# Travel Demand Modelling of work trips for Nashik city, Maharashtra, India

**Darshankumar Patel[1], Bikram Prasad[2]**

[1]Research Scholar,
Department of Civil Engineering, Oriental University, Indore, Madhya Pradesh, India
darshptl12354@gmaill.com

[2]Associate Professor,
Department of Civil Engineering, Oriental University, Indore, Madhya Pradesh, India
bikram2010@gmail.com

***Abstract*: Models based on trip have been developed over a period of time. This models which is based on trips uses the individual trips as the major factor for analysis in modelling. In this paper four step trip based model developed for the Nashik. In first step Pilot study was conducted in city to collect the necessary data after that multiple regression method is used to derive trip production regression equation. This is used for calculating existing and projected trip production. In second step existing and projected trip distribution is calculated and mapped. In third step for modal split analysis binary logit model is used to calculate mode choice. In last step the shortest path between zones is drawn from network analysis in Arc-GIS.Based on the travel demand modelling for work trip shows that maximum number of peoples are using private mode of transportation for trip rather than public transport.**

***Keywords*: model split, travel modelling, trip attraction, trip production, work trips**

**(Article history: Received: 11th December 2021 and accepted 7th February 2023)**

## I. INTRODUCTION

Transportation modelling is the technique of predicting how many individuals will utilize a specific means of transportation in the future. The volume of vehicular traffic, along with rail and public transit ridership, could be predicted. Passengers visiting airport, number of ships coming to airport etc. The collection of data for the current traffic scenario is the very first step in transport modelling. To develop a transport demand model for the present situation, the acquired data can be integrated with existing data available like demographics, economic status, available employment, and so forth. Then the generated model is feeded with the predicated data of population, employment level etc. to get future traffic scenario and estimate value is checked against transportation infrastructure, road width, railway station etc. In transit planning, transportation forecasting has been used for a variety of purposes. Transport policy, transportation planning to assess large databases, including such determining roadway capacity, economic and personal sustainability and economic evaluation. Transportation planners and decision-makers are associated with a multitude of difficult challenges to which they would develop appropriate responses. What will the national, regional and even municipal transportation systems be forward to in the next 20 years? What impact will demographics, financial and land-use developments have over the performance of transportation infrastructure? What kind of resources and strategies might have had an impact on the productivity? This all the questions can be answer by the travel modelling in very efficient manner

## II. LITERATURE REVIEW

Scheurer and Curtis gives brief overview of how accessibility related to transportation has to be measure by considering different parameters along with its physical application [1]. Petersen and Sweet establishing predictive modelling, it shows the effectiveness of connecting decision makers implementation as well as improvisation accountabilities in maneuverings ambiguity [2].Geurs and van Wee provides the how we can measure the accessibility with travel modelling with consideration of land use and strategies related to transportation in detail [3]. Handy and Niemeier gives us brief overview of accessibility issues in transportation and their alternatives for better analysis [4].Khoo, Ong, and Khoo explain the assessment of the quick influence of the transformation throughout fuel costs strategy on travel demand in Major cities of Malaysia [5]. Ortuzar has done the comprehensive literature survey encompassing on thirty four scenarios in which mixed-mode regulations had already been incorporated and revealed that neither of the methods used would have addressed properly a made by model mixing [6].Cheng and Bertolini has done the analysis of job related accessibility in the Amsterdam City [7].Shah and Adhvaryu uses the transport modelling and accessibility as an analytical tool to measure the impact on urban poor and its effect related to the transportation system present in Ahmedabad City [8].

Zhong and Hanson uses the transport demand modelling with GIS to estimate the traffic on the rural roads [9].Hsiao uses the structural equation modelling (SEM) method for exploring the association respectively various means of transit services and telecom services[10].Petrik, Moura, and

Silva uses the discrete choice model for travel demand forecasting along with its uncertainties for one of rail project in Portugal [11]. Gehrke and Reardon has done the travel demand modelling to forecast activity related to cycling for proposed infrastructure [12].Apronti and Ksaibati has done the four step demand modelling for rural area in Wyoming[13].Klein and Löwa evaluating year-to-year differences in vehicular traffic caused through change in land usage and transportation systems, implies thresholds for performance indicators[14].Ahmed uses the simple 4-step travel demand modelling for the Dhaka City in detail [15].

### A. *Types of travel model*

There are three types of Travel models as given in Table 1 along with their corresponding spatial details, household details, sensitivity toward the transportation and cost require for respective travel demand models.

TABLE I. TYPES OF TRAVEL MODELS

| Model Type | Spatial Detail | Household Details | Policy Sensitivity | Cost |
|---|---|---|---|---|
| Sketchy Planning | Low | Low | Low | Low |
| Strategic Planning | Low-Moderate | Low-High | Moderate-High | Low |
| Activity Based | Moderate-High | High | Moderate-High | Moderate |

### B. *Trip Based Models*

Over several years, trip-based models have been developed. Journey-based models, as the names indicate it utilize the individual trip as the primary unit of analysis. Trip-based models are widely used in practical to facilitate transportation assessment and decision at the region, regional level and project levels. Trip-based models are often referred as "Four Step" models as they have four key components. These is trip generation, trip distribution, and mode choice and trip assignment's workplace accessibility in inner city area has intense impacts in the residents. The lack of employment level has severe impact on city ranging from criminal behavior, social disorder. The reason behind it might be socioeconomic factors including vehicle ownership.

### C. *Use of travel models*

After generating traffic volumes, a model should be calibrated. Calibration is the process of changing various model parameters and elements and rerunning the model until it accurately matches current travel behavior and volume of traffic. Modifications and successive modelling runs should regularly be undertaken before satisfactory outcomes are obtained. The model can then be used to forecast future scenarios after it is validated. Details of types of Travel Models shown in Table 1.

