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KARNATAKA URBAN INFRASTRUCTURE DEVELOPMENT AND FINANCE CORPORATION

COMPREHENSIVE TRAFFIC AND TRANSPORTATION PLAN FOR BANGALORE

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RITES Ltd
(A Government of India Enterprise)

Comprehensive Traffic and Transportation Plan for Bangalore

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LIST OF ABBREVIATIONS

AMP	Automated Mechanical Parking
ATC	Area Traffic Control
BBMP	Bruhat Bangalore Mahanagara Palike
BDA	Bangalore Development Authority
BIAPPA	Bangalore International Airport Planning Authority
BMA	Bangalore Metropolitan Area
BMICAPA	Bangalore Mysore Infrastructure Corridor Area Planning Authority
BMRCL	Bangalore Metro Rail Corporation Limited
BMRDA	Bangalore Metropolitan Region Development Authority
BMTC	Bangalore Metropolitan Transport Corporation
BRTS	Bus Rapid Transit System
B-TRAC	Bangalore Traffic Regulation and Control
CBD	Central Business District
CMP	Conventional Multi-storey Parking
CRR	Core Ring Road
CRS	Commuter Rail System
GPS	Geographical Positioning System
HCV	Heavy Commercial Vehicle
IFC	Integrated Freight Complex
ITS	Intelligent Transport System
IVRS	Interactive Voice Recording System
KSPCB	Karnataka State Pollution Control Board
KSRTC	Karnataka State Road Transport Corporation
KUIDFC	Karnataka Urban Infrastructure Development and Finance Corporation
LCV	Light Commercial Vehicle
MCV	Medium Commercial Vehicle
NHAI	National Highways Authority of India
NICE	Nandi Infrastructure Corridor Enterprise
ORR	Outer Ring Road
PCU	Passenger Car Unit
PHPDT	Peak Hour Peak Direction Traffic
PIS	Passenger Information System
PRR	Peripheral Ring Road
ROB	Road over Bridge
RUB	Road under Bridge
T&CP	Town & Country Planning
TTMC	Traffic &Transit Management System
VMS	Variable Messaging Signs

CHAPTER – 1

INTRODUCTION

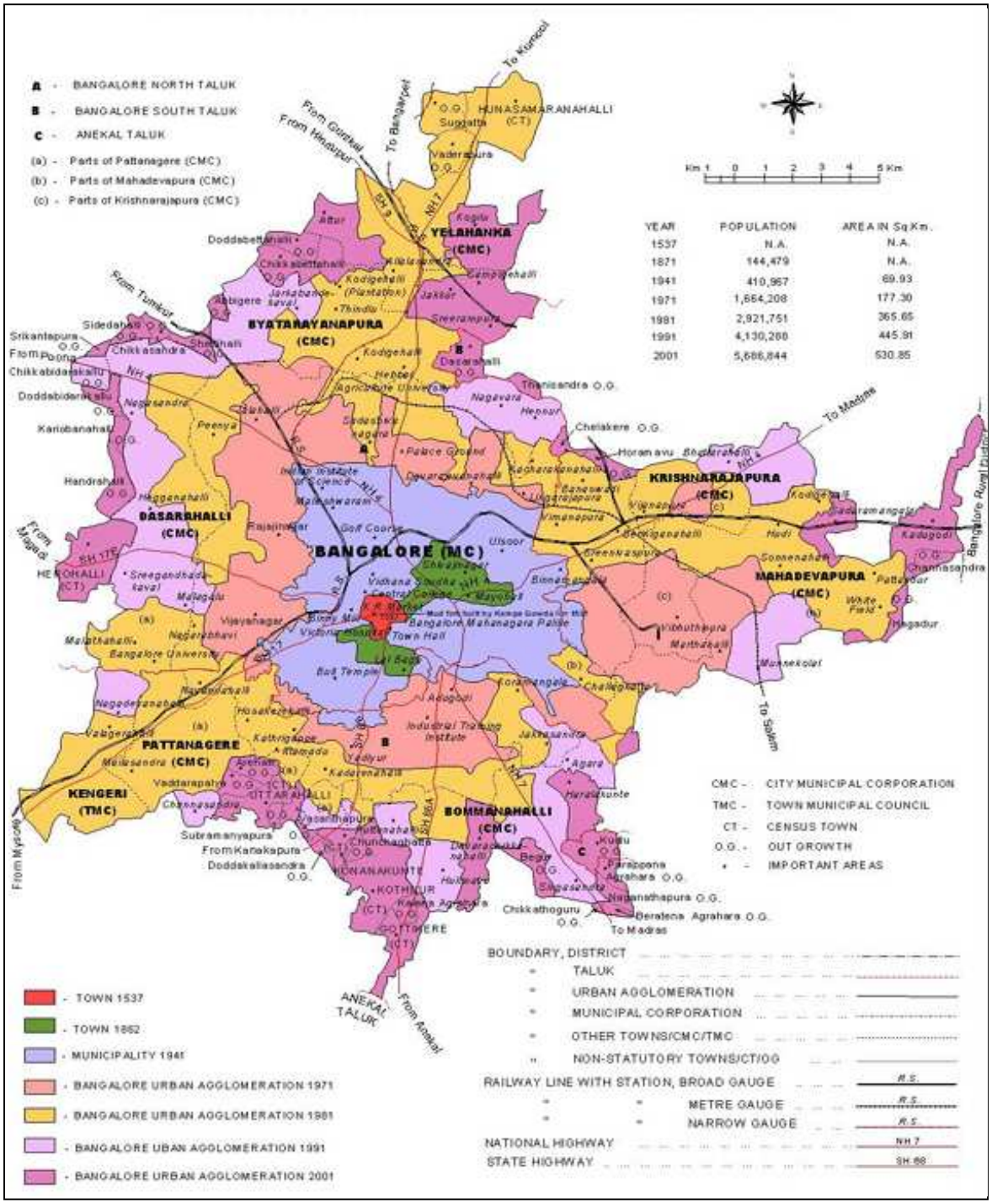
1.1 GENERAL BACKGROUND

1.1.1 Bangalore is the fifth largest metropolis (6.5 m in 2004) in India and is one of the fastest growing cities in Asia. It is also the capital of State of Karnataka. The name Bangalore is an anglicised version of the city's name in the Kannada language, Bengaluru. It is globally recognized as IT capital of India and also as a well developed industrial city.

1.1.2 Bangalore city was built in 1537 by Kempegowda. During the British Raj, Bangalore developed as a centre for colonial rule in South India. The establishment of the Bangalore Cantonment brought in large numbers of migrant Tamil Nadu and Andhra Pradesh and North Indian workers for developing and maintaining the infrastructure of the cantonment. New extensions were added to the old town by creating Chamarajpet, Seshadripuram, Nagasandra, Yediyur, Basavanagudi, Malleswaram, Kalasipalyam and Gandhinagar upto 1931. During the post independence period Kumara Park and Jayanagar came into existence. The cantonment area covers nearly dozen revenue villages, which included Binnamangala, Domlur, Neelasandra and Ulsoor to name a few. In 1960, at Binnamangala, new extension named Indiranagar was created. The defence establishments and residential complexes are in part of the core area. It is a radial pattern city growing in all directions. The Bangalore city which was 28.85 sq. Km. in 1901 increased to 174.7 sqkm in 1971 to 272 sqkm in 1986 and presently it has expanded to nearly 437 sqkm. **Figure 1.1** shows the physical growth of Bangalore during the last five centuries. This indicates that the city has a long history and the transport system has grown organically with its inherent problems to meet the requirements of changing times.

1.1.3 The city which was originally developed as a Garden City has slowly transformed into an industrial and software hub of India. The establishment of the Silicon Park on the outskirts of the city has converted the city and its surroundings into Silicon Valley of the country. It has also caused an urban sprawl around, to some extent lop sided towards south and east. It has become a commercial, administrative and military centre for the region because of its salubrious climate and cosmopolitan nature of people. It is also known as pensioner's paradise with well developed residential areas, roads with well grown trees, good commercial establishments, shopping malls etc. Despite such growth it is trying to maintain its character of garden city.

