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MODELLING OF TRIP DISTRIBUTION FOR VADODARA CITY

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ABSTRACT - *The main objective of this study is to present an overview of the travel demand modelling for transportation planning. Mainly there are four stages model that is trip generation, trip distribution, modal split and trip assignment. After the first stage of transportation planning i.e. trip generation, it is necessary to determine the direction of flow. The number of trips generated in various zones of the area under study must be appropriated to the various zones to which these trips are attracted. These generated trips from each zone are then distributed to all other zones based on the choice of destination i.e. Trip Distribution. this paper gives a framework for the trip distribution for the city of Vadodara based on Household Survey, as the data is main input for O-D matrix. The trips are combination of work trips, educational trips, shopping trips, recreational trips and religious trips.*

KEYWORDS: *O-D survey, Trip Distribution, Transcad, Household survey, Transportation planning*

I. INTRODUCTION

Transportation planning process plays an important role in construction of new transportation facilities. The basic purpose of transportation planning and management is to match the supply and demand of the population which can create a need. Transportation planning is one field where approach has already been tried and found extremely useful. Operations research is mainly concerned with optimising the performance of a system. A system is defined as a complex whole, an organised whole, consisting of set of connected things or parts, whose components and interconnections are vital to the operation of the system. Transportation planning process includes four stages i.e.: Trip Generation, Trip Distribution, Modal Split and Traffic Assignment, which is provided in the form of flow diagram in Figure below. For any city like Vadodara which already facing the problem of Traffic it is very much important to know about Future Traffic Conditions.

Urbanization is an index of transformation from traditional rural economy to modern industrial one. It is taking place at a faster rate in India. The process of urbanization increases both the number and size of town and cities. With this, there is a requirement for a good transport network. With increase in population, Vadodara started facing problems of traffic, parking, pedestrians' safety, congestion in the city. The solution may include,

- Land use and city planning controls.
- Transportation studies are to be carried out and plans for new roads and reorganization of existing network are to be formulated.
- Traffic restraint measures like restriction in parking, road charges etc.

It is the process that leads to decisions on transportation policies and program. In this process, planner develops information about the impacts of implementing alternative courses of action involving transportation services such as new roadways, introduction to new modes of public transport, etc. or parking restrictions.

Vadodara city has witnessed establishment of medium and large-scale industries. With great strides in economic field, the city has giant industrial complexes and public undertaking like Gujarat Refinery, Indian Petrochemicals, Gujarat State Fertilizers, Heavy Water Project, etc. the city getting future development at the outskirts areas which were less flourished compare to the main city, as the development in industrial sectors leads to the development of road network. The traffic network is in terms of public transport run by the contract agency and by the administrative authorities (VMC) for the city and hinterland areas. The intrastate network of road transport is supported by GSRTC and private bus operators. The city is more dependent on this mode of transport.

There is constant increase in the number of privately-owned vehicles in the region. The trips by private vehicles and auto rickshaws constitute most trips leading to increased demand for parking and add to the noise and air pollution problems. The increasing numbers of vehicles and inadequate carrying capacity of road along the improper geometry of road network are major causes for traffic congestion, delay, and accidents. So due to increase in number of private vehicles and due to increase in population and income, numbers of trips increase.

Following issues which are identified in Vadodara related to transportation are as:

a. Areas in the old city are highly congested
b. Lack of pedestrian facilities
c. Rapid growth in private vehicles

d. Improper ratio of public and vehicles
e. Poor road geometry
f. Need of improvement of existing road networks
g. Public transports in the urban region are inadequate to cater to the commuters beyond the arterial roads
h. Reduction in road width due to the improver parking practises
i. Absence of traffic sense which again leads to travel time and uncontrollable situations
j. Proper implementation of traffic rules is missing

The study area for which transportation facilities are being planned is first identified. Transportation planning can be at national level, regional level, or at the urban level. Very often known as the cultural capital of Gujarat, Vadodara may not have had a colourful history like Calcutta or Bombay or seen the great empire builders like Delhi. But then, unlike these cities, its history begins somewhere in the mid-Pleistocene period. There are evidences of the existence of the early man of old stone age at the Mahi River valley at several sites within 10 to 20 kms. To the North-East of the present Vadodara. Vadodara formerly known as Baroda is the third-largest city in the Western Indian state of Gujarat, after Ahmedabad and Surat. It is the administrative headquarters of Vadodara District and is located on the banks of Vishwamitri river, 141 kilometres (88 mi) from the state capital Gandhinagar. As of 2011, Vadodara had a population of almost 16.66 lacs people.

