TRAVEL DEMAND MODELING OF KAKINADA TOWN

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ABSTRACT

The travel forecasting process is at the heart of urban transportation planning. Travel forecasting models are used to project future traffic and are the basis for the determination of the need for new road capacity, transit service changes and changes in land use policies and patterns. Travel demand modeling involves a series of mathematical models that attempt to simulate human behavior while traveling. The models are done in a sequence of steps that answer a series of questions about traveler decisions. Attempts are made to simulate all choices that travelers make in response to a given system of highways, transit and policies. Many assumptions need to be made about how people make decisions, the factors they consider and how they react in a particular transportation alternative. The travel simulation process follows trips as they begin at a trip generation zone, move through a network of links and nodes and end at a trip attracting zone. The simulation process is known as the four-step process for the four basic models used. These are: trip generation, trip distribution, modal split and traffic assignments. This paper describes the process of the traditional four steps transportation modeling system using a simplified transport network in Kakinada Town, Andhra Pradesh.

Keywords: *Travel forecast, travel demand modeling, four steps transportation modeling, trip generation, trip distribution, modal split and traffic assignments.*

I. INTRODUCTION

Travel forecasting models are used to predict changes in travel patterns and the utilization of the transportation system in response to changes in regional development, demographics, and transportation supply. Modeling travel demand is a challenging task, but one that is required for rational planning and evaluation of transportation systems. Transportation planning involves the decision-making process for potential improvements to a community's roadway infrastructure. To aid in the decision-making process, several computer-based and manual tools have been developed. Travel demand forecasting models for implementing the four-step urban planning process. Travel rate indices for providing congestion and delay information for a community. The four-step urban planning process is comprised of the following:

Objectives:

- To conduct the household survey to collect the Socio-demographic data and travel patterns of the Kakinada town. To understand the behavior of the traffic condition of Kakinada town on the zonal basis.
- To forecast the travel patterns for the future from the current travel behavior data of the Kakinada town.
- To conduct four step urban transport modeling for Kakinada town using BIOGEME software. The traditional four step transportation modeling system has been taken to achieve the objectives.

II. LITERATURE REVIEW

[1] ***Mc NALLY, MICHAEL G (2000):*** In this paper four-step model was used First they analyze the transportation system after that they explained each and every topic like problems, study areas, models and data to be taken. In this, the household data was taken as zone wise by conducting household survey, which classifies the number of employed, unemployed persons, about their income whether it is low, medium or high, type and number of vehicles in household and where there travel details. Trip generation process is done by using the following formula;

Pip= fPp Aip= fAp

Pip= total trip productions generated for trip type p for analysis unit i Ajp= total trip attractions for trip type p for analysis unit i

[2] ***DR. GOFRAN J. QASIM:*** In this paper how to collect household data and transportation data by conducting household survey was shown. This tells the factors affecting travel demand, sequential steps for travel forecasting and survey design. The objectives of this paper are to learn about the urban transport modeling system, to gain a better understanding of the behavior of the traffic conditions of Dhaka metropolitan area on the zonal basis and prepare the network assignment through the transport modeling system. First, they took the study area map and analyzed, and they separated the zones and collected the household data of study area. After that traditional four step process had done for the population of Dhaka city after 10 years.

[3] ***INTERNATIONAL JOURNALS OF ENGINEERING RESEARCH & TECH (IJERT) (2016):*** This journal deals with travel demand modeling and forecasting A CASE STUDY OF SITAPURA INDUSTRIAL AREA. The main content of this paper is the travel forecasting model for Sitapura area, in this case we learn about study area methodology- trip generation, trip distribution, mode choice and trip assignment these four steps are done with "macro-level working procedure". The forecasting of the population of city after 10 years had done to determine the travel details of people after 10 years the formulas used for trip distribution is:

$$\mathbf{cij = a1tvij + a2\ twij + a3ttij + a4tnij + a5Fij + a6\varphi j + \delta}$$

Formula to determine utility functions in mode choice:

$$\mathbf{UCAR= - 0.02304TT- 0.07302TC}$$

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

Formula to calculate the way which took minimum time in trip assignment:

$$\mathbf{GTC=TC+(a1/a2)TT}$$

Where, TC=Travel Cost, TT=Travel time a1= Co-efficient of the Travel Time factor a2= Co-efficient of the Travel Cost fact

[4] ***NADEZDA ZENINA, ARKADY BORISOV:*** Mode choice analysis has received the most attention among discrete choice problems in travel behavior literature. Most traditional mode choice models are based on the principle of random utility maximization derived from econometric theory. This paper investigates performance of mode choice analysis with classification methods - decision trees, discriminant analysis and multinomial logit. Several recent studies in the field of decision trees and neural networks [14], [15] have showed better performance indicators compared to discrete choice models.