Figure 1.1 Physical Growth of Bangalore during the Last Five Centuries



1.2 PHYSICAL CHARACTERISTICS

1.2.1 Bangalore is located in the south east of Karnataka. It is located in the heart of the Mysore Plateau at an average elevation of 920 m (3,018 feet) above mean sea level. It is positioned at 12.97° N 77.56° E. Bangalore District borders with Kolar District in the northeast, Tumkur District in the northwest, Mandya District in the southwest, Chamarajanagar District in the south and the neighbouring state of Tamil Nadu in the southeast.

1.2.2 The topography of Bangalore can be classified as a plateau, with a central ridge running NNE–SSW and land sloping gently on either side and longitudinally. The highest point is Doddabettahalli, which is 962 m and lies on this ridge. The roads generally have gentle to medium gradients. No major rivers run through the city, but the Arkavathi and South Pennar cross paths at the Nandi Hills, 60 km to the north. River Vrishabhavathi, a minor tributary of Arkavathi, originates within the city at Basavanagudi and flows through the city. Bangalore has a number of fresh water lakes and water tanks, the largest of which are Madiwala Tank, Hebbal Lake, Ulsoor Lake and Sankey Tank. The soil is predominantly of red soil interspersed with rock helping quicker drainage.

1.2.3 Due to its elevation, Bangalore enjoys a pleasant and equable climate throughout the year. The highest temperature recorded is 41°C and the lowest is 7.8°C. Winter temperatures rarely drop below 12°C and summer temperatures seldom exceed 38°C. Monsoons commence sometime around mid April. The wettest months are August, September and October, in that order. The summer heat is moderated by fairly frequent thunderstorms. Bangalore, receives both incoming and outgoing monsoons because of its geographic location. The city receives rainfall of about 860mm from the North-East and South-West monsoons.

1.3 DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS

1.3.1 Population of Bangalore has been growing @ over 3% per annum since independence as shown in **Table 1.1**. The city, which had a population of 1.6 lakh in 1901 reached nearly 61 lakh in 2001. With a decadal growth rate of 49%, Bangalore was one of the fastest-growing indian metropolis for the decade 1991-2001. It has an average density of about147.97 people/hectare. Currently the Bangalore Metropolitan Area (BMA) is estimated to have population of about 70 lakh and is expected to be 80 lakh by 2011 and 88.40 lakh by 2015 as per Master Plan, 2015. By 2025, population of BMA is expected to be 122.52 lakh as indicated in **Table 1.1**.

Table 1.1 Growth of Population in Bangalore

YEAR	Population (lakh)	Decadal Growth (%)	Annual Growth
1901	1.63	-9.58	-1.00%
1911	1.89	16.18	1.51%
1921	2.40	26.69	2.39%
1931	3.10	29.05	2.58%
1941	4.11	32.66	2.87%
1951	7.86	91.34	6.70%
1961	12.07	53.49	4.38%
1971	16.64	37.88	3.26%
1981	29.22	75.56	5.79%
1991	41.30	41.36	3.52%
2001	61.70*	49.39	4.10%
2011	80.15*	29.90	2.65%
2015	88.00*		
2025	122.52**		3.07%

(* -Revised Master Plan, 2015 for BMA, ** -projected for BMA)

1.3.2 Bangalore has the second highest literacy rate (83%) for an Indian metropolis, after Mumbai. The city's workforce structure is predominantly non-agrarian, with only 6% of Bangalore's workforce being engaged in agriculture-related activities. Roughly 10% of Bangalore's population lives in slums - a relatively low proportion when compared to other cities in the developing world.

1.3.3 Bangalore's Rs. 26000 crore economy makes it a major economic centre in India. Indeed, Bangalore is India's fourth largest and fastest growing market. Bangalore's per capita income of Rs.49,000 is one of the highest for any Indian city. The city is the third largest hub for high net worth individuals after Mumbai and Delhi.

1.3.4 In the 1940s industrial visionaries such as Sir Mirza Ismail and Sir Mokshagundam Visvesvaraya played an important role in the development of Bangalore's strong manufacturing and industrial base. Bangalore is headquarters to several public manufacturing heavy industries such as Hindustan Aeronautics Limited (HAL), National Aerospace Laboratories (NAL), Bharat Heavy Electricals Limited (BHEL), Bharat Electronics Limited, Bharat Earth Movers Limited (BEML) and Hindustan Machine Tools (HMT). In 1972 the Indian Space Research Organisation (ISRO) was established under the Department of Space and headquartered in the city. Globalisation has seen the city's potential to grow as an IT capital of the country so much so that foreign visitors to the country including many Heads of Governments make it appoint to visit the city during their visit to the country. Bangalore is also called the "Silicon Valley of India" because of the large number of Information Technology companies located in the

city which contribute 38% of India's IT and software export market. As headquarters to many IT companies, Bangalore's place in the global IT map is prominent. Bangalore's IT industry is divided into three main clusters — Software Technology Parks of India, Bangalore (STPI); International Technology Park Bangalore (ITPB), formerly International Technology Park Ltd. (ITPL); and Electronics City. Infosys and Wipro, India's largest software companies, have big campuses in Electronics City. If the growth of Information Technology has presented the city with unique challenges, Biotechnology has now become another rapidly expanding field in the city. Bangalore accounts for 47% or 127 of the approximately 265 biotechnology companies in India. The Bangalore Stock Exchange is the largest in South India. **Figure 1.2** shows the major activity centres along with the transport network in Bangalore.

1.3.5 With the growth of population and industries, the number of educational institutions has also grown up in the city and BMA. Numerous educational institutions up to High School and Colleges have come up in almost all the developing residential localities and extensions. Most of the institutions for higher learning like engineering colleges and medical colleges are located on the outskirts of Bangalore Corporation area. There are a few institutions of higher learning and special requirements like Government Educational Institutions are spread all over the city. Bangalore also has internationally acclaimed educational institutions like Indian Institute of Management (IIM), National Law College (NLC) and Indian Institute of Science (IISc).

1.3.6 In the planned growth over the last 2 decades, the primary and secondary educational institutions have been provided in each of the residential locality and to this extent the educational requirement of the younger people is satisfied by and large locally. It is for the higher and selective learning, that the people have to make longer trips requiring vehicular journeys.

1.4 TRANSPORT NETWORK

1.4.1 Road Network Characteristics

Bangalore is endowed with a radial pattern of road network converging in the core area of the city. The total road network of the city is about 4000 km of which arterial/sub-arterial roads account for about 350 km. The road network is shown in **Figure 1.2**. The road network in the central parts of the city has developed organically over the last few centuries and has inadequate right-of-way. There is also a ring road (Outer Ring Road of about 62 km) which cuts across the various radial roads. An intermediate ring road has been constructed in fragments e.g. at south-east between Koramangala and Airport Road. The National Highways which pass through Bangalore include:

Figure 1.2 Major Activity Centres along with the Transport Network in Bangalore

- NH – 4 connecting to Pune and Chennai
- NH – 7 connecting to Varanasi and Capecamorin
- NH – 209 connecting Dindigul / Pollachi

The following are the State Highways in Bangalore:

- SH – 17 connecting Mysore & Gundlupet
- SH – 17E connecting T G Halli
- SH – 19 connecting Hindupur via Yelahanka and Doddaballapur
- SH – 86 connecting Mysore via Kanakapura

Mostly the road network is underdeveloped in terms of size, structure, continuity and connectivity. Nearly 82% of the total existing road network of 1763 km (taken for travel demand modeling purposes) is with 2-lane carriageway as shown in **Table 1.2**. Length of roads with carriageway of 4 lanes and above is only 290 km. The roads indicating carriageway widths are shown in **Figure 1.3**. Thus most of the roads have inadequate carriageway widths to cater to growing traffic at an acceptable level of service. Most of the roads in the city are also used for on-street parking facility which even reduces the effective carriageway width available for traffic. Most of the major roads in Bangalore have V/C ratios > 1.0 indicating high congestion, low speeds and high delays. The intersections are also spaced quite closely which further increases the problem of traffic. Many of the intersections in core area are with 5 legs. This adds to traffic delays.

