CHAPTER 7
MANAGEMENT STRATEGIES FOR TRANSPORTATION SECTOR
IN HYDERABAD

Growing motorization coupled with limited road space, inadequate separation of the working space from the living space and an ageing and ill-maintained vehicle stock, a sizeable share of two-stroke engine technologies, absence of efficient public transport and lower quality of fuels have all led to traffic congestion resulting in longer travel time, greater fuel consumption, growing air pollution, discomfort to road users and degradation of the urban environment. In order to take full advantage of the process of economic liberalization, the Govt. of Andhra Pradesh has mooted a VISION document (Hyderabad 2020, 2003) to achieve development totally sustainable. Amongst the strategies, managing urban growth has received attention, with transportation as a critical element in the infrastructure development.

It is therefore imperative to study the impact of each proposed alternative on the nature and magnitude of air pollution emission load in the city. The methodological framework described in chapter 6 section 6.4, of the thesis is used to study the pollution potential of each proposed strategy in GIS environment. The suggested strategies critically examined include (a) strengthening public transport to reduce urban congestion (b) intersection geometry improvement (c) Road widening (d) grade separations (e) parallel roads (f) Railway barriers RUB/ ROB’s at major River and railway crossings and (g) promoting cleaner and alternative fuels and improved engine technologies.
7.1. INTRODUCTION:
Growing personalized motorization coupled with limited road space, inadequate separation of the working space from the living space and the space for movement, an ageing and ill-maintained vehicle stock, a sizeable share of two-stroke engine technologies, absence of efficient public transport and lower quality of fuels have all led to traffic congestion resulting in longer travel time, greater fuel consumption, growing air pollution, discomfort to road users and degradation of the urban environment.

Amongst the strategies, managing urban growth in Hyderabad Urban Development Authority has received attention, with transportation as a critical element in the infrastructure development (Hyderabad 2020, (2003)). Three mutually reinforcing policies need to be used to try to reduce the growing energy demand and emissions from the transport sector in Hyderabad: improve the efficiency of fuel pricing; reduce urban congestion; and promote cleaner fuel and improved engine technologies (World Bank, 1992). Though many studies on the implications of some of these strategies on energy demand and emissions have been undertaken in India, each of them presents only a broad overview of the problem (IIP, 1985; GOI, 1987; TERI, 1989; TERI, 1992; Bose and Chary, 1993; Bose and Mackenzie, 1993; IIP, 1994; Bose, 1996; Dass and Bose, 1997; World Bank, 1997).

It is therefore imperative to study the impact of each proposed alternative on the nature and magnitude of air pollution emission load in the city. The strategies examined include: (a) strengthening public transport to reduce urban congestion (b) intersection geometry improvement (c) Road widening (d) grade separations (e) parallel roads (f) Railway barriers RUB/ROB’ s at major River and railway crossings and (g) promoting cleaner and alternative fuels and improved engine technologies.

The HUDA master plan was used to study the present and future scenario testing. In this sense the study is very place oriented and activity specific. Twenty four hour links and eight hour and 16hr intersection points, whose vehicular inventory data were available or can be calculated using growth factors, are used to study the proposed developmental strategies and their sensitivities to the impact of transit supportive development. Figure 7.1 shows the different planning zones under Hyderabad Urban Development Authority (HUDA) and Figure 7.2 shows the boundaries of ten municipalities under HUDA region.
The detailed study is carried out in a methodological manner, initially the dimensions of travel behavior and travel demand changes in Hyderabad are studied at a broad level, then the change of travel by year 2020 was computed using attractive index. Then the changes in the emission load by the year 2020 are computed using the methodological framework described in chapter 6 of the thesis work. The impacts of each management strategy on the emission load are critically examined by hypothetically implementing the strategy into the developed transportation network and studying the reduction in the emission loads of each proposed alternative strategy.

7.2. PREDICTING THE TRAVEL DEMAND CHANGE AND RELATIVE CHANGES IN EMISSION LOAD BY YEAR 2020:

The central focus of transport planning processes is predicting and modeling traffic flows in a transport network based on an understanding of the complex nature of land use and transportation systems. For this, computerized models, usually termed travel demand models (TDM) are applied extensively in practice. TDM aims to provide information for the design of transport networks that allow optimum and efficient movements of traffic (Michael J Bruton, 1985, Barnes, G. and G. Davis. 1999). The travel demand modeling methods are applied to current and future road network scenarios to assess their performance in terms of traffic flow efficiencies (usually as volume/capacity ratios) (John M, Levy, 1998).

It has been demonstrated that much of the data required for modeling the environmental impacts of traffic are already produced as output from the Traffic survey carried out by various agencies in Hyderabad (HATS - 1999 & Chari and Reddy, 2002). In the present thesis work the author has made use of the traffic inventory data under GIS platform to predict the changes in the pollution load for each proposed management strategy. Model data, including traffic counts, land use, and network characteristics were collected and developed specifically to develop a calibrated model to represent 1999 conditions.

The modeling area encompassed of the entire Municipal Corporation of Hyderabad and the major road network surrounding the zone, and was divided into small geographic areas (Traffic analysis zones, TAZs), the main reason for considering Municipal Corporation of Hyderabad Area is the availability of statistical data pertaining to housing characteristics, number of workers and employment pattern etc.
Figure 7.1 The different planning zones under Hyderabad Urban Development Authority
Figure 7.2 The boundaries of ten municipalities under MCH region
The model included a total of 35 TAZ's. Figure 7.3 shows the cordon line of the planning area. The development of the TAZ structure considered barriers to travel as well as available ward-wise housing data that would naturally separate land uses, natural loading points in the network, and existing data source structures.

