CALIBRATION OF GRAVITY MODEL: A CASE STUDY OF AVKUDA REGION

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Abstract

The Trip Distribution is the most complex and also important model in the urban transportation planning process .This paper gives a framework to calibrate a doubly constrained gravity model of the trip distribution stage for the AVKUDA area based on a Household Information Survey which is carried out in 2014-2015. Large sample is used for the calibration of gravity model. The model is also validated by comparing observed and calculated trips by calibrated gravity model. Calibration is carried out for different trip purposes like home based work, home based education and home based shopping trips using Trans CAD software.

Keywords- *Trip Distribution; Trans CAD; Gravity Model; Household Information Survey; Deterrence Functions*

I. INTRODUCTION

Transportation engineering is the application of scientific principles to the planning, design, operation and management of transportation system. The transportation System in the reference to society as a whole because it provides a service for the movements of goods and people from place to place. Population growth and Economic growth seems to have generated levels of demand exceeding the capacity of most transport facilities. Due to the continuing expansion of cities with the development of societies and technology the existing transportation systems are not sufficient to meet the increasing demands. To provide the free and safe flow of traffic from one place to another without encountering any congestion problem, it might be necessary to improve the existing transportation facilities or to construct new facilities. Transportation Planning Process plays an important role in construction of new transport facilities. The basic purpose of transportation planning and management is to match transportation supply with travel demand.

II. TRIP DISTRIBUTION

Trip distribution is important and complex stage in transportation planning Process. Trip distribution is used to estimate present as well as future trips. A trip distribution model produces an origin-destination trip matrix to reflect trips made by population. Trip distribution models used to forecast the origin-destination pattern of travel into the future and produce a trip matrix.

Trip distribution models connect the trip origins and destination estimated by the trip generation models to create estimated trips. It provides the planner with a systematic procedure capable of estimating zonal trip interchanges for alternate plans of both land use and transportation facilities.

A) METHODS OF TRIP DISTRIBUTION

➢ Growth Factor Methods

- Uniform Growth Factor Method
- Average Growth Factor Method
- Fratar Method
- Furness Method
- Detroit Method

➢ Synthetic Models

- Gravity Model
- Opportunity Model

B) GRAVITY MODEL

The concept of gravity model came from Newton's law of gravity, which states that:

$$F = \frac{k*m1*m2}{d^2}$$

Where, F = Force of attraction between m_1 and m_2
m_1 and m_2 =Mass of object 1 and 2
d = Distance between objects
k = Constant

The application of this concept to trip distribution takes the form:

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

Classical form of gravity model:

$$Tij = \frac{Pi*Aj*F(dij)*Kij}{\sum\{Aj*F(dij)*Kij\}}$$

Calibration of gravity model:

$$Tij = \frac{Pi*Aj*F(dij)}{\sum\{Aj*F(dij)\}}$$

Where $F(dij) = 1/dij^c$ = Distance impedance

Tij = Total number of trips between zone i and zone j

Pi = Total number of productions at zone i

Aj = Total number of attractions at zone j

dij = Distance, Cost or Time between zone i and j

kij = socio economic factor

➢ Various deterrence functions:

1) Inverse Power Function

$$F(dij) = dij^{-c}$$

2) Exponential Function

$$F(dij) = \exp(-\beta dij)$$

3) Tanner Function

$$F(dij) = dij^{-c} \exp(-\beta dij)$$

III. STUDY AREA PROFILE

The constituted AVKUDA (Anand Vidhyanagar Karamsad Urban Development Authority) area is covering 29 villages of Anand taluka and in addition to the Anand, Karamsad, Vallabh Vidhyanagar, Boriyavi nagarpalika and Vitthal Udyognagar, a notified area. The developed area of AVKUDA is well connected with road and railway network to other regions of state. The linkages in the region currently provide help in growth of settlements with better economic potential and future prospects. The AVKUDA having area of 279.62 km² and population of area is 501526 as per census 2011.

