Transportation Planning Using Conventional Four Stage Modeling : An Attempt for Identification of Problems in a Transportation System

Geetanjali Yadav[1], Sujesh D Ghodmare[2]

[1]P.G. Research Scholar, Department of Civil Engineering, G H Raisoni College of Engineering, Nagpur, Maharashtra, India

[2]Assistant Professor, Department of Civil Engineering, G H Raisoni College of Engineering, Nagpur, Maharashtra, India

ABSTRACT

In the formative development of urban transportation planning, travel forecasting is essential. Various travel simulation techniques are used to estimate possible traffic scenarios. It's been used to analyze road capability, transportation system developments, and new land use strategies and policies. The solution to travel decisions is generally obtained if the models are done in sequence. Many attempts are made to simulate the variety of choices made by travellers as a part of a response to a particular highway system, related transit system, and connected policies. For this purpose number of assumptions are considered regarding the decisions made by the people, factors considered by them, and their reaction as a response to the alternatives available in the transportation system. Generally, the process of travel simulation follows trip generating at the trip generation zone and moves through different links of the network and nodes. It ultimately ends at the trip attraction zone. The simulation method is known as Traditional Four Steps Transportation Modeling, and it includes the four basic models namely Trip Generation, Trip Distribution, Mode Choice, and Traffic Assignments. This paper it is tried to focus on the process of this traditional four-step transportation modeling system. The modeling method calculates a simplified transportation network from the city of Ulhasnagar, India.

Keywords :- Travel simulation, four steps transportation modeling, Mathematical model, Ulhasnagar city.

I. INTRODUCTION

Passenger transportation is vital to the city's operation, and transportation is the backbone of urban management. One of the most important factors is transit planning and infrastructure growth, which is particularly important in major metropolitan areas with a high and rapid population growth [1]. It is essential to have a clear understanding of current travel patterns in order to identify and represent a

diverse traffic problems. To manage, develop, evaluate, and regulate transportation and supply chain networks, precise forecasts of total passenger and freight demand, as well as efficient and comparable transportation connections, are needed [11]. The main objective of transportation planning and management is to strike a balance between transportation supply and travel demand. Transportation planning implements a decision-making process for future road infrastructure improvements in a region. To guide in the decision-making process, various programming software and manuals have been generated. [2] Is one of the most essential processes?

1. Simulations for calculating travel demand for the four-step planning phase.

2. Measurements of transport costs that provide details on regional congestion in the city.

Travel demand analysis methods are used for the four-step urban planning process. In relation to rising in regional development and road network supply, travel forecasting models are used to estimate changes in traffic patterns and the operation of the transportation system. Travel demand modelling is a challenging task, but it is crucial for good transportation planning and analysis [1]. The aims of this project are just to gain a clearer knowledge of the traffic situation in Ulhasnagar, Maharashtra, on a zonal basis, and to improve network Assignment by using Urban Transport Modeling System.

II. STUDY AREA

The data collection for this study has been chosen from Ulhasnagar Municipal Corporation area [5]. Ulhasnagar town, Thane district, Maharashtra has 5 camps. Ulhasnagar 1, Ulhasnagar 2, Ulhasnagar 3, Ulhasnagar 4, Ulhasnagar 5 are examples. The city is surrounded into 20 zones and 78 wards. For this project, 6 zones from Ulhasnagar camp no. 4 have chosen as traffic analysis area.
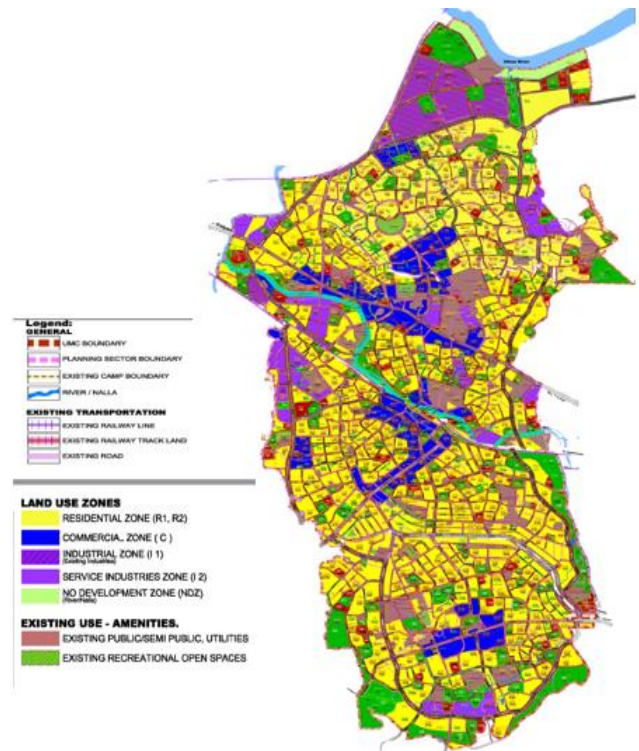