Table 1.2 Distributions of Roads with Carriageway Widths in Bangalore

Type of Road	Length (Km)	%
Two Lane Undivided One Way	62.3	3.53
Two Lane Undivided Two Way	1379.2	78.21
Three Lane	31.6	1.79
Four Lane Undivided One Way	10.3	0.59
Four Lane Undivided Two Way	49.7	2.82
Four Lane Divided Two Way	198.5	11.25
Six Lane Divided	31.4	1.78
Six Lane Undivided One Way	0.5	0.03
Total	**1763.5**	**100.00**

The available right-of-way of major roads are generally inadequate to allow for their major widening as given in **Table 1.3**. This is a major issue in augmenting the capacity of transport system in Bangalore. This indicates public transport system will have to play a very major role in satisfying the mobility requirements of people of Bangalore as they are the most economic users of the road space.

Figure 1.3 Carriageway Widths of the Roads

Table 1.3 Distribution of Roads with available ROW in Bangalore

Road ROW (m)	Length of Major Roads (%)
Less than 20	40.7
20-30	40.0
More than 30	19.3
Total	**100.0**

1.4.2 Rail Network

Bangalore is served by 5 radial rail corridors (shown in **Figure 1.2**), which are listed below.

- B.G. line from Chennai on east
- B.G. line from Mumbai-Pune on north-west
- B.G. line from Guntakal on the north
- B.G. line from Salem / Trivandrum from east
- B.G. line from Mysore from south-west

Though at present these rail corridors serve only intercity traffic, a small number of conventional short distance passenger trains are run in morning and evening hours to nearby (satellite) towns like Tumkur, Chikballapur, Bangarapet, Hosur and Mandya to serve the commuters. Its layout is conducive to convert them as "Commuter Rail System" (CRS), to provide viable commuter services to suburbs and also some nodes in the Bangalore.

1.4.3 Airport

The Bangalore Airport located about 11 km from city centre towards the east of the city and adjacent to the Hidusthan Aircrafts Ltd (location of Airport in shown in **Figure 1.2**), was opened to passenger traffic in 1947. Direct flights from Bangalore fly to destinations in Asia, the Middle East and Europe. The liberalisation of India's economic policies has led to increase in the number of domestic carriers within India, with several carriers such as Indian, SpiceJet, Kingfisher Airlines, Jet Airways, Air Deccan, Paramount and Go Air servicing the city. Unlike most airports in the country which are controlled by the Airports Authority of India, the quasi government-owned Hindustan Aeronautics Limited owns and operates Bangalore's HAL Airport. This airport at present serves both domestic and international passengers. Due to its limited capacity and shorter runway, it has not been able to satisfy the growing demand for air traffic. A new international airport (catering to both domestic and international passengers) is being constructed at Devanahalli and is expected to become operational in early 2008. As part of its planning there are proposals to provide a dedicated rail line and an expressway connecting the city to the airport.

1.5 GROWTH OF MOTOR VEHICLES

1.5.1 Vehicle Growth and Composition

The vehicle population in all cities in India started growing rapidly since later part of 1980s. Bangalore is no exception. It has always had a reputation of having more two wheeler users. The liberalization policy of the country made availability of not only vehicles but also loans for buying vehicles. With the rapid growth of IT sector in Bangalore, the affordability of larger segment of employees increased for ownership of vehicles, more specially two wheelers. Coupled with inadequacy of comfortable and convenient public transport gave an impetus to more and more commuters shifting to cars and two wheelers for their commuting in Bangalore. Growth of motor vehicles is shown in **Table 1.4**. The number of registered motor vehicles has crossed 2.5 million and is growing at a rate of over 12% per annum. The two wheelers, which constitute about 72% of the total registered vehicles, are growing at a rate of about 13% per annum. Lately, cars have been growing even faster than two wheelers. Vehicle ownership has grown from 58 to 365 per 1000 population from 1981 to 2006. The trend is likely to continue. This will result in higher use of personalised modes of transport particularly cars unless extensive and convenient public transport system is provided.

Table 1.4 Growth of Motor Vehicles in Bangalore (in lakh)

Year	2-Wheelers	M/Cars	A/R, Cabs	Others	Total
1980	0.97	0.30	0.10	0.31	1.68
1985	1.89	0.47	0.11	0.30	2.77
1990	4.01	0.71	0.15	1.41	6.28
1995	5.94	1.07	0.34	0.62	7.97
1996	6.69	1.21	0.39	0.71	9.00
1997	7.58	1.38	0.47	0.80	10.23
1998	8.39	1.52	0.54	0.84	11.29
1999	9.10	1.64	0.55	0.94	12.23
2000	9.94	1.84	0.58	1.01	13.37
2001	10.92	2.07	0.62	1.12	14.73
2002	11.83	2.26	0.64	1.23	15.96
2003	13.23	2.53	0.69	1.37	17.83
2004	14.44	2.77	0.76	1.53	19.50
2005	16.71	3.51	0.81	1.69	22.72
2006	18.96	4.06	0.82	1.73	25.57

Source: Bangalore Traffic Police Web Site and RTO, Bangalore

1.5.2 Intermediate Public Transport

Autorickshaws (popularly known as autos) and taxis are the IPT facility available in Bangalore. Autos are the popular form of transport and can be called common man's taxi in Indian cities and towns. It is a hybrid three wheel, three-seater (in addition to driver) low floor vehicle, which is easily maneuverable and at the same time provides a fast service. Priced much lower than a car, majority of autos are owned by the driver himself. Apart from thee autos, regular small cars (Maruti Omni vans and Indica diesel cars) as taxis are provided by several operators commonly referred to as City Taxis or call Taxis. The number of autos and call taxis registered in Bangalore is about 82000 and they are growing at the rate of 5-6 % p.a. The autos are used more for education and other trips and to a large extent by the visitors to the city. The drivers tend to take advantage of the vehicle's size and maneuverability and criss cross in traffic contributing a lot to accidents and traffic indiscipline and delays to overall traffic flow.

1.5.3 Public Transportation System

Buses are the predominant public transport system in all Indian cities except Mumbai. While four other metropolises Mumbai, Kolkata, Chennai, Delhi and even Hyderabad have one or more forms of rail transport systems to cater to varying extents for commuters, Bangalore has only bus as its public transport system. The city has one of the better run city bus transport systems in the country. It is operated in the Public Sector by Bangalore Metropolitan Transport Corporation (BMTC), a wholly owned company of the State Government. BMTC at present operates services on 1726 routes by utilizing 4100 buses with 3953 schedules. BMTC has 24 depots in and around Bangalore city. The corporation has 18500 employees to man its operation. It has established state of the art commuter friendly modernized bus stations at Shivaji Nagar and Shanti Nagar. The Kempegowda bus station at Subhash Nagar is also modernized with improved commuter amenities. In addition to this, sub nodal stations at different parts of the city have been constructed for the benefits of commuters. The corporation is operating more than 60,000 trips and carrying about 35 lakh passengers every day. Its patronage has started having significant growth since 2002-03. In order to increase the frequency of services and to provide direction-oriented services in place of the present destination oriented services, 27 high density trunk corridors (grid routes) have been started. These grid routes have been shown in **Figure 1.4**. The progress of BMTC during the last few years is briefly given in the **Table 1.5** below.

