

## **PARKING VOLUME STUDY OF SELECTED LOCATIONS; A CASE STUDY ON KHULNA CITY**

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### **ABSTRACT**

Parking volume study has got much more importance with the increased urbanization and vehicle demand. Parking is more than essential for wider residential or commercial areas; it merits consideration as a separate land use that influences traffic and travel behavior along with the environment. Parking of vehicles is an integral part of the Khulna city area. Parking demand is particularly high in the Khulna city area because of intense commercial activities. Providing adequate parking space to meet the demand for parking may necessitate the provision of parking bays along curbs which reduces the capacity of the roads and may affect the level of service (LOS). Inaccurate parking facilities reduce the effective width of roads or reduce the traffic flow capacity of roads and cause a considerable amount of congestion. In the Khulna city area, it is a common feature that many motorized and non-motorized vehicles are parked on streets and intersections of the selected locations which results in heavy traffic congestion. So it is important to analyze the effect of that uncontrolled parking on roads in order to mitigate the adverse effect of intolerable congestion. Eight strategically important locations in Khulna city were selected by a reconnaissance survey for this study to find out parking volume and analyze whether the parking patterns of selected locations are different or the same. The maximum 375, 79, and 38 number of two-wheelers, three-wheelers, and four-wheelers were found parked at Khulna Shopping Complex, New Market, and also New Market zone respectively for a specific period of time. The related maximum Passenger Car Unit (PCU) values of Khulna Shopping Complex and New Market are 224.5 and 348.5 respectively indicating New Market is the busiest parking area of all the selected locations. Among the selected eight locations, Khulna New Market and KCC Building hold the highest and lowest PCU value of 348.5 and 20 respectively. Parking management was found controlled by the local authority and a considerable amount of fees are required in some locations for a specific period of time. But parking on streets is a major problem in every locations that is responsible in creating congestion. One sample t-test conducted by SPSS V25 suggests that the parking facilities, as well as the pattern of parking in the eight selected locations, are different from each other.

**Keywords:** *Parking Volume Study, Capacity of Roads, Congestion, PCU, Khulna City.*

## 1. INTRODUCTION

Khulna is the third-largest city in Bangladesh after Dhaka and Chittagong (Geonames, February 2019). It is the ministerial zone of the Khulna District and Khulna Division. In the 2011 census, the city had a population of 663,342 (Population & Housing Census, 2011). The Khulna metropolitan area had an estimated population of 1.022 million in 2014 (World Urbanization Prospects, 2014). Khulna stands on the bank of the Rupsha and Bhairab Rivers. Khulna being the center of the Bangladeshi industry, it hosts many national companies. Khulna acts as a gateway to the nearby seaport of Mongla (the second-largest seaport in the country) and is one of two principal naval-command centers hosting the Bangladesh Navy. The navy base Bangladesh Naval Ship (BNS) Titumir is in the city. The N7 highway connects Khulna with the rest of Bangladesh, and the Khulna City Bypass is a major road. The R760 connects Satkhira and western Khulna Districts. There are several nationwide bus services available in Khulna (most privately owned), and the Bangladesh Road Transport Corporation (BRTC) operates an inter-district bus service from the city. Sonadanga Bus Terminal is Khulna's main bus terminal. Rickshaws are the most popular means of public transport in Khulna for short trips, and auto-rickshaws are also common. Nagar Paribahan buses have frequent service between Rupsha and Phultala, with stops throughout Khulna. Motorcycles are popular among the middle class, and wealthier people prefer a private car. Parking is an issue of significance both at local and at strategic level planning (William, Russell & Michael, 1991). In order to make a firm parking policy, it is desirable to study the parking behavior and characteristics properly. In recent years, there has been a growing concern about the need for more parking facilities which has been reflected through the editorials or special articles, published in the national weekly newspapers and journals (Hossain, 1988; Mahmood, 1988; Mahmood, 1989; Rahman, 1989; The Bangladesh Observer, 1990). Lack of parking facilities also has been focused in the scenario through the recommendations of some seminars (Ahmed and Hoque, 1988; Ahsan and Hoque, 1989; Seminar on Prevention of Accident, 1989), memorandum of Dhaka Metropolitan Police (1986). Parking spaces are very important to cities. A city must have enough parking spaces to provide its residents and their visitors a place to park their vehicles. So proper design of parking space is very important for good transporting system. If there will be a lack of parking space and facilities then it will be a chaotic condition for everyone. And that's why analysis of parking spaces of a city is very important before designing a parking space. Although adequate vehicular parking is a necessary prerequisite of sound urban development, trade and commerce cannot prosper without it. But the provision of space for parking of vehicles is the most neglected issue in the context of total urban transportation management in Khulna city. The specific objectives of the study are to find out the volume, types, and number of vehicles of selected locations in Khulna City and to find out whether the parking patterns of these selected locations are the same or different from each other.