Figure 1 : Ulhasnagar city Corporation (study area)
Source: Ulhasnagar Municipal Corporation, 2020

III. METHODOLOGY

To achieve the goals of this research paper, the traditional four-step transportation modelling system is used. It's a technique for performing at a macro level [6]. In the next section, you must complete the following four steps:

TRIP GENERATION

The traditional four-step transportation planning model, which is commonly used for forecasting travel demand, begins with trip generation. It forecasts the number of trips departing from or arriving at a specific traffic analysis zone [3]. The number of people in the household and the number of vehicles available are used to produce trips. Usually, trip attractions are measured by the level of workforce in a particular interval.

This stage describes trip production and attraction after ten years (2021) (base year 2011). To continue,

actual trip production and attraction parameters are calculated using 10-year growth rates (Figure 1). These growth rates are based on a region basis [4]. Tables 2 and 3 have been provided using Figure 1.
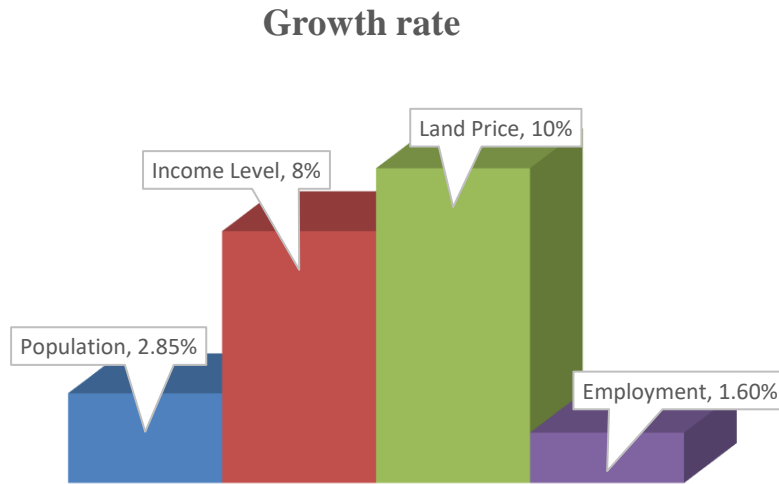
Growth rate

Figure 1 shows the growth value of various components after ten years.
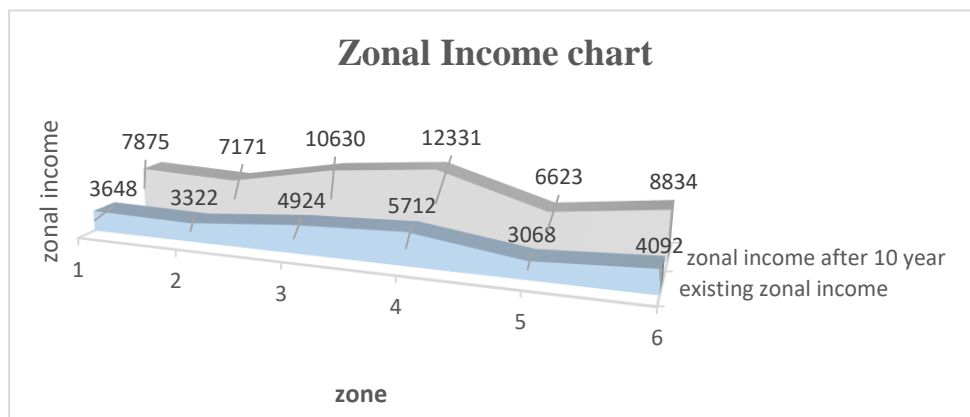

