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Parking Demand and Supply Management as Strategy to Reduce Congestion and Improving Mobility: A Case Study on Chawk Bazar Area at Chattogram City

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Keywords:

Parking Demand Management; Traffic Congestion; Parking Turnover; Accumulated Parking; Parking Usage Survey; Choice of Parking; Preference of Pricing.

Abstract

Parking management plays a vital role in urban transportation systems and significantly influences mobility, accessibility, and economic activities. Chattogram, one of the largest and fastest-growing cities in Bangladesh, faces increasing parking demand and inadequate parking supply, particularly in its central business districts. This study examines parking demand and supply conditions in the Chawk Bazar area of Chattogram, and proposes parking management strategies to reduce congestion and improve mobility. Primary data were collected through field surveys, including parking inventory surveys, parking usage surveys, and questionnaire surveys. Key parking characteristics such as parking accumulation, parking duration, parking turnover, occupancy, and user preferences regarding parking location and pricing were analysed for both two-wheel and four-wheel vehicles. The findings reveal a significant mismatch between parking demand and available supply, contributing to roadside parking and traffic congestion in the study area. Based on the analysis, a parking pricing strategy is proposed, including pre-implementation activities such as stakeholder awareness, institutional preparation, and pricing system development, followed by implementation, monitoring, and evaluation phases. The study highlights the importance of effective parking management policies in optimizing parking utilization, reducing congestion, and improving overall urban mobility in Chattogram City.

1. Introduction

1.1 Background of the Study

A significant coastal metropolis and financial hub in southeast Bangladesh is Chittagong metropolis, officially known as Chattogram and also known as the Port City of Bangladesh. The city is the second-largest metropolis in the nation with a population of more than 8.6 million as of 2017. It serves as the name-brand District and Division's capital. The city is situated between the Chittagong Hill Tracts and the Bay of Bengal on the banks of the Karnaphuli River. After Dhaka,

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Chattogram is the second-largest urban area in Bangladesh (Nazarko *et al.*, 2017). The commercial center of Bangladesh, Chattogram, is likewise struggling with a number of socio-environmental issues as its population continues to grow. The metropolitan region was the second-largest city in the nation in 2011 with a population of 4,009,423. It is one of the most populous cities in Bangladesh after Dhaka (Ahmad *et al.*, 2010). Because of this, Chattogram requires more parking places that are properly situated. Thus, there is a growing public desire for freedom of movement outside. Therefore, it is important to comprehend parking choice behavior and actual parking space demand. Car parking is one of the primary challenges for transportation and traffic management around the world due to the rising rate of private car usage in metropolitan areas because of the rapidly expanding economy, negligent regulations, and subsidies. Parking is becoming a barrier to the operation of through traffic, as seen by the synchronization between parking policies and traffic management. Additionally, it is in charge of the ineffective use of resources available, even when policy decisions are made on an as-needed basis (Parmar *et al.*, 2020).

1.2 Aim and Objectives

The aim of the study is to explore the demand and supply management in urban region. To fulfill the aim, the objectives considered for this study are:

- To assess existing parking supply and the parking demand in Chawk Bazar area at Chattogram city.
- To assess the existing pricing method and its acceptance by using a willingness to pay.

2. Literature Review

Parking demand and supply management has become an important component of urban transport planning due to its influence on traffic congestion, accessibility, and mobility. Previous studies have examined parking demand estimation, parking occupancy, parking pricing, shared parking, travel behaviour, and parking management strategies from different perspectives. This section reviews the existing literature related to parking demand and supply management, and identifies the research gap addressed by the present study.

Parking Demand and Supply Management: Parking supply refers to all available parking spaces within a study area, including private, public, on-street, and off-street parking facilities. It is generally estimated by accounting for all parking spaces within a defined region such as a central business district. Parking supply reflects the response of the parking system to parking demand and plays an important role in evaluating parking performance (Mulu, 2019; Parmar *et al.*, 2020). Effective parking analysis requires information regarding parking availability, utilization level, parking duration, and demand characteristics. Such information is commonly collected through field surveys and observational methods to understand parking behaviour and system performance (Mulu, 2019; Parmar *et al.*, 2020). Various studies have highlighted parking supply management

as an effective strategy for reducing congestion and improving mobility. Parking demand and supply are interrelated components of the urban transportation system. Parking demand is influenced by land use characteristics, travel behaviour, and urban activities, whereas parking supply reflects the available capacity to accommodate vehicles (Kadhum Nemaa *et al.*, 2017; Zahabi *et al.*, 2012). Therefore, assessing existing parking demand and supply is essential for identifying parking-related problems and developing suitable management strategies.

Parking Demand and Supply Characteristics: Parking demand and supply are widely used indicators for evaluating parking performance. Parking demand forecasting is considered an important component of urban parking planning and parking facility development. Different approaches have been proposed to estimate future parking demand under varying growth scenarios and urban development conditions. In addition, optimization-based approaches have been applied to assess parking demand-supply gaps and improve parking resource utilization (Nadimi *et al.*, 2021). Studies indicate that parking occupancy and utilization patterns provide useful insights into parking performance. Shared parking strategies have been identified as an effective approach for improving utilization efficiency by redistributing parking spaces among different user groups according to temporal demand variations (Huang *et al.*, 2020; Ji *et al.*, 2022).

Parking Demand Measurement Using Accumulation: Parking demand is commonly measured through parking accumulation, occupancy, and turnover analysis. These indicators help quantify parking characteristics and evaluate the performance of parking facilities. Parking accumulation represents the number of vehicles parked at a given time and is widely used to identify peak parking demand periods. Parking surveys conducted during peak and off-peak periods provide information regarding parking duration, parking frequency, and occupancy characteristics (Zaenal *et al.*, 2019). The assessment of parking demand requires detailed information regarding parking availability, usage level, and parking duration. Such information is useful for identifying parking shortages and evaluating the effectiveness of existing parking facilities (Huang *et al.*, 2020).

Parking Turnover and Parking Studies: Parking turnover refers to the frequency with which parking spaces are used over a specified period. It provides an indication of parking efficiency and helps determine whether existing parking facilities are being utilized effectively. Parking turnover, accumulation, and occupancy are among the most commonly used indicators in parking studies (Zaenal *et al.*, 2019). Parking studies generally involve inventory surveys, operational assessments, and traffic-related investigations. These studies provide information regarding parking characteristics, traffic conditions, and transportation system performance that can support parking management decisions (Khanam & Marufuzzaman, 2019).

Illegal Parking and Traffic Impact: Illegal parking is a common problem in urban areas and contributes to traffic congestion, reduced road capacity, and safety

concerns. The shortage of available parking spaces often encourages drivers to park illegally near their destinations. As a result, traffic flow becomes disrupted and mobility conditions deteriorate. Previous studies suggest that parking management policies play an important role in influencing travel behaviour and transport system performance. Parking-related factors such as search time, accessibility, and parking availability significantly affect parking demand and user behaviour (Huang *et al.*, 2020; Parmar *et al.*, 2020).