## 2. METHODOLOGY

### 2.1 Selection of Strategic Locations

Khulna is Bangladesh's third-largest city, in the south-western part of the country, on the Rupsha and Bhairab Rivers, it covers an area of 59.57 sq km (Area, Population and Literacy Rate by Paurashava, 2001). The district covers 4,394.46 sq km. Study areas were selected after conducting a reconnaissance survey based on the amount and type of traffic, parking characteristics along with management of parking. The selected locations for this research are some busy commercial, hospital, and trading zones named New Market, Bangladesh Bank, City Inn. Hotel, Jalil Tower, Khulna City Corporation (KCC) Building, Khulna Development Authority (KDA) Building, Khulna City Medical College Hospital (KCMCH), and Khulna Shopping Complex.

### 2.2 Data Collection and Analytical Approach

This exploratory research is split into different parts. The research started by conducting a reconnaissance survey in all of the parking lots of the selected locations in order to find out the existing availability of parking facilities. To do this accurately, the study section of each area was divided into suitable numbers of different sites. Then each of the different sites was surveyed by an observer.

The number of vehicles that entered and exited the parking lot was counted for a particular time interval. In this study case, the total duration of study is 6 hours for each of the locations. This duration is subdivided into 12-time slots having a beat duration of 30 minutes. At the start of each time slot, each individual observer recorded the number of vehicles parked in that particular site of road assigned to them. The same procedure was repeated 12 times for each time slot. In this study case, from 9:00 AM to 12:00 PM at the morning hour and from 5:00 PM to 8:00 PM at the evening hour. The number of vehicles was categorized into 3 different groups i.e. Four-Wheeler, Three-Wheeler & Two-Wheeler. In terms of this study case, these working procedures have been conducted for eight (8) days for the eight (8) different selected locations. The related PCU of the parked vehicles were calculated using Table 1 that shows the PCU value for different types of vehicles in Bangladesh.

Table 1: PCU for Different Types of Vehicles in Bangladesh

Vehicle Categories	PCU
Passenger Car	1.00
Light Goods Vehicles	1.00
Truck	3.00
Bus	3.00
Auto Rickshaw / Motor Cycle	0.75
Rickshaw / Van	2.00
Bicycle	0.50

(Source: MoC, 2001)

For this research, t-test analysis has been applied using SPSS V25. The t-test estimates the true difference between two group means using the ratio of the difference in group means over the pooled standard error of both groups. Equations (1) and (2) show the formula for t value and df value. A t-test was conducted to find out whether the parking pattern, facility, and characteristics are different from each other or not.

$$t = \frac{a_1 - a_2}{\sqrt{s_1^2 - s_2^2}} \quad (1)$$

$$df = \frac{(s_1^2 - s_2^2)^2}{\frac{s_1^4}{n_1 - 1} + \frac{s_2^4}{n_2 - 1}} \quad (2)$$

Where, “t” indicates the t-value, while “a” denotes the parameters, parameters included mean and intercept, “s” indicates standard error, “d” denotes the value of degree of freedom, and “n” indicates number of samples.

