On-Street Night Car Parking Demand Estimation in Residential Areas: A Case Study at Delhi

Ashwani Bokadia and Mokaddes Ali Ahmed

Abstract The parking problem is a huge issue everywhere in the world. Delhi is one of India's biggest cities, which is affected by parking problems. The gradual growth in income and vehicle ownership per family is also the reason for the increase in parking demand. Day by day, the parking demand is also increasing in residential areas during nighttime due to insufficient space for car parking in most houses in residential areas, which leads to roadside parking at night. An appropriate management strategy should therefore be put into place for on-street night parking demand. In this study, three residential areas—Ber Sarai, Jia Sarai, and Katwaria Sarai, Delhi, have been selected as the case study areas. Parking demand models are developed to estimate the parking demand and determine the important parameters. The demand model's formation includes parameters like the number of cars owned, the presence of garage facilities, future car ownership, etc. The parking accumulation is found from field surveys such as in–out survey and license plate survey. The parking volume and peak hours for each location are obtained using a questionnaire survey. The parking demand model is generated using linear regression analysis using a statistical package for social sciences (SPSS). Using regression analysis, the good parking demand model with less error is found. In this study, a parking policy is also suggested to reduce and control parking demand during night-time based on vehicles' locations and parking demand.

Keywords Parking demand · On-street night parking · Parking accumulation · SPSS software · Regression analysis · Parking policy

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1 Introduction

Nowadays, due to the metro cities' worldwide rapid growth, there is an increasing rate of parking, which causes major parking issues in the majority of urban areas. On-street night parking demand in residential areas is increasing daily due to insufficient parking space and vehicle ownership. Also, It has been observed that car owners park their vehicles on-street at night in metro cities such as Chennai, Kolkata, and Mumbai. One of the largest cities, Delhi, has a similar issue with parking in residential neighborhoods. The city, which covers an area of 1,484 km^2, is the greatest commercial center in northern India and is situated in the northern region of the country. The demand cannot be satisfied by the availability of parking space in many residential areas of Delhi due to the insufficient parking system and facilities there. This will create more demand for parking in residential areas. A town planner must thus do a thorough analysis of parking in order to manage on-street parking.

The objective of the study is to find the important factors that affect the night car parking demand in residential areas, to study the present parking condition in residential areas, to develop a night parking demand model, and to suggest some policies to reduce on-street night car parking demand.

2 Literature Review

Developed an approach, according to cluster analysis, to create profiles of aggregate parking accumulation in parking lots, to improve the effectiveness of surveys' data gathered. According to the authors, accumulation profiles might help transportation experts make decisions and evaluate parking demand models. Furthermore, such profiles can help in the creation of parking information systems in real-time as well as the assessment of various traffic management tactics [1]. Conducted a campus study at the Beijing University of Aeronautics and Astronautics. The research collected data flow into and out of the university campus at the main university entrance and exit in order to analyse demand at different times of the day. Parking duration was calculated for each car by withdrawing entering time from exit time. A basic analysis of parking demand, duration, and turnover was carried out in the research [2, 3]. The research was done on three different land use patterns, including downtown, malls, and seaside parks. The study used a continuous investigation of license plate numbers gathered for a minimum of 3 h and recorded every 5 min. According to one study, license plates should be observed less than every 30 min in urban areas and every 60 min in coastal parks to identify all potential ideal parking features and cost-effective surveying [4]. Investigated the alteration in occupancy as a result of parking charge changes for a San Francisco study area where a parking policy based on performance was introduced. The authors determined that there is a considerable negative correlation between changes in occupancy and parking charges [5–7]. Created a method that may be used uniformly to analyse the potential savings in cruising time brought on by adopting

intelligent parking services (IPS). Using probability macroscopic parking models and theory, the authors investigated cruising situations with and without IPS. The authors calculated that IPS might save up to 15.6 h (17%) of traveling time in a normal, typical workday in a small downtown area (0.28 km^2) [8, 9]. Studied the efficacy of urban on-street parking charging schemes. The authors found that improving enforcement of on-street parking is possible to prevent negative parker attitudes. Such behavioral methods decrease overall traffic safety and accessibility, particularly in metropolitan areas. Furthermore, raising awareness of different alternative offerings in the respective field (PT, P&R, shared mobility, walkability, etc.) allows for the reduction of uncontrolled use of personal cars and the development of a co-modal strategy for sustainability [10–12]. Investigated the efficacy of parking strategies in reducing parking demand and vehicle use. The authors observe that visitors respond to parking restrictions by shifting to a new parking lot instead of transferring to another form of transportation. Based on simulations of various policies, authors concluded that when pricing and measure policies are combined, they have a greater overall impact on shaping parking demand than if they were used alone [13–15].

