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Traffic Impact Assessment for Sustainable Development in Urban Areas

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Abstract

Since long, Traffic Impact assessment (TIA) has been recognized as an integral and mandatory part of Environmental Impact assessment in developed countries. Accordingly, it is mandated that any proposed development expected to generate 100 or more additional / new trips during peak hours should undergo a TIA. However, in developing countries like India, TIA has gained importance only during the last decade spearheaded by the need to develop sustainable solutions to the congestion problem. In this paper we discuss the findings of two case studies one being an official complex coming up close in the Central Business District (CBD) area of New Delhi, India and the other being the assessment of the impact due to proposed extension of an Information Technology (IT) Park located at the Special Economic Zone at a distance of 4 Kms from the corporation limits along the eastern periphery of city of Madurai, Tamilnadu, India. The case studies highlight the importance of TIA and brings out the need to make TIA an integral and mandatory requirement in the case of new as well as capacity augmentation.

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1. Introduction

Traffic Impact assessment (TIA) gives a comprehensive overview of the traffic pattern changes on the network encompassing the proposed development. The traffic impact of the development often dissipates in its intensity with its maximum impact on the felt on the road links adjacent to the network as compared to further away from the development, (Botha J.L 2005, Withanaarachchi, B 2012). The impact of the development depends on the envisaged trips being generated from the same. The Institute of Transportation Engineers (ITE) provides a clear guideline on the horizons for which the impact assessments are to be carried out (refer Table 1). The Environmental protection act 1986 (29 of 1986) of India indicates that for any development in Indian context, a EIA needs to be submitted in accordance to the rule for any envisaged new / modified infrastructure development.

Table 1: Appropriate study horizon years (source: ITE journal, 19, 1988)

Development Size	Suggested Horizons
Small (generating less than 500 peak hour trips)	Anticipated opening year assuming full build out and occupancy
Moderate (Single Phase) 500-1000 peak hour traffic	<ol style="list-style-type: none"> 1. Anticipated opening year assuming full build out and occupancy 2. Adopted transportation plan horizon year if the development is significantly larger than that included in the adopted plan or in forecasts for the area.
Large or single phase (over 1000 peak hour traffic)	<ol style="list-style-type: none"> 1. Anticipated opening year assuming full build out and occupancy 2. Adopted transportation plan horizon year
Moderate, Large or multiple phase	<ol style="list-style-type: none"> 1. Anticipated opening years for each major phase, assuming full build out and full occupancy of each phase 2. Anticipated year of complete build out and occupancy 3. Adopted transportation plan horizon year 4. Additional years when major area transportation improvement is completed.

2. Methodology

As indicated in Table 1, the influence area of TIA is assessed based on the number of anticipated trips from the proposed complex. In the current paper we shall look into two case studies highlighting the steps involved in assessment of trips generated from the proposed complex and the impact the trips shall have on the overall traffic. The broad methodology for any TIA irrespective of the defined influence area comprises of the steps shown in Figure 1.

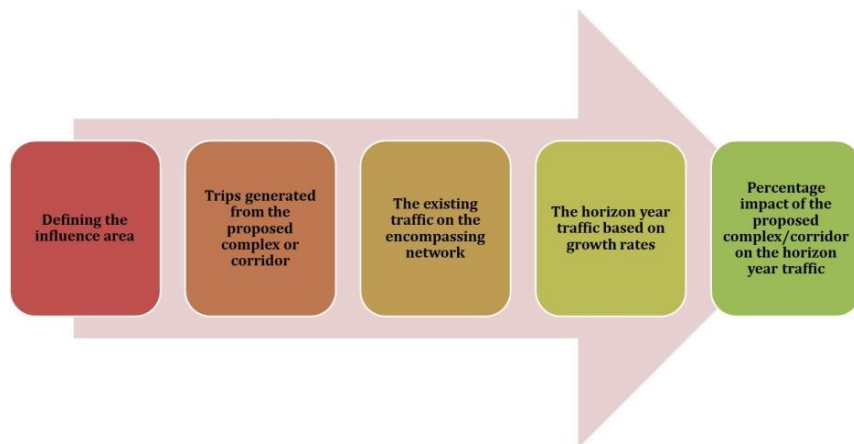


Fig 1 Essential steps involved in Traffic Impact Assessment

The definition of the influence area would invariably start with the reconnaissance survey of the study area to identify the possible traffic and transportation planning studies to be carried out (Xinhao, W.,2004). This would help to derive envisaged trips from the proposed complex. The traffic studies essentially must comprise of the classified traffic volume counts of the roads within the influence area, the occupancy survey, speed and delay studies of the influence area road network, coupled with questionnaire survey of similar establishments, complexes. In addition to the above, other associated studies such as parking studies and pedestrian studies shall be carried out based on the requirement of the study area. The questionnaire survey (either house hold survey or establishment survey) shall enable the quantification of trips being generated from similar developments and shall help in determining the number of trips from the current development.