Zoning of study area is done by Trans CAD software as shown in figure 1. Study area is divided into 33 zones based on administrative boundaries.
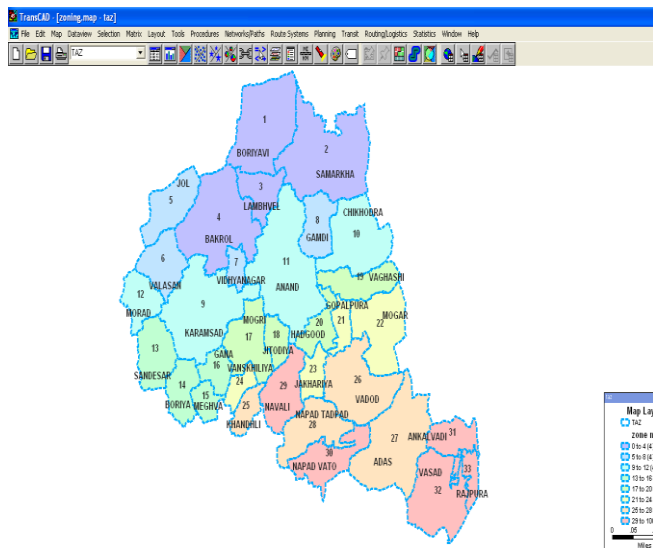
Figure 1 : Zoning of study area

IV. HOUSEHOLD INFORMATION 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. The data collected by household interview survey are of wide range and involved high cost and also time consuming so it is necessary to standardize the procedure for such survey. The size of the sample is usually determined on the basis of the population of the study area and the standards for sample size are given by Bureau of Public Roads as given in Table 1.

Table 1: Standards for sample size

Population of Study Area	Sample Size
Under 50,000	1 in 5 households
50,000 – 1,50,000	I in 8 households
1,50,000 – 3,00,000	1 in 10 households
3,00,000 – 5,00,000	1 in 15 households
5,00,000 – 10,00,000	1 in 20 households
Over 10,00,000	1 in 25 households

Out of total 98395 households of AVKUDA region 2441 households were successfully surveyed.

V. ANALYSIS

The data collected from household information survey is entered into Microsoft Excel. Then these entered data is imported into Trans CAD software for analysis purpose.

The decision to travel for a given purpose is called trip generation. The decision to choose destination from origin is directional distribution of trips forms the second stage of travel demand modeling. Trip distribution is determined by the number of trips end originated in zone-i to number of trips end attracted to zone-j, which can be understood by the matrix between zones. The matrix is called origin–destination (O-D Matrix).

From the household information data, using Trans CAD tool the observed O-D matrix is obtained as given in Figure 2. The desire line diagram for O-D matrix is given in Figure 3.

Figure 2 : Observed O-D Matrix

The desire line diagram drawn is shown in figure 3. This shows predominant traffic on Vidhyanagar to Anand, Karamsad to Anand, Karamsad to Vidhyanagar, and Bakrol to Anand.
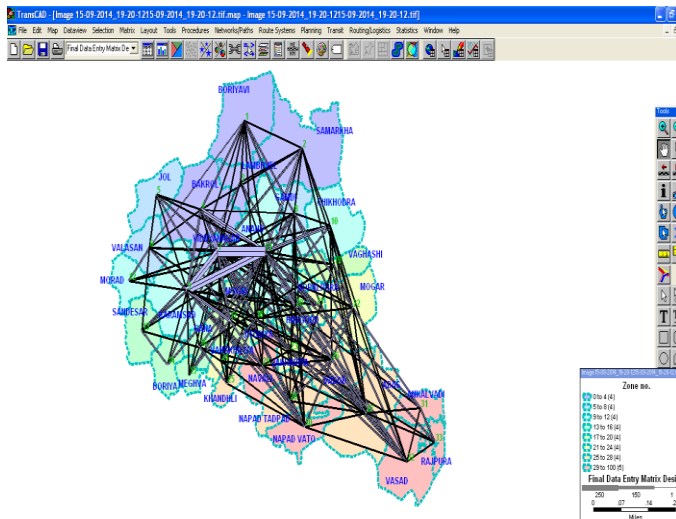
Figure 3 : Observed Desire Lines Diagram

Trans CAD software is used for calibration of gravity model using Travel Time, Travel Cost and Travel Distance attributes for number of iterations. The calibrated exponent values for educational trips, work trips and shopping trips are as shown in Table 2.

