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Parking Infrastructure Evaluation and Management Strategies in Kurukshetra City

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ABSTRACT

Kurukshetra is a city with significant cultural and historical significance that is experiencing rapid urbanization and an increase in private vehicle use, creating significant parking issues. Congestion, poor accessibility, and inefficient use of urban space, particularly in core areas, have been brought on by an increasing population, mixed land use, narrow streets, and insufficient parking facilities. This study examines the demand for parking based on peak hours, spatial distribution, and user behavior, as well as existing on- and off-street parking facilities. Markets, government offices, and tourist destinations with a high parking shortage are identified as major problem areas. To effectively manage demand, the study suggests solutions like multi-level parking structures, smart parking systems, paid parking policies, and strict enforcement. Additionally, it places an emphasis on expanding last-mile connectivity and promoting alternative modes of transportation to lessen the reliance on private automobiles. In general, the study offers a planned and long-lasting framework for enhancing parking management and supporting future urban expansion.

***Key Words*: Parking Management, Urban Mobility, Parking Demand Assessment, Smart Parking Systems, Traffic Congestion, Sustainable Transportation, Land Use Planning, Kurukshetra.**

1. INTRODUCTION

Parking is an essential component of transportation that ensures people can move around cities efficiently and make the best use of urban land. In Kurukshetra, which has approximately 1,55,000 residents, the demand for parking has increased with the growth in private vehicles. This highlights the importance of well-planned parking management strategies to address both current and future challenges. Proper parking management makes it easier for businesses, tourists, and residents to travel and helps make the best use of limited road space. It also supports economic and social activities by making travel more convenient.

Effective parking policies, such as time restrictions and pricing, can reduce dependence on private vehicles. Managing parking supply and demand encourages the use of alternative modes of transportation. Understanding the relationship between parking demand and land use helps in better planning of parking facilities. Integrating parking planning with land use planning can improve accessibility and traffic flow. Solutions such as shared parking, multi-level parking, and smart parking systems can further improve efficiency. Overall, effective parking management can support organized and sustainable urban development.

1.1 LITERATURE

- **History of parking - First parking meter**
- In the 1930s, Oklahoma City experienced congestion as a result of unregulated street parking. The first parking meter, Black Maria, was developed by Carl Magee's team to control parking time.
- **Parking Garages: -** Garages were created in response to the growing number of automobiles on the road in order to conserve space and keep vehicles dry. They are frequently repurposed from stables or storage buildings.
- **Automated parking system (APS): -** Lifts were used to move cars in the first semi-automated garage, which opened in Paris in 2005. APS was developed to make the most of available space and lessen problems with parking on the road.

Parking Definitions: -

- **Parking accumulation: -** Number of vehicles parked at a particular time.
- **Parking volume: -** Total number of vehicles parked over time.
- **Parking load: -** Total vehicle-hours of parking use.
- **Parking types and the sector controlling it: -**
- **There are two main types of parking: -**

On-street parking: - The practice of parking automobiles on public streets or roads is referred to as "on-street parking." It is convenient and simple to get to, but if it isn't managed properly, it can reduce road capacity, cause traffic jams, and obstruct traffic flow.

- **Off-street: -**A car park not on the public road, in which any member of the public can park their car, subject to complying with any regulations maximum stay or paying a fee. This kind of car park may be owned and/or operated by the public and/or private sector.
- **Parallel parking: -** The cars are parked all the way down the road. When parking or unparking the vehicle here, there is no need to move the vehicle backward. As a result, it is the most accident-free parking option. However, due to the fact that it takes up the maximum length of the curb, only a specified number of vehicles can be parked there at any given time. Because a smaller amount of road width is used, this method of parking causes the least amount of road obstruction to the ongoing track.
- **30-degree Parking:**
- The vehicles are parked 30 degrees from the round alignment in thirty-degree parking. In this case, more vehicles can be parked compared to parallel parking. Additionally, there is improved manoeuvrability. In this kind of parking, there is also a minimum amount of delay for the track.
- **Concept of parking in case of management**
- **Free or Paid parking: -** The open space surrounding and adjacent to the road, as well as the basement floors and ground floors of the buildings, that the authority may have designated for free car parking.
- **Authorized and Unauthorized parking: -** Contract parking entails parking in a predetermined space during predetermined hours for a predetermined fee.
- **Puzzle parking: -**Puzzle system is aimed for optimum use of space on ground. It is electromechanically designed to travel horizontally as much space as is available on the ground and vertically up to seven.
- **Stack parking: -** Stackers aim to double the parking space above ground/ basement type parking.

- **Fully or Semi-automated parking: -** The state-of-the-art in technology. In each level, they have horizontal carts and a vertical lift that takes the car from the drive level to various floors. When compared to the multi-story parking garage, the APS saves space primarily through a significant reduction in space not directly related to car parking.
- **Parking Strategies: -**
- **Park and Walk: -** Park close (Bus stand, Railway station) by, then walk to your destination.
- **Park and Ride: -** Take the bus or train instead of parking at the edge.
- **Pickup and Dropoff: -** zones with short stops to let passengers move quickly.
- **1.2 Norms and standards**

Parking regulations in India must be adhered to in an appropriate manner in order to manage traffic in congested areas effectively and efficiently. According to Indian conditions, the guidelines for urban areas are provided.

Table -1: Standard Parking Dimensions

Car	3 m x 6 m	When individual parking space is required
	2.5 m x 5 m	When community parking space is required
Truck	3.75 m x 7.5 m	To park a Truck

Source: Tentative recommendations on the provisions of parking spaces for urban special, I.R.C., New Delhi, 1973

Table -2: Types of Land use

Planning Norms for Underground Parking	
Extent of area	Minimum 1000sq.m. subject to provision of ramps, service lanes, pedestrians' circulation, lifts and staircases as per building byelaws
No. of basements/ floors	Min. 2 within the envelope area
Uses permitted	Parking, services and electrical substation, other uses subject to the approval
Other controls	(a) The basements shall be kept with the ground and shall be ventilated with mechanized means of ventilation (b) Basements shall be designed to take full load of the fire tender, wherever required and subject to adequate safety measures.

Source: Tentative recommendations on the provisions of parking spaces for urban special, I.R.C., New Delhi, 19

Table -3: Entry/Exit standards of parking's

Entry point (vehicles/hour/lane)	Exit point (vehicles/hour/lane)
Free flow - 600	Free flow - 600
Semi-Automatic/ Card Reader- 400	Ticket or token acceptance unit and boom gate - 300
Automatic ticket issue and boom gate - 300	Cashier controlled - 200 to 250
Manually controlled - 250	

Table-4: Land use based Standards

S.no	Land use		Parking space standard
1	Ofiices		one space for every 70 sq.m. of floor area
2	Industrial premises		one space for upto 200sq.m. of initial floor area. Aditional spaces at the rate of one for every subsequent 200sq.m. of fraction thereof
3	Shops and market		one space for every 80sq.m. of floor area
4	Restaurants		one space for every 10 seats
5	Theatres and cinemas		one space for every 20 seats
6	Hotel and Motels	Five- and four-star hotels	one space for every 4 guest rooms
		Three-star hotels	one space for every 8 guest rooms
		two-star hotels	one space for every 10 guest rooms
		Motels	one space for each guest rooms
7	Hospitals		one space for every 10 beds

Source: Tentative recommendations on the provisions of parking spaces for urban special, I.R.C., New Delhi, 1973

Table -5: Standards for car parking bays

Type of parking	Dimensions of parking bay in meters		
	Width	Length	Area (Sq.m.)
Parallel	2.50	5.90	14.75
30*	4.66	5.00	23.30
45*	5.31	3.54	18.30
60*	5.58	2.89	16.13
90*	5.30	2.50	12.50

Source: (Norms Specified from - Planning, Design and Engineering of Sustainable Urban Transport by AK Jain, 2015)

Table -6: Space standard for parking facilities

(a) Bus Bay parking	
Idle parking	145 sq.m.
Angular parking	76 sq.m.
Parallel	104 sq.m.
(b) Parking of other modes	
Car	25 sq.m.
Two-Wheeler	4 sq.m.
Taxi	16 sq.m.
Auto Rickshaw	5 sq.m.
Cycle	1.2 sq.m.

