

# Analysis of Parking Demand and Supply for Residential Landuse

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**Abstract---**Most medium-size and large cities worldwide are suffering from parking congestion. With the number of motor vehicles rapidly increasing, urban parking has become an intolerable problem in major cities. The evaluation of parking facility service plays an important role in urban transportation planning and operation. Severe parking problems in congested urban areas have led to the use of non-traditional parking options such as elevated parking in residential buildings in some countries. The residents' choice of apartment is influenced by parking availability. Parking demand is affected by different factors like household income, family size, built up area, parking space available, and visitor parking space, number of vehicles, vehicle type and location of the building. Parking facilities are provided as per the parking policy norms (IRC: SP: 12). Regression models have been developed to show relationship between vehicle ownership and family size and family income to predict vehicle ownership in future. This gives future scenario for parking demand in future. This study will be useful for further modification for the parking guidelines for residential locations.

**Key Words---** Parking Congestion Parking demand, Parking supply, Parking policy norms

## I. INTRODUCTION

Parking is the act of stopping and disengaging a vehicle and leaving it unoccupied. Parking on one or both sides of a road is often permitted, though sometimes with restrictions. Some buildings have parking facilities for use of the buildings' users. Countries and local governments have rules for design and use of parking spaces. One of the most common problems today is the saturation of parking space. Vehicles continue to outnumber existing parking spaces, thus clogging roads. Incidences of violence over occupancy, deformed cars due to a space crunch, and overcharging for parking are some problems that result. Parking is one of the major problems that is created by the increasing road traffic. It is an impact of transport development. The availability of less space in urban areas has increased the demand for parking space especially in areas like Central business district. This affects the mode choice also. This has a great economic impact.

The recommended area requirement for residential parking varies according to the population in different types of cities. There are no separate provisions for cities having population less than 2 lakhs. For cities having population in the range of 2 lakhs – 10 lakhs, one car parking space is recommended for every 2 tenements having built-up area 101 – 200 sq. m. For cities having population in the range of 10 lakhs – 50 lakhs, one car parking space is recommended for every 1 tenement having 100 sq. m. built-up area. In the

cities with population of 50 lakhs and above, one car parking space is recommended for every 1 tenement of 75 sq. m. built-up area. For population more than 50 lakhs, one car parking space is recommended for every 50 sq. m. built-up area or 2 ECS (Equivalent Car Space) per 100 sq. m.

Parking is one of the serious problems that confront the urban planner and the traffic engineer. Before any measures for the betterment of the conditions can be formulated, basic data pertaining to the availability of parking space, extent of its usage and parking demand are essential. It is important to predict the parking demand by considering different factors like household income, family size, built up area, parking space available, visitor parking space, number of vehicles, vehicle type, location of the building, etc.



**Figure 1.0** Parking problem in Residential area



Figure 2.0 Parking Scenario in Residential building



Figure 3.0 Parking Board Example in Residential building

Parking space availability scenario is worse where there is mix land-use. i.e. residential scheme with commercial land-use along with shops and offices. There are two types of parking observed as per location of parking: On street and off-street parking. As per direction of parking types are as below:

- Parallel parking: parallel to street
- Angular parking: parking at 30°, 45°, 60°
- Right angle parking or at 90°

TABLE I. ECS (EQUIVALENT CAR SPACE) REQUIREMENT FOR VEHICLES

Vehicle Type	2-wheeler	Car / Taxi	3-wheeler	Bicycle
ECS	0.25	1.00	0.50	0.10

Source: URDPFI Guidelines, MoUD 2014

## II. STUDY AREA

Ahmedabad is the largest city and former capital of Gujarat state. It is located at 23.03°N 72.58°E on the banks of the Sabarmati River in north-central Gujarat. It is the fifth largest city with 6.2 million population and seventh largest

metropolitan area of India. To find out the Parking Demand in Ahmedabad city, 25 residential schemes which have their built-up area range is between 50-150 sq. m. are randomly selected.