## III. STUDY AREA: NASHIK CITY

The city is located on the banks of the Godavari River, near the foothills of the Western Ghats Mountains. In 1947, Nashik was Maharashtra's seventh largest city, behind Mumbai, Pune, Nagpur, Solapur, Ahmednagar, and Amravati, which all have industrial operations. It has become the fourth largest city in the country. In a west-east direction, major rivers, the Godavari and the Nasardi run through to the town's heart. Nashik, after Aurangabad has the second highest workforce in the service industry (27%) in the state (31 percent). As a result, Nashik is categorized as "Industrial City." Grape City or Wine City is yet another name for this city. Nashik had long been a central spiritual town, pulling large number of tourists and organizing one of the world's biggest festivals every twelve years, the Kumbhmela, which itself is meant to draw 100 million tourists over the period of 55 days during August-September 2015.Fig.1 showing the location of Nashik City.[16]

Fig. 1. Location of Nashik City

### A. *Study Area Zoning*

A pilot study was conducted in Nashik city to study the travel pattern of Nashik city in core area with the help of questionnaire. This study shows, the working trip are from within city limits as well as from peripheral area of city also. The Military area is not considering for survey. To analyze the accessibility, it is needed to add this area in zoning. Therefore, totally six zones are classified as Traffic Analysis Zone (TAZ) for accessibility study purpose of work trips in Nashik City as shown in the Fig.2 below

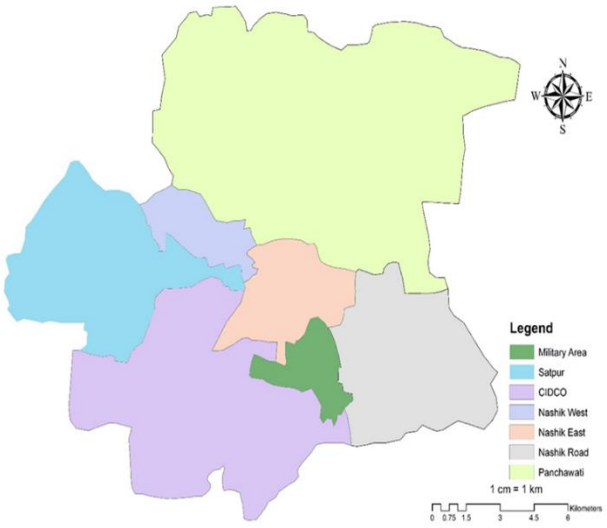


Fig. 2. Traffic Analysis zones of Nashik City

In the Zoning of the area Nashik city is divided into seven different zones. Different parameters like road network,

population, working population and many other factors are considered for the zoning purpose. In the travel demand modelling the Military area is not included as the data is not easily available and it is sensitive area of the city.

### B. Data Collection

Nashik City having population 14,86,053 according to 2011 Census. The area of Nashik city is 264.2 km$^2$. Distinctly contributes in the Maharashtra's state income as it has an important position in commerce, industry, education, and tourism. Consequently, it attracts and generates yearly a huge number of personal trips within the city and also across the state. Therefore, the derivation of travel demand models in this region is so necessary and important for transportation system development in Nashik city.

### C. Data Sources

There are two types of data sources discussed in the following sections.

#### 1) Questionnaire data

A special questionnaire had been prepared and depending on household interviews conducted different information is collected such as Population, Average Zonal Income, Number of households, Net Working population Density, Vehicle travel time between different zone, Walking time to and from stops, Waiting time at stops, Fare charged to travel from different zones etc.

#### 2) Transportation Network Data

Data collected for Road network present in Nashik city along with the location of the bus station which is very important for public transportation purposes within the city area. This road network plays very important role in finalizing the zoning system for the Nashik city. Fig.3 showing the road network map of Nashik City.

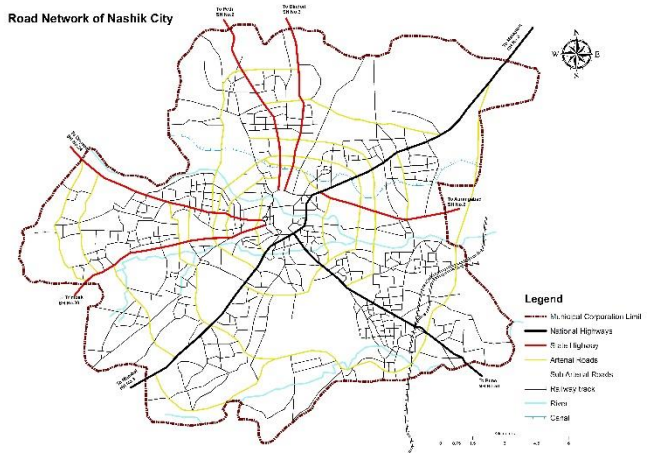


Fig. 3. Road Network of Nashik City

### D. Data Processing

#### 1) Spatial organization of city

In this Distance from city Centre of Gravity to ward Centre of Gravity is calculated with the help of Arc GIS and mapped as given the Fig.4. This analysis will be going to provide the distance between the city centers and ward center so that we can get idea about in which direction the city is spreading. This analysis is going to helpful to know that how city is spatially distributed from center of city. Such information is very useful for the in which area expansion of the public transport infrastructure is needed can be identified in better manner.

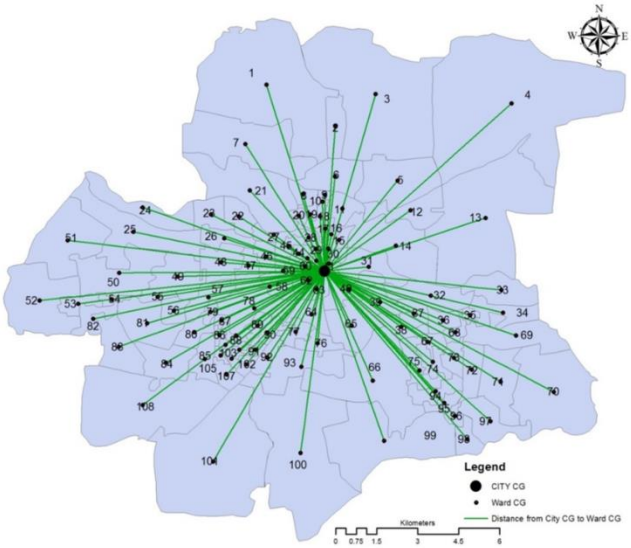


Fig. 4. Distance from city CG vs. Ward Number

After mapping graph is plotted for spatial analysis which is shown in Fig.5 which shows that the distance of ward centroid from city centroid. Ward number 52 shows maximum distance about 10.48 Km and Ward number 61 shows minimum distance about 130 M from City Centroid.