II. TRIP DISTRIBUTION

Trip distribution is another of the major aspects of the transportation simulation process and although generation, distribution and assignment are often discussed separately. In trip distribution two known sets of trip ends are connected without specifying the actual route and sometimes without reference to travel mode, to form a trip matrix between known origins and destinations. There are two basic methods by which this may be achieved:

A. Growth Factor Methods
- Uniform Growth Factor Method
- Average Growth Factor Method
- Fratar Method
- Detroit Method
- Furness Method

B. Synthetic Models
- Gravity Model
- Opportunity Model

a. Intervening Opportunity Model
b. Competing Opportunity Model

A. Growth factor method:

The growth factor methods assume that the present travel pattern can be projected in future for design year by using expansion factors.

B. Synthetic models:

Utilize the present data to determine a relationship between trip marking, the resistance and the attractiveness of the zones for travel. Once a model is established based on the present data the model can be used to predict the future pattern of travel between zones.

Gravity Model: This model is originally generated from an analogy with Newton's gravitational law i.e. the attractive force Newtons' law of gravity which says that the force of attraction between two bodies is directly proportional to the product of the masses of the two bodies is inversely proportional to the square of the distance between them. Similarly, in the gravity model, the number of trips between two zones is directly related to activities in the two zones and inversely related to the separation between the zones as a function of travel time, cost and length.

$$Tij = \frac{k \times Pi \times Aj}{dij^{c}}$$

Where, k & c = parameter of model estimates through calibration using base year data
Aj = total trip attraction at zone j
Pi = total trip production at zone i
dij = impedance between zone i and zone j

Using the usual mathematical modelling terminology, the trips are the dependent variables, the production, attraction and impedances are the independent variables. The constant k and c are the parameters of the model that must be estimated through calibration using base year data.

III. LITERATURE REVIEW

Study done by Zala K in (2013) describe the calibration of a gravity model for various trip purposes like business, service and home and for the same, the value for the deterrence functions ranges between 1 to 3 depending upon travel factors.
Study done by Guler in Turkey (2014) aims to calculate the transportation demand of the Marmaray corridor. The model was used to estimate freight and passenger transportation between Istanbul and other Turkish provinces. The estimated results were used to calculate the required train numbers daily through the Marmaray corridor and some suggestions were put forward to increase the capacity of this corridor.
Study done by S A Veentra in Netherlands (2010) aims a new trip distribution model for destinations that are not homogeneously distributed. The model is a gravity model in which the spatial configuration of destinations is incorporated in the modelling process. The performance was tested on a survey with reported grocery shopping trips in the Dutch city of Almelo.
Study done by Thomas Hudecek in Prague (2017) searched for places with the highest potential for the construction of new parks and attempted to determine the level of the need for public investment for these individual localities. It has been shown, however, that the time-related accessibility of parks is only one aspect, and therefore, the step was taken to expand and deepen the methodologies used. Information about population density as an indicator of the lack of parks has been added. Finally, the results of this research will help the City of Prague in the process of making a new metropolitan land-use plan.

IV. STUDY AREA PROFILE

Vadodara has a population of almost 16.66 lacs people as per census 2011. Vadodara is the third largest city in the Gujarat state. It is the administrative headquarters of Vadodara district. The main two institutions involved in planning and development of Vadodara are VMC (Vadodara municipal corporation) and VUDA (Vadodara urban development authorities). The city is on the major rail and road arteries joining Mumbai with Delhi and Mumbai with Ahmedabad. Due to this Vadodara is known as a Gateway to the Golden Quadrilateral.
The study area is divided into 13 wards based on population data and ward size data. The zoning of Vadodara city done in transaCAD software is shown below in fig 1.