TABLE II. LOCATION OF RESIDENTIAL BUILDINGS INCLUDED IN STUDY AREA

Sr. no	Residential building name	Ward name	Ward no.	Zone
1	Ilaj	KHOKHRA	57	South zone
2	Beleview	Thaltej	8	New West zone
3	Sukti	Thaltej	8	New West zone
4	Safal	Gota	1	New West zone
5	Rudra Greens	Lambha	60	South zone
6	Dev Elegance	Kankaria	46	South zone
7	Deep Kamal	Khokhra	57	South zone
8	Adharshila	Maninagar	58	South zone
9	Shyam	Maninagar	58	South zone
10	Viral	Khokhra	57	South zone
11	Kumkum	Maninagar	58	South zone
12	Yash-1	Khokhra	57	South zone
13	Sadhbhavna	Maninagar	58	South zone
14	Jeevan Saathi	Khokhra	57	South zone
15	Vidhi	Maninagar	58	South zone
16	Radhika	Maninagar	58	South zone
17	Yash-2	Khokhra	57	South zone
18	Gold Coin	Thaltej	8	New West zone
19	Sarovar-3	Maninagar	58	South zone
20	Mangalam	Maninagar	58	South zone
21	Gokul	Maninagar	58	South zone
22	Rudra-2	Lambha	60	South zone
23	Ganesh	Lambha	60	South zone
24	Saral-D	Gota	1	New West zone
25	Clifton	Danilimda	59	South zone

TABLE III. PARKING DEMAND AND SUPPLY FOR RESIDENTIAL BUILDING

RESIDENTIAL BUILDING	PARKING DEMAND	PARKING SUPPLY
ILAJ	64	51
BELEVIEW	22	16
SUKTI	60	48
SARAL	94	75

RUDRA GREENS	59	47
DEV ELEGANCE	23	16
D.K	50	38
ADHARSHILA	45	40
SHYAM	55	39
VIRAL	31	26
YASH-1	54	43
KUMKUM	43	38
RADHIKA	37	40
MANGALAM	35	28
YASH-2	34	30
GOLD COIN	41	32
SAROVAR-3	45	38
JEEVAN SAATHI	57	45
CLIFTON	59	48
SARAL-D	52	55
RUDRA-2	44	30
GOKUL	39	32
GANESHA	60	48
VIDHI	52	38

- Total no of persons - 112
- Built - up area - 85 sq. m. / unit
- Total number of vehicle - 64 (Parking demand)
- Two – wheeler - 54 numbers
- Four - wheeler - 10 numbers
- Building Age – 24 (1996)
- Visitor Parking not allowed / No space
- Total number of vehicles – 51 (Parking Supply)
- Two - wheeler - 45 numbers
- Four – wheeler - 06 numbers
- Parking Facility - At Ground & Peripheral

