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Estimation of Trip Generation Rates for different Land Uses

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Abstract

An important aspect of planning for new developments is to predict the amount of generated traffic. This is a necessary input both for traffic design and traffic planning activities. The ultimate purpose of traffic generation studies is to improve estimates of traffic activity associated with land uses of particular types and magnitudes. Trip generation provides the linkage between land use and travel. Determination of specific trip generation rates will help in site impact studies and regional planning studies. This research study is to evolve out an easy-to-apply process for use by transportation professionals when estimating vehicular trip generation in built-up urban areas, incorporating the effects of site-specific, local, and area-wide land use and transportation characteristics on estimates of vehicular trip generation.

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Keywords: Proxy site surveys; Infill development; Trip attraction rate; Trip generation rate; Traveller Intercept Surveys; Cordon count surveys

1. Introduction

Travel demand forecasting is a key component of the transportation planning sector. It allows to predict the volume of traffic that will use a given transportation facility in the future. Trip generation is the first step of the conventional sequential forecasting procedure. Trip Generation analysis is done to understand the intensity of trip making to and from landuse parcels to measure the type and intensity of landuse. Presently, there are no standardized and nationally accepted infill trip estimation rates. Determination of specific trip generation rates will help in site impact studies and regional planning studies. This research study is to evolve out an easy-to-apply process for use by transportation professionals when estimating vehicular trip generation in built-up urban areas, incorporating the effects of site-specific, local, and area-wide land use and transportation characteristics on estimates of vehicular trip generation.

Different land uses are identified in Thiruvananthapuram Urban Area which includes varied land uses. Cordon count surveys at the proxy site were conducted obtaining the details of Conventional vehicle counts at site driveways, Number of persons entering and exiting all entries to the concerned building(s) or land use on the site, and the number of persons in vehicles entering or exiting the site.

Trip rate analysis method is used in the study to obtain trip generation rates of various land uses or activity centres (trip rates/unit) which could be further used for transportation impact analysis (evaluating the transportation impacts of proposed developments in future) and for long range forecasting (evaluating the alternative transportation plans for future years), community level planning and in corridor studies.

2. Literature Review

The main aim of the literature study has been to review the present transportation generation rates for different land users. Zmud, Johanna and Jean Wolf, August 2003 in the paper “Identifying the Correlates of Trip Misreporting” presented the calculation of the number of trips generated by different kinds of activity or land-uses which forms the fundamental building block in the estimation of travel. NCHRP REPORT 758, 2013”Trip Generation Rates for Transportation Impact Analyses of Infill Developments” developed an easily applied methodology to estimate automobile trip generation and mode shares of non-vehicular trips that can be used in the preparation of site-specific transportation impact analyses of infill development projects located within existing higher-density built-up areas This study recommends an approach that adjusts trip generation estimates based on data in the ITE Trip Generation Manual using mode share and vehicle occupancy as adjustment factors to more accurately reflect the travel characteristics of the context in which the proposed project is located. The primary recommendation of the research team is to focus future research on validating one LUC in one urban context in one metropolitan area. This will produce a more definitive conclusion on whether the method can be validated for a given use, while minimizing the required resources. The State Highway Administration Research Report, December 2009,”Trip Generation Studies for Special Generators” examines the effects of town centers and senior housing developments on surrounding roadways and nearby transit. The general purpose of a trip generation study is to collect and analyze data on the relationships between trips attracted and produced to and from a development, as well as the characteristics of the land use. It provides trip rates, equations and data plots based on traffic counts and characteristics of the surveyed land uses. The results also indicate that town centers warrant their own listing in the manual.

3. Study Area

This study involves the estimation of Trip Generation Rates of different landuses like work centres, official complexes, shopping centers, institutional campuses and other land use developments in Thiruvananthapuram City. Thiruvananthapuram (or Trivandrum) is the capital of the southern Indian state of Kerala, located in the southwestern tip of India. This city is a good representative sample from the Kerala because it consists of all major types of land uses. Proxy sites are identified for the conduct of study. This is a significant step towards the accomplishment of the study. The location of the landuses selected for the study is marked in the Fig. 1.