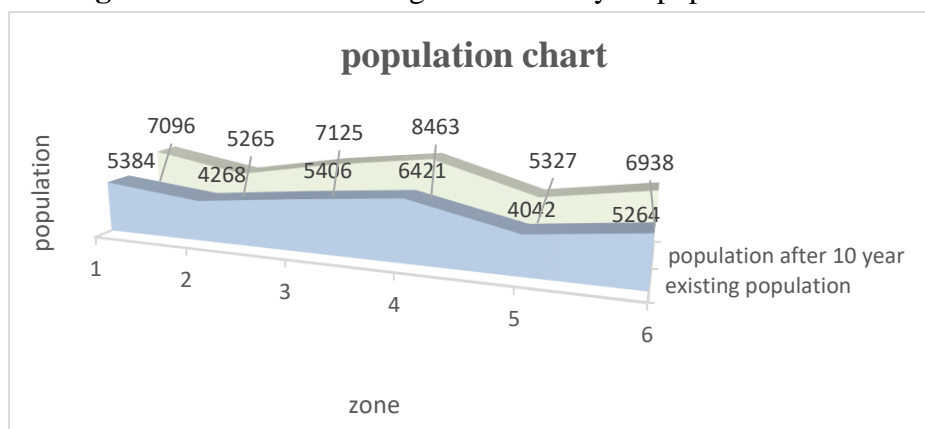**Figure 2** shows the existing and after 10 year population values

Figure 3 existing and after 10 year zonal income values

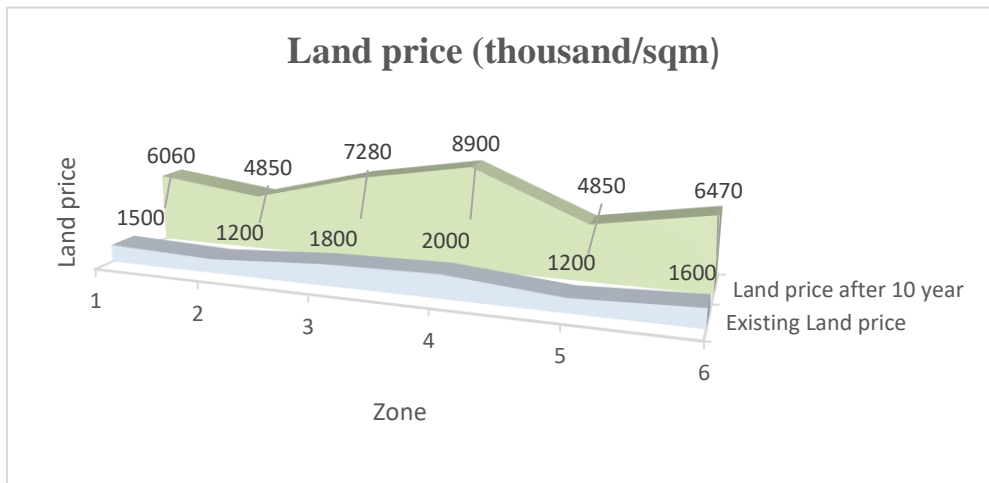For trip production analyses, the population and zonal income graph is used.