Source: (Norms Specified from - Planning, Design and Engineering of Sustainable Urban Transport by AK Jain, 2015)

Conclusion

To control demand, alleviate congestion, and ensure effective land use, parking regulations are absolutely necessary. Effective standards take into account land use, the growth of automobiles, and accessibility to public transportation. Efficiency is increased, and sustainable urban development is aided by efficient systems, pricing, and proper enforcement.

1.3 Derived Parameters

- **Demographic & Urban Growth: -** Population growth and rapid urbanization increase the number of vehicles in a city. More people visit because of changing patterns of land use, especially the rise of mixed-use and commercial areas. In crowded urban areas, this results in a higher demand for parking spots.
- **Parking Demand & Supply: -** Parking demand depends on vehicle ownership, duration of stay, and turnover rate. Parking space availability and utilization are evaluated through field surveys. A rate of occupancy greater than 85 percent indicates a lack of and inefficient supply of parking.
- **Road Geometry:** - Parking space availability is determined by road width and classification. Narrow roads and lower hierarchy streets are more sensitive to on-street parking. The effective parking space on the road is further reduced by encroachments and informal activities.
- **Travel Demand & Trip Generation: -** Trip characteristics like purpose, duration, and frequency affect parking demand. In commercial and institutional areas, peak-hour traffic causes the greatest parking demand. Planning the timing and location of parking facilities is made easier with an understanding of travel patterns.
- **Parking & Mobility Management: - Smart systems and shared parking make searching quicker and more efficient.**
- **Parking Pricing: -** Demand is controlled, revenue is guaranteed, and user behaviour is influenced by fixed or dynamic pricing.

2. Objectives

The main objectives of the study are: -

- **To assess the Existing and future parking demand and supply in Kurukshetra: -** This objective focuses on assessing the current parking situation by evaluating the number of occupied parking spaces, peak-hour demand, and available parking spaces. To estimate future parking requirements, it also involves studying factors like population growth, trends in vehicle ownership, and land use patterns. By comparing demand and supply, deficiencies in the parking infrastructure can be identified. This helps in understanding critical areas facing shortages and planning for future needs effectively.
- **To propose suitable parking strategies for Kurukshetra: -** This objective aims to find effective solutions to the parking issues facing the city. It includes recommending strategies like pricing mechanisms, management of on- and off-street parking, and the introduction of smart parking systems. Additionally, park-and-ride, shared parking, and increased enforcement are considered. With these strategies, congestion can be reduced, space can be better utilized, and urban mobility can be made more sustainable.

3. Study Area

Kurukshetra, a historic city in Haryana, is located at approximately 29°57′57″N and 76°50′13″E with an elevation of about 260 meters above sea level. It lies about 160 km north of Delhi on the Delhi–Ambala railway line and shares boundaries with Ambala, Yamuna Nagar, Karnal, and Kaithal districts. Known as the land of the Mahabharata and mentioned in the Bhagavad Gita, the city is an important religious and historical destination attracting visitors from across the world. The city has strong regional connectivity through rail and road networks, especially via National Highway 44, which connects it to Delhi and Chandigarh. Kurukshetra covers about 95 sq km and has a largely linear road network. However, rapid growth in vehicles has led to congestion, illegal parking, and environmental concerns. Nearly half of the roads are less than 15 meters wide, making on-street

parking difficult. The lack of proper parking pricing and planning increases congestion and reduces road efficiency. The city has a subtropical climate with hot summers, cool winters, and about 580 mm of annual rainfall. According to the 2011 Census, Kurukshetra had a population growth rate of 15.3%, a literacy rate of 76.7%, and a sex ratio of 889 females per 1,000 males.

Study Area Location Map

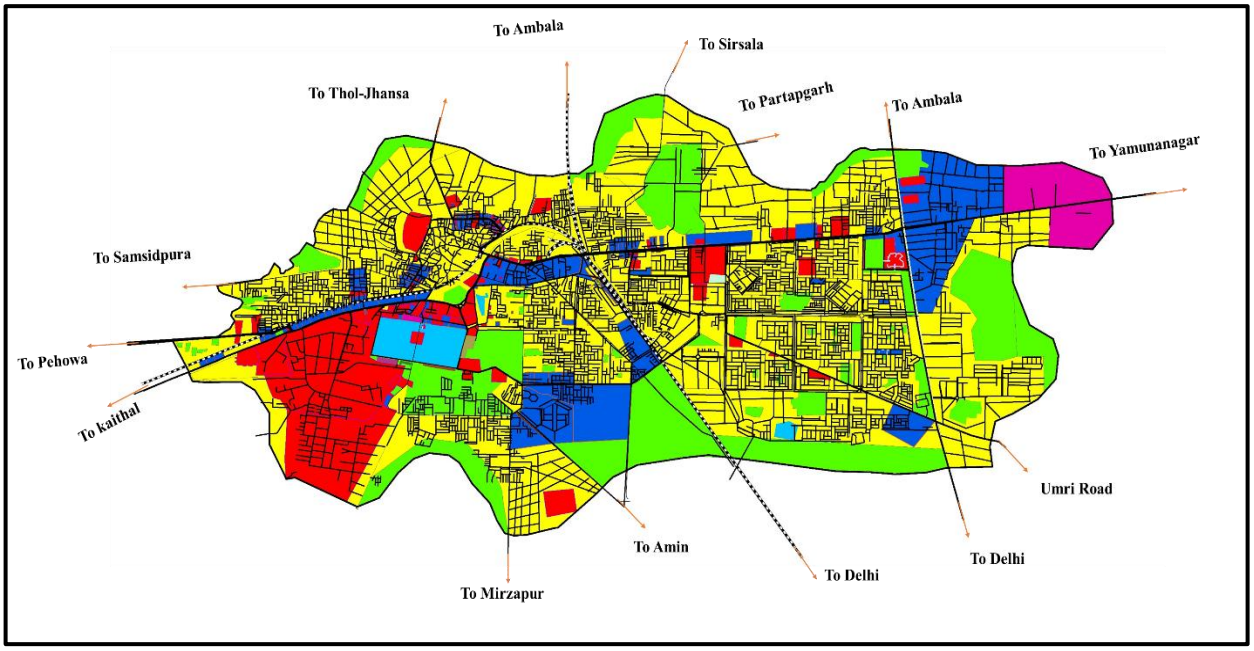


Fig-1: Study Area Location Map

4. DATA AND SOFTWARE USED: -

4.1 Data

Table -7: Parameters for parking study

Parameter	Sub-Parameters	Indicators	Data Source
1. Demographic & Urban Growth	Growth rate	% Annual growth	Secondary survey
	Urban land use	% Change in land-use zones	
2. Parking Demand & Supply	Land use type	No. of parking bays public semi-public and commercial land-use	Primary survey
	Vehicle ownership	Registered Vehicles	
	Parking duration	Avg. parking time (min)	
	Occupancy rate	% Occupancy	
	Peak demand	Peak hour parked vehicles	
3. Road Geometry	Carriageway width	Width in meters	
	Road hierarchy	Type (arterial, sub-arterial, local)	
	On-/Off-street space	No. of marked parking spaces	
	Road encroachments	Encroachment extent	
5. Travel Demand & Trip Generation	Trip purpose	Trip category counts (work, leisure)	
	Trip length	Avg. trip distance (km)	
	Peak trip generation	Vehicles per hour	
6. Parking & Mobility Management	Shared parking	% Of lots shared	
	Smart systems	No. of smart features installed	
7. Parking Pricing	Fee structure	₹/hour	
	Dynamic pricing	% Change in rates by demand	

4.2 Software-

- Arcgis 10.8
- Zwcad
- Vissum
- Microsoft package

5. Methodology

The methodology has been divided into 4 stages (Fig 2). The first stage of the study begins with the need of the study, where the rationale for exploring parking management in Kurukshetra is established. This includes identifying key issues such as increasing vehicle ownership, traffic congestion, and environmental impact, which necessitate a focused investigation into the city's parking system.