Traffic volume count and the occupancy survey shall quantify the trips currently plying on the influence area network. The growth rates as established from the econometric analysis of the Per Capita Net State Domestic Product (NSDP) or Per Capita Income (PCI) for individual vehicles types shall be used for predicting the horizon year traffic. The proportion of the generated traffic from the proposed development vis-a-vis the horizon year traffic shall be used to assess the TIA of the proposed development. We shall now highlight the above methodology using two separate case studies impressing upon the varying nature of anticipated trips from the proposed development. During the course of the analysis, the horizon year assessment is done for 5 and 10 year period after the commissioning of the proposed development, Chen J et.al (2009).

3. Case study 1:

Delhi Metro Rail Corporation (DMRC) has given due consideration to assess the traffic impact due to a proposed office complex at 8 Jantar Mantar Road, New Delhi, which is located closer to the Central Business District (CBD) of New Delhi Municipal Council (NDMC). The proposed office complex is bound by Ashoka Road, Parliament Street / Sansad Marg and Jantar Mantar Road on its south, west and east sides respectively. Some of the office buildings located on the north west of the project site have up to 5 floors and Patel Chowk metro station lies in south. The historical monument of Jantar Mantar is located about 200 m away north of the site. DMRC in its effort to construct the office complex had approached NDMC who had sought clarification from MoUD and DDA, which in turn had referred to get the viewpoints of Delhi Traffic Police to understand whether the complex would add to the traffic congestion on the adjoining roads. In order to understand if indeed such an impact would arise, DMRC had approached CSIR - CRRRI vide their letter dated DMRC/CE-PD/JMNM/2016-06 dated 4.11.2016 to conduct a scientific study to assess the traffic impact.

3.1 Objectives of the study

- To estimate the passenger/vehicular traffic generated by the proposed DMRC office complex and assess the impact of traffic on the adjoining road network.
 - Enumeration of the existing traffic flows on the major road links in the vicinity of the proposed development and appreciate the present and future traffic scenarios on the adjoining road network.
- Focus of Evaluation

3.2 The main scope of the work is as follows

- Identify the road network that is likely to be affected / used by the proposed office complex development and the assessment of the travel characteristics of the commuters
- Study the present operating conditions of traffic in the influence network and also project the future traffic on the adjoining road network.
- Estimate the quantum of travel / traffic that will be generated by the proposed development.

- Conduct studies that are required to estimate the impact of generated traffic from the proposed development and assess the magnitude of impact and draw the necessary inferences that could help in decision making.

3.3 Study Area:

The proposed study area is located at a distance of 1.5 km radial to the Central Business District area (CBD). It is surrounded by Ashoka Road, Sansad Marg and Jantar Mantar Road. It has several office complexes such as the Sanchar Bhavan, Jeevan Deep building and Jeevan Tara building. It also houses the Patel Chowk metro station. Since the proposed office complex is expected to accommodate MNC and Corporate Offices it has been understood that a substantial number of trips can be made by cars with minimal number of visitors in a day. Since the adjoining road of Jantar Mantar is a regular location for conduct of strikes and procession; in the event of such an occurrence the available right of way to the traffic needs to be assessed. Figure 2 shows the study area and the proposed office complex location.

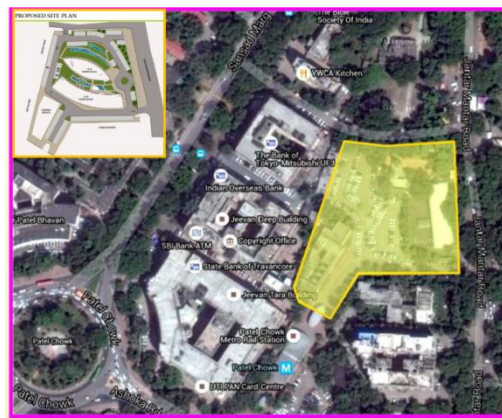


Fig 2: Study Area - DMRC

In order to assess the base year traffic, the traffic volume counts, pedestrian counts, parking studies, occupancy studies, speed and delay studies were carried out at the adjoining network namely Ashoka Road, Sansad Marg and Jantar Mantar Road. The observed base year traffic flow patterns at present i.e. as of 2017 on the adjoining roads are shown in Table 3 which comprises of 12 hour traffic flow along with the Peak Hour Traffic presented both in terms of total vehicle and Passenger car Units (PCUs). Basically, PCUs have been derived based on IRC: 106 (1990)

Table 2: Traffic flow pattern on the adjoining roads as on 2017

Name of the Road	Total Traffic	Peak hour Traffic	Peak Hour PCU
Ashoka Road	44056	3690	3983
Sansad Marg**	24192	3729	5059
Jantar Mantar Road*	1467	155	179

*there was partial restriction of traffic (11 A.M. to 2 P.M) and there were strike happening. Hence the traffic on the road was somewhat lesser than on normal days.