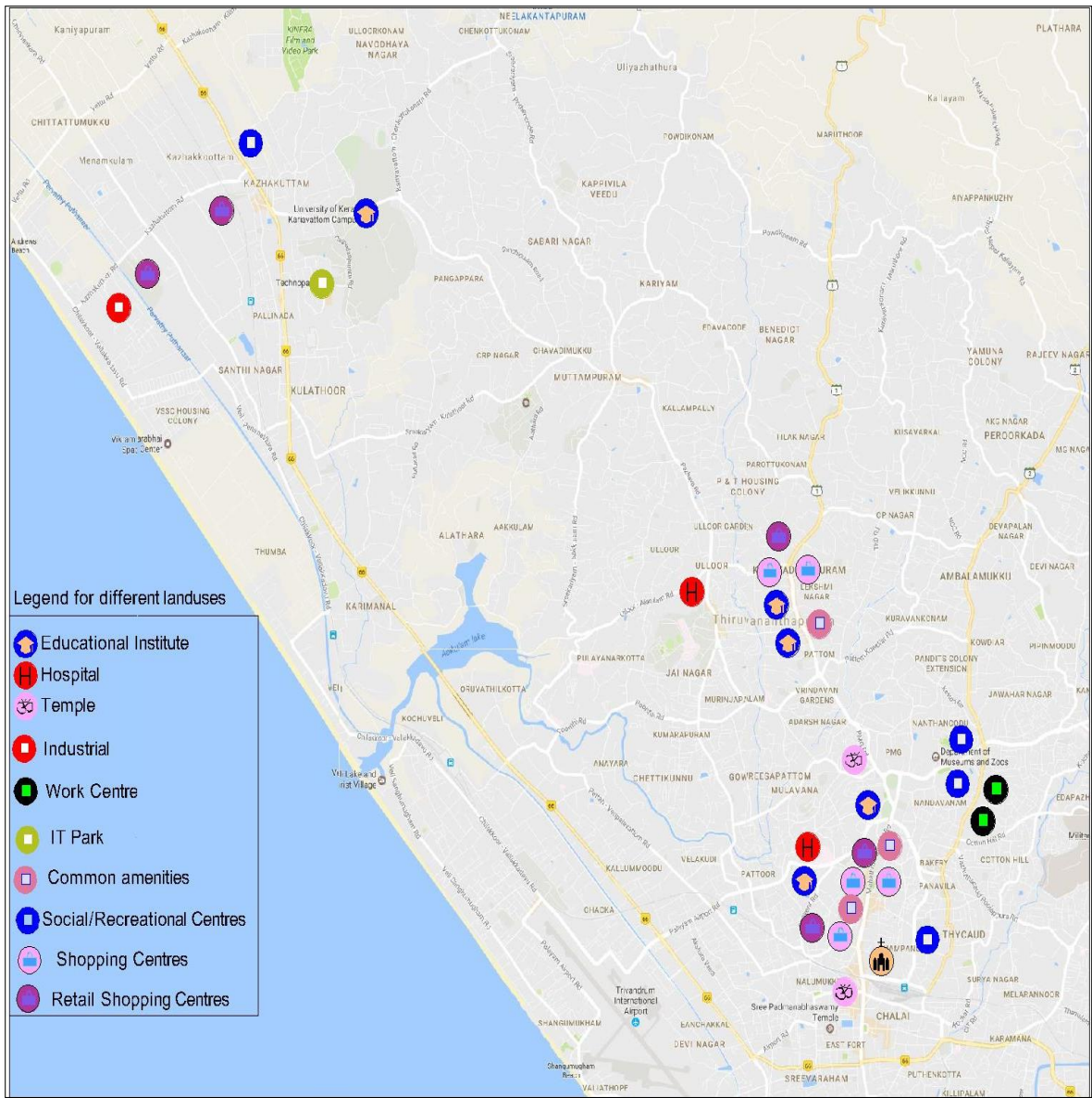


Fig. 1. Location of selected land uses in Thiruvananthapuram city

4. Methodology

Trip generation rates can be estimated for the specific infill developments in the state of Kerala. Based on review of past studies concerned with Estimation of Trip Generation rates for various land uses and developments, the following framework of methodology is to be adopted for the study.