The second stage focuses on comprehensive data collection, encompassing both primary and secondary sources to develop a detailed understanding of Kurukshetra's parking conditions. Primary data is gathered through field surveys, while secondary data is sourced from existing reports, records, and municipal documents. The stage begins with Land-Use and Population Density Surveys, which map the city's land-use patterns and assess population distribution to correlate with parking demand. Additionally, Mobility, Accessibility, and Connectivity Surveys are conducted to analyze how people move within the city and access key areas, providing insights into the impact of connectivity on parking requirements.

The third stage of the study is dedicated to Analysis and Model Development, focusing on interpreting the collected data and creating predictive tools to inform parking management strategies in Kurukshetra. The process begins with Data Analysis, where the gathered information is systematically examined to identify patterns, trends, and challenges in parking demand and supply across various land-use types.

The final stage of the study focuses on the assessment of parking needs and the development of actionable recommendations tailored to Kurukshetra. The process begins with a Parking Demand Assessment, where the results from the parking model and data analysis are used to estimate the current and future demand for parking across different land-use zones. This assessment highlights key areas of deficiency, identifies high-demand zones, and provides a clear understanding of the scale and nature of parking requirements in the city.

Building on this, Demand-Based Parking Pricing strategies are formulated. These strategies involve linking parking fees to demand levels, incentivizing efficient use of parking spaces, and discouraging excessive reliance on private vehicles. Dynamic pricing models, time-based tariffs, and differentiated rates for on street and off-street parking are proposed to optimize space utilization and reduce congestion.

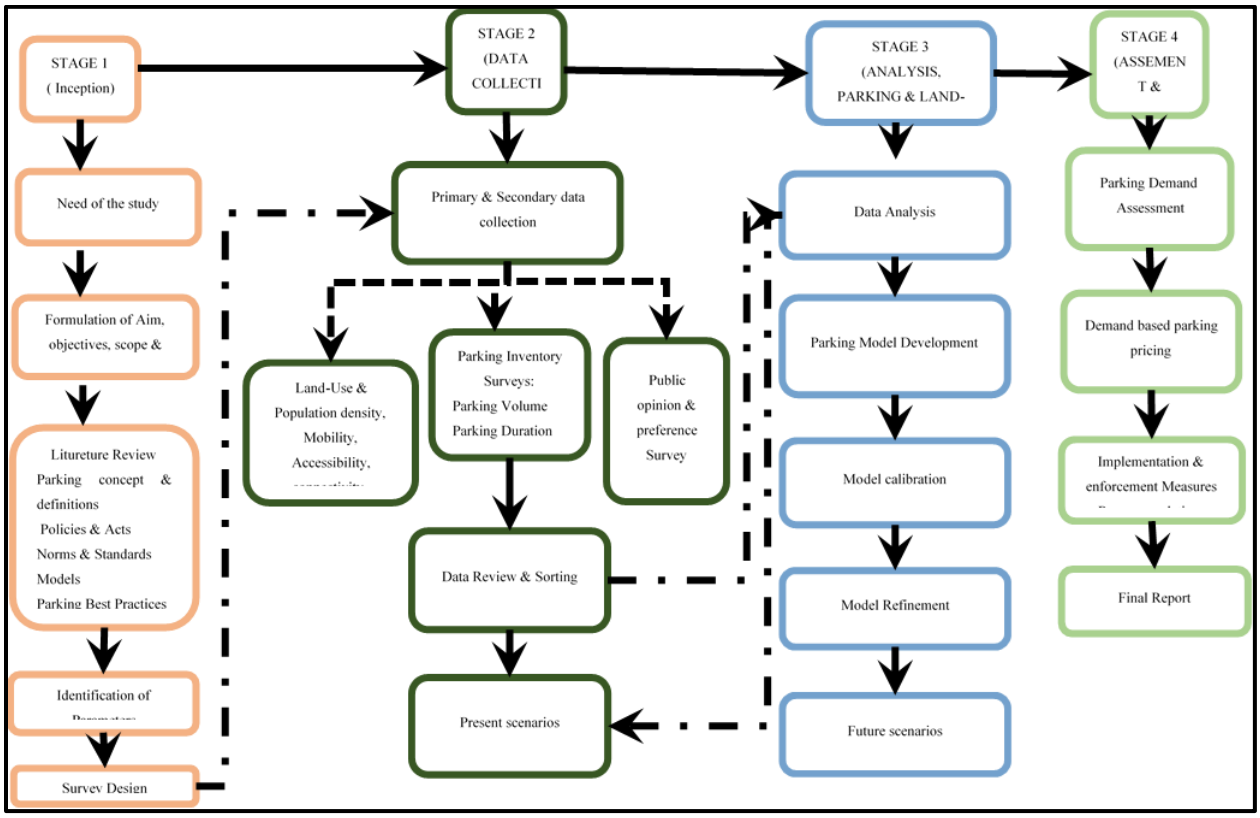


Fig-2: Methodology

6. Analysis Road Inventory

Table -7: Road inventory of the following stretches and gives exact measurement of the road components:

Road Name	Node Name		Road inventory of the following stretches and gives exact measurement of the road components:														
							Carriage Way (Curb to Median)			Footpath							
										LHS			RHS				
	From node	To node	Length in (km)	Pavement Type (Flexible/Rigid/Unpaved)	No. of lanes	Divided/ Undivided	LHS Width (m)	Median Width (m)	RHS Width (m)	Type(P/UP)	Length(m)	Width(m)	Type(P/UP)	Length(m)	Width (m)		
							Comparision with IRC standards										
							7m	2m-5m	7m	-	-	1.5 - 2m	-	-	1.5-2m		
Kaithal Road	kuk 3rd gate	HIRMI	1	Rigid	6	Undevided	3.5	/	3.5	P	NA	NA	P	100	1		
Kaithal Road	kuk 3rd gate	Panorma	2.2	Rigid	6	Divided	3.5	/	3.5	P	400	1.7	P	400	1.5		
Pehowa	kuk 3rd gate	Raj palace	1	Rigid	6	Divided	6.1	0.4	6.5	P	700	1.5	P	700	1.5		
KDB Road	Bharamsarovra	DC office	6	Rigid	6	Divided	7	4	7	P	1200	1.3	P	1200	1.5		
Thol-Jhansa Road	Old bus stand	Bhadarkali temple	1.5	Rigid	4	devided	7	2.2	7	P	510	2	P	510	2		
Pipli Road	Old bus stand	Aggarsain chowk	1.9	Rigid	4	Divided	7.5	1	7.5	P	800	1.5	P	800	1.5		
Pipli Road	Aggarsain chowk	New bus stand	1.1	Rigid	6	Divided	10	1.7	10	P	400	1.5	P	400	1.5		
Pipli Road	New bus stand	Pipli Bus stand	3.5	Rigid	6	Divided	10	1.7	10	P	1300	1.5	P	1300	1.5		