** There was partial restriction traffic movement between (9 A.M. to 2 P.M.) due to Parliament Session happening. Hence the traffic on the road was somewhat lesser than on normal days.

3.4 Base year Trips and Traffic

Based on the passenger occupancy survey, the number of private vehicle trips passing through the encompassing roads of the study area in the base year (refer Table 3) was determined. As the first step, the built-up area available

in the influence zone was earmarked which was found to be 49767 sq meters. From the establishment survey, the average trip rate per square metre was found to be 0.32 trips/sq metre which implied that a total of 15925 trips would be generated on a typical working day from the study area which included both the originating as well as destining trips. A look at Figure 3 reveals that 33.5 % of the trips used private vehicles to perform their trips to the offices located in the vicinity of the study area. Considering the above estimated share of private vehicles, it was deduced that out of the 15925 trips, 5335 trips were made using private vehicles.

Table 3: Estimated Base Year Private Vehicle Trips on various Roads encompassing the Study Area

Road Section	Direction	Passenger Trips	Passenger Trips by Two
		By Car	wheeler
Ashoka Road	Towards Patel Chowk	19258	5186
	Away from Patel Chowk	20286	4884
Sansad Marg	Towards Patel Chowk	13245	21912
	Away from Patel Chowk	9825	1396
Jantar Mantar Road	Towards Jantar Mantar	565	235
	Away from Jantar Mantar	463	302

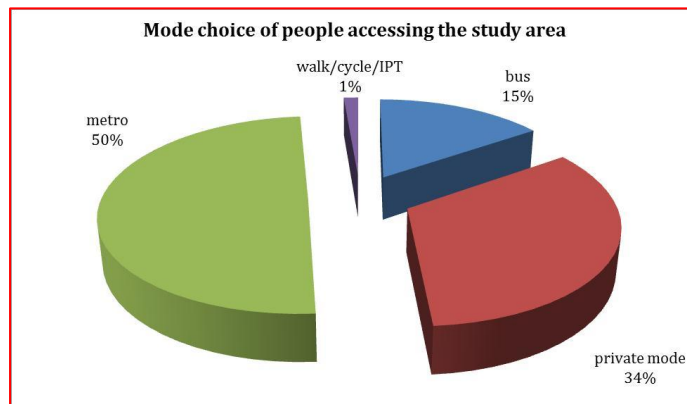


Fig 3: Mode Choice of people accessing the DMRC complex

Based on the primary data collected through the questionnaire survey, the distribution of traffic onto the adjoining links encompassing the study area was estimated and presented in Table 4. The percentages in Table 4 indicate the percentage of private trips originating / terminating within the study area with respect to the total number of private trips plying on the adjoining roads.

Table 4: Distribution of Private Vehicle Trips on to the Adjoining Road Links in the Study Area

Road Name	Ashoka Road	Jantar Mantar Road	Sansad Marg
Base year: Private vehicle (cars + two wheelers) Trip distributed on adjoining roads from study area	1119	1549	2668
Percentage of private vehicle trips (cars + two wheelers) on the roads in proportion to the base year total trips	2.2	98.9**	6*

*During the survey a partial blocking of vehicles along Sansad Marg was observed between 9 A.M. to 2 P.M..Hence the percentage shown is the worst case scenario percentage and will reduce further if the traffic is plying at its full strength on Sansad Marg.

**During the survey a partial blocking of vehicles along Jantar Mantar area was observed between 11 A.M. to 2 P.M..Hence the percentage shown is the worst case scenario percentage and will reduce further if the traffic is plying at its full strength on Jantar Mantar Road.

The above estimated passenger vehicle trips has been converted into traffic flow and presented in Table 5 which basically depicts the percentage of base year traffic by various vehicles types contributed from the study area to the total number of private traffic during the study period using the adjoining road links namely, Ashoka Road, Jantar Mantar Road and Sansad Marg. Table 5 is obtained by converting Table 4 into firstly car and two wheeler trips and secondly by dividing the trips with occupancy.

