Travel Demand Modelling and Forecasting (A Case Study of Sitapura Industrial Area)

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***Abstract*— Travel demand forecasting is the root of any urban or sub urban planning project. Forecasting models are being used for projecting future traffic and defines whether there is a need of new road network or transit mode or land use policies. Modeling involves a series of mathematical models that just simulates human behavior. Modeling is done by completing different processes and answering the series of questions about human behavior. Many attempts are being made to simulate all choices that traveler make in response to given system of highways. As no model is perfect assumptions are to be made about decisions by traveler. the process of traffic modeling follows the steps as generation of trips in zones, moving through various nodes, through a network of links and ends at attracting zone. This modeling process is known as Four step modeling. These four steps are as Follow-Trip Generation, Trip Distribution, Mode choice and traffic assignment. This paper deals with four step modeling in the context of Sitapura industrial area with the complete Jaipur city, Rajasthan**.

Keywords*— Travel demand, Four steps model, Transportation, Jaipur.

I. INTRODUCTION

Travel forecasting models are used to anticipate changes in traffic patterns and the use of the transportation system in counter to changes in regional development, and road networks supply. Travel demand modeling is a challenging task, but it is required for perceptive planning and analysis of transportation systems [1]. Transportation planning involves the decision-making process for possible improvements to a community's roadway infrastructure. To aid in the decision-making process, several computers based and manual tools have been developed. Two of these key tools are: a) Travel demand forecasting models for executing the four-step urban planning process b) Travel rate indices for providing congestion and delay information for a community[2]. The four-step planning process consist of the following: a)Trip Generation)Trip Distribution, c)Mode Choice, and d)Trip Assignment [1]. The objectives of this paper are to learn about the Urban Transport Modeling System and to gain a better understanding of the behavior of the traffic condition of sitapura industrial region in context with Jaipur area on the zonal basis and to develop the Network Assignment through the Transport Modeling System.

II. STUDY AREA

91 wards (the smallest electoral unit) of Jaipur municipal Corporation area are being selected as the study area for this paper (Figure 1).

These 90 wards are divided into 8 zones known as TAZ (Traffic Analysis Zone) according to Jaipur nagar nigam. And a major zone is marked as MZ and termed as Sitapura Industrial area Figure 1 Jaipur City Ward Map
(Source Jaipur Nagar Nigam)

III. METHODOLOGY

The conventional four step transportation modeling system is used to achieve the objectives of this research paper. It is a macro-level working procedure [3]. The following four steps are to be performed in the next stage:

A. TRIP GENERATION

The very first step of traditional four step modeling is the trip generation [1]. It anticipates the number of trips which are originating in or going for a particular traffic analysis zone (TAZ). Trip generation uses trip rates which are averages for large portion of the study area. Trip productions are based upon household characteristics as the number of people living in the household and the number of vehicles available [1].

The growth rate of population and employment as given by census India 2011 is shown in table 1.

Table 1: Growth rate of population and employment.

Variable	Growth rate (%)
Population	4.5
Employment	2.5

: Source census 2011

Forecasted population data of various zones is shown in table 2. Values are calculated using growth factor data

Table 2: Forecasted population data

ZONE	POPULATION 2011	2016	2026
ZONE 1	729676	745913	779480
ZONE 2	545583	557724	582822
ZONE 3	424564	434012	453543
ZONE 4	352980	360835	377073
ZONE 5	294880	301442	315007
ZONE 6	355523	363435	379790
ZONE 7	177918	181878	190063
ZONE 8	134428	137420	143604
TOTAL	3015552	3082659	3221382

: source Census India 2011

Calculation process: ***Population after 10 years (2026): - Existing population (1 .045) ^1***

Regression Equation for Trip Production:
Yattraction=4339.50557+.001602498Xpopulation
Where, a_1=4339.50557, a_2=.00160249818
Using these regression equations now forecasted trips, for trip attraction after 10 years, are calculated.

