CHAPTER - 9

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS
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9.0 SUMMARY

GIS represents a new paradigm for the organization of information and information system design, with the concept of location as the basis for structuring of the information. GIS-T has now emerged as the technology with large potential for achieving dramatic gains in efficiency and productivity for multitude of traditional transportation applications. In present study a detailed methodology for development of GIS database is presented. Trip generation equations developed. Trip O-D matrices generated. The O-D travel demand is assigned on network of NH and SH. The links with \( v/c \geq 0.50 \) are identified. The national average growth rate of traffic and Government of Gujarat 2008 based growth rates adopted for horizon year traffic volumes on network. The links with \( v/c \geq 0.5 \) are identified and proposed for capacity augmentation, so that traffic can operate on LOS B, i.e. as per designed efficiency. The road links inventory collected for NH-8 and using Mile Post Linear Referencing Method, the data is georeferenced. The road crashes data collected for NH-8 are joined with linearly referenced data to develop Crash Information Recording and Analysis System (CIRSA). Based on hazardous index and crash frequency black spots and stretches of 2.0km each identified and proposed for crash mitigation measures. This will help in safe movement of road users. Thus long term strategic planning of capacity improvements and crash mitigation measures will help in safe and efficient road users' movement in the study area.

9.1 CONCLUSIONS

The important conclusions drawn from the present study are described as under:

9.1.1 GIS DATABASE DEVELOPMENT

1. The development of GIS-T database needs huge textual and geographic data, which should be structured and organized to facilitate its easy integration, retrieval and quarrying. The use of GIS-T database depends on existing organizational framework and legacy database. Large scale spatial database requires more resources for its development. When digital database is available
from Survey of India (SOI) and database vendors, the work will be faster and simplified.

2. A map of Anand District with spatial scale of 1:250000 is used for district level database criterion. The map is georeferenced using ground control points obtained using Garmin GPS.

3. The vector model for database creation is adopted and the various points, polygons and line layers used, with sets of attributes to create thematic maps.

4. Taluka boundaries are used. Talukas are TAZs. For eight Talukas polygon layer is joined with zonal socio economic database in thematic maps.

5. Point layers created for bus depots and survey locations. Non-spatial data joined with point layer include name of depots, fleet size, survey location name, traffic and sample size.

6. The road and rail network digitized as line layer and their attributes are joined.

7. The point layer is used to represent airports, harbours with attributes in present study in map of Gujarat State.

8. Map of Gujarat and India digitized for creating location map and thematic map for ports and airports in Gujarat.

9.1.2 FIELD SURVEY OBSERVATIONS

The household interview survey data analyzed gives following:

9.1.2.1 HOUSEHOLD CHARACTERISTICS

- The average household size in the study area is 4.11 person/HH in Petlad (minimum) and 6.2 person/HH in Tarapur (maximum). For Anand district it is 4.88 person/HH. The deviation observed is 1.15 to 3.17 person/HH.

- The number of persons in a household observed 13 as maximum and 4 to 5 members' households are in largest number.

- The vehicle ownership in study area reveals that about 8% HH own cars, 58% own motorized two-wheelers, and 46% owns bicycles.
• The house ownership data indicates that more than 80% HH have their own house and about 15% are staying in government quarters.

9.1.2.2 PERSONAL CHARACTERISTICS
• The income data analyzed show that 78.797% individuals have income upto Rs.5000. The 18.40% individuals have income from Rs.5001 to Rs.15000. Only 2.81% individuals have income level above Rs.15000.
• The licence holders data analyzed show that 39.98% persons do not have licence. 47.36% persons have licence for motorized two-wheelers, 12.71% persons have car driving licence and 4.95% persons have heavy-duty licence.

9.1.2.3 TRIP CHARACTERISTICS
• The purpose based trip distribution in District of Anand show that work, education, business, shopping, social, and recreation trips are 11.932, 9.711, 9.091, 5.682, 10.279 and 1.756 percentages respectively. The return home trips are 44.73% and remaining trips are health/hospital and other purpose.
• The region wise maximum and minimum trips observed are given below.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Maximum (%)</th>
<th>Taluka Region</th>
<th>Minimum (%)</th>
<th>Taluka Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>17.49</td>
<td>Anand</td>
<td>4.65</td>
<td>Sojitra</td>
</tr>
<tr>
<td>Education</td>
<td>18.75</td>
<td>Tarapur</td>
<td>4.00</td>
<td>Petlad</td>
</tr>
<tr>
<td>Business</td>
<td>13.46</td>
<td>Anklav</td>
<td>0.00</td>
<td>Tarapur</td>
</tr>
<tr>
<td>Shopping</td>
<td>12.44</td>
<td>Anand</td>
<td>2.55</td>
<td>Borsad</td>
</tr>
<tr>
<td>Social</td>
<td>16.86</td>
<td>Sojitra</td>
<td>5.73</td>
<td>Borsad</td>
</tr>
<tr>
<td>Recreation</td>
<td>3.00</td>
<td>Petlad</td>
<td>0.00</td>
<td>Tarapur</td>
</tr>
</tbody>
</table>

• The mode choice observed for trips is rail (5.28%), bus (30.47%), IPTs (14.03%) and private vehicles (50.22%).