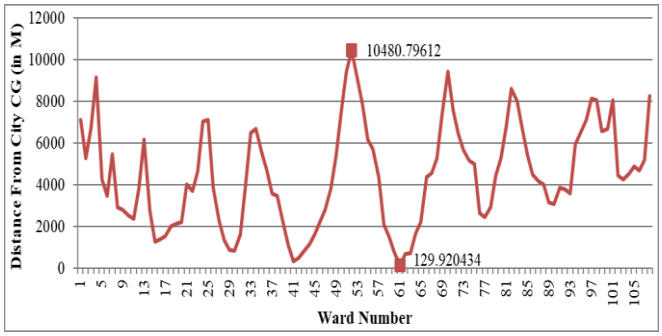


Fig. 5. Distance between City Centroid and Ward Centroid

#### 2) Analysis of Population Density Based on Built up Area

After analyzing the road network of city and special organization of the city, we have collected the population data for the city. Along with this area of the each zone is collected and based on that we have calculated the Population density for the each ward of Nashik city. This data is very important for the travel demand modelling purposes in regression analysis equation.

From Fig.6 it is observed that the Population density is Maximum in core areas of city as well as areas around the Satpur and Ambad MIDC. Maximum Population density present in ward number 65 which is about 1688 PPHa and minimum is about 17 PPHa in ward number 75. Average Population based on built-up area is 342.36 PPHa and also the population density decreasing as we move away from

city centroid except in Ward number 51, 52, 53 and 88 which is present around Satpur MIDC area.

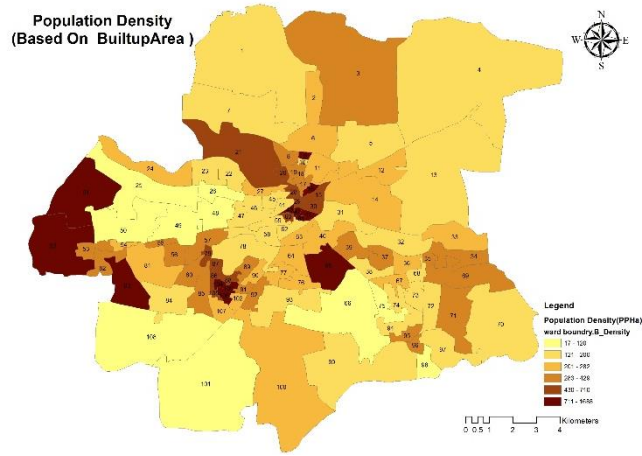


Fig. 6. Population density map based on built-up area

### 3) *Analysis of Work Density Based on Built up Area*

As the study consider the working trip calculation for modelling purpose so it is important to do the work density analysis for the Nashik city. Therefore the analysis of work density has been done with the help of data collected in initial stages related to working population. Work dentistry is calculated based on built up area of the respective ward.

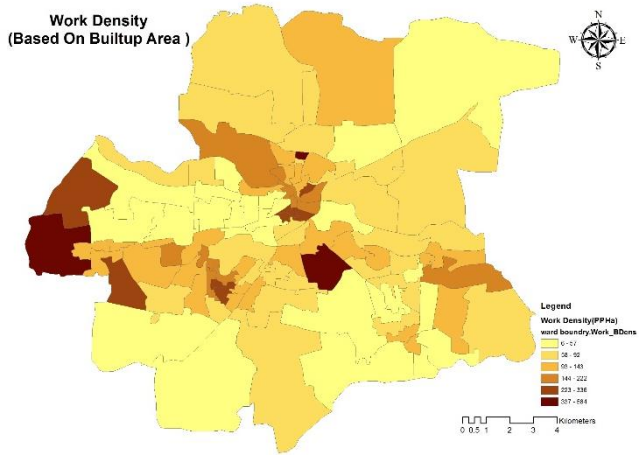


Fig. 7. Work density based on built up area

From Fig.7 it is observed that the Work density is maximum around Satpur MIDC area and along NH-50 in ward number 65.Maximum Work density is 584 PPHa in ward number also area around Ambad MIDC also shows significant amount of work density. Average population density of City is about 122 PPHa also the Work density goes on decreasing exponentially as we go away from city centroid as shown in graph except in the Area around Satpur and Ambad MIDC.The Industrial workers density can be 100 PPHa to 125 PPHa As per URDPFI Guidelines.

### 4) *Zone wise House Hold Structure*

From this analysis it is identified that zone 5 and 6 has maximum number of average working members in households. Average number of school going person is maximum in zone 1 and zone 5.This analysis also shows the maximum and minimum Household size present in respective zones. Table II shown below given the Zone wise Household Structure based on the pilot study conducted within the city.

TABLE II. ZONE WISE HH STRUCTURE

| Zone | Min HH Size | Max.HH size | Avg.HH Size | Avg.School going persons | Avg.working members |
|---|---|---|---|---|---|
| 1 | 3 | 9 | 5.64 | 1.94 | 1.45 |
| 2 | 4 | 8 | 5.50 | 1.60 | 1.50 |
| 3 | 3 | 8 | 4.82 | 1.70 | 1.63 |
| 4 | 4 | 7 | 4.93 | 1.72 | 1.29 |
| 5 | 4 | 8 | 5.70 | 1.71 | 2.16 |
| 6 | 3 | 8 | 5.57 | 1.84 | 1.65 |

### 5) *Income Structure*

Income structure for the city is very important to understand for travel modelling purpose. It gives us idea about the Income level throughout the city so that planning can be done in better manner for the public transportation around the city. Based on the pilot study conducted it is observed that the Income structure analysis of Nashik city shows in Fig.8. It shows that maximum average zonal income is present in Nashik west and Nashik east zone. These two zones are present in core area of Nashik city.

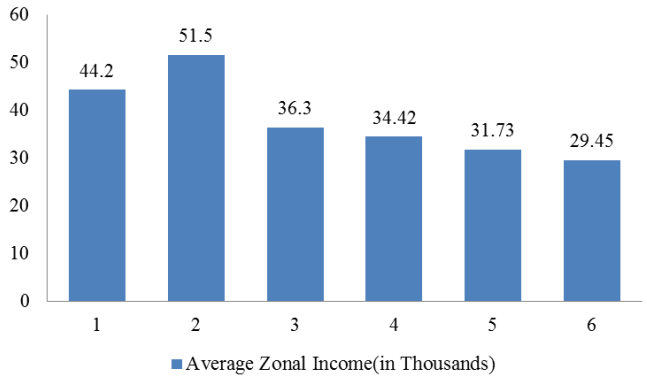


Fig. 8. Average zonal income

## IV. METHODOLOGY

Methodology adopted for research purpose is given in the Fig.9. In travel demand modelling data includes are Population, Employment level, Income Level, Density, Working population , Density of working population , road network data, growth factors related to different parameters consider. Firstly literature review has been done related to travel demand modelling. In this we have studied how travel demand modelling is done considering different conditions for the respective cities. After that secondary data is collected for the Nashik City.