Table 3: Forecasted Trips for Various Zones

Sr. No.	ZONES	MZ
1	ZONE 1	5589
2	ZONE 2	5274
3	ZONE 3	30836
4	ZONE 4	4944
5	ZONE 5	4844
6	ZONE 6	4948
7	ZONE 7	4644
8	ZONE 8	4569
TOTAL		65648

Here the first step of trip generation after forecasting future productions/origin and attractions/destination ends (shown in table 3).

B. TRIP DISTRIBUTION

Trip distribution of the second component in the traditional 4-step transportation forecasting model. In this step origins and destinations to develop are calculated and a "trip table" a matrix that displays the number of trips going from each origin to each destination is developed [1]. Since we are just focusing over Sitapura region where trip production is very low therefore only matrix of attraction is formed. We are neglecting the production trips. (Table4)

Table 4: Distribution of trips

Sr. No.	ZONES	MZ
1	ZONE 1	5589
2	ZONE 2	5274
3	ZONE 3	30836
4	ZONE 4	4944
5	ZONE 5	4844
6	ZONE 6	4948
7	ZONE 7	4644
8	ZONE 8	4569
TOTAL		65648

Cost matrix of Cars and Buses using the formula of generalized cost shown below.

Table 5: Cost matrix table (C ij) in terms of time

Zones	1	2	3	4	5	6	7	8
Car	8.38	8.02	4.16	5.87	6.65	6.86	6.68	13.15
Bus	7.14	6.01	3.34	4.39	6.32	5.76	5.65	6.8

here, for calculation purpose,

$$\mathbf{c_{ij} = a_1 t^v_{ij} + a_2 t^w_{ij} + a_3 t^t_{ij} + a_4 t^n_{ij} + a_5 F_{ij} + a_6 \varphi j + \delta}$$

and ,a_1 ,a_2,a_3,a_4 are .03,.04,.06,.1 respectively (assumed [1])

Cij General cost of travel between zone i to zone j

C. MODE CHOICE

Mode choice analysis is the third step of the traditional four-step transportation planning process . Trip distribution's zonal interchange analysis is a set of origin destination tables which states that from where the trips will be made; mode choice is the step which allows the modeler to determine which mode of transport will be used for traffic assignment [1]. Mode choice is one of the most vital parts of the travel demand modeling process. It is the step where trips between a given origin and destination are divided into trips using public transport, trips by car pool or as passengers and trips by two wheelers. A utility function is one which measures the degree of gratification that people derive from their choices and a disutility function represents the total generalized cost that is affiliated by each choice of mode [2]. The most commonly used process in mode choice splitting is to use the 'Logit' model. This involves a comparison of the "utility" of travel between any two points for the different modes which are available at the zone. Utility is a term which is used to represent a combination of travel time, cost and convenience of any mode between an origin and a destination. It is found by placing modal parameters or multipliers (weights) on these factors and adding them together [2].

Moreover, utility functions for these three modes are assumed. The utility functions are as follows [3]:

U_{CAR}= - .02304TT- .07302TC

Where, TT=Travel Time from one Zone to other zone& .
TC=Travel cost from one Zone to other zone

Using these equations a utility matrix is being developed for bus and car(shown in table 6).

Table 6: Utility Matrix Table for Car and Bus

Zones	1	2	3	4	5	6	7	8
Car	4.19	4.01	2.08	2.935	3.325	3.43	3.34	6.575
Bus	3.57	3.05	1.67	2.195	3.16	2.88	2.825	3.4

$P_{ij}^{1}=T_{ij}^{1}/T_{ij}=e^{-bcij1}/\ e^{-bcij1}+\ e^{-bcij2}$

Where, b=.5(assumed)

Here C_{ij} = Generalized Cost of different modes.

Table 7: Probability Matrix for Bus and Car.

Zone	1	2	3	4	5	6	7	8
Car	0.3497	0.2679	0.3989	0.323	0.4588	0.3658	0.374	0.0401
Bus	0.6502	0.7321	0.6011	0.677	0.5412	0.6342	0.626	0.9599

Modal share is calculated by the product of the trip making from one zone to other zone (from trip distribution) with the probability (table 8). This is calculated as:

Modal Share for any Mode = $Trip_{ij}$ X Probability of mode.