Parking Pricing and Traffic Congestion: Parking pricing is widely recognized as an important parking demand management tool. Appropriate pricing strategies can influence parking demand, occupancy levels, and user behaviour. Parking management aims to achieve a balance between parking demand and supply while minimizing congestion and improving mobility (Ignaccolo *et al.*, 2017). Research indicates that parking fees can encourage more efficient use of parking facilities and support broader transportation management objectives. Pricing policies are therefore frequently considered in efforts to reduce traffic congestion and improve urban mobility (Ji *et al.*, 2022; Ignaccolo *et al.*, 2017).

Parking Behaviour and Characteristics: Parking behaviour significantly influences urban transportation systems. Studies have shown that parking availability can affect vehicle ownership, travel decisions, and parking choice behaviour. Delays associated with searching for parking spaces contribute to increased travel time and congestion (Nicholls, 2001). Understanding parking behaviour is therefore important for developing effective parking management strategies. Factors such as accessibility, convenience, parking availability, and user preferences influence parking decisions and overall parking system performance (Parmar *et al.*, 2020).

Car Sharing as a Parking Demand Management Strategy: Car sharing has emerged as an alternative transportation option that can reduce private vehicle ownership and parking demand. Different forms of car sharing, including round-trip, one-way, and peer-to-peer systems, have been implemented in various urban areas to improve mobility and reduce reliance on private vehicles (Ji *et al.*, 2022). Previous studies suggest that car sharing contributes to reduced vehicle usage and supports more sustainable transportation behaviour. As a result, car sharing can help reduce parking demand and improve the efficiency of urban transportation systems (Ji *et al.*, 2022; Sallis *et al.*, 2004).

Trip Purpose and Parking Demand: Trip purpose is an important factor in travel behaviour analysis and parking demand estimation. Understanding the purpose of trips helps explain travel patterns and parking requirements associated with different activities. Various analytical approaches have been used to predict trip purposes and travel behaviour using survey and location-based data (Nguyen *et al.*, 2020). Research indicates that trip characteristics influence parking demand and can support the development of more accurate parking demand estimation models (Zaenal *et al.*, 2019; Nguyen *et al.*, 2020).

Cruising Time and Parking Saturation: Parking cruising occurs when drivers spend time searching for available parking spaces. High parking occupancy levels increase cruising time and contribute to additional traffic congestion and travel delays. Studies have shown that parking search behaviour is influenced by parking occupancy, walking distance, and parking demand supply imbalance (Zhu *et al.*, 2020). Therefore, reducing parking saturation and improving parking availability are important considerations in urban parking management.

Shared Parking Concept: Shared parking refers to the utilization of parking spaces by multiple user groups at different times of the day. This approach improves parking efficiency by maximizing the use of existing parking resources and reducing the need for additional parking facilities (Ji *et al.*, 2022). Research on shared parking has highlighted the importance of parking allocation mechanisms, pricing strategies, and walking time considerations in improving overall parking system performance (Huang *et al.*, 2020; Ji *et al.*, 2022).

Parking Pricing Strategy: Parking pricing directly affects parking demand, occupancy levels, and user decisions. Low parking fees may increase parking demand, while excessively high fees may discourage parking facility use. Therefore, determining an appropriate pricing structure is important for balancing parking demand and supply (Ji *et al.*, 2022). Studies indicate that parking pricing strategies should consider factors such as parking duration, user characteristics, and occupancy conditions to improve parking management effectiveness (Ignaccolo *et al.*, 2017; Ji *et al.*, 2022).

Synthesis of Existing Literature: The reviewed literature indicates that parking demand and supply have been extensively studied in terms of estimation, pricing, optimization, and behavioural modelling (Parmar *et al.*, 2020; Nadimi *et al.*, 2021). However, most studies adopt either a modelling-oriented or a policy-oriented approach without integrating field-level empirical assessment with behavioural and spatial characteristics. Moreover, there is limited research focusing on commercial activity-based parking systems in secondary cities of developing countries. In the context of Chattogram City, particularly the Chawk Bazar commercial area, empirical evidence regarding actual parking demand-supply mismatch, utilization patterns, and associated mobility problems remains insufficiently explored.

Research Gap: Existing literatures largely emphasized theoretical modelling, optimization techniques, and generalized parking management frameworks. However, there is a lack of context-specific empirical studies that assess real-world parking demand-supply imbalance in rapidly growing commercial urban environments. Therefore, this study addresses this gap by providing a field-based empirical assessment of parking demand and supply conditions in the Chawk Bazar commercial area of Chattogram City. Unlike previous studies that primarily focus on forecasting or simulation models, this research integrates observed parking behaviour, occupancy characteristics, and spatial activity patterns to identify practical parking management challenges.

Conceptual Framework: This study is grounded in the urban land use–transport interaction theory, which posits that land use patterns influence travel behaviour and generate transport demand, including parking demand. In this framework, land use characteristics and trip purposes generate parking demand, which interacts with existing parking supply to produce observable system outcomes such as occupancy, accumulation, and turnover. When parking demand exceeds available supply, it leads to negative externalities including illegal parking, cruising behaviour, congestion, and reduced mobility efficiency. To mitigate these impacts, parking demand management strategies such as pricing mechanisms, shared parking systems, and regulatory interventions are introduced to optimize system performance. This theoretical framework establishes a structured relationship between land use, travel behaviour, parking demand, parking supply, and management interventions, forming the analytical basis of this study.

3. Study Area

Parking and parking-related issues have become more prevalent in many developing-nation cities, particularly in the central business districts and other specific commercial zones (Zahabi *et al.*, 2012). According to Zannat *et al*., (2013), private automobiles constitute 60% of the vehicles parked in Motijheel, one of the busiest commercial areas of Dhaka, Bangladesh. As indicated earlier in the chapter, a systematic approach must be taken into account when balancing other measures with the demand and supply for parking. It also demonstrates how providing appropriate parking spaces is increasingly difficult in developed countries' big cities. The situation in the central business district of Chattogram, the nation's commercial centre, is hardly an anomaly. Therefore, the commercial district of Chawk Bazaar was chosen as the subject region for this research project. Actually, the Chawk Bazaar region was chosen for this research project's study location. In reality, the Chawk Bazaar is in Ward No. 25 of Chattogram City Corporation.