7. Existing Parking Locations-

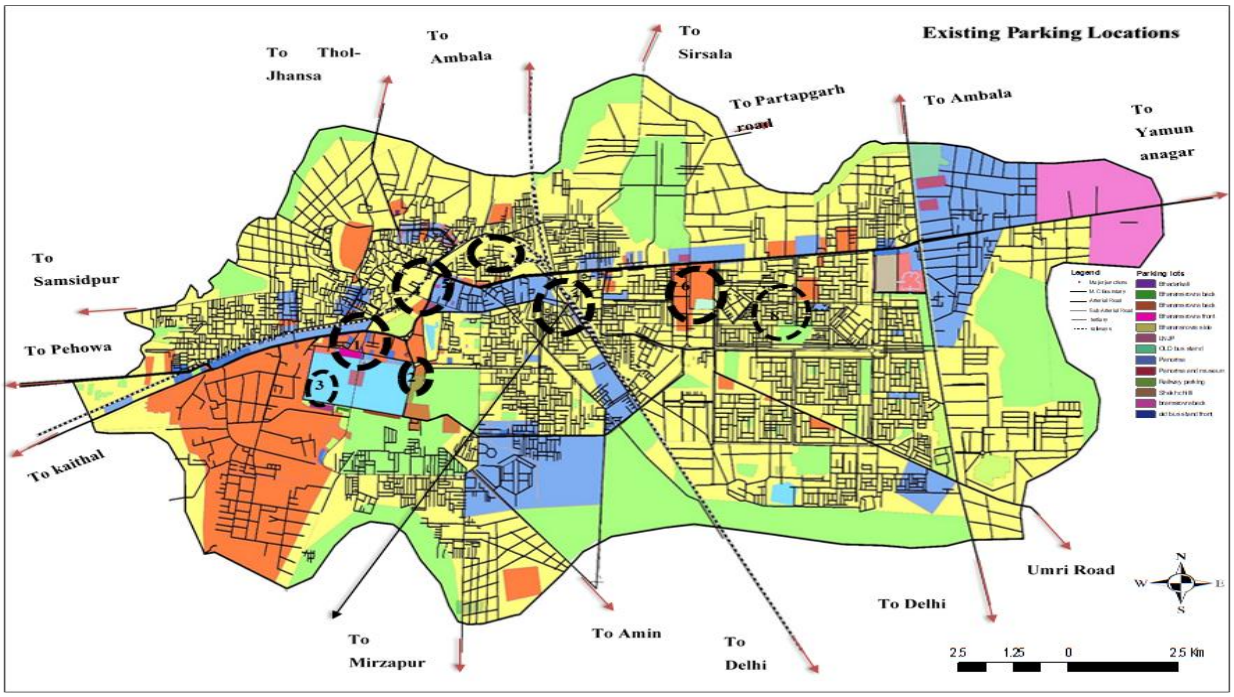


Fig-3: Existing Parking Locations

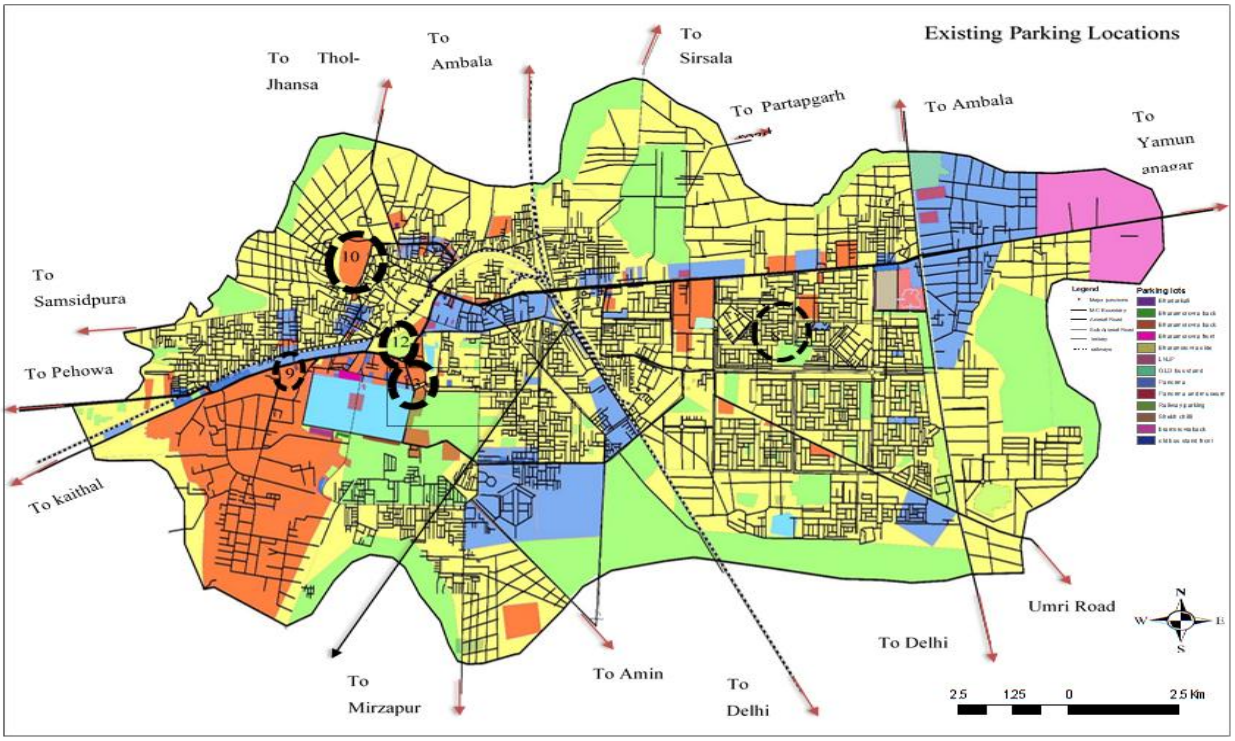


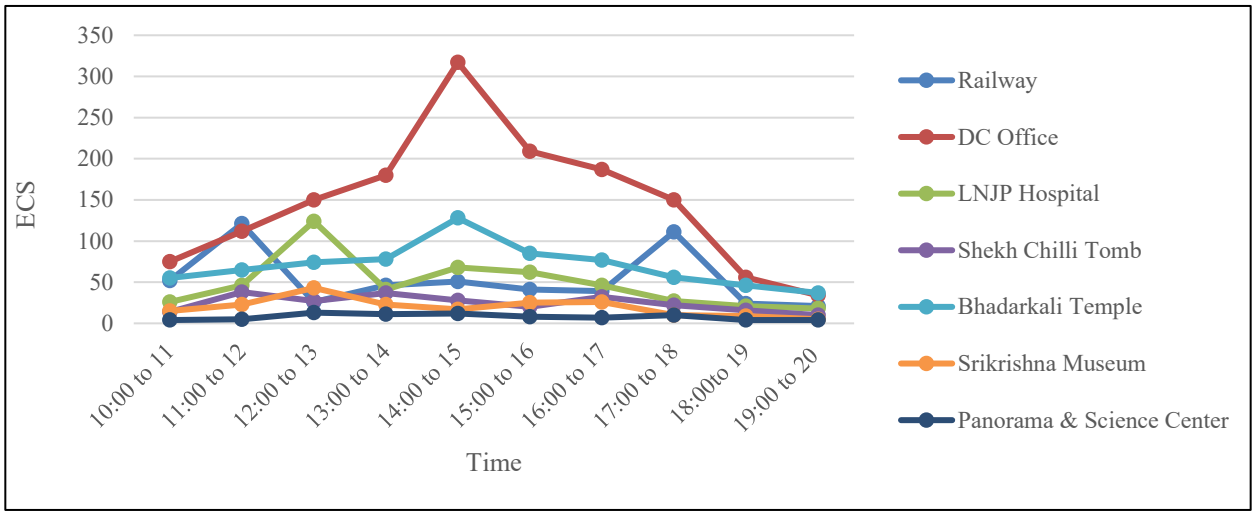
Fig-4: Existing Parking Locations

Table 8: - Existing Parking Analysis

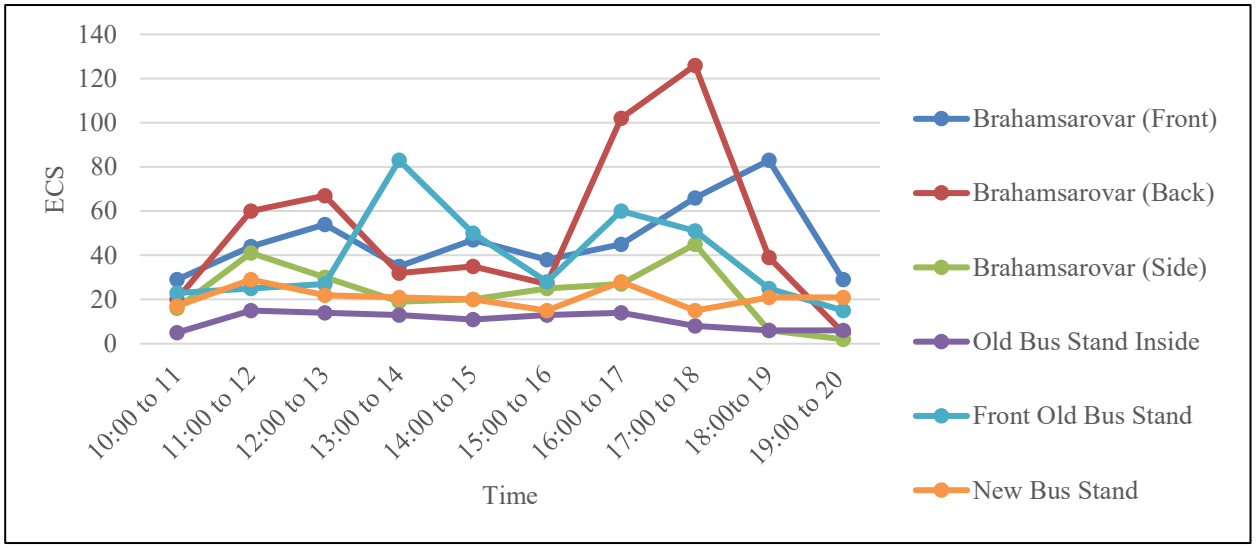
Sr.No.	Name of Parking Lot	Authorized / Unauthorized	Organized/Unorganized	Angle parking (30,45,60&90) yes/no	No. of parking lots	Dimension of parking lot (in sqm)	Occupancy (%)					
							Car	2W	Auto	Cycle	Rickshaw	Bus
1	Brahamsarovar(Front)	Authorized	Unorganized	no	55	1300	60	20	30	10	20	10
2	Brahamsarovar(Back)	Authorized	Unorganized	no	453	10,455	-	-	-	-	-	-
3	Brahamsarovar(Side)	Authorized	organized	90	625	14500	-	-	-	-	-	-
4	Old bus stand Inside	Authorized	Unorganized	no	10	300	-	-	-	-	-	--
5	Front Old Bus stand	Authorized	Unorganized	no	61	1500	50	30	20	-	-	-
6	New Bus stand	Authorized	Unorganized	no	30	766	-	-	-	-	-	-
7	Railway	Authorized	Unorganized	no	76	1840	-	-	-	-	-	-
8	DC office	Authorized	Unorganized	no	78	1900	-	-	-	-	-	-
9	LNJP Hospital	Authorized	Unorganized	no	53	1328	30	40	20	-	-	-
10	Shekh chilli tomb	Authorized	Unorganized	no	23	608	-	-	-	-	-	-
11	Bhadarkali tample	Authorized	organized	90	90	2073	-	-	-	-	-	
12	Srikrishna Museum	Unauthorized	Unorganized	no	31	800	50	30	20	-	-	-
13	Panorma and Science Center	Authorized	Unorganized	no	27	207	-	-	-	-	-	-

Parking Fee										Nearest PT Stop	Distance from PT stop
Car	2W	Auto	Cycle	Rickshaw	Bus	Operating hours	Hourly Income	Daily Income	Monthly Income		
