Feasibility Analysis For Planning Of Parking Markets In Commercial Areas

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Abstract

A balance of oversupply and undersupply of parking system has a striking influence on the overall transportation and land development system that helps to realize community development objectives such as land use efficiency, good urban design and economic vitality. The planning of such systems poses a critical threat to the planners especially in the crowded commercial areas where high land use intensity leads to poor level of service and operational conditions on the neighborhood supply systems. Parking markets acceptable to the road users that cater to the peak demands of the future traffic can reduce the intensity of congestion and can promote an improved transportation system in the urban fabric. An attempt has been made in this study to develop a framework for conducting the feasibility analysis for parking markets comprising of multilevel parking structures. The guiding principles for the feasibility check considered in the study are the user preferences, user demand profiles and the walking impedance to provide road user dominated system that meets the need of users and non-users. Preliminary traffic impact analysis of the proposed parking centers is also attempted on the neighborhood corridors to recommend the parking management measures. A case study of 3 parking markets in Powai area of Mumbai is taken for analysis.

Key words: Community development, neighborhood supply, parking markets, urban fabric, road user dominated system.

1. Introduction.

Parking plays an important role in mobility, access and the economic development of cities; at the same time, it is a profitable business for both the private and public sectors. Parking is an essential part of the overall transportation and land development system, as well as a means to help realize other community development objectives such as land use efficiency, good urban design and economic vitality. An oversupply of parking is costly for business, visually unattractive, and may negatively impact urban design and streetscape. Conversely, an undersupply of spaces may compromise access and circulation, and create spillover problems for adjacent uses. It is, therefore, important for the supply of parking to strike a balance between oversupply and undersupply.

2. Purpose and Objectives of study.

The purpose of study is to assess parking demand for the design of Multi level car parking facilities in some selected stretches in Powai, Greater Mumbai. Following are the specific objectives framed in the study.

- Development of a comprehensive parking plan for the study area
- Future parking demand assessment
- Identify the location and concentration of any parking surpluses;
- Examine utilization of on-street spaces in terms of maximizing the availability of convenient short-term, on-street parking areas that depend on that support.
- Evaluate the effectiveness of current enforcement against standards recognized within the government.

- Identify any parking related problems and suggest remedial measures
- Preliminary traffic impact analysis due to parking markets

3.0 Literature Review.

Parking plays an important role in the transport system since all vehicles require storage.Parking demand problems have been studied for many years and got much progress on approach. The approaches can be divided into three types, the Network analysis model, Probabilistic models and linear programming models.

The first one, such as Young [1] used the Network analysis models for the center business district area of Cincinnati. Because of the geographical location, the CBD has limited alternatives to cope with major traffic demands. Sleepy Hollow [2] used the characteristics like Land use profiles, Roadway characteristics, Intersections in the area of influence, Location of bus stops, Traffic characteristics, Parking characteristics, Travel profiles, Utilities for the analysis and location of parking sites. Xiuyuan ZHANG, Yaming SHAO [3] and Wilbur Smith [4] assessed the parking demand using Parking usage survey, Parking Intercept survey and classified volume count surveys. Rich and Associates [5] evaluated the current and the Future Parking Demands considering all the relevant parking characteristics. Shoup [6] assessed parking demand based on the accumulation of vehicles parked at a given time. Shoup[7] found that many people assume that their parking demand will be met at no cost, thus cities use peak demand for free parking spaces to determine the required parking ratios . Shoup, advocating getting rid of parking requirements all together, argues that by eliminating the inefficiency of requiring off-street parking, over time the "ratio of parking spaces to people will decline" and the cost of parking will increase . Tsukaguchi [8] provided an overview of traffic management giving considerations on parking. Tsukaguchi and Jung [9] studied and developed a parking assignment model for the High-tech Business District of Osaka City, Japan. The future parking demand based on the Trip attractions and the feasibility of the parking market can be found out from the network analysis as described by Russell, G. T. and Anthony, J.R.[10].