A confidence interval indicates the probability that a parameter will fall between a pair of values around the mean. Confidence intervals measure the degree of uncertainty or certainty in a sampling method. They are most often constructed using confidence levels of 95% or 99%.

### 3. RESULTS AND DISCUSSIONS

#### 3.1 Volume of Vehicles with PCU in the Selected Locations

Eight strategically important locations were selected on the basis of volume and density of parking. Table 2 below shows the parking characteristics with PCU of New Market area of Khulna-

Table 2: Parking Characteristics with PCU in New Market Area

Time	Volume of Vehicles Parked			PCU
	Two-Wheeler	Three-Wheeler	Four-Wheeler	
9:00 AM -9:30 AM	9	7	1	21.5
9:30 AM -10:00 AM	33	17	6	68.5
10:00 AM -10:30 AM	79	41	12	157.5
10:30 AM -11:00 AM	114	55	19	224
11:00 AM -11:30 AM	119	46	21	214.5
11:30 AM -12:00 AM	124	61	27	265
5:00 PM -5:30 PM	104	39	14	172
5:30 PM -6:00 PM	109	48	17	201.5
6:00 PM -6:30 PM	129	60	23	253.5
6:30 PM -7:00 PM	141	67	29	291.5
7:00 PM -7:30 PM	158	75	35	334
7:30 PM -8:00 PM	153	79	38	348.5

Table 2 shows the parking characteristics of the New Market area Khulna. Being a busy commercial zone this place accepts a huge amount of parking vehicles of different types all through the day. Motorcycle and car are the main two types of vehicles that are parked in 3 to 4 places in New Market. The highest volume of two-wheelers, three-wheelers, and four-wheelers were 158, 79, and 38 respectively. The lowest average PCU at the location is 21.5, which is recorded from 9:00 AM to 9:30 AM and the highest average PCU at the location is 348.5 that was recorded from 7:30 PM to 8:00 PM. Being a very busy trading and marketplace, this area's parking system is variant in nature. There are mainly 3 spaces (In front of Baitun Nur Jame Masjid, Gate 2, Gate 3) of parking where people have to pay fees to park their vehicles. As a huge number of vehicles come in and out every single hour, the related PCU value is much higher than the other sample locations taken into consideration for this study.

Table 3 below shows the parking characteristics of the Bangladesh Bank building, a branch of the central bank of Bangladesh. A huge amount & various types of vehicles are parked every day in this area. Private cars, motorcycles, and bicycles are the major vehicles that are being parked in this area.

Table 3: Parking Characteristics with PCU in Bangladesh Bank Area

Time	Volume of Vehicles Parked			PCU
	Two-Wheeler	Three-Wheeler	Four-Wheeler	
9:00 AM -9:30 AM	32	4	5	39
9:30 AM -10:00 AM	53	2	8	54.5
10:00 AM -10:30 AM	61	1	14	74.5
10:30 AM -11:00 AM	64	3	14	80
11:00 AM -11:30 AM	57	3	19	91.5
11:30 AM -12:00 AM	60	2	18	88
5:00 PM -5:30 PM	45	5	15	77.5
5:30 PM -6:00 PM	33	4	13	63.5
6:00 PM -6:30 PM	24	1	8	38
6:30 PM -7:00 PM	17	2	7	33.5
7:00 PM -7:30 PM	14	0	7	28
7:30 PM -8:00 PM	12	2	5	25

The highest volume of two-wheelers, three-wheelers, and four-wheelers were 64, 5, and 19 respectively. The above table implies that the lowest average PCU at the location is 25, which is recorded from 7:30 PM to 8:00 PM and the highest average PCU at the location is 91.5, which is recorded from 11:00 AM to 11:30 AM. The most dominant vehicle in this area is motorcycle and government-owned cars. Being

a commercially important zone, it has a separate parking space controlled by the authority, and parking is without fees.