[5] ***LIN CHENG, ZHAOMING CHU:*** Activity-based models belong to the third generation of travel demand models, which have received extensive interest in the past three decades. Activity-based modeling of travel demand treats travel as being derived from the demand for activity participation. This paper presents an overview of recent and on-going contributions made by "activity-based approaches" to forecast travel behavior. More behavior-oriented activity-based models had replaced the traditional statistic oriented trip-based models.

III. METHODOLOGY

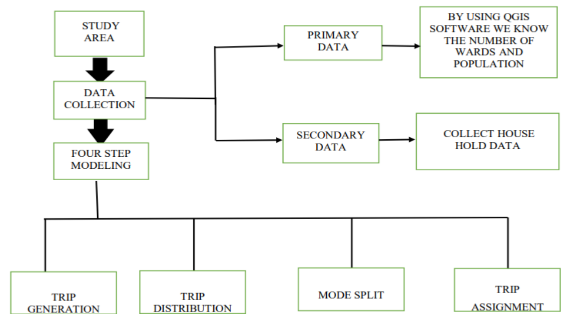


Figure 1 Flowchart methodology

The above flow chart represents process of steps involved in the travel demand modeling which are taken in to consideration to continue the further process to be done.

IV. STUDY AREA PROFILE

The 50 wards Kakinada Town area has been selected as the study area. Then these 50 wards are divided into 10 zones known as TAZ (Traffic Analysis Zones). Transportation planning can be at the national level, regional level or at the urban level. For planning at the urban level, the study area should embrace the whole conurbation containing the existing and potential continuously built-up area of the city. The imaginary line representing the boundary of the study area is termed as the external cordon. The area inside the external cordon line determines the travel pattern to a large extent and as such is surveyed in great detail. The selection of the external cordon line for an urban transportation study should be done carefully due to the following factors.

1. The external cordon lines should circumscribe all areas which are already built-up and those areas which are considered likely to be developed during the period of study.

2. The external cordon line should be compatible with previous studies and the area of studies planned for the future. 3. The external cordon line should be continuous and uniform in its course so that movement

crosses it once. The line should intersect roads where it is safe and convenient to carry out traffic surveys

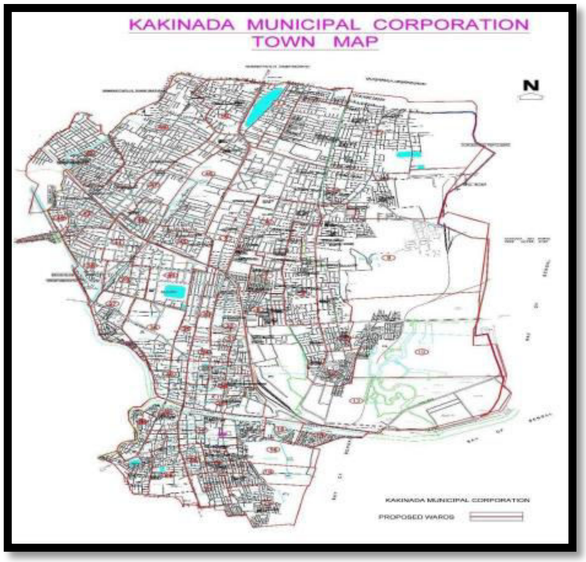


Figure 2 raw image of Kakinada municipal corporation town map.

The above image represents the raw map of Kakinada urban area which was taken in to consideration as study area to know the travel behavior; Total wards in the Kakinada city are shown in the above image.

Zoning the study area:

To facilitate the data collection in transportation planning processes, the defined study area is subdivided into smaller areas called zones or traffic analysis zones (TAZ). Zones are modeled as if all their attributes and properties were concentrated in a single point called the zone centroid. The centroids are connected to the nearest road junction or rail station by centroid connectors.

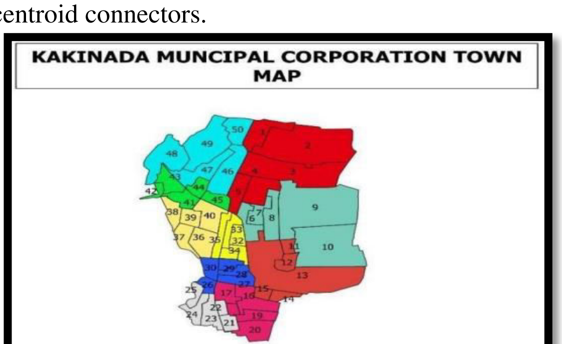


Figure 3 Kakinada municipal corporations town map according to the zones, which we taken as a study area.

Both centroid and centroid connectors are notional and it is assumed that all people have the same travel cost from the centroid to the nearest transport facility which is the average for a zone. The intersection from the outside world is normally represented through external zones. The external zones are defined by the catchment area of the major transport links feeding to the study area. The purpose of such a subdivision is:

1. Better understanding of the structures of the area in terms of land use and activity.
2. Simplifying the collection and presentation of data.
3. Reducing the computation time and storage needed for data processing.
4. Subdivision into zones further helps in geographically associating the origins and destinations of travel.

