OPTIMUM ROUTE PLANNING OF A CITY USING GIS TECHNOLOGY

[1]Vaishali Mahavar, [2]Jayesh Juremalani, [3]Indra Prakash, [4]Khalid Mehmood
[1]M.Tech Student, [2]Assistant Professor, [3]Faculty, [4]Manager
[1,2]Civil Engineering Department, [3,4]Department of Science and Technology
[1,2]Parul Institute of Engineering and Technology Vadodara Gujarat, [3,4]Bhaskaracharya Institute for Space Applications & Geo-informatics Gandhinagar Gujarat

Abstract: Dahod is included in the development of smart cities but Dahod city is an old city having a narrow roads passing through Central Business District (CBD) area of the city which are unable to take load of the traffic especially during peak period due to rapid urbanization. Therefore, in the present study attempt is made to solve this problem by using GIS network analysis tool. Results of the analysis show that proper planning of the city surface transport system can be done by providing alternative routes to commuters and service providers to reach their destination in shortest route in short time. The present study is useful to the city management authorities in redefining development and the road network system considering present and future needs.

IndexTerms- Network analysis, Geographic information system, Shortest path analysis, Service area analysis.

I INTRODUCTION

Network analysis nowadays is important considering rapid development of cities and thus to solve increase in traffic movement by designing and providing adequate surface transport facilities to all commuters to avoid congestion. Road network planning depends on the traffic-influencing events and traffic demand (de Souza)[1]. Vonderohe [12]. Richard et. al [9] used GIS to develop road information management system. GIS can solve a complex road network problem easily and scientifically.
GPS-GIS integration brings real world to the desktop for common man's benefit. The time-consuming site visits and data analysis can now be performed at the workplace itself, Madhav N. Kulkarni and Mahendra Kamath[3] in their study selected a few important places of Mumbai as a origin and destination and for collection of data of travel time and delay using GPS.
Optimal route selection is obtained with the use of GIS based on two criteria: 1. Distance cost and 2.time cost. This is important, especially time, in some cases like services of fire brigade and ambulance (Pondi Brian Ochieng [5]). Keshkamat et. al [7] used GIS for the formulation and evaluation of route planning and alternative routes for services. Satish Kumar et. al [8] also used GIS and generated a route with the length impedance to reach tourist location in short distance. Mohammad et.al [4]used GIS for finding fastest delivery route for vegetable, they focused to reduce drive time, so their impedance were distance and average speed of transportation vehicle. About a half century back shortest path Dijkstra algorithm was developed based on distance citeria (Tomasz Neumann [10]) B.Ganesh kumar and Ramesh [2] also used Dijkstra algorithm for finding best path .
Road network is a typical spatial network, where nodes and edges are embedded in space. In the network analysis nodes represent intersections and the edges represent road sections. Zhao Tian et.al [13] used a weighted network model to analyses the statistical characteristic of the urban road traffic network. Rutu Doshi et.al [6] also used GIS to plan transportation network of Nadiad city. Vaishali et.al [11] reviewed the existing surface transportation network analysis system.
In the present study Dahod city of Gujarat, India has been selected as it is facing problems of traffic congestion due to increase in traffic as a result of city development. Parameters like peak period volume, travel time, speed of vehicle and locations of services have been considered in the network analysis. This study will help decisions makers in planning better optimum road network system.

II STUDY AREA

Dahod city is located between 20 ° 30 ' and 23 ° 30 'Latitude North, 73 ° 15' and 74 ° 30 'East Longitude. This city has been selected by the Government of India to be developed as smart city. Dahod is connected to all major cities of Gujarat by road and rail network. However, road network of the city is not well planned. Population of city is 130,503 and of district 2127086 (Census 2011) which is increasing fast with the industrial development.