Table 4 shows the parking characteristics of City Inn Hotel Ltd., which is the most modern facilitated international standard hotel and holds a prime location and booming area in Khulna city the southern part of Bangladesh. This upmarket hotel comprising two recognized parking areas; one outside the main opening and the other in the basement. Parking is charge-free here and security to vehicles parked here is much better than the other sample locations. The table below indicates that dominant vehicles in this zone are two-wheelers and four-wheelers. Being an important meeting and recreation place, many national and international programs are arranged here.

Table 4: Parking Characteristics with PCU in Hotel City Inn. Area

Time	Volume of Vehicles Parked			PCU
	Two-Wheeler	Three-Wheeler	Four-Wheeler	
9:00 AM -9:30 AM	12	2	6	28
9:30 AM -10:00 AM	14	3	6	31
10:00 AM -10:30 AM	11	1	7	28.5
10:30 AM -11:00 AM	15	5	9	44.5
11:00 AM -11:30 AM	10	3	9	38
11:30 AM -12:00 AM	12	2	12	46
5:00 PM -5:30 PM	15	7	14	63.5
5:30 PM -6:00 PM	17	5	11	51.5
6:00 PM -6:30 PM	22	5	12	57
6:30 PM -7:00 PM	24	8	13	67
7:00 PM -7:30 PM	20	6	15	67
7:30 PM -8:00 PM	27	4	11	54.5

The Maximum volume of two-wheelers, three-wheelers, and four-wheelers is 27, 8, and 15 respectively. The above table implies that the lowest average PCU at the location is 28, which is recorded from 9:00 AM to 9:30 AM and the highest average PCU at the location is 67, which is recorded from 6:30 PM to 7:30 PM. On any occasion, the volume of parked vehicles is much higher than this and so is the PCU.

Table 5 shows the parking characteristics of Jalil Tower also known as Jalil Market. It is one of the leading markets of Khulna City Which comprising of one recognized parking area. Motorcycle and bicycle are the two types of vehicle which are parked inside. This place is mainly known as the market for computer accessories. Parking here requires fees of Tk 10. A much larger volume of motorcycles are parked here and sometimes the authority has to return the vehicles for lack of space for parking.

Table 5: Parking Characteristics with PCU in Jalil Tower Market Area

Time	Volume of Vehicles Parked			PCU
	Two-Wheeler	Three-Wheeler	Four-Wheeler	
9:00 AM -9:30 AM	67	9	1	54.5
9:30 AM -10:00 AM	89	15	3	83.5
10:00 AM -10:30 AM	104	20	4	104
10:30 AM -11:00 AM	119	18	2	101.5
11:00 AM -11:30 AM	127	17	2	103.5
11:30 AM -12:00 AM	129	12	3	97.5
5:00 PM -5:30 PM	140	22	4	126
5:30 PM -6:00 PM	146	25	4	135
6:00 PM -6:30 PM	151	16	2	113.5
6:30 PM -7:00 PM	147	19	1	114.5

7:00 PM -7:30 PM	131	14	2	99.5
7:30 PM -8:00 PM	110	13	2	87

Above Table 5 shows that the maximum volume of two-wheelers, three-wheelers, and four-wheelers are 151, 25, and 4 respectively. The lowest average PCU at this location was 54.5, which is recorded from 9:00 AM to 9:30 AM and the highest average PCU at the location was 135, which is recorded from 5:30 PM to 6:00 PM. So, it is evident that this parking space remains busier than any other location in Khulna city.

Table 6 shows the parking characteristics of the Khulna City Corporation (KCC) Building. It is one of the major divisional city corporations of Bangladesh. Motorcycle; bicycle and car are the main types of vehicles that are parked here. Being a busy place people of different professions visit here for various reasons.