After that based on secondary data, analysis has been done and after gap identification primary data is collected based on the pilot study conducted within the Nashik city. Analysis of the primary data is already given the Data Processing

section. After primary data analysis travel demand modeling is done in four different steps and analysis has been done.

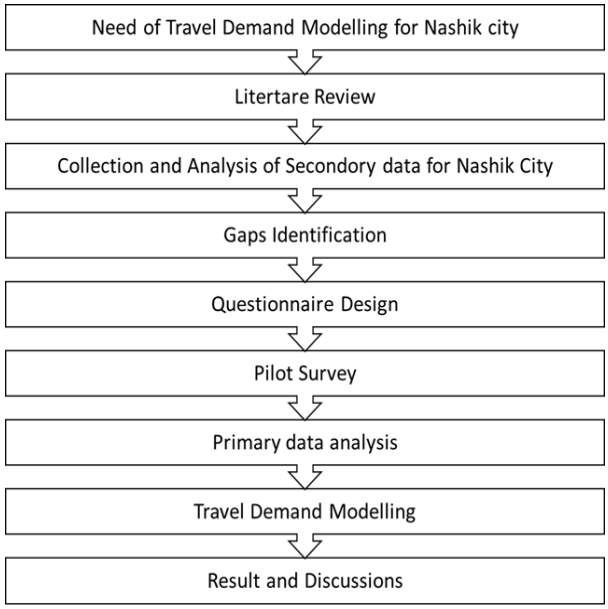


Fig. 9. Methodology used for research purpose

### A. *Travel Demand Modeling*

Travel demand modelling is done in four different steps. In First step work Trip production is calculated for respective zones means from which zones more number of trips are generating can be identified. In second step where this work trips are going is calculated which is called as trip attraction. This will give us idea about where more number of peoples are travelling for the job purposes. It will also give us information about the where the density of working places are more and where it is less. In third step we calculate the how this work trips are distributed between zone to zone. In this we map it with help of desire line mapping to get better idea about for which zones trip production and attraction is more or less. In last step we find out the shortest route to travel from one zone to other zone by considering traffic volume of city. In the travel demand modelling growth factors which plays very important role for forecasting the travel demand related to respective zones .Growth Factor are used to do mathematical modeling growth factor for following variables are calculated based on data collected through different sources.

TABLE III. GROWTH FACTOR FOR ALL VARIABLES

| Variables | Growth Factor |
|---|---|
| Population Growth Average | 37.22 |
| Employment Level | 41.87 |
| Population Between 5 to 29 | 49.42 |
| Income Level | 10 |
| Land Value | 17.50 |
| No of HH | 51.38 |
| Net Population Density | 53.14 |
| Net-work Density | 60.87 |
| Student Population | 20.48 |

Income level growth is assumed 10 % by considering pay scale increase in India. Land growth is calculated from ready reckoner rate given by Government of Maharashtra. This Growth rate is used for calculating horizon year data. Table III shows the growth factors for all variables consider for the travel demand modeling.

For doing the regression analysis of work trips which is very important for travel demand modelling. The dependent and independent variables which are consider for analysis as given in the Table IV below

TABLE IV. VARIABLES CONSIDER FOR WORK TRIPS

| | Trip Production | Trip Attraction |
|---|---|---|
| Dependent Variable Used | Trips Produced per HH per day from Zone to zone | Trips Attracted per HH per day towards Zone to zone |
| Independent Variable Used | Population, Number of HH,Income Level, Net Work density of each Zone | Employment Level In zone, Land Value |

### B. *Trip Generation*

Trip generation is the first stage of the classical first generation aggregate demand models. The trip generation aims at predicting the total number of trips generated and attracted to each zone of the study area. In other words this stage answers the question to how many trips originate at each zone, from the data on household and socioeconomic attributes.

#### 1) *Trip Production*

In first step work trip production is calculated considering the population, average zonal income, number of household, and net working population density as an independent variables.

Multiple regression method is used to derive trip production regression equation. Equation (1) given below is used for calculating existing trip production and projected trip production,

$$Y_{Production} = 126914 + 3.50X_1 - 3.32X_2 - 16.27X_3 + 2473X_4 \quad \text{.....(1)}$$

Where,
$Y_{Production}$= Trip Production for each zone
$X_1$=Population
$X_2$= Average Zonal Income
$X_3$= Number of house holds
$X_4$= Net Working population Density

In this Multiple Regression Method, Population, Average Zonal income, Number of households and Networking population density for each zone is consider as an independent variables. This independent variables are responsible for the trip production for the each zone separately. Based on the (1) existing trip production along with the future trip production coming from the each zone is calculated.
Existing as well as projected trip production is maximum for the Panchawati zone. Minimum existing trip production is for the Nashik road zone and Minimum projected trip production is for the Nashik west zone.

Based on this trip production mapping has been done for existing and projected trips production. Existing an Projected
Work trip productions are shown in the Fig.10 and Fig.11 respectively.