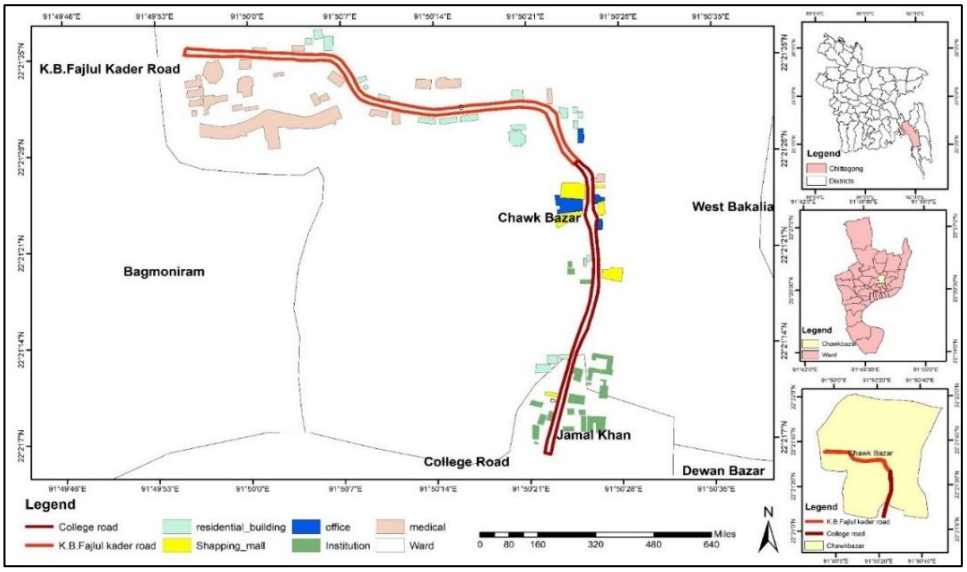

Figure 1: Location map of chawk bazar area in Chattogram City

4. Methodology

The overall methodological framework is presented in Figure 2, illustrating the sequential steps from literature review to the formulation of recommendations based on existing conditions to reduce congestion and improve mobility.

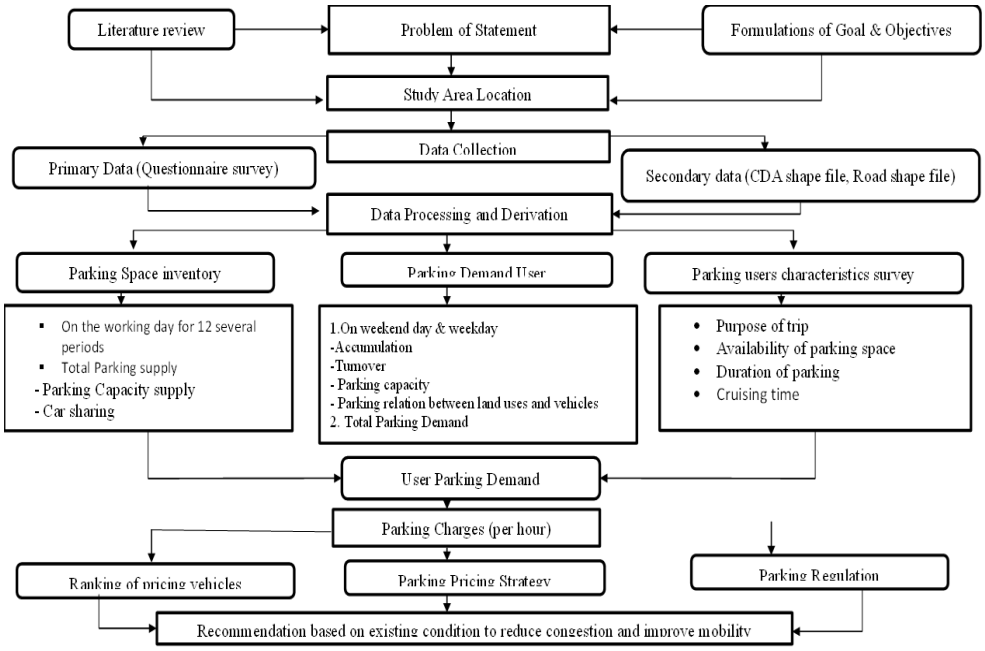

Figure 2: Flowchart of the methodology

Data Collection: Data collection was conducted to estimate the parking demand and supply in the core commercial area of Chawk Bazar, Chattogram City. Both on-street and off-street parking data were collected using different survey methods. For estimating off-street parking demand, a parking usage survey using the petrol (patrol) method was conducted. For on-street parking demand, a questionnaire-based parking usage survey was used. Parking supply data for both on-street and off-street parking was collected through parking inventory surveys and observation of designated parking areas. For the parking usage petrol survey, two separate parking inventory sheets were prepared for off-street and on-street parking for both weekday and weekend conditions.

Survey Design and Coverage: The parking survey was conducted over two days (one weekday and one weekend day). A total of seven commercial centers and two road links were selected for estimating parking demand and supply. The selected commercial centers represent major parking activity locations within the Chawk Bazar commercial area. A total of 100 observations/respondents were collected for each survey method to capture parking demand and supply characteristics across the selected commercial centers and road links.

Survey Team and Procedure: A total of seven surveyors were engaged for conducting the off-street parking demand survey using the petrol method. For on-street parking demand estimation, four surveyors were assigned, where each side of the road was monitored by one surveyor.

Survey Timing: Both off-street and on-street surveys were conducted during three peak periods of the day, including: Morning, Noon, Afternoon. These peak periods were selected based on school timing, office hours, shopping center opening and closing patterns, and break times.

Data Recording Method: The petrol survey was conducted using the vehicle registration number recording method. This method was used to estimate parking duration for each vehicle, which is important for analysing parking demand characteristics and preparing a parking demand management plan. After data collection, all information related to parking supply and demand was compiled for analysis.

Questionnaire Design: A structured questionnaire was designed to collect primary data on parking demand, travel behavior, and parking supply management strategies in the study area. The questionnaire consisted of three main sections: user parking demand information, willingness to pay (stated preference using Random Utility framework), and parking satisfaction assessment. The first section captured trip characteristics such as origin–destination, trip purpose, vehicle type, parking duration, and parking facility type. The second section applied a stated preference approach based on Random Utility Theory to analyze users' willingness to pay and parking-related decision behavior. The third section assessed user satisfaction regarding parking conditions, accessibility, and service quality using a 5-point Likert scale.

Data Analysis: After data processing, the collected survey data were analysed to estimate both parking supply and demand in the Chawk Bazar commercial area. Parking demand was analysed using parking concepts such as parking accumulation, parking turnover, parking duration, and parking capacity. Parking accumulation represents the total number of vehicles parked at a specific time interval and is presented using an accumulation curve or profile. Parking supply was calculated by estimating the total capacity of both on-street and off-street legal parking spaces in the study area. Separate analyses were conducted for two types of vehicles: two-wheelers (motorbikes) and four-wheelers (cars and CNGs). Parking demand and supply were compared across weekday and weekend conditions for different time periods using graphical representations. Differences in parking demand patterns were identified from these comparisons. The study employed descriptive statistical techniques, including frequency distribution, percentage distribution, mean values, and variability assessment, to examine parking demand and supply characteristics. The analysis focused on identifying parking shortages, parking utilization patterns, and user preferences within the study area. If parking demand exceeds available supply, it indicates the need for appropriate parking demand management strategies.