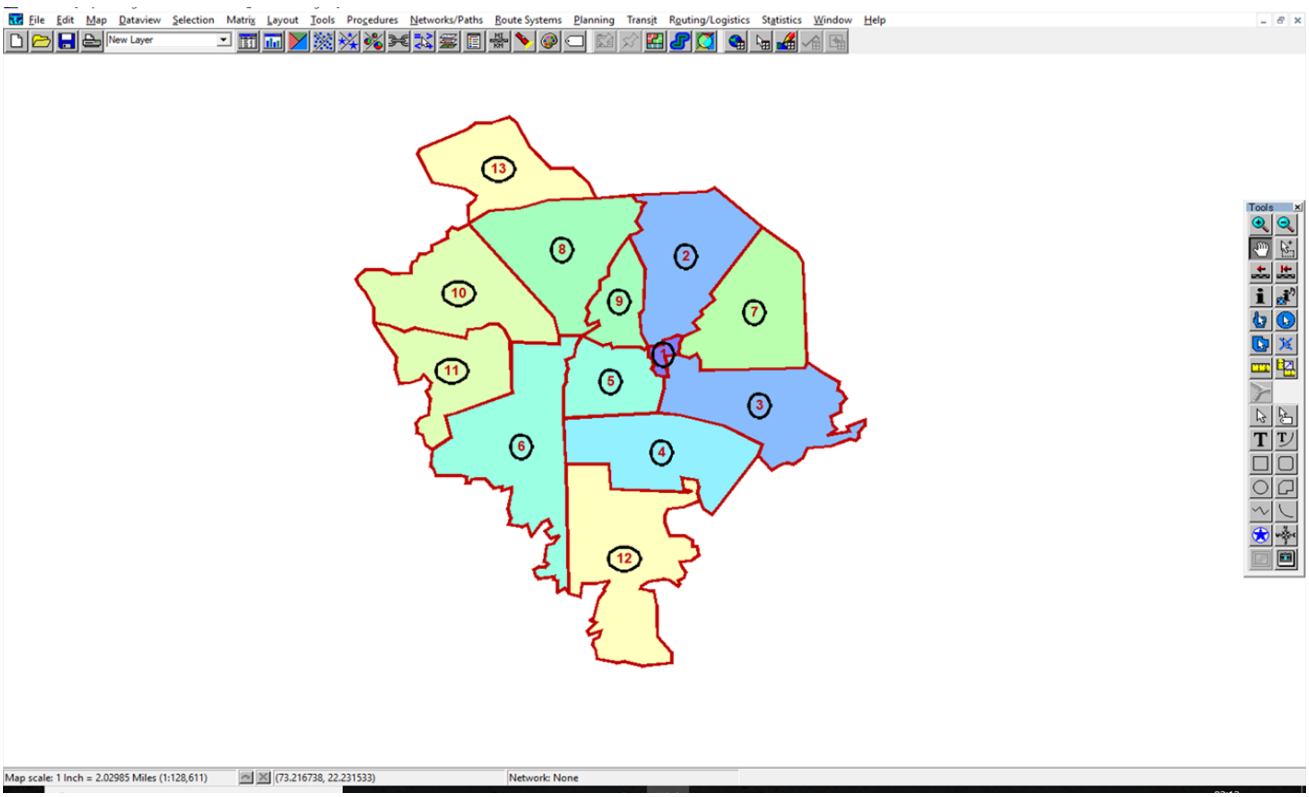
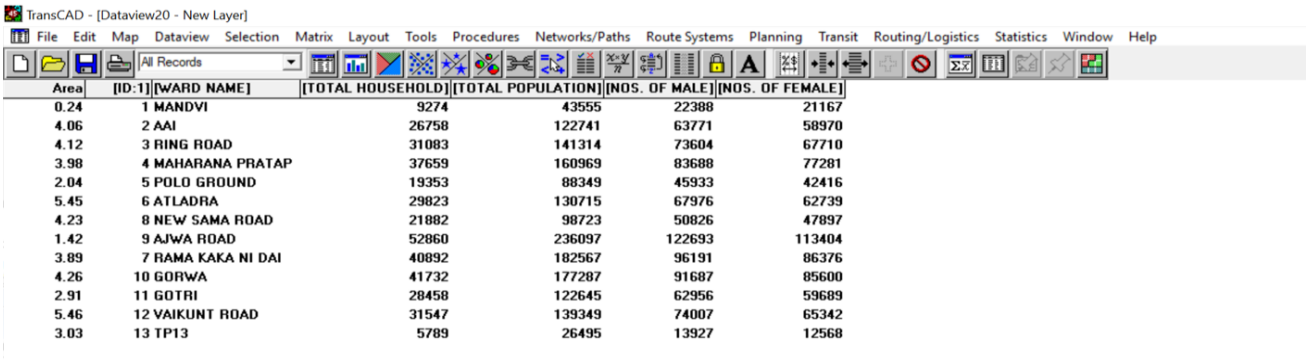