Table 8: Modal Share Matrix For Bus And Car.

Zone	1	2	3	4	5	6	7	8
Car	1954	1412	12300	1596	2222	1809	1736	183
Bus	3635	3862	18536	3348	2622	3139	2908	4386

D. TRIP ASSIGNMENT

Trip assignment, affects the selection of routes (or paths) between origin and destination of transportation networks. It is the fourth step in the traditional transportation planning model. Mode choice analysis decides which travelers will use which mode of transport. To determine facility needs and costs and benefits, we need to know the number of travelers at each route and links of the network [1]. Once trips have been split into highway and bus trips, the particular path that they use to travel from their origin to their destination must be found. These trips formed then formed are assigned to that path in the step called traffic assignment [2]. The process initially involves the calculation of the shortest path from each origin to destinations (usually the minimum time path is used). The assigned trip volume is then balanced to the capacity of the link to see if it is congested. If there is any change in travel time, then it may also affect the shortest path. Traffic assignment is the most composite calculation of the travel modeling process and there are number of ways in which it is done to keep commuter time to a minimum [1].

$$GTC=TC+(a_1/a_2)TT$$

Where, TC=Travel Cost ,TT=Travel time

a_1= Co-efficient of the Travel Time factor

a_2= Co-efficient of the Travel Cost factor

The values a_1 & a_2 come from the utility functions mentioned earlier in the Modal Choice step.

$$a_1/a_2=.3155$$

Now using the GTC table, the calculated values of GTC for different modes are put into the different links of the assumed network. Thus Generalized Travel Time (GTT) can also be calculated from the equation below:

$$GTT= (a_2/a_1) * TC + TT$$

Now by using the Dijkstra's Method the shortest distance in terms of GTC from one node to the other node for different mode is calculated. Here all-or-nothing assignment for the calculation of traffic flow for the different modes from one node to other node is calculated. In highly congested areas, or in large urban areas, the amount of physical highway capacity results in the spreading at the peak hours. While it is not possible for a designed roadway to carry an hourly volume of traffic which is greater than its theoretical maximum capacity, the highway assignment algorithms are commonly used which can produce traffic volumes on the roadways that exceed the capacity.

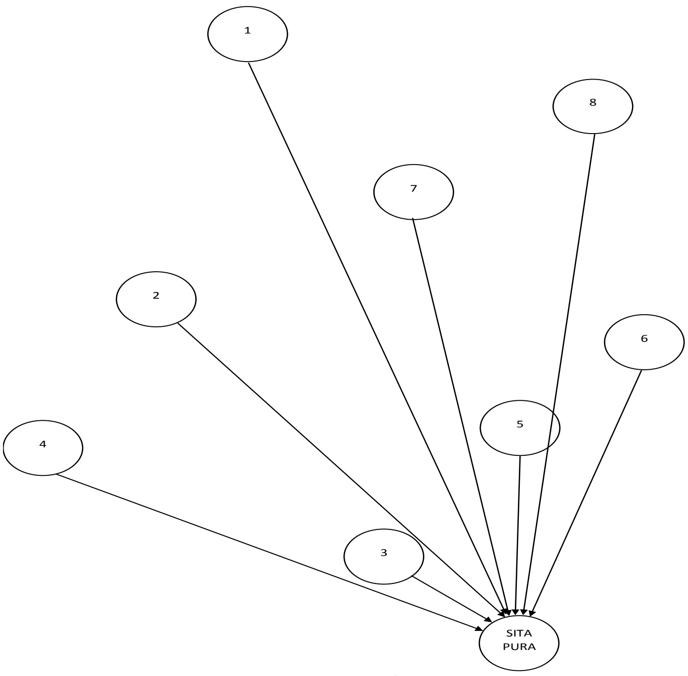

Figure 1-Line Diagram of Study Area

Generalized distance between different zones is shown in figure 1 as a line diagram.