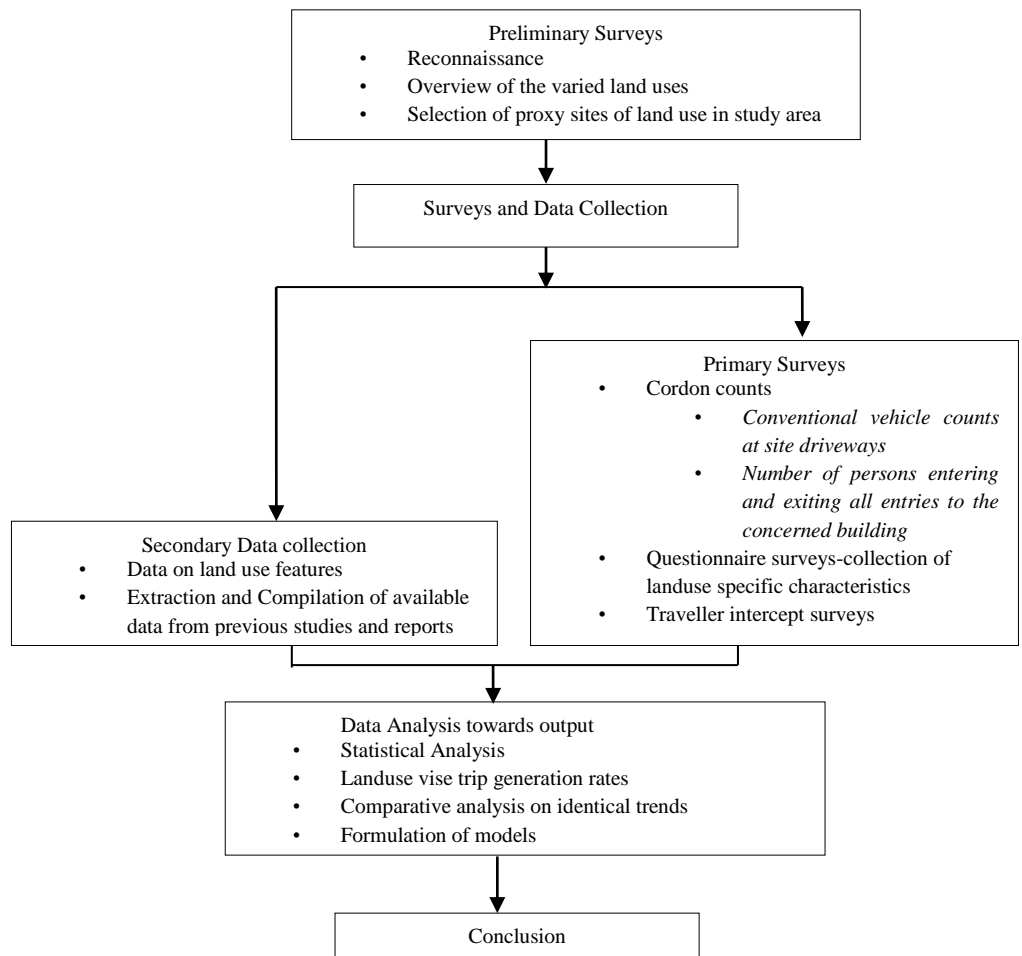


Fig. 2. Flow chart showing the methodology of the study.

4.1. Data Collection

Reconnaissance survey of the study area and general overview of the land use pattern is done. Based on the reconnaissance survey and general analysis of the landuse of the study area, the proxy sites are identified for the conduct of study. The details of conventional vehicle counts at site driveways, vehicles entering/exiting site during the peak period of adjacent street traffic (a.m. or p.m.), number of persons entering and exiting all entries to the concerned building(s) or land use on the site and the number of persons in vehicles entering or exiting the site were collected. The land uses selected for the study are listed in the Table 1.

Table 1. Identified list of different kinds of land uses in Thiruvananthapuram city.