FIGURE 1 : ZONING OF VADODARA CITY


TransCAD - [Dataview20 - New Layer]

File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help

All Records

Area	[ID:1]	[WARD NAME]	[TOTAL HOUSEHOLD]	[TOTAL POPULATION]	[NOS. OF MALE]	[NOS. OF FEMALE]
0.24	1	MANDVI	9274	43555	22388	21167
4.06	2	AAI	26758	122741	63771	58970
4.12	3	RING ROAD	31083	141314	73604	67710
3.98	4	MAHARANA PRATAP	37659	160969	83688	77281
2.04	5	POLO GROUND	19353	88349	45933	42416
5.45	6	ATLADRA	29823	130715	67976	62739
4.23	8	NEW SAMA ROAD	21882	98723	50826	47897
1.42	9	AJWA ROAD	52860	236097	122693	113404
3.89	7	RAMA KAKA NI DAI	40892	182567	96191	86376
4.26	10	GORWA	41732	177287	91687	85600
2.91	11	GOTRI	28458	122645	62956	59689
5.46	12	VAIKUNT ROAD	31547	139349	74007	65342
3.03	13	TP13	5789	26495	13927	12568

FIGURE 2: POPULATION OF VADODARA CITY

V. DATA COLLECTION

The transportation planning is first required transport survey to collect various data on all factors that are influencing the travel pattern. The data collection involves number of surveys to collect the information on existing travel pattern, existing transport facilities and information on existing land use and economic activities. The cost involved for survey is high and it is also time consuming, so this emphasized on the need for proper organization and careful planning.

In many urban areas the travel survey data plays an important role. Sometimes this data is collected for forecasting and then for modelling. In other cases, the data is used mostly to draw a picture of the existing situation.

The surveys can collect the data

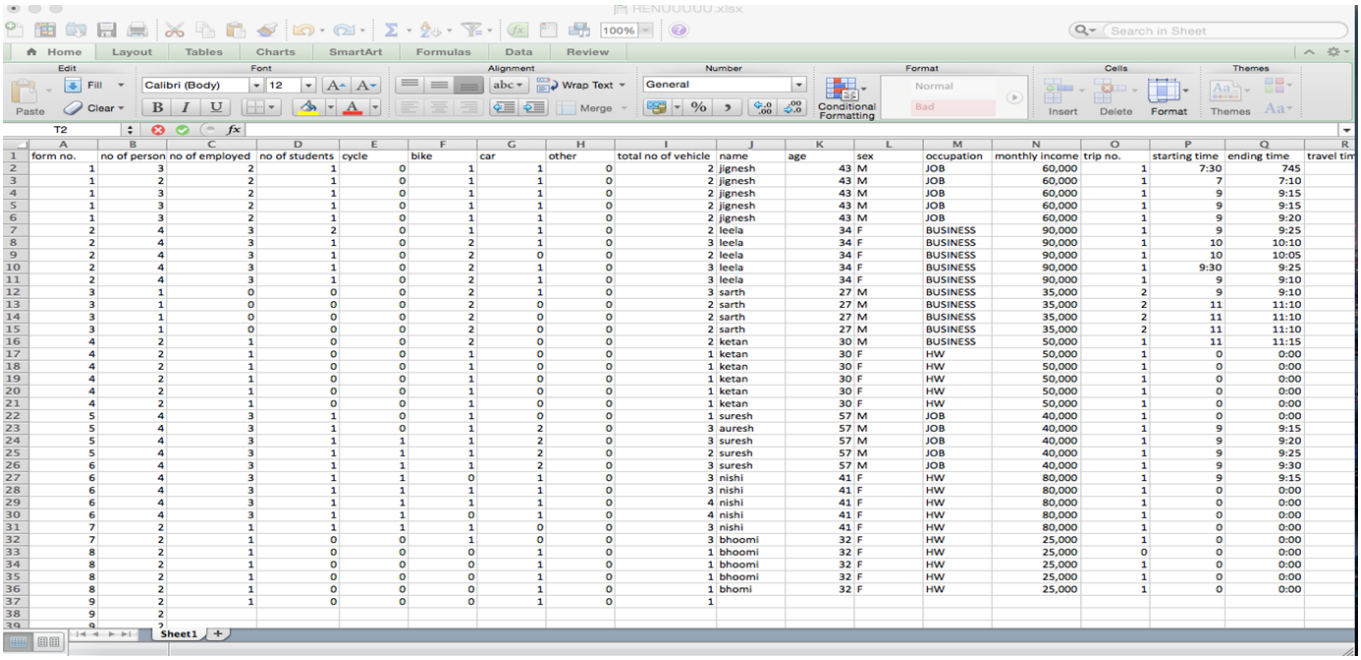
a. At the home
b. During the trip
c. At the destination ends of the trip.