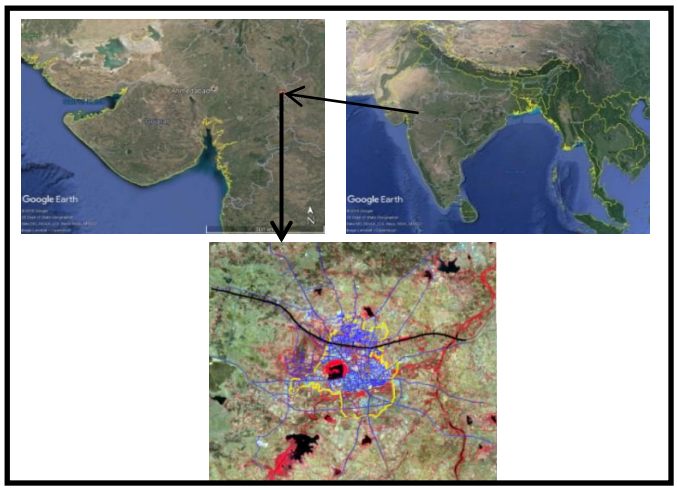

Figure 1: Study area location

III METHODOLOGY

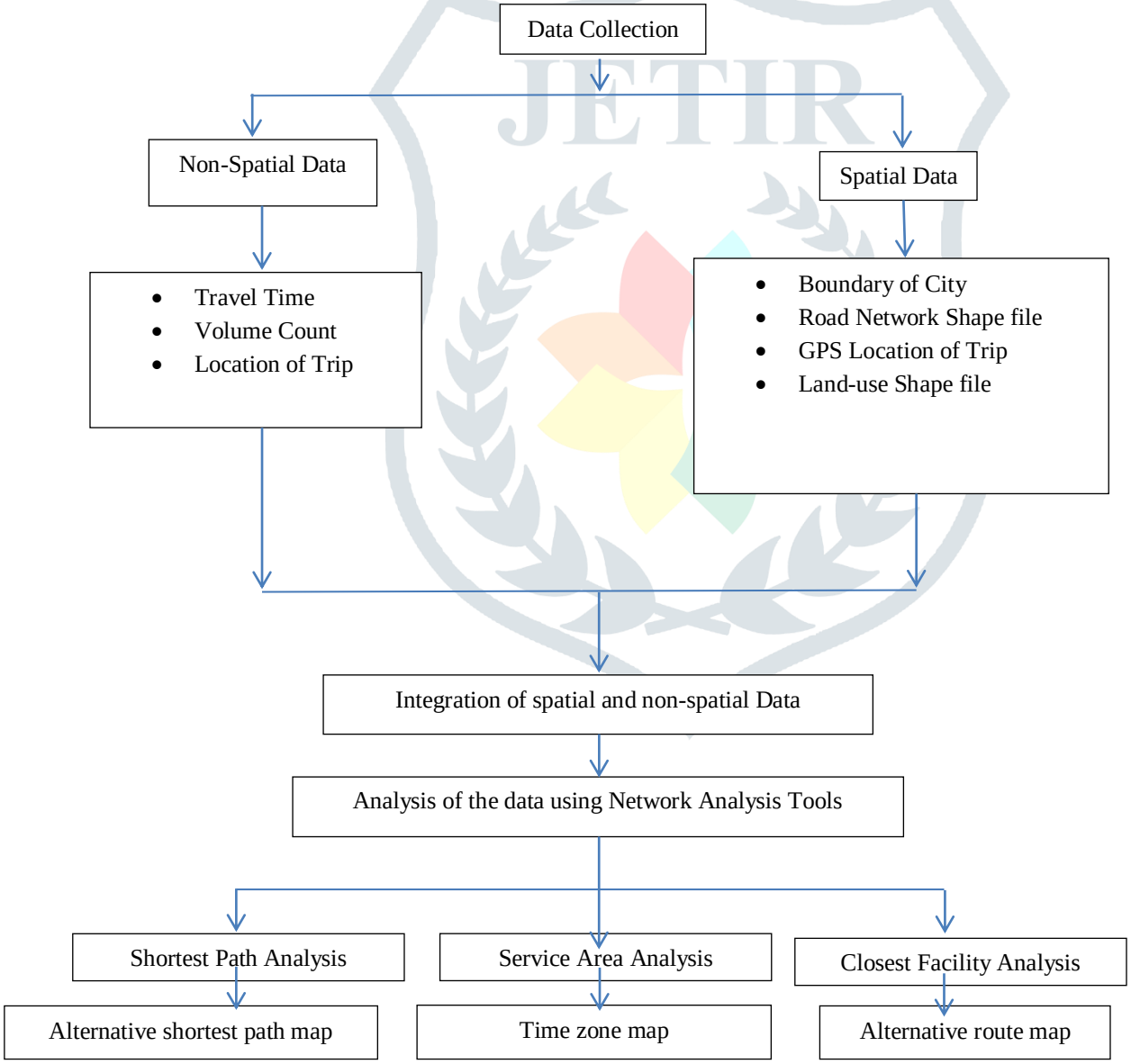

Figure 2: Flow diagram of Road Network analysis Methodology

Following is a summary of methodology adopted in the present study:

1. Preparation of thematic maps of existing road network and service facilities.
2. Identification of the areas of road congestions.
3. Developing nodes and edges in the road network.
4. Road network analysis using GIS
5. Finding optimum route of service places considering time and distances

3.1 GIS Network Analysis

The data analysis for Road Network system can be done by using Q-GIS or ArcGIS Network Analysis tool. In this study GIS Network analysis tool has been used for finding the optimum route path under different conditions.

GIS tool was used to manage and analyse network- based spatial data to solve routing problems including point-to-point routing and time-based delivery problems considering various spatial attributes. Following major steps have been adopted to solve the problems:

- Determination of service area coverage of a service or facilities based on Finding of to and fro shortest routes from facilities.
- Distance and travel time.
- Optimum location of services and facilities.
- Creation of a travel cost matrix from a facility or service to all destinations.
- Finding the closest facilities with a given area.
- Creating route direction.
- Performing Point-to-Point transportation Routing

3.2 New route tool

New route tool was used to determine an optimal route/ shortest route from a facility location to point of demand.

IV DATA COLLECTION

4.1 Spatial Data

Boundary area of the City and Road network data are taken from open source Google Earth are shown in Fig.3 ,Land use map is collected from City Nagarpalika it shows mixed land use patter in Fig. 4, Location of the trip are collected through GPS are shown in Fig. 5.