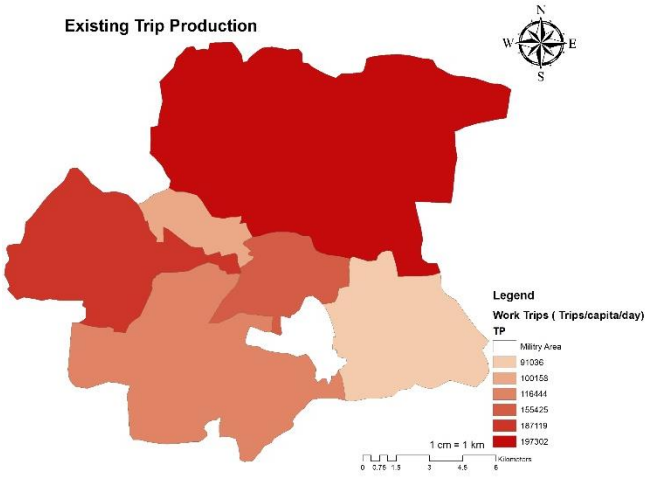


Fig. 10. Existing work trip Production Map

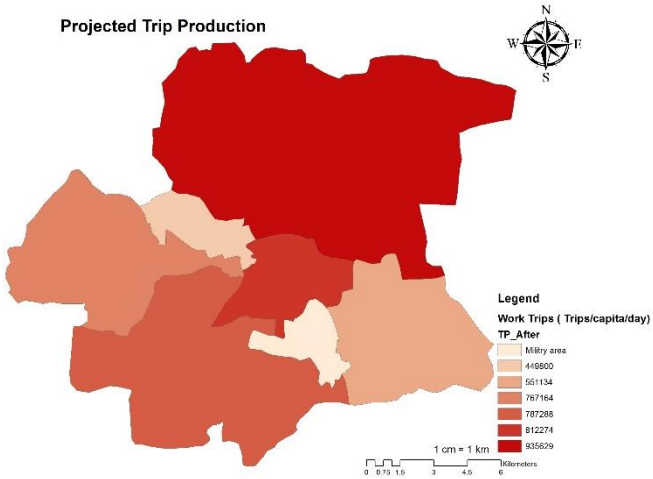


Fig. 11. Projected work trip Production Map

### 2) *Trip Attraction*

In second step work trip attraction is calculated considering land value and employment present level in zone as an independent variable. First existing zonal employment level and land value is collected and projected for horizon year using the growth factor method. Multiple Regression method is used to derive the trip attraction regression equation. Equation (2) given below is used for calculating existing trip attracted and projected trip attraction,

$$Y_{Attraction} = 936987 - 11.13X_1 + 3.05X_2 \qquad (2)$$

Where,

$Y_{Attraction}$= Trip Attraction for each zone
$X_1$=Land Value
$X_2$=Employment Level Present in zone

Based on this trip attraction mapping has been done for existing and projected trips attraction given below in Fig.12 and Fig.13.

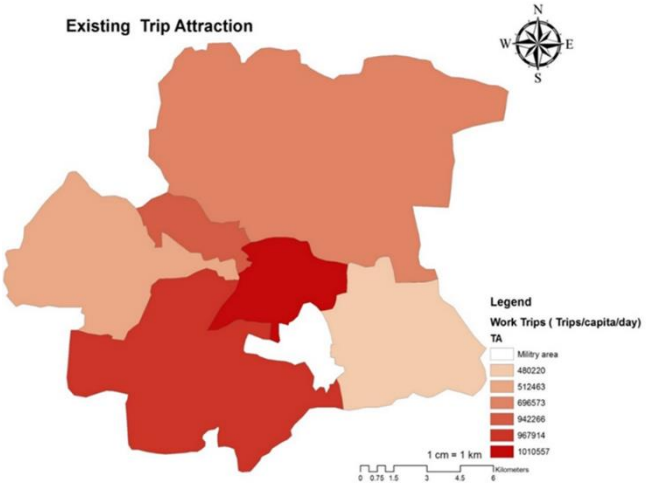


Fig. 12. Existing work trip attraction Map

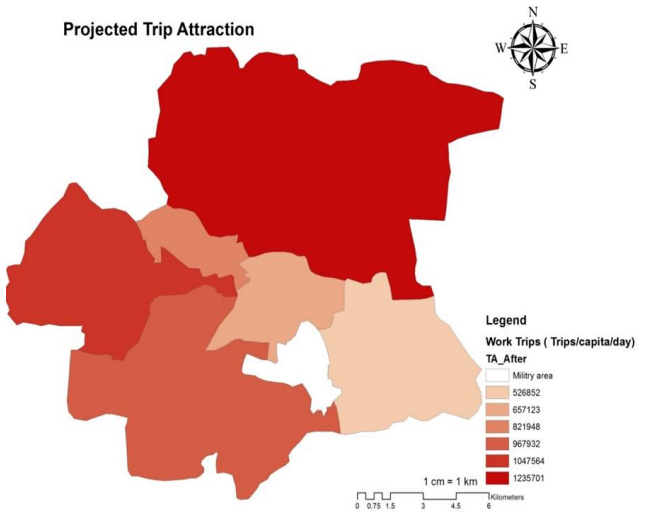


Fig. 13. Projected work trip attraction map

### 3) *Trip Distribution*

The generated trips from each zone are then dispersed to all other zones based on the destination decision in the second step of travel demand modelling. This is referred to as Trip Distribution. The growth factor model and the gravity model are two of the strategies for distributing user trips among destinations. For study purpose gravity model method is used. We begin with hypotheses regarding trip-making activity and how it is affected by numerous variables in this approach. Calibration of gravity models, or the work of adjusting such variables so that when the base year trend is accurately replicated by the modelling, is really an important aspect of its application. Applying this study, a desire line mapping representing work trips by modes is produced, that represents zonal travel among areas.

Table V is giving the details of origin and destination Matrix for the work trips. Based on this mapping has been done with help of desire line for the work trips by two wheeler in the Fig.14, by bus in the Fig.15,by four wheeler in the Fig.16 and overall desire line mapping for work trips in the Fig.17.

TABLE V. O-D TRIP DISTRIBUTION MATRIX FOR WORK TRIPS

| | 1 | 2 | 3 | 4 | 5 | 6 | Ai | Sum($O_i$) |
|---|---|---|---|---|---|---|---|---|
| **1** | 50002.2 | 18466.2 | 32602.3 | 16208.9 | 23354.6 | 30021.1 | 1.16E-05 | 1010557 |
| **2** | 32807.8 | 35834.3 | 34951.1 | 14961.7 | 21229.1 | 32290.5 | 1.28E-05 | 942266 |
| **3** | 12243 | 7387.45 | 68109.9 | 9550.21 | 9217.66 | 17023.3 | 1.14E-05 | 696573 |
| **4** | 16832.1 | 8150.31 | 23093.6 | 24985.8 | 11858.8 | 21265.3 | 1.73E-05 | 480220 |
| **5** | 27591.9 | 16027.3 | 23275.4 | 14953.8 | 32582 | 27652.6 | 1.12E-05 | 967914 |
| **6** | 15947.6 | 14292.1 | 15269.5 | 10375.1 | 18202.1 | 58865.7 | 1.46E-05 | 512464 |
| **$B_j$** | 0.15814 | 0.17139 | 0.19107 | 0.24118 | 0.17527 | 0.2416 | | |
| **SUM ($D_j$)** | 155425 | 100158 | 197302 | 91035.5 | 116444 | 187118 | | |