9.1.2.4 REGIONAL ROAD TRAFFIC CHARACTERISTICS
• The RSI data for CVC analyzed indicate composition of buses, trucks, IPTs, motorized tow-wheelers, cars, tractors, and bicycles are 4.25, 8.57, 29.26, 29.50, 10.00, 3.26 and 14.41 percentages respectively.
• The average occupancy observed in cars, two-wheelers, auto-rickshaw, chhakda, taxi, bus, truck, tractor and animal driven carts are 4.62, 1.99, 5.09, 6.19, 7.28, 36.38, 3.66, 5.51, and 2.94 persons per vehicle respectively.

• The low occupancy vehicles are highest in the traffic stream. The group with occupancy 1 to 5 persons/vehicle is 82.50% followed by occupancy group 6 to 12 persons per vehicle is 9.81% and higher occupancy vehicles are only 7.69%.

9.2.1 ORIGIN–DESTINATION DATA

• The O-D matrix database was not available for area under study. The questionnaire was designed, training set for interviewer prepared and geographically well spread data collected which helped to prepare O-D matrix for Anand district.

• O-D observations based on 18 zones in HHI and RSI and adjusted matrix show that there was 248830 PCU trips/day. The total trips include E-E trips 90295 PCU (31.702%), I-E and E-I trips 121072 PCU (42.506%) and I-I trips 73463 PCU (25.792%).

• The vehicle type wise O-D matrices developed and desirelines prepared using GIS-T tools.

9.2.2 PERSON TRIPS TO PASSENGER CAR UNIT TRIPS FACTORS

• The mode choice, occupancy and PCU based person trips to passenger car unit trip conversion methodology is unique feature in this research. The PTPCU factors developed for various modes are as given below.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Two-wheelers</th>
<th>Cars/ jeeps</th>
<th>Metador/ vans</th>
<th>Autorickshaw</th>
<th>Buses</th>
<th>Chhakda</th>
<th>Tractors</th>
<th>Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTPCU</td>
<td>0.07427</td>
<td>0.01013</td>
<td>0.00725</td>
<td>0.02281</td>
<td>0.02512</td>
<td>0.00171</td>
<td>0.00108</td>
<td>0.04775</td>
</tr>
</tbody>
</table>

9.2.3 NETWORK ANALYSIS

• The network database is prepared using line layer and O-D demand is assigned after creating network files in TransCAD. Assignment results are compared with traffic projection methods and compromised solution used for suggesting
widening of road links with $v/c >= 0.50$. The identified links are highlighted in bold letters in Annexure VI.

### 9.3.1 Accident Analysis

The analysis of accident data is a very important aspect in the safety analysis of road users. The following results were observed during analysis:

#### 9.3.1.1 Accident Scenario in the Study Area.

The road accident statistics 1970-2004 for India were analyzed. It gives the following observations:

**National Level:**

- Number of persons killed per 10,000 registered motor vehicles decreased from 53.09 persons in 1980 to 12.74 persons in 2004.
- Number of accidents per 10,000 registered motor vehicles decreased from 338.86 in 1980 to 59.12 persons in 2004.
- Total number of persons killed increased from 24,000 persons to 92,618 persons in 2004. This shows that every 10 minutes 2 persons are killed on roads due to road crashes.
- Total number of accidents increased from 153,200 in 1980 to 429,910 in 2004. This means there are 8 to 9 accidents on roads in every 10 minutes on Indian roads.

The analysis of accident data collected from the study region helps to conclude the following:

- The accident data analysis on roads of the study area shows that NH is highest accident prone with 4.44 crash/km (average of 2004-2006 data) and lowest MDR+ODR+VR with 0.62 crash/km.
- The data analyzed for lane based carriageway indicates highest share of crashes on two lane (66.92%) followed by three lane or more lanes without median (26.97%), single lane (3.90%) and four lane with median (2.21%).
- Inter section type based analysis shows four arm and staggered junctions are more crash prone. Age group and accident analysis shows that 18 to 54 years age group have 76.17% accidents.
SAFE AND EFFICIENT REGIONAL ROAD USERS' MOVEMENT FOR GUJARAT STATE IN GIS ENVIRONMENT

• The average crashes and fatality rates worked out in the study area for 2004-2006 data show following crash and fatality rates. Compared to bus how many times the mode is unsafe is presented in Table below.