Table 1.5 Operational statistics of Bangalore Metropolitan Transport Corporation

Sl. No.	Factor	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
1.	Operations	1924	1960	2017	2190	2253	2302	2581	3199	3531
2.	Schedules	1934	2030	2121	2376	2535	2932	3291	3827	3957
3.	Fleet	2098	2160	2285	2473	2658	3036	3460	3925	4106
4.	Daily Average Scheduled Km (in lakh)	4.43	4.44	4.86	5.15	5.77	6.19	7.18	9.02	9.33
5.	Routes	1036	1048	1063	1147	1212	1345	1523	1690	1726
6.	City Services	740	783	789	798	817	988	1029	1131	1102
7.	Suburban Services	925	983	1065	1282	1412	1647	1985	2382	2542
8.	Pushpak Services	269	264	267	296	306	297	287	314	313
9.	Passengers carried per day (in Lakh)	24.50	25.00	25.50	25.75	26.25	26.75	30.35	32.07	34.78
10.	Accidents per Lakh Km	0.32	0.29	0.26	0.26	0.22	0.22	0.23	0.18	0.16

Source: BMTC

BMTC has plans to add new fleet through inducting new types of buses. It also has plans of adding new depots, new bus stations, commuter amenity centres, bus shelters, GPS system etc.

1.6 THE BANGALORE METROPOLITAN REGION :

1.6.1 The Bangalore Metropolitan Region Development Authority (BMRDA) has been given the responsibility of planning the 8,000 sq km of Bangalore Metropolitan Region (BMR) consisting of 2191 sq km in the Urban Districts and 5814 sq km in the Rural Districts. The planning areas falling in the BMR are indicated in the **Figure 1.5** and **Table 1.6.**