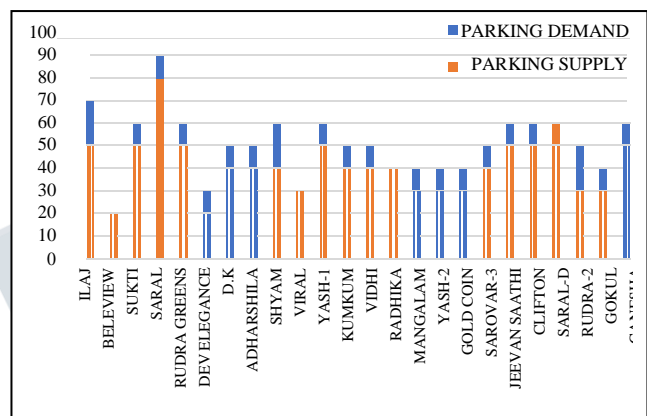


Figure 4. Number of 2-wheelers and 4-wheelers

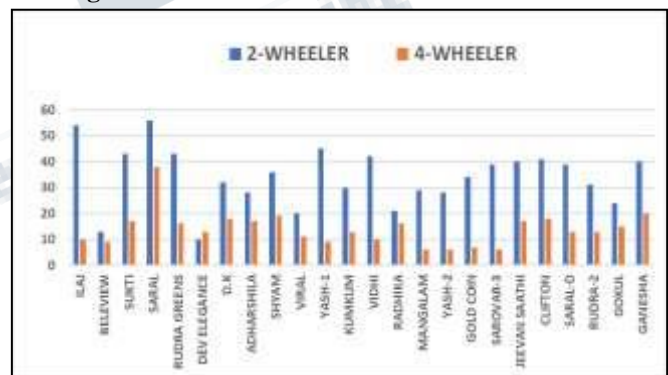


Figure 5 Parking Demand and Supply

### III. DATA COLLECTION AND DATA ANALYSIS

This research aims at identifying the main factors that affect Parking demand for residential building based on field surveys.

- 1) Home Interview Survey
- 2) Parking Survey

1) Home interview survey was conducted using web base questionnaire and details of different factors that affect parking demand like built-up area, household income, total number of vehicles, number of two-wheelers, Number of four-wheelers, if they are supposed to purchase car in future, family member, age, gender, occupations, etc. were collected. Data is collected using web-based questionnaire (google forms) by interviewing individual households at the residential buildings.

2) Parking survey was conducted to collect the data like available parking space, availability of visitor parking, if there is provision of allotted parking or not, parking is sufficient or not, etc. This data includes the details of the Parking Characteristics. This is real-time data collection and analysis as per interaction of author in the day to day life in the field of education and observations as a user of the road network of Ahmedabad. Hence, no specific literature review of technical papers is included here for reference.

Sample data collection for ILAJ Apartment is as shown below:

- G + 5 multi-storied building from 1993
- 36 number of Households (GF-2, FF-6, SF-8, TF-8, FoF-8, FiF-4)

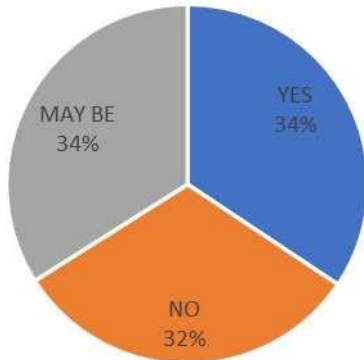
**Parking deficiency:** Average difference between Parking demand and supply is observed as 30% deficiency as shown below in Fig. 5.

**Suppose to purchase car in future:** From Home Interview survey, 34.4% people say that they are willing to purchase car in future. 31.6% of people deny to purchase car in future and 34% of people were confused or say may be purchase car in future as shown in Fig. 6.

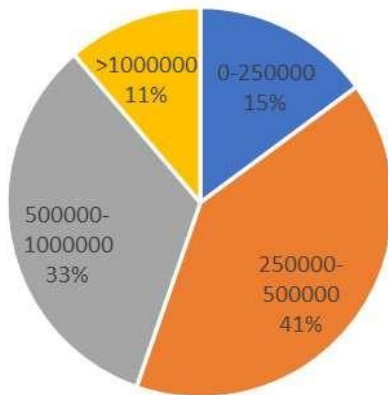
**Household income Per Year:** Distribution of Household income per year is defined in four ranges. 41% of Households have their annual income ranging between



2,50,000 to 5,00,000. 33% of households income per year ranges in between 5,00,000 to 10,00,000. Majority of household income per year is above range as shown in Fig. 7.