Table 2 : Calibrated value of Exponents

Trip Type	Travel Impedance	Inverse Power Function	Exponential Function
		c	β
Work	Distance	1.4804	0.1834
	Time	1.5764	0.0581
	Cost	1.6122	0.0622
Study	Distance	2.0708	0.2827
	Time	2.2255	0.0913
	Cost	2.9744	0.1301
Shopping	Distance	1.9726	0.5234
	Time	1.4770	0.0628
	Cost	0.0763	0.0762

VI. MODEL VALIDATION

Validation of model is done by comparing observed and calculated trips by calibrated gravity model. Validation of model is done using trip length distribution. Model is validated for both inverse power function and exponential function. Figure 4 and figure 5 shows trip length distribution for inverse power function and exponential function respectively.
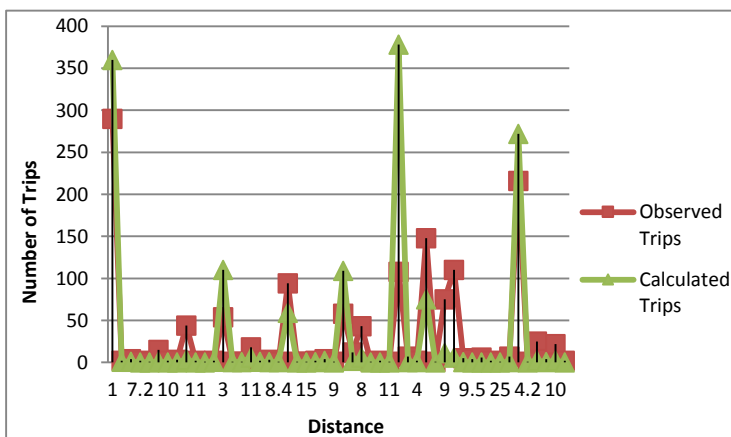

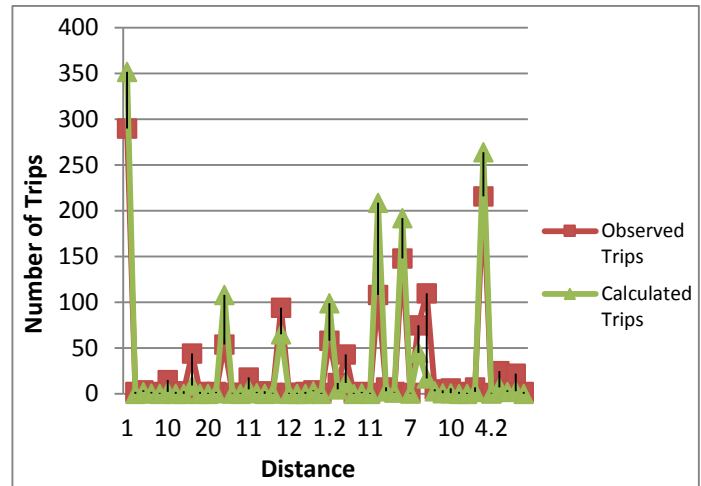
Figure 4 : TLD for Inverse power function

Figure 5 : TLD for exponential function

VII. CONCLUSIONS

1. The population growth rate in the last decade (2001-2011) is 1.3%.
2. The trip rate observed is 4.5 trips/HH/day.
3. The proportion of purpose based trip types is 54.4% Work, 41.6% Educational trips, 0.62% Social trips, 2% Shopping trips, 1.42% Recreational trips.
4. The derived final O-D Matrix can be used for transportation corridor planning.
5. The exponent in inverse power function c for work, study and shopping trips are 1.48, 2.07, 1.97 for distance; 1.57, 2.22, 1.5 for time and 1.61, 2.97 and 0.08 for cost.
6. The exponent in exponential function β for work, study and shopping trips are 0.18, 0.28, 0.52 for distance; 0.06, 0.09, 0.06 for time and 0.06, 0.13 and 0.07 for cost.

VIII. REFERENCES

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