Figure 4 existing and after 10 year employment details
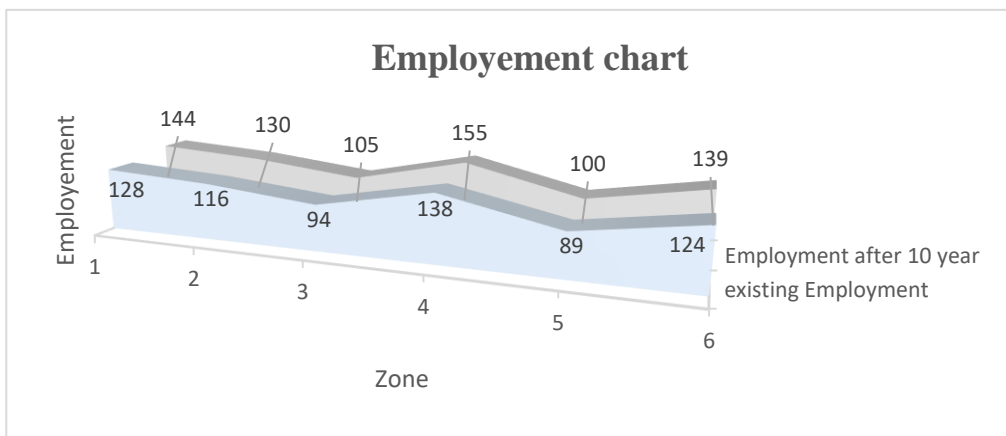
Figure 5 existing and after 10 year land price value in thousand /sqm

For trip attraction analyses, the employment and land price graph is used.
Calculation process for future forecasting *(2031): -*
Existing values x (1+growth rate) ^ projected year

As a result, forecasted values for either trip production and attraction variables are calculated using similar formulas. Two regression equations are identified from the measured variables for trip production and trip attraction after 10 years [2]. The two additional regression equations have been found:

For trip production: $Y_{Production} = 4.251743 - 0.02181\ X\ X_1 + 0.3285\ X\ X_2$

For trip attraction: $Y_{Attraction} = 3.88933 - 0.000571\ X\ X_1 + 0.0003863\ X\ X_2$

These regression equations are then used to determine travel simulations for both trip production and attraction after 10 years. After identifying possible productions and attractions, the stage of trip generation comes to an end.

TRIP DISTRIBUTION

Enable the collection of trip productions and trip attractions, the next step is to arrange the productions and attractions in order to evaluate how trips created in one zone are divided across all other zones. To put it simply, it's the method of predicting how people will choose their ultimate destinations. There are a variety of reasons why one location is preferred over another. In general, traffic distribution is a function of [8]

1. population socioeconomic characteristics,
2. transportation facility type and extent, and
3. Land-use pattern, including position and intensity.

The first step in the trip distribution process will be to develop an origin-destination matrix for each of six zones.

Table 1: Origin-Destination (OD) matrix

O-D	ZONE1	ZONE2	ZONE3	ZONE4	ZONE5	ZONE6	TOTAL
ZONE1							2436
ZONE2							2245
ZONE3							3341
ZONE4							3870
ZONE5							2064
ZONE6							2754
TOTAL	1500	1200	1800	2000	1600	1200	9300

Total trip production value is 16705 and total trip attraction is 9300, Therefore trip Production > trip Attraction. The adjustment factor is used to create trip attraction equivalent to trip production [2].

$$Adjustment\ factor = \frac{Trip\ production}{Trip\ attraction} * Trip\ attraction\ value$$

Table 2 : Adjusted origin-destination matrix

O-D	one1	zone2	zone3	zone4	zone5	zone6	total
zone1							2436
zone2							2245
zone3							3341
zone4							3870
zone5							2064
zone6							2754
Total	2700	2160	3240	3600	2160	2880	19920

The path overload makes it difficult to move from one node to another in a network. While 'Link Impedance' can be expressed as a duration for modelling purposes, travel time or apparent costs are typically more correct measures. Now that a cost matrix has been formed (in terms of time), table 3 is constructed by estimating the cost of travel from one zone to another. The gravity model is used in trip distribution stage.