Only one zone- division usually suffices for all stages in the traditional traffic model. When available time and funds allow, one may deviate from this procedure. It has been shown, for example, that an adequate modeling of public transport benefits from a more detailed study area. The provincial model of Antwerp, for example, shows nearly every public transport stop, especially in the town itself. In such cases, a hierarchical division into zones and sub zones would be applicable. The Below image represents the study area which we taken in to consideration and the total area is divided in to ten zones according to population and number of households in the wards. We had a total of 50 wards and each 5 wards are taken as one zone.

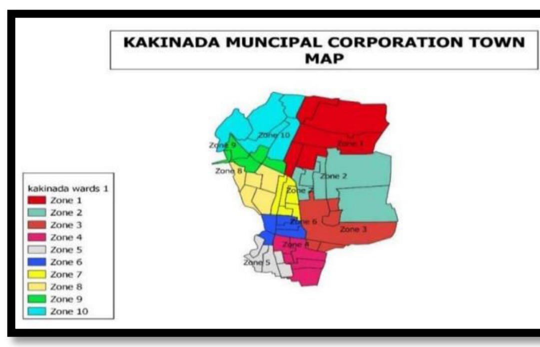


Figure 4 Kakinada Municipal Corporation town map showing different zones which we divided.

V. COLLECTION OF DATA

The first stage in the formulation of a transportation plan is to collect data on all factors that are likely to influence travel patterns. The work involves a number of surveys so as to have an inventory of existing travel patterns, an inventory of existing transportation facilities, and an inventory of existing land use and economic activities.

Information Needed:

Typical information required from the data collection can be grouped into four categories, enumerated as below.

1. Socio-economic data: Information regarding the socio-economic characteristics of the study area. Important ones include income, vehicle ownership, family size, etc. This information is essential in building trip generation and modal split models

2. Travel surveys: Origin - destination travel survey at household and traffic data from cordon lines and screen lines. Former data include the number of trips made by each member of the household, the direction of travel, destination, the cost of the travel, etc. The latter include the traffic flow, speed, and travel time measurements. These data will be used primarily for the calibration of the models, especially the trip distribution models.

3. Land use inventory: This includes data on the housing density at residential zones, establishments at commercial and industrial zones. This data is especially useful for trip generation models.

4. Network data: This includes data on the transport network and existing inventories. Transport network data includes road network, traffic signals, junctions etc. The service inventories include data on public and private transport networks. These particulars are useful for the model calibration, especially for the assignment models.

VI. TYPES OF SAMPLING METHODS:

1) Simple random sampling
2) Stratified random sampling
3) Variable fraction stratified random sampling
4) Multi-stage sampling
5) Cluster sampling
6) Systematic sampling

Simple Random Sampling:

- Simple random sampling is the simplest of all random sampling methods and is
- The basis of all other random sampling techniques. In this method, each unit in
- The population is assigned an identification number and then these number are
- Sampled at random to obtain the sample.

00	01	**02**	03	04	05	06	07	08	09
10	11	12	13	**14**	15	16	**17**	18	19
20	21	22	23	24	25	26	27	28	29
30	31	**32**	**33**	34	35	36	37	38	39
40	**41**	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	**62**	63	64	65	**66**	67	68	69
70	71	**72**	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89
90	91	92	93	94	95	96	97	98	**99**

Figure 5 represents the simple random sampling process

Stratified Random Sampling:

- It is clear that we have inadvertently over-sampled females and under-sampled males
- As a result, any inferences drawn from this sample will be biased towards the behavior or attitudes of females because they are over-represented in the sample compared to their representation in the population

Systematic Sampling:

- When random sampling is being performed in conjunction with a sampling frame list, it is frequently more convenient to use a technique called systematic sampling rather than rely on the use of random numbers to draw a sample.
- Systematic sampling is a method of selecting units from a list through the application of a selection interval.
- The selection interval is simply derived as the inverse of the desired sampling fraction.
- Selection of every 10th unit (100*1/10) for a 10% sample.

00	01	02	03	**04**	05	06	07	08	09
10	11	12	13	**14**	15	16	17	18	19
20	21	22	23	**24**	25	26	27	28	29
30	31	32	33	**34**	35	36	37	38	39
40	41	42	43	**44**	45	46	47	48	49
50	51	52	53	**54**	55	56	57	58	59
60	61	62	63	**64**	65	66	67	68	69
70	71	72	73	**74**	75	76	77	78	79
80	81	82	83	**84**	85	86	87	88	89
90	91	92	93	**94**	95	96	97	98	99

Figure 6 represents the process of systematic sampling

Secondary Data:

By using QGIS software we divided the study area in to the zones and we found out each zone population

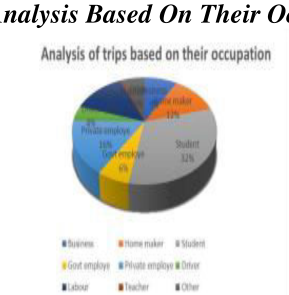
ZONE	POPULATION	NO.OF HOUSES
ZONE 1	27334	9602
ZONE 2	36586	13003
ZONE 3	35499	12701
ZONE 4	28518	10134
ZONE 5	28771	10536
ZONE 6	22822	9498
ZONE 7	22866	8477
ZONE 8	21518	8050
ZONE 9	22586	8353
ZONE 10	28026	10124

Figure 7 represents the population and number of houses of study area according to the zones

The above picture shows the population and number of houses in the study area according to zones which we divided.