Parking Demand Management Plan Preparation: Parking demand management strategies were developed based on the identified conditions. These strategies include:

- Supply, management, and pricing of on-site employee, resident, and student parking
- Dissemination of information about alternatives to single-occupant vehicle commuting
- Identification of a site or campus TDM coordinator
- Financial incentives for carpooling, car-sharing, transit, bicycling, and walking
- Strategies to reduce total trips such as telework or compressed work week scheduling or on-site housing
- Availability of end-of-trip facilities such as bicycle lockers, showers, and secured bicycle parking

Transportation Demand Management (TDM) aims to reduce reliance on single-occupancy vehicles and improve mobility efficiency while reducing environmental and transportation system impacts.

5. Parking Demand Analysis

5.1 Off-Street Parking Accumulative Curve on Weekend

Figure 3 shows off-street parking accumulation for the weekend, indicating clear temporal variation in parking demand for both vehicle types. Two peak periods are observed at 12:30-12:45 and 1:15-1:30, with maximum accumulation of 91 four-wheelers and 78 two-wheelers. Lower accumulation is recorded during 9:15-9:30 and 4:00-4:15, indicating off-peak underutilization of parking spaces. Overall, the

results indicate a time-dependent imbalance between parking demand and supply in the study area.

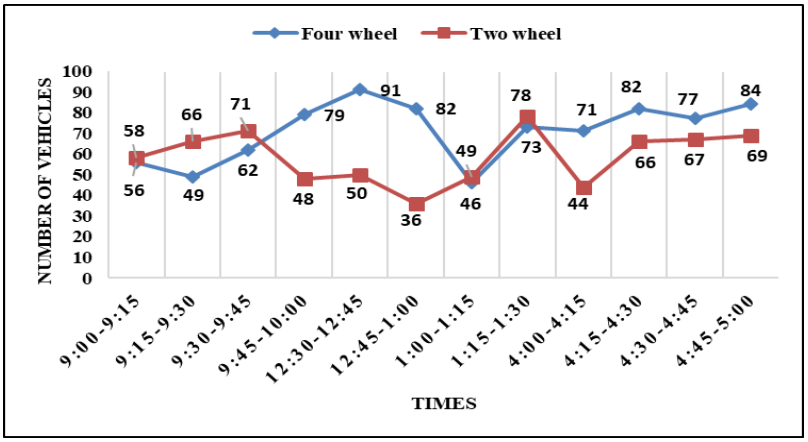

Figure 3: Off-street parking accumulative curve on weekend day

5.2 On-Street Parking Accumulative Curve on Weekend

From Figure 4, the on-street parking accumulation during weekend shows clear temporal variation for both vehicle types. The highest peak for four-wheel vehicles occurs at 4:30-4:45 with 169 vehicles, while two-wheel vehicles peak at 9:00-9:15 with 90 vehicles. This indicates concentrated parking demand during specific time intervals. Lower accumulation is observed at 12:45-1:00 for four-wheel vehicles and at 9:15-9:30 and 4:45-5:00 for two-wheel vehicles, indicating off-peak underutilization of parking spaces. Overall, the results show a time-dependent imbalance in parking demand, leading to uneven utilization of on-street parking supply.

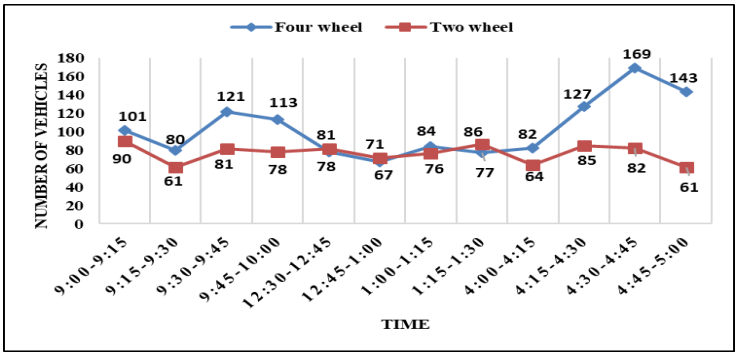

Figure 4: On-street parking accumulative curve on weekend day

5.3 Off-Street Parking Accumulation Curve on Weekday

From Figure 5, off-street parking accumulation on a weekday shows clear temporal variation for both vehicle types. The highest accumulation for four-wheel

vehicles occurs at 12:45-1:00, while two-wheel vehicles show dual peaks at 9:00-9:15 and 9:30-9:45, with maximum values of 85 and 76 vehicles respectively. Lower accumulation is observed at 1:00-1:15 for four-wheel vehicles and 4:15-4:30 for two-wheel vehicles, indicating off-peak conditions with reduced parking demand. Overall, the results indicate time-dependent variation in weekday parking demand and uneven utilization of parking space.

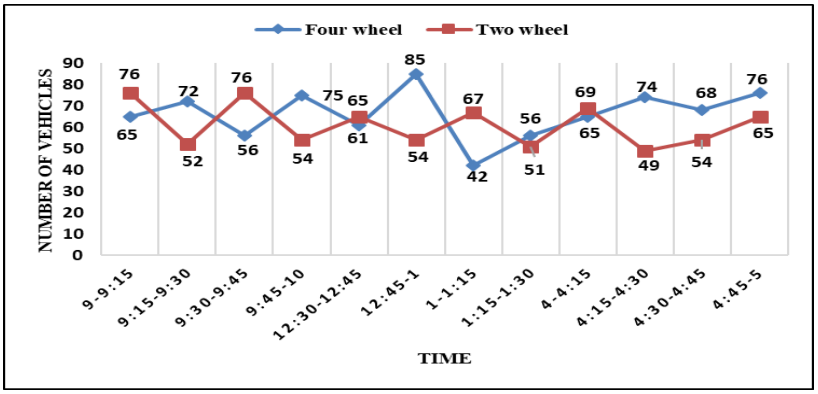

Figure 5: Off-street parking accumulative curve on weekday

5.4 On-Street Parking Accumulation Curve on Weekday

From Figure 6, on-street parking accumulation on a weekday shows noticeable temporal variation for both vehicle types. The highest accumulation for four-wheel vehicles occurs at 09:45-10:00, while two-wheel vehicles peak at 4:00-4:15, with maximum values of 97 and 78 vehicles respectively. The lowest accumulation is observed at 4:00-4:15 for both vehicle types, with 34 four-wheel and 26 two-wheel vehicles, indicating reduced parking demand during this period. Overall, the results indicate uneven temporal distribution of on-street parking demand throughout the weekday.