Table 3: Cost matrix table (C in) in terms of time

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	0.368	0.223	0.135	0.165	0.135	0.111
Zone2	0.223	0.368	0.165	0.135	0.202	0.165
Zone3	0.135	0.165	0.368	0.223	0.202	0.135
Zone4	0.165	0.135	0.223	0.368	0.110	0.165
Zone5	0.135	0.202	00.202	0.111	0.368	0.302
Zone6	0.111	0.165	0.135	0.165	0.302	0.368

$$Impendence\ factor = e^{-\beta * C_{ij}}$$

Table 4: Impedance factor values

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total
Zone1	465	282	171	209	171	140	1438
Zone2	282	465	209	171	255	209	1591
Zone3	171	209	465	282	255	171	1553
Zone4	209	171	282	465	140	209	1476
Zone5	171	255	255	140	465	382	1668
Zone6	140	209	171	209	382	465	1576
Total	1450	1590	1540	1470	1670	1580	9300

Therefore, total impendence factor is 7.3595 and total trip is 9300

The trip to every zone with different zones is now calculated using the formula below.

$$Trip\ of\ any\ zone = \frac{Total\ trip}{Total\ impendence\ factor} * Impendence\ factor\ for\ the\ particular\ zone$$

Table 5: Trip distribution for future forecasting

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Zone1	10	15	20	18	20	22
Zone2	15	10	18	20	16	18
Zone3	20	18	10	15	16	20
Zone4	18	20	15	10	22	18
Zone5	20	16	16	22	10	12
Zone6	22	18	20	18	12	10

Now, comparing Tables 2 and 5, it is clear that the trip productions and trip attractions are vastly different from what they should be. Although the overall number of trips is the same, there are variations in total output and attraction between zones. This indicates that the inter-zonal distribution is incorrect.

Table 6: Adjusted trip distribution after 10 years

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total
Zone1	406	449	363	381	426	411	2436
Zone2	436	271	368	559	209	402	2245
Zone3	508	344	627	556	723	832	3341
Zone4	483	540	804	752	362	929	3870
Zone5	476	180	497	521	173	217	2064

Zone6	391	376	581	831	267	338	2754
Total	2700	2160	3240	3600	2160	2880	19920

Adjusted trips from various zones are found to solve the problem. After 10 years, this is the final O-D matrix for trip distribution among different zones.

Finally, trip distribution from one zone to different ends at the result.

MODAL SPLIT

The process of separating person-trips by mode of travel is known as modal split. In general, modal split refers to trips taken by private car rather than public road or rail transportation. One of the most important parts of the travel demand modelling process is mode selection [16]. The 'Logit' model is a regularly adopted model for mode split [2]. This step provides a matrix for calculating the utilities for two modes of transportation: car and rickshaw. Furthermore, utility functions are assumed for these tow modes.
The following are the utility functions [4]:

$$U_{car} = -0.60 Travel\ Time - 0.040 Travel\ Cost\ \&\ U_{Auto} = 1.2 - 0.060 Travel\ Time - 0.040 Travel\ Cost$$

Table shows utility matrix tables for various modes of transportation.

Table 7: Utility matrix for car

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	-1.2	-1.7	-2.08	-1.8	-2.08	-2.32
Zone2	-1.7	-1.2	-1.88	-2.08	-1.68	-1.88
Zone3	-2.08	-1.88	-1.2	-1.62	-1.76	-2.08
Zone4	-1.8	-2.08	-1.62	-1.2	-2.32	-1.88
Zone5	-2.08	-1.68	-1.76	-2.32	-1.2	-1.44
Zone6	-2.32	-1.88	-2.08	-1.88	-1.44	-1.2

Table 8: Utility matrix for rickshaw

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	0.32	-0.3	-0.8	-1.02	-0.92	-1.36
Zone2	-0.3	0.32	-0.42	-0.56	-0.34	-0.72
Zone3	-0.8	-0.42	0.32	-0.48	-0.4	-0.92
Zone4	-1.02	-0.56	-0.48	0.32	-0.88	-1.02
Zone5	-0.92	-0.34	-0.4	-0.88	0.32	-0.6
Zone6	-1.36	-0.72	-0.92	-1.02	-0.6	0.32