50	20	30	Free	20	200	10	3,300	33,000	9,90,000	Birla mandir bus stop	400 m
Free	Free	Free	Free	Free	Free	12	-	-	-	Birla mandir bus stop	1.5 km
Free	Free	Free	Free	Free	Free	12	-	-	-	Khanda bus stop	900 m
Free	Free	Free	Free	Free	Free	24	-	-	-	Old Bus stand	/
50	20	30	Free	Free	Free	10	3,050	30,500	9,15,000	Old Bus stand	200 m
Free	Free	Free	Free	Free	Free	24	-	-	-	New Bus stand	/
Free	Free	Free	Free	Free	Free	24	-	-	-	Railway station	50 m
Free	Free	Free	Free	Free	Free	12	-	-	-	New Bus stand	750 m
30	10	20	Free	Free	Free	10	954	9,540	2,86,200	Civil hospital bus stop	50 m
Free	Free	Free	Free	Free	Free	12	-	-	-	Birla mandir bus stop	1.5 km
Free	Free	Free	Free	Free	Free	12	-	-	-	Old Bus stand	1.5 km
50	20	30	Free	Free	Free	10	1,550	15,500	4,65,000	Khanda bus stop	500 m
Free	Free	Free	Free	Free	Free	12	-	-	-	Khanda bus stop	450 m

- **Peak Hour Parking**



Graph1: Accumulation Curve



Graph2: Accumulation Curve

8.Travel Characteristics of Kurukshetra city

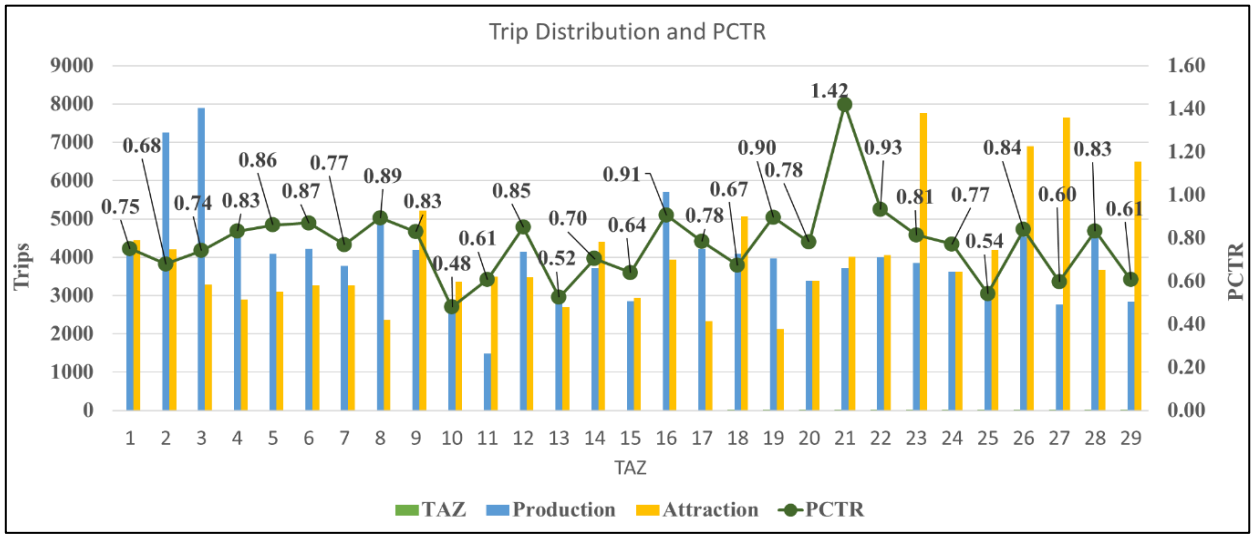
The total number of trips across the 29 Traffic Analysis Zones (TAZs) is 117,596. Zones with high trip production are mainly residential, while those with high attraction are commercial or institutional. Imbalances in trip production-attraction ratios indicate travel stress and congestion in certain zones. High trip-producing zones strain transport infrastructure and fuel resources, while high-attraction zones suffer from congestion, parking demand, and pollution.