VII. DATA ANALYSIS

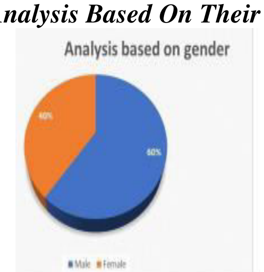
Analysis Based On Their Occupation:



OCCUPATION	NUMBER OF TRIPS
Business	282
Home maker	395
Student	1045
Govt employe	198
Private employe	527
Driver	147
Labour	442
Teacher	20
Other	193

The above analysis describes the trips generated in the study area based on their occupation, and students are generated 32% of the trips when compared to other occupations. Because education is now more important for all people to gain knowledge and achieve their dreams, and all students are selecting best colleges that are far away from cities, and students are active and energetic to travel for gyms, movies, parks, and so on, which increases travel demand.

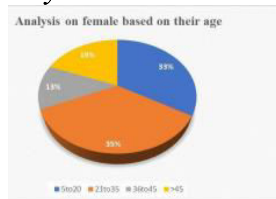
Analysis Based On Their Gender:



GENDER	Number of trips
MALE	1164
FEMALE	860

The above graph describes the trips generated by individuals based on their gender. And the majority of the trips are initiated by men, because men are the one who need to earn money for their families in order to meet their daily needs, and men are suitable for all jobs in which they can actively participate. As a result, males generate more trips than females.

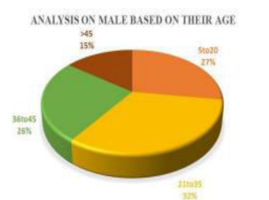
Analysis on Female Based On Their Age:



AGE	NUMBER OF TRIP
5to20	287
21to35	301
36to45	108
>45	164

The above chart describes the analysis based on female age, and the females between the ages of 21 and 35 are generated more trips because most of the females between those ages are doing jobs and working in different companies, and there are some students in those ages who are studying, and for this aspect they are travelling to different places by different modes of transportation, and the trips increased between 21 and 35 when compared to other age groups

Analysis on Male Based On Their Age:



AGE	NUMBER OF TRIPS
5to20	319
21to35	377
36to45	296
>45	172

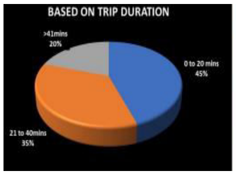
The above chart describes the analysis based on male age, and the males between the ages of 21 and 35 are generated more trips because most of the males between those ages are doing jobs and working in different companies, and there are some students in those ages who are studying, and mostly the males between these age groups are more responsible for the works in houses and they are travelling to different places by different modes of transport and the trips get more than other age groups

Analysis Based On Travel Distance:

DISTANCE	NUMBER OF TRIPS
0 to 10 kms	3192
11 to 20kms	1370
21 to 30 kms	537
31 to 40kms	351
>41kms	28

The above chart describes the trip analysis based on travel distance, and the majority of the trips are generated between 0 and 10 km because Kakinada is an urban city, and all the shopping complexes, movie theaters, and daily needs are available in the locality, and the development in the locality is very high, and we can get anything in our locality between ten kilometers, and most of the people are willing to work in the locality in order to travel short distance to save time and money so the travel distance below 10 kms is more

Analysis Based On Trip Duration:

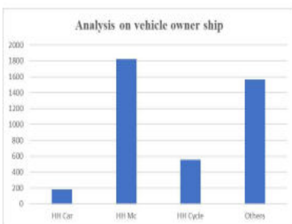


DURATION	NUMBER OF TRIPS
0 to 20 mins	2795
21 to 40mins	2196
>41mins	1249

The above chart describes the analysis based on trip duration, and the majority of trip duration is between 0 and 20 minutes, and with less trips are which exceeding 41 minutes, because people are choosing to travel less distances in order to save money and time, so maybe they are doing their work in their locality and they are changing houses to nearest places to their job location to decrease the distance to travel, so the trips between 0 to 20 minutes are more and people are not willing to travel more distance, so the duration exceeds 41 minutes are very less.