Table 5: Base Year Quantum of Private traffic contributed to the Adjoining Road Links of the study Area

Road Name	Numbers			
	Small Car	Car	Two wheeler	Total
Ashoka Road	406 (1.44)	69 (0.24)	185 (0.65)	660 (2.33)
Jantar Mantar Road*	326	45	319	690
Sansad Marg**	879 (6.53)	228 (1.7)	343 (2.55)	1450 (10.78)

*During the survey, a partial blocking of vehicular traffic movement on Jantar Mantar area was in vogue between 11 A.M. to 2 P.M; Hence the percentage shown is the worst case scenario percentage which will reduce further if the traffic is plying at its full strength on Jantar Mantar Road.

**During the survey a partial blocking of vehicles along Sansad Marg was observed between 9 A.M. to 2 P.M. hence the percenta ge shown is the worst case scenario percentage and will reduce further if the traffic is plying at its full strength on Sansad Marg.

From Table 4, it can be inferred that Ashoka Road and Sansad Marg account for the minimal portion of private vehicle trips to the study area which is ranging between 2 - 11 % during the 11 hour period i.e. 8.00 A.M to 7.00 P.M on a typical working day. On the other hand, Jantar Mantar road is contributing for the sizable share of private vehicle trips as it is seen that about 371 (58 %) of cars (Small Car + Big Cars) and 319 (84 %) of two wheelers travelling on this link primarily emerge from the study area with very minimal percentage forming the through traffic. It is to be noted that the percentages have been calculated considering the typical office working hours of 9.00 A.M to 7.00 P.M by including the buffer time of 1 - 3 hours to account for early and late reporting staffers in such office complexes. It was corroborated during the questionnaire survey that all offices in the study area worked maximum up to 7 PM with no night shifts.

It is to be noted that the percentage share of the observed traffic in the base year contributed from the study area onto the major arterials may further reduce. This is because of the fact that the total traffic on these roads would be much higher on normal working days as the observed is a result of traffic being blocked on Jantar Mantar and Sansad Marg for vehicular use during certain time periods due to external factors like strikes and Parliament Session.

3.5 Trips originating from the proposed office complex

Considering the data collected for the base year and based on the established relationship between the trip rates and the area of associated buildings, it is estimated a total of about 3183 trips /day (9946 * 0.32) would be generated from the proposed office complex. It is assumed that most of the offices in the entire vicinity of the study area would remain the same as these offices work on sanctioned strength and hence the total number of employees seldom changes. It is therefore further assumed that the trips that generate from within the study area shall remain the same as in the base year with only the addition of trips from the proposed office complex which is estimated to the order of 3183 daily trips.

3.6 Growth Rate

In order to ascertain the growth of traffic on Ashoka Road, Jantar Mantar Road and Sansad Marg an econometric analysis between the number of registered two wheelers, cars and the Per Capita NSDP (Per Capita Net State

Domestic Product) for Delhi region over the years from 2008 to 2015 was made. The vehicle population of two wheelers and cars registered a positive relationship with per capita NSDP. The growth of two wheelers is found to be the similar to that of cars as the public transport is inadequate in Delhi (Vaishali M.P et.al., 2007), However, a negative relationship between per capita NSDP and the population of autos and buses was observed along with a negative relationship between NSDP and office vehicles. The reason for the same may be attributed to the fact that the registration of new buses made by the Government of National Territory of Delhi (GNCTD) and Delhi Transport Corporation (DTC) is not keeping pace (due to severe budget constraints faced by DTC) with the introduction of new CNG Buses commensurate with the phasing out of the old buses after 8 years as per the Supreme Court Order. Similarly, there is tab on the number of registration of new auto rickshaws as per the stipulation of GNCTD. These two aspects would have contributed for the decline / stagnation in the number of registered buses and autos. Considering the above, growth projection of the base year traffic is made on four scenarios namely

- Scenario-1 2022 adopting growth rate 1
- Scenario-2 2027 adopting growth rate 2
- Scenario-3 2022 adopting growth rate 3
- Scenario 4 2027 adopting growth rate 4

The growth rates for the scenarios are given in Table 5.

Table 5: Growth Rates for various scenarios adopted for the study

Year	Car	Auto	Bus	Mini Bus	TW	LCV	HCV	MAV	Cycle
2017-2022 (Scenario 1)	7.6*	3**	Same as base year	Same as base year	7.5*	3**	3**	3**	3**
2022-2027 (Scenario 2)	7.2*	3**	Same as base year	Same as base year	7.01*	3**	3**	3**	3**
2017-2022 (Scenario 3)	5**	3**	2.5**	2**	5**	3**	3**	3**	3**
2022-2027 (Scenario 4)	4**	3**	2.5**	2**	4**	3**	3**	3**	3**

*From regression analysis between registered vehicles and per capita NSDP

**From CRRI (2009-2010) study sponsored by SIAM

The total quantum of private vehicles generated from the office complex is shown in Tables 6 as per the observed occupancy on the field. Subsequently, the percentage contribution to the total traffic is computed.

