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Parking Volume Study of Strategically Important Locations in Khulna City, Bangladesh

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Abstract:- With rapid urbanization and increased vehicle demand, the study of parking volume has gained significant importance. Adequate parking facilities are crucial for residential and commercial areas, as they influence traffic, travel behavior, and the environment. In the context of Khulna City, parking demand is particularly high due to intense commercial activities. However, the provision of parking bays along curbs to meet this demand often reduces road capacity and affects the level of service (LOS).

Congestion happens when parking isn't done right by reducing effective road width and traffic flow capacity. The common practice of parking presence of both motorized and non-motorized cars on streets and at intersections make traffic worse in Khulna City. The study reveals that parking management is controlled by the local authority, with fees being imposed in some locations. However, parking on streets remains a major problem, contributing to congestion. With the help of SPSS V25 and a one-sample t-test, it was determined parking facilities and patterns in eight selected locations differ significantly.

This research highlights the critical need for effective parking management strategies to mitigate traffic congestion in Khulna City. It emphasizes the importance of understanding parking patterns and developing comprehensive solutions that consider both residential and commercial areas. The findings of this study can aid urban planners, policymakers, and local authorities in making informed decisions to improve parking infrastructure, optimize road capacity, and enhance the overall travel experience within the city.

In this research, to reduce congestion, unrestricted parking was examined in the Khulna city area. Eight strategically selected locations were surveyed to calculate parking volume and examine parking patterns across locations. The findings revealed that during the study period, Khulna Railway Market, Khulna Railway Market, and Hotel Castle Salam zone had maximum parked vehicles of 127, 86, and 21 two-wheelers, three-wheelers, and four-wheelers, respectively.

According to data analysis of Passenger Car Units (PCUs) that Khulna Railway Market had the highest value of 269, making it the busiest parking lot of the selected places. On the other hand, Sonali Bank, Corporate Branch had the lowest PCU value of 3. The study also revealed that parking management was under the control of local authorities, with certain locations requiring fees for parking during specific time periods. However, street parking emerged as a major problem in all locations, contributing to congestion.

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

I. INTRODUCTION

A. Background of Study

Parking is an essential element of residential and commercial areas, influencing travel behavior and the environment. It is important to consider parking as a separate land use that affects mode choice and economic competitiveness. Proper design and analysis of parking spaces are crucial for efficient transportation systems.

Lack of parking facilities can lead to chaotic conditions and hinder businesses. Parking management aims to create availability near businesses, reducing the perception of parking shortages. Inefficient parking management causes frustration, wasted time, and fuel consumption. Implementing effective parking strategies, such as shared parking and supporting public transit, can optimize parking availability and mitigate parking-related issues.

In the financial year 2020-21, the BRTA (Bangladesh Road Transport Authority) facilitated registration of 424,530 motor vehicles. This process was carried out through the operation of five Metro Circles and 57 District Circle Offices. The registration of motor vehicles plays a crucial role in ensuring compliance with regulations and maintaining an organized transport system in Bangladesh.

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Table 1: Class-Based Motor Vehicle Number

SL. NO	Class of Motor Vehicle	Number
1	Bus	48,789
2	Minibus	27,361
3	Track	1,41,053
4	Private Car	3,73,806
5	Motorcycle	32,99,112
6	Microbus	1,05,412
7	Pick-up	1,37,915
8	Jeep	68,354
9	Covered Van	38,752
10	Delivery Van	31,340
11	Human Hauler	17,348
12	Tractor	43,640
13	Others	4,44,062
	Total	47,76,944

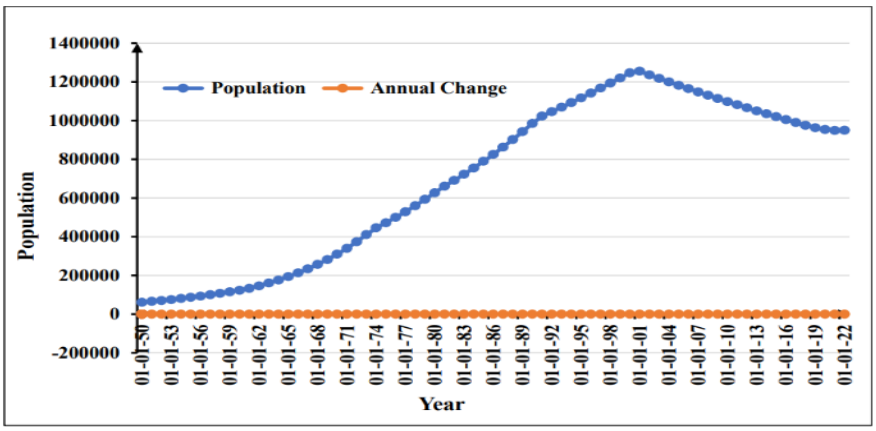
(BRTA, Annual Report, 2020-2021)

Parking shortage leads to frustrated drivers wasting time and fuel searching for spots. Poor management and signage can leave nearby lots empty while people complain about downtown parking scarcity.