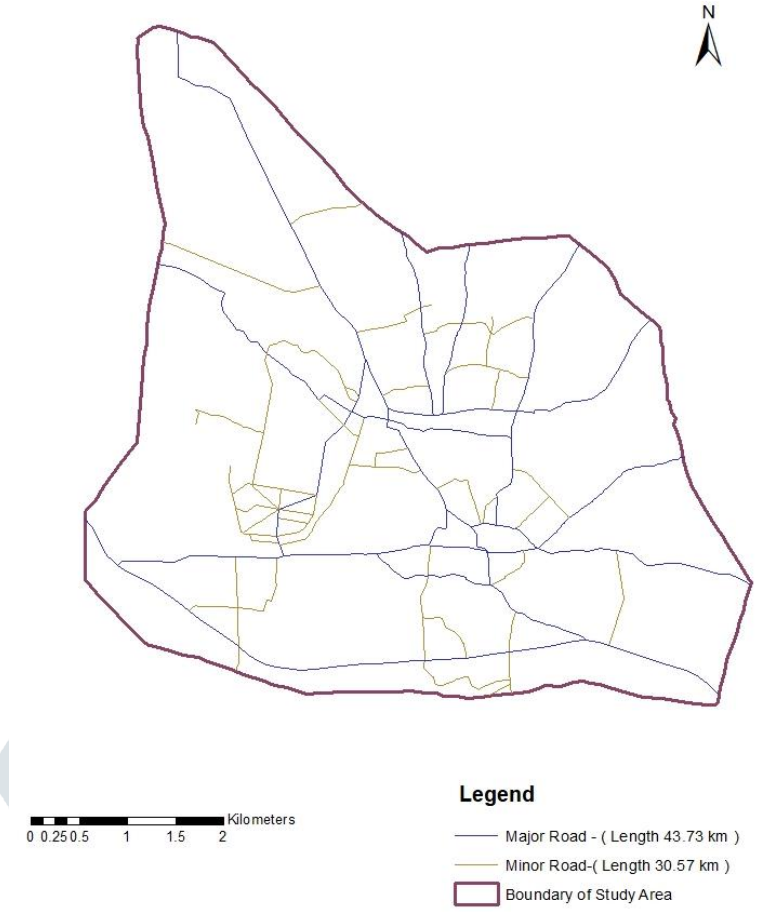

Figure 3: Road Network of Dahod City

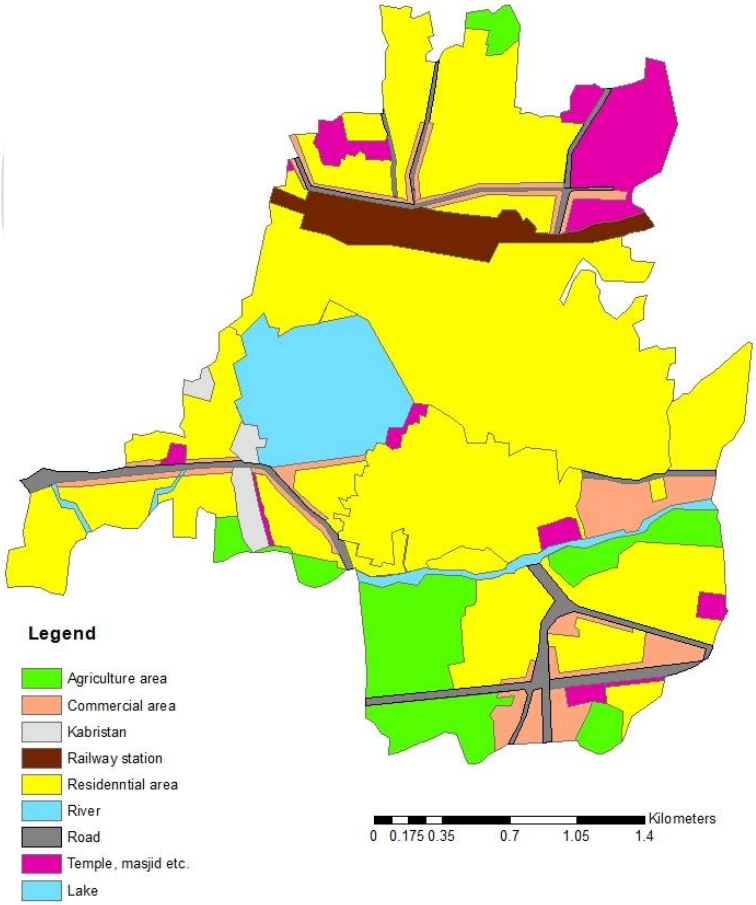

Figure 4: Land use Map of Dahod City

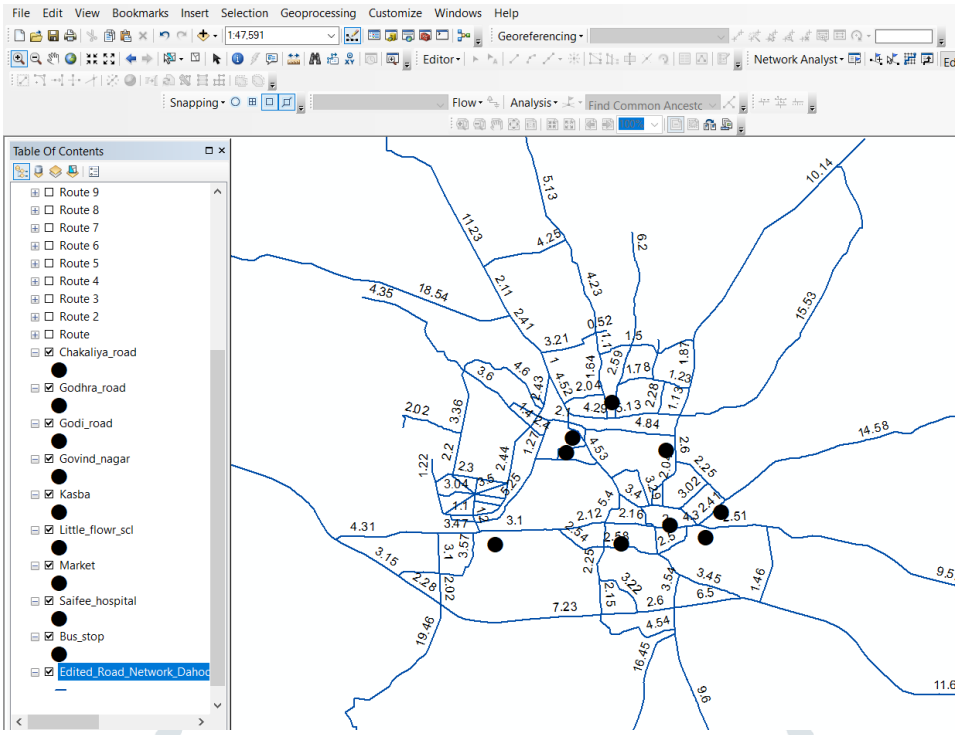

Figure 5: Locations of travel points

4.2 Non-Spatial Data

To know the area of congestion and to determine the traffic volume of the city for planning the road network, field survey was done during the period 25-2-2019 to 13-03-2019. Following is output Fig. 6, Fig 7, and Fig 8.