Table 6: Horizon Year Traffic conforming to Observed Share of Private Vehicle and Occupancy

Road Name	Numbers		
	Car	Two Wheeler	Total Vehicles
Ashoka Road	96	31	127
Jantar Mantar Road*	74	64	138
Sansad Marg**	221	55	276
Total	391	150	541

*the traffic projected for the horizon year is from the days when in the base year there was partial restriction of traffic and there were strikes happening .Hence the traffic on these roads are lesser than on normal days.

**the traffic projected for the horizon year is from the days when in the base year there was partial restriction of traffic and there was parliament session happening .Hence the traffic on these roads are lesser than on normal days.

The horizon year traffic from the proposed office complex in case of single occupancy of vehicles is as shown in Table 7.

Table 7 Horizon Year Traffic conforming to Observed Share of Private Vehicle and Occupancy

Road Name	Numbers		
	Car	Two Wheeler	Total Vehicles
Ashoka Road	177	45	222
Jantar Mantar Road*	205	105	310
Sansad Marg**	448	85	533
Total	830	235	1065

*the traffic projected for the horizon year is from the days when in the base year there was partial restriction of traffic and there were strikes happening .Hence the traffic on these roads are lesser than on normal days.

**the traffic projected for the horizon year is from the days when in the base year there was partial restriction of traffic and there was parliament session happening .Hence the traffic on these roads are lesser than on normal days.

The impact of the proposed office complex with respect to the total traffic is shown in Figure 4. Figure 4 is built using the base year traffic as observed in CVC survey and the horizon year traffic is obtained from the summation of traffic obtained from growth rates and the traffic generated from proposed office complex. A close look at the figure reveals that under the scenarios of ‘with’ and ‘without’ office complex the increase in traffic on all the encompassing roads is negligible during the horizon years on Ashoka Road and Sansad Marg. Table 8 presents the estimated peak hour traffic on various adjoining roads during the horizon period. Similarly, Table 9 presents the estimated peak hour PCUs (1 in case of Car and 0.75 in case of two wheelers) for various adjoining roads during the horizon period. It is seen that there is a percentage contribution of the 33.5 % of generated traffic from the proposed building with single occupancy on the peak hour PCUs. It is assumed that in the case of Ashoka Road (which is Four Lane divided in the influence area), the peak hour trips are divided equally for both directions of travel. In the case of Jantar Mantar and Sansad Marg (since both are undivided two lane carriageways), the percentages are calculated by considering the peak hour PCUs for both directions together. Similarly, PCU percentages are accordingly calculated for the encompassing stretches. In the case of trips made by buses, 15 % of the total generated trips estimated from the establishment survey were used as the base. At the same time, since Jantar Mantar road does not have any bus routes running; it is assumed that the bus passengers assign themselves equally between Ashoka Road and Sansad Marg.

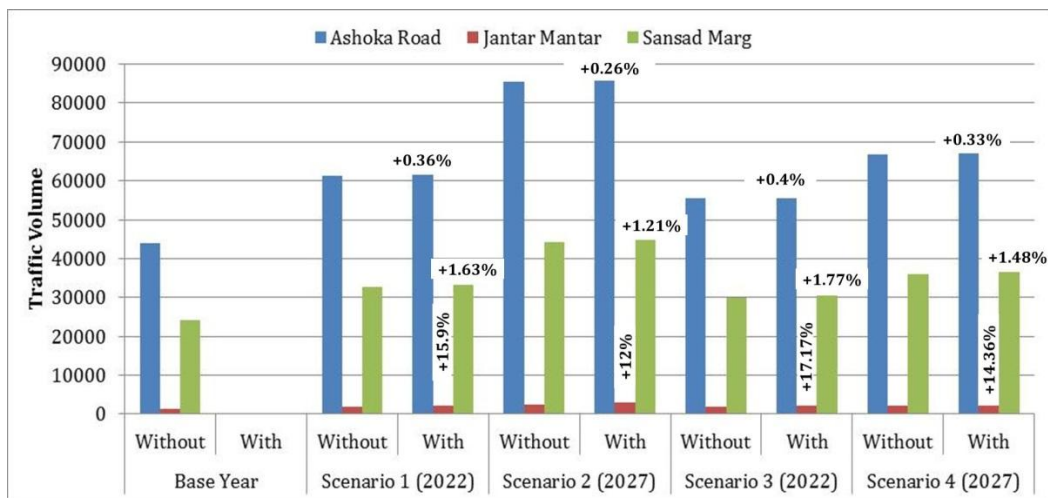


Fig 4: Traffic Impact Assessment ‘with’ and ‘without’ Office Complex

Table 8: Horizon Year Peak Hour PCUs on the Study Stretches

Base and Horizon Year Traffic	Ashoka Road		Jantar Mantar Road (both directions)	Sansad Marg (both directions)
	Towards Patel Chowk	Away from Patel Chowk		
Scenario 1 2022	2924	3140	225	6456
Scenario 2 2027	3975	4340	286	8291
Scenario 3 2022	2662	2857	214	6137
Scenario 4 2027	3204	3438	253	7275