The second is the Probabilistic models which gives the analysis of the existing parking demand based on the attraction indices as described by Evans, S.P[11].

In linear programming models, the objective function minimizes the modified walking distances of users from parking lots to destinations over the study period subject to the demand and supply constraints. The modified walking distance, in fact, consisted of two terms; the actual distance and the parking fee. Eldin et al. [12], Anthony Gibbons[13] studied the parking issue in the High-tech Business District by integrating parking with the traffic assignment problem. Theoretically, two link types had been proposed in their study. They are real links and imaginary links that were utilized to connect real links with the destinations. The imaginary links consisted of searching-time links, parking links and walk links. The searching time links corresponded to the time that driver spends in finding a parking space. The parking links represented the parking fee that users had to pay for their parking. The walk links accounted for the walking time from the parking lot to the destination.

4.0 Methodology.

The methodological framework has been framed under the following modules.

4.1 Module 1: Development of GIS base map of the area of influence.

GIS base map development involves identification of road network under the area of influence of the study area, spatial referencing the road network with GPS coordinates and projecting the map using a suitable reference system. The area of influence is selected based on the acceptable walking distance to the proposed parking markets which is considered as 0.5 km.

4.2 Module 2: Survey development and data schema.

Surveys for road network characterization, travel pattern and traffic characterization , parking characterization gives an input data required for analysis. Series of surveys to be conducted with its relative importance to assess parking demand is given in table 1.

Table 1: Surveys and its relative importance.

S. No	Name of survey	Details collected during the survey	Duration of survey	Method adopted
1	Road inventory survey and parking space inventory survey	Total length of kerb, and lengths governed by no waiting and limiting waiting restrictions Number of parking spaces provided on the street Street width Location of bus stops, bus bays, pedestrian crossings etc that are likely to affect the use of the street for parking Traffic management measures in force, such as prohibited turns, one way streets, exclusive bus lanes etc Number and type of traffic signs for regulation of parking Median locations Information on parking lots	-	Manual
2	Reconnaisance survey	Identification of existing parking locations – on street and off-street Vacant or unused land suitable for temporary or permanent parking spaces. Existing land use details Upcoming establishments in the area of influence	-	Manual
3	Parking usage survey	No. of parked vehicles	16 hrs on a neutral weekday and weekend	Patrolling
4	Parking intercept survey	extent of usage of the parking facilities, parking requirements and demand, the distribution of demand over an area and time journey purposes of car parkers	16 hrs on a neutral weekday and weekend	Stated preference approach / Opinion survey
5	Classified volume count survey	Traffic flows on major links in the area of influence	12 hr counts on 2 neutral weekdays and one week end	Manual

The parking study initially evaluates existing conditions, determined primarily through parking occupancy surveys, and intercept surveys through interviews. The examination of existing conditions provides the baseline data from which future development, with its impact on parking supply and demand, could be evaluated.

4.3 Module 3: Assessment of existing parking demand.

Existing parking demand is assessed in terms of parking accumulation, parking index, parking turnover, parking utility on the road links in the area of influence. The parking demand from the upcoming development is to be considered to assess the total demand in the analysis.

4.4 Module 4: Determination of attraction potential for the parking markets.

Impedance factor measured in terms of distance governs the attraction of the parking users to the sites. To identify the probability of attraction to a parking market site, a statistical distribution function is fitted from the distance matrix.

4.5 Module 5: Estimation of trip growth rate

The trip growth is a function of the demographic and socio economic factors like population, employment, workers and vehicle registrations. The past growth trends were analyzed and the future parking demand was assessed based on the trend analysis. A design period of 30 years was considered for the analysis.

4.6 Module 6: Future parking demand estimation.

The growth rate of trips or parking users is considered as a proxy to the growth rates of population, employment and vehicle registrations. An average of the growth rates is considered for the study to assess the future parking demand in the area.

4.7 Module 7: Preliminary traffic impact analysis of parking markets.

Preliminary traffic impact analysis is done to know the impact of the parking markets on the traffic. The intersections and the major links that area affected in the area of influence are considered in impact assessment.