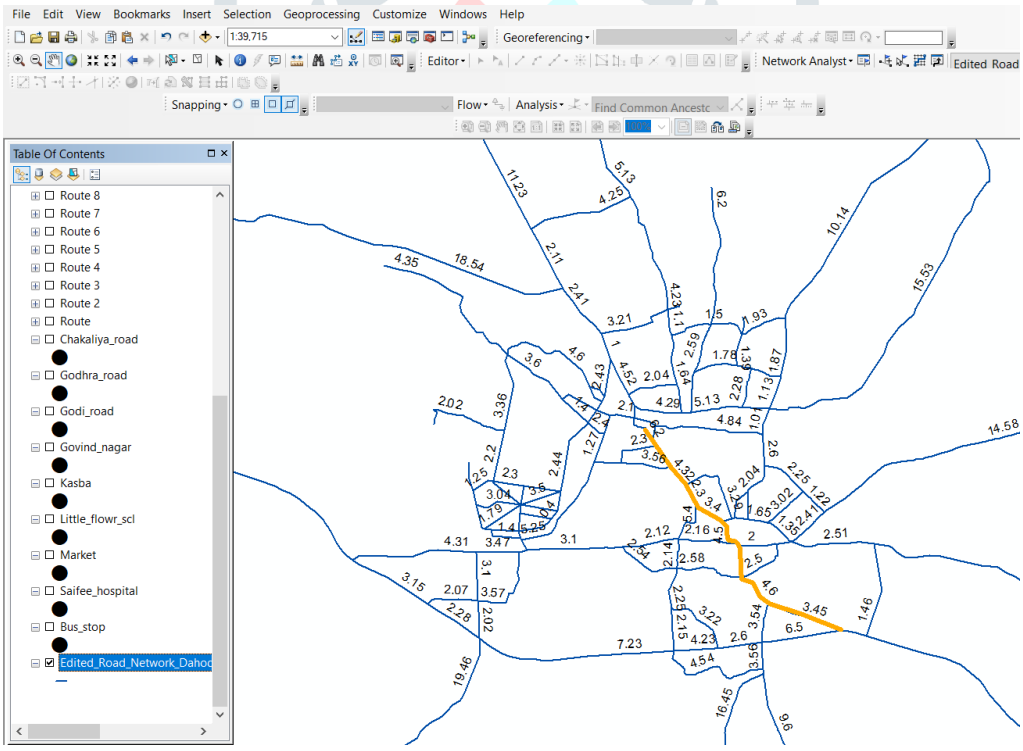

Figure.6: Road section of heavy traffic based on the travel time calculation

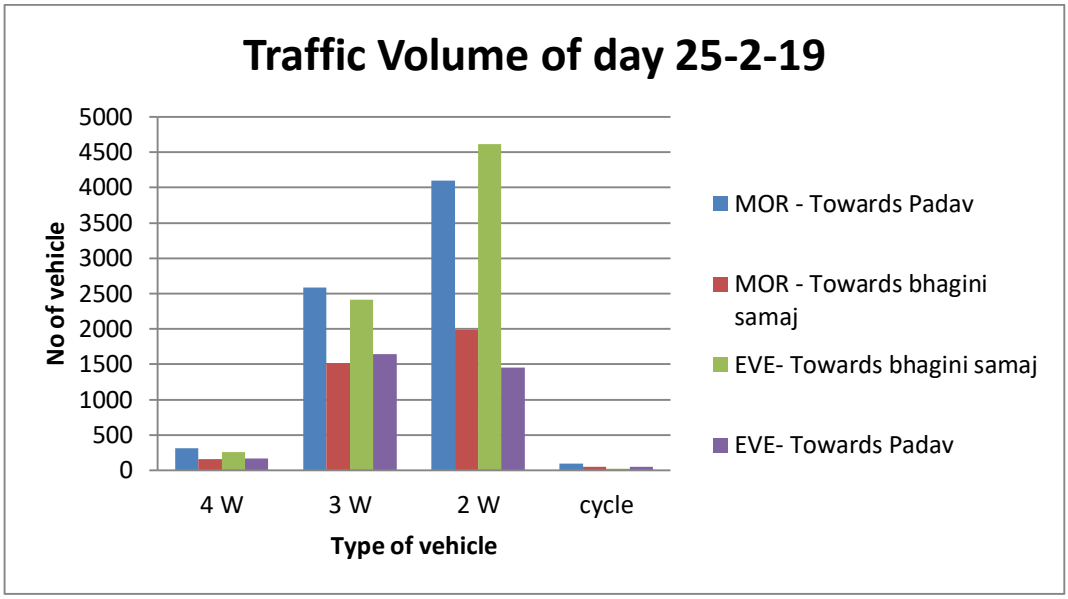

Figure 7: Traffic Volume of the day 25-2-19

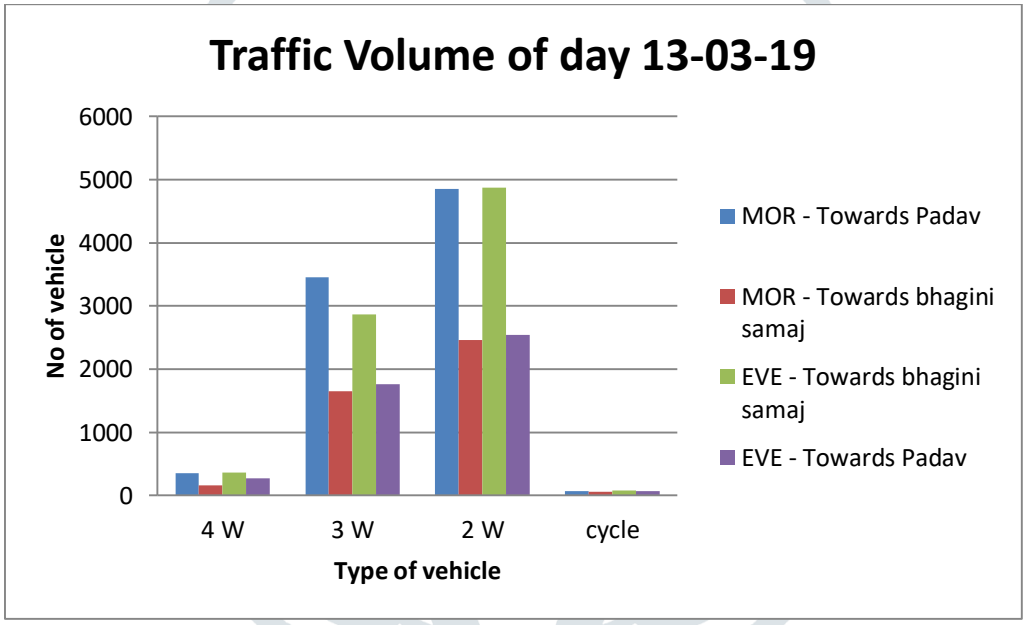

Figure 8: Traffic Volume of the day 13-03-19

V Data Analysis and Discussion

Location of the trips are taken as a origin destination of the trips , Routes are analyse in Network analysis tools considering time as a cost attribute, Fig 9 shows the output of one route and Table.1 shows output of all route.