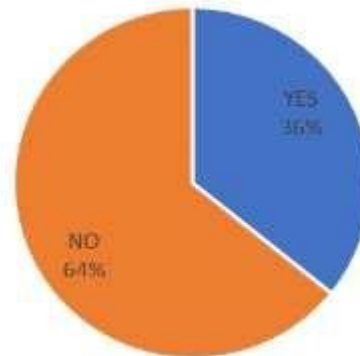
**Figure 7 Household Income in Rupees per year**



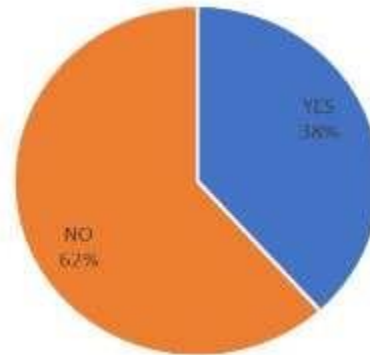
**Figure 6 Proposed Car purchase in future**

**Sufficient Parking:** From Home Interview survey, 64% of respondents said that parking was not sufficient in their residential buildings and 36% of respondents agreed that parking was sufficient as shown in Fig. 8.

**Convenient Parking:** From Home Interview survey, 62% of respondents said that parking was not convenient in their residential buildings and 38 % of respondents said that parking was convenient as shown in Fig. 9.



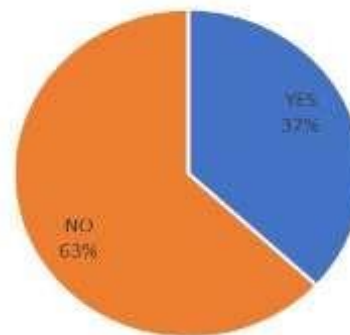
**Figure 8. Parking Sufficiency**



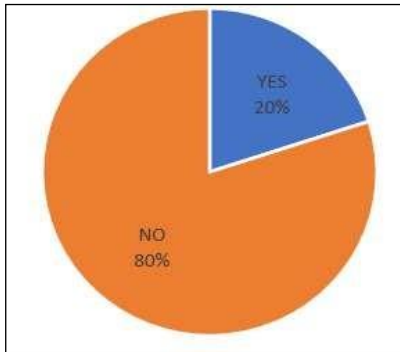
**Figure 9. Parking Convenience**

**Allocated Parking:** From Home Interview survey, 63 % of respondents said that provision of allocated parking was not there in their residential buildings and 37 % of respondents had provision of allocated parking in their buildings as shown in Fig. 10.

**Visitors Parking:** Around 80% of Residential buildings Visitor Parking not allocated and visitor Parking not allowed inside the residential schemes as shown in Fig. 11. Visitors either park on periphery or on street (occupying road width).



**Figure 10. Allocated Parking scenario**



**Figure 11. Visitor Parking scenario**

According to IRC: SP:12 - 2015 Guidelines for Parking facilities in Urban Areas, 0.25 multiplying constant is taken for two-wheelers and 1.0 is taken for four-wheelers to find out the ECS for that particular household.

model development

The main factors that affect parking demand for residential apartment buildings based on field surveys for randomly selected apartment buildings from Ahmedabad City. Field surveys were conducted to collect comprehensive data about parking demand for residential apartment buildings and their expected major influencing factors. A total no of 12 apartment buildings were surveyed from the Ahmedabad City.

Multiple linear regression (MLR) is used to determine a mathematical relationship among a number of random variables. In other terms, MLR examines how multiple independent variables are related to one dependent variable.

Collected data included the weekday building parking demand ( maximum number of parked cars by residents and visitors during weekdays), building age (years), number of floors, number of apartments in the building, building gross floor area (square meters), average apartment floor area (square meters), apartment income , average current apartment price, average apartment car ownership (It is the ratio of total number of cars owned by the residents of the building to number of apartments in the building), and building location. Stepwise regression analysis was used to identify the significant influencing factors and find the best model for predicting the parking demand for residential apartment buildings. The two variables Family size and Household income were found to be significant. Here two different models are developed for different built-up area like 50-100 sq. m. and 101-150 sq. m. here Select mainly these range of built-up-area because majority of the residential buildings built in that range.

$$Y = a + bX_1 + cX_2$$

Y = Total number of Vehicle = Two-Wheeler ( $Y_1$ ) + Four-Wheeler ( $Y_2$ )

$X_1$ =Family size

$X_2$ =Household income

$R^2$ =Coefficient of Correlation

➤ **Coding of variable categories**

For using the collected data as an input for Excel, the data first needs to be coded into numeric values as per variable categories.