4.8 Module 8: Feasibility of the location of parking markets.

Feasibility on the location of parking markets is done based on the future parking demand assessment and the traffic impacts of the parking markets. The framework is outlined in Figure 1.

the identified study locations to assess the demand for multi level parking facilities. An approximate radius of about 800 m was covered under the study as

5. Study area.

Three sites namely Jalvayu Vihar site, Bus Terminal site, Fab India site in Powai, Mumbai are more potential was observed during the reconnaissance survey. The land use in the area of influence is dominantly residential establishments followed by retail / office and commercial establishments. Nine major roads, Poway road, Orchard Avenue, Birchwood street, High street, central avenue, forest street, Ridge street, Lake Blvd Road, Jalvihar road have been identified in the area of influence. Powai road is the major arterial road amongst all the roads and all the corridors connect to the Powai road. Nine stretches of parking locations have been identified in the area of influence that has proximity to the parking sites identified. The location of parking stretches with their extent is shown in the figure 3. All the parking lots identified are unauthorized on street parking lots.

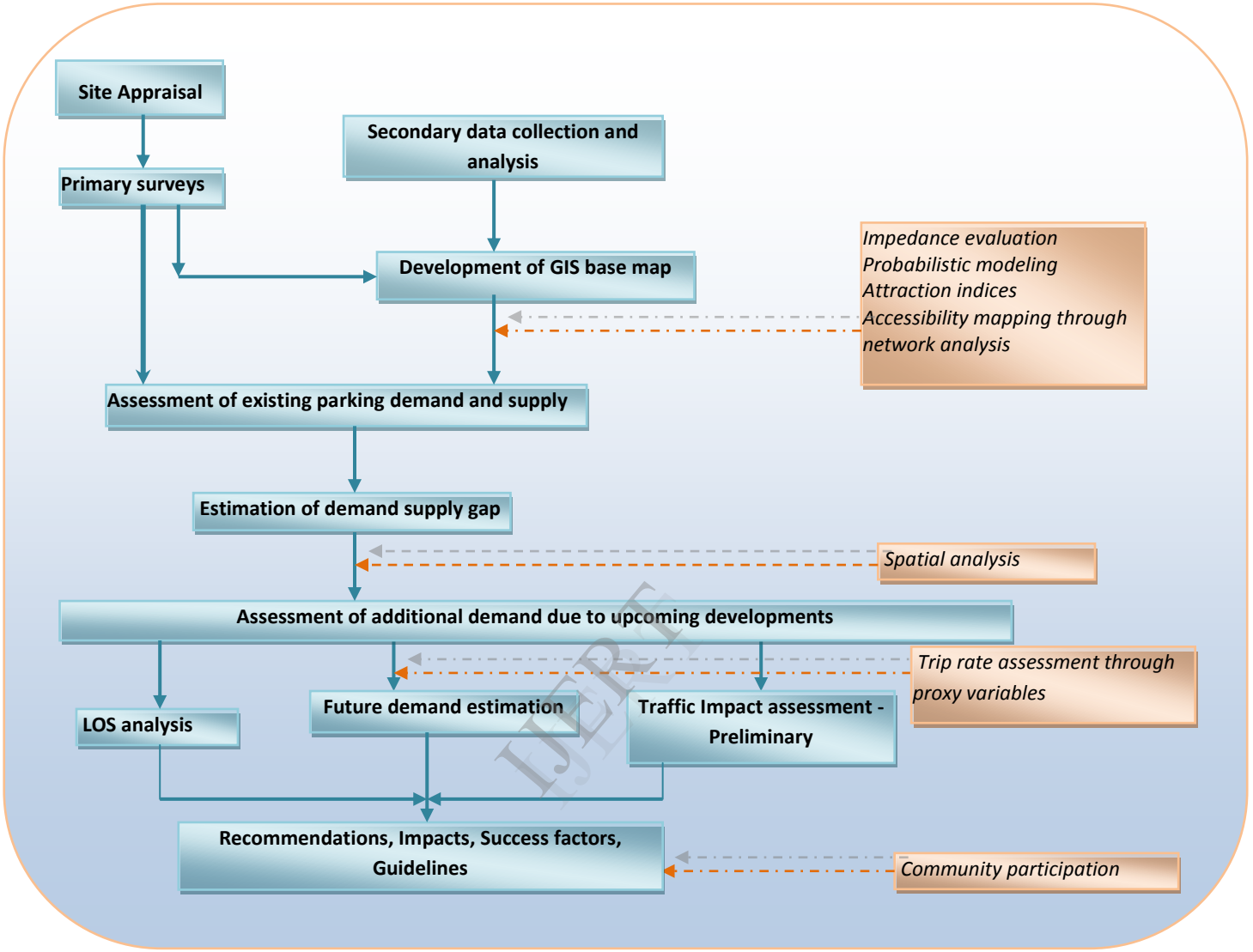

Figure 1. Methodology adopted for the study

6.0 Application of Methodology.

The methodology is applied to the study area in the following modules.

6.1 Module 1: Development of GIS base map of the area of influence.

The GIS base map developed showing the existing parking locations is shown in the figure 2

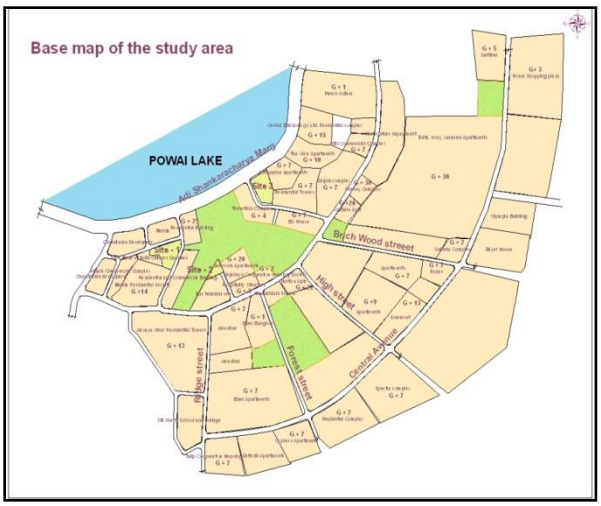

Figure 2. Base map of the study area

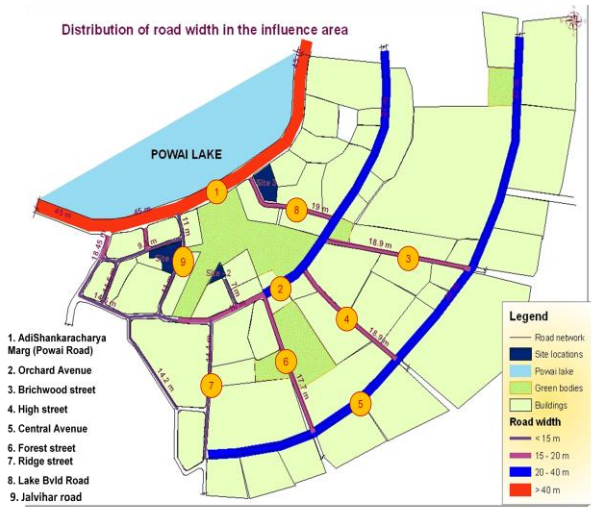

Figure 3. Location of parking spots in the study area- Their variation with respect to widths.

6.2 Module 2: Survey development and data schema

The surveys mentioned in table 1 of methodology have been conducted in the catchment area of the site. Nine locations were identified in the influence area for the parking usage survey which are shown in figure 3.