3 Study Area

Parking locations in various Delhi neighborhoods have been chosen for this study in residential areas. The areas of study were selected based on on-street night parking demand. The three areas, namely, Ber Sarai, Jia Sarai, and Katwaria Sarai, Delhi, are all residential areas of Delhi City and are under the municipal corporation of Delhi, as shown in Figs. 1, 2, and 3. The majority of residents in these neighborhoods drive their own automobiles, and they typically leave them in the street overnight close to houses or flats. People may encounter several issues in these places at night, such as congestion, accidents, delays, etc., as a result of on-street night parking.

4 Methodology

This study developed a methodology to calculate the impact of residential parking on car demand. Utilize the initial phase survey data collection methods like in–out survey and license plate to find out the all-over idea about the location and parking demand. Moreover, from a questionnaire survey, obtain the data from houses with the help of parameters. In the second step, with the help of SPSS software and regression analysis, estimate the parking demand equation and formulate the parking demand model for the study and the overall methodology shown in Fig. 4.

The quantity of parking space required in a specific location at a given time is known as the parking demand. When demand exceeds parking availability, the issue for the transportation system becomes more serious. The data gathered from various

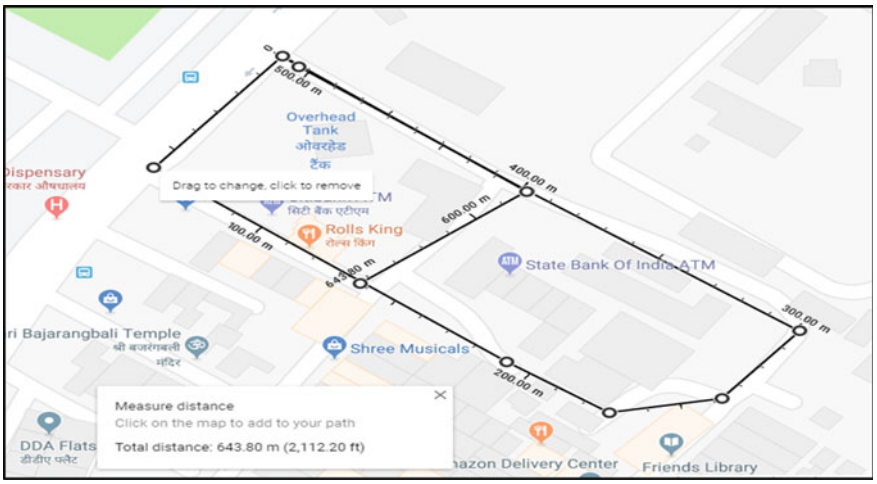

Fig. 1 Survey location map: Ber Sarai, Delhi

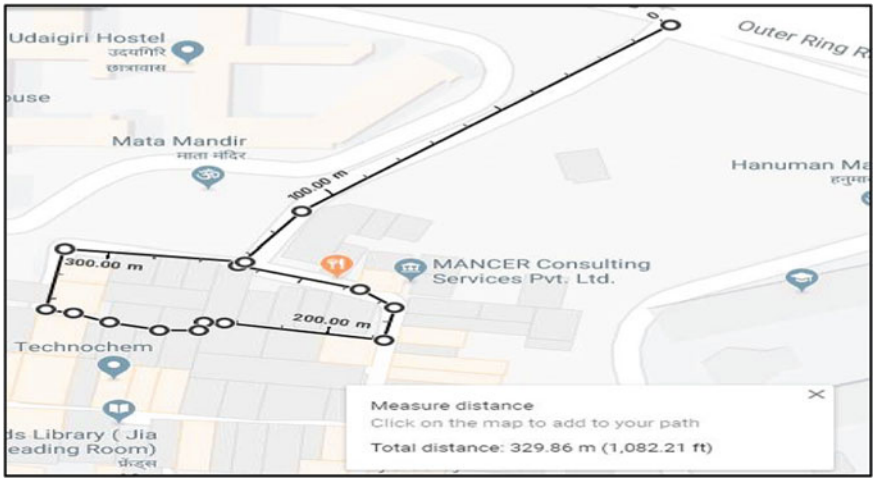

Fig. 2 Survey location map: Jia Sarai, Delhi