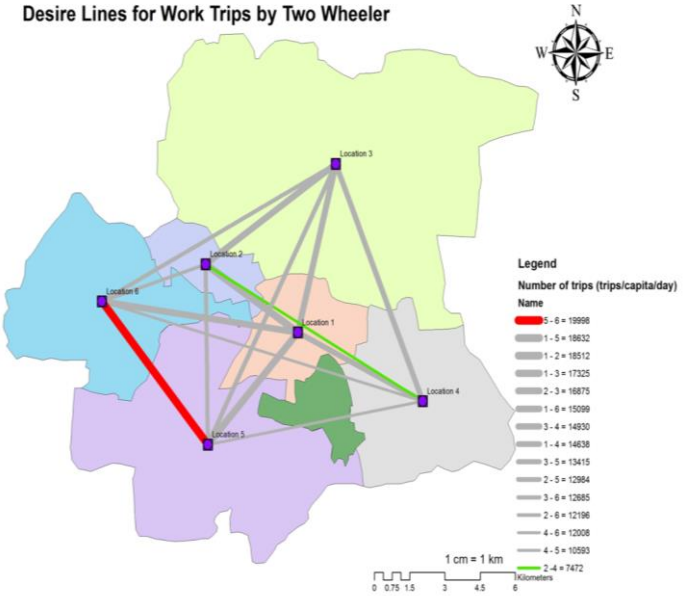


Fig. 14. Desire Line mapping for work trips by two wheeler

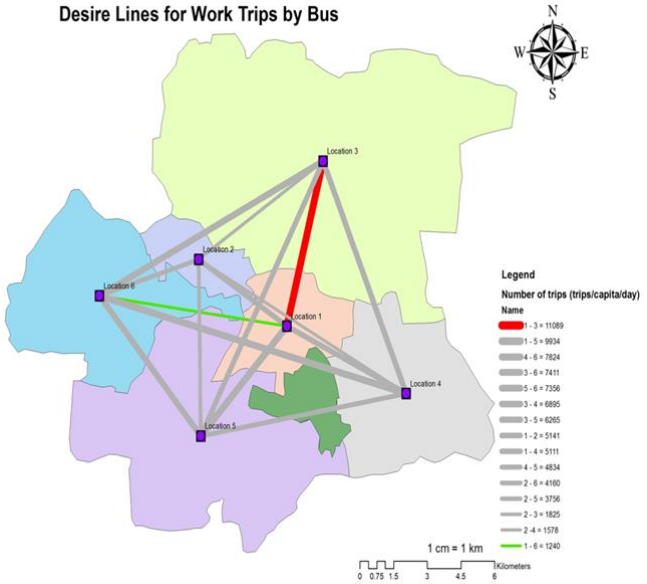


Fig. 15. Desire Line mapping for work trips by bus

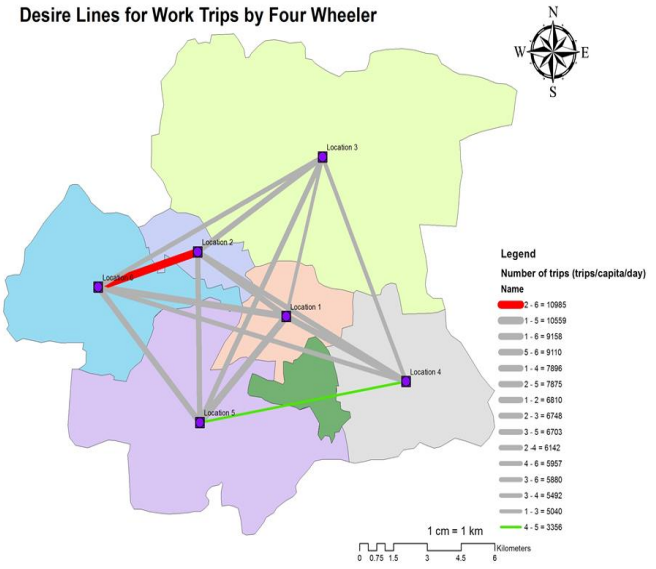


Fig. 16. Desire Line mapping for work trips by four wheeler

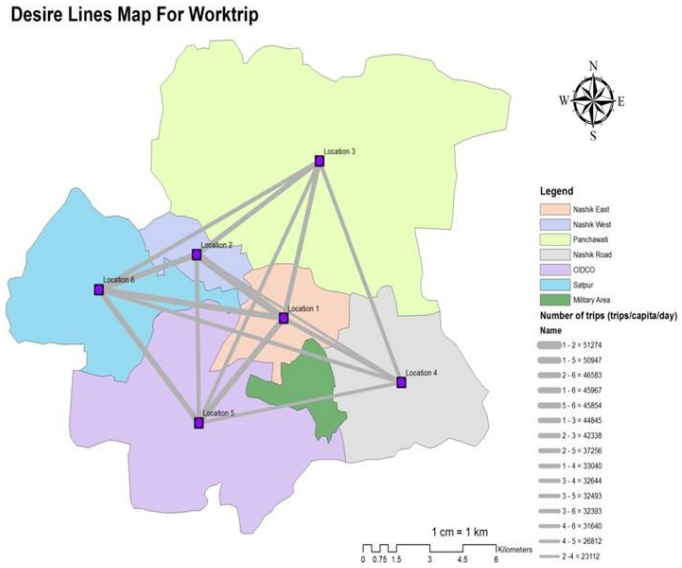


Fig. 17. Desire Line mapping for work trips overall

### *4) Modal Split*

In the traditional four-stage transportation planning approach, choice analysis is the third step. The zonal interchange assessment of trip distributions produces a set of origin destination tables that indicate where the trips will be performed and what mode of transportation will be used.

It is just the step where travels between a particular origin and destination are divided into those that take public transportation, those that take a car, two-wheelers, bicycles, or those that walk. For modal split analysis binary logit model is used to calculate mode choice when choices between two modes made.