TAZ data contains information on existing housing and employment pattern within each zone. Land use information consisted of 1) Employment centers 2) Residential locations 3) Recreation and Cinema theaters 4) Business and Shopping complexes 5) Educational institutions and 6) Hospitals for each Traffic analysis Zones. Residential dwelling unit data was generated from 1999 District Statistics Hand Book, Census data at the ward and Municipal and block level (Hyderabad District statistics – 1999 & 2002). The model network contained both links (representing street segments) and nodes (representing intersections).

There are at least three characteristics of land use and trip-makers that are important (Michael J Bruton, 1985). The density or intensity of the land use is important and many studies begin by determining the number of dwellings, employees, or tenants per acre. The intensity can be related to an average number of trips per day, based on experience with the type of land use at hand. Next, the social and economic character of the users can influence the number of trips that are expected. Character attributes like average family income, education, and car ownership influence the number of trips that will be produced by a zone. Finally, location plays an important role in trip production and attraction. Street congestion, parking, and other environmental attributes can increase or decrease the number of trips that an area produces or attracts.

Forecasting is primarily designed to model hourly traffic conditions, and as such both trip generation and link capacities were developed using hourly rates. All trips within the model area were distributed by peak hour origins and destinations according to three trip types; Home based work (HBW) trips, home based non-work (HBO) trips, or non-home based (NHB) trips. Figure 7.4 and 7.5 shows Population, Households and Residential characteristics of the study area during 1991.
Transport Analysis Zones for the Travel Demand Forecasting
In Hyderabad Urban Development Authority

Figure 7.3 The cordon line of the planning area

Source: MCH Residential map
Population, Households and Residential characteristics of the study area
1991 Census

Figure 7.4 Population, Households and Residential characteristics of the study area during 1991
Map showing Average Household size and Home based trips in the Study area

Average Household size = 5.7
Total Home Based trips in the study area = 510904

Prepared By
Center For Environment
IST, JNT University,
Kukupally, Hyderabad - 72

Figure 7.5 Average Household size and home based trips in study area
7.2.1. Dimensions of travel behavior in Hyderabad:

7.2.1.1. Trip Generation

Trip generation is the first step in the modeling process that utilizes the land use data (socioeconomic data) to calculate the trip making characteristics (person trips) of each TAZ that will eventually be modeled on the roadway network. Many factors influence the amount of travel in a region, including automobile ownership, income, household size, density and type of development.

Trip generation models consist of two sub-models: trip production models and trip attraction models. While household data is used to estimate trip productions, employment as well as residential data is the primary data used to estimate trip attractions. Figure 7.5 shows the average household size and home based trips in the study area. It is observed that the total number of home based trips in the region stands to 510904 during 1991 and with the present population size it stands at 861034. The important factor in understanding the increase in trips is the increase in the number of jobs. This has two-pronged effect. One is the obvious point of two trips per day approximately. The second impact is that people with jobs have disposable income and mobility, thus providing both the means and the reason for making additional trips for shopping, entertainment or other activities. This increase in jobs resulted both from the increase in adult population and also the large growth in workforce participation among women that started in the 1980s.

Auto ownerships have also affected in increasing trip rates through the obvious means of making travel easier. This variable in-fact is the most closely related to the number of trips of any factor in Table 7.1. If a car is available it tends to be used. However, the argument could be that auto ownership is not really a cause of trips, but is simply like trips a result of other factors. The final major factor influencing the trip rates is demographic changes between 1960 and 2001 many people who grew up with automobiles, and who tend to make more trips replaced people in the population.

7.2.1.2. Types of trip generation:

Trips undertaken for different reasons tend to have different characteristics. Work trips, for example are longer than other trips, more likely to use transit, more likely to go to the down towns and more likely to be taken during peak periods. Other types of trips such as shopping and recreation differ from work trips in most characteristics. They tend to go to different destinations, are substantially less likely to use transit and are more likely to be taken during off peak hours. Not only do non-work trips
manifest themselves in different ways in terms of their effects on the system, but their different characteristics also reflect different traveler objectives. In other words policies such as improved express transit that makes work trips better might not have the same positive impact on the other trip types. Figure 7.6 shows the Total workers and Marginal workers and total work based trips in the study area work based and home based trip generation in the TAZ’s of the region during 1991. It is observed that the total number of workers and non workers in the region are 788861 and 70656 respectively with the total number of trips being 510904.

The initial production model results were compared with available local data and with available work trip data from the 1991 census. Factoring 1991 census data (trips to work by mode) of year 2020 levels (total population = 5174) indicated that about 138,600 daily HBW trips could be expected from the model area.

A major complication in exploiting trip purposes as a way of improving the transportation system is chaining, i.e. people, don’t always drive from home to a destination and then back again, instead they make tours chaining different purposes into a sequence of shorter trips. This is especially prevalent as part of the trips to and from work.

7.2.2. Trip Attraction Model

Trip attractions are the trip end associated with the non-home end of a trip, such as a workplace, shopping center, or school. Trip attractions are estimated based on employment, shopping and recreational activities within each TAZ. For the calculation of the trip attraction weightings were assigned to each particular trip attracting activity. Preference has been given to Governmental institutions, educational centers, medical facilities and industries in different regions. Weightage were assigned after studying the relative importance of each activity. Weightage ranging from 1 to 0.25 has been given to each category, with least preference being given to recreational centers and parks.
Figure 7.6 Total workers and Marginal workers and total work based trips in the study area.