The peak and total parking accumulation, peak parking hour, parking turn over are presented in table 2 below

Table 2. Critical parking parameters after comparison of week day and week end profiles

S.No	Road name	Total parking accumulation in ECS	Peak parking accumulation in ECS	Peak parking turnover	Peak parking hour
1	Fab India - BG	887	48	5.57	7:00 PM
2	BG – Orchid	4335	196	14.9	11.30 am
3	Histreet – Somerset	729	39	7.77	8.30 pm
4	Bayer – BG	1791	94	11.1	12.30 pm
5	Bayer – Shopping	3172	184	11.74	3.30 pm
6	Jalvayu – School	835	65	8.5	1:00 PM
7	Bayer – School	2726	130	8.99	7.30 pm
8	Bus terminal – Site	690	37	13.9	1.30 pm
9	Hiranandani School – OS Garden	1312	77	7.03	6:00 PM

Parking index is the percentage of theoretically available number of parking bays actually occupied by parked vehicles. The peak parking index and the average parking index observed during 15.5 hours is represented in the table 3. Parking utility which is the percentage of parking capacity by parking accumulation is also indicated in the table

Table 3. Parking index and utility characteristics of parking lots.

SNO	Road name	Peak Parking index in %		Average parking index observed during 15.5 hours in %		Parking capacity in ECS	Peak parking accumulation in ECS	Parking utility in %
		Week day	Week end	Week day	Week end			
1	Fab India - BG	62	61	35	35	92	48	52
2	BG – Orchid	100	81	86	49	171	196	115
3	Histreet – Somerset	85	81	47	48	48	39	81
4	Bayer – BG	100	100	71	72	48	94	196
5	Bayer – Shopping	100	93	66	47	165	184	112
6	Jalvayu – School	100	90	51	52	50	65	130
7	Bayer – School	87	57	58	35	180	130	72
8	Bus terminal – Site	100	100	82	85	22	37	168
9	Hiranandani School – OS Garden	82	32	44	20	97	77	79

About 10% of the sample is chosen for the parking intercept survey. It has been observed that the parking users constitute majority of cars followed by two wheelers. Mumbai city has been divided into 11 zones where first zone falls under Powai. The user's responses on the approximate distance from parking lot to the destination 65% of the parking users walk at a distance of less than 100m. 32% of the users have trip purpose as work, 19% shopping, 21% leisure and 28% others. In the area of influence, 47.5 % users have come for the basic purpose of the work. Out of 47.5 %, 19.3 % are residents, 49 % are visitors and 31 % are workers. Majority of the residents visit daily for work and majority of the visitors visit occasionally for work. Most (36 %) respondents occasionally drive to the area. Twenty three percent (23 %) are weekly visitors while 21 % are infrequent visitors. The vast majority (72 %) park for less than one hour indicating the need for an adequate supply of short-term parking.During the observations and survey of the area, most of the users were able to find parking within two to four minutes. The fact that over 20 % need more than two minutes to find parking may indicate a need to improve the parking availability in the area due to lack of parking areas. On an average, 59% of the users were satisfied with the existing facility whereas 41% were not satisfied.

6.3 Module 3 and 4: Existing parking demand and attraction potential for the parking markets.

The distance matrix obtained from the network analysis is shown in the table 4 below. The values in the matrix indicate the shortest distance in meters from the parking lot to the three sites individually.

Table 4. Distance matrix.

SNO	Road name	Distance in meters		
		Site 1	Site 2	Site 3
1	Fab India - BG	195	300	0
2	BG – Orchid	448	308	220
3	Histreet – Somerset	457	173	347
4	Bayer – BG	478	245	275
5	Bayer – Shopping	864	661	636
6	Jalvayu – School	216	67	587
7	Bayer – School	496	380	636
8	Bus terminal – Site	283	0	520
9	Hiranandani School – OS Garden	350	67	453

Impedance factor measured in terms of distance governs the attraction of the parking users to the sites. To identify the probability of attraction to a site, an exponential distribution function is fitted. Since the acceptable data range for an exponential distribution function ranges from 0 to 4, the distance matrix has been normalized to the scale of 0 to 4. Probability of attraction is inversely proportional to the impedance factor. Hence zero normalization indicates high attractiveness whereas 4.0 scaling indicates less attractiveness. The normalized matrix is shown in the following table 5.