surveys are examined to create the parking demand model. This study includes variables such as the number of four-wheelers owned, the presence of garage facilities, and future car ownership. The standard regression equation form (by incorporating the parameters mentioned earlier) is shown below in Eq. 1. The following equation gives the demand equation:

$$N = \alpha_0 + a_1 \times x_1 + a_2 \times x_2 + a_3 \times x_3 \tag{1}$$

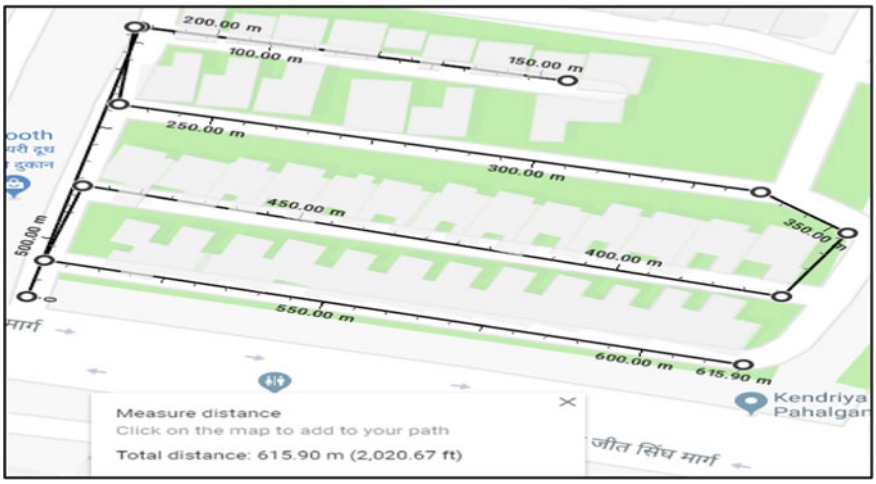

Fig. 3 Survey location map: Katwaria, Sarai, Delhi

where

N = parking demand.

$\alpha_{0,}a_{1,}a_{2,}a_3$ are constant values.

x_1= No. of cars owned.

x_2=Availability of garages at home.

x_3= Future car ownership.

Number of car owned increase in vehicle ownership leads to requirement for parking space in buildings or apartments. Parking space requirement directly influences parking demands. If sufficient parking space isn't available in the structure or apartments, at that point, there will be an increase in on-street night parking demand. Availability of garages at home will decrease the night parking demand at nighttime. If the resident has no garage facilities for car parking in our building and apartment, there will be more chances they park their vehicle on-street during nighttime. And this will directly affect parking demand. And future car ownership increase in car ownership but fixed is available in parking space in buildings and apartments. Parking spot requirements indirectly affect parking demands.

5 Survey and Data Collection

5.1 In–Out Survey

An in–out survey is conducted to determine the parking area's occupancy and track the accumulation profile. From the survey, the initial number of the space-occupied area is used, after which the number of cars entering the parking area for a specific