B. Statement of the Problem

Khulna, the country's third-largest City, is a significant economic and industrial center. The population has rapidly increased over the years, and the city serves as a gateway to the Mongla seaport. However, parking is a significant issue in Khulna, both locally and strategically, as highlighted by the need for more parking facilities and concerns expressed in national newspapers and journals.

Proper design and analysis of parking spaces are crucial to ensure an efficient transportation system and avoid chaotic conditions. Adequate parking is essential for urban development and the prosperity of trade and commerce in Khulna, yet it remains a neglected aspect of overall transportation management in the city.



(United Nations - World Population Prospects)

Fig. 1: Khulna Metro Area Population 1950-2022

C. The Objective of the Research

The following are the specific objectives of the Research work:

- To determine vehicle volume, types, and numbers in chosen Khulna City sites.
- Calculate the Passenger Car Unit (PCU) values for vehicles in the selected locations.
- Assess whether there are similar or distinct parking patterns among the chosen locations in Khulna City.

II. METHODOLOGY

A. Selection of Study Area

Khulna City faces various challenges in providing adequate parking facilities for its residents. Factors such as overpopulation, a high number of vehicles, unfit vehicles, unskilled drivers, and poor road conditions contribute to this problem. Khulna covers an area of 59.57 square kilometers, with the entire district spanning 4,394.46 square kilometers.

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To address the parking issues in Khulna City, this research focuses on studying specific areas that were selected based on a reconnaissance survey. The selection criteria considered factors such as traffic volume, parking characteristics, and parking management. Eight strategic Khulna City locations have been selected for the study, with their precise coordinates (latitudes and longitudes) provided in Table 2. These locations are marked on a map of Khulna City for easy reference.

Table 2: Strategic Selected Study Areas

Serial No	Station Name	Latitude	Longitude
01	Hotel Castle Salam	22°48'35"N	89°33'45"E
02	Khulna Railway Station	22°49'00.1"N	89°33'58.8"E
03	Popular Diagnostic Center Ltd.	22°49'47.8"N	89°32'14.6"E
04	Khulna Medical College & Hospital	22°49'43.9"N	89°32'12.4"E
05	Gazi Medical College & Hospital	22°49'5.9"N	89°32'43.5"E
06	Sonali Bank Ltd. Khulna Corporate Branch	22°49'13.1"N	89°56'03.6"E
07	Khulna Railway Market	22°49'4.1"N	89°33'43.5"E
08	Khulna Sonkho Market	22°48'57.4"N	89°33'54.5"E

The study focuses on eight strategically chosen locations, including busy commercial areas, hospitals, and trading zones, as outlined in Google Maps View. By analyzing these areas, the research aims to shed light on the parking space problems in Khulna City.

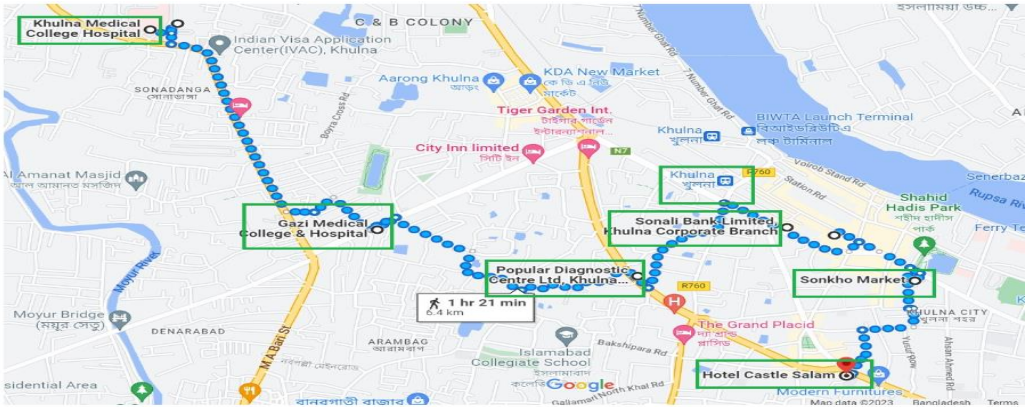
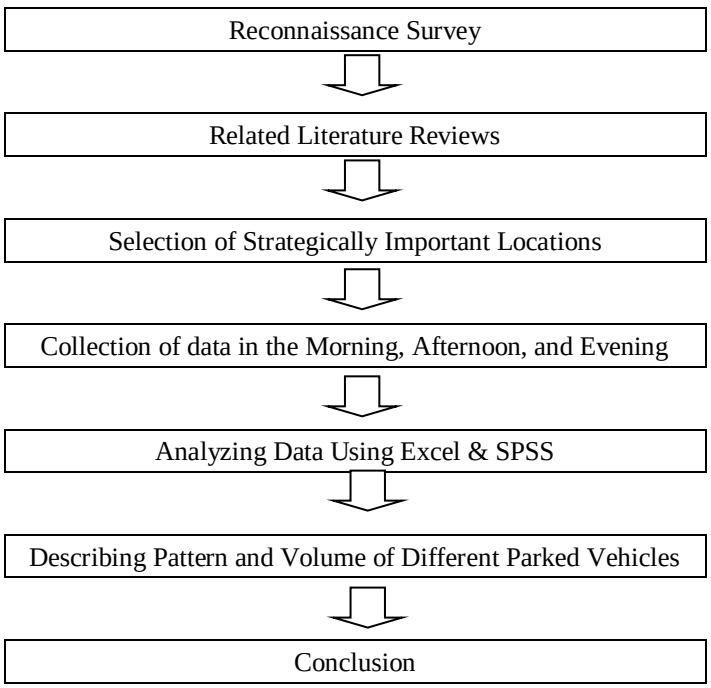


