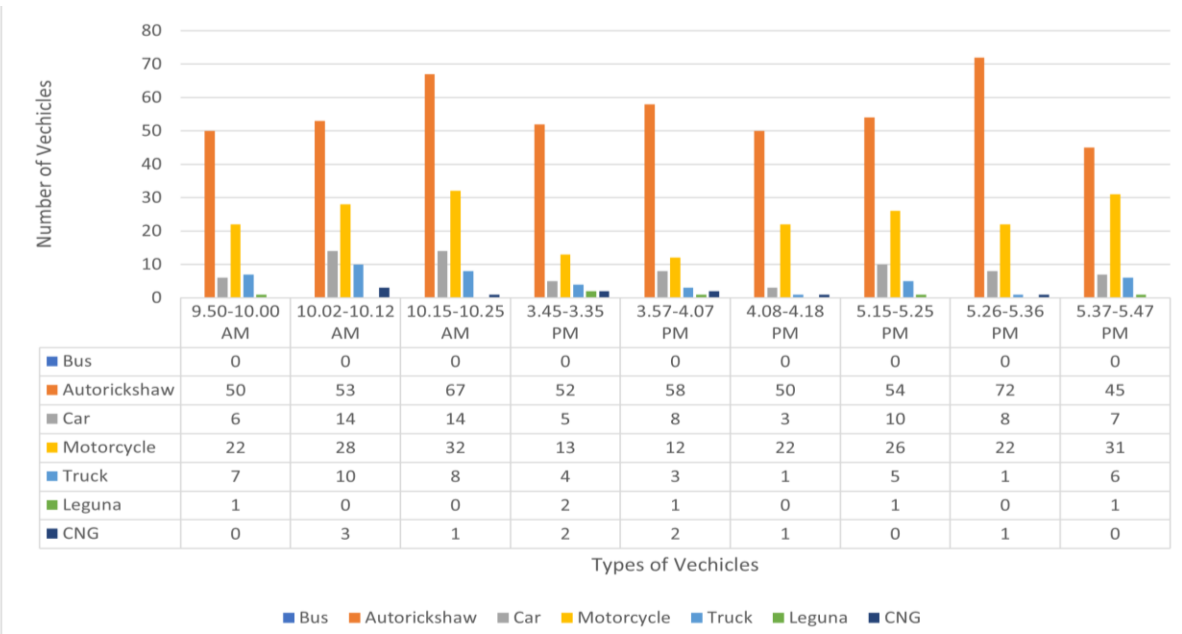


Figure 12 percentage of pie chart

The overall traffic of Khagan road to Akran road has also been calculated. A total of 180 minutes of data has been collected to estimate the traffic from the Khagan road to Akran road. A total of 92 buses, 766 autorickshaws, 566 cars, 423 motorcycles, 60 trucks, 159 leguna, and 11 CNG have been appeared in during data collection time periods.

3.6 Akran to savar road

During the data collection, at first, the traffic data from Savar Road to Akran road has been collected. We have collected the data in three different time durations on this road. Figures 13, Figure 14, Figure 15, and Figure 16 show how many vehicles appeared on this road during the three different time periods. Since Savar Road to Akran road is quite busy, from these four Figures we can see, no buses or CNG appear during that time. The dataset has been collected on two different days, as shown in the. On 15/4/2022, a total of 501 autorickshaws, six laguna, 45 trucks, 208 motorcycles, and 10 CNG appeared. There were no buses that appeared during this time period.



	9.50-10.00 AM	10.02-10.12 AM	10.15-10.25 AM	3.45-3.35 PM	3.57-4.07 PM	4.08-4.18 PM	5.15-5.25 PM	5.26-5.36 PM	5.37-5.47 PM
Bus	0	0	0	0	0	0	0	0	0
Autorickshaw	50	53	67	52	58	50	54	72	45
Car	6	14	14	5	8	3	10	8	7
Motorcycle	22	28	32	13	12	22	26	22	31
Truck	7	10	8	4	3	1	5	1	6
Leguna	1	0	0	2	1	0	1	0	1
CNG	0	3	1	2	2	1	0	1	0

Figure 13 Calculation Flow chart at savar road

Figure 14 demonstrates the pie chart of the traffic from Savar Road to Akran road on 15/4/2022. From the pie chart, we can observe that a maximum of 59% percent of autorickshaws have arrived. On the other hand, 25% of motorcycle have appeared. Only 5% trucks, 1% laguna, 9% cars, 1% CNG have arrived. There was no bus that arrived during the data collection time period.