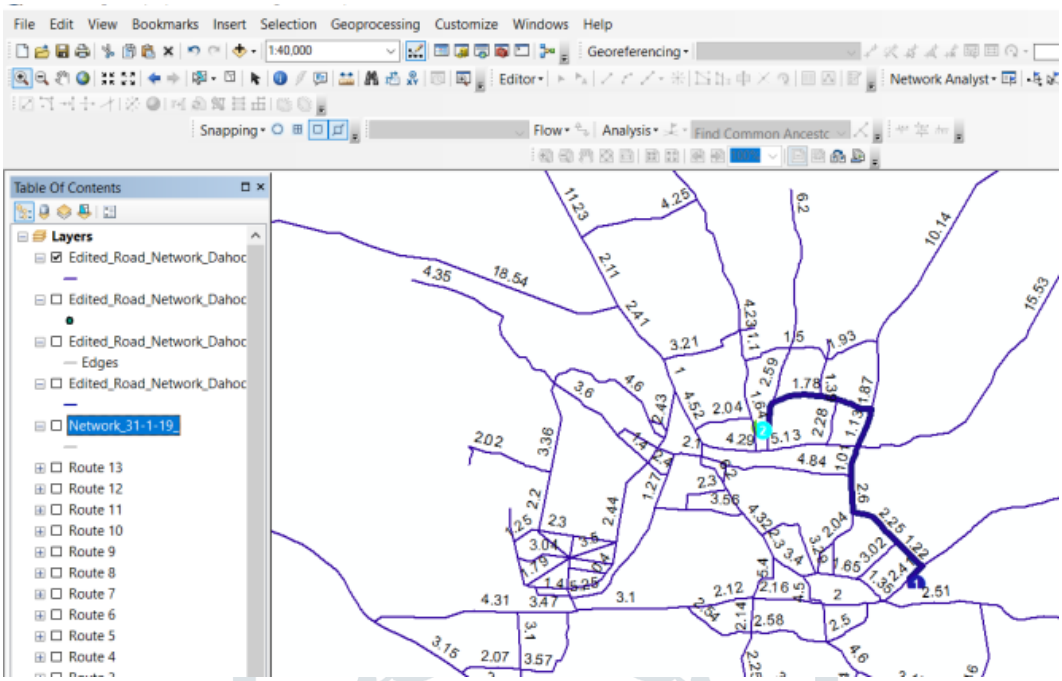

Figure 9: Proposed Route example

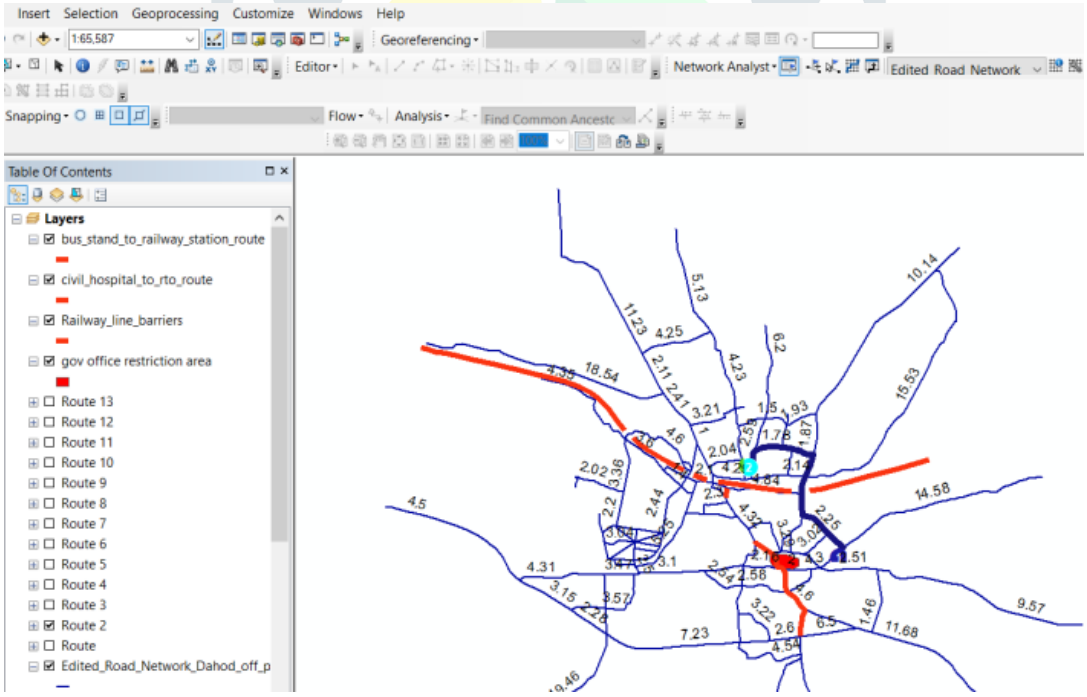

Figure 10: Route Proposed with the use of Restrictions

5.1 Network analysis with various Restrictions

We have carried out Dahod city network analysis with following traffic restrictions:

1. Route diversion (Fig.10). Line was broken by providing nodes at the place of diversion.
2. Crossing of Railway line only at Railway gates.(Fig.10). For this railway line was broken (provided nodes) considering width of the railway gates.
3. Prohibited/ Restricted area (Fig 10.). This area was developed in the form of polygon and considered as restricted area in the analysis.

Table 1. Results and Differences of the Existed & Proposed Routes

Route No	Existing Route		Proposed Route		Differences
	Travel Time (Min and Sec)	Length (Meter)	Travel Time (Min and Sec)	Length (Meter)	Travel Time (Min and Sec)
1	11.06	1450.79	7.5	1953.92	3.56
2	16.02	2527.67	13.45	3078.48	2.57
3	14.57	2412.67	14.57	2412.67	0
4	26.43	2482.67	16.45	3651.27	10.38
5	21.23	1857.08	19.36	2446.26	2.27
6	18.46	2901.45	15.48	3526.42	3.38
7	12.03	1131.75	11.56	1346.93	0.47
8	19.04	364.69	18.54	3064.69	0.5
9	40.26	3510.96	23.54	4555.25	17.12
10	27.17	2165.51	17.07	3082.6	10.1
11	20.33	3122.06	19.46	3726.24	1.27
12	6.06	1699.73	6.06	1699.73	0
13	10.55	2604.17	10.55	2604.17	0

Results of the route no 3, 12, 13 shows zero difference because it has a same travel time.