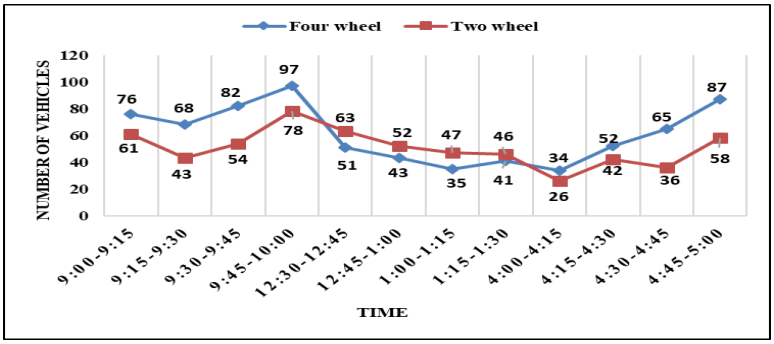

Figure 6: On-street parking accumulative curve on weekday

6. Calculation of Parking Supply

6.1 On-Street Parking Capacity for both Four and Two-Wheel Vehicles

Table 1 presents on-street parking capacity for four-wheel and two-wheel vehicles under weekday and weekend conditions. For four-wheel vehicles, capacity is 21.47 vehicles/hour on weekdays and 23.99 vehicles/hour on weekends, while observed peak demand is 18.77 and 16.63 vehicles/hour respectively. For two-wheel vehicles, capacity is 31.28 vehicles/hour on weekdays and 32.63 vehicles/hour on weekends, compared to peak demands of 24.13 and 28.15 vehicles/hour respectively. Overall, the results indicate that parking supply is generally sufficient, although utilization levels vary across vehicle types and time periods.

Table 1: On-street parking capacity for both four and two-wheel vehicles

Day	Vehicle type	Number of area (S)	Average of parking duration (D)	Parking capacity (vehicle/hour) (S/D)
Sunday	Four wheels	28	1.304	21.472
	Two wheels	37	1.183	31.276
Friday	Four wheels	28	1.167	23.993
	Two wheels	37	1.134	32.628
Average	Four wheels			22.733
	Two wheels			31.952

6.2 Off-Street Parking Capacity for both Four and Two-Wheel Vehicles

Table 2 presents off-street parking capacity and demand for four-wheel and two-wheel vehicles under weekday and weekend conditions. For four-wheel vehicles, parking capacity is 14.22 vehicles/hour on weekdays and 14.07 vehicles/hour on weekends, while peak demand is 12.33 and 13.62 vehicles/hour respectively. For two-wheel vehicles, capacity is 26.64 vehicles/hour on weekdays and 28.99 vehicles/hour on weekends, compared to peak demand of 22.55 and 23.89 vehicles/hour respectively. Overall, off-street parking supply is sufficient to accommodate observed demand, although weekends show relatively higher utilization for both vehicle types.

Table 2: Off-street parking capacity for both four and two-wheel vehicles

Day	Vehicle type	Number of area (S)	Average of parking area (D)	Parking capacity (vehicle/hour) (S/D)
Sunday	Four wheels	21	1.477	14.2180
	Two wheels	32	1.201	26.6445
Friday	Four wheels	21	1.493	14.0656
	Two wheels	32	1.104	28.9855
Average	Four wheels			14.1418
	Two wheels			27.8150

6.3 Comparison of Parking Demand and Supply

Figures 7 and 8 compare parking demand and supply for weekday and weekend conditions for both vehicle types. The results show that parking demand is generally higher during weekdays compared to weekends for both two-wheel and four-wheel vehicles, while supply remains constant across the study period. This higher weekday demand is associated with increased activity from offices, institutions, and commercial functions in the study area, whereas weekend demand is relatively lower due to reduced institutional and office-related trips. However, weekend demand remains concentrated in shopping and medical activities, leading to localized peak usage. Across both time periods, four-wheel vehicles consistently show higher demand than two-wheel vehicles, indicating a preference for private car usage for family and group travel in the commercial core area. Overall, the findings indicate a clear demand-supply imbalance during peak weekday periods, highlighting the need for targeted parking management strategies.

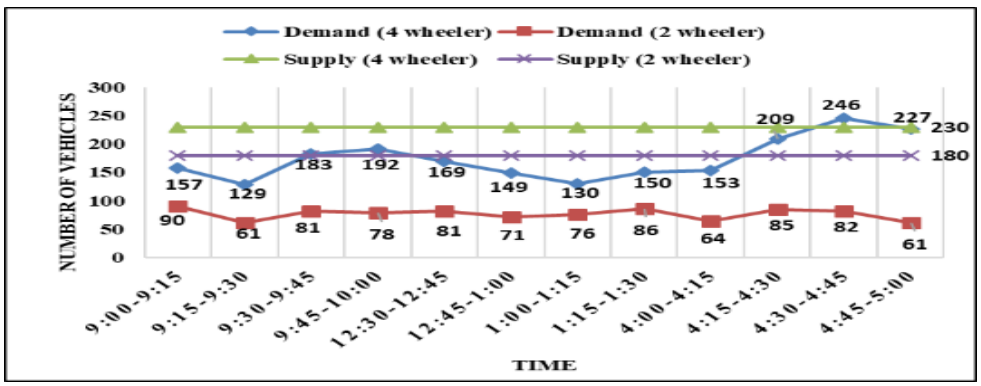

Figure 7: Comparison of Parking demand & supply on weekday

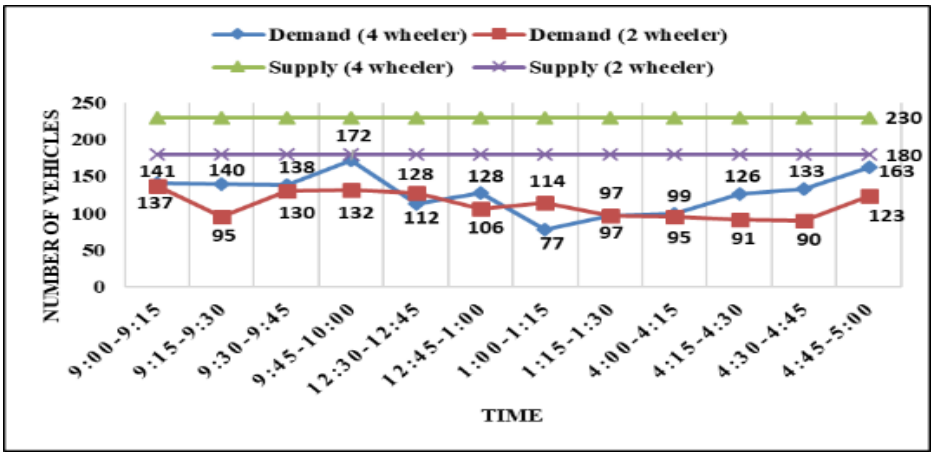

Figure 8: Comparison of Parking demand & supply on weekend day

7. Calculating of Parking Turnover Rate

7.1 Parking Turnover Rate of Two-Wheel and Four-Wheel Vehicle of On-Street Parking

Table 3: The level of parking turnover for four-wheel of on street parking

Day	Number of vehicles (Nt)	Number of area (S)	Survey Period (TS)	Level of turnover, TR= Nt/(S.TS)
Sunday	221	28	12	0.658
Friday	112	28	12	0.333
Average				0.496

Table 4: The level of parking turnover for two-wheel of on street parking

Day	Number of vehicles (Nt)	Number of area (S)	Survey Period (TS)	Level of turnover, TR= Nt/(S.TS)
Sunday	543	37	12	1.223
Friday	212	37	12	0.477
Average				0.850