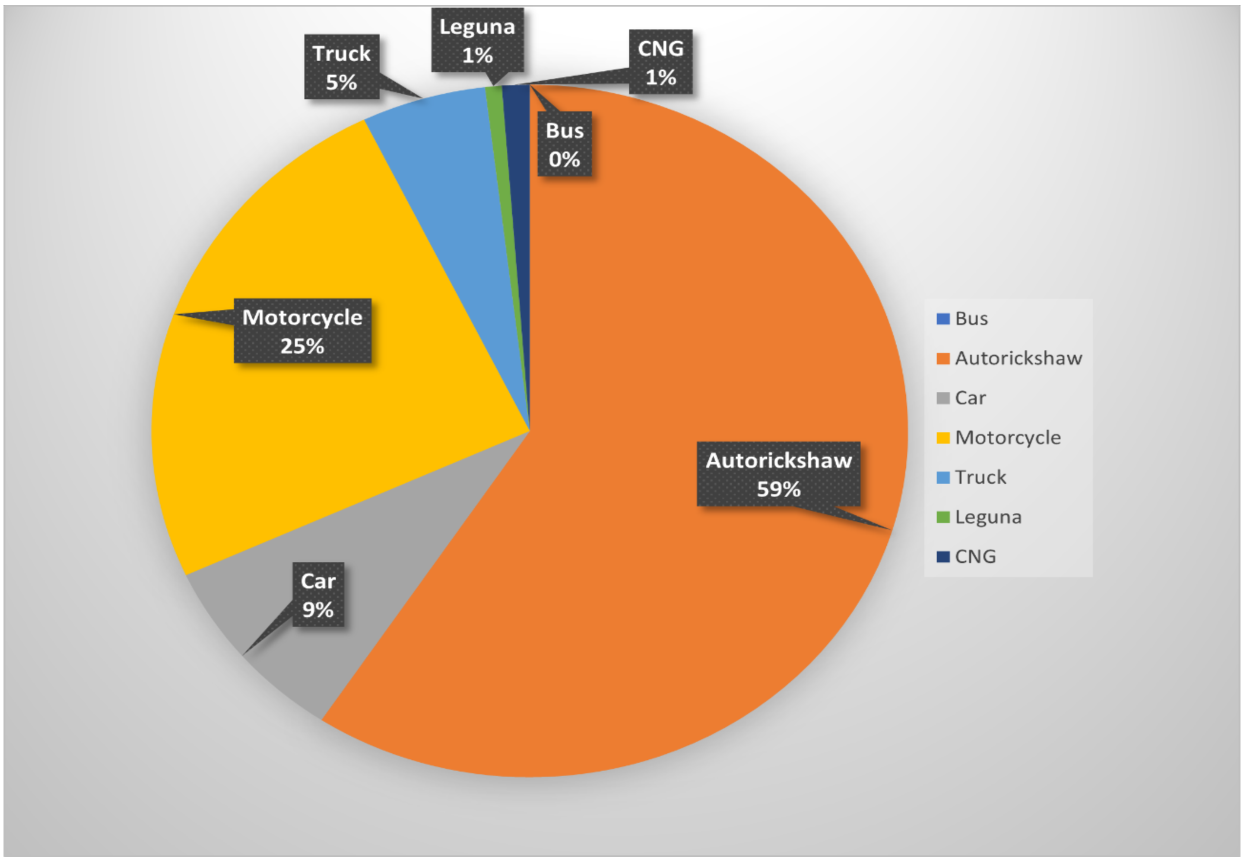
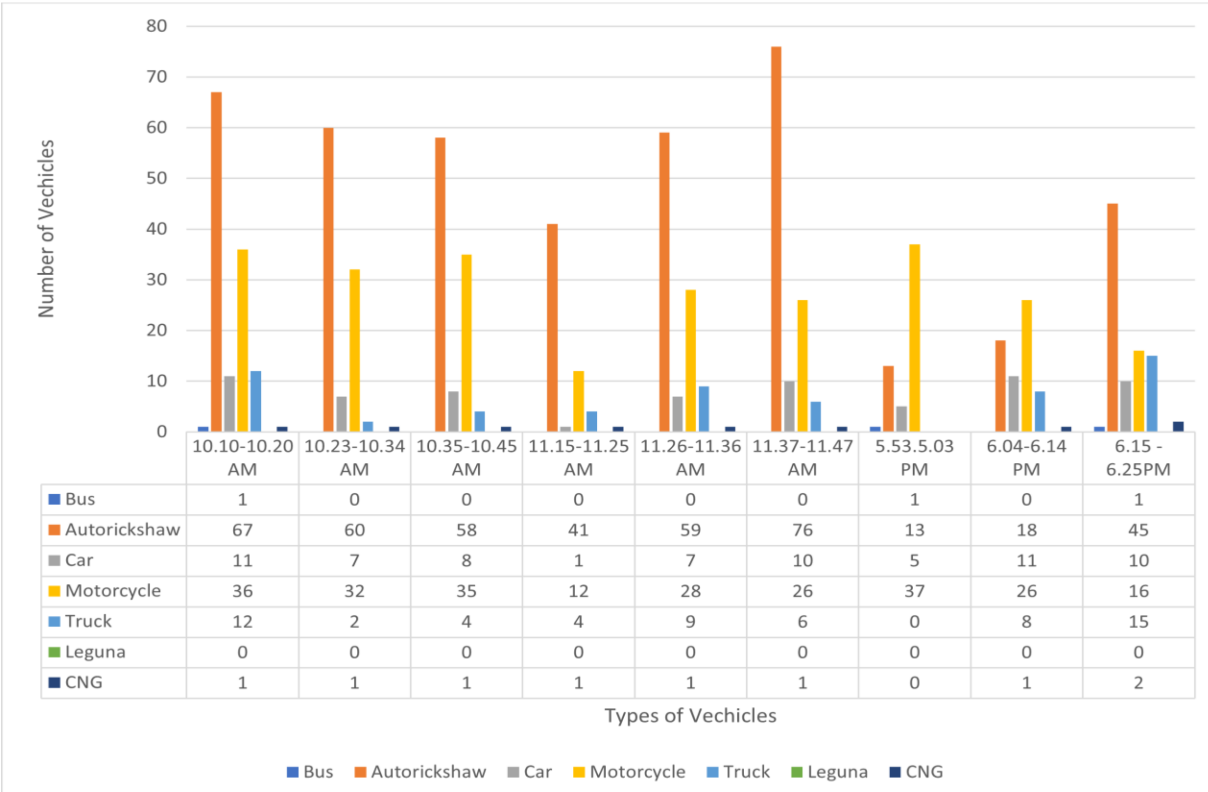


Figure 14 percentage of pie chart

In 16/04/2022, a total of 90 minutes of traffic data was collected. During the period, a total of 437 autorickshaws, 248 motorcycles, 60 trucks, 0 leguna, and 9 CNG appear in Figure 15. Only 3 buses have been observed.



	10.10-10.20 AM	10.23-10.34 AM	10.35-10.45 AM	11.15-11.25 AM	11.26-11.36 AM	11.37-11.47 AM	5.53.5.03 PM	6.04-6.14 PM	6.15 - 6.25PM
Bus	1	0	0	0	0	0	1	0	1
Autorickshaw	67	60	58	41	59	76	13	18	45
Car	11	7	8	1	7	10	5	11	10
Motorcycle	36	32	35	12	28	26	37	26	16
Truck	12	2	4	4	9	6	0	8	15
Leguna	0	0	0	0	0	0	0	0	0
CNG	1	1	1	1	1	1	0	1	2

Figure 15 Calculation Flow chart at khagan road

Figure 16 illustrates the pie chart of the traffic from Savar Road to Akran road on 16/4/2022. From the pie chart, we can observe a maximum of 53% percent autorickshaws, and 30% of motorcycle have arrived. Besides, 7% trucks, 0% leguna, 9% cars, and 1% CNG arrived during the data collection period.