Table 6: Parking Characteristics with PCU in Khulna City Corporation Area

Time	Volume of Vehicles Parked			PCU
	Two-Wheeler	Three-Wheeler	Four-Wheeler	
9:00 AM -9:30 AM	95	2	4	63.5
9:30 AM -10:00 AM	102	3	6	75
10:00 AM -10:30 AM	127	6	10	105.5
10:30 AM -11:00 AM	138	2	13	112
11:00 AM -11:30 AM	124	4	15	115
11:30 AM -12:00 AM	142	3	19	134
5:00 PM -5:30 PM	97	2	11	85.5
5:30 PM -6:00 PM	88	2	10	78
6:00 PM -6:30 PM	63	1	7	54.5
6:30 PM -7:00 PM	29	3	5	35.5
7:00 PM -7:30 PM	17	0	4	20.5
7:30 PM -8:00 PM	12	1	4	20

The above table implies that the lowest average PCU at the location is 20, which is recorded from 7:30 PM to 8:00 PM and the highest average PCU at the location is 134, which is recorded from 11:30 AM to 12:00 PM. The maximum volume of two-wheelers, three-wheelers, and four-wheelers are 142, 6, and 19 respectively.

Table 7 shows the parking characteristics of the Khulna Development Authority (KDA) Building. It is a governing body in Khulna City. Motorcycle and car are the main two types of vehicles that are parked inside.

Table 7: Parking Characteristics with PCU in Khulna Development Authority Building Area

Time	Volume of Vehicles Parked			PCU
	Two-Wheeler	Three-Wheeler	Four-Wheeler	
9:00 AM -9:30 AM	18	3	8	39
9:30 AM -10:00 AM	31	5	11	58.5
10:00 AM -10:30 AM	36	4	12	62
10:30 AM -11:00 AM	43	3	12	63.5
11:00 AM -11:30 AM	46	2	14	69
11:30 AM -12:00 AM	51	1	12	63.5
5:00 PM -5:30 PM	37	5	11	61.5
5:30 PM -6:00 PM	30	2	9	46
6:00 PM -6:30 PM	24	3	10	48

6:30 PM -7:00 PM	17	4	9	43.5
7:00 PM -7:30 PM	14	2	8	35
7:30 PM -8:00 PM	9	1	8	30.5

The highest volume of two-wheelers, three-wheelers, and four-wheelers are 51, 5, and 14 respectively. The above table implies that the lowest average PCU at the location is 30.5, which is recorded from 7:30 PM to 8:00 PM and the highest average PCU at the location is 69, which is recorded from 11:00 AM to 11:30 AM.

Table 8 shows the parking characteristics of Khulna City Medical College Hospital (KCMCH). It is one of the best private medical college hospitals in Khulna City. Motorcycles, bicycles, rickshaws, auto, cars, and especially ambulances are parked here. This place has recently become one of the busiest places in the Khulna city area. It has a parking space that charges free and a specified basement for parking. But most of the motorcycles and auto-rickshaws are parked just outside the hospital creating congestion.

Table 8: Parking Characteristics with PCU in Khulna City Medical College Hospital Area

Time	Volume of Vehicles Parked			PCU
	Two-Wheeler	Three-Wheeler	Four-Wheeler	
9:00 AM -9:30 AM	83	7	8	79.5
9:30 AM -10:00 AM	90	5	10	85
10:00 AM -10:30 AM	102	4	7	80
10:30 AM -11:00 AM	113	5	12	102.5
11:00 AM -11:30 AM	128	7	15	123
11:30 AM -12:00 AM	121	6	13	111.5
5:00 PM -5:30 PM	165	4	14	132.5
5:30 PM -6:00 PM	144	6	15	129
6:00 PM -6:30 PM	132	8	18	136
6:30 PM -7:00 PM	147	10	21	156.5
7:00 PM -7:30 PM	154	6	18	143
7:30 PM -8:00 PM	151	5	16	133.5

The maximum volume of two-wheelers, three-wheelers, and four-wheelers is 165, 10, and 21 respectively. The above table implies that the lowest average PCU at the location is 79.5, which is recorded from 9:00 AM to 9:30 AM and the highest average PCU at the location is 156.5, which is recorded from 6:30 PM to 7:00 PM.