Figure 1.4 Grid Routes of BMTC

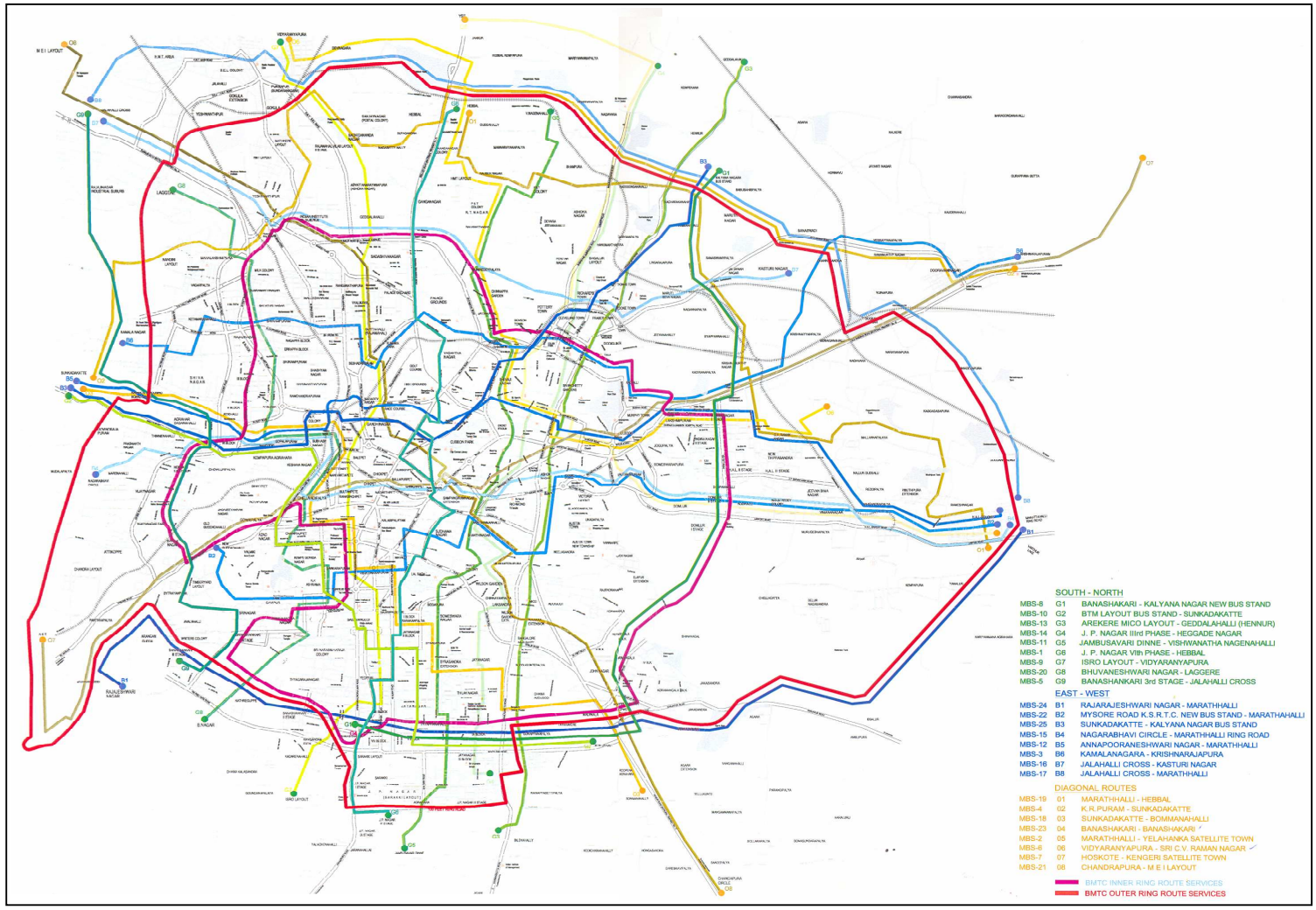


Table 1.6 Bangalore Metropolitan Region

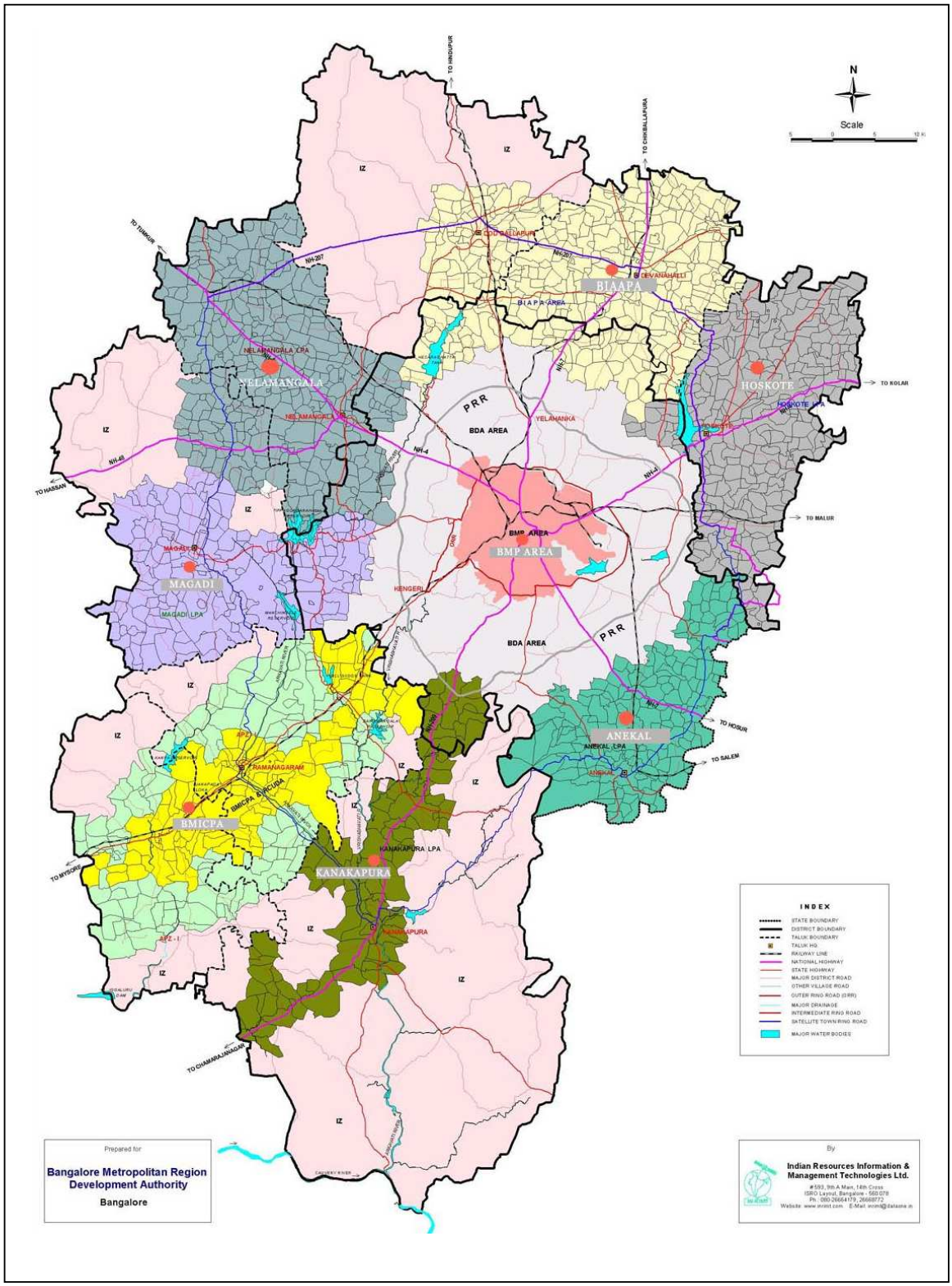
Sl. No.	Area		Area Sq. Kms
1	B M A		1240.69
2	BMICAPA (within BMA)	65.31	
3	BMICAPA (outside BMA but within BMR)	338.74	404.05
4	Ramanagaram Taluk		200.25
5	Channapatna Taluk		110.60
6	Bangalore South Taluk		27.89
7	Anekal LPA		406.00
8	Nelamangala LPA		750.00
9	Magadi LPA		501.00
10	Hoskote LPA		591.00
11	Kanakapura LPA		879.00
12	BIAAPA LPA		985.00
13	RCUDA LPA		62.50
14	APZ-1 (excl. RCUDA)		462.50
15	Industrial Zones in B.M.R		1723.26
	Total		**8005.00**

1.6.2 The regional plan while emphasizing on development of a regional transport network is also under taking the planning and development of 5 new township at Bidadi, Ramanagaram, Solur, Sathanur & Nandagudi covering a total area of 61,000 hectares on the outskirts of BMA. These townships are proposed to create the modern work and play environment in urban settlements within the areas as per **Table 1.7**.

Table 1.7 BMRDA TOWNSHIPS AREAS (Acres)

Township	Pvt. Land	Govt. Land	Total
Bidadi	6959	2725	9684
Ramnagar	3621	392	4013
Sathanur	5891	10341	16232
Solur	9661	2864	12525
Nandagudi	13762	4745	18507
Total	**39894**	**21067**	**60961**

Figure 1.5 Bangalore Metropolitan Region – Local Planning Areas



1.6.3 The following road network proposed by the BMRDA within the BMR consists of:

1)	Satellite Town Ring Road	-	204 km
2)	Intermediate Town Ring Road	-	130 km
3)	Radial Roads	-	180 km
4)	Town Ring roads	-	176 km

1.7 URBAN LAND USE STRUCTURE FOR BMA

1.7.1 Existing Situation

Bangalore city has spatially developed in a concentric manner. The economic activities have been growing at an unprecedented pace locating themselves in a sporadic manner with limited plan intervention covering an area of 1307 Sq. Kms. The existing landuse distribution of the BMA for 2003 & its comparison with the proposed Land use as per Revised Master Plan 2015 is given in the **Table 1.8**. The spatial distribution of existing land use is shown in **Figure 1.6**.

1.7.2 Revised Master Plan - 2015

Bangalore Development Authority (BDA) is responsible for preparing Master Plan for the BMA and guiding its development. Salient features of the Revised Master Plan-2015 are as follows:

a. Local planning area(LPA) or Bangalore Metropolitan Area (BMA) - 1307 sqkm (including BMICAPA area)
b. The city has to be planned for a population of 80 lakh by 2011 and 88 lakh by 2015.
c. Land Use Proposals: Keeping in view the rapid socio-economic development in Banglore and the development patterns in the BMR, the Master plan has evolved the following proposed land use for the Banglore Metropolitan Area as indicated in **Table 1.8** and **Figure 1.7**.
d. Economic activities & their spatial distribution: During the year 2003 approx. 6,30,000 Sq. Mts of office space was sold which consisted 5,00,000 Sq. Mts for suburban Hi-Tech firms and the balance 150,000 Sq. Mts for other businesses. For the year 2015 the Plan envisages following requirement of office spaces:

	Area in Sq. Mts		
Office Type	**Suburb**	**CBA**	**Total**
High-Tech	6,71,006	813,293	1484299
Non- High-Tech	234,093	585,394	819,487
Total	905,009	1,398,687	2,303,786