Table 9 PCUs from the Proposed DMRC Office complex assuming Single Occupancy

PCUs from proposed Commercial complex	Ashoka Road		Jantar Mantar Road (both directions)	Sansad Marg (both directions)
	Towards Patel Chowk	Away from Patel Chowk		
	128	128	142	279

3.7 Inferences on Case Study 1

- The study area is at present predominantly having a blend of commercial and office complex area representing government, private and some corporate sectors as discussed in section 3.
- The presence of Patel Chowk metro station in the area makes it an ideal location for public transport usage which is corroborated from the primary survey data as well. The predominantly preferred public transport mode of travel is metro (50%) followed by bus (15%) for the 349 samples obtained during survey.
- The major arterial roads encompassing the study area namely, Jantar Mantar Road and the Sansad Marg present a unique and defining feature wherein at times, they remain barricaded for a substantial period of time of the day allowing for minimal flow of traffic on these roads. During such occasions, Ashoka road along with adjoining Link Road becomes the sole access road for getting to the above office complexes by private vehicles in the vicinity.
- The average speed on these corridors ranges between 23 Km/h to 9 Km/h with highest of 23 Km/h on Ashoka Road and lowest of 9 Km/h on Link Road.

The study has been undertaken by CSIR - CRRRI study team to test the hypothesis that in the event of construction of the proposed office complex, it could contribute towards substantial increase in traffic on the encompassing roads of Jantar Mantar, Ashoka and Sansad Marg. Eventually, the above hypothesis has been tested through extensive surveys performed on these roads followed by base year and horizon year traffic flow analysis.

The inferences drawn are briefly summarized:

- From Table 7 (assuming single occupancy), it can be inferred that even when the Sansad Marg is not having normal days of traffic operations (traffic disruptions due to blockades discussed in Section 3.3), the estimated contribution from the proposed office complex to Sansad Marg would be up to a maximum of 0.95 % considering the share of different types of private vehicles.
- Similarly, the percentage share of trips likely to use the Ashoka Road would be of the order of 0.5 % of individual modes only.

- On the other hand, most of the traffic on the Jantar Mantar road would be from the proposed office complex.
- Looking at the overall traffic situation given in table 8.5 it is observed that Jantar Mantar road is operating well below its capacity of 4 lane undivided road due to strikes and hence need to be addressed through segregation of traffic from the place of protest.

3.8 Study Outcome

- In summary, the analysis revealed that the proposed Office complex would by itself would not make any substantial addition to the estimated traffic flow in the horizon years 2022 and 2027. At the same time, the above roads namely, Ashoka Road, Jantar Mantar Road and Sansad Marg during the horizon year will experience congestion due to natural growth of traffic.
- Based on the recommendations evolved in the above study, No Objection Certification for the start of proposed office complex was granted by the enforcement agency i.e. Delhi Traffic Police.

4. Case Study 2

We shall now look into the second case study which is of an Information Technology (IT) park functioning since 2011 spanning an area of about 28.91 acres and located on the road connecting Airport to Mattuthavani Ring Road falling under Madurai North Taluk. The above IT park located at Illandhaikulam village in the northern periphery is about 4 Kms beyond the corporation limits of Madurai city and accommodates about 1500 employees at present covering about 7 major companies. Adjacent to the IT park, renowned Bus Stand, MGR Intercity Bus stand (erstwhile Mattuthavani Bus Stand) is functioning which caters to both inter-city and intra-city traffic movements. The number of people working in the IT industry within Madurai city is gradually increasing. As of now, around 4000 employees are working in the IT sector in Madurai with the above IT park accommodating about 3000 employees. Two major IT giants namely, Honeywell and HCL who are already having their base in the above IT park are in the process expanding which is likely to add 1000 more employees (Anna University,2017). The site map is as shown in Figure 5.