7.2 Parking Turnover Rate of Two-Wheel and Four-Wheel Vehicle off-Street Parking

Table 5: The level of parking turnover for four-wheel of off-street parking

Day	Number of vehicles (Nt)	Number of area (S)	Survey Period (TS)	Level of turnover, TR= Nt/(S.TS)
Sunday	179	21	12	0.710
Friday	114	21	12	0.452
Average				0.581

Table 6: The level of parking turnover for two-wheel of off-street parking

Day	Number of vehicles (Nt)	Number of area (S)	Survey Period (TS)	Level of turnover, TR= Nt/(S.TS)
Sunday	431	32	12	1.122
Friday	178	32	12	0.464
Average				0.793

8. Parking Duration

8.1 Parking Duration Based on Different Land Use Types

Figure 9 shows clear variation in parking duration across different land use types. Office buildings are dominated by long-duration parking, with 60% of vehicles parked for more than 8 hours, while 26% remain parked for 4-8 hours. In mixed commercial buildings, parking duration is more evenly distributed, with 45% of vehicles parked for 2-4 hours and 20% exceeding 8 hours. At shopping malls, short-duration parking is dominant, where 76% of vehicles are parked for 2-4 hours, while only a small proportion remain for longer durations. Similarly, hospitals show predominantly short-duration parking, with about 60% of vehicles parked for 1-2 hours, indicating high turnover. Overall, parking duration patterns vary significantly by land use, reflecting differences in activity type and user behavior.

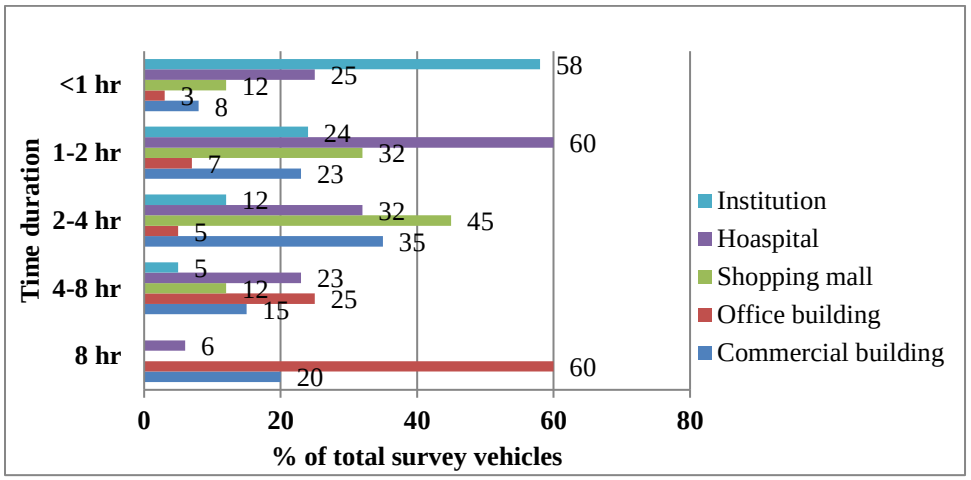

Figure 9: Parking duration based on different land use types

8.2 Average Parking Duration

Figure 10 presents the average parking duration for both on-street and off-street parking across weekday and weekend conditions for four selected roads. The results indicate variation in parking duration across different locations and vehicle types. Among the observed roads, K. B. Fajlul Kader Road shows the highest average parking duration for four-wheel vehicles at 1.496 hours compared to other study locations. Overall, the findings suggest spatial variation in parking duration, reflecting differences in land use intensity and activity patterns along different road segments.

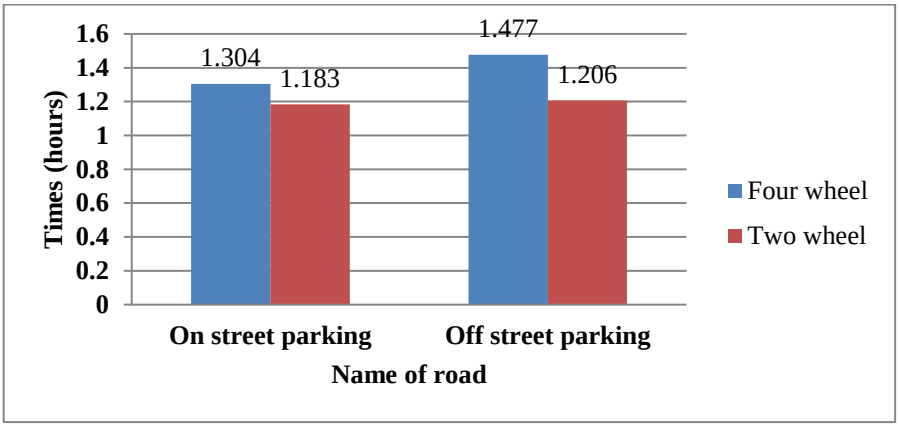

Figure 10: Measurement of average parking duration on Weekend and Weekday

9. Cruising Time & Relation between Trip Purpose and Vehicle Types

9.1 Impact of Cruising for Parking on Travel Time on both Weekend and Weekday

Figure 11 illustrates the variation in cruising time for parking under weekday and weekend conditions. The results show that cruising time is generally higher on weekdays compared to weekends. Most vehicles experience cruising times of 3-5 minutes under normal conditions, while peak congestion conditions lead to waiting times of up to 10 minutes. On weekdays, 36% of vehicles experience cruising times of 5-7 minutes, while 24% exceed 7 minutes, indicating higher search time for parking. Overall, the findings suggest that increased weekday traffic intensity contributes to longer cruising time, reflecting parking search delays and localized congestion in the study area.

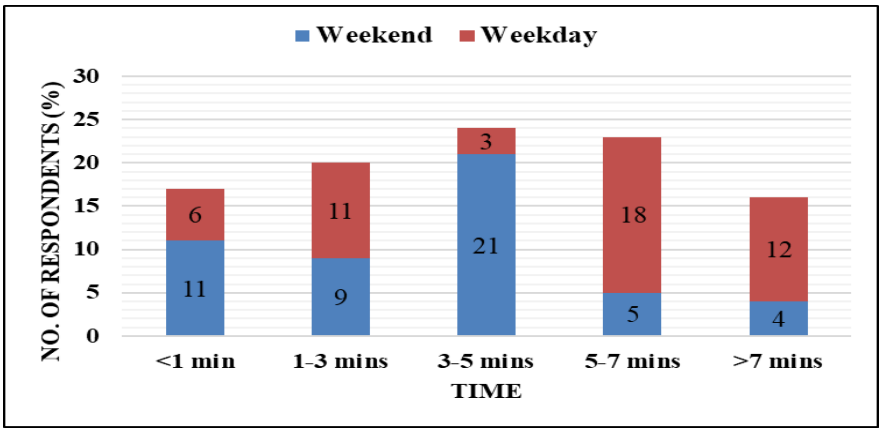

Figure 11: Cruising for Parking on Travel Time on both weekend and weekday

9.2 Relation between Trip Purpose and Vehicle Types

Figure 12 illustrates the relationship between trip purpose and vehicle types in the study area. The results show that shopping trips are primarily associated with rickshaws and CNGs, indicating their dominance in short-distance urban travel. CNG vehicles are more frequently observed in parking areas due to their relatively higher mobility and longer allowable waiting time compared to rickshaws. Temporal variation is also observed, where CNG usage is higher during morning periods, while rickshaws are more dominant in the evening. For service-related trips, buses, CNGs, and tempos are commonly used, reflecting their suitability for cost-effective and medium-to-long distance travel. Overall, trip purpose significantly influences vehicle choice patterns in the study area.