Fig. 2: Map of Selected Locations in Khulna City
(Source: Google Maps)

B. Flow Chart of Methods of the Study



C. Passenger Car Unit

The Passenger Car Unit (PCU) is a highway traffic flow metric used in transportation engineering. In the United States, the commonly used method for calculating PCU values is based on the density method, which assumes homogeneous traffic conditions with strict lane discipline and consistent vehicle widths. However, in countries like India where traffic is heterogeneous and lane discipline is less strict, alternative methods are needed to compute PCUs.

Various methods exist for determining PCUs, including the Simulation Method, Walker's Method, Headway Method, Homogenization Coefficient, Multiple Linear Regression Method, and Semi-Empirical Method. These methods take into account factors such as the volume of vehicles, vehicle types, and their corresponding PCU values.

Table 3 was used to calculate parked vehicle PCUs in this investigation. The formula used is:

Volume of Two-wheelers × PCU + Volume of Three-wheelers × PCU + Volume of Four-wheelers × PCU.

Table 3: Different Types of PCU for Different Vehicles in Bangladesh

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

(Source: MoC, 2001)

D. Readability Analysis

Reliability analysis, measured through Cronbach's Alpha α (or coefficient alpha) is a commonly used method to assess the internal consistency of Likert scale surveys. Developed by Lee Cronbach, Cronbach's Alpha determines the reliability of a scale composed of multiple Likert questions. It examines the interrelatedness of the questions that measure latent variables, such as personality traits, which are difficult to directly observe. The higher the Cronbach's Alpha value, the more reliable and consistent the scale is considered to be. While Cronbach's Alpha has limitations, such as lower reliability for scales with fewer items and potential influence from the sample size, it remains widely used to demonstrate the internal consistency of collected data.

E. Correlation Analysis

Correlation refers to the relationship between variables, and in statistics, it is used to assess the connection between two or more variables. Inter-Item Correlation Matrix is a method to analyze the internal consistency of a test or questionnaire. It examines if different items intended to measure the same construct yield similar scores. The range of correlation coefficients is -1.0 to +1.0, where values above 0.7 indicate a strong correlation, Moderate correlation is 0.5–0.7, and < 0.4 indicates a weak or no correlation. It is desirable to have inter-item correlations between 0.5 and 0.7 to capture different aspects of the construct without redundancy, as higher correlations can diminish the validity of the measure.

F. T-test Analysis

A t-test is a statistical test that is used to compare the means of two groups in order to evaluate whether or not the means of the groups are statistically different from one another. It is commonly used in hypothesis testing and examines factors such as the t-statistic, t-distribution values, and degrees of freedom to assess significance. The t-test implies independent, approximately regularly distributed, and similar variances within each group. The t-test measures genuine differences by comparing group means to pooled standard error. This can be calculated manually or using statistical analysis software.

$$t = \frac{a_1 - a_2}{\sqrt{{S_1}^2 - {S_2}^2}} \quad \text{---------- (1)}$$

$$df = \frac{({S_1}^2 - {S_2}^2)^2}{\frac{{S_1}^4}{n_1 - 1} + \frac{{S_2}^4}{n_2 - 1}} \quad \text{---------- (2)}$$

In order to determine if the parking pattern is different, we use the equations mentioned above. The t-value (denoted as 't') is calculated using parameters such as mean, intercept, and standard error (denoted as 'a' and 's' respectively). The degree of freedom ('df') is obtained based on the number of samples ('n'). By referencing the t-table and selecting a specific confidence interval, we find the t-critical value. In the event that the t-statistic is larger than the t-critical value, it indicates a different parking pattern.

Conversely, if the t-statistic is lower, the parking pattern is not considered different. This comparison is made for both the mean of PCUs and the intercept of the straight lines.

G. One Sample T-test Analysis

The parametric One Sample T-test examines if the population mean is substantially different from a known or hypothesized value. It compares the mean of a test variable against a "test value" representing the expected population mean. The test value can be based on various sources such as literature, research organizations, legal requirements, or industry standards. The term "Single Sample T-test" can be used to refer to this test as well.

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H. Descriptive Analysis

Descriptive statistics involve summarizing and quantifying features within a dataset. These statistics provide simple summaries, either in numerical or visual form, of the sample and observations collected. They can serve as the foundation for an initial data description or as standalone summaries for specific investigations. Descriptive statistics play a crucial role in data analysis, enabling to understand and communicate key characteristics of the data effectively.