This can be represented by (3)

$$c_{ij} = a_1 t_{ij}^{v} + a_2 t_{ij}^{w} + a_3 t_{ij}^{t} + a_4 t_{nij} + a_5 F_{ij} + a_6 \varphi_j + \delta \qquad (3)$$

Where,

$t_{ij}^{v} = In\ vehicle\ travel\ \ time\ between\ zone\ \ i\ and\ j$

$t_{ij}^{w} = Walking\ \ time\ to\ and\ from\ stops$

$t_{ij}^{t} = Waiting\ \ time\ at\ stops$

$F_{ij} = Fare\ charged\ to\ travel\ from\ zone\ i\ to\ j$

$\varphi_{j} = Parking\ Cost$

Probability of mode to be selected from one zone to other zone is calculated by using the equation (4)

$$P_{ij}^{1} = \frac{T_{ij}^{1}}{T_{ij}} = \frac{e^{-\beta c_{ij}^{1}}}{e^{-\beta c_{ij}^{1}} + e^{-\beta c_{ij}^{2}}} \quad (4)$$

TABLE VI. MODAL SPLIT CALCULATION FOR ZONE 1 TO ZONE 1

| | $t_{ij}^{v}$ | $t_{ij}^{w}$ | $t_{ij}^{t}$ | $F_{ij}$ | $c_{ij}$ | Exp(-$c_{ij}$) | $P_{ij}$ |
|---|---|---|---|---|---|---|---|
| **Co-efficient** | 0.1 | 0.04 | 0.06 | 0.1 | | | |
| **Bicycle** | 20 | | | 0 | 2 | 0.135 | 0.244 |
| **2 wheeler** | 10 | | | 5 | 1.5 | 0.223 | 0.403 |
| **4 wheeler** | 15 | | | 10 | 2.5 | 0.0820 | 0.148 |
| **Auto** | 15 | | | 20 | 3.5 | 0.0301 | 0.0546 |
| **Bus** | 10 | 5 | 5 | 10 | 2.5 | 0.0820 | 0.148 |

Similarly modal split analysis have been perform from zone 1 to all other zones and the probability of mode to be selected for trip from zone 1 To other zones is found which is shown in table VI.

Modal split analysis shows that maximum number of peoples is using private vehicles for work trip is about 41% and public transportation share is 20 % as per analysis. It Show that for educational trips maximum users preferred for private vehicle compared to public transportation. Modal Split for Work trips is given in Fig.18.

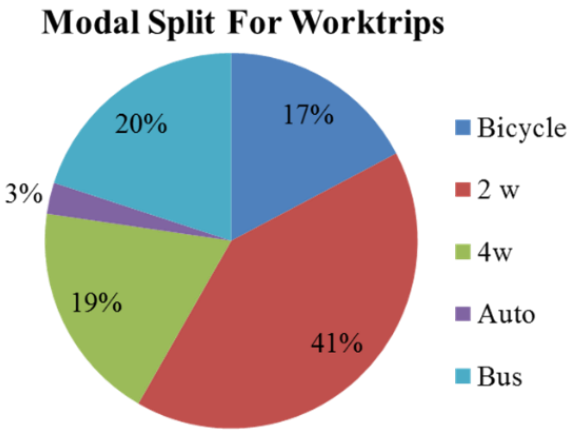


Fig. 18. Modal Split for Work trips

*5) Route Assignment*

Route assignment is the action of allocating the trip choice for the given transportation system. The main aim of this action is to provide the vehicular pattern movement which can be identified when the demand of travel is given by the trip matrix in modelling. For route assignment, all or nothing method is used. For this method trips from starting point to end point of travel journey are directly or indirectly related to single or multiple path, cost of travel and route which is used for the travelling purpose. This model may also be used to identify the desired route for the users which the users can preferred for travelling purpose in the absence of congestion. In this model it is assumed that travel time on link do not vary and all trip makers have precise knowledge of travel time. Based on these assumptions, traveler can make travel with shortest path and in minimum time. The shortest path between zones is drawn from network analysis in Arc-GIS and shown in Fig.19.

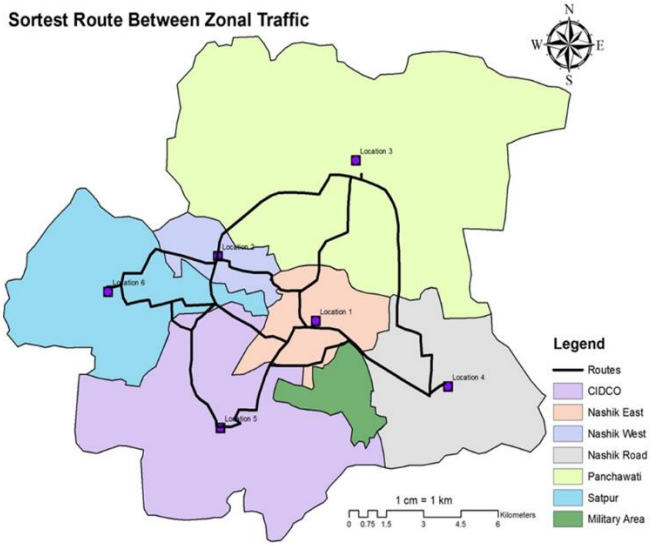


Fig. 19. Shortest route between zonal traffic

## V. RESULT AND DISCUSSIONS

The travel demand modelling study was conducted within the Nashik city to understand the work trip pattern related to the Transportation infrasturcre present in Nashik city. After doing the travel demand modelling and analysis with help of GIS mapping it is observe that more number of peoples are using the personal vehicles for going to work trips rather than using the public transportation which was given by city Municipal Corporation.

The study shows that the Existing work trip production is maximum in Panchavati, Satpur and Nashik East zone and for Horizon year consider it will be maximum for Panchavati, Nashik East and CIDCO zone. This Show in future the identified zone needs enhancement in transport infrastructure. Existing work trip attraction is shows that Nashik east, Nashik West and CIDCO zone has maximum trip attraction and for Horizon year Satpur, Panchavati and CIDCO zone will have maximum trip attraction. These zones will be affected by transport issues in future because of maximum trip attraction. Trip Distribution analysis shows zonal movement between zones Nashik East to Nashik East, Nashik West to Nashik West ,Satpur to Satpur, Nashik East to Satpur, CIDCO to CIDCO,Panchavati to Panchavati ,NW to Satpur are more. This shows that it will create problem like traffic congestion, increase in travel time etc. between this zonal movements.

The results of the Desire lines map of Work trips shows that to and from movement between zones are more for Nashik East - Nashik West, Nashik East -CIDCO, Nashik

West -Satpur and Nashik East -Satpur. It shows that zonal traffic is maximum between these zones. Desire lines map of Educational trips shows that to and from movement between zones are more for Nashik East - Nashik West, Nashik East - CIDCO, Nashik West -Satpur, Nashik West -CIDCO and Nashik West -Panchavati. It shows that zonal traffic is maximum between these zones.