5.2 Service Area Analysis

Service areas are those areas which provide services to population including normal activities such as offices, schools, hospital etc and emergency services such as fire brigade ambulances etc. In the present study we have used GIS network analysis tool to provide fire brigade services in the Dahod city considering time factor as cost. For this we used road network of Dahod city and location of one of the fire station to reach different places within 0-5min,5-10min ,10-20min,20-30min time. In the road network cost factor (attribute) was taken as time. Result of service area analysis is shown in Fig.11. From the Fig.11 we concluded that service area is divided in four time zones 0-5 min, 5-10 min, 10-20 min, 20-30 min and the coverage area are 1km, 2km, 9km and 9km respective to time zone.

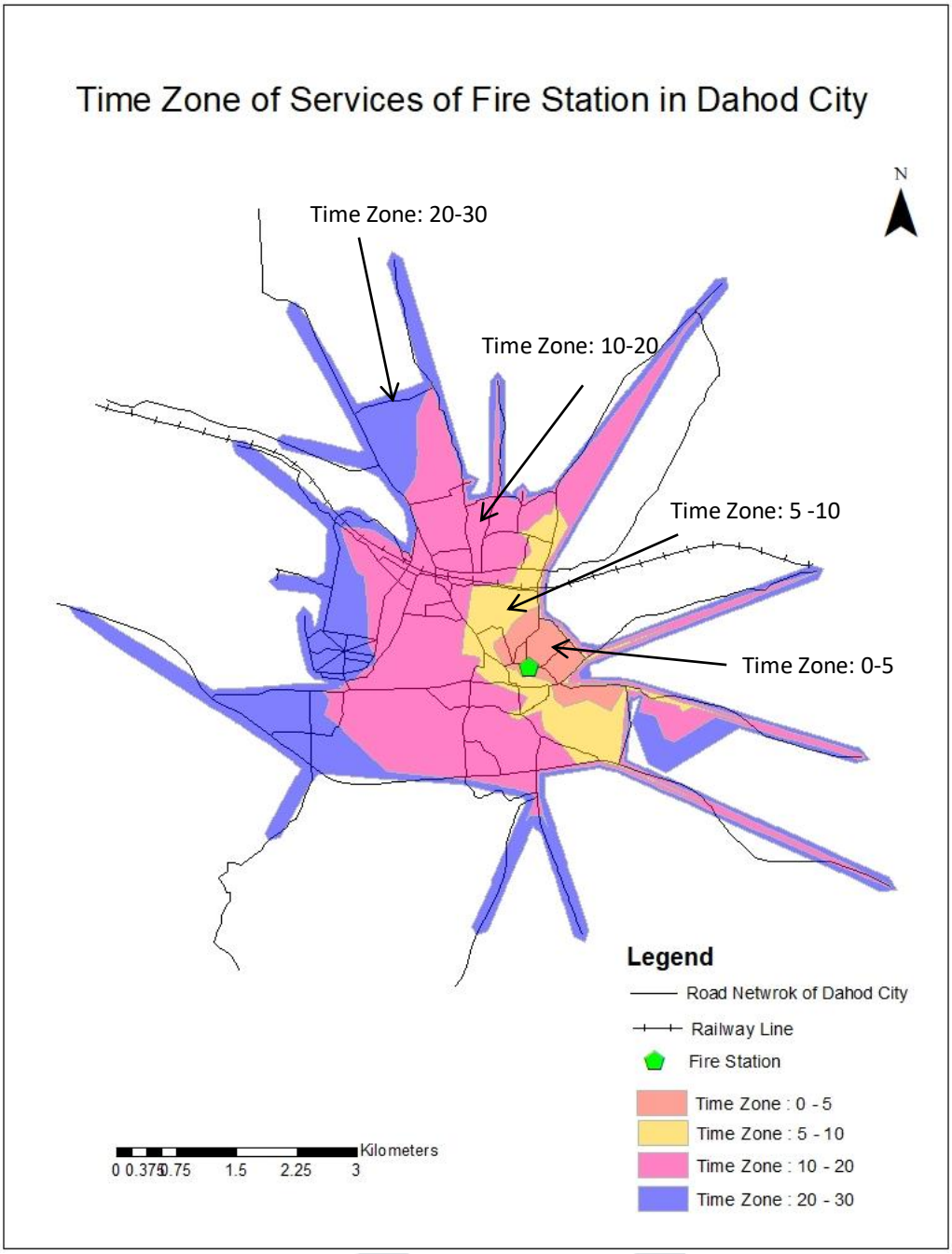

Figure.11: Time Zone Services of Fire Station in Dahod City

5.3 Closest facility analysis

Generally we have to find out shortest route to reach closest facility such as market, hospital, offices from residence and emergency fire brigade facility from fire station to industrial area or other fire locations in shortest time. For this we used road network of Dahod city and time as cost attribute. We can also change this attribute to distance, if time is not consideration and only shortest distance is required in view of the fuel cost. Result of shortest time required to reach fire brigade to various locations of industries is shown in the Fig 12.