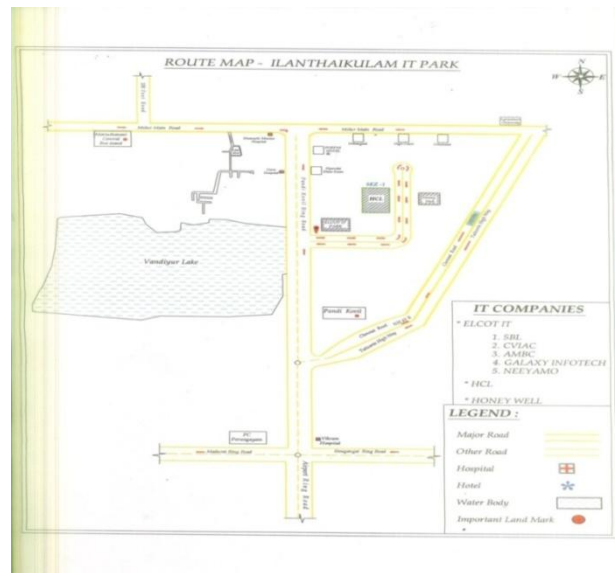


Fig 5 Study area – IT corridor in outskirts of Madurai

4.1 Objectives of the Study

The objectives of the study are as follows:

- To estimate the passenger / vehicular traffic generated by the proposed IT Park expansion and assess the impact of this traffic on adjoining road network.
- Enumeration of the existing traffic flows on the major road links in the vicinity of the proposed expansion and appreciate the present and future traffic problems on the road network.

4.2 Focus of Evaluation

To meet the objectives, the scope of the study has been defined as given below:

- Conduct a reconnaissance survey of the area of development and its surroundings so as to appreciate and delineate the area of study.
- Identify the road network that is likely to be affected / used by the proposed development and the travel of the residents.
- Estimate the quantum of travel / traffic that will be generated by the proposed developments.
- Study the present operating conditions of traffic in the influence network and also project the future traffic on this network.
- Conduct such studies that are required to estimate the impact of generated traffic from the proposed development and assess the magnitude of impact and draw the necessary inferences that could help in decision making.

4.3 Study area

As an entire zone is being developed into an IT hub we shall consider the entire Madurai city as the study area. The city area of Madurai has been divided into 5 zones (Table 9) with the 5th zone being the development of IT hub. The zones, links and nodes in the city of Madurai were digitized using VISUM software. A total of 30,000 Links and 10,000 Nodes are created using the software. Table 10 furnishes details of traffic zones considered in the present study.

Table 10: Traffic Zones considered in the Study Area Network

Details	Zone 1	Zone 2	Zone 3	Zone 4	Total
Wards(Nos.)	23	26	25	26	100
Ward list	1 to 23	24 to 49	50 to74	75 to100	1 to 100
Area (sq.km)	37.35	46.94	27.01	36.7	148

4.4 Base year trips and traffic

As a four stage modelling approach is to be adopted for the study, as the first step it is necessary to understand the trips being generated within the study area of Madurai city. In order to ascertain the trips being generated the trips produced and attracted o each zone needs to be quantified. A series of multiple regression equations have been developed based on the demand strata identified for both production and attraction. The demand strata were segregated as

- Work Purpose trips using cars
- Work Purpose trips using two wheeler
- Work Purpose trips using buses
- Work Purpose trips using other modes
- Education Purpose using two wheeler
- Education purpose using buses
- Education Purpose using other modes

Other Purpose (including Social and Recreational) using cars

1. Other Purpose (including Social and Recreational) using two wheeler
2. Other Purpose (including Social and Recreational) using bus
3. Other Purpose (including Social and Recreational) using others

The regression models developed for the trips produced from the demand strata included the following variables

- Veh per Household (Veh _PH)
- Income per Household (Inc_ PH)
- Earner per Household (EPH)
- Number of Households (HH)
- Population (P)
- Total Area (A)
- Commercial Area (CA)
- Residential Area (RA)

The form of trip production models deduced was as follows:

$$Y_{PROD} = a_{PROD} + a_{Veh_PH}Veh_PH + a_{Inc_PH}Inc_PH + a_{EPH}EPH + a_{HH}HH \quad (1)$$

$$Y_{ATT} = a_{ATT} + a_P P + a_A A + a_{CA}CA + a_{RA}RA \quad (2)$$

Where a_{PROD} , a_{ATT} , a_{Veh_PH} , a_{Inc_PH} , a_{EPH} , a_{HH} , a_P , a_A , a_{CA} , a_{RA} etc are the coefficients of the regression analysis.

The zone-wise trip productions and attractions for various demand strata were calculated. Based on the zonal productions and attractions the trip distribution was carried out. Before distribution of the trips the mode wise skim matrix was developed. A matrix combination step was carried out in order to arrive at the skim matrix for demand strata with ‘other’ as mode of travel. The trip distribution model developed in the study is of the following form:

$$T_{ij} = A_i B_j P_i D_j F(U_{ij}) \quad (3)$$

Where

$A_i B_j$: Balancing factors

P_i : Production from ith zone

D_j : Attraction to jth zone

$F(U_{ij})$: Deterrence Function

$$F(U_{ij}) = a e^{(cU_{ij})} \quad (4)$$

Where a, c are coefficients and U_{ij} – Generalised cost of travel from i to j . The trip distribution was followed by mode choice for each demand strata.