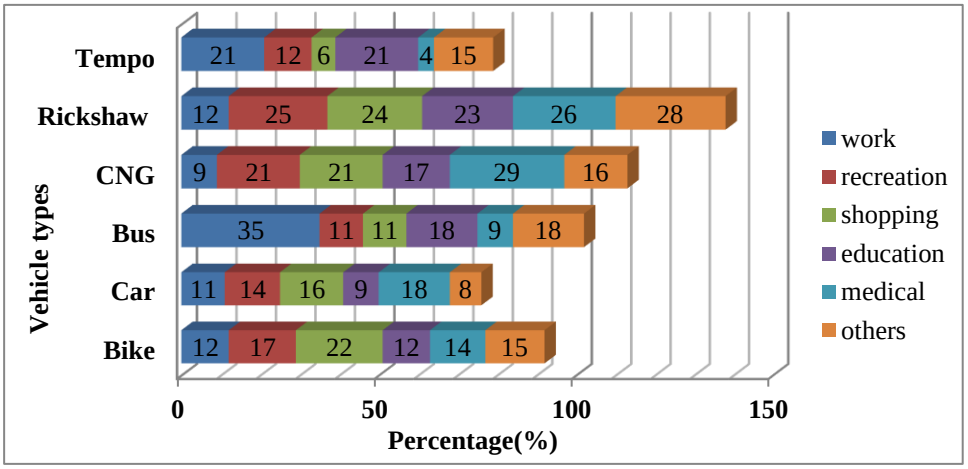

Figure 12: Relation between Trip Purpose and Vehicle types

10. Existing Parking Pricing on Different Vehicles

10.1 Existing Parking Pricing for Four-Wheel Vehicles

Figure 13 presents the existing parking pricing structure and user preferences for four-wheel vehicles in the Chawk Bazar commercial area. The results show that the highest preference is for a parking charge of 40 BDT for the first hour followed by 10 BDT per hour in both shopping centers and restaurant areas. This option accounts for 37.53% and 66.31% of user preferences respectively. The second most preferred pricing option is 30 BDT for the first hour followed by 15 BDT per hour. Lower preference levels are observed for other pricing structures, with 32% and 8.9% in restaurant and shopping center areas respectively. Overall, the results indicate that users generally prefer pricing structures that support longer parking duration at relatively moderate incremental costs.

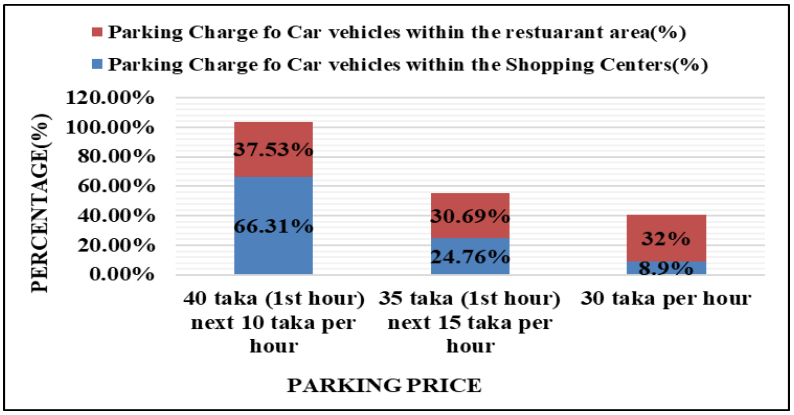

Figure 13: Existing Parking Pricing for Four-wheel vehicles

10.2 Existing Parking Pricing for Two-Wheel Vehicles

Figure 14 presents the existing parking pricing structure and user preferences for two-wheel vehicles in restaurant and shopping center areas. The results show that the most preferred pricing option accounts for 47.61% and 49.47% of users in restaurant and shopping center areas respectively. The second most preferred option is 25 BDT for the first hour followed by 10 BDT per hour, while lower preference levels are observed at 23.14% and 20.61% respectively. Overall, the findings indicate that users generally prefer affordable pricing structures that support longer parking duration, reflecting a demand for cost-effective parking solutions in high-activity commercial zones.

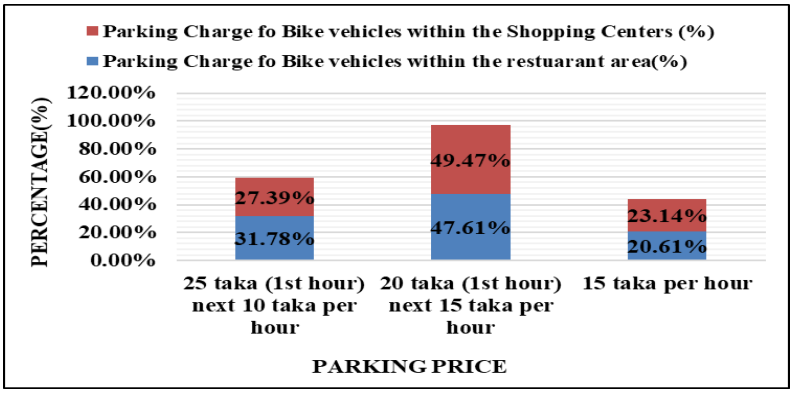

Figure 14: Existing Parking Pricing for Two-wheel Vehicles

11. Findings and Recommendations

11.1 Most Prioritized Parking Duration Limit

From field survey it is clear that the short time (15-20 minutes) and very short times (3-10 minutes) parked vehicles mostly dominating in this area. Actually, the short times (15-30 minutes) duration vehicles refer the short time duration shopping, restaurants, bank and college activities. On the other hand, very short time periods vehicles refer the shortest time duration shopping, business, coaching centres activities.

11.2 Implementation of Parking Regulation Strategy

Table 7: Implementation of Parking Regulation Strategy

General steps for parking regulation	Best selected option for implementing Chawk Bazar Area
Step-1: Rank types of vehicles parked based on use priorities.	A. Vehicle used by people (Private) B. Vehicle used by people (Public) C. Delivers and service vehicles

	D. Freight trucks and trailers
Step-2: Fixation of time limit for parking	Short time (15-30 minutes) and very short time (3-10 minutes) duration parked vehicles.
Step-3: Highest priority facility to be enforced among parking regulations.	Improve of existing facilities; improve enforcement and control, improving parking sign, more accurate and effective management.