Total Workers = 789881
Total marginal workers = 70936
Total Non workers = 2168183
Total Work related trips = 519994
Figure 7.7 Trip attraction in different transport analysis zones and the corresponding vehicle load during 1999 – 2000.
Relationship between Attractive index and vehicular count in Hyderabad

\[ y = 10755x + 15552 \]
\[ R^2 = 0.922 \]

7.8. Linear Regression values for attraction index versus traffic at selected junctions in Hyderabad
Table 7.1 Aggregate statistics (all numbers in lakhs)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>NA</td>
<td>17.96</td>
<td>25.46</td>
<td>43.44</td>
<td>57.52</td>
<td>NA</td>
</tr>
<tr>
<td>Households</td>
<td>NA</td>
<td>NA</td>
<td>51727</td>
<td>839421</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Workers</td>
<td>4,10000</td>
<td>NA</td>
<td>NA</td>
<td>1217071</td>
<td>1605192</td>
<td>NA</td>
</tr>
<tr>
<td>Automobiles</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>585644</td>
<td>1447932</td>
<td>147.24</td>
</tr>
<tr>
<td>Pollution load (tons/day)</td>
<td>22</td>
<td>50</td>
<td>160</td>
<td>528</td>
<td>1246</td>
<td>600</td>
</tr>
</tbody>
</table>

NA: Not available

Table 7.2 Housing data 1981 - 1991

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1981</th>
<th>1991</th>
<th>Rate of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupied Residential house</td>
<td>491713</td>
<td>821508</td>
<td>+67</td>
</tr>
<tr>
<td>Households</td>
<td>51727</td>
<td>839421</td>
<td>+62</td>
</tr>
<tr>
<td>Population</td>
<td>2993589</td>
<td>4665950</td>
<td>+55.86</td>
</tr>
<tr>
<td>Persons per house</td>
<td>6.09</td>
<td>5.68</td>
<td>0.41</td>
</tr>
<tr>
<td>Persons per household</td>
<td>5.79</td>
<td>5.56</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 7.3 Percentage change in main workers population in Hyderabad

<table>
<thead>
<tr>
<th>Component</th>
<th>% Of main workers 1991</th>
<th>% Of main workers 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCH</td>
<td>26.65</td>
<td>26.92</td>
</tr>
<tr>
<td>Sec'Cantt</td>
<td>33.69</td>
<td>29.93</td>
</tr>
<tr>
<td>Osmania University</td>
<td>20.76</td>
<td>18.11</td>
</tr>
<tr>
<td>9 Municipalities (10 in 2001)</td>
<td>31.03</td>
<td>29.50</td>
</tr>
<tr>
<td>Other components</td>
<td>30.34</td>
<td>30.83</td>
</tr>
</tbody>
</table>

7.2.3. Trip Distribution

Trip distribution is the second major step in the travel demand modeling process. Trip generation (the first major step) provided methodology for estimating trip productions and attractions for each purpose within each TAZ. Trip distribution is the process that
links the productions to attractions for each zonal pair. It is these trip interchanges that must be accommodated by the transportation system. The trip distribution process utilizes a gravity model to define the intrazonal and interzonal trip interchanges between zones. A gravity model is the most common form of trip distribution model. A gravity model utilizes an impedance matrix that reflects the distance, time, or cost (or some combination of these) between zones and explicitly relates flows between zones to interzonal impedance.

The gravity model was originally motivated by the observation that flows decrease as a function of the distance (impedance) separating zones, and increase as a function of the number of productions or attractions (size) of zones. Many different measures of impedance can be used, such as travel distance, time, or “cost”. Several potential impedance functions are also available to describe the relative attractiveness of each zone from the impedance, including exponential, inverse power, and gamma functions. The gamma function is the one most often used and recommended in many planning practice, and is the function that has been utilized for the present model.

7.2.4. Relationship between trip attraction centers and vehicular density:

The gravity model assumes that the trips produced at an origin and attracted to a destination are directly proportional to the total trip productions at the origin (HATS, 2000) and the total attractions at the destination (total employment and residential centers). The calibrating term or “friction factor” (F) represents the reluctance or impedance of persons to make trips of various duration or distances (length of the road network). The general friction factor indicates that as travel times increase, travelers are increasingly less likely to make trips of such lengths. Calibration of the gravity model involves adjusting the friction factor, which is carried out using ten selected links and fifteen traffic junctions. The socioeconomic adjustment factor is an adjustment factor for individual trip interchanges which is calculated based on the personal knowledge for the residential locations.

Although an important consideration in developing the gravity model is "balancing" productions and attractions. Balancing means that the total productions and attractions for a study area are equal which is given as a future work. Standard form of gravity model used for generating travel demand is given by

\[ T_{yu} = \sum_{l \text{ link} \in \text{ set}} \frac{A_j F_{yl} K_{yl} x_{yl}}{A_k P_{yl} K_{yl}} x_{yl} \]
Where:

\[ T_{ij} = \text{trips produced at } I \text{ and attracted at } j \]

\[ P_i = \text{total trip production at } I, \quad A_j = \text{total trip attraction at } j \]

\[ F_{ij} = \text{a calibration term for interchange } ij, \text{ (friction factor) or travel time factor } \quad (F_{ij} = C/t_i^n) \]

\[ C = \text{calibration factor for the friction factor, } K_{ij} = \text{a socioeconomic adjustment factor for interchange } ij, \quad i = \text{origin zone} \quad n = \text{number of zones.} \]

The intercept value observed is \( y = (10755x + 15552) \) for the future projections, where \( x \) is the index value. It is observed that the present regression equation holds true for low attraction values.

### 7.2.4.1. Mode of Travel:

The method used to make a trip is another factor that impacts a variety of different problems. Autos for example create air pollution while bicycles don’t. Cars on the other hand have the other advantage, most notably the vastly increased range of convenience of travel that they provide.

The average percent composition of vehicles in the traffic flows on the city roads has witnessed a major change in mode of travel during the past few decades. One major change that is observed is the fast declining trend in the use of bicycles. The major commuting mode for regular work and education trips is still with State run buses. Unfortunately the patronage remained static over the years, though the bus fleet is continually augmented from time to time and expected to remain so in coming years also. There may be several reasons for this trend, including improved per capita incomes, availability of affordable two wheelers with MIS schemes for the purchase of vehicles from major automobiles dealers and non-availability of transportation systems during peak hours at many places for example such as link connecting Masabtank towards Satantnagar areas.