VIII. ANALYSIS

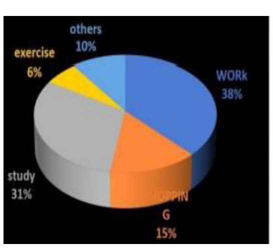
Based On Vehicle Ownership:



TYPES OF VEHICLES	NO OF TRIPS
HH Car	180
HH Mc	1826
HH Cycle	555
Others	1569

The above chart represents an analysis based on vehicle ownership, and most people own motorcycles rather than cars or other vehicles because motorcycles are more affordable for all income levels, and motorcycles are more economical to travel short distances in traffic because they consume less fuel than other vehicles, take up less space for parking, and allow us to travel shorter distances in less time, so motorcycles are used by a greater number of people.

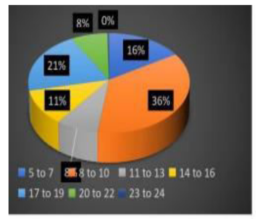
Analysis Based On Trip Purposes:



TRIP PURPOSES	NUMBER OF TRIPS
Work	1210
SHOPPING	478
study	1002
return home	1917
exercise	204
others	322

The above chart describes the analysis based on trip purposes, with the majority of trips generated for the purpose of work (38%), and the trips generated for the purpose of study (31%), because in today's society, everyone is either at home or working to make money, so people who are working have made 38% of the trips, while those who are studying have made 31% of the trips.

Analysis Based On Time Interval:



TIME	NUMBER OF TRIP
5 AM TO 7AM	933
8 AM TO 10AM	2079
11AM to 13PM	467
14PM to 16PM	652
17PM to 19PM	1176
20PM to 22PM	452
23PM to 24PM	19

The above chart represents the analysis based on time interval and most of the people travel between 8:00 a.m. and 10:00 a.m. because at that time all the people have their works like duties and the students about to attend colleges in that time every person should go to travel for different purposes like marketing, gyms, yoga centers and to buy groceries for droppings, pickups for attending colleges schools and to the companies etc.

VIII. FORECASTING POPULATION:

The main goal of the project is to know the travel demand of the study area after 10 years. For this, we gained basic knowledge of the traffic conditions of the study area at the time, and we needed to forecast the population of the study area after 10 years, so we calculated the trip rate and total trips of the study area at the time, and by knowing the growth of population, we forecasted the population for the study in future and by the growth of population we had calculated the total trips after 10 years, and by those calculations we are going to predict the travel behavior of the study area after 10 years.

Calculation Trip Rate for the Year 2019:

- Trip Rate = Total Trips in the Study Area/Number Of Members Surveyed
- Total trips in the study area=sum of the trips in all zones=664+738+660+664+391+693+664+660+693+402=6229
- Population of study area who generated trips=2452 Trip rate= Total trips in the study area / Population of study area who generated trips
- Trip rate=6229/2452 Trip rate=2.54

Calculation of Population for the Year 2019:

Total trips = trip rate * population in study area =2.54*274526 =697296.04

Forecasting of population for the year 2029: Geometrical method:

- Pn = P (1+ r/100) ^n r = geometric mean (%)
- P = Present
- Population N = no. of year
- r= [1.04+1.63+1.66] ^ (1/3)
  =1.44 P2029= 274526*[1+ (1.44/100)] ^10 P2029 = 317659

Calculation of total trips for the year 2029:

Since we had calculated the total trip rate of the year 2019 by the population in that year and we had forecasted the population for the year of 2029 and we are calculating the trip rate of the study area for the year of 2029 by assuming the constant growth of trip rate with the population in 2029. So, we are assuming the trip rate in the year 2029 as 2.54 for the calculation of total trips in the year of 2029.

Total trips = trip rate * population in study area =2.54*3, 17,659 =8, 06,854

The total trips in the year 2029 is 8, 06,854ϖ

IX. FOUR STEP MODELLING

To achieve the goals of this research paper, the traditional four-step transportation modeling system is used. Travel forecasting models are used to predict changes in travel patterns and the utilization of the transportation system in response to changes in regional development, demographics, and transportation supply. Modeling travel demand is a challenging task, but one that is required for rational planning and evaluation of transportation systems.

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. 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. They are two types 1.Trip production 2.Trip attraction.

Trip Production:

A trip end that is produced in a zone is called a "production" Every trip has an origin and a destination, which we divided into a number of zones and independently analyzed. Using the analyses of the trips generated in each zone, we identified the production area, from where the trips had started to reach the destination. Each trip's starting point is taken to show the production areas separately in different zones.

ZONES	PRODUCTION VALUES
1	92
2	109
3	159
4	214
5	346
6	99
7	71
8	98
9	96
10	296

Table 1 shows the trip production values of each zone

Trip Attraction:

A trip end that is attracted to a zone is called an "attraction. " Trips produced in different zones end up in different zones. The ending of each trip in that zone is referred to as trip attraction, and the trips that end in each zone are considered here to show the number of trip attractions in each zone.