4.5 Horizon Year:

Based on the review of the various hard copies of the presentations, letters and floor plan of the proposed IT Park, it has been inferred that the vision of IT Park is to augment the facility by developing a Ground plus four Floor measuring total built-up area of 27316 sq.m. In the above built-up area, the expanded IT Park is expected to include amenities like conference hall, meeting rooms and a canteen apart from the regular office rooms. As mentioned earlier, the companies who are investing will have a parking facility within the plot area for the employees and visitors to the proposed building. It is further understood that it is planned to go for expansion within the above IT Park which would have minimal number of visitors on a typical working day. Considering the data collected for the base year and based on the established relationship between the trip rates and the area of associated buildings, it is estimated a total of about 4097 trips /day ($27316 * 0.15$) would be generated from the proposed IT Park. It is assumed that most of the offices in the entire vicinity of the study area would remain the same as that of the existing IT facility. Further, it was assumed that companies that would be augmenting their office would work on their sanctioned strength and hence the total number of employees would seldom change. It is therefore further assumed that the trips that generate from within the study area shall remain the same as in the base year with only the addition of trips from the proposed IT Park expansion which is estimated to the order of 4097 daily trips. Hence the total trips emanating from the study area and the adjoining road after the expansion of IT Park is estimated to be 16547 trips per day. Table 11 shows the growth rates adopted for the current study and based on the occupancy fixed for each vehicle the horizon year trips are converted to number of vehicles.

Table 11: Growth Rates for scenarios adopted for the study

Year	Car	Auto	Bus	TW	LCV	HCV	MAV	Cycle
2028 (Scenario)	2	3	Same as base year	6.8	3	3	3	3

Table 11 highlights the base year two wheeler traffic whereas table 12 gives the horizon year two wheeler traffic. From Table 12 and 13 it can be ascertained that the growth rate of two wheelers due to the development of IT corridor is given in Table 14.

Table 12: Estimated Bus Passenger Trips across Various Zones in the Base Year of 2018

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Zone 1	7883	7892	8110	8137	7929
Zone 2	7361	7264	7174	7092	6975
Zone 3	7522	7539	7558	7483	7187
Zone 4	7289	7397	7492	7493	7290
Zone 5	5902	6188	6273	6551	6535

Table 13: Estimated Bus Passenger Trips across Various Zones in the Horizon Year

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Zone 1	7883	7892	8110	8137	7929
Zone 2	7361	7264	7174	7092	6975
Zone 3	7522	7539	7558	7483	7187
Zone 4	7289	7397	7492	7493	7290
Zone 5	5902	6188	6273	6551	6535

Table 14 Percentage Increase in traffic volume of Two Wheeler

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Zone 1	5.8	4.0	8.7	7.4	4.3
Zone 2	8	3.8	4.1	6.6	5.4
Zone 3	4.6	4.1	8.0	3.9	7.3
Zone 4	6.4	4.6	5.1	7.4	8.7
Zone 5	12.5	6.3	13	11.4	9.9

4.6 Inferences on Case Study II

The base year peak hour traffic and yearly increase in peak hour traffic volume up to the horizon period of 2028 due to the proposed IT Park Extension has been estimated and presented in the study. The likely increase in two wheeler traffic across various zones due to the proposed IT Park Extension is expected to range between 3.8 % to 12.4 % during the peak hours. In summary, it is estimated that a yearly increase of 6.9 % in the peak hour share of two wheeler traffic is estimated due to the proposed IT Park Extension. On the other hand, the likely increase in traffic in the immediate vicinity due to the proposed IT Park Extension is of course highest on Ring Road (301 Vehicles) followed by other two roads (113 vehicles each) during the peak hours. However, it may be noted due to the non-availability of car commuters during the Establishment Survey conducted on the existing IT park, increase in car traffic due to the proposed IT Park extension could not be ascertained in this study. Hence this can be considered as one of the basic limitation of the study.

5. Conclusion:

The paper through its case studies highlighted the importance of TIA and brings out the need to make TIA an integral and mandatory requirement in the case of new as well as capacity augmentation. Depending on the envisaged impact, the influence area as well as study steps have been modified within the case studies in this paper. At the same time, it is to be noted that the end assessment in both the case studies requires the study of the impact of proposed development on the overall traffic plying within the influence area during the horizon year period.

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