### 7.2.5. Calculation of future travel in the links using the regression equation:

The proposed draft master plan for Hyderabad Urban Development Authority (Hyderabad 2020, 2003), has allocated land for each specific application such as Residential, Commercial, Public Semi-public etc. The Municipal Corporation of Hyderabad land is break up is given in figure 3.15 chapter 3, for the base year of 2003. However the for the modeled year 2020 the Municipal Corporation of Hyderabad has not given any specific projections in land use pattern inside the city. keeping the same into consideration, the HUDA master plan was used to compute the zonal statistics for the year 2020. Based on the density changes in the employment
centers and residential centers the probable traffic counts for each area were computed.

Table 7.4 Modal split by vehicle count in Hyderabad

<table>
<thead>
<tr>
<th>Mode</th>
<th>% By vehicle count on roads 1999</th>
<th>% By vehicle count on roads 2002</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two wheelers</td>
<td>49.7</td>
<td>77.66</td>
<td>27.96</td>
</tr>
<tr>
<td>Three wheelers</td>
<td>17.7</td>
<td>4.91</td>
<td>-12.79</td>
</tr>
<tr>
<td>Cars/van</td>
<td>13.3</td>
<td>11.41</td>
<td>-1.89</td>
</tr>
<tr>
<td>Buses</td>
<td>3.2</td>
<td>0.66</td>
<td>-2.54</td>
</tr>
<tr>
<td>Trucks</td>
<td>3.6</td>
<td>2.81</td>
<td>0.79</td>
</tr>
<tr>
<td>Cycles</td>
<td>10.90</td>
<td>0</td>
<td>-10.90</td>
</tr>
<tr>
<td>Others</td>
<td>1.6</td>
<td>0.47</td>
<td>-1.13</td>
</tr>
</tbody>
</table>

Source: RTA, Hyderabad

Figure 7.9 shows the projected traffic generation by the year 2020 in Hyderabad Urban Development Authority area. The numbers of links which are expected to have more than 1 lakh vehicles per day are observed to increase from 8 to 20 links. The links connecting kompally at Nizamabad road is predicted to have minimum vehicular number by the year 2020, during the selected peak hours (9 am – 11 am). Nalgonda – Chadergaht is shown to have more vehicular numbers by the year 2020, which warrants immediate attention.

These numbers give a general sense of how the average person might perceive traffic conditions in the year 2020. Because of the total increase in vehicle was largely by population increase, the difference to the average person is relatively small. Perhaps the most surprising is that the large increase in total miles traveled leads to surprisingly small decrease in peak period speeds. This is partially because of much of the population increase will be at the edge of the city (see chapter 3 figure 3.16).

Finally it is interesting to note that the geographical extent of expected congestion in the year 2020, currently freeway congestion is a problem most at places like Chaderghat, Ameerpet, Ranjara Hills, Liberty and Secunderabad areas, by 2020 virtually every freeway inside as the carriage width being narrower in the core areas, are unable to accept the influx of these flows and area expected to suffer from peak period congestion.
The carriage width being narrower in the core area, are unable to accept the influx of these flows. Figure 7.10 shows the peak hour traffic flows on major traffic junctions having more than one lakh vehicular units during 2000 and their expected junctions by 2020. Figure 7.11 shows links with traffic volume more than one lakh vehicles per day and their expected number by year 2020.

It is also worth noting that as the freeway become more crowded, shorter trips will increasingly be shunted onto local arterial roads and smaller roads, as is already observed in places like Domalguda, Yousufguda areas. These roads will become more crowded, making it more difficult for area residents to complete everyday jobs and generally reducing the quality of life in many neighborhoods.

7.2.6. Emission load estimation for the year 2020:

The emission model described in chapter 6 was run for the year 2020 and the modeled emission loads were calculated. Analysis of the traffic flows diversions for the proposed ring roads carried out using shortest route method indicated about 14.7% increase in vehicle kilometers traveled during peak hours over the modeled network by year 2020. Figure 7.12 to 7.16 show the future pollution loads at different locations in Hyderabad using 1km² grid. The areas such as Chaderghat – Nalgonda X roads was observed with high emission load while the Kompally region was found to have minimum pollution load. The pollution load observed for different pollutant sources was given in figure 7.12 – 7.16 as pie chart.
Modeled Vehicular growth by the year 2020 at selected links in Hyderabad Urban Development Authority

Figures 7.9, projected vehicular growth by the year 2020 at selected links in HUDA based on attractive index.
Location of junctions having traffic more than one lakh vehicles from all the directions

Figure 7.10 Map showing Location of junctions having more than one lakh vehicles from all directions
Map showing present and future traffic links and their expected traffic flows

Legend Vehicles / day

Year 2000

\[
\begin{align*}
\& 75000 - 100000 \\
\& > 100000 \\
\end{align*}
\]

Year 2020

\[
\begin{align*}
\& 75000 - 100000 \\
\& > 100000 \\
\end{align*}
\]

Road Network

Prepared By:
Center For Environment,
IST, I.I.T University,
Kukatpally, Hyderabad - 72

Source: RTA Vehicular growth data
HATS Survey 2000 - 2001

Figure 7.11 Map showing present and future traffic links and their expected traffic flows.
Modeled Carbon Monoxide emissions during year 2020 using 1 Sq.Km grid in Hyderabad

Figure 7.12 Modeled carbon monoxide emission during year 2020 using 1K.M2 grid in Hyderabad Urban Development Authority
Modeled Hydrocarbon emissions during year 2020 using 1Sq.km grid in Hyderabad

Figure 7.13 Modeled hydrocarbon emissions during the year 2020 using 1km2 grid in Hyderabad Urban Development Authority
Modulated Oxides of Nitrogen Emissions during year 2020 using 1Sq.Km grid in Hyderabad

Legend Kg/day
- 3.149 - 49.33
- 49.33 - 95.511
- 95.511 - 141.692
- 141.692 - 187.872
- 187.872 - 234.053
- 234.053 - 280.234
- 280.234 - 326.414
- 326.414 - 372.595
- 372.595 - 418.776