Sl No	Category of landuse	Corresponding Survey Locations
1	Educational / Institutional	KV Pattom, University college, Govt Model HSS for Girls pattom and St. Joseph's HSS, Public library palayam
2	Commercial centres/ shopping malls	Pothy's, Kedaram, Sabhalyam complex, Connemara market, Big-Bazaar
3	Retail shopping centres/ Jewellery/ Hotels	Bheema jewellery, Al-saj restaurant, Zam-Zam
4	Social/ Recreational Centres	Al-Saj community hall, Kairalinilasree Theatre, Meuseum, Kanakakunnu Palace
5	Medical	Credence Hospital, General Hospital
6	Industrial	Kinfra International Apparel Park, Thumba
7	Work centre/ Office campuses	Public office building, Thiruvananthapuram Corporation Office
8	Public Services/ Common Amenities	GPO Complex, LIC, Corporation building, State Bank of India LMS junction
9	Religious places	Palayam Mosque, St. Joseph's Metropolitan Cathedral palayam, Hanuman Swami temple palayam, Lourde Forane church palayam, Pazhavangadi Ganapathy temple

The number of persons and vehicle attracted to the land use were counted as they visit the particular building. The survey was conducted continuously in every 15 minutes interval during the working hours of the land use to get the peak hour trip value. The enumerators were positioned near the entrance and exit points to get the complete trip details of the land use. The office buildings, institutions, work centers etc were surveyed in the week days whereas, the social and recreational centers on holidays in order to get the peak value.

5. Trip generation analysis

An important aspect of planning for new developments is to predict the amount of generated traffic. This is a necessary input both for traffic design and traffic planning activities. The ultimate purpose of traffic generation studies is to improve estimates of traffic activity associated with land uses of particular types and magnitudes. Trip generation provides the linkage between land use and travel. Determination of specific trip generation rates will help in site impact studies and regional planning studies. The data collected at each landuse were processed and statistical analysis was done to determine the trip attraction rate.

The following equations were used for calculating different trip attraction rate:

Peak hour person trip attraction rate (Trips per 1000 sq. ft. per hour) = (Peak hour person trip /Gross Floor Area)*1000

Peak hour car trip attraction rate (Trips per 10,000 sq. ft. per hour) = (Peak hour car trip/ Gross Floor Area)*10,000

6. Data Analysis and Results

6.1. Industrial Land Use-Kinfra International Apparel Park, Thumba

a. Peak Hour Vehicle Trip Rate

The survey was conducted on a typical working day in order to understand day time trip attractions satisfactorily. From the survey data, hourly variation of total vehicle trips entering the land use during the working hours of the landuse, the morning and evening peak hours of vehicle trips observed are 8:00am to 9:00am and 4:30pm to 5:30pm respectively.

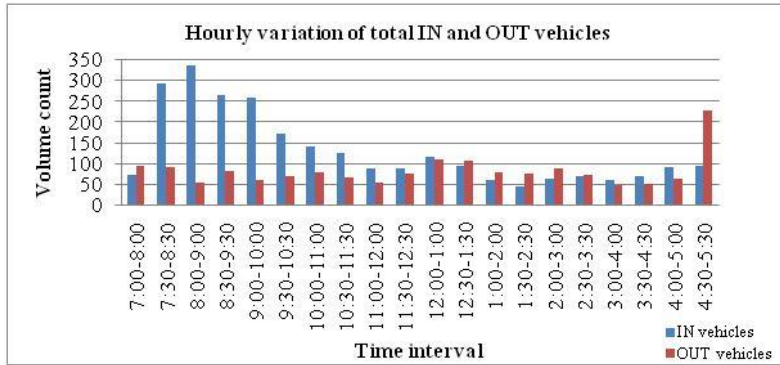


Fig 3 Hourly variation of IN and OUT vehicle trips during the working hours of Kinfra Apparel park, Thumba

The highest of trip rate reaches upto a value of 386. The peak hour vehicle trips generation rate of Kinfra apparel park estimated as 0.78 vehicles trips/1000sq.ft./hr on a typical working day.