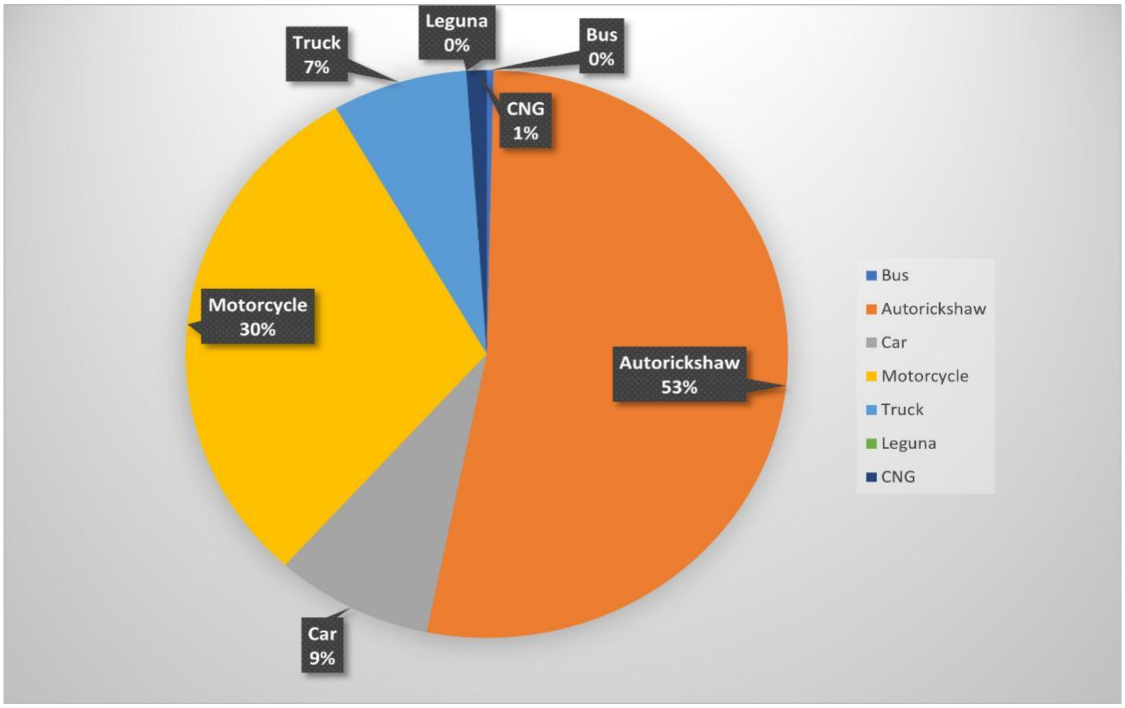
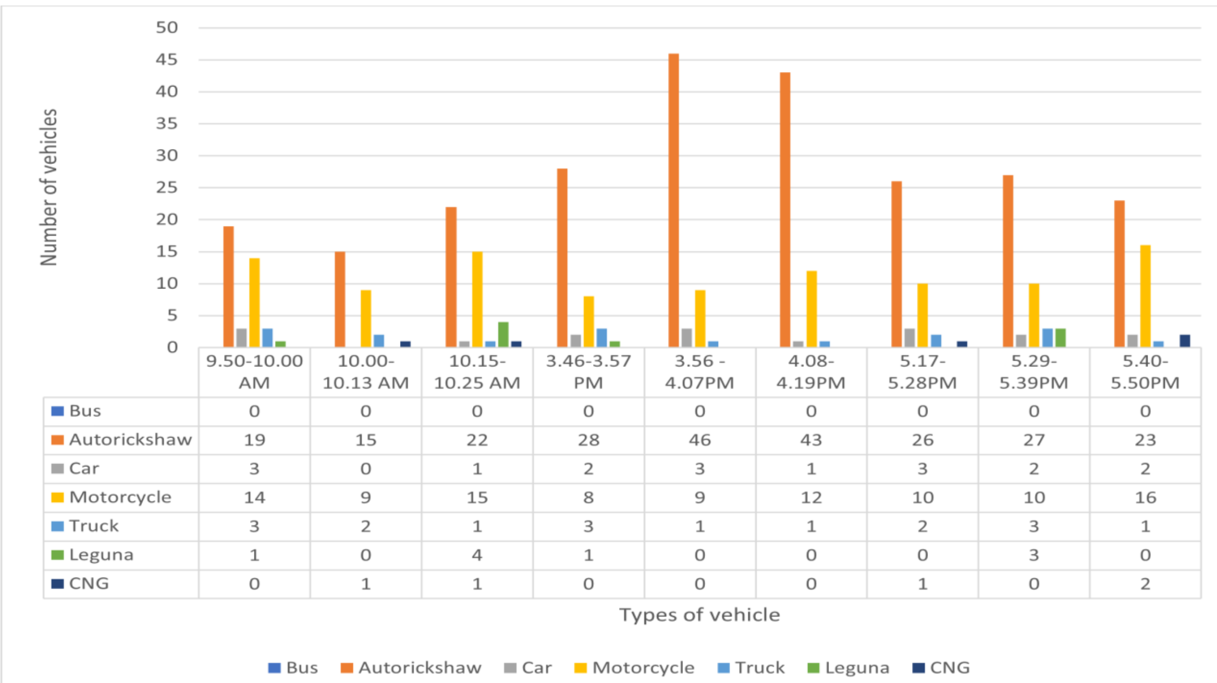


Figure 16 percentage of pie chart

The overall traffic of Golap Gram to Akran Road has also been calculated. A total of 180 minutes of data has been collected to estimate the traffic from golap gram road to akran road. A total of 911 autorickshaws, 487 motorcycles, and 387 have appeared during data collection time periods. On the other hand, other vehicles appeared less frequently, such as 45 buses, 82 trucks, 98 Lagunas and 16 CNG.

3.7 Akran to golap gram Road

At first, the traffic data from the Golap Gram to Akran Road was collected during the data collection. The traffic data has been collected on this road in three different time durations. Figures17, Figure 18, Figure 19, and Figure 20 show how many vehicles appeared on this road during the three different time periods, as shown in Figure 17. Since golap gram road is not a highway, from these four Figures, we can see no buses or CNG are appearing during that time. The data sheet was collected on different days, as shown in Figure 100. From this Figure, we can see that the autorickshaw appeared more frequently than the other vehicles. On 15/4/2022, 249 autorickshaws, 103 motorcycles, 17 trucks, 9 laguna, and 5 CNG appeared. There were no buses that appeared during this time period.