Table 5: Normalized matrix to a scale of 0 to 4 (Effective area in exponential distribution)

SNO	Road name	Site 1	Site 2	Site 3
1	Fab India - BG	0.90	1.39	0.00
2	BG – Orchid	2.07	1.39	1.02
3	Histreet – Somerset	2.12	0.80	1.61
4	Bayer – BG	2.21	1.13	1.27
5	Bayer – Shopping	4.00	3.06	2.94
6	Jalvayu – School	1.00	0.31	2.72
7	Bayer – School	2.30	1.76	2.94
8	Bus terminal – Site	1.31	0.00	2.41
9	Hiranandani School – OS Garden	1.62	0.31	2.10

The objective function is minimization of distance which is represented as

$$P(x) = e^{-x}$$

Where P(x) is probability of attraction when the impedance factor is x. X is the impedance factor which is the normalized distance to a scale of 0 to 4. The probability of attractions measured through the exponential function is given below.

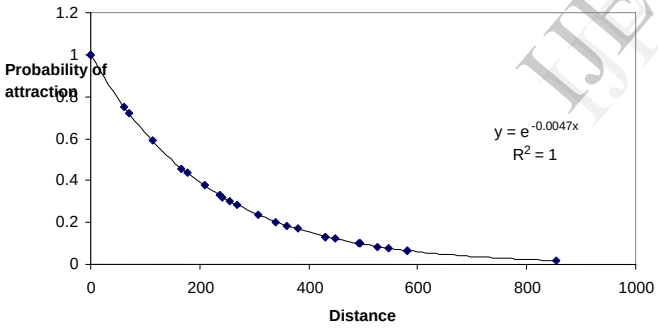

Figure 4 . Measurement of exponential function

Table 6: Attraction indices in percentage:

SNO	Road name	Site 1	Site 2	Site 3
1	Fab India - BG	0.0	0.0	100.0
2	BG – Orchid	0.0	34	66
3	Histreet – Somerset	0.0	74	26
4	Bayer – BG	0.0	61	39
5	Bayer – Shopping	0.0	0	20.0
6	Jalvayu – School	32.0	68	0
7	Bayer – School	20.0	55	0
8	Bus terminal – Site	0.0	100	0
9	Hiranandani School – OS Garden	0.0	100	0

Based on the attraction indices and the peak parking accumulation in the parking lots, the number of lots possible in each site is worked out.

Table 7: Parking users (ECS) attracted to each site from parking lots in the influence area

SNO	Road name	Site 1	Site 2	Site 3
1	Fab India - BG	0	0	48
2	BG – Orchid	0	67	129
3	Histreet – Somerset	0	29	10
4	Bayer – BG	0	57	37
5	Bayer – Shopping	0	0	37
6	Jalvayu – School	20	45	0
7	Bayer – School	26	72	0
8	Bus terminal – Site	0	37	0
9	Hiranandani School – OS Garden	0	77	0

The additional parking demand due to upcoming developments are worked out based on the visual extent and areas of upcoming establishments

Description	Site 1	Site 2	Site 3
Total users attracted to each site (ECS) = Existing Parking demand	46	383	261
% of parking demand attracted to each site	7	55	38
Additional parking demand due to upcoming establishments	40	35	25
Total parking demand	86	418	286

The existing parking demand for the parking market site 1 is 289, and site 3 is 510.

6.4 Module 5: Assessment of trip growth.

The past growth trends were analyzed and the future parking demand was assessed based on the trend analysis.

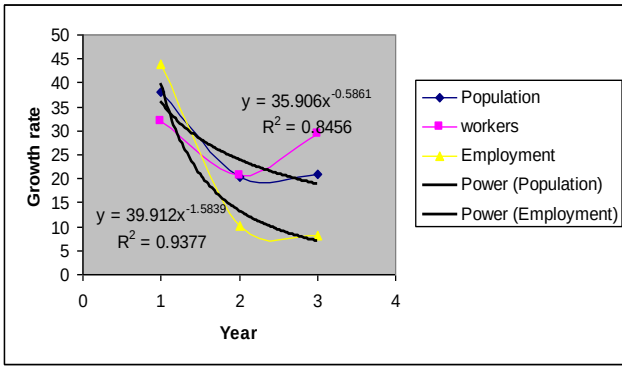

Figure 5 . Assessment of growth rate of trips

The projected growth rates are shown in the table 8.