Exploration Factor is calculated=Total population of TAZ

No. of Samples in TAZ

TAZ 1Pop=155037/700=221

Hence Size of 1 sample=221 Population of TAZ



Graph 3: TAZ wise attraction/production

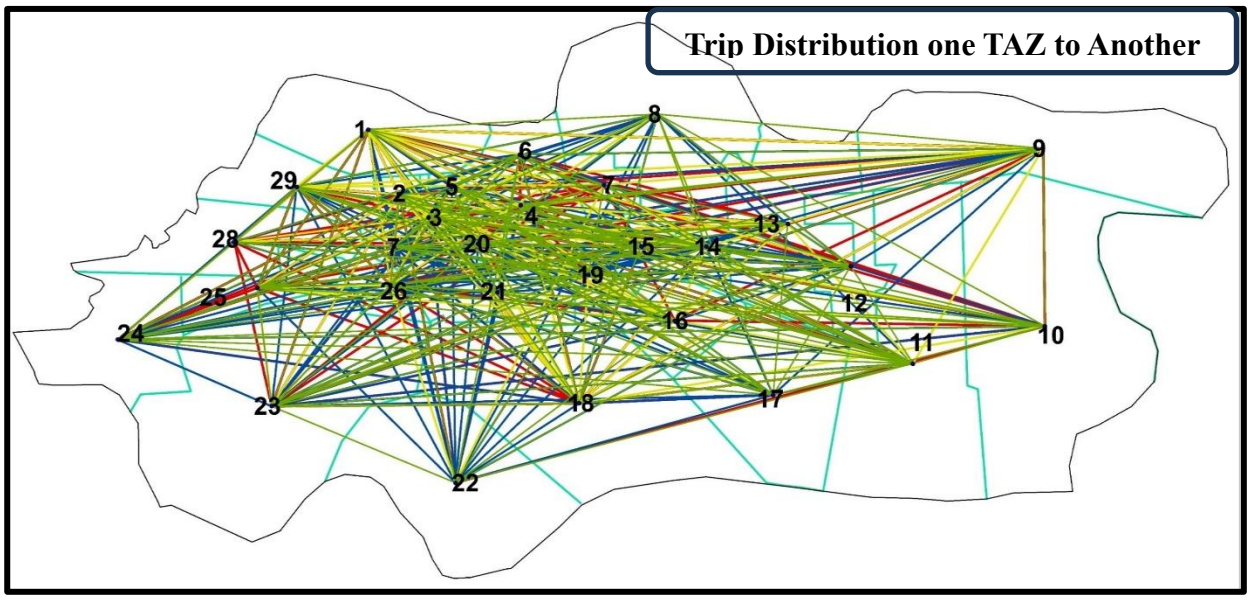


Fig 5: Trip Distribution one TAZ to Another

9. Proposals

Table 9: Parking sign and signals

Rating System .1 = Very Poor/None .2 = Poor .3 = Fair .4 = Good .5 = Excellent

Parking Lot	Current Rating (Rating 1 to 5 on Visual Basis)	Parameters Needing Improvement
New Bus Stand	Poor (2)	Line Marking, Slot Numbering, Disabled Marking, Directional Arrows, Entry/Exit Signs, No-Parking Signs, Obstruction-Free Space, Barriers, Paving, Drainage, Cleanliness, Lighting, Digital Payment System, Parking Management System, Camera System
Old Bus Stand Inside	Very Poor (1)	Line Marking, Slot Numbering, Disabled Marking, Directional Arrows, Entry/Exit Signs, No-Parking Signs, Obstruction-Free Space, Barriers, Paving, Drainage, Cleanliness, Lighting, Digital Payment System, Parking Management System, Camera System
Front Old Bus Stand	Very Poor (1)	Line Marking, Slot Numbering, Disabled Marking, Directional Arrows, Entry/Exit Signs, No-Parking Signs, Obstruction-Free Space, Barriers, Paving, Drainage, Cleanliness, Lighting, Digital Payment System, Parking Management System, Camera System
LNJP Hospital	Poor (2)	Line Marking, Slot Numbering, Disabled Marking, Directional Arrows, Entry/Exit Signs, No-Parking Signs, Obstruction-Free Space, Barriers, Paving, Drainage, Cleanliness, Lighting, Digital Payment System, Parking Management System
DC Office	Fair (2)	Line Marking, Slot Numbering, Disabled Marking, Directional Arrows, Entry/Exit Signs, No-Parking Signs, Barriers, Drainage, Cleanliness, Digital Payment System, Parking Management System, Digital Signage
Shekh Chilli Tomb	Fair (2)	Line Marking, Slot Numbering, Disabled Marking, Directional Arrows, Entry/Exit Signs, No-Parking Signs, Barriers, Drainage, Cleanliness, Digital Payment System, Parking Management System, Digital Signage, Vehicle Detection Sensors
Bhadarkali Temple	Fair (2)	Line Marking, Slot Numbering, Disabled Marking, Directional Arrows, Entry/Exit Signs, No-Parking Signs, Barriers, Drainage, Cleanliness, Digital Payment System, Parking Management System, Digital Signage, Vehicle Detection Sensors
Railway Station	Good (3)	Minor Paving Repairs, Upgrade Digital Payment System, Digital Signage, Real-Time Data Sharing, Vehicle Detection Sensors, Camera System
Brahmsarovar (Front)	Excellent (4)	Real-Time Data Sharing, Vehicle Detection Sensors, Digital Signage Enhancement
Brahmsarovar (Back)	Good (3)	Line Marking Touch-up, Drainage Minor Repairs, Real-Time Data Sharing, Vehicle Detection Sensors, Digital Signage
Brahmsarovar (Side)	Good (3)	Line Marking Touch-up, Entry/Exit Signs, Digital Payment System Upgrade, Digital Signage
Srikrishna Museum	Excellent (4)	Maintain Existing Standards, Upgrade Camera System, Maintain Drainage and Paving
Panorma & Science Center	Excellent (4)	Maintain Existing Standards, Upgrade Camera System, Maintain Drainage and Paving

The growing parking challenges in Kurukshetra and to ensure smooth traffic movement, a combination of on-street and off-street parking proposals is recommended. These proposals are based on existing road widths, traffic volume, land use, and field observations, aiming to optimize space utilization and minimize congestion.

9.1 On Street Parking Proposals: -

These specific objectives are set to achieve the vision and strategies: -

PROPOSAL 1

Practical design for on street Parking from Old bus stand to Mohan nagar.