	9.50-10.00 AM	10.00-10.13 AM	10.15-10.25 AM	3.46-3.57 PM	3.56 - 4.07PM	4.08-4.19PM	5.17-5.28PM	5.29-5.39PM	5.40-5.50PM
Bus	0	0	0	0	0	0	0	0	0
Autorickshaw	19	15	22	28	46	43	26	27	23
Car	3	0	1	2	3	1	3	2	2
Motorcycle	14	9	15	8	9	12	10	10	16
Truck	3	2	1	3	1	1	2	3	1
Leguna	1	0	4	1	0	0	0	3	0
CNG	0	1	1	0	0	0	1	0	2

Figure 17 Calculation Flow chart at golap gram road

Figure 18 illustrates the pie chart of the traffic Golap Gram to Akran Road on 15/4/2022. From the pie chart, we can observe that a maximum of 63% of autorickshaws have arrived. On the other hand, 26% of the motorcycle have appeared. There are a few cars, trucks, laguna, and CNG arrived.

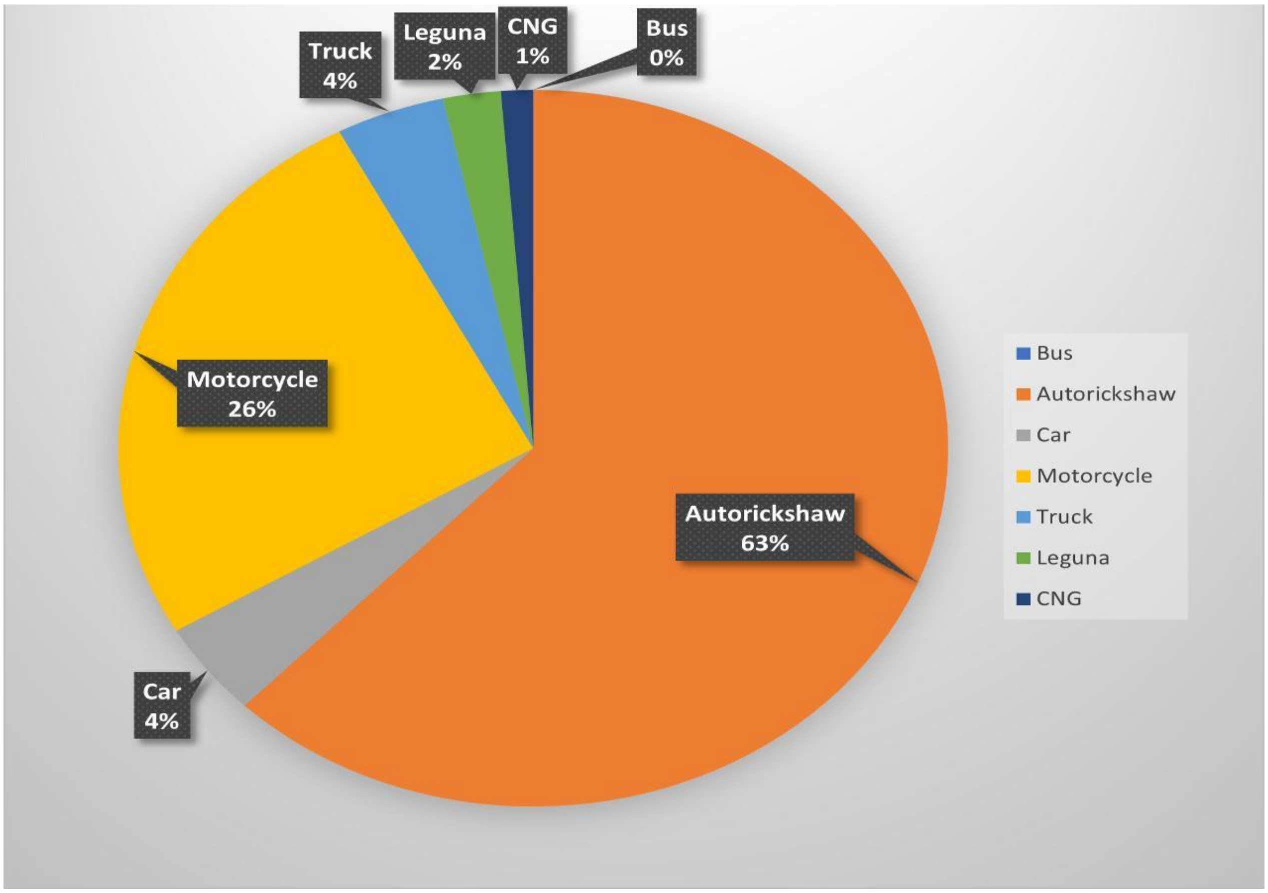
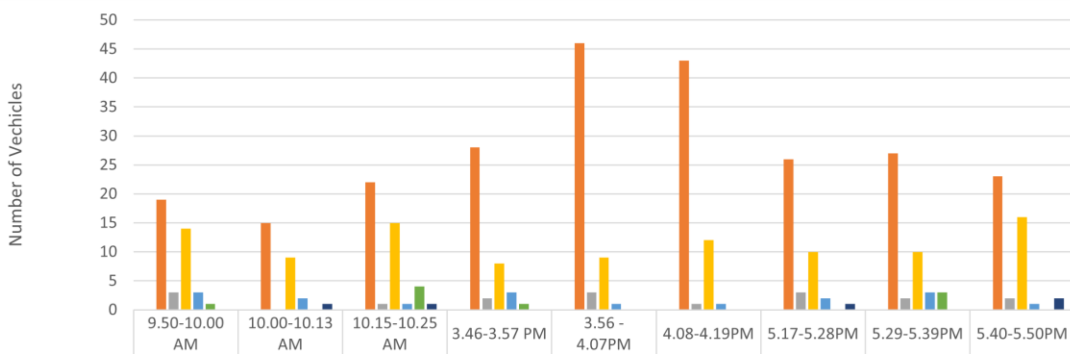


Figure 18 percentage of pie chart

On 16/04/2022, a total of 90 minutes of traffic data was collected. During the time period, 257 autorickshaws, 80 motorcycles, 18 trucks, 11 laguna, and 3 CNG have appeared, as shown in figure 19. No bus has been observed.