Table 2. Peak hour vehicle trips generation rate

Peak Hour	Time	In	Out	In and Out trips
Morning peak hour	8:00-9:00	333	53	386
Evening peak hour	4:30-5:30	94	227	321
Peak hour vehicle trips generation rate		0.78		trips/1000sq.ft./hr

b. Peak Hour Person Trip Rate

From the Fig 3, it is seen that there is a morning peak hour seen between 8:00am and 9:00am and an evening peak hour between 4:30pm and 5:30pm. These trips are mainly the in and out trips of the day shift employees of the landuse. From person trip data analysed, the peak hour person trips rate for the Kinfra Apparel Park were calculated and are shown in the Table 1.3 shown below.

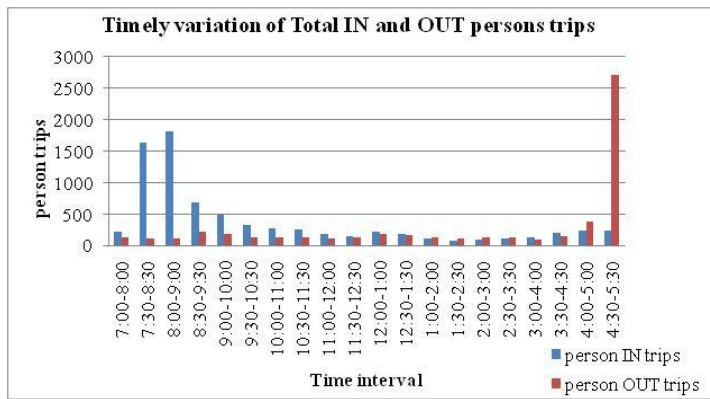


Fig 4 Hourly variation of IN and OUT person trips entering the land use

Table 3 Peak hour person trips generation rate for the Kinfra Apparel Park

Peak Hour	Time	In	Out	In and Out trips
Morning Peak Hour	8:00-9:00	1818	112	1930
Evening Peak Hour	4:30-5:30	225	2705	2930
Peak Hour Person Trips Generation Rate		5.89		Trips/1000sq.ft./hr

c. Mode Share of Person Trips

The classified mode share of the person trips are shown in the Fig 4. It is seen that the major proportion of trip makers use non motorized mode of transport. Of the motorized transport mode, two wheelers are the major mode used by the trip makers to access the land use.

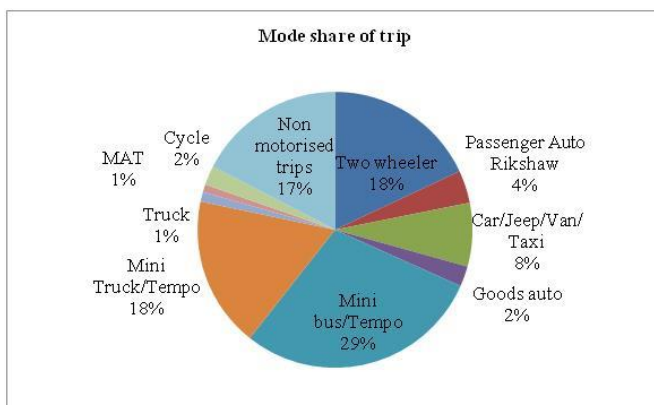


Fig 5 Mode share of the person trips at the landuse

d. Mode wise Trip Generation Rate

The hourly variation of the classified vehicle trips at the land use and their corresponding trip rate are calculated

Table 4 Peak hour Vehicle trips rates for different modes

Vehicle type	Peak hour trip	peak hour trip generation rate
Two wheeler	4.32	trips/1000sq.ft./hr
Passenger autorikshaw	0.76	trips/1000sq.ft./hr
Car/Jeep/Van/Taxi	0.82	trips/1000sq.ft./hr
Goods auto	0.50	trips/1000sq.ft./hr
Mini bus/Tempo	1.93	trips/10000 sq.ft./hr
Mini Truck/Tempo	1.21	trips/10000 sq.ft./hr
Truck	0.34	trips/1000sq.ft./hr
MAT	0.24	trips/10000 sq.ft./hr
Cycle	1.25	trips/1000sq.ft./hr

Similarly, the trip generation rates (trip rates/unit) of various land uses or activity centres considered for the study were estimated which could be further used for transportation impact analysis (evaluating the transportation impacts of proposed developments in future) and for long range forecasting (evaluating the alternative transportation plans for future years), community level planning and in corridor studies.