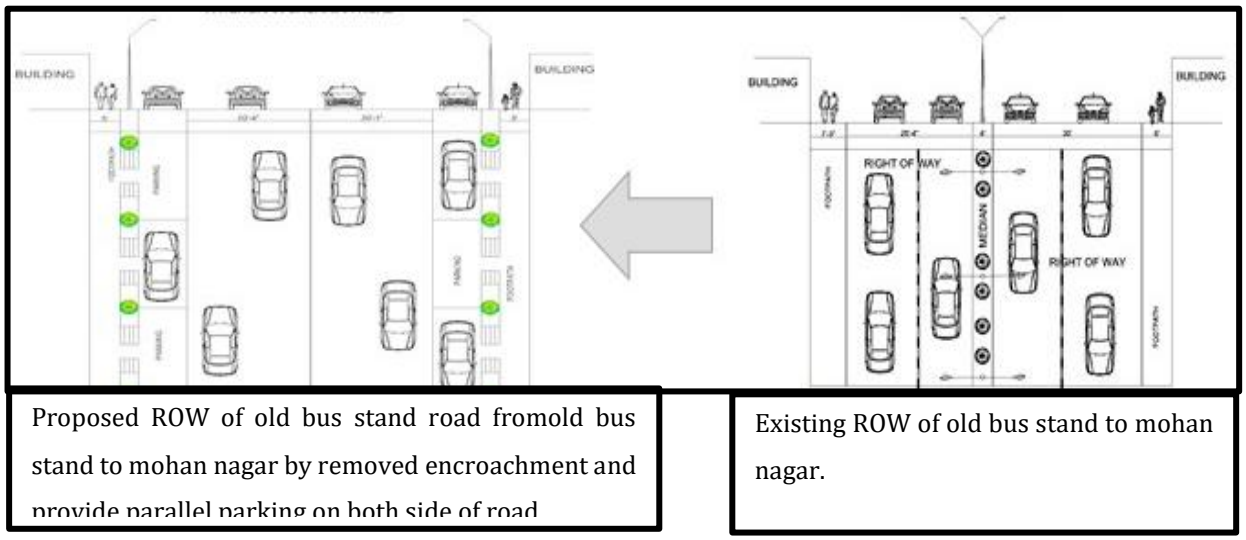


Fig-6: Practical design for on street Parking from Old bus stand to Mohan nagar.

PROPOSAL 2

These specific objectives are set to achieve the vision and strategies for Pipli Road

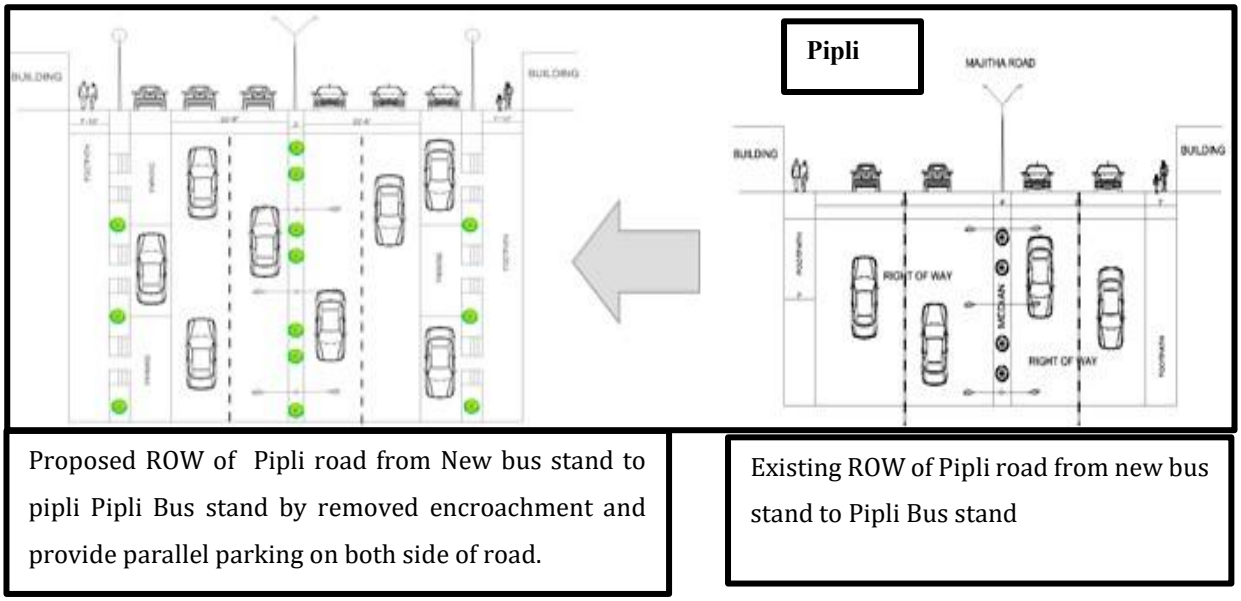


Fig-7: Practical design for on street Parking from New bus stand to Pipli Bus Stand

PROPOSAL 3

These specific objectives are set to achieve the vision and strategies for Brahamsarovra

Practical design for on street Parking Brahamsarovra Front

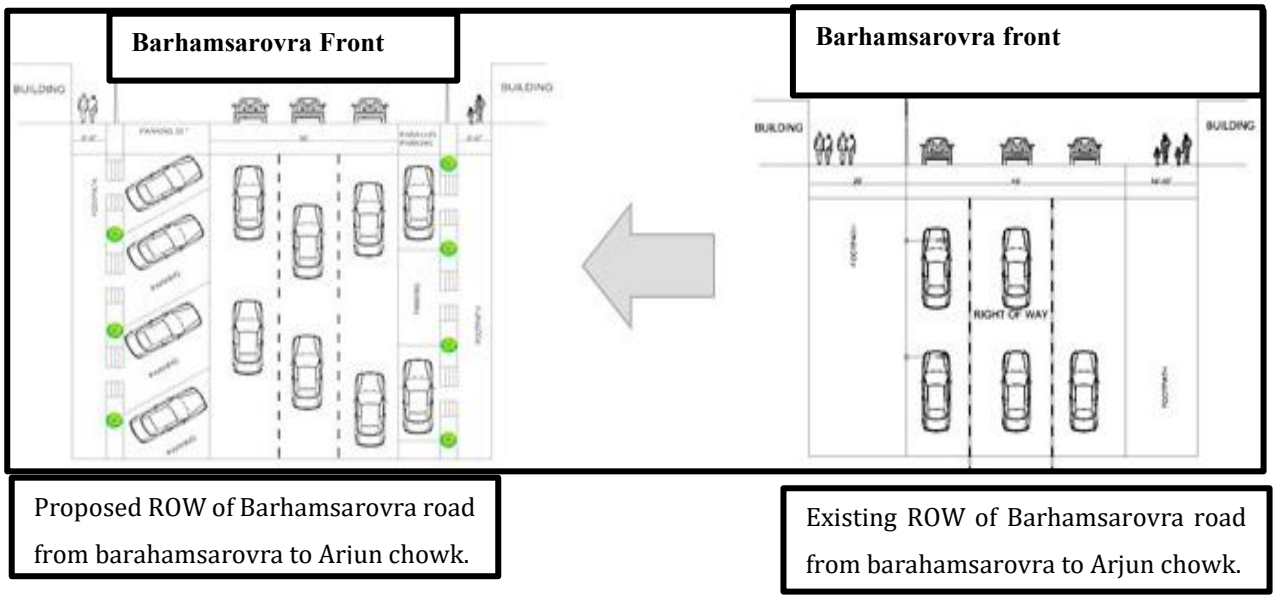


Fig-8: Practical design for on street Parking Brahamsarovra Front

Table 10: On-Street Parking Turnover

Vehicle Type	Hourly Charge (INR)	No. of Slots	Occupancy Rate (Assumption)	Operating Hours/Day	Daily Revenue (INR)	Monthly Revenue (INR)	Based on Guidelines and Common Practice in India
Two-Wheeler	₹ 10	50	60%	10 hours	3,000	90,000	10/hr is standard for bikes in urban areas like Chandigarh, Delhi (Smart City Policy)
Four-Wheeler	₹ 20	30	60%	10 hours	3,600	1,08,000	₹20/hr for cars follows MoHUA Model Parking Policy
Total	-	80	-	-	6,600	1,98,000	-