III. RESULT AND DISCUSSION

The highest average PCUs obtained at Hotel Castle Salam, Railway Station, Popular Diagnostic Center, Khulna Medical College & Hospital (KMCH), Gazi Medical College & Hospital (GMCH), Sonali Bank Corporate Branch, Railway Market, Sonkho Market are 87, 117.75, 30.5, 105.75, 56.75, 34, 269, and, 80.50 consecutively.

And the lowest average PCUs obtained at the following locations are 15.25, 53.75, 9, 53.75, 25.50, 3, 93.25, and 44 respectively.

A. Parked Vehicles at Specific time Period

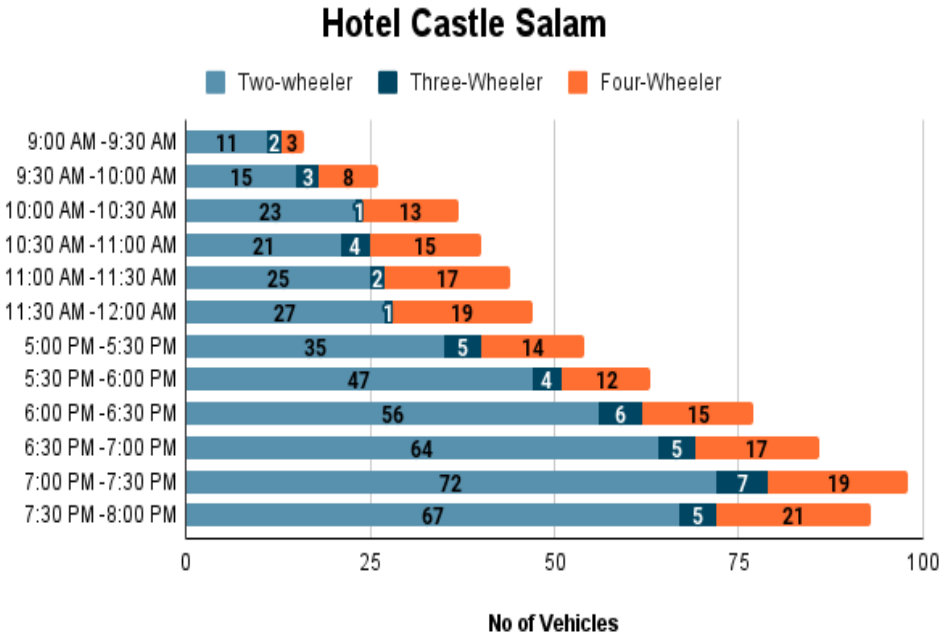

Fig. 3: Hotel Castle Salam Vehicles at Specific Times

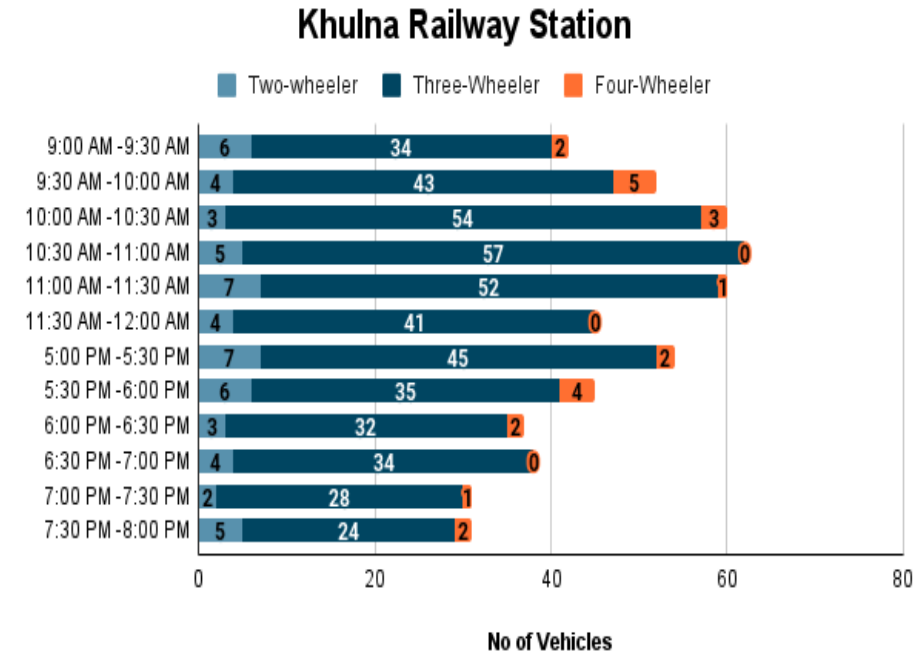

Fig. 4: Khulna Railway Station Vehicles at Specific Times

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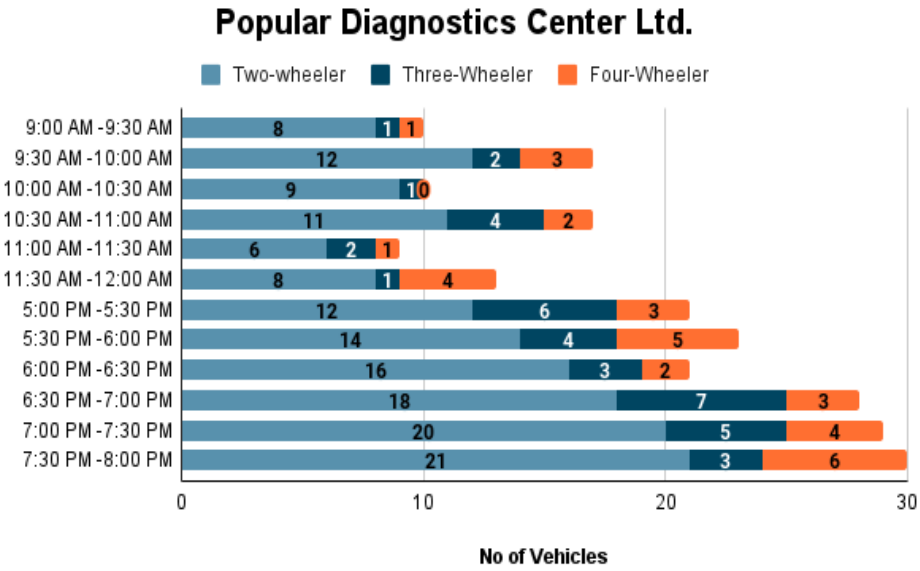