Table 8: Projected growth rates in %

Year	Projected growth rate of population	Projected growth rate of employment	Projected growth rate of vehicle registrations	Average growth rate
2001 - 2011	15.9	4.4	136.4	52.2
2011 - 2021	14.0	3.1	137.3	51.5
2021 - 2031	12.6	2.3	138.0	51.0
2031 - 2041	11.5	1.8	138.6	50.6

6.5 Module 6: Future parking demand estimation.

The future parking demand forecasted is shown in the following table

Table 9. Future parking demand in ECS.

Year	Site 1	Site 2	Site 3
2012	86	418	286
2014	95	488	325
2021	121	664	583
2031	182	1002	881
2041	275	1510	1327

6.6 Module 7: Preliminary traffic impact analysis due to parking markets.

The additional volume on the links and the junctions is estimated based on the traffic mobility patterns and the network analysis. The additional volume generated during the peak hour (12.30 pm) on the intersections in the area of influence is as follows.

Table 10. Additional volume generated during peak hour at the intersections at the area of influence.

Intersection name	**Additional volume generated during peak hour in pcu / hr**
BG House Junction	428
Jalavayu vihar Jn.	29
NMDC Jn.	0
Bayer House Jn.	36
SM Shetty School Jn.	19
FAB India Jn.	0
Total volume	**512**

BG House junction is the highest affected junction if the parking markets are open. It is recommended for signalization at this junction. Other junctions in the area of influence are not affected by the opening of parking markets. The additional volume generated during the peak hour (12.30 pm) on the links in the area of influence is as follows.

Table 11: Additional volume generated during peak hour

Link name	Additional volume generated during peak hour in pcu / hr	Influence observed by the parking lot numbers
Powai road	-	-
Orchard Avenue (BG – Orchid or Jalvayu –BG)	428	2,3,4,5,6,7,9
Brichwood street (BG – Bayer)	36	5,7
High street (High street – Somerset)	33	7
Central avenue (Bayer – Shopping)	-	-
Forest street (Hiranandani school - OS Garden)	35	7
Ridge street (Jalvayu – School)	19	7
Lake Blvd road (Fab India – BG)	268	2,3,4,5
Jalvihar road (Jalvayu – Junction)	29	6,7

Out of all the links / corridors in the influence area, Orchard avenue road is the worst affected road on opening of the parking markets at the proposed sites.

6.7 Module 8: Feasibility of the location of parking markets.

Existing parking demand in ECS is 790 for the entire area of influence, out of which 86 are influenced to site 1, 418 to site 2 and 286 to site 3. The future demand at the end of design life of 30 years is 3112 ECS , out of which 275 attribute to site 1, 1510 to site 2 and 1327 to site 3.The parking demand can be considered to the sites when there is a complete restriction to parking on all the sites. Site 2 and 3 are found to have highest potential to attract parking.

7. Conclusion.

A series of parking surveys were undertaken to examine how the proposed development's demand would impact parking markets. Within an acceptable walking distance from the site (the parking survey area) it was found that there were potentially 789 safe car parking spaces. By the end of 2041, it is forecasted that there is a need for 3112 car parking spaces.

Since all the parking lots in the area of influence are unauthorized parking lots, the potential to the parking markets can be considered if the parking is restricted on the road. But some of the roads in the area of influence offer high level of service inspite of onstreet parking. But based on the existing functional hierarchy of roads , these roads are categorized as sub arterial or collector streets as they are directly connected to an arterial road. Hence it is recommended to impose parking restriction on the roads which increases the potential of the proposed parking markets.

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