Grid layer
Road Network

Prepared By:
Center for Environmental
IIT, NIT University
Hyderabad - 50

Source: HATS traffic Survey 2000 - 2001
cPCB Emisison factors
Arithmetic Average growth rate from RTA data

Figure 7.14 Modeled Oxides of Nitrogen emissions during the year 2020 using 1 KM2 in
Hyderabad Urban Development Authority
Modeled Particulate matter emissions during year 2020 using 1 Sq. Km grid in Hyderabad

Figure 7.15 Modeled Particulate matter emissions during the year 2020 using 1Sq. Km grid in Hyderabad Urban Development Authority
Modeled Sulphur Dioxide emissions during year 2020 using 1Sq.Km grid in Hyderabad

Figure 7.16 Modeled sulfur dioxide emissions during year 2020 using 1 Km2 grid in Hyderabad Urban Development Authority
Traffic-generated environmental pollution requires serious attention in Hyderabad. This is due to many factors. Firstly, in many areas, rapidly increasing traffic volumes, lower vehicle operating speeds, and the older age of vehicles have resulting in excessive gas emissions and the generation of traffic pollution. Secondly, traffic problems such as congestion, and their resulting effects on the quality of the local environment, are becoming major items in the key agenda of issues, and environmental considerations will play a dominant role in urban traffic systems in the future. Thirdly, there are significant relationships between the characteristics of a traffic system and the quality of the urban environment.

Thus, it is necessary to analyze motor vehicle emissions, vehicle-generated problems and introduce some technological changes or policies/regulations to control and reduce them. The major management options analyzed include (a) strengthening public transport to reduce urban congestion (b) intersection geometry improvement (c) Road widening (d) grade separations (e) parallel roads (f) Railway barriers RUB/ROB’s at major River and railway crossings and (g) promoting cleaner and alternative fuels and improved engine technologies.

7.3.1. Strengthening public transport system and construction of new roadways:
The major thrust is to integrate various modes and to develop multi modal transportation system to avoid flooding private vehicles for regular commutation in the cities. It is proposed to develop knowledge corridor by making large extensions with the Hi-Tech city at one end and extending towards south. There will be three new zones each around medical and biotechnology, industrial technology and IT enable remote services. Besides there are active proposals to develop several activity centers around Hyderabad city like Apparel Park, Hardware park, Tourist zones etc. the suggestion is to develop an outer and inner expressway system with provision for exclusive mass transit way.

In order compute the impact of new roads on the emission reduction scenario. The new road segments were added to the existing road network; each particular route is identified and assigned a code. Using the shortest path the model was run and the generated new travel roads were identified.
The emissions changes for each route were calculated using the emission factors. Figure 7.17 – 7.21 shows the impact of pollution load by the year 2020. The proposed road network is observed to reduce the present day emission load by nearly 12%. It is observed that relative emission load changes were reduced at the peripheral areas of the city whereas the center area still has the more or less similar emission load due to the proposed ring roads. However the development of more arterial roads connecting the radial roads will be a useful for the reduction of emission load. The development of such arterial roads will ease the traffic movement from one end of the city to the other end without traversing into the interiors of the city.

7.3.2..: Impact of bridges over river Musi:

Important barriers for the free flow of traffic in Hyderabad are the river musi. It is essential that these barriers be punctured as many points as possible to improve connectivity on either side of the barrier. Such connections develop grid movements and reduce circuitry between the areas. (Reddy R 2003) To relieve this funneling effect several new bridges at eight places over river musi has been proposed. Presently bridges are available at eight places across river musi at various points. Figure 7.22 shows the major proposed bridges over river Musi. As shown in figure 7.23 the reductions in the emission load during peak hours at Nalgonda X roads and Chaderghat areas being more with the development of more bridge at different points across river Musi.

For studying the impact of bridges over river musi, the average road capacity of the road network is calculated from the existing lane width and dimensions of the road. The significance of congestion on vehicular speeds was computed. Then the corresponding pollution load for the lane was computed emission equation describe in previous chapter. It is observed that these developments around the river will reduce the pollution load by nearly 40 – 70% at Chaderghat area with the thickening of traffic along the link during the peak periods of the day. The peak hour pollution load from 88gm/hour is reduced to 23gm/hour at the link.
Modeled Oxides of Nitrogen emissions due to proposed inner and outer ring roads in Hyderabad by year 2020

Legend Kg/day

- 3.149 - 49.33
- 49.33 - 95.511
- 95.511 - 141.692
- 141.692 - 187.872
- 187.872 - 234.053
- 234.053 - 280.234
- 280.234 - 326.414
- 326.414 - 372.595
- 372.595 - 418.776
- Sampled links
- Grid layer
- Road Network

Prepared by
Center For Environment,
IST, JNT University,
Kukatpally, Hyderabad - 72

Source: CPCB Emission factors
Method: Shortest route method
Baseline data: NASS Survey 2000 - 2001

Figure 7.17 Modeled Nitrogen oxides emissions due to proposed inner and outer ring roads in Hyderabad by year 2020
Modeled Hydrocarbons emission due to proposed inner and outer ring roads in Hyderabad by year 2020
Modeled particulate matter emissions due proposed inner and outer ring roads in Hyderabad by year 2020

Legend Kg/day
- 0.166 - 1.616
- 1.616 - 3.066
- 3.066 - 4.515
- 4.515 - 5.965
- 5.965 - 7.415
- 7.415 - 8.865
- 8.865 - 10.314
- 10.314 - 11.764
- 11.764 - 13.214

Sampled links
Road Network
Grid layer

Figure 7.19 Modeled Particulate matter emissions due to proposed inner and outer ring roads in Hyderabad by year 2020