Fig. 5: Popular Diagnostic Center Ltd. Vehicles at Specific Times

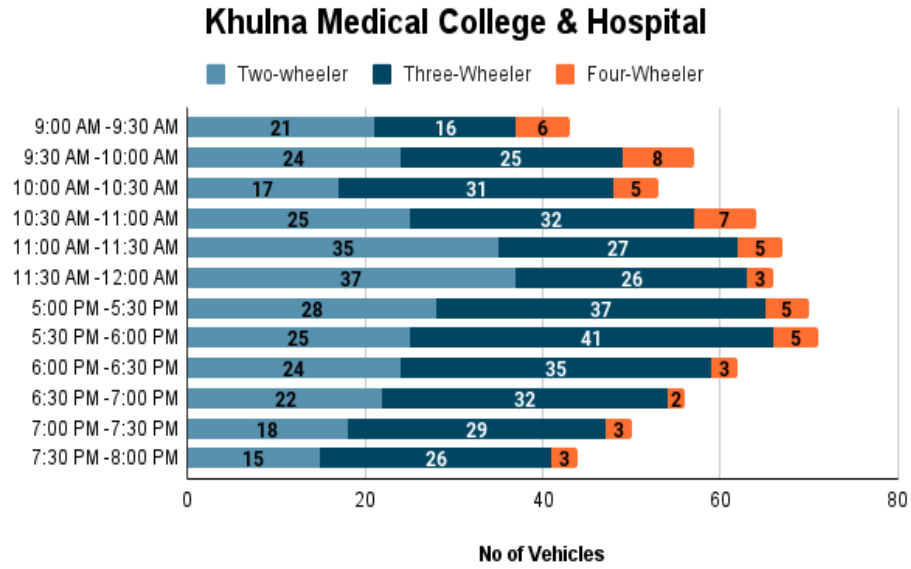

Fig. 6: Khulna Medical College & Hospital Vehicles at Specific Times

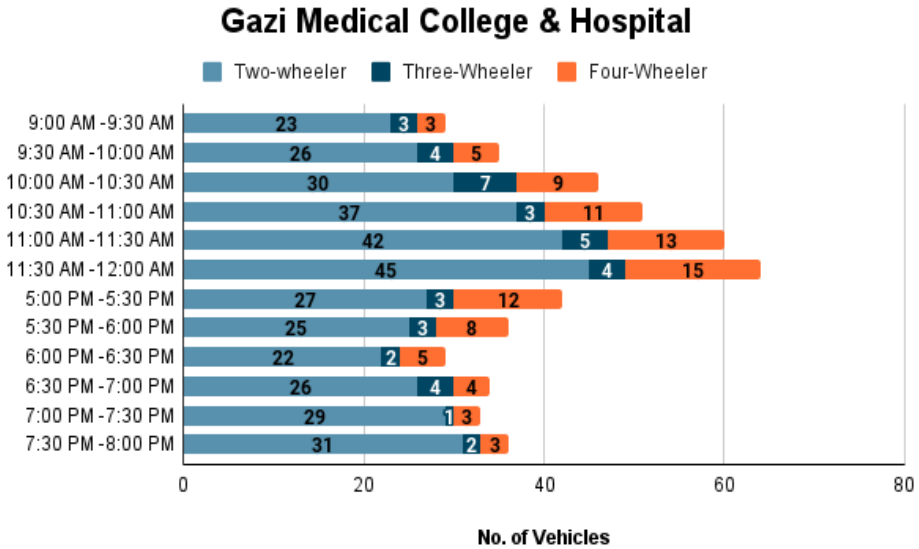

Fig. 7: Gazi Medical College & Hospital Vehicles at Specific Times

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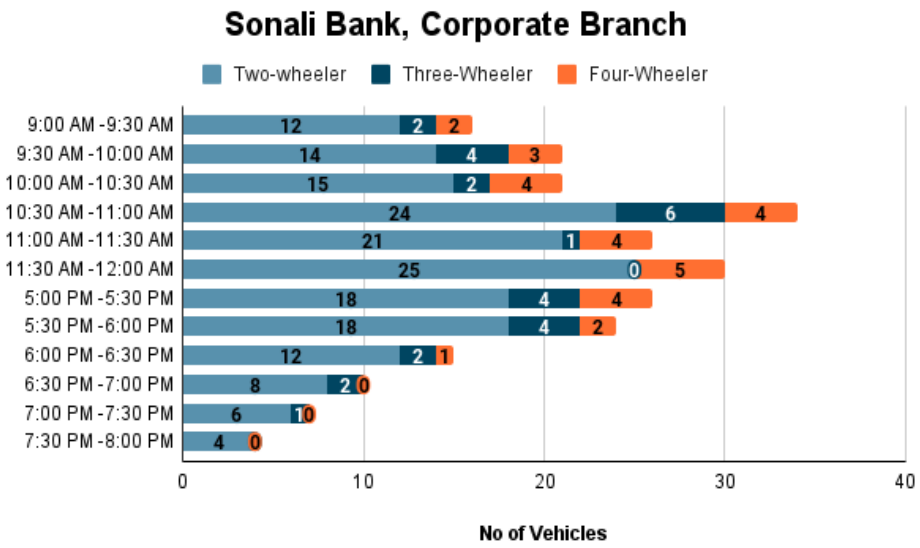