Figure 1.6 Spatial Distribution of Existing Land Use

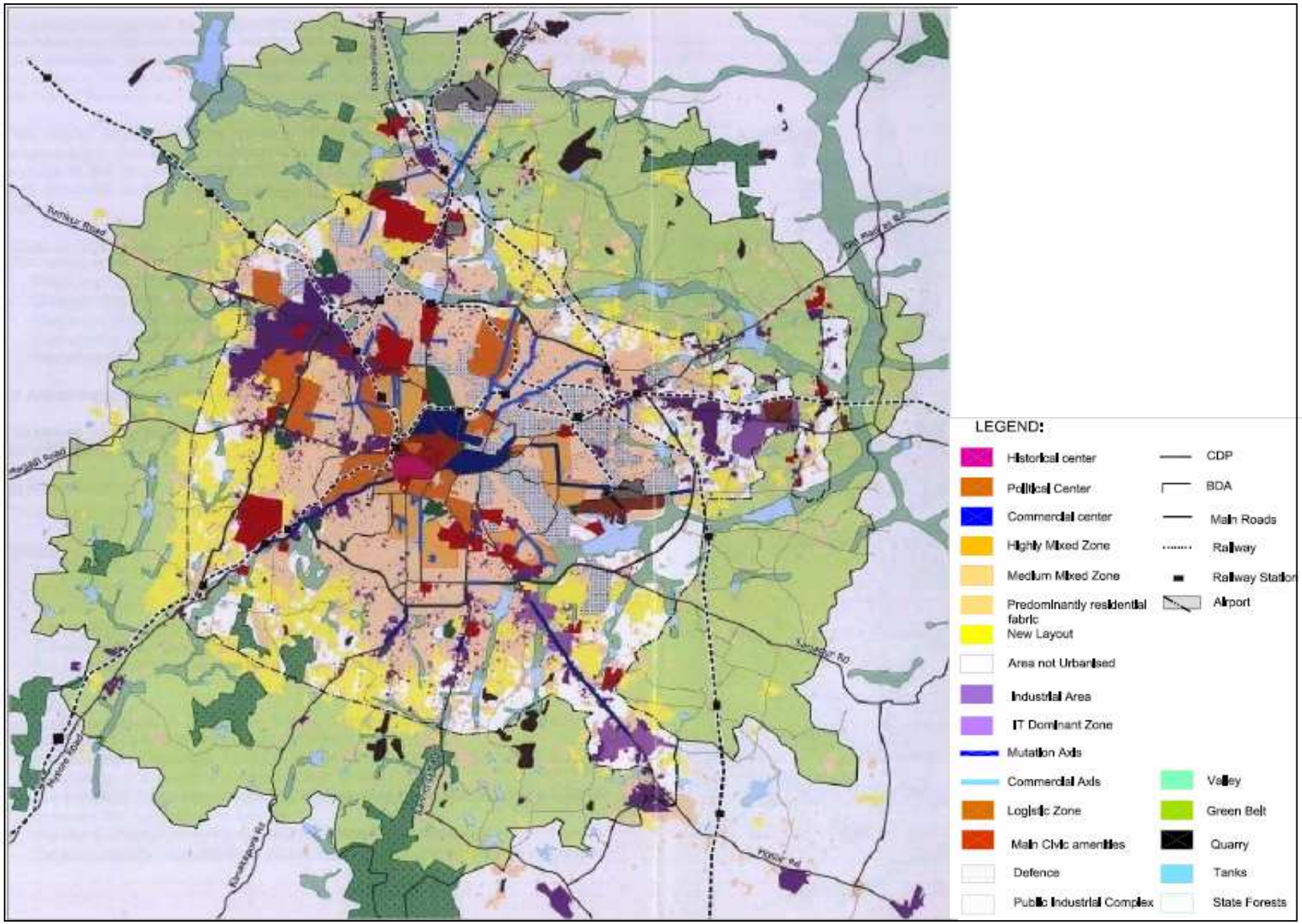


Figure 1.7 Proposed Land Use for the Bangalore Metropolitan Area

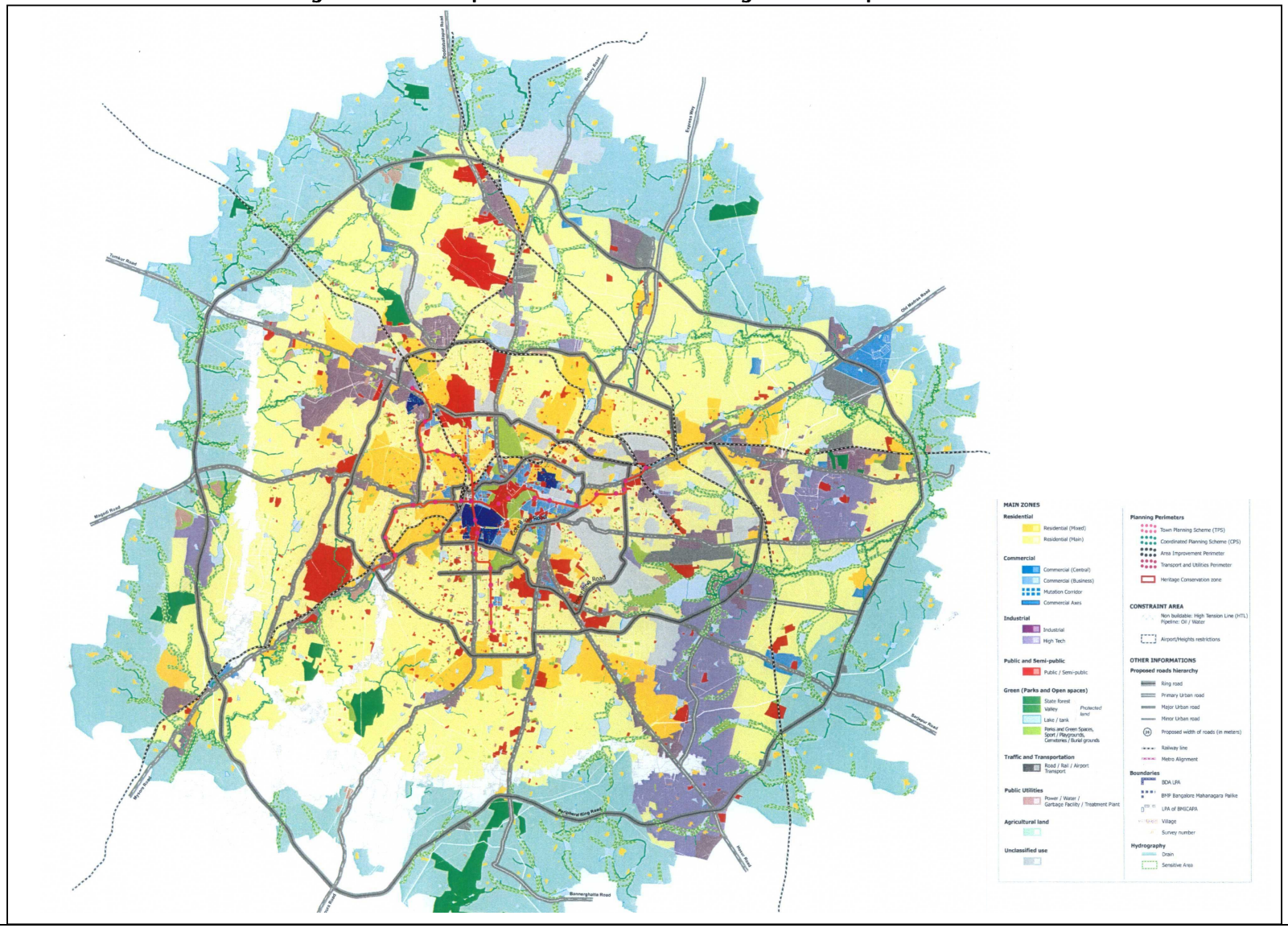


Table 1.8 Existing and Proposed Land Use for BMA

Land Use	2003		2011	
	Sq. Kms	% age distribution	Sq. Kms	% age Distribution
Residential	159.76	37.91	243.69	43.16
Commercial	12.83	3.04	16.43	2.91
Industrial	58.83	13.96	38.44	6.81
Open spaces	13.10	3.11	77.88	13.79
Publi & Semi-public	46.56	11.05	49.08	8.69
Public Utilities	2.49	0.59	-	0.00
Offices and Services	4.27	1.01	-	0.00
Traffic & Transportation	88.31	20.96	116.97	20.72
Un-classified	35.26	8.37	22.14	3.92
Total	421.41	100	564.63	100
Agriculture land	649.24			
Lakes & Tanks	39.02			
Quarry	9.61			
Vacant	187.72			
Total	**1307.00**		**564.63**	

Source- Revised Master Plan-2015

Keeping the above in view, the Master Plan has proposed the following development strategy:

i. In order to reap the benefits of the potential expected to be created by Multi-Modal Transport System at the transport Hub in the centre, Highest FAR is proposed in identified Central Business Area. FAR 2.5; Ground Coverage 75%. within the core area surrounded by the proposed Core Ring Road.
ii. Strengthening and extensions of employment areas along major roads and in clusters like Peenya, Bommasandra or Electronic City.
iii. Identifying new industrial areas. – 3 locations in the north accessible directly from PRR and the Radial Roads.
iv. High tech zone with FAR ranging between 2 to 3.25 – vacant area between Whitefield (ITPL) and Electronic City proposed as Hi-tech zone.

e. Secondary Centres: 10 Secondary Sub Centers (administrative / education & health) to be located at places to be served by Public transport – near railway station and big rail road junction.
f. Compact City Development: Vacant areas in the City need to be occupied and spread of layouts needs to be minimised.
g. Protection of natural drainage and ground water sources.

h. Land values to be linked to market economy – built area density to be proportionate to land price and presence of transport infrastructure.
    i. Higher FAR for old bungalow and villa areas.
    ii. Review of the areas accompanied by Industries along the major Roads – Virtually extension of core area to the periphery – Mutation zones.
    iii. Redevelopment of derelict industrial areas – promotion of market (actual and creation of mini zones of activities public amenities & infrastructure and social housing.
    iv. Densification of low density area (< 200 ppha)
    v. Encourage mixed land use in core areas – the live work mixed use reduces commuting time and mix of different activities increases economic efficiency. For these areas action imperatives defined are:
        - Diversion of traffic in mixed land-use areas by introduction of "one way"
        - Enforcement of new parking regulations.
        - Ban on entry of heavy goods vehicles in such areas
        - Widening of Roads
        - Removal of encroachments.
        - Appropriate transport system for the commuters to reduce owner vehicle usage
        - Demarcation into transport and utility zones.
        - Maintenance of open spaces
        - Improvement of Civic services.