Source: CPCB Emission factor
Method: Shortest route method
Baseline data: HTTS Survey 2000 - 2004
Modeled changes in Sulphur dioxide emission due to proposed inner and outer ring roads in Hyderabad by year 2020

Figure 720 Modeled sulfur dioxide emissions due to proposed inner and outer ring roads in Hyderabad by year 2020
Figure 7.21 Modeled sulfur dioxide emissions due to proposed inner and outer ring roads in Hyderabad by year 2020
Figure 7.22 Proposed and existing bridges over river Musi
Figure 7.23 Impact of bridges over river Musi on the pollution levels at Chaderghat during peak hours of the day
7.3.3. Impact of grade separators on pollution potential:
There are situations where even signalized intersections fail because of excessive queue lengths building up on all arms. In this situation choice of solution is limited to bypassing the traffic on one or more directions by grade separation. Typically this situation occurs when the total traffic volume of all the arms of the intersection is in excess of 10,000 vehicles per hour.
Some areas in Hyderabad are so severely congested that no further improvement is possible without proper at grade – traffic management measures. The benefits include 1) uninterrupted access and benefits traffic and emergency vehicles 2) Higher capacity for current and future travel demand 3) Reduced traffic congestions and delays 4) Lower maintenance and liability costs compared to signalized intersections.
The major intersections requiring grade separations in Hyderabad is shown in figure 7.24, some of the important places include 1) Ameerpet 2) Punjagutta 3) M.J. Market and 4) Green lands. A modeling study is carried out to analyze the benefits of implementing low clearance grade separations at different intersections in Hyderabad. Separate base map network model were built for a peak hour and average daily conditions. Then different, intersections were modified by inserting grade separations. The results enabled comparisons of networks with and without grade separations. The analysis of the grade separations was using the integration traffic simulation model.
The total network length studied varied from intersection to intersection with average being 1km road length. The recommended grade separations were given based on the average vehicle occupancy and pollution load. Based on these assumptions and values, the results provided a lower bound estimate for the expected savings in terms of pollution load. It is concluded from the study that the intersections with heavily loaded conflicting directions are a major source of pollution, congestion. Grade separation not only help in reducing pollution directly they also help indirectly in reducing the peak time traffic congestion amounting to nearly 20% during peak periods.

7.3.4. Intersection geometry improvements:
One of the major contributors for reducing the efficiency of free flow of traffic is the performance of intersections. This is an area of immediate intervention that can be implemented with marginal investments and where improvement in the performance can be felt. Hyderabad has about 386 intersections, out of which 224 are manned and 162 unmanned. There are a large number of staggered junctions, which are difficult
treat. It is observed that several intersections in the city do not have channelizers to
direct merging, crossing and diverging flows into specific channels. Figure 7.25
shows the major manned and unmanned junctions in Hyderabad requiring proper
geometry improvements.

At these locations considerable delays are occurring due to in disciplined behavior of
2-wheeler and 3-wheeler traffic not obeying the yield principle. Since junction
improvement is a constant process, and also since loading on intersection depend to a
great extent on the land use along the corridor, it would be difficult to pin point those
intersections, which would require improvement in the coming years. However based
on the available intersection flow information and the observed delays about 50
intersections have been identified that need immediate attention.

7.3.5. Development of parallel roads:
There are situations when alternative roads have to be developed to reduce the load on
overburdened links. Finding space for such development is difficult in densely built
up areas of the Urban Area. Only possible open areas for such purpose can be created
from the vacant space along the river Musi and the Railway Track. Such a plan will
have dual benefits of providing alternate routes and also help in non-encroachment of
important lands. For example for reaching ESI from Masabtank the traffic can be
diverted via Time of India office – Srinagar Colony road, which will reduce the
pollution by nearly 12% and reduce the two wheelers numbers during peak period and
consequent traffic congestion. It is observed that by developing such strategy the
pollution load at Punjagutta can be reduced by 12%.

7.3.6. MMTS implementation barriers:
Table 7.10 shows the patronage of buses over the years in Hyderabad. It can be
observed from table 6.4 that the vehicular occupancy of buses has remained stable
over the years though with the increasing population. The important reason attributed
for this could be deteriorating service especially in the peak hours and a concomitant
proliferation of seven seated Para transit modes providing convenient accessibility.
Figure 7.26 and 7.27 shows the MMTS transportation system implemented in
Hyderabad.
Place where grade separations need to be implemented to reduce pollution during peak times of the day.

Figure 7.24 Places where grade separations need to be implemented to reduce pollution during peak hours of the day.
List of Intersections which need to be improved under Hyderabad Urban Development Authority

Figure 7.25 List of major intersections which need to be improved under Hyderabad urban Development Authority
While improvements to road network can ease traffic flow, an alternate rail based public transport system carrying substantial load of commuting would drastically reduce the traffic load on the road network or at least mop up incremental increase in the travel demand in coming years. Active synergy between road and rail can deliver best possible solution at the least possible cost to the commuter and the society at large. To this purpose it is proposed to link all the MRTS stations with proper and good approach roads enabling buses and other vehicles to reach them. 26 stations are being upgraded for the purpose including 10 new stations to improve the catchments area.

However, the MMTS patronage is being slowly increasing over the period. It will take few years to have stabilized passenger owing to initial limitations such as vehicular parking places, train timings and improper guidance to general public about the train timings. However the major obstacle being that the system has been implemented at places where the accessibility to main bus bays being a major problem. The incorporation of shuttle services from MMTS stations to main bus bays or use of Bus Rapid Transit systems will ease the pressure on the traffic in Hyderabad. However, such implementations require a floor space of nearly 2000 - 7000 ft, which needs coordinated traffic engineering and transit service planning (TCRP Report 90 (2004)).