Summary of Peak hour Person trips rates for different land uses estimated are listed in the Table 5. Summary of Peak hour Vehicle trips rates for different land uses estimated are listed in the Table 6.

Table 5 Summary of Peak hour Person trips rates for different land uses

SI No	Name of Landuse	Type of Landuse	Peak Hour Person Trip Rate
1	Kinfra International Apparel Park, Thumba	Industrial Land Use	5.89 trips/1000sq.ft./hr
2	Kedaram shopping complex		6.11 trips/1000sq.ft./hr
3	Pothys Trivandrum		4.7 trips/100sq.ft./hr
4	Connemara market	Commercial centres	1.41 trips/100sq.ft./hr
5	Big Bazaar		3.16 trips/1000sq.ft./hr
6	Saphalyam Shopping Complex		0.4 trips/100sq.ft./hr
7	Kairali / Sree / Nila theatre		1.83 trips/seat/hr
8	Al-Saj Convention Centre, Kazhakkootam	Recreational centres	1.58 trips/1000 Sq. ft./hr
9	Napier Museum		0.12 trips/100sq.ft./hr
10	Kanakakkunnu Palace		3.05 trips/100sq.ft./hr
11	PalayamJuma Mosque, Thiruvananthapuram		2.38 trips/10 sq.ft./hr
12	St. Joseph's Cathedral, Palayam		27.51 trips/1000sq.ft./hr
13	O.T.C Sree Hanuman Swamy Temple, PMG Junction	Religious places	7.85 trips/1000sq.ft./hr
14	PazhavangadiGanapathy Temple ,East fort		2.15 trips/10sq.ft./hr
15	Lourdes Forane Church, Trivandrum		1.2 trips/100sq.ft./hr
16	Thiruvananthapuram General Post Office	Public Services/ Common Amenities	5.38 trips/1000sq.ft./hr
17	Thiruvananthapuram Municipal Corporation		50.73 trips/1000sq.ft./hr
18	Public office Complex, Thiruvananthapuram	Work centre/ Office Campuses	0.83 trips/100sq.ft./hr
19	Life Insurance Corporation, Pattom		0.3 trips/100sq.ft./hr
20	Al-Saj Restaurant, Kazhakkootam	Retail shopping centres/	2.5 trips/100 sq.ft./hr
21	BhimaJewellers, Trivandrum	Jewellery/ Hotels	16.63 trips/1000sq.ft./hr

22	ZamZamRestaurant,Palayam		1.22	trips/100sq.ft./hr
23	Credence Hospital, Trivandrum		3.5	trips/1000sq.ft./hr
24	General Hospital	Medical Landuse	5.6	trips/1000sq.ft./hr
25	State Central Library Thiruvananthapuram	Educational / Institutional Landuse	6.97	trips/1000sq.ft./hr