Using the formulas below, the probability of various modes (Table 9-10) is measured using the Tables 7-8

$$Probability_{car} = \frac{e^{U_{Car}}}{e^{U_{Car}} + e^{U_{Auto}}}$$

$probability_{auto}$

$$e^{u\ auto}$$

Table 9: Probability matrix for car

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	0.52	0.29	0.24	0.35	0.26	0.22
Zone2	0.29	0.52	0.26	0.22	0.30	0.29
Zone3	0.24	0.26	0.52	0.49	0.29	0.26
Zone4	0.35	0.22	0.49	0.52	0.17	0.33
Zone5	0.26	0.30	0.29	0.17	0.52	0.37
Zone6	0.22	0.29	0.26	0.33	0.37	0.52

Table 10: Probability matrix for rickshaw

O-D	zone1	zone2	zone3	zone4	zone5	zone6
zone1	0.4756	1.1	0.7503	0.6035	0.7897	0.7732
zone2	0.5576	0.4628	0.7327	0.7614	0.696	0.7044
zone3	0.6488	0.6572	0.4756	0.6876	0.6745	0.738
zone4	0.649	0.6794	0.6766	0.4756	0.8219	0.6695
zone5	0.5182	0.6433	0.7075	0.8186	0.4756	0.6023
zone6	0.6183	0.7045	0.738	0.6695	0.6023	0.4628

The modal share is now determined by multiplying the number of trips made from one zone to another (from the trip distribution) by the probability (Table 9-10). The following equation is used to measure this:

Modal share for any mode $= Trip_{i-j} * Probability_{i*j}$

Table 11

o-d	zone1	zone2	zone3	zone4	zone5	zone6
zone1	70	51	14	23	10	11
zone2	30	71	18	12	22	17
zone3	17	20	51	25	24	14
zone4	21	16	26	48	10	20
zone5	17	26	21	10	70	42
zone6	15	17	11	19	44	0.53

Table 12: Modal share matrix for rickshaw

o-d	zone1	zone2	zone3	zone4	zone5	zone6
zone1	63	70	36	36	31	31
zone2	45	62	43	37	51	42
zone3	32	40	62	54	50	36
zone4	38	34	54	63	32	40
zone5	25	47	52	32	63	66
zone6	24	42	30	40	20	86

Finally, the modal distribution tables 11-12 for the two vehicles are arranged. This is the end outcome of the modal selection stage. We can see how many trips are made between zones using various modes of transportation.

TRIP ASSIGNMENT

The traveller's route option to the total or part of a network is specified by the traffic assignment method. The inter-zonal modal trips are allocated to the different routes of each mode in the final step of the travel estimation process. At least four factors influence people's decision to take one path over another. They are as follows:

1 Duration of travel

2 Travel expenses

3 Convenience and Service level (volume/capacity)

The most commonly used considerations are travel time and prices.

The process starts with determining the shortest route. From any point of origin to any point of destination. Each O-D pair's trips are then allocated to the minimum path's links, and the trips are counted for each connection. To determine if the connection is congested, the allocated trip volume is compared to the link's capacity. If there is a When a connection becomes congested, its speed must be decreased, resulting in a longer travel time As travel times change, the shortest path can change as well. As a result, the entire process is repeated several times until travel demand and supply are in balance. Trips on overcrowded routes will be rerouted to traffic free routes before this equilibrium is reached. The most difficult calculation in the travel modelling series is traffic assignment.

The shortest distance in terms of GTC from one node to the other node for different modes is now calculated using Dijkstra's Method. For calculating the traffic flow for various modes from one node to another, an all-or-nothing assignment is used. After assuming a network, the Generalized Travel Cost (GTC) factor for each mode is calculated. The steps for calculating GTC are given below.