There is need to improve public transport infrastructure in this zones which can improve accessibility for work trip and educational trips. Along with this it also decreases travel time for work and educational trips. Modal split analysis shows that maximum number of peoples is using private vehicles for work trip is about 41% and public transportation share is only 20 % as per analysis. So it is important to increase usability of public transportation by considering the different factors which is discus in this study. Along with this future expansion of the public transportation is very important considering the increase in private vehicle usage and decrease in usage of the public infrastructure.

## REFERENCES


[1] J. Scheurer and C. Curtis, "Accessibility measures: overview and practical applications," *Impacts Transit Led Dev. a New Rail Corridor*, no. 4, pp. 1–53, 2007. http://wiki.dpi.inpe.br/lib/exe/fetch.php?media=ser300:wiki_pessoal_tatiana:overview_and_practical_applications.pdf

[2] E. Petersen and M. Sweet, "Navigating a fad or the future? Opportunities and limitations in integrating carshare membership and automated vehicle propensity in travel demand forecasting," *Transp. Plan. Technol.*, vol. 44, no. 3, pp. 223–245, 2021. https://doi.org/10.1080/03081060.2021.1883225

[3] K. T. Geurs and B. van Wee, "Accessibility evaluation of land-use and transport strategies: Review and research directions," *J. Transp. Geogr.*, vol. 12, no. 2, pp. 127–140, 2004. https://doi.org/10.1016/j.jtrangeo.2003.10.005

[4] S. L. Handy and D. A. Niemeier, "Measuring accessibility: An exploration of issues and alternatives," *Environ. Plan. A*, vol. 29, no. 7, pp. 1175–1194, 1997.https://doi.org/10.1068/a291175

[5] H. L. Khoo, G. P. Ong, and W. C. Khoo, "Short-term impact analysis of fuel price policy change on travel demand in Malaysian cities," *Transp. Plan. Technol.*, vol. 35, no. 7, pp. 715–736, 2012. https://doi.org/10.1080/03081060.2012.710039

[6] J. D. D. Ortuzar, "Mixed-mode travel demand forecasting techniques," *Transp. Plan. Technol.*, vol. 6, no. 2, pp. 81–95, 1980. https://doi.org/10.1080/03081068008717179

[7] J. Cheng and L. Bertolini, "Measuring urban job accessibility with distance decay, competition and diversity," *J. Transp. Geogr.*, vol. 30,pp.100–109,2013. https://doi.org/10.1016/j.jtrangeo.2013.03.005

[8] J. Shah and B. Adhvaryu, "Public transport accessibility levels for Ahmedabad, India," *J. Public Transp.*, vol. 19, no. 3, pp. 19–35, 2016. https://doi.org/10.5038/2375-0901.19.3.2

[9] M. Zhong and B. L. Hanson, "GIS-based travel demand modeling for estimating traffic on low-class roads," *Transp. Plan. Technol.*, vol. 32, no. 5, pp. 423–439, 2009. https://doi.org/10.1080/03081060903257053

[10] M. H. Hsiao, "Structural equation modeling for national travel demand: an examination of the relationships between communication modes," *Transp. Plan. Technol.*, vol. 38, no. 8, pp. 889–908, 2015. https://doi.org/10.1080/03081060.2015.1079389

[11] O. Petrik, F. Moura, and J. de A. e. Silva, "Measuring uncertainty in discrete choice travel demand forecasting models," *Transp. Plan. Technol.*, vol. 39, no. 2, pp. 218–237, 2016. https://doi.org/10.1080/03081060.2015.1127542

[12] S. R. Gehrke and T. G. Reardon, "Direct demand modelling approach to forecast cycling activity for a proposed bike facility," *Transp. Plan. Technol.*, vol. 44, no. 1, pp. 1–15, 2021. https://doi.org/10.1080/03081060.2020.1849959

[13] D. T. Apronti and K. Ksaibati, "Four-step travel demand model implementation for estimating traffic volumes on rural low-volume roads in Wyoming," *Transp. Plan. Technol.*, vol. 41, no. 5,pp.557–571,2018. https://doi.org/10.1080/03081060.2018.1469288

[14] T. Klein and S. Löwa, "Applying measures of modelling quality to a national time series: a benchmark for transport demand models," *Transp. Plan. Technol.*, vol. 42, no. 7, pp. 679–695, 2019. https://doi.org/10.1080/03081060.2019.1650426

[15] B. Ahmed, "The Traditional Four Steps Transportation Modeling Using a Simplified Transport Network: A Case Study of Dhaka City, Bangladesh," *Int. J. Adv. Sci. Eng. Technol. Res.*, vol. 1, no. 1,pp.19–40,2012. https://discovery.ucl.ac.uk/id/eprint/1418961/4/Ahmed_Four%20Step_Final_BAYES.pdf

[16] "Nashik Draft Revised Development Plan, 2016-2036.," vol. 28, no.4,1966. https://nmc.gov.in/assets/admin/upload/download/Report_under_section_26.pdf


## AUTHORS PROFILE


**Mr. Darshankumar Patel**

He is currently a Ph. D research scholar at Civil Engineering Department, Oriental University, Indore, Madhya Pradesh, India. He has pursued his Masters in Urban Planning from VNIT,Nagpur. He has published more than 6 research papers in Reputed Journals or Conference proceedings. His area of interest is in urban transportation and planning, geo spatial data analysis, Transportation Accessibility analysis etc.

Email: darshptl12354@gmail.com



**Dr. Bikram Prasad**

He is currently working as Associate Professor at Civil Engineering Department, Oriental University, Indore, Madhya Pradesh, India. He has done B.Tech. (Hons) Civil Engineering from KIIT-University, Bhubaneswar. M.Tech (Hons) (Hydro Power Engg),Civil Engg department, from MANIT, Bhopal and Ph. D. (WRE) MANIT, Bhopal. He is having 8 Year Teaching and Research Experience with 2 Years of Industrial Experience also. He has also qualified GATE 5 times. He has guided 1 PhD Scholar and Guiding 5 more PhD scholars. He is also Life Member of ISH, IAH and Association of Agro meteorology. He has also work as Editor in 4 journals and active reviewer in many reputed journals.

PUBLICATIONS: 60 Papers Published (25-IJ, 8-NJ, 23- IC, 4-NC)

Email: bikram2010@gmail.com