Fig. 8: Sonali Bank Ltd Khulna Corporate Vehicles at Specific Times

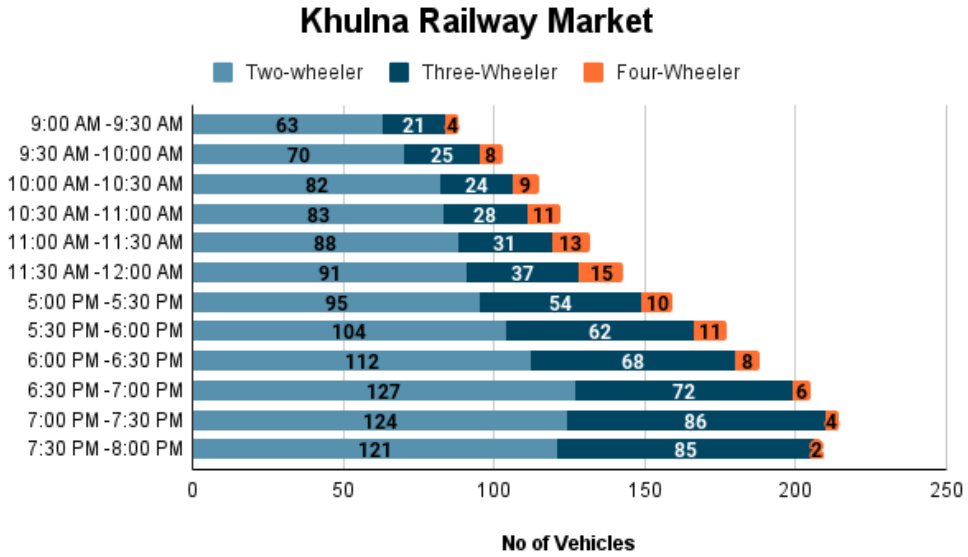

Fig. 9: Khulna Railway Market Vehicles at Specific Times

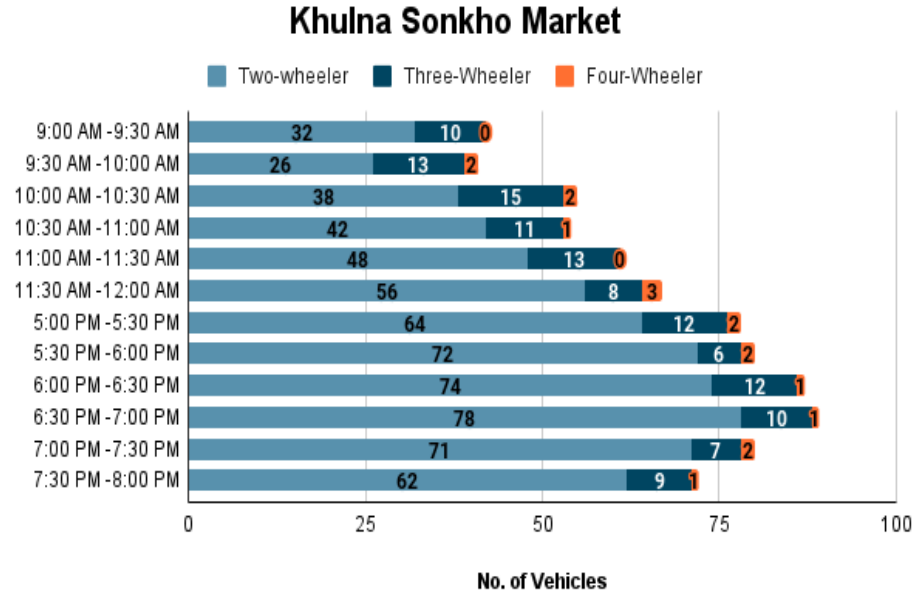

Fig. 10: Khulna Sonkho Market Vehicles at Specific Times

B. Passenger Car Unit (PCU) for all Selected Locations

Table 4: Passenger Car Unit of All the Selected Locations

HCS	KRS	PDC	KMCH	GM CH	SB	KRM	KSM
15.25	74.5	9	53.75	26.25	15	93.25	44
25.25	94	16	73	32.50	21.50	110.50	47.50
32.25	113.25	8.75	79.75	45.50	19.25	118.50	60.50
38.75	117.75	18.25	89.75	44.75	34	129.25	54.50
41.75	110.25	9.5	85.25	54.50	21.75	141	62
43.25	87	12	82.75	56.75	23.75	157.25	61.75
50.25	97.25	24	100	38.25	25.50	189.25	74
55.25	78.50	23.5	105.75	32.75	23.5	213	68
69	68.25	20	91	25.50	15	228	80.50
75	71	30.5	82.50	31.50	10	245.25	79.50
87	58.50	29	74.50	26.75	6.50	269	69.25
81.25	53.75	27.75	66.25	30.25	3	262.75	65.50

The Table 4 shows the highest average PCUs at Hotel Castle Salam, Railway Station, Popular Diagnostic Center, Khulna Medical College & Hospital, Gazi Medical College & Hospital, Sonali Bank Corporate Branch, Railway Market, Sonkho Market, 87, 117.75, 30.5, 105.75, 56.75, 34, 269, and 80.50.

15.25, 53.75, 9, 53.75, 25.50, 3, 93.25, and 44 have the lowest average PCUs.