	9.50-10.00 AM	10.00-10.13 AM	10.15-10.25 AM	3.46-3.57 PM	3.56 - 4.07PM	4.08-4.19PM	5.17-5.28PM	5.29-5.39PM	5.40-5.50PM
Bus	0	0	0	0	0	0	0	0	0
Autorickshaw	19	15	22	28	46	43	26	27	23
Car	3	0	1	2	3	1	3	2	2
Motorcycle	14	9	15	8	9	12	10	10	16
Truck	3	2	1	3	1	1	2	3	1
Leguna	1	0	4	1	0	0	0	3	0
CNG	0	1	1	0	0	0	1	0	2

Figure 19 Calculation Flow chart at golap gram road

Figure 20 demonstrates the pie chart of the traffic from Golap Gram to Akran Road on 16/4/2022. The pie chart shows that a maximum of 67% percent of autorickshaws have arrived. On the other hand, 21% of the motorcycle have appeared. Only 5% trucks, 3% laguna, 3% cars, and 1% CNG have arrived. There was no bus that arrived during the data collection time period.

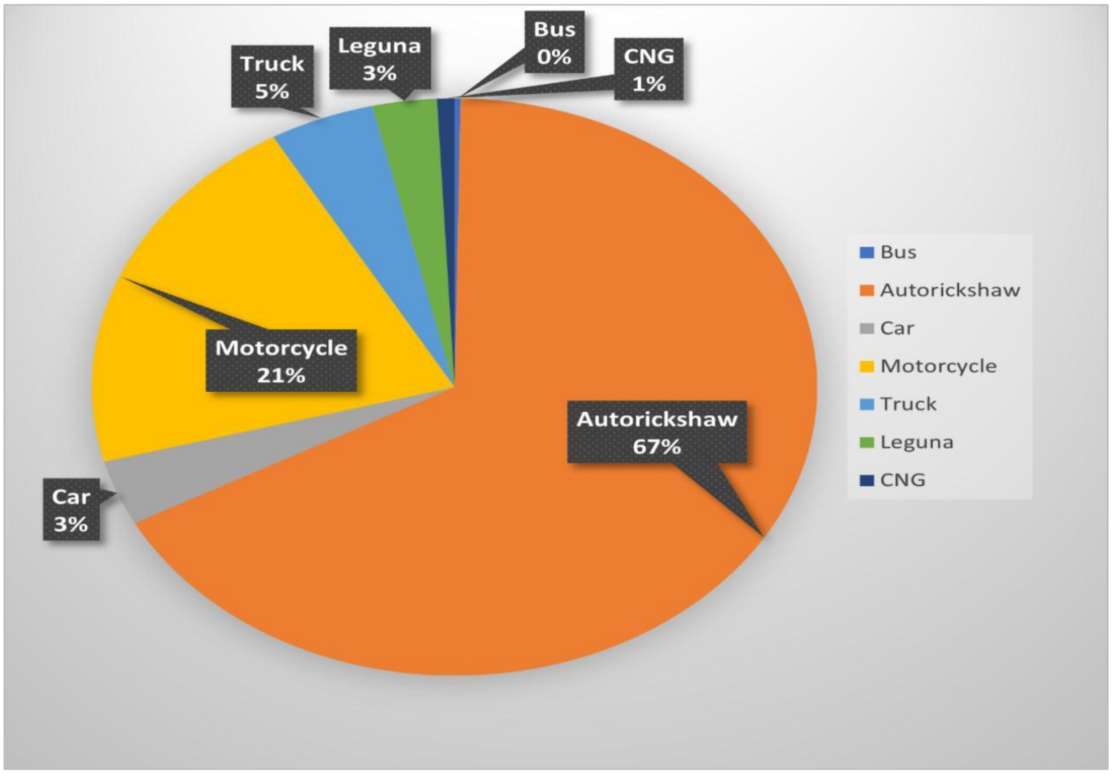


Figure 20 percentage of pie chart

The overall traffic of Golap Gram to Akran Road has also been calculated. A total of 180 minutes of data has been collected to estimate the traffic from golap gram road to akran road. A total of 506 autorickshaws have appeared during data collection time periods. In the second case, a total of 183 motorcycles appeared during the time period. Since this tiny road, other vehicles have appeared less frequently.

CHAPTER 4
Calculation

This study also analyzed the morning and evening peaks' average (Avg) travel time. Finally, the delay time is also calculated for each vehicle. In this study, the average time and the delay have been calculated to estimate the delay of the roadside. This also helps to prepare a traffic system and the effect of the traffic in daily life. The reduced number of lanes and slower vehicle speeds contribute to traffic delays in construction zones. There are two types of traffic delays: those under uncongested conditions and those under crowded conditions. When the traffic volume exceeds the capacity of the work zone, traffic congestion occurs, leading to vehicle lines and traffic delays. Alternatively, when the traffic volume is below the work zone's capacity, cars may pass a work zone smoothly, albeit at a slower pace than the typical freeway speed. At this slower speed, it takes longer for vehicles to pass the work zone than it would cross the same distance of roadway without a work zone. This increased time spent in the work zone is partly a result of the work zone's impact on traffic flow. In addition, because of the stochastic nature of traffic flow, traffic lineups may occur in work zones even when the traffic flow rate is below the capacity of the work zone. To assess the impact of work zones on highway traffic and the consequent user costs, it is necessary to account for and quantify all these forms of traffic delays in work zones.

4.1 Results and Discussions

Collected traffic data is analyzed in this section. The average (avg) travel time of each vehicle in peak hour was measured by the cumulative avg method, and then the approximate delay was determined by subtracting from free flow data. Data was average travel time, delay at peak conditions and free flow is plotted in table 1. These data are collected for different vehicles which is akran intersection.

4.2 Biruliya to akran

Vehicle type	Avg. Travel Time at Morning Peak	Avg. Travel Time at Evening Peak	Avg. Travel Time at Free Flow	Delay at Morning Peak	Delay at Evening Peak
motorcycle	25.54sec	27.58 sec	3.21sec	22.33 sec	24.07 sec
CNG	39.55 sec	40.74 sec	3.77 sec	35.78 sec	36.97 sec
Laguna/mini truck	60.40 sec	61.13 sec	5.31 sec	55.09 sec	55.82 sec
Car	58.98 sec	70.84 sec	6.16 sec	52.82 sec	64.68 sec
Bus	84.23 sec	82.43 sec	7.06sec	77.17 sec	75.37 sec
truck	81.65 sec	95.68 sec	7.22sec	74.48 sec	86.46 sec
Auto rickshaw	63.73 sec	66.48 sec	7.04sec	56.69 sec	59.40 sec

Table 1 delay calculation

Avg. delay/vehicle (morning peak):

(22.33 +35.78 +55.09 +52.82 +77.17 +74.48 +56.69)/7

=53.48 sec

Avg. delay/vehicle (evening peak):

(24.07 +36.97 +55.82 +64.68 +75.37 +86.46 +59.40)/7

= 57.54sec

So, avg. delay

(53.48+57.54)/2

=55.51 sec

So, we have calculated average delay in the intersection for 1 hour 339.06 sec.