<table>
<thead>
<tr>
<th>Mode of vehicle</th>
<th>Vehicle-km travelled</th>
<th>Crashes per100 MVKT*</th>
<th>Fatality per 100 MVKT</th>
<th>Persons Killed per 100 MPKT**</th>
<th>Times unsafe compared to Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-wheelers</td>
<td>313.040</td>
<td>71.05</td>
<td>11.91</td>
<td>5.99</td>
<td>6.58</td>
</tr>
<tr>
<td>Cars+ Three wheelers</td>
<td>306.03</td>
<td>139.09</td>
<td>13.40</td>
<td>2.53</td>
<td>2.78</td>
</tr>
<tr>
<td>Buses</td>
<td>40.22</td>
<td>198.91</td>
<td>33.15</td>
<td>0.91</td>
<td>1.00</td>
</tr>
<tr>
<td>Truck+ LCV+ Tractors</td>
<td>331.61</td>
<td>157.41</td>
<td>29.75</td>
<td>6.49</td>
<td>7.13</td>
</tr>
<tr>
<td>Cycles</td>
<td>78.27</td>
<td>68.14</td>
<td>7.24</td>
<td>4.76</td>
<td>5.23</td>
</tr>
</tbody>
</table>

Source: Police Dept, Anand District, PWD & Surveys

*MVKT=Million Vehicle Kilometer Travelled, MPKT**= Million Passenger Kilometer Travelled

9.3.1.2 GIS BASED ANALYSIS

The advantage of GIS use in highway safety analysis is integration of different types of data. It provides the means for referencing the road network and the same can be used for integration of roadway inventory, crashes, and traffic and landuse data. This results into development of crash information and recording system (CIRS) for safety analysis and safety audits.

• In the country crash data is collected mainly using accident reporting forms (IRC) for NE, NH, SH and details available in FIR. This data is difficult to analyze for road safety mitigation measures. However, crash data is used with road inventory, traffic, and landuse using common linear referencing system, analysis become easy.

• The crash information of National Highway No. 8 collected from Anand and Kheda District for three years attached to the route system layer with road inventory, traffic data and landuse forms GIS-T database for crash analysis.

• A total road length of 76km of NH-8 was analyzed using combination of average frequency of accident per km and hazard index and hazardous location i.e. black points are identified. The hazardous the identified black points and 2km long stretches of NH under study are plotted.
The present study shows the use of GIS-T technology in developing regional zoning, movement of road users and integrated highway network information system which is useful for regional transportation planning and analysis for safe and efficient operations. The functionalities available in GIS-T are useful in querying capability, a tool for management and safety analysis is presented in the study.

9.4 CONTRIBUTION OF RESEARCH WORK

The major contributions of this research work are as follows:

1. The conceptual models formulated for spatial database and attribute database for regional GIS database creation. Since, the future regional transportation database are to be updated, the models will be immensely useful.
2. Data collection methodology developed for use with GIS-T formats.
3. GIS database for Anand District and present transportation status evaluated.
4. PCU/day O-D matrix developed for Anand district can be utilized for future planning and decision making by planners.
5. The road network database with inventories created in GIS-T is very useful for identification of constrained links in network ensuring early up gradation and efficient movement of road users.
6. The trip TRIP_GEN_POP Models and TRIP_GEN_MULTI_VAR Models are useful for future forecasting of trips.
7. The PTPCU factors developed will help to convert person trips in to Passenger Car Trips based on Occupancy and mode choice proportions.
8. Network maintenance study based on BBD method for overlay design is useful in data presentation and decision making.
9. Linearly referenced road network and crash information and analysis system presented is easy to use and identify black spots on road network. The identification of black spot and improvement ensures the safe movement of road users in the regional road network.
10. v/c ratio based on projected traffic, will help preparing network improvement-capacity augmentation scheduling ensuring efficient and safe movement of traffic.
9.5 RECOMMENDATIONS

The present study shows the potential use of GIS-T in development of an integrated database for regional zones and road network, which can be used for various types of transportation system analysis. The following are the recommendations based on present study.

1. The entire data related to various regional zones and highway network should be prepared on the GIS-T at the earliest to have efficiency in decision making for district level planning.
2. A spatial scale of 1:250000 is to be used in database creation. For ITS purpose, larger scales are to be used.
3. The data collection and updating cycles are to be fixed after preparing comprehensive listing of datasets for transportation system planning for the country.
4. GIS data enterprise is to be established to have standard database availability for various organizations and stakeholders in field of transportation.
5. The PWDs have started creating GIS databases with the help of consultants. It is required to train people in-house for maintenance and operations of GIS database.
6. The NH network database at National level with inventories and v/c constraints to be created and links for LOS B to be identified for strategic planning. The similar database for SH and MDR to be created at state levels.

9.6 LIMITATIONS AND SCOPE OF FUTURE WORK

There are opportunities for future improvements in developing regional transportation models in GIS environment. Some of them are given below:

1. In conventional four stage modelling the first step trip generation model is important, hence should be cross-checked with large sample size and connected to activity systems, as this models developed do not reflect
   a) The relation between person trips and activities.
b) The temporal behavior to be included.
   The mode choice model to be evaluated based on impedance functions between origin and designations.

2. In present study road users are considered in aggregate. The separate regional transit assignment to be carried out.

3. In assignment of traffic the default values of $\alpha = 0.15$ and $\beta = 4.0$ adopted. This can be calibrated for specific routes.

4. The black spot identification is based on hazardous index and average crash/km. This black spot can be worked out by using most widely used Bayesian Analysis Techniques.

5. Identified black spots improvement study should be taken up at micro-level geometric designs.