Table 6. Summary of Peak hour Vehicle trips rates for different land uses

SI No	Name of Landuse	Type of Landuse	Peak Hour Vehicle Trip Rate	
1	Kinfra International Apparel Park, Thumba	Industrial Land Use	0.78	trips/1000sq.ft./hr
2	Kedaram shopping complex		1.22	trips/1000sq.ft./hr
3	Pothys Trivandrum		11.87	trips/1000sq.ft./hr
4	Connemara market	Commercial centres	2.47	trips/1000sq.ft./hr
5	Big Bazaar		1.26	trips/1000sq.ft./hr
6	Saphalyam Shopping Complex		0.76	trips/1000sq.ft./hr
7	Kairali / Sree / Nila theatre		0.16	trips/seats/hr
8	Al-Saj Convention Centre, Kazhakkootam	Recreational centres	2.54	trips/Sq. ft./hr
9	Napier Museum		0.03	trips/1000sq.ft./hr
10	Kanakakkunnu Palace		6	trips/1000sq.ft./hr
11	PalayamJuma Mosque, Thiruvananthapuram		-	-
12	St. Joseph’s Cathedral, Palayam		1	trips/100sq.ft./hr
13	O.T.C Sree Hanuman Swamy Temple, PMG Junction	Religious places	1.79	trips/1000sq.ft./hr
14	PazhavangadiGanapathy Temple ,East fort		5	trips/100sq.ft./hr
15	Lourdes Forane Church, Trivandrum		0.3	trips/100sq.ft./hr
16	Thiruvananthapuram General Post Office	Public Services/ Common Amenities	1.33	trips/1000sq.ft./hr
17	Thiruvananthapuram Municipal Corporation		17.8	trips/1000sq.ft./hr
18	Public office Complex, Thiruvananthapuram	Work centre/ Office Campuses	4.15	trips/1000sq.ft./hr
19	Life Insurance Corporation, Pattom		0.15	trips/100sq.ft./hr
20	Al-Saj Restaurant, Kazhakkootam		0.81	trips/100sq.ft./hr
21	BhimaJewellers, Trivandrum	Retail shopping centres/ Jewellery/ Hotels	3.27	trips/1000sq.ft./hr
22	ZamZamRestaurant,Palayam		0.33	trips/100sq.ft./hr
23	Credence Hospital, Trivandrum	Medical Landuse	1.63	trips/1000sq.ft./hr
24	General Hospital		1.81	trips/1000sq.ft./hr
25	State Central Library Thiruvananthapuram	Educational / Institutional Landuse	2.39	trips/1000 sq.ft./hr

7. Summary And Conclusion

The study focused on preparation of improved and accurate estimates of traffic activity associated with land uses of particular types and magnitudes. The different land uses like Educational / Institutional, Commercial centres/ shopping malls, Retail shopping centres/ Jewellery/ Hotels, Social/ Recreational Centres, Medical, Industrial, Work centre/ Office campuses, Public Services/ Common Amenities, Religious places in Thiruvananthapuram Urban area considered in this phase of study. Cordon count surveys at the selected proxy sites were conducted to understand

the trend of vehicle trips and person trips. The data was analysed and the trip generation rates for each land use were estimated.

The trip generation rates of various land uses or activity centres (trip rates/unit) could be used for transportation impact analysis (evaluating the transportation impacts of proposed developments in future) and for long range forecasting (evaluating the alternative transportation plans for future years), community level planning and in corridor studies.

References

- Zmud, Johanna and Jean Wolf, “Identifying the Correlates of Trip Misreporting - Results from the California Statewide Household Travel Survey GPS Study”, 10th International Conference on Travel Behaviour Research, August 2003
- Trip Generation Rates for Transportation Impact Analyses of Infill Developments, NCHRP Report 758, 2013
- Trip Generation Studies for Special Generators, State Highway Administration Research Report, December 2009
- Md Majbah Uddin et.al, “A Comprehensive Study on Trip Attraction Rates of shopping centers In Dhanmondi Area”, International Journal of Civil & Environmental Engineering IJCEE-IJENS Vol:12 No:04, August 2012
- Kimley-Horn and Associates, “Trip-Generation Rates for Urban Land Uses in California Infill”, Report Prepared for the California Department of Transportation (CALTRANS), Headquarters Divisions of Transportation Planning and Research & Innovation June 15,2009
- Nadezda Zenina, Arkady Borisov, “Regression Analysis for Transport Trip Generation Evaluation”, Riga Technical University, 2013
- Navya S V., S. Sanjay Kumar, Gymmy Joseph Kattoor, “Trip Generation Model for the Core Area of Thiruvananthapuram City”, International Journal of Innovative Research in Science, Engineering and Technology, Volume 2, Special Issue 1, December 2013.
- Land Development Code (San Diego Municipal Code), Trip Generation Manual, Revised May 2003
- Konstadinos G. Goulias Ram M. Pendyala Ryuichi Kitamura, “Practical Method for the Estimation of Trip Generation And Trip Chaining” , University of California at Davis , Transportation Research Record No. 1285, 1991.
- Kristina M. Currans, Kelly J. Clifton, “Using household travel surveys to adjust ITE trip generation rates”, The Journal of Transport and Land Use <http://jtlu.org>, Vol 8 No 1 [2015] pp. 85–119
- Trip Generation Handbook 2nd edition, Chapter 4 ITE “Conducting a Trip Generation Study”, pp. 15-27.