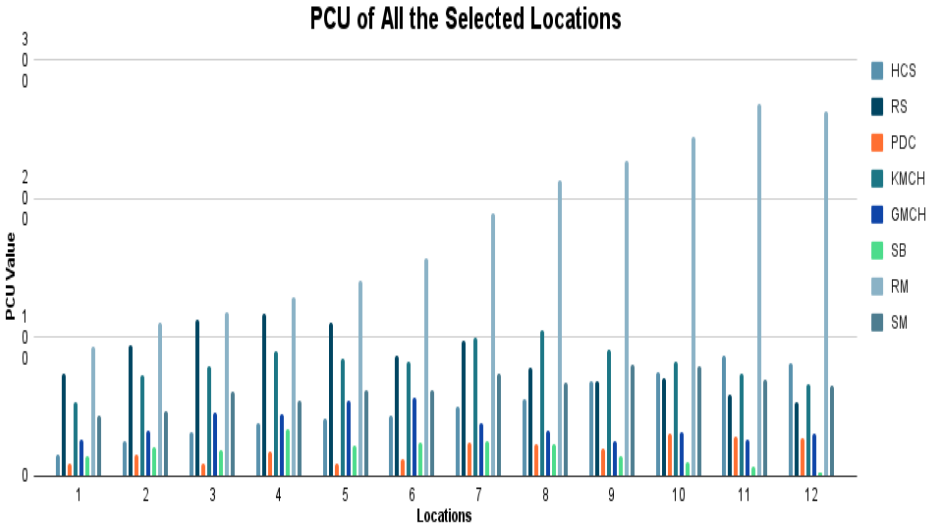

Fig. 11: Passenger Car Unit of All the Selected Locations

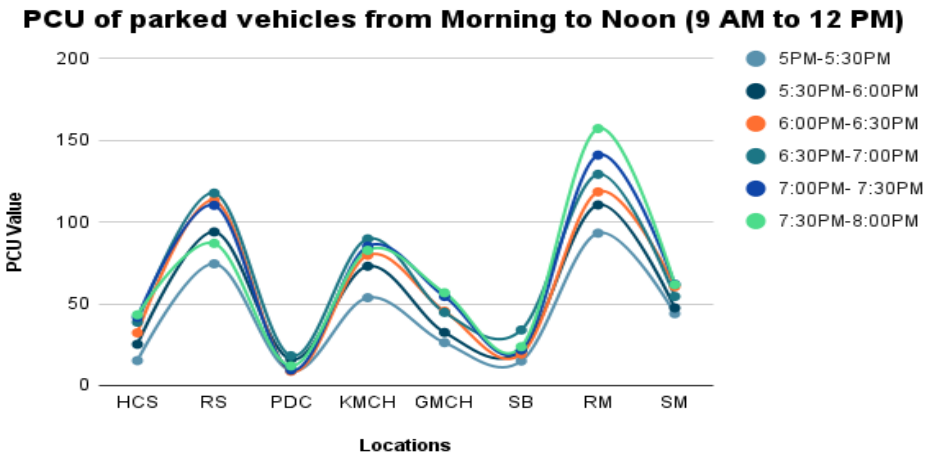

Fig. 12: PCU of parked vehicles from 9 AM to 12 PM

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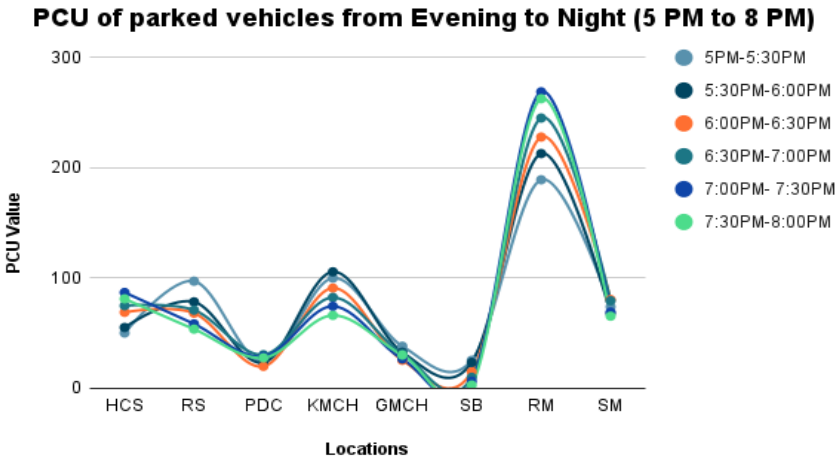

Fig. 13: PCU of parked vehicles from 5 PM to 8 PM

C. Correlation Analysis

HCS, RS, PDC, KMCH, GMCH, SB, RM, SM stand for Hotel Castle Salam, Railway Station, Popular Diagnostic Center Ltd., Khulna Medical College & Hospital, Gazi Medical College & Hospital, Sonali Bank Corporate Branch, Railway Market, Sonkho Market.

Table 5 shows that Hotel Castle Salam's vehicle volume is highly correlated with Popular Diagnostic Center Ltd., Railway Market, and Sonkho Market. It doesn't match Khulna Medical College & Hospital. The inter-item correlations matrix value for Railway Station, Gazi Medical College & Hospital, and Sonali Bank Corporate Branch is negative; hence the volume parked at Hotel Castle Salam is quite different.

Table 5: Inter-Item Correlation Matrix

	HCS	RS	PDC	KMCH	GMCH	SB	RM	SM
HCS	1.000							
RS	-.672	1.000						
PDC	.850	-.621	1.000					
KMCH	.187	.324	.230	1.000				
GMCH	-.367	.720	-.548	.268	1.000			
SB	-.628	.834	-.466	.546	.587	1.000		
RM	-.620	.834	-.466	.546	.587	-.628	1.000	
SM	.791	-.365	.648	.562	-.173	-.303	.801	1.000

D. Descriptive Analysis

Table 6 shows that N equals 12 since all eight locations collected data at 12 distinct times. Each place's PCU value affects the mean value. Railway Market has the highest Mean value at 179.75.

Table 6: One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Hotel Castle Salam	12	51.1875	22.79881	6.58145
Khulna Railway Station	12	85.3333	21.42596	6.18514
Popular Diagnostic Center Ltd.	12	19.0208	8.02798	2.31748
Khulna Medical College & Hospital	12	82.0208	14.23482	4.10924
Gazi Medical College & Hospital	12	37.1042	10.85884	3.13468
Sonali Bank Ltd. Khulna Corporate Branch	12	18.2292	8.74932	2.52571
Railway Market	12	179.75	62.70865	18.10243