Figure 7.27 MMTS Train and Bus Rapid Transit
7.3.8 Promotion of cleaner fuels:

Energy consumption by transport sector has increased to an abnormal extent in recent years. The reason for such phenomenon increase is the increase in automobile population and other modes of transportation. As a result the rate of growth of energy consumption in the last three decades in Hyderabad has been faster than the rate of growth of economy as a whole. For the purpose of analyzing the environmental pollution caused by transport sector in Hyderabad, the author has gathered information regarding the growth of the use of vehicles in Hyderabad city, the total sale of inflammable oil (both petrol and diesel) and level of traffic density. The sale of petrol and diesel in Hyderabad data collected from three major distributor’s viz. Indian Oil Corporation, Hindustan Petrochemical Corporation Limited, Bharat Petrochemical Corporation Limited, for the period of 16 years.

7.3.8.1. Oil consumption and its Environmental impacts:

The data collected from the dealers of oil shows that, there has been a consistent increase in the sale of oil in Hyderabad city. Figure 7.28 shows the level of oil consumption in Hyderabad city for the last three years. The analysis of environmental pollution caused by automobiles is concerned, calculation of various emissions like particulates, hydrocarbons, carbon monoxide, sulphur dioxide and nitrogen oxide has been made on the basis of the emission standards fixed for various types of vehicles using petrol and diesel and for various kinds of emissions. For the present analysis, only the average emission standard for all types of petrol and diesel vehicles (average emission unit for petrol vehicles and average emission unit for diesel vehicles) have been taken into account since the oil consumption for each category of vehicle was not available.

7.3.8.2. Conversion of existing vehicular fleet to CNG and LPG

The present day bus fleet in Hyderabad is around 2605 with occupancy of around 59%. The total trip length of all the buses for day comes to around 703350 km/day. The average fuel consumption for each Bus in Hyderabad is around 5.5 km/liter. Table 7.15 shows the pollution load generated from the bus fleet for day in Hyderabad. The CNG conversion for conventional high purity diesel driven buses is 1.5 lakh for each bus the total expenditure comes to around 3908 lakh.

It can be recalled that the use of LPG as an automotive fuel has become legal in India, with effect from April 24, 2000, albeit with the prescribed safety terms and conditions. As far as safety of the gas is considered, unlike CNG which is pressurized
The infrastructure necessary for the establishment of a CNG-based transportation system includes "a local reserve of gas is clearly the first requirement, both because the expense of transport internationally is likely to make it uneconomic and because that increases the probability of securing a substantial balance of payments advantage by its exploitation. More important than large gas reserves is the availability of a city gas distribution network" The time required to load 70 kg of CNG is approximately 15 minutes vs. less than 2 minutes for an equivalent amount of diesel. Whilst CNG filling stations are considerably more expensive than diesel pumps and tanks, the investment required is multiplied by this difference in filling time. This was not taken into account in the CNG program and hence they lack sufficient filling capacity. A depot with 130 buses would require 3 or 4 CNG compressors, which is an expensive proposition. For reducing the pollution load by bus fleet in Hyderabad by 30% nearly 20 CNG filling stations need to be established at different bus depots in Hyderabad.

The overall operating cost of a diesel Euro II bus is Rs 34.72/km whilst the overall operating cost of a CNG bus is Rs 37.86/km. The principal difference lies in component costs. An imported CNG piston costs around Rs 5000 whilst 6 nationally sourced diesel pistons can be purchased for the same amount.
7.3.9. Isolated traffic signals:
While channelization of intersections reduces the conflict area, they function only when the flows are low in nature and allow sufficient gaps for crossing flows to accept them. These gaps decrease as the volume of flows increase thereby necessitating physical stoppage of one of the conflicting flows to facilitate movement of the other.

7.3.10. Bus bays and pedestrian crossings:
Frequent weaving movements of buses in busy corridors have a significant effect on the speed of traffic. Further, stopping buses in the face of traffic at bus stops tends to block the traffic moving on the left lane. Since most of the roads in the city are four lanes with an un-mountable central divider, the problem traffic blockade becomes even more acute on such occasions. Figure 7.31 shows the major bus stoppage points in Hyderabad and recommendations for changed locations. It is observed that major bus bays at locations such as Masabtank, Sadan College, Lakdika Pool towards Koti at Dwaraka Hotel, Chaderghat stop do not have proper bus bays, the proper identification for provision of convenient stoppages for buses without inconveniencing the traffic following will be a major factor in facilitating transport problems.
List of Bus bays which need to be relocated for the free flow of traffic under Hyderabad Urban Development Authority

Figure 7.31 List of Bus bays which need to be relocated for the free flow of traffic under Hyderabad Urban Development Authority
7.3.11. Parking management in Hyderabad:

Hyderabad, like other cities is confronted with a downtown-parking problem. This problem is aggravated by excessive population densities, large number of pavement hawkers, side walk encroachments and heterogeneous nature of traffic and commercial area development along all the major roads. On street parking surveys conducted during the year 1998-99 have indicated that in 500 m of kerb space in Abids shopping area, about 2500 cars are parked during business hours. Average parking duration is between 100 to 120 minutes. As such it is proposed to demarcate parking stalls and design the parking fee structure to improve parking turnover.

A proper parking policy which looks at users-pay principle is imperative. Off street parking complexes for private vehicles at 22 important nodal points in the city are required to ease traffic congestion by releasing precious carriage way. Besides there is urgent need to stream line the para-transit vehicles at major trip attraction centers by provision of suitably designed para-transit hubs. As many as 23 locations have been identified to implement this scheme (Chary & Reddy.2003) Similarly there is a need for providing parking spaces for private bus operators. 10 such locations, on all major arterial roads are identified for this purpose.

7.3.12. Rescheduling of work activities:

Rescheduling of work activities will allow the sudden increments of traffic on roads, for example it has been observed that at many places in Hyderabad the closure of schools and the end of cinema shows coincides releasing more traffic to the roads causing traffic congestions. The extent of road congestion during the periods depends on the length of the road, intersection dimensions and the average speed on the roadways i.e road capacity. Model has been developed in to study the areas where rescheduling of work is needed under HUDA limits.