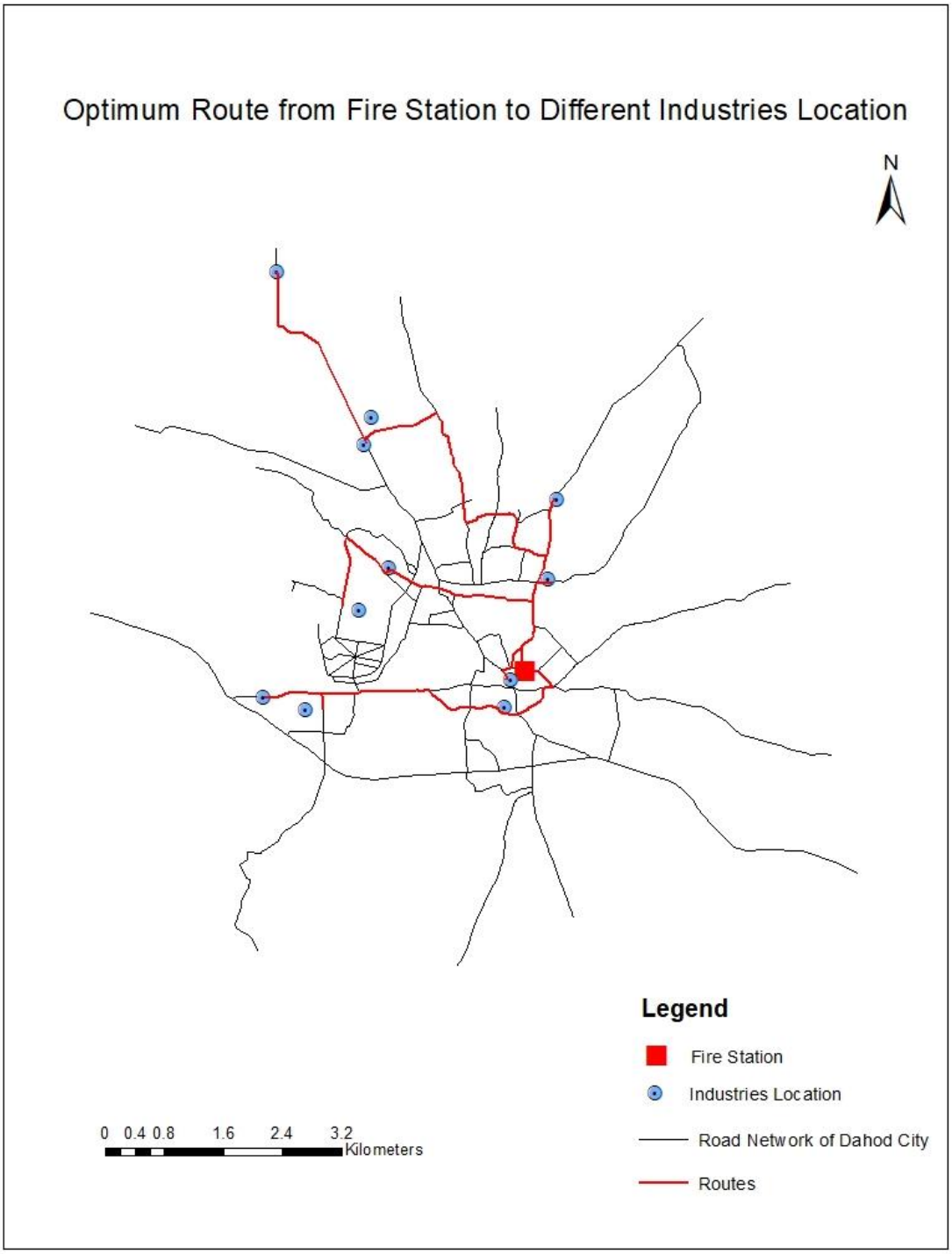

Figure 12.Optimum Route from Fire Station to Different Industries Location

Major finding of the research.

1. Dahod City has a Major road length is 43.73 km and Minor road length is 30.57 km
2. Dahod city has a mix land use pattern, which includes Commercial area 508874 sq.m, Agricultural 748364.35 sq.m, Residential 4738135 sq.m, Lake 546121.85 sq.m, and River 90146.75sq.m.
3. Fire Station Coverage area is divided into 4 time zones 0-5 min,5-10min,10-20min,20-30min and which covers 1sq.km, 2 sq.km , 9 sq.km, and 9 sq. km areas respectively.
4. Routes are identified connecting different industries with fire station.

VI CONCLUSION

Dahod city is one of the developing city of Gujarat which requires improvement in surface transport network as at present it is facing problem of congestion at many places. This city has also been proposed by the Government of India to be developed as smart city considering future needs. In view of this road and railway network analysis has been done using GIS technology. In the present study, shortest route path analysis, service area analysis and rerouting analysis of the traffic avoiding restricted places and railway line have been done. This study will be useful to the city planner in planning adequate surface network system considering present and future needs of the traffic. However, it would be better to plan overhead bridges and subways besides widening and extending existing road systems to improve the traffic flow and to avoid congestion for the development of city.

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