11.3 Parking Pricing Strategy

From the figure 15 it is clear that the activities are divided into three parts such as: pre-implementation, implementation and post implementation phases. For parking pricing strategy, the pre implementation phases are: increase awareness among the owners, increase the awareness among the owners and authorities about the importance of parking pricing strategy, improve the arrangements of pricing collection system for implementing parking pricing strategy etc. Then the implementation phase of parking regulation strategy will be conducted. The post implementation phase actually consists with the monitory's evaluation parts and peak period occupancy increasing, addressing the problem parts.

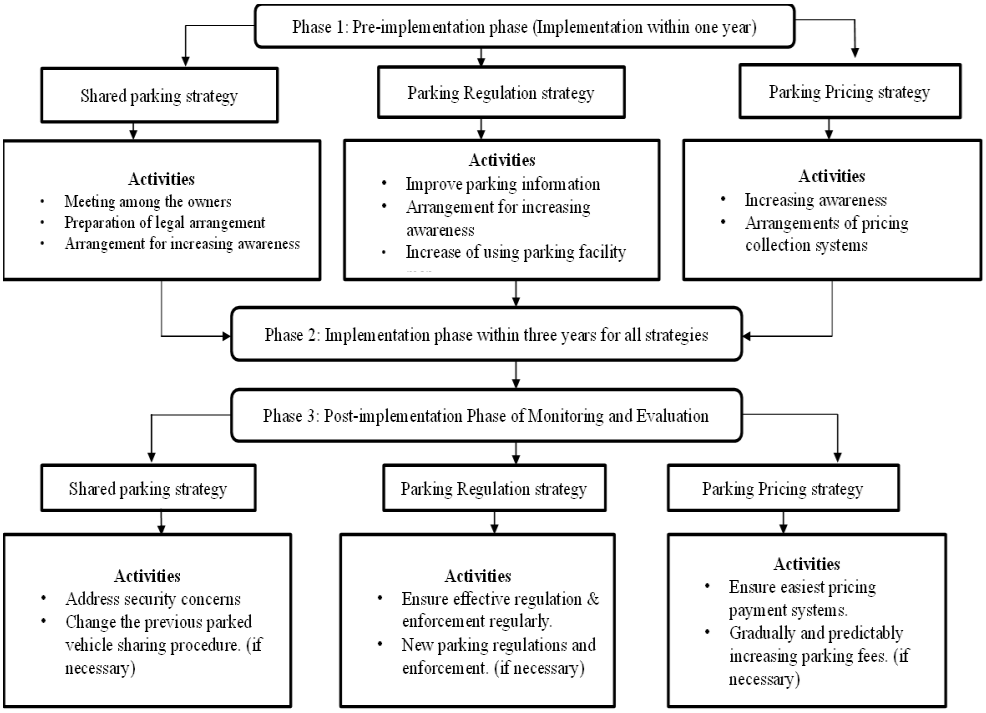

Figure 15: Contingency Based Parking Demand Management Plan

12. Discussion

The findings of this study provide important insights into parking demand-supply dynamics in the Chawk Bazar commercial area of Chattogram City. The results indicate significant temporal and spatial variations in parking accumulation, turnover, duration, and pricing preferences, which are consistent with previous studies on urban parking systems in developing cities (Parmar *et al.*, 2020; Nadimi *et al.*, 2021). The observed peak parking accumulation during specific time intervals reflects concentrated urban activities such as commercial transactions, institutional functions, and service-related trips. Similar patterns have been reported in other urban studies where parking demand is strongly linked with land use intensity and time-specific activity clustering (Zahabi *et al.*, 2012; Kadhum Nemaa *et al.*, 2017). The results also reveal a clear mismatch between parking demand and supply during peak periods, particularly for on-street parking. This finding aligns with previous research indicating that inadequate parking supply in commercial zones contributes to cruising behaviour, illegal parking, and increased traffic congestion (Zhu *et al.*, 2020; Huang *et al.*, 2020). In contrast, off-street parking facilities show relatively better capacity utilization, suggesting that structured parking provision can partially mitigate demand pressure. However, variability in utilization indicates inefficient distribution of parking demand across available facilities. The analysis of parking duration highlights distinct behavioural patterns across land use types. Long-duration parking is dominant in office areas, while short-duration parking is more common in shopping malls and hospitals. These results are consistent with the findings of Nicholls (2001) and Sallis *et al.* (2004), who emphasized the role of trip purpose and land use in shaping parking behaviour. Furthermore, the cruising time analysis confirms that higher weekday congestion leads to increased parking search time, which directly contributes to travel delay and localized traffic inefficiency. This supports existing literature that identifies parking search behaviour as a significant factor influencing urban congestion (Zhu *et al.*, 2020). The study also shows that users prefer flexible and relatively affordable parking pricing structures, particularly those that support longer parking duration at moderate incremental costs. This indicates that pricing strategies can play a key role in managing demand, as also suggested by Ignaccolo *et al.* (2017) and Ji *et al.* (2022). Overall, the findings demonstrate that parking problems in the study area are not only a function of supply shortage but also of temporal demand concentration, behavioural patterns, and land use characteristics. Therefore, integrated parking management strategies combining pricing regulation, shared parking, and enforcement mechanisms are necessary to improve system efficiency and reduce congestion in the Chawk Bazar commercial area.

13. Conclusion

This study examined the existing parking conditions in the Chawk Bazar area of Chattogram City, one of the city's major commercial and activity centers. The findings indicate that parking plays a critical role in ensuring safe, efficient, and comfortable movement within the area. As Chawk Bazar accommodates important

educational institutions, healthcare facilities, commercial establishments, and significant passenger and freight movements, the provision of adequate parking facilities is essential for the effective functioning of the area. The study revealed that increasing vehicle ownership, inadequate parking supply, and haphazard parking practices have contributed significantly to traffic congestion in the study area, particularly during peak periods. The existing parking facilities are insufficient to meet current demand, resulting in operational inefficiencies and reduced mobility. Therefore, appropriate parking demand management strategies should be implemented through a comprehensive parking management plan that includes short-, medium-, and long-term interventions. As Chawk Bazar serves as a major commercial hub and a key activity center of Chattogram City, improving parking management is essential for enhancing traffic operations and urban mobility. The adoption of effective parking policies, including parking regulation, pricing mechanisms, and enforcement measures, can contribute to reducing congestion and improving accessibility. Without timely intervention, increasing travel demand and vehicle growth may further intensify traffic and parking-related challenges in the area. Therefore, coordinated and sustainable parking management initiatives are necessary to support the efficient development of Chattogram City and ensure the long-term functionality of the Chawk Bazar area.

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Conflict of interest

The authors confirm that all ethical standards have been followed. The manuscript is original and free from plagiarism. No data fabrication, falsification, duplicate publication, redundant publication, or other forms of research misconduct were involved in this study.

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