ZONES	NUMBER OF ATTRACTIONS
1	102
2	327
3	133
4	96
5	88
6	174
7	148
8	156
9	200
10	156

Table 2 shows the trip attraction values of each zone

Calculation of PCU Values:

starting	Ending	no.of trips	bicycle	bike	car	share auto	bus	others	Total Values
zone 1	zone 10	8	0	7	1	0	0	0	4.5
	zone 2	44	5	32	3	2	2	0	29.5
	zone 3	8	0	5	1	0	2	0	9.5
	zone 6	6	0	5	0	0	1	0	5.5
	zone 7	15	0	11	1	2	1	0	11.5
	zone 9	10	0	9	0	0	1	0	7.5
zone 2	zone 10	33	0	25	3	3	2	0	24.5
	zone 2	61	11	40	2	5	0	2	35.5
	zone 3	16	2	13	0	1	0	0	8.5
	zone 4	15	0	15	0	0	0	0	7.5
	zone 5	17	0	13	2	2	0	0	10.5
	zone 6	12	0	12	0	0	0	0	6
	zone 7	7	0	5	1	1	0	0	4.5
	zone 8	17	0	11	3	3	0	0	11.5

Table 3 shows the PCU value of the vehicles according to zones

Input Data

To get the required data as an output from Biogeme software we need to give input in the required format which is accepted by the Biogeme software. There are two types of input which we need to give to the Biogeme software they are:-

1) Numerical language.
2) Python code

	HH ID	IND ID	TRIP ID	TRIP PURPOSE	SEX	AGE	OCCUPATION	Time of Activity	Trip Length	Travel Time (min)	Travel Mode
2	1	1	1	1	0	2	1	0	0	0	1
3	1	1	2	5	0	2	1	1	0	0	1
4	1	1	3	0	0	2	1	1	1	1	1
5	1	1	4	5	0	2	1	3	1	1	1
6	1	1	5	1	0	2	1	1	0	0	4
7	1	1	6	5	0	2	1	1	0	0	4
8	1	2	1	3	0	1	5	1	0	0	1
9	1	2	2	5	0	1	5	1	0	0	1
10	1	2	3	2	0	1	5	1	1	1	3
11	1	2	4	5	0	1	5	2	1	1	3
12	2	1	1	0	0	2	6	1	0	0	3
13	2	1	2	5	0	2	6	3	0	0	3
14	2	1	3	4	0	2	6	1	0	0	1
15	2	1	4	5	0	2	6	1	0	0	1
16	2	1	5	1	0	2	6	1	0	0	4
17	2	1	6	5	0	2	6	1	0	0	4
18	2	2	1	2	1	2	4	2	0	0	4
19	2	2	2	5	1	2	4	2	0	0	4
20	2	3	1	2	1	0	5	1	0	0	4
21	2	3	2	5	1	0	5	2	0	0	4
22	2	4	1	2	1	0	5	1	0	0	4
23	2	4	2	5	1	0	5	2	0	0	4
24	3	1	1	1	0	2	3	1	0	0	1
25	3	1	2	5	0	2	3	1	0	0	1

Table 4 represents the input data.

```
// File modechoiceMNL.mod

[ModelDescription]
"Simple logit choice model"


[Choice]
chosen


[Beta]
// Name Value  LowerBound UpperBound  status (0=variable, 1=fixed)
ASC_AIR         0       -10000      10000       0
ASC_RAIL        0       -10000      10000       0
BETA_TOTCOST    0       -10000      10000       0
BETA_IVTT       0       -10000      10000       0
BETA_OVTT       0       -10000      10000       0
BETA_FREQ       0       -10000      10000       0


[Utilities]
// Id Name  Avail linear-in-parameter expression (beta1*x1 + beta2*x2 + ... )
   1  CAR   one                   BETA_TOTCOST * TOTCOST_CAR  + BETA_IVTT * IVTT_CAR
   2  AIR   one   ASC_AIR  * one + BETA_TOTCOST * TOTCOST_AIR  + BETA_IVTT * IVTT_AIR  + BETA_OVTT * OVTT_AIR  + BETA_FREQ * FREQ_AIR
   3  RAIL  one   ASC_RAIL * one + BETA_TOTCOST * TOTCOST_RAIL + BETA_IVTT * IVTT_RAIL + BETA_OVTT * OVTT_RAIL + BETA_FREQ * FREQ_RAIL


[Expressions]
// Define here arithmetic expressions for name that are not directly
// available from the data
one = 1


[Model]
$MNL
```

Figure 8 python code

Output Files:

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```
In [1]: import pandas as pd
        import biogeme.database as db
        import biogeme.biogeme as bio
        import biogeme.models as models
        from biogeme.expressions import Beta

C:\Users\Admin\anaconda3\envs\tensorflow\lib\site-packages\scipy\__init__.py:146: UserWarning: A NumPy versi
on >=1.16.5 and <1.23.0 is required for this version of SciPy (detected version 1.24.2
  warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversion}"

In [9]: # Load the data (replace 'your_data.csv' with the path to your data file)
        data = pd.read_csv('C:/Users/Admin/OneDrive - IIT Delhi/Desktop/Biogeme/Sudheer/Kakinada.csv')
        data