Figure 7.32 shows the areas where rescheduling of work activities is needed for reducing the traffic and pollution potential. The relative rescheduling factor is identified using the unity of road length, number of educational centers and cinema theaters around 1km² areas. Rescheduling the work activities at places such as Nampally, Abids and Narayanaguda, RTC X Roads, and Secunderabad paradise area will be highly useful to reduce the unnecessary traffic congestions.
Areas where work rescheduling is needed to reduce traffic pollution under
Hyderabad Urban Development Authority

Figure 7.32 areas where work rescheduling is needed to reduce traffic pollution under
Hyderabad Urban Development Authority
7.3.13. Fuel Adulteration:
Fuel adulteration is an important issue, but one that is extremely difficult to quantify since adulteration by definition is a covert operation and as a result little hard data is available. There are several types of adulteration for automotive fuels: 1) Blending large amounts of hydrocarbon-based industrial solvents into gasoline 2) Blending small amounts of distillate fuels such as diesel and kerosene into gasoline. 3) Blending large amounts of kerosene into diesel 4) Blending small amounts of heavier fuel oils into diesel 5) Blending small amounts of waste products such as lubricants into diesel as means of disposal.

When gasoline is adulterated with kerosene or diesel, higher emissions of HC, CO and articulates result, because these fuels are more difficult to burn. The higher sulphur levels in kerosene can also deactivate the vehicles catalytic converter. If too much kerosene is added, engine "knock" can result which also increases NOx emissions, which is a precursor for secondary particulate and ozone formation.

If gasoline is adulterated with low-tax gasoline-boiling-range solvents such as toluene or xylenes, or other light materials such as pentanes and hexanes, it can be very difficult to detect and the vehicle’s drivability may not deteriorate. Large amounts, however, can increase HC, CO and NOx emissions from the vehicles exhaust. Adulterants that contain halogens, phosphorous or metallic elements completely outside the range of normal gasoline can provoke costly internal damage to the engine components such as valves and valve seats, fuel injectors, spark plugs, catalytic converters and oxygen sensors. Naphtha which is a feedstock for chemicals production is finding its way into fuel as an adulterant for gasoline, as is kerosene and “other solvents". Even white spirit was mentioned in the context of 2-stroke, three-wheelers.

Both diesel and kerosene added to gasoline will increase engine deposit formation including in fuel injectors, potentially leading to increased emissions. In the short term, however, kerosene added to gasoline will reduce CO emissions (in the low idle PUC test) but causes white smoke. For gasoline, any additive that changes its volatility can affect drivability and emissions. Adding too much oil to the fuel of 2-stroke engines and using reclaimed or other unsuitable oil is a major problem wherever premixed 2T fuel is not available. The adulteration of diesel with kerosene does not increase engine emissions but for low sulphur diesel, it could cause the
sulphur level to exceed the specification, increasing sulphate-based particulate emissions.

7.3.14. Computerized area traffic control systems:
In areas where traffic signals are close together, the co-ordination of adjacent signals is important and gives great benefits to road users. Linking traffic signals along a single route so that vehicles get a green signal at each junction in turn is relatively simple. Coordinating signals over a network of conflicting routes is much more difficult. Computer techniques have been developed to calculate optimum signal settings for a signal network such as vehicle Actuation, SCOOT, UTM, SVD, and CLF are probably the best known options for controlling the traffic in real time.

A purpose built computer system with suitable software can provide continual second by second monitoring, and control if required, of traffic signals over a wide area. In addition, the system sends out control messages to cause the signals to change to a particular traffic sequence, or stage, and remain on that stage for an appropriate length of time. The particular stage and its running time is based either upon fixed Time plan data, or on real-time traffic information under SCOOT control. The overall purpose of such systems is to manage traffic flow efficiently.

As a preliminary basis the major traffic junctions where the traffic has been exceeding one lakh the utility of fixed time plan may be implemented. Each junction within an area should be run to a common cycle time and each traffic stage at each junction should begin at a set point in each cycle, this should be allowed each junction to be offset from the next to provide coordination between junctions for the main peak traffic flow.

Fixed time plans are developed from traffic count information and split up the time within each cycle between the various traffic stages. Main road stages generally receive the majority of available time. A disadvantage of FT plans is that they have to start early enough to cater for the build up of the peak periods and continue until the peak dies down. However, they are only really efficient during the busiest part of the peak period at which point, time is divided up appropriately. Early in the peak, the main road may not require quite as much green time as it is being given and, consequently, any vehicles turning up on the side roads must await their turn. Additionally, as traffic flow changes over time, new counts must be performed, in theory every two years, and new FT plans developed.
Similar to the concept of online air pollution monitoring and data dissemination using Internet by incorporating the CCTV based traffic control cameras the efficiency of the transportation system may be assessed to make any necessary changes quickly. Also, during unusual circumstances such as a traffic accident, a significant breakdown on a busy road, or events, the system operators can take control of signals and operate them manually from the control centre. This would be impossible without the help of the cameras.

7.4. CONCLUSIONS:

Hyderabad City is experiencing rapid growth and transportation issues have assumed critical importance. Various development plans focused mainly on land use deployment and only a residual component of land assigned to roads to address transportation issues. Only an integrated and sustained programmes that combines transportation planning with land use in the longer term will able to address this issue comprehensively.

Present trend indicates that while rapid development is taking place along the transportation corridors in the form of ribbon development, considerable amount of growth is taking in the form of gradual increase in the interior areas of the municipalities and other areas of urban agglomeration making transportation options difficult to implement.

Simulation studies carried in the present thesis work will help the planners and transportation engineers and environmentalists in providing the environmental pollution burden and the means by which each proposed alternative affects. The author has carried out the work assuming economy based on environmental pollution burden only and a strong financial operation plan is required for making this exercise into a sustained and coordinated campaign for improvement of transportation situation in Hyderabad.
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