Similarly, we calculate the average delay for all other points. The average delay for khagan to akran , savar to akran golam gram to akramn was 347.28 sec,230.88 sec, and 190.94 sec respectively.

So, the total delay at akran intersection is 1108.16 sec for 1 hour.

Theoretical Analysis with HCM 2000 Model: We analyzed the collected data theoretically with HCM 2000 Model, which is shown below in table 2. Roadway names are taken for biruliya to akran as 'A'; as; khagan to akran as'B''akran to savar as 'C 'D'.akran to golap gram D'

Road way Name	C sec	g sec	T hr	g/C	v vec/ hr	s veh/ hr	c=s* (g/c)	X=v /c	d1	d2	P=R p*(g /c)	d
A	420	97	0.083	0.23	1488	3855	886	1.679	161	110.65	0.230	271.65
B	420	73	0.083	0.17	988	4926	852	1.159	173	41.41	0.173	214.41
C	420	137	0.083	0.32	1308	3545	1152	1.132	141	34.87	0.326	175.87
D	420	142	0.08	0.33	1436	3436	1161	1.23	139	47.3	0.33	186.35

Table 2 Theoretical Analysis

Where, d = average overall delay (sec/veh) = d1 *PF + d2 d1

= uniform delay (sec/veh)

d2 = incremental or random delay (sec/veh)

K= incremental delay factor

I = upstream filtering (1.0) for an isolated intersection

PF = adjustment factor for the effect of the quality of progression in a coordinated system

v = arrival flow rate (vph) s = saturation flow rate (vph)

C = counting time (sec) and c= capacity (vph)

g = effective green time (sec) and T = length of analysis period (hr) Min

(1, X), fpa, PF and Rp were taken 1.0 for the whole calculation.

Comparison of Theoretical and Field Delay: The theoretical delays from the HCM 2000 which are shown in table 2, and the field delays explained above are plotted in table3. Where the highest percent increase was found at the khagan to akran, which is 61.97. The lowest percent increase was 2.46, found at akran to golap gram.

Location	**Theoretical Delay (HCM 2000) (sec)**	**Field Delay (sec)**	**Percent Increase**
biruliya to akran	271.65	339.06	24.81
khagan to akran	214.41	347.28	61.97
akran to savar	175.87	230.88	31.27
akran to golap gram	186.35	190.94	2.46

Table 3 Comparison of Theoretical and Field Delay

CHAPTER 5
DISCUSSION AND FUTURE WORK

In this study, initially, the traffic data was collected and analyzed. This study also estimated the delay of the real-time traffic system. There are some existing traffic delay estimation methods, but the traffic scenario of Dhaka city is different from the others city because it is the world's most densely populated. On the other hand, real-time data collection is one of the prerequisite requirements for developing an intelligent traffic system. For this reason, this study focuses on real-time data collection. Moreover, Machine learning (ML) and deep learning (DL) techniques have become more famous due to their successful application and cost-effective approach. The researcher has widely used the ML and DL methods and implemented this method in real-time applications. In the future, it will help reduce the human effort in the traffic system. Some studies proposed image processing-based traffic systems and delay estimation techniques and showed that they achieved higher accuracy in this field.

CONCLUSION

This study calculated the practical delay at an intersection of Dhaka city (intersection of Akran Bazar) and compared that delay with the theoretical delay model with **existing** models. This study has acquired traffic data by the use of videography, which is significantly less labor-intensive than manual data collecting. Despite the fact that recorded video can give a permanent and comprehensive record of the traffic scene, the data extraction procedure is lengthy and demands close attention throughout the whole video. For the experimental data collection analysis, it is clear that the proposed study provides significant outcomes for the delay estimation of Dhaka city. Besides, the level of drivers in Bangladesh may be different than other cities. Therefore, the researchers recommend additional surveys to determine how drivers perceive the delay. Moreover, the road conditions and traffic management system of the city of Dhaka are significantly different from the model, necessitating additional research.

REFERENCE

[1] "Development of a saturation flow and delay models for signalized intersection in Dhaka city | Semantic Scholar." https://www.semanticscholar.org/paper/Development-of-asaturation-flow-and-delay-models-Hadiuzzaman/f69ac0dd7ea6736ad810e8ff8169b874941e6ea5 (accessed May 15, 2022).

[2] L. Mussone, S. Grant-Muller, and J. Laird, "Sensitivity analysis of traffic congestion costs in a network under a charging policy," *Case Stud. Transp. Policy*, vol. 3, no. 1, pp. 44–54, Mar. 2015, doi: 10.1016/J.CSTP.2014.03.001.

[3] "(PDF) Modelling of traffic delays at priority junctions using Artificial Neural Network".

[4] "(PDF) MEASURING CONTROL DELAY AT SIGNALIZED INTERSECTIONS: CASE STUDY FROM SOHAG, EGYPT." https://www.researchgate.net/publication/313035279_MEASURING_CONTROL_DELAY_AT_SIGNALIZED_INTERSECTIONS_CASE_STUDY_FROM_SOHAG_EGYPT (Accessed May 15, 2022).

[5] I. Shatnawi, P. Yi, and I. Khliefat, "Automated intersection delay estimation using the input–output principle and turning movement data," *Int. J. Transp. Sci. Technol.*, vol. 7, no. 2, pp. 137–150, Jun. 2018, doi: 10.1016/J.IJTST.2018.04.001.

[6] C. Liu and M. J. Kochenderfer, "Analyzing Traffic Delay at Unmanaged Intersections," May 2018, Accessed: May 15, 2022. [Online]. Available: http://arxiv.org/abs/1806.02660

[7] G. Perakis and G. Roels, "An analytical model for traffic delays and the dynamic user equilibrium problem," *Oper. Res.*, vol. 54, no. 6, pp. 1151–1171, Nov. 2006, doi: 10.1287/OPRE.1060.0307.

[8] S. Stanković, N. Čelar, J. Kajalić, and I. Vukićević-Biševac, "Micro- and Macroapproach to Modeling Relationship between Control and Stopped Delays at Signalized Intersections," *J. Transp. Eng. Part A Syst.*, vol. 146, no. 1, p. 04019058, Nov. 2019, doi: 10.1061/JTEPBS.0000288.