i. Development of a Structured Road Network : The emphasis being on:
    i. Core Ring Road
    ii. Supplementing Outer Ring Road
    iii. Organising transportation/Logistic facilities: Specific Areas strategically located to provide for storages facilities, garages, and heavy vehicles supported by personnel, technicians and offices as well as integrating various transport modes like road, railway and air.
    iv. Developing Multimodal Public Transport System: consisting of rail & road based systems i.e. Metro-Rail, Mono-Rail, Circular Rail and other proven MRT systems.

j. Local Planning Area: The entire local planning area of Bangalore has been categorised into three major areas for application of Zonal Regulations and consist of:
    1. Main Areas : Comprising
        i. Old Urban Areas including the Petta Zone & Traditional Area Zone

ii. Urban Redevelopment Areas M.G. Road Area Zone, CBD Zone, CBD Areas, CD Precinct Zone, Transformation / Development Zone and Mutation Corridor Zone

iii. Residential Areas including mixed residential area, mainly residential area, and Commercial Axis Zone.

iv. Industrial / Activities Areas including Industrial, High Tech and Logistics/ Transport Zone

v. Green Areas including Protected Land, Restricted Development, and Agriculture Land Zones.

2. Specific Areas: Areas not covered by main areas and comprise large public and semi-public infrastructure; large transport structures, dedicated land uses, scheme areas & heritage conservation areas.

3. Constraint Areas: Areas having restrictions on type of development with its internal technical rules determining regulations within the site and around.

k. Based on the ward boundaries, existing physical features, and the analysis of the existing development trends within the City, 47 Planning Districts (PDs) have been delineated to implement the Master Plan. The planning districts are organized in three rings :

1st Ring: The Core area PDs 1.01 to 1.07

2nd Ring: The development urban areas surrounding the core are PDs 2.01 to 2.18

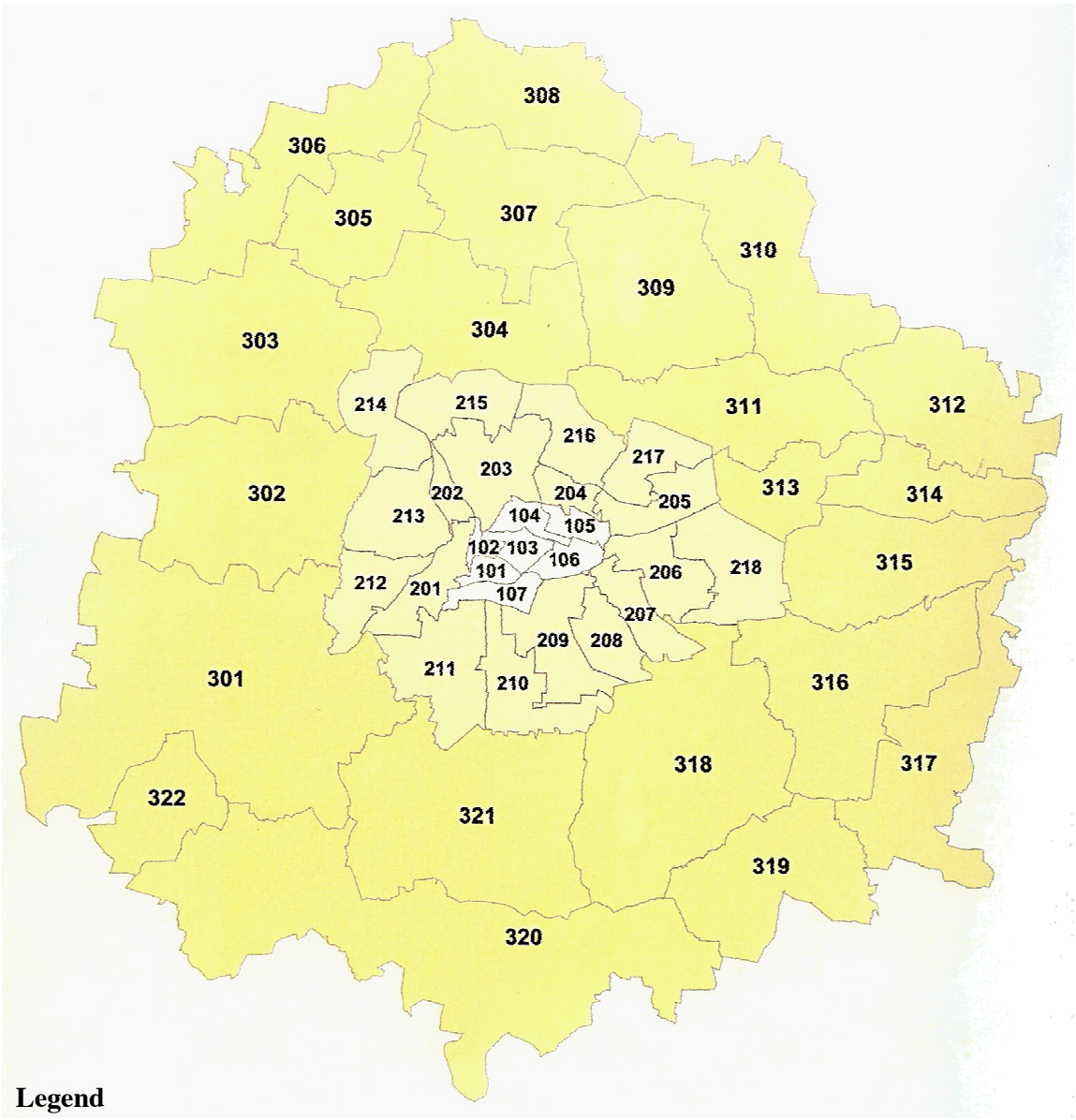
3rd Ring: The urban extension areas in the City's outskirts PDs 3.01 to 3.22

These planning district boundaries are indicated in the **Figure 1.8**

1.8 BANGALORE MYSORE INFRASTRUCTURE CORRIDOR AREA PLANNING AUTHROITY (BMICAPA)

The BMICAPA Planning Area comprises of BMIC Project Area and its environs. The total area is 701.01 Sq.kms. The BMICP comprises five self sustainable new townships viz., Corporate Township, Commercial Township, Industrial Township, Heritage Township & Eco-Tourism Township, 111 kms. of Expressway between Bangalore & Mysore, 41 kms. of Peripheral Road connecting NH 4 and NH 7 on the southern segment of Bangalore and about 9 kms. of Link Road connecting west of Chord Road/Mysore Road junction and "O'' point of the Expressway. It also includes interchanges at the junction of main, arterial and major roads.

Figure 1.8 Planning Districts in the Bangalore Metropolitan Region



101	Petta	210	Jayanagar	308	Bettaalasuru
102	Majestic	211	Banashankari	309	Tanisandra
103	Gandhi Nagar	212	Vijaya Nagar	310	Bagaluru
104	Vasantnagar	213	Rajaji Nagar	311	Horamavu
105	Shivaji Nagar	214	Peenya	312	Avalahalli
106	Richmond Town	215	Mathikere	313	K R Puram
107	Chamarajpet	216	Kaval Byrasandra	314	Sadara Mangala
		217	Kammanahalli	315	Whitefield
201	Kempapura Agrahara	218	C.V. Raman Nagar	316	Varthur
202	Srirampuram			317	Dommasandra
203	Malleswaram	301	Kengeri	318	Begur
204	Jayanagar	302	Herohalli	319	Electronic City
205	Baiyyappanahalli	303	Makali	320	Bannerghatta
206	Indiranagar	304	Byatarayanapura	321	Anjanapura
207	Unclassified	305	Bavalakere	322	Kumbalagodu
208	Koramangala	306	Hesarghatta		
209	Shanti Nagar	307	Yelahanka		

The BMICP Planning area (64 sq km in BMA) within which the 41 kms. of Peripheral Road connecting NH 4 and NH 7 on the southern segment of Bangalore and the link road are located has been planned for various land uses as under:

Table 1.9 Proposed Land Use of BMICAPA in BMA

Land Use	Area (Ha.)	% age
Residential	4882	8
Commercial	2174	3
Industrial	708	1
Public & Semi-Public	415	1
Parks & Open Spaces	1052	2
Traffic & Trans.	3230	5
Sub Total	**12461**	**19**
Agriculture Land	51875	81
Total	**64336**	**100**

Assuming a normal residential density of 350 pph & overall density of 150 pph this corridor will be able to accommodate between 17 to 18 lakh of population.