Table 9 shows the parking characteristics of the Khulna Shopping Complex. It is the only central AC and escalator-based shopping complex in Khulna City. Lots of motorcycles and bicycles are parked inside the parking lot. This place has the largest underground parking in Khulna city.

Table 9: Parking Characteristics with PCU in Khulna Shopping Complex Area

Time	Volume of Vehicles Parked			PCU
	Two-Wheeler	Three-Wheeler	Four-Wheeler	
9:00 AM -9:30 AM	79	8	0	55.5
9:30 AM -10:00 AM	101	11	2	78.5
10:00 AM -10:30 AM	172	16	2	124
10:30 AM -11:00 AM	205	12	1	129.5
11:00 AM -11:30 AM	251	12	0	149.5
11:30 AM -12:00 AM	287	10	3	172.5
5:00 PM -5:30 PM	334	15	2	203

5:30 PM -6:00 PM	369	9	2	208.5
6:00 PM -6:30 PM	375	17	1	224.5
6:30 PM -7:00 PM	361	14	1	211.5
7:00 PM -7:30 PM	368	10	2	210
7:30 PM -8:00 PM	352	11	1	201

The highest volume of two-wheelers, three-wheelers, and four-wheelers are 375, 17, and 3 respectively. The above table implies that the lowest average PCU at the location is 55.5, which is recorded from 9:00 AM to 9:30 AM and the highest average PCU at the location is 224.5, which is recorded from 6:00 PM to 6:30 PM.

### 3.2 Characteristics of Parking Pattern in Selected Locations:

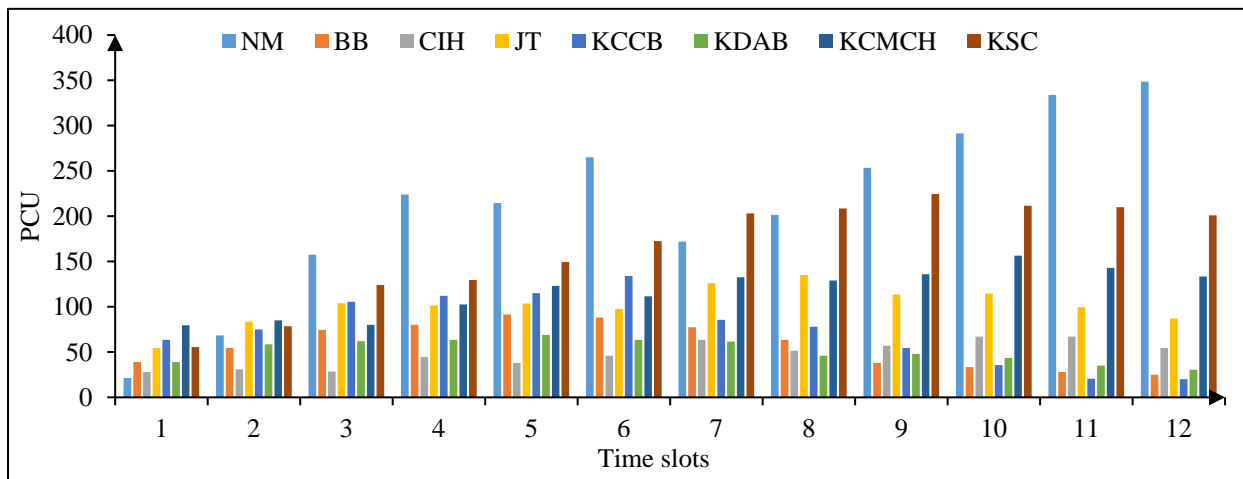


Figure 1: PCU comparison of selected strategic locations of Khulna city.