Sonkho Market	12	63.9167	11.44966	3.30523

Table 7 displays the IBM SPSS (25)-calculated t-Critical value of 5.256. As said, this T-Critical value determines the parking pattern of the selected places. First, check the selected places' t-stat values. The t-stat value has to be greater than the t-critical value which is 5.256 for the parking patterns to be different.

Table 7: One-Sample t-tests based on Passenger Car Unit (PCU) of locations

	Test Value = 0						
	t value	Critical t Value	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
HCS	7.77	5.256	11		51.1875	36.7018	65.6732
RS	13.7		11	.000	85.33333	71.7199	98.9467
PDC	8.20		11	.000	19.02083	13.9201	24.1216
KMCH	19.96		11	.000	82.02083	72.9765	91.0652
GMCH	11.837		11	.000	37.10417	30.2048	44.0035
SB	7.217		11	.000	18.22917	12.6701	23.7882
RM	9.93		11	.000	179.75	139.9068	219.5932
SM	19.338		11	.000	63.91667	56.6419	71.1914

IV. CONCLUSION

The main goal of this thesis work is to count how many cars are parked and look at how they are parked in some of Khulna City's most important places. Here is more information about the project goals that have been met:

- Depending on traffic and importance, two-wheelers, three-wheelers, and four-wheelers varied. Up to 127 two-wheelers, 86 three-wheelers, and 21 four-wheelers halted at Khulna Railway Market, Hotel Castle Salam zone, and Khulna Railway Market for a time.
- The maximum PCU values for Khulna Railway Market are 269. This means that Railway Market has the most cars of all the places chosen. Khulna Railway Market has the highest PCU value at 269, and Sonali Bank, Corporate Branch has the lowest PCU value at 3.
- The local government was found to be in charge of parking, and in some places, you have to pay a lot of money to park for a certain amount of time. Based on how parking is managed, the t-test showed that people park considerably differently.

All of the above goals have been met, and all of the needs have been met throughout the project.

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