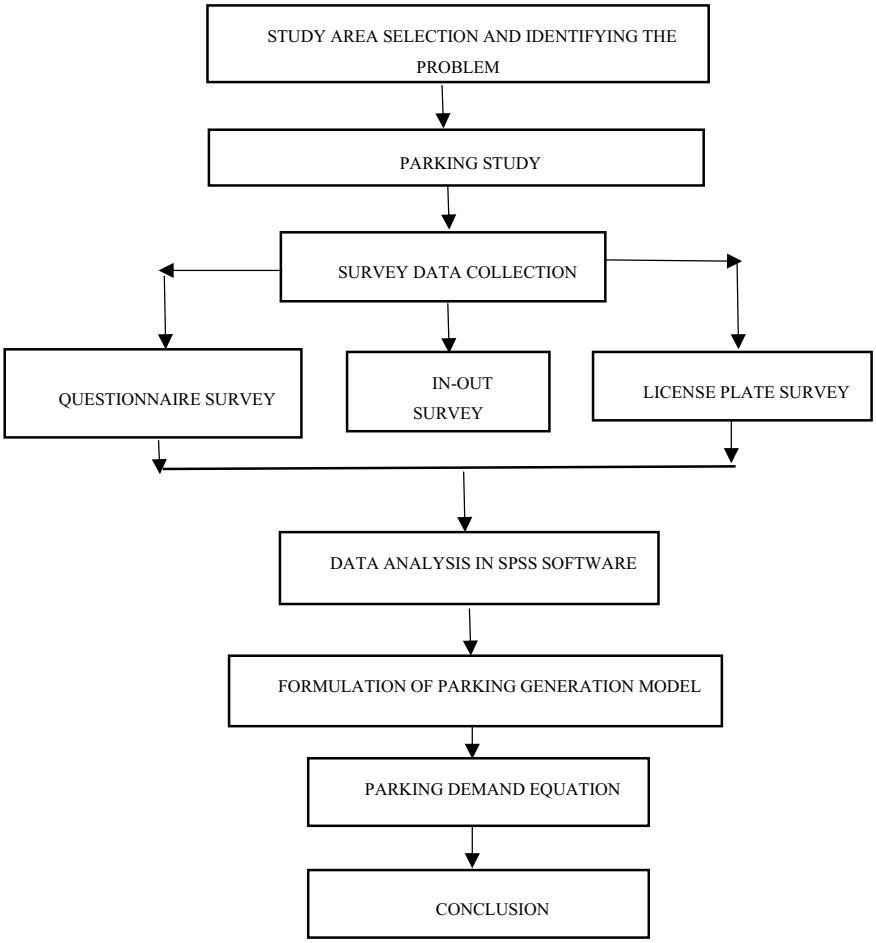

Fig. 4 Methodology flow chart

time period is counted. The quantity of cars leaving the parking area is also taken. The final occupancy is recorded at the survey's location. The poll was taken at three locations, Ber Sarai, Jia Sarai, and Katwaria Sarai in Delhi, from 9 PM to 6 AM to determine the parking accumulation as shown in Fig. 5.

5.2 Questionnaire Survey

It has been conducted at various survey locations so that the survey form has a minimum number of questions and gets the full user information. Seventy respondents from each location were collected and a detailed summary was prepared, as