[9] P. Chen, H. Qi, and J. Sun, "Investigation of Saturation Flow on Shared Right-Turn Lane at Signalized Intersections," *https://doi.org/10.3141/2461-09*, vol. 2461, pp. 66–75, Jan. 2014, doi: 10.3141/2461-09.

[10] Y. Wang, J. Rong, C. Zhou, and Y. Gao, "Dynamic estimation of saturation flow rate at information-rich signalized intersections," *Inf.*, vol. 11, no. 4, Apr. 2020, doi: 10.3390/INFO11040178.

[11] "(PDF) Development of Saturation Flow and Delay Model at Signalised Intersection of Kathmandu." https://www.researchgate.net/publication/312319228_Development_of_Saturation_Flow_and_Delay_Model_at_Signalised_Intersection_of_Kathmandu (accessed May 15, 2022).

[12] S. Ramireddy, E. Sala, and K. V. R. Ravishankar, "Effect of Encroaching Vehicles on Saturation flow at Signalized Intersections in Mixed Traffic conditions," *J. Inst. Eng. Ser. A*, vol. 101, no. 2, pp. 273–279, Jun. 2020, doi: 10.1007/S40030-019-00425-4.

[13] "(PDF) Prediction of saturation flows at junctions controlled by traffic signals." https://www.researchgate.net/publication/330798651_Prediction_of_saturation_flows_at_junctions_controlled_by_traffic_signals (accessed May 15, 2022).

[14] H. Al-Hamadani and S. Al-Arkawazi, "The Influence of Driver Behavior on Saturation Flow Rate at Signalized Intersection," *Sulaimani J. Eng. Sci.*, vol. 6, no. 4, pp. 43–56, 2019, doi: 10.17656/sjes.10113.
[15] C.-Q. Shao, J. Rong, and X.-M. Liu, "Study on the Saturation Flow Rate and Its Influence Factors at Signalized Intersections in China," *Procedia Soc. Behav. Sci.*, vol. 16, pp. 504–514, 2011, doi: 10.1016/j.sbspro.2011.04.471.
[16] S. Biswas, S. Chakraborty, I. Ghosh, and S. Chandra, "Saturation flow model for signalized intersection under mixed traffic condition," *Transp. Res. Rec.*, vol. 2672, no. 15, pp. 55–65, Jun. 2018, doi: 10.1177/0361198118777407.
[17] I. Bargegol, A. T. Amlashi, and V. N. M. Gilani, "Estimation the Saturation Flow Rate at Far-side and Nearside Legs of Signalized Intersections - Case Study: Rasht City," *Procedia Eng.*, vol. 161, pp. 226–234, 2016, doi: 10.1016/J.PROENG.2016.08.539.
[18] X. J. Ban, Y. Li, A. Skabardonis, and J. D. Margulici, "Performance Evaluation of Travel-Time Estimation Methods for Real-Time Traffic Applications," *https://doi.org/10.1080/15472451003719699*, vol. 14, no. 2, pp. 54–67, Apr. 2010, doi: 10.1080/15472451003719699.
[19] Y. Cheng, X. Qin, J. Jin, B. Ran, and J. Anderson, "Cycle-by-Cycle Queue Length Estimation for Signalized Intersections Using Sampled Trajectory Data," *https://doi.org/10.3141/2257-10*, no. 2257, pp. 87–94, Jan. 2011, doi: 10.3141/2257-10.
[20] A. D. (Adolf D. May, "Traffic flow fundamentals," p. 464, 1990.
[21] A. Sharma, D. M. Bullock, and J. A. Bonneson, "Input–Output and Hybrid Techniques for Real-Time Prediction of Delay and Maximum Queue Length at Signalized Intersections," *https://doi.org/10.3141/2035-08*, no. 2035, pp. 69–80, Jan. 2007, doi: 10.3141/2035-08.
[22] D. H. Nam and D. R. Drew, "Traffic Dynamics: Method for Estimating Freeway Travel Times in Real Time from Flow Measurements," *J. Transp. Eng.*, vol. 122, no. 3, pp. 185–191, May 1996, doi: 10.1061/(ASCE)0733-947X (1996)122:3(185).
[23] A. Bhaskar and E. Chung, "Fundamental understanding on the use of Bluetooth scanner as a complementary transport data," *Transp. Res. Part C Emerg. Technol.*, vol. 37, pp. 42–72, Dec. 2013, doi: 10.1016/J.TRC.2013.09.013.
[24] S. M. Turner, W. L. Eisele, R. J. Benz, and J. Douglas, "Travel time data collection handbook," *Fed. Highw. Adm. USA.*, vol. 3, no. 5, p. 293, 1998.
[25] "Queue length estimation from probe vehicle location and the impacts of sample size."
[26] M. D. Fontaine and B. L. Smith, "Probe-Based Traffic Monitoring Systems with Wireless Location Technology," *Transp. Res. Rec. J. Transp. Res. Board*, vol. 1925, no. 1, pp. 2–11, Jan. 2005, doi: 10.1177/0361198105192500101.
[27] "Travel Time Estimation on the San Francisco Bay Area Network Using Cellular Phones as Probes." https://escholarship.org/uc/item/8xn8m01v (accessed May 15, 2022).
[28] H. Bar-Gera, "Evaluation of a cellular phone-based system for measurements of traffic speeds and travel times: A case study from Israel," *Transp. Res. Part C Emerg. Technol.*, vol. 15, no. 6, pp. 380–391, Dec. 2007, doi: 10.1016/J.TRC.2007.06.003.
[29] C. M. Day, T. M. Brennan, A. M. Hainen, S. M. Remias, and D. M. Bullock, "Roadway System Assessment Using Bluetooth-Based Automatic Vehicle Identification Travel Time Data," *JTRP Affil. Reports*, Dec. 2012, doi: 10.5703/1288284314988.

[30] M. Abbas, L. Rajasekhar, A. Gharat, and J. P. Dunning, "Microscopic Modeling of Control Delay at Signalized Intersections Based on Bluetooth Data," *https://doi.org/10.1080/15472450.2013.784653*, vol. 17, no. 2, pp. 110–122, Apr. 2013, doi: 10.1080/15472450.2013.784653.