Figure 1 shows the PCU values of parked vehicles in different time slots for eight strategic locations in Khulna city. Here NM, BB, CIH, JT, KCCB, KDAB, KCMCH and KSC indicate New Market, Bangladesh Bank, City Inn Hotel, Jalil Tower, Khulna City Corporation Building, Khulna Development Authority Building, Khulna City Medical College Hospital and Khulna Shopping Complex respectively. PCU variation occurred due to change in volume of parked vehicles and it is quite evident in last six time slots. New Market area is seen the most busy parking zone among the selected locations of Khulna city followed by Khulna Shopping Complex.

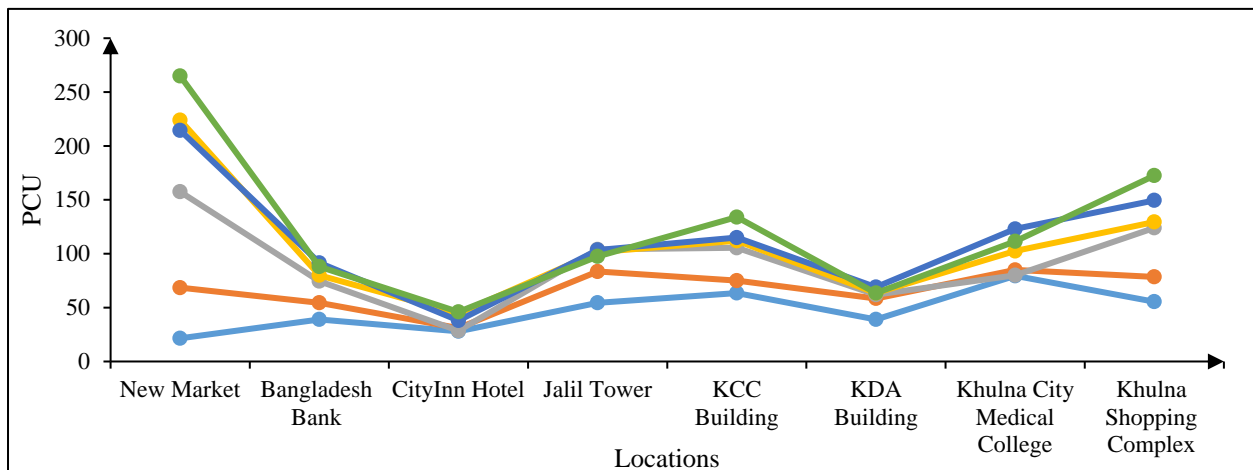


Figure 2: PCU of parked vehicles from morning to noon (9 AM to 12 PM)



Figure 2 shows the variation of parked vehicle’s PCU value from 9 AM to 12 PM. Both the highest and lowest PCU of 265 and 21.5 have been recorded for New Market. According to Figure 2, New Market, KCC building and Khulna Shopping Complex are the busiest places during the sepcific time period.