The table presents a detailed financial estimation for a proposed parking facility accommodating both two-wheelers and four-wheelers. It includes 50 slots for two-wheelers and 30 for four-wheelers, totaling 80 parking spaces. Based on standard hourly parking charges 10 for two-wheelers and ₹20 for four-wheelers—drawn from practices in cities like Delhi and Chandigarh, the revenue model assumes a 60% average occupancy rate. The facility is expected to operate for 10 hours daily. With these assumptions, the daily revenue from two-wheelers is estimated at ₹3,000, while four-wheelers contribute 3,600, totalling 6,600 per day. This adds up to a monthly income of approximately 1,98,000. These projections demonstrate the financial sustainability of the parking system. Moreover, structured pricing helps regulate parking demand and discourages long-term occupation of slots. generation.

9.2 Off Street Parking Proposals

PROPOSAL 1: -Design based proposal of organized parking in commercial

In busy commercial areas like Sector 1, a well-planned off-street parking facility is necessary to reduce congestion and parking shortages. Shop owners, employees, customers, and visitors alike will be able to park two-wheelers and four-wheelers at the proposed facility. Moving parking from the roadside to a designated location will free up road space, increase safety and traffic flow. The parking area ought to have the right markings, lighting, security, entry-exit points, and digital payment systems. Utilizing intelligent features like occupancy sensors and real-time parking information can further enhance user convenience and efficiency.

Table 11: Multi-level spiral ramped parking proposal for DC office parking

S. No	Location	Area in Sq. Meter per Floor	Total Floors	Clear Floor Height
1	Near DC office	880 Sqm. Appox.	Above Ground 03 levels & Below Ground 01 levels Total 5 levels incl. Ground	2.1-2.4m for Basements 1.8-2.1m for Ground and above floors
2		148 Sq.m. approx..	Ground Floor for min 50 Nos. two-wheeler parking	3-3.2m for GF cover slab
3		80 sqm approx.	Utility Area (Visitors Facility centre, PublicToilet)	On GF

Table 12: On-Street Parking Turnover

Vehicle Type	Available Units	Avg. Daily Usage	Fee per Use	Daily Revenue	Monthly Revenue
2-Wheeler	**50**	**50**	**30**	**1,500**	**45,000**
Car	**218**	**174 (80%)**	**100**	**17,400**	**5,22,000**
Total	**—**	**—**	**—**	**18,900**	**5,67,000**

Proposal 2: - Parking proposal for railway station

By assigning separate zones for various vehicle types, a well-organized and segregated parking layout near high-demand areas like railway stations improves space utilization. Overcrowding, illegal parking, and misuse of parking spaces are all reduced as a result. During peak hours, separate entry and exit points improve traffic flow and reduce congestion. By reducing the amount of walking required and making it easier to pick up and drop off passengers, conveniently located parking lots also improve passenger convenience. Overall, the design supports transport management that is effective and well-organized, reduces conflicts, and increases safety.

Table 13: Parking proposal for railway station

Vehicle Type	Standard Size per Vehicle	Area (m^2)	No. of Parking Units	ECS Conversion Factor	Total ECS
Cars	2.5 m × 5.0 m = 12.5 m^2	850 m^2	68	1.0	68
2-wheelers	1.0 m × 2.0 m = 2.0 m^2	510 m^2	255	0.25	64
Auto	2.0 m × 3.0 m = 6.0 m^2	255 m^2	42	0.5	21

Proposal 3: - Proposal for brahamsarovra parking

A regulated parking system is necessary to reduce traffic and enhance safety around Brahma Sarovar. Due to the high volume of pedestrian traffic and the narrow roads, only two-wheeled vehicles should be permitted in front of the site. The designated side parking area, which is better suited for larger vehicles, should be used for cars and buses. To prevent unauthorized parking, barricades and clear no-parking signs should be installed. Enforcement and monitoring on a regular basis will help to maintain a smooth flow of traffic and improve the visitor experience.

Proposal 4: - Bhadarkali temporary management

During weekends and peak pilgrimage times, a temporary parking management plan around Bhadrakali Temple is necessary. With appropriate signage and clearly marked entry and exit points, congestion can be reduced and traffic flow maintained. To improve space utilization and organization, two-wheeler and four-wheeler parking zones should be established. Elderly and disabled visitors will benefit from a designated drop-off location near the temple entrance, and illegal parking will be avoided. During times of high traffic, these measures will increase safety, accessibility, and overall parking efficiency.

Proposal 5: - Temporary parking at the time of geeta Jayanti

Kurukshetra experiences a sharp increase in visitors and parking demand during the Geeta Jayanti Mahotsav. The Theme Park area can be used as a parking facility for a month to manage this. Brahma Sarovar and Bhadrakali Temple, among other major attractions, will see less traffic as a result of this. For smooth operation, fundamental amenities like lighting, security, signage, and entry/exit points should be provided. The parking area and event locations can be connected by shuttle services or e-rickshaws, enhancing convenience and traffic management.

Results

The urban parking system in Kurukshetra is having a lot of problems that need to be fixed right away and planned strategically. The city's parking infrastructure is currently overwhelmed by a number of interconnected factors, necessitating an all-encompassing, multi-dimensional solution. The parking demand in Kurukshetra has distinct spatial patterns that are closely linked to the characteristics of land use. The highest demand for parking is found in commercial areas, which account for 11% of the city's land area and require between 30,000 and 50,000 equivalent car spaces (ECS). This high demand comes from the concentration of shopping malls, office complexes, and entertainment hubs that receive a large daily number of visitors. The linear regression model ($y = 0.00507x + 1$), which quantitatively demonstrates how parking requirements in these commercial zones scale proportionally with built-up floor area, is a useful predictive tool for urban planners. A different obstacle exists in the public and semi-public institutional areas, which make up 17% of the city. Examples of these areas include educational establishments, government offices, and hospitals, each of which has a significant but more predictable demand of 10,000 to 20,000 ECS. The distinct linear model for these areas ($y = 0.00681x + 20.80$) demonstrates that as the size of the institution and the number of visitors rise, so do parking requirements. Religious and tourist destinations like Brahmasarovar and Bhadarkali

Temple, which experience significant spikes in demand during festivals and evening rituals that overburden existing facilities, contribute to the complexity. The city's road infrastructure makes these parking issues even worse. Unauthorized parking accounts for 23% of road encroachment, while vendor activity accounts for 6%, both of which reduce effective carriageway width and create dangerous traffic bottlenecks. Parking inattention directly contributes to urban gridlock in important corridors like the Bhadarkali Chowk to Aggarsain Chowk stretch and the 3rd Gate to Museum route, both of which have VC ratios of 1.16, indicating severe congestion. Utilization of service lanes in close proximity to crucial locations like Kurukshetra University and the New Bus Stand contributes to these issues by disrupting planned traffic flows. An evaluation reveals that the existing parking facilities differ significantly in both quality and efficiency. The potential of well-organized layouts, digital payment systems, and CCTV surveillance is demonstrated by the Brahmasarovar Front, Srikrishna Museum, and Panorama Center, all of which received a score of four out of five. However, these are the exceptions rather than the rule. The majority of facilities, including the Old Bus Stand (LNJP Hospital), lack essential amenities like appropriate line marking, and disabled parking slots.

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