[31] A. Haghani, M. Hamedi, K. F. Sadabadi, S. Young, and P. Tarnoff, "Data Collection of Freeway Travel Time Ground Truth with Bluetooth Sensors," *https://doi.org/10.3141/2160-07*, no. 2160, pp. 60–68, Jan. 2010, doi: 10.3141/2160-07.

APPENDIX

Morning Peak

biruliya to akran						
15/04/2022	Duration		Time			Link: Video
	10min		9.50 am-10.00 am			
Bus	AUtorickshaw	**Car**	**Motorcycle**	**Truck**	**Leguna**	**CNG**
84.23	66.33	57.1	26.18	83.66	58.2	40.1
	61.97	60.68	24.22	85.08	57.26	38.05
	62.09	54.23	23.93	80.14	60.67	42.15
	61.23	54.5	27.1	80.22	60.86	37.3
	65.77	67.33	27.32	81.47	60.76	36.05
	64.29	72.98	31.83	79.33	67.43	43.15
	64.66	68.12	22.11	81.65	65.07	39.46667
	67.41	64.16	22.13		54.95	
	60.21	54.32	25.39		58.48	
		36.47	25.24			
AVG: **84.23**	**63.73**	**58.989**	**25.545**	**81.65**	**60.40889**	**39.55556**

Free Flow

Free flow	Free flow	free flow	free flow	Truck	free flow	free flow
7.33	18.8	4.14	3.37	5.73	4.85	
6.9	8.03	4.11	3.39	4.41	5.09	6.09
6.97	7.09	3.52	4.1	9.61	7.61	3.48
	6.72	3.04	3.34	5.01	4.2	3.89
	5.08	2.85	3.08	6.6	4.84	4.23
	3.66	3.42	2.83	11.97		4.4225
	4.45	9.93	3.22			
	5.68	9.86	2.91			
	3.93	13.97	3.17			
		6.83	2.7			
AVG:7.066667	**7.04**	**6.167**	**3.211**	**7.221667**	**5.318**	**3.77**

Evening peak

biruliya to akran						
15/04/2022	Duration		Time			Link: Video
	10min	9.50–10.00 am				
Bus	AUtorickshaw	**Car**	**Motorcycle**	**Truck**	**Leguna**	**CNG**
78.35	65.47	72.87	25.9	123.56	53.91	37.53
79.01	62.87	74.18	25.59	128.05	62.45	39.6
67.96	62.09	74.23	24.31	89.26	67.89	45.09
104.42	60.86	77.03	31.44	81.32	63.24	
	71.35	67.19	33.12	56.24	61.38	
	72.17	73.86	33.94		57.95	
	68.28	73.11	34.02			
	67.41	68.39	21.75			
	63.97	67.94	22.8			
	70.34	59.61	22.98			
AVG: 82.43	66.481	70.841	27.585	95.68	61.13667	40.74

Biruliya to akran

Vehicle type	Avg. Travel Time at Morning Peak	Avg. Travel Time at Evening Peak	Avg. Travel Time at Free Flow	Delay at Morning Peak	Delay at Evening Peak
motorcycle	25.21 sec	25.57 sec	4.08sec	21.13 sec	21.49 sec
CNG	39.10 sec	40.26 sec	4.77 sec	34.33 sec	35.49 sec
Leguna/mini truck	57.21sec	59.38 sec	7.39 sec	49.85 sec	51.99 sec
Car	55.43sec	58.18 sec	7.53 sec	47.9 sec	50.65 sec
Bus	84.23 sec	80.32 sec	7.06sec	75.86 sec	71.95 sec
Truck	81.65 sec	89.60 sec	7.22sec	72.39 sec	80.71 sec
Auto rickshaw	63.55 sec	67.22 sec	7.59sec	55.96 sec	59.63 sec

khagan to akran

Vehicle type	Avg. Travel Time at Morning Peak(8-12)	Avg. Travel Time at Evening Peak	Avg. Travel Time at Free Flow	Delay at Morning Peak	Delay at Evening Peak
motorcycle	27.21 sec	36.00 sec	2.51 sec	24.7 sec	33.49 sec
CNG	43.00 sec	51.21 sec	4.7 sec	38.3 sec	46.51 sec
Leguna/mini truck	64.11sec	89.27 sec	6.12 sec	54.99 sec	83.15 sec
Car	54.37sec	62.39 sec	5.9 sec	48.37 sec	56.49 sec
Bus	89.00 sec	81.30 sec	6.37sec	82.63 sec	74.93 sec
truck	78.53 sec	87.19 sec	6.22 sec	72.31 sec	80.97 sec
Auto rickshaw	57.23 sec	67.37 sec	5.54sec	51.69 sec	61.83 sec

Savar to akran

Vehicle type	Avg. Travel Time at Morning Peak	Avg. Travel Time at Evening Peak	Avg. Travel Time at Free Flow	Delay at Morning Peak	Delay at Evening Peak
motorcycle	22.31 sec	26.11 sec	2.90sec	19.41sec	23.21sec
CNG	29.04sec	35.42 sec	3.52 sec	25.52 sec	31.09sec
Leguna/mini truck	33.50sec	40.56 sec	5.11 sec	28.39 sec	35.45 sec
Car	30.26sec	50.17 sec	4.18 sec	26.8 sec	45.99 sec
Bus	59.12 sec	67.40 sec	5.59sec	53.53 Sec	61.81 sec
truck	57.39 sec	65.06sec	7.12 sec	50.27 sec	57.94 sec
Auto rickshaw	36.25 sec	51.55sec	4.21sec	32.04 sec	47.34sec

Golap gram to akran

Vehicle type	Avg. Travel Time at Morning Peak	Avg. Travel Time at Evening Peak	Avg. Travel Time at Free Flow	Delay at Morning Peak	Delay at Evening Peak
motorcycle	19.81 sec	22.76 sec	2.97sec	16.84sec	19.79 sec
CNG	25.37sec	29.34 sec	3.17 sec	22.2 sec	26.17Sec
Leguna/mini truck	29.72 sec	35.26 sec	5.42 sec	24.3 sec	29.84sec
Car	30.95sec	39.44 sec	5.11 sec	25.84 sec	34.33 sec
Bus	51.89 sec	57.78 sec	7.13sec	44.76sec	50.65 sec
truck	62.66 sec	55.39sec	8.12 sec	44.54sec	47.27 sec
Auto rickshaw	33.49 sec	37.51sec	4.91sec	29.58 sec	32.6sec