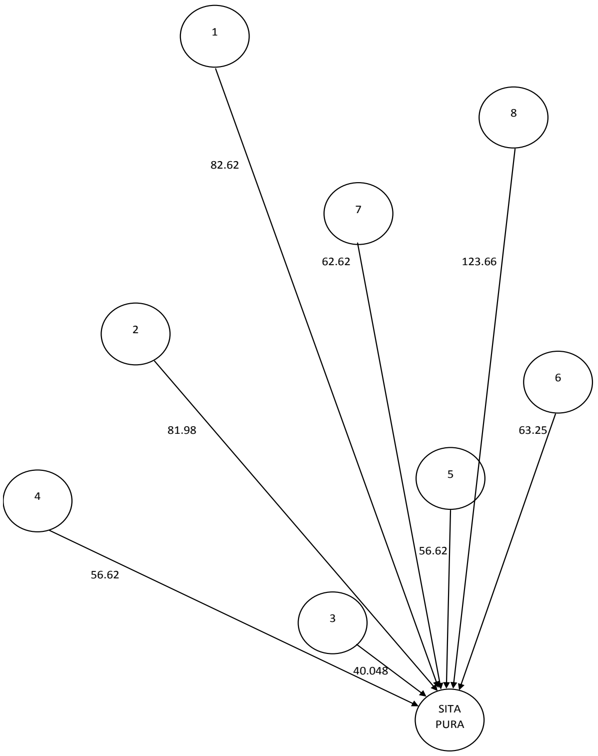

Figure 2- Generalized Cost for Cars

Generalised cost diagram on the bases of Table 5 is shown in figure 2 and figure 3.

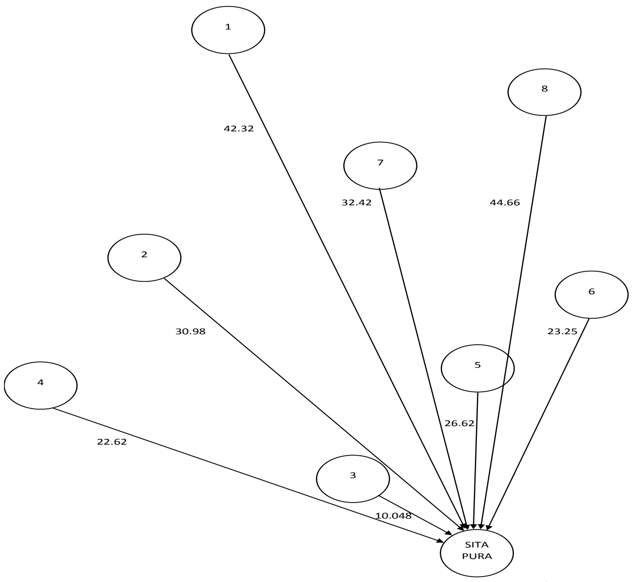

Figure 3: Generalized Cost of Buses

Traffic assignment is done for peak hour traffic while forecasts of trips are done on a daily basis. ratio of peak hour traffic to daily travel is to be calculated to convert daily trips to peak hour travel total trips in each link is shown in table 9. In this report it is assumed that 10% of travel occurs in the peak hour. For this 10% of the flow in peak hours of total trips per link according to their shortest path are calculated for the all two modes Units.

Table 9: Total Trips in each link for different modes.

LINK	FLOW FOR BUS	FLOW FOR CAR	FLOW FOR TWO WHEELERS
A-1	112	951	4527
A-2	106	897	4272
A-3	617	5243	2492
A-4	99	841	4004
A-5	97	824	3924
A-6	98	842	4007
A-7	93	790	9762
A-8	90	776	3700

Occupancy of various modes is assumed according to reference [1].