Out[9]:
```

	Purpose	Sec	Age	Occupation	Time_Activity	Trip_Length	Travel_Time	Choice
0	1	0	2	1	0.0	0	0	1
1	5	0	2	1	1.0	0	0	1
2	0	0	2	1	1.0	1	1	1
3	5	0	2	1	3.0	1	1	1
4	1	0	2	1	1.0	0	0	4
...	...	...	...	...	...	...	...	...
6226	5	0	2	1	3.0	0	0	1
6227	2	1	1	5	1.0	0	0	3
6228	5	1	1	5	2.0	0	0	3
6229	1	1	2	4	1.0	0	1	4
6230	5	1	2	4	2.0	0	1	4

6231 rows × 8 columns

```
In [10]: # Create the Biogeme database
         database = db.Database('Choice', data)

In [13]: # Define the variables
         travel_time = database.variables['Travel_Time']
         gender = database.variables['Sec']
         age = database.variables['Age']
         occupation = database.variables['Occupation']
         time_of_activity = database.variables['Time_Activity']
         purpose = database.variables['Purpose']
         trip_length = database.variables['Trip_Length']
         choice = database.variables['Choice']

In [14]: # Define the parameters
         ASC_CAR = Beta('ASC_CAR', 0, None, None, 0)
         ASC_BIKE = Beta('ASC_BIKE', 0, None, None, 0)
         ASC_BUS = Beta('ASC_BUS', 0, None, None, 1)
         ASC_BICYCLE = Beta('ASC_BICYCLE', 0, None, None, 0)
         ASC_WALK = Beta('ASC_WALK', 0, None, None, 0)

         B_TIME = Beta('B_TIME', 0, None, None, 0)
         B_GENDER = Beta('B_GENDER', 0, None, None, 0)
         B_AGE = Beta('B_AGE', 0, None, None, 0)
         B_OCCUPATION = Beta('B_OCCUPATION', 0, None, None, 0)
         B_TIME_OF_ACTIVITY = Beta('B_TIME_OF_ACTIVITY', 0, None, None, 0)
         B_PURPOSE = Beta('B_PURPOSE', 0, None, None, 0)
         B_TRIP_LENGTH = Beta('B_TRIP_LENGTH', 0, None, None, 0)
```

```
In [16]: # Define the utility functions for each mode
         V_CAR = ASC_CAR + B_TIME * travel_time + B_GENDER * gender + B_AGE * age + \
                 B_OCCUPATION * occupation + B_TIME_OF_ACTIVITY * time_of_activity + \
                 B_PURPOSE * purpose + B_TRIP_LENGTH * trip_length

         V_BIKE = ASC_BIKE + B_TIME * travel_time + B_GENDER * gender + B_AGE * age + \
                  B_OCCUPATION * occupation + B_TIME_OF_ACTIVITY * time_of_activity + \
                  B_PURPOSE * purpose + B_TRIP_LENGTH * trip_length

         V_BUS = ASC_BUS + B_TIME * travel_time + B_GENDER * gender + B_AGE * age + \
                 B_OCCUPATION * occupation + B_TIME_OF_ACTIVITY * time_of_activity + \
                 B_PURPOSE * purpose + B_TRIP_LENGTH * trip_length

         V_BICYCLE = ASC_BICYCLE + B_TIME * travel_time + B_GENDER * gender + B_AGE * age + \
                     B_OCCUPATION * occupation + B_TIME_OF_ACTIVITY * time_of_activity + \
                     B_PURPOSE * purpose + B_TRIP_LENGTH * trip_length

         V_WALK = ASC_WALK + B_TIME * travel_time + B_GENDER * gender + B_AGE * age + \
                  B_OCCUPATION * occupation + B_TIME_OF_ACTIVITY * time_of_activity + \
                  B_PURPOSE * purpose + B_TRIP_LENGTH * trip_length
```

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```
In [18]: # Associate utility functions with alternatives
         V = {0: V_CAR, 1: V_BIKE, 2: V_BUS, 3: V_BICYCLE, 4: V_WALK}

         # Define the model
         logprob = models.loglogit(V, None, choice)

         # Create a Biogeme object
         biogeme = bio.BIOGEME(database, logprob)
         biogeme.modelName = "mode_choice_mnl"

         # Estimate the parameters
         results = biogeme.estimate()

         # Print the estimated parameters
         print(f"Results:\n{results.getEstimatedParameters()}")

[17:44:29] < Warning >   Cannot read file __mode_choice_mnl.iter. Statement is ignored.
Results:
                           Value  Rob. Std err   Rob. t-test  Rob. p-value
ASC_BICYCLE         6.533838e-01      0.045982  1.420961e+01           0.0
ASC_BIKE            1.347620e+00      0.041858  3.219465e+01           0.0
ASC_CAR            -1.933376e+00      0.104898 -1.843095e+01           0.0
ASC_WALK            5.601684e-01      0.046744  1.198368e+01           0.0
B_AGE               2.355405e-15      0.000118  1.996160e-11           1.0
B_GENDER            7.115766e-16      0.000067  1.054278e-11           1.0
B_OCCUPATION        3.243142e-14      0.002597  1.248796e-11           1.0
B_PURPOSE           3.278190e-14      0.004794  6.837586e-12           1.0
B_TIME              1.366985e-15      0.000138  9.889482e-12           1.0
B_TIME_OF_ACTIVITY  2.961161e-15      0.000232  1.273721e-11           1.0
B_TRIP_LENGTH       5.357918e-16      0.000132  4.056315e-12           1.0

In [ ]:
```