1.9 EARLIER STUDIES

1.9.1 The first committee to work on a planned development of Bangalore was Bangalore Development Committee (BDC) constituted in 1952. Subsequently in 1961, the Bangalore Metropolitan Planning Board was constituted for bringing out a Master Plan for Bangalore. The BMPB prepared an outline development plan for BMPA.

1.9.2 The Town and Country Planning Act came into force from 1965 and a City Planning Authority was constituted in August 1967. A Comprehensive

Development Plan (CDP) was prepared by the City Planning Authority for the year 2001 with an estimated population of 38 lakh.

1.9.3 In order to implement CDP, the Bangalore Development Authority (BDA) came into existence in 1976 with the authority to control the land-use in the metropolitan area. The result of 1981census, however, threw over board the assumptions of CDP. As the population anticipated for 1991 was reached in 1981 itself, the CDP had to be revised drastically and the population projections were revised in view of the recent trends. A plan was prepared and approved in 1984, then revised 10 years later and approved in 1995 for a population of 45 lakhs in 1991 and 70 lakhs for the year 2001. This plan is merely a zoning document with rough location of the road network. This has now been updated by BDA and French Consultants using satellites imagery and digital area maps and Revised Master Plan – 2015 published.

1.9.4 However, rapid growth in population and economic activities after independence brought to the fore increasing traffic and transportation problems due to the gap between demand and supply of transport system. In order to look for solutions to the traffic problems, several studies have been conducted in the past. Some of these major traffic studies are described briefly below.

1.9.5 The first Comprehensive Traffic and Transportation Plan was prepared in 1963 – 64 by CRRI, New Delhi. The plan was based on the population, land use and area projections made in the Outline Development Plan for Bangalore Metropolitan Region prepared by the Town Planning Department.

1.9.6 An effort to refresh the data and update the proposals was made by the Town Planning Department in 1977. One of its recommendations was to look into a Mass Rapid Transit Project i.e. a metro for Bangalore in 1981. Based on Lynne Committee's recommendations, Southern Railway team recommended a 2-corridor metro of 24 km, 3 commuter rail lines, and a 58 km ring railway at a cost of Rs.6500 million in 1983 terms and to be completed over a period of 25 years.

1.9.7 In 1988 under World Bank funding, RITES Ltd was commissioned to carryout another transport study with broad coverage of roads, traffic and mass transit. The study was completed proposing various roads and traffic improvements, as also commuter rail lines but again without much follow up.

1.9.8 In 1993, State of Karnataka established a committee to look into MRTS, which recommended the same metro project put forward by Southern Railway in 1983 and the same circular railway.

1.9.9 In 1994, the Government of Karnataka created BMRTL to seek public/private partnership of MRTS project. BMRTL commissioned a feasibility study, which pointed out to develop LRT based 96 km long MRTS network.

1.9.10 A study was carried out in 1999 proposing a large and varied road improvement program, including 45 multi-grade intersections, 25 pedestrian underpasses and various corridor improvements. In the process, grade separators were reduced to 19 with 9 to be done in the first phase.

1.9.11 In 2001, the State Government along with railways commissioned RITES to study introduction of commuter rail facility. The report is still under active consideration of the State Government.

1.9.12 In 2003, Government of Karnataka, commissioned Delhi Metro Rail Corporation (DMRC), to carry out a Detailed Project Report for metro in Bangalore. The study recommended 2 line metro, 18 km and 15 km in length, cross shaped. The lines intersect at the Bangalore city railway station and Bus station.

1.10 NEED FOR THE COMPREHENSIVE TRAFIC AND TRANSPORTATION PLAN

1.10.1 Thus several studies have been carried out for the city to improve transportation system in Bangalore. As short-term measures, road widening, flyovers, junction improvements were suggested and some of them have been implemented also. As long term solution, versatile and comfortable Mass Rail Transit System and commuter rail services have been recommended. However, the traffic and transportation scenario continues to be worsening. The BDA has recently got prepared a comprehensive development plan (Revised master Plan-2015). This plan has considered the first phase of Bangalore Metro Rail Project as well as network augmentation of Bangalore Metropolitan Transport Corporation. It, however, does not cover the urban transportation needs of the city fully. Therefore, it was felt by the Government of Karnataka to take a stock of the prevailing situation and prepare a comprehensive traffic and transportation plan which will not only cover short term requirements but also medium and long transport system requirements upto 2025. It should also provide for proper inter-modal transport integration.

1.10.2 It is in this context that Karnataka Urban Infrastructure Development Finance Corporation (KUIDFC) has initiated this study for preparing a Comprehensive Traffic and Transportation Plan for Bangalore and engaged RITES Ltd, a Government of India Undertaking, to carry out this study.

CHAPTER – 2

STUDY OBJECTIVES AND METHODOLOGY

2.1 STUDY GOALS

The present study goals include:

i) Development of transportation network to achieve convenient and cost effective accessibility to places of employment and education for the next 20 years;

ii) Optimal utilization of funds and human resources.

2.2 OBJECTIVES OF THE STUDY

i) Identify travel pattern of residents of the local planning area of Bangalore which is co-terminus with the territorial jurisdiction of Bangalore Development Authority (BDA);

ii) Select, develop and operationalise an Urban Transport Planning model using state of the art modeling techniques and software package, appropriate to the conditions and planning needs of the study area;

iii) Assess the relevance of the existing strategy, identify the consequences of pursuing alternative transportation strategies and recommend / update a long – term comprehensive transportation strategy for the study area up to 2025 (2015 and 2025);

iv) Identify for all modes, a phased program of appropriate and affordable investments and policy proposals; and also integration of various modes of mass transits.

v) Help strengthen transport planning skills, and transfer all data, planning model/tools and knowledge obtained through the study to KUIDFC and other agencies such as BDA, BMTC, KSRTC, South Western Railway, BMRTL, Traffic Police, etc.

vi) Strategize transport policy as an integrate part of urban planning

vii) Recommend institutional mechanism for inter agency co-ordination

viii) Assess existing infrastructure and forecast requirement – short term and long term.

2.3 SCOPE OF THE STUDY

In line with the specific objectives of the study described above, the scope of work is divided roughly into the following areas of activities as follows.

i) Collecting household, land use, and travel demand data

ii) Development and operation of an urban transport model

iii) Formulation of transport strategy and institutional mechanism;

iv) Identification of a phased program of transport investments and management proposals; and
v) Training and knowledge transfer to the concerned agencies

2.4. STUDY METHODOLOGY

The adopted study methodology to achieve the set objectives and scope is given in **Figure 2.1**. The study methodology adopted can be broadly divided in to five stages.

Stage 1:
Finalisation of study methods
- Secondary data collection and analysis.
- Finalization of zone plans and hierarchy of zones
- Detailed sampling basis and questionnaires for Household interviews, Business interviews and Roadside interviews.
- Base road and public transport network survey.
- Draw up Proposal for traffic surveys like speed- flow, parking, traffic counts, network