Table 10: Total no. of Modes in each Link at peak hours

	BUS			CAR			TWO WHEELERS		
LINK	FLOW	OCCUPANCY	NUMBER	FLOW	OCCUPANCY	NUMBER	FLOW	OCCUPANCY	NUMBER
A-1	112	28.5	4	951	1.85	514	4527	1.63	2777
A-2	106	28.5	3	897	1.85	485	4272	1.63	2620
A-3	617	28.5	22	5243	1.85	2834	2492	1.63	15288
A-4	99	28.5	3	841	1.85	454	4004	1.63	2456
A-5	97	28.5	4	824	1.85	445	3924	1.63	2400
A-6	98	28.5	3	842	1.85	455	4007	1.63	2488
A-7	93	28.5	3	790	1.85	427	3762	1.63	2111
A-8	90	28.5	4	776	1.85	410	3700	1.63	2144

Number of buses available at peak hour is calculated using the given formula and is shown in figure 4

Number = Flow/Occupancy

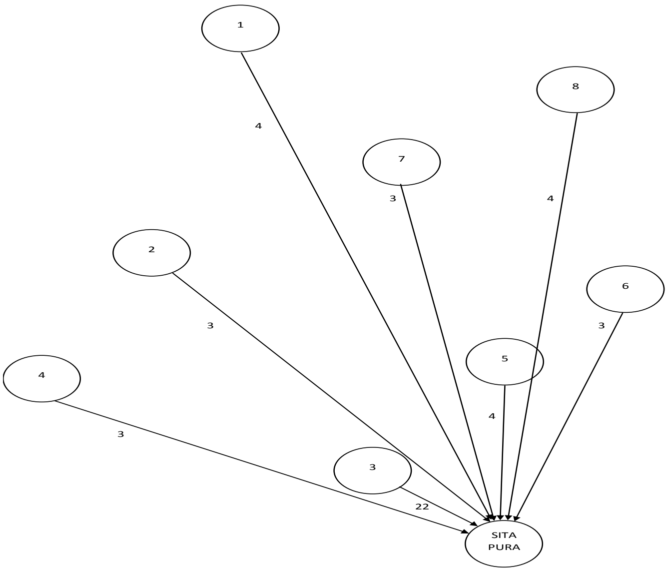

Figure 4: Buses available at the peak hour traffic

IV. CONCLUSION

Transportation models are used to provide forecasts for a complex set of problems that goes beyond their capabilities and original purpose. Travel demand management, pedestrian and bicycle programs and employer based trip reduction programs may not be handled well in the process. Transportation travel forecasting models use packaged programs of computers which have their own limitations on how easily they can be changed. In some cases, the models can be redesigned to accommodate extra factors or procedures while in other cases major modifications are needed or new software are required. All models are based on data which we provide about travel patterns and behavior. If this data is out-of-date, incomplete or inaccurate, the results will not be good no matter how good the models itself is. One of the best ways of improving model value and accuracy is to have a good data to be used to calibrate the models and to provide for checks for their accuracy. Models need to demonstrate that they provide an accurate picture of current travel pattern before they are to be used to forecast future travel. Better data, improved representation of pedestrian and bicycle travel, better auto occupancy models, use more trip purposes, better time of day factors , better representation of access, incorporate costs into trip distribution, addition of land use feedback, addition of intersection delays- are some important points which should be considered and included in the conventional transport modeling system to make it much more convenient and realistic.

REFERENCE

[1] L.R. Kadiyali, Traffic Engineering and Transport Planning, Delhi: Khanna Publishers, 2004.

[2] P.H. Wright, Highway Engineering, United States: John Wiley & Sons Inc, 1996..

[3] Indian Population Census-2011 , Community Series, Indian Bureau of Statistics, India, 2011..

[4] Jaipur municipal coorporation, ward list area wise ,dated:2/12/2014.

[5] Bayes Ahmed “The traditional four step transportation modeling using simplified transport network: A case study of dhaka city Bangladesh february 2012 ,volume 1 issue 1,issn 1839-7239.

[6] Detailed Project Report Phase 2 Sitapura to Ambabari of JMRC,march, 2011.