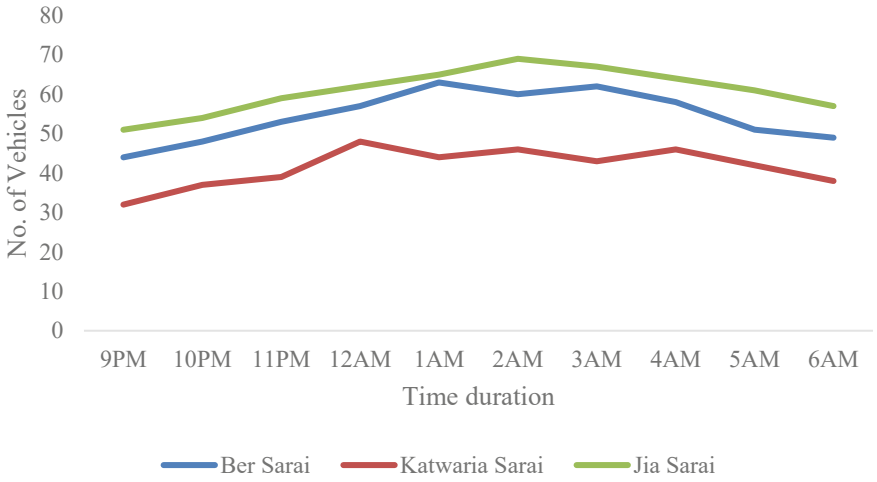

Fig. 5 Parking accumulation profile for all three locations

Table 1 Data collected

Data collected by questionnaire survey	Responders -in numbers total no. of sample (70)
Ber Sarai	
No. of four-wheelers owned	(a) 0 (5) (b)1 (61) (c) 2 (1) (d) > 2 (0)
Presence of garage facilities	(a) Yes (11) (b) No (59)
Do you wish to buy a car in future	(a) Yes (39) (b) No (31)
Jia Sarai	
No. of four-wheelers owned	(a) 0 (14) (b) 1 (44) (c) 2 (9) (d) > 2 (3)
Presence of garage facilities	(a) Yes (4) (b) No (66)
Do you wish to buy a car in future	(a) Yes (46) (b) No (24)
Katwaria Sarai	
No. of four-wheelers owned	(a) 0 (17) (b) 1 (40) (c) 2 (6) (d) > 2 (7)
Presence of garage facilities	(a) Yes (16) (b) No (54)
Do you wish to buy a car in future	(a) Yes (52) (b) No (18)

shown in Tables 1 and 2. Using the extracted data, linear regression analysis in SPSS has been used to evaluate the parking demand equation (Eq. 1).

6 Results and Discussions

Data from several types of surveys have been examined and presented as follows.

Table 2 Descriptive summary of the survey locations

Survey locations	Registered number of families	Total width of the road (in m)	Width available after parking (in m)	Type of parking
Ber Sarai, Delhi	602	7.73	3.73	Two side parallel parking
Jia Sarai, Delhi	690	7.62	4.02	Two side parallel parking
Katwaria Sarai, Delhi	2348	7.54	3.94	Two side parallel parking

6.1 Parking Accumulation

It refers to the total number of parked cars at any particular moment. The peak parking accumulation for each survey location is shown in Fig. 6. From the figure, it can be seen that Jia Sarai is more congested than the other two areas.

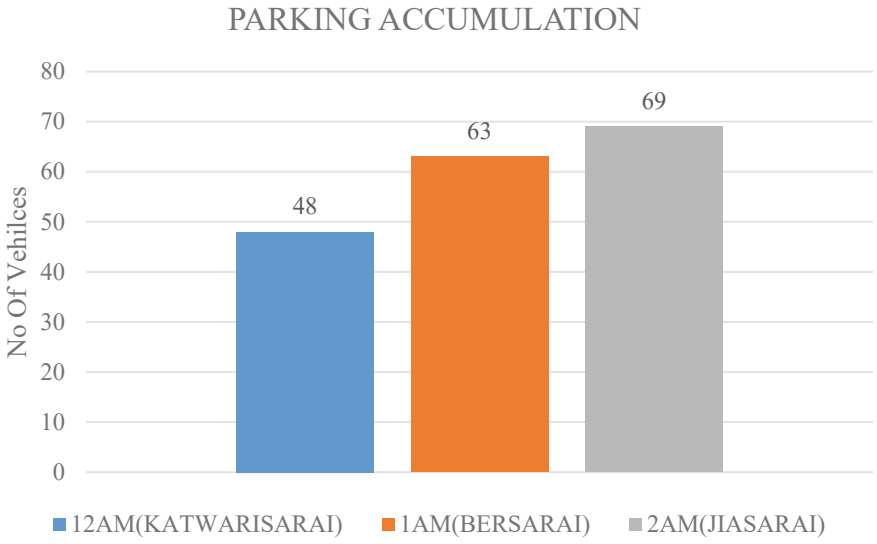

Fig. 6 Peak night parking accumulation profile

6.2 Parking Demand Model

The information gathered through the questionnaire survey was utilized in SPSS, a linear regression analysis was performed, and the regression equation for the three locations was obtained.

The model summary for the locations is shown in Table 3. The R-Squared values shows the correlation between the dependent and independent variables and the standard error of the estimate shows the accuracy of the predicted value.