$$GTC = TC + \left(\frac{a_1}{a_2}\right) * TT$$

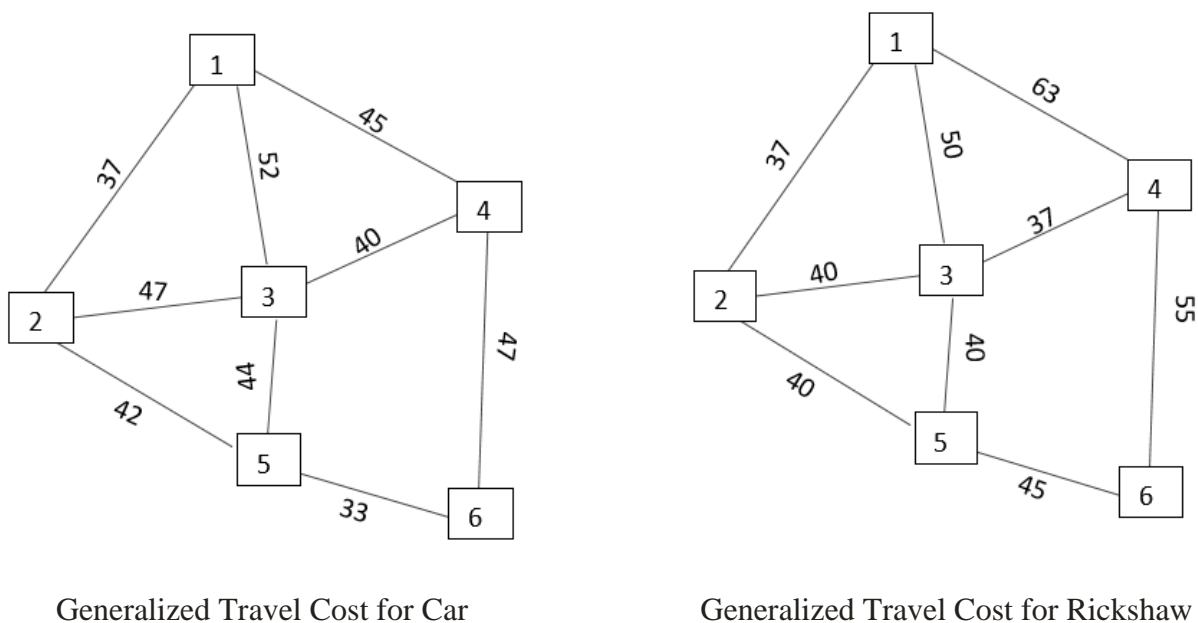Where $\frac{a_1}{a_2} = \frac{0.060}{0.040} = 1.5$

Generalized Travel Cost for Car   Generalized Travel Cost for Rickshaw

Figure 6: Generalized Travel Cost (GTC) for car and rickshaw

Figure 7 displays the traffic flow from one node to another during peak hours for various modes of traffic:
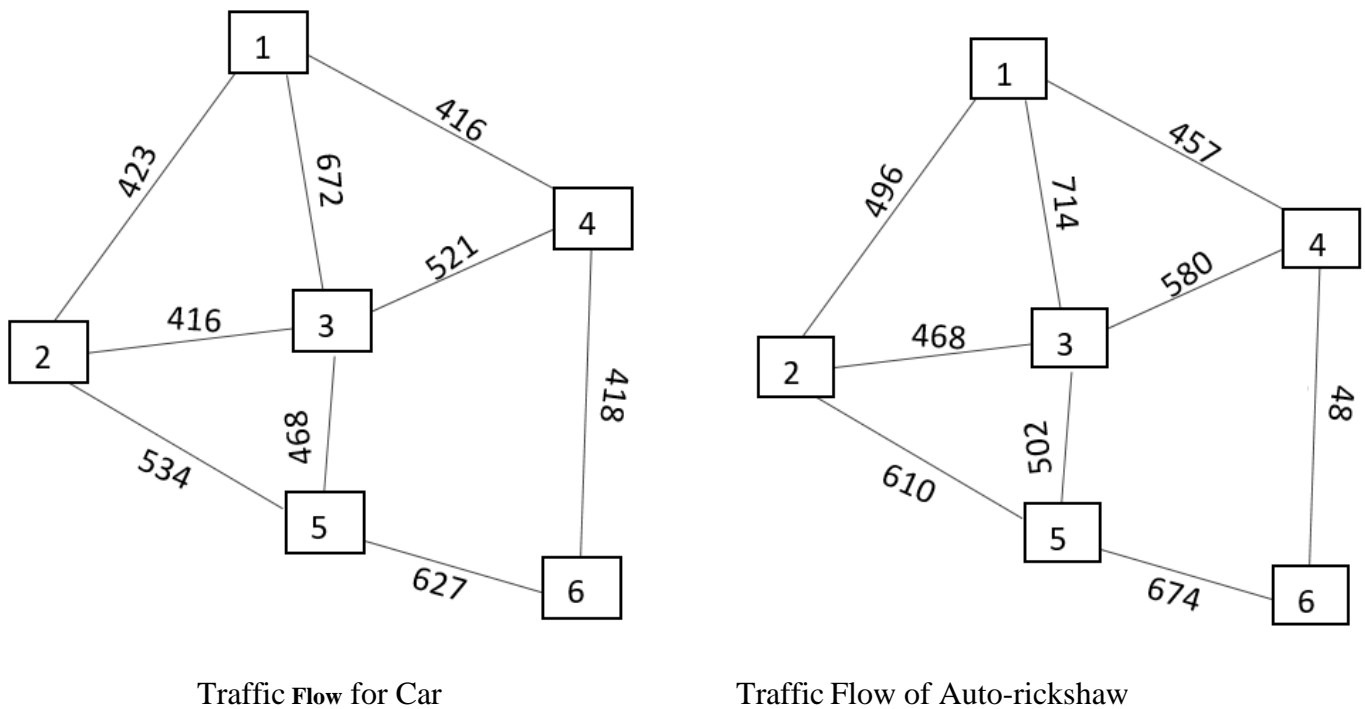