Various types of survey listed below can be executed for data need. In present study HOUSEHOLD INTERVIEW SURVEY is carried out.

1. Household Interview Survey
2. Commercial Vehicle Survey
3. Taxi Survey
4. Road Side Interview Survey
5. Post Card Questionnaire Survey
6. Registration Number Survey
7. Tag Survey
8. Public Transport Survey

Household information survey is one of the most reliable types of survey to collect data on origin and destination. The survey is intended to collect data on the travel pattern of the members of the household and the general characteristics of the household influencing trip making. Several techniques are available for household information surveys are full interview techniques and home questionnaire techniques. The full interview technique involves interviewing as many members of the household as possible and directly recording all the information. In home questionnaire techniques, the interviewer collects only details of the household characteristics and leaving forms for household members to fill the information regarding trips. The completed forms are collected by the interviewer after a day or two.

Out of 18,836 actual sample size we have successfully collected 400 samples from all zones. This data is transformed in excel sheet.



form no.	no of person	no of employed	no of students	cycle	bike	car	other	total no of vehicle	name	age	sex	occupation	monthly income	trip no.	starting time	ending time	travel tim
1	3	2	1	0	1	1	0	2	jignesh	43	M	JOB	60,000	1	7:30	745	
1	2	2	1	0	1	1	0	2	jignesh	43	M	JOB	60,000	1	7	7:10	
1	3	2	1	0	1	1	0	2	jignesh	43	M	JOB	60,000	1	9	9:15	
1	3	2	1	0	1	1	0	2	jignesh	43	M	JOB	60,000	1	9	9:15	
1	3	2	1	0	1	1	0	2	jignesh	43	M	JOB	60,000	1	9	9:20	
2	4	3	2	0	1	1	0	2	leela	34	F	BUSINESS	90,000	1	9	9:25	
2	4	3	1	0	2	1	0	3	leela	34	F	BUSINESS	90,000	1	10	10:10	
2	4	3	1	0	2	0	0	2	leela	34	F	BUSINESS	90,000	1	10	10:05	
2	4	3	1	0	2	1	0	3	leela	34	F	BUSINESS	90,000	1	9:30	9:25	
2	4	3	1	0	2	1	0	3	leela	34	F	BUSINESS	90,000	1	9	9:10	
3	1	0	0	0	2	1	0	3	sarth	27	M	BUSINESS	35,000	2	9	9:10	
3	1	0	0	0	2	0	0	2	sarth	27	M	BUSINESS	35,000	2	11	11:10	
3	1	0	0	0	2	0	0	2	sarth	27	M	BUSINESS	35,000	2	11	11:10	
3	1	0	0	0	2	0	0	2	sarth	27	M	BUSINESS	35,000	2	11	11:10	
4	2	1	0	0	2	0	0	2	ketan	30	M	BUSINESS	50,000	1	11	11:15	
4	2	1	0	0	1	0	0	1	ketan	30	F	HW	50,000	1	0	0:00	
4	2	1	0	0	1	0	0	1	ketan	30	F	HW	50,000	1	0	0:00	
4	2	1	0	0	1	0	0	1	ketan	30	F	HW	50,000	1	0	0:00	
4	2	1	0	0	1	0	0	1	ketan	30	F	HW	50,000	1	0	0:00	
5	4	3	1	0	1	0	0	1	suresh	57	M	JOB	40,000	1	0	0:00	
5	4	3	1	0	1	2	0	3	auresh	57	M	JOB	40,000	1	9	9:15	
5	4	3	1	1	1	2	0	3	suresh	57	M	JOB	40,000	1	9	9:20	
5	4	3	1	1	1	2	0	2	suresh	57	M	JOB	40,000	1	9	9:25	
6	4	3	1	1	1	2	0	3	suresh	57	M	JOB	40,000	1	9	9:30	
6	4	3	1	1	0	1	0	3	nishi	41	F	HW	80,000	1	9	9:15	
6	4	3	1	1	1	1	0	3	nishi	41	F	HW	80,000	1	0	0:00	
6	4	3	1	1	1	1	0	4	nishi	41	F	HW	80,000	1	0	0:00	
6	4	3	1	1	0	1	0	3	nishi	41	F	HW	80,000	1	0	0:00	
7	2	1	1	1	1	0	0	3	nishi	41	F	HW	80,000	1	0	0:00	
7	2	1	0	0	1	0	0	3	bhoomi	32	F	HW	25,000	1	0	0:00	
8	2	1	0	0	0	1	0	1	bhoomi	32	F	HW	25,000	0	0	0:00	
8	2	1	0	0	0	1	0	1	bhoomi	32	F	HW	25,000	1	0	0:00	
8	2	1	0	0	0	1	0	1	bhoomi	32	F	HW	25,000	1	0	0:00	
8	2	1	0	0	0	1	0	1	bhomi	32	F	HW	25,000	1	0	0:00	
9	2	1	0	0	0	1	0	1									
9	2																
9	2																