Table IV shows the income groups and coding used for development of model. Income is taken as Rupees per year.

**Table IV Annual Income category and coding for model development**

Coding	Annual Income Group
1	< 2.5 Lakhs
2	2.5 – 5 Lakhs
3	5 – 10 Lakhs
4	>10 Lakhs

Source: Income tax Slab 2018-19 Year

**Model-1 For built-up Area 50 - 100 Sq. m.**

1) Dependent Variable  $Y_1$  = Number of Two-wheeler  
 $Y_1 = - 0.4430 + 0.1542X_1 + 0.6984X_2$

$$R^2 = 0.69862$$

In the Multilinear regression here additive constant is - 0.4430 and Multiplying constant for family size is 0.1542,for household income 0.6984.here coefficient of correlation  $R^2$  is 0.69862.Coefficient of correlation  $R^2$  of a model takes between 0 and 1,where values close to 1 imply more correlation and 0 implies no correlation.it describes how  $X_1, X_2$  and  $Y_1$  correlated. Here  $R^2$  values close to 1 which is 0.69862 so dependent variable and independent variable imply more correlation.

2) Dependent Variable  $Y_2$  = Number of Four-wheeler

$$Y_2 = - 0.5378 + - 0.0128X_1 + 0.4162X_2$$

$$R^2 = 0.63443$$

Here  $R^2$  values close to 1 which is 0.63443 so dependent variable and independent variable imply more correlation.

**Model-2 For built-up Area 101 - 150 Sq. m.**

1) Dependent Variable  $Y_1$  = Two - wheeler

$$Y_1 = -1.2571 + 0.3974X_1 + 0.5982X_2$$

$$R^2 = 0.58164$$

Here  $R^2$  value more than 0.50 shows dependent variable and independent variable imply good correlation.

2) Dependent Variable  $Y_2 =$  Four-wheeler

$$Y_2 = -3.5625 + 0.72917X_1 + 0.5730 X_2$$

$R^2 = 0.9082$

Here  $R^2$  values close to 1 which is 0.9082 so dependent variable and independent variable imply more correlation.

#### IV. CONCLUSION

From the study area as per sample size 25 number of residential buildings have been selected in Ahmedabad city. Data regarding the parking characteristics and socio-economic characteristics were collected by Home Interview Survey (HIS). Data analysis has been carried out in Excel.

The factors affecting the Parking demand for two different categories of built-up-area 50-100 sq.m. and 101-150 sq.m. are considered. Difference between Parking demand and supply is observed as 30%. Parking space provided is insufficient and it is recommended that in new residential schemes parking area provision should be more than the prevailing space. To overcome parking deficiency, it is recommended that no car purchases should be allowed where there are no parking spaces. Residents often suffer from spill over parking because of visitors and excessive vehicle ownership. Visitors are not allowed to park in residential schemes if they make social visit or visit for any purpose. Two-wheeler ownership is more compared to four - wheeler.

Model-1 for built-up area 50 - 100 Sq-m. for  $Y_1$  (Number of Two - wheeler) for  $R^2$  is 0.69862 and for  $Y_2$  (Number of Four - wheeler)  $R^2$  is 0.63443. Model - 2 for built-up area 101 - 150 Sq.m. for  $Y_1$  (Number of Two - wheeler)  $R^2$  is 0.58164 and for  $Y_2$  (Number of Four - wheeler) for  $R^2$  is 0.9082. Parking demand model based on family size and household income per year is showing good correlation among dependent and independent variables. Family size and household income are major factors affecting vehicle ownership and parking demand at residential landuse.

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