Traffic **Flow** for Car   Traffic Flow of Auto-rickshaw

Figure 7: Total trips in each link for different modes at peak hour

The average number of people that occupy a vehicle is referred to as its occupancy. According to the Ulhasnagar corporation survey, the occupancy for a car is 1.85, for a bus is 1.63, and for a rickshaw is 1.85. The number of cars and rickshaws that flow in the peak time in different links is estimated using these occupancy values.

The total number of vehicles for a particular mode can be calculated from the formula:
Total No of vehicles= Flow of that vehicle / Occupancy of that vehicle

Table 13: Total number of modes in each link at peak hours

Link	Flow	occupancy	Number	Flow	Occupancy	Number
	Car	car	Car	auto	auto	Auto
1 2	423	1.85	228	496	1.63	304
1 5	672	1.85	363	714	1.63	438
2 3	416	1.85	224	457	1.63	280
2 4	534	1.85	288	610	1.63	374
3 4	468	1.85	252	502	1.63	307
3 6	627	1.85	338	674	1.63	413
4 5	416	1.85	224	468	1.63	287
4 6	521	1.85	281	580	1.63	355
5 6	418	1.85	225	482	1.63	295

The traffic assignment details reflect the amount of travel that can be expected on each path in the network with a given transportation system at some point in the future. Congestion levels, travel times, travel speeds, and vehicle miles travelled are all direct outputs of the modeling process. For plan evaluation, connection traffic volumes are often used to assess other travel results.

Thus, the existing transport modelling process is carried out step by step, as detailed in this paper, while collecting data for the 6 zones of the Ulhasnagar City Corporation for research purposes.

IV. CONCLUSION

By integrating theory and practice, transportation modeling was used to investigate and solve "absolute" problems. Four traditional models will be developed for future planning. The total number of trips created to and attracted from different zones in the study area is estimated using trip generation. The trip matrix can be used to define the trip distribution pattern in the study field. The trip matrix is calculated using the gravity model and the growth factor equation. The number of trips taken by people who use a particular mode of transportation is determined by mode selection. The model Logit is used in this method. By comparing the outcomes of their trip, travellers would select the path with the shortest route time and distance. One of the most critical ways to enhance model accuracy and value is to build a good set of recent data to calibrate the models and provide for accuracy assessments. Travel demand management, employer-based trip reduction systems, pedestrian and cycling programmers, changing population age structure, and land use policies are not covered by this approach. In order to make the traditional transportation modelling system more realistic and practical, several important points should be considered and implemented.

V. REFERENCES

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