FIGURE 3: EXCEL SHEET OF 400 SAMPLES

VI. ANALYSIS

Trip distribution can be understood by matrix between zones . The matrix is called origin – destination matrix (O-D) matrix. Matrix involves trip data like travel distance, travel time and number of trips which is important for trip distribution. A matrix is generated after analysis of 400 samples collected from 13 wards of Vadodara and then calculating the numbers of trip per ward through which an O-D pattern has generated which is shown below in figure 4.

O-D	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
1	28	18	21	8	15	11	7	13	16	4	9	8	5	163
2	18	40	14	11	16	13	12	30	19	8	10	17	12	222
3	21	14	41	16	10	5	18	9	17	20	11	3	6	191
4	8	11	16	39	12	23	4	17	4	14	8	11	10	177
5	15	16	10	12	21	1	5	20	12	3	7	15	17	154
6	11	13	5	23	1	19	9	3	6	10	12	6	9	127
7	7	12	18	4	5	9	43	1	4	9	10	13	0	135
8	13	30	9	17	20	3	1	29	0	2	6	0	4	134
9	16	19	17	4	12	6	4	0	30	8	1	0	3	120
10	4	8	20	14	3	10	9	2	8	14	8	19	15	134
11	9	10	11	8	7	12	10	6	1	8	22	0	2	106
12	8	17	3	11	15	6	13	0	0	19	0	18	4	114
13	5	12	6	10	17	9	0	4	3	15	2	4	21	108
TOTAL	163	222	191	177	154	127	135	134	120	134	106	114	108	1885

FIGURE 4: O-D MATRIX GENERATED THROUGH SPSS

VII. CONCLUSION

- The generated trips from each 13 wards are distributed to all the 13 wards based on the choice of destination.
- The distribution of trips is based on attraction of zones.
- The total number of trips were 1885 which include all trip purposes like work, business, educational, social, recreational activities

VIII. FUTURE SCOPE

- The most important model for trip distribution i.e. gravity model can be framed for different types of trips and based on males and female's population with the help of various deterrence function like trip length, distance, cost by the tools available in TRANCAD.

- With the help of deterrence function keeping past population in consideration we can able to predict the future numbers of trips and the scenarios for which planning can be done.

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