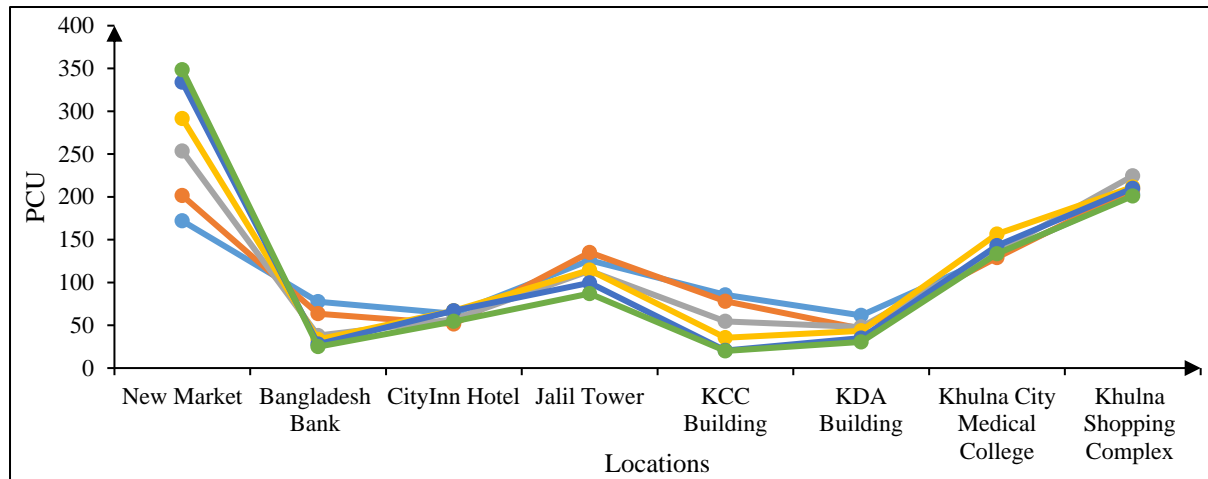


Figure 3: PCU of parked vehicles from afternoon to night (from 5 PM to 8 PM)

Figure 3 shows the variation of parked vehicle’s PCU value from 5 PM to 8 PM. The highest and lowest PCU of 348.5 and 20 have been recorded for New Market and KCC building resepectively. According to Figure 3, New Market, Khulna Shopping Complex, Khulna City Medical College Hospital and Jalil Tower are the busiest places during the sepcific time period.

The One-Sample t-test examines whether the mean of a population is statistically different from a known or hypothesized value. The One-Sample t-test is a parametric test. This test is also known as, Single Sample t-test (t-test analysis, Investopedia).

Table 10: One-Sample t-test based on PCU of locations

Locations	t Value	Critical t Value	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
					Lower	Upper
New Market	7.502	4.437	11	.000	150.2	275
Bangladesh Bank	8.198		11	.000	42.2	73.2
City Inn Hotel	11.551		11	.000	38.8	57.1
Jalil Tower	16.844		11	.000	88.3	114.9
KCC Building	6.890		11	.000	50.9	98.8
KDA Building	13.879		11	.000	43.4	59.8
Khulna City Medical College Hospital	15.797		11	.000	101.2	134
Khulna Shopping Complex	10.063		11	.000	128.1	199.8

Confidence Interval of the difference has been selected to 95% for this research. From table 10, it can be seen that the t-critical value is 4.437 where the t-stat value ranges from 6.890 to 16.844. So, the highest t-stat value is 16.844, for Jalil Tower Market and the lowest t-stat value is 6.890, for Khulna City Corporation Building. The t-stat value has to be greater than the t-critical value which is 4.437 for the parking patterns to be different. As the analyzed t-stat values for the selected eight locations are greater than t-critical value 4.437, the parking pattern for the selected eight locations is different from each other. None of the parking patterns for the eight locations are similar to each other.

#### 4. CONCLUSIONS

Studying parking volumes is a tough task, and this study focused on the parking volumes of some strategically important locations in Khulna city. It was found that parking volume varied from one location to another, as did the PCU. The volume of Two-wheelers, Three-wheelers and Four-wheelers varied on the basis of the intensity of traffic and the importance of the locations. The highest PCU value was found in Khulna Shopping Complex, which was selected as the busiest of the selected locations. The t-test showed that the patterns of parking are very different from each other on the basis of parking management. Despite having a parking facility, many vehicles are found parked on the street, which creates congestion. Aside from that, there are some other tasks to be completed, such as parking accumulation, parking index, parking load, and so on, at some other strategically important locations in Khulna. Mass awareness should be developed about effective parking management so that traffic facilities may be enhanced to achieve a hassle-free transportation system.

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