Figure 9 represents the output data

X. CONCLUSION

In summary, this study provided a detailed assessment of travel demand modeling. For this, we collected the total population in the study region as well as the number of wards. The overall area was then divided into ten zones. Based on the population of the research region in 2019. We also acquired primary data from 1000 households by performing a questionnaire survey. By using the data, we collected; we conducted an analysis based on various categories such as age, gender, occupation, travel duration, mode of transportation used, and so on. According to such analyses, students generate 32% of trips when compared to other occupations. Males generate 60% of trips, while females generate 40% of trips. The majority of trips are generated by males and females between the ages of 21 and 35 years because students and job holders are more prevalent in that age group, and the majority of trips are made between the distance of 0 to 10 kms with a time duration of 20 minutes because people prefer to travel less distance to save time and money. As a result, people may be performing work in their communities and relocating their homes closer to their places of employment. So, the percentage of journeys between 0 and 20 kilometers is approximately 45%. To make journeys, individual's priorities motorbikes in order to save time and money. A total of 1826 motorcycles are used for trip generating from 1000 households. In terms of travel purpose, those who are studying and working in various sectors have taken more journeys. The current population of the research region has a trip rate of 2.54. and the total number of trips created by the city's current population is 697296.04. The geometrical approach was used to anticipate the population for the year 2029, and the forecasted population for 2029 is 317659. And, assuming continuous trip rate growth, we computed that the total number of trips projected to be generated in 2029 is 806854. To know the equivalent traffic factor for all vehicles moving to particular zone from the particular area. We used relative weight age factor given to the traffic volume of individual vehicle for calculated passenger car unit for total vehicles used in study area while travelling from one zone to another. In the process of trip generation 346 trips are produced by the zone 5 and distributed to different zones. And 396 trips are attracted by the zone 2 which are produced by remaining zones in our results, the ASCs are: **ASC_Bicycle: 0.653 ASC_BIKE: 1.3476 ASC_Car: -1.933 ASC_walk: 0.5602**

These results suggest that choosing the "BIKE" mode has the highest utility among the four alternatives, as it has the highest ASC of 1.3476. The "Car" mode has the lowest utility among the alternatives, as it has the lowest ASC of -1.933. The ASCs for "Bicycle" and "Walk" modes suggest that they have intermediate levels of utility. The standard errors for the ASCs in our MNL model results indicate the precision or uncertainty associated with the estimated parameter values. The standard errors are typically used to compute confidence intervals and hypothesis tests for the parameters. In our results, the standard errors for the ASCs are: **ASC_Bicycle: 0.045982 ASC_BIKE: 0.041858 ASC_Car: 0.104898 ASC_walk: 0.046744**

The ASCs with smaller standard errors (i.e., ASC_Bicycle, ASC_BIKE, and ASC_walk) are estimated more precisely than the ASC with a larger standard error (i.e., ASC_Car). This means that the estimated ASCs for Bicycle, BIKE, and Walk modes are relatively more reliable and less prone to random error or sampling variation than the estimated ASC for Car mode. The estimated coefficients for the explanatory variables in our Biogeme MNL model results are: **Beta_AGE: -0.0235; Beta_Gender: -0.00711; Beta_Occupation: -0.3243 Beta_Purpose: 0.32781**; **Beta_Time: -0.01366; Beta_Activity: -0.029611; Beta_Length: -0.005357**

These coefficients represent the change in the utility of each transportation mode associated with a one-unit change in the corresponding explanatory variable, holding other variables constant. Based on the results we have obtained, the following are some summary and conclusions regarding the MNL model results: The model includes alternative-specific constants (ASCs) for different transportation modes, including ASC_Bicycle, ASC_BIKE, ASC_Car, and ASC_walk.The estimated ASC values suggest that, compared to the reference category (e.g., ASC_Car), ASC_Bicycle and ASC_walk have relatively higher utility or preference, while ASC_BIKE has the highest utility or preference.The standard errors for the estimated ASC values indicate that theestimates are relatively precise, with the exception of ASC_Car which has a larger standard error.The model includes several explanatory variables, including Beta_AGE, Beta_Gender, Beta_Occupation, Beta_Purpose, Beta_Time, Beta_Activity, and Beta_Length

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