The model coefficients are shown in Table 4. These are the independent variables found from the model, where the number of vehicles owned by a family and future car ownership are all significant. The presence of any garages is also significant enough to affect the parking demand. The significant value of less than 0.05 shows that the variables are significant, thereby developing a good relationship with the dependent variables and hence the predicted model is suitable for the study. The small value of standard error also signifies that the variables are positively related to the dependent variables.

The final demand equation for all three locations is equated using regression analysis with the help of SPSS software, as shown in Table 5.

ANOVA is also done for the locations and the results are shown in Table 6. The significant value is less than 0.05, which shows that the predicted model is suitable for all the locations.

Table 3 Model summary

Location	Model summary				
	R	R squared	Adjust R squared	Std. error of the estimate	Durbin watson
Ber Sarai	0.657	0.431	0.406	0.391	1.910
Jia Sarai	0.821	0.675	0.660	0.296	2.071
Katwaria Sarai	0.739	0.546	0.525	0.350	2.208

Table 4 Model coefficients

Location	Model	Unstandardized coefficient		Standardized coefficient	T	Sig.
		B	Std. error	Beta		
Ber Sarai	(Constant)	−1.461	0.451		−3.241	0.002
	No. of cars owned	0.561	0.097	0.542	5.804	0.000
	Home garages	0.503	0.198	0.237	2.538	0.014
	Future car ownership	0.339	0.095	0.333	3.553	0.001
Jia Sarai	(Constant)	−1.603	0.330		−4.860	0.000
	No. of cars owned	0.667	0.065	0.722	10.270	0.000
	Home garages	0.500	0.150	0.236	3.340	0.001
	Future car ownership	0.269	0.074	0.258	3.655	0.001
Katwaria Sarai	(Constant)	−1.304	0.384		−3.395	0.001
	No. of cars owned	0.558	0.072	0.647	7.711	0.000
	Home garages	0.555	0.177	0.261	3.135	0.003
	Future car ownership	0.189	0.091	0.174	2.067	0.043

Table 5 Parking demand equation

Location	Demand equation
Ber Sarai	$N = -1.461 + 0.561 \times X_1 + 0.503 \times X_2 + 0.339 \times X_3$
Jia Sarai	$N = -1.603 + 0.667 \times X_1 + 0.500 \times X_2 + 0.269 \times X_3$
Katwaria Sarai	$N = -1.304 + 0.558 \times X_1 + 0.555 \times X_2 + 0.189 \times X_3$

Table 6 ANOVA results

Location	ANOVA			
	Sum of squares	Mean square	F	Sig.
Ber Sarai	7.666	2.555	16.688	0.000
Jia Sarai	11.989	3.996	45.618	0.000
Katwaria Sarai	9.701	3.234	26.442	0.000

7 Conclusion

Car parking demand has been evaluated using the demand equation, and a multilinear regression model has been used to determine the parking demand during night-time. Three types of surveys have been conducted at Ber Sarai, Jia Sarai, and Katwaria Sarai, Delhi, to collect data on parking vehicle accumulation and peak time. The result shows that Jia Sarai is highly congested compared to the other two locations, with a maximum number of parked vehicles of 69 and a peak time of 2 am. Factors that affect on-street parking demand have been analysed. The number of cars owned, the presence of garage facilities, and future car ownership are the parameters that are used to generate the demand model, and the result shows that all of these parameters are found to be significant. In this study, Jia Sarai shows less error than Katwaria Sarai and Ber Sarai, signifying that the Jia Sarai model predicts better results for the study location. This model and demand equation will help reduce and control future on-street night parking demand in residential areas.

A policy that controls or reduces the increase in car ownership and legislation that encourages public transit instead of private vehicles should be introduced. It is recommended that a parking fee should be charged in order to reduce the use of private cars in the city. A study in Hong Kong shows that only 7% of all commuters use personal cars (Travel characteristics survey, 1993) [16]. This is because car ownership is so low and expensive parking fees are enforced at the workplace. Therefore, this strategy is beneficial for decreasing car ownership and usage in cities. The land value should determine the parking cost in a specific location or the rent being charged for the same. Promoting the use of public transportation and reducing the use of private cars is also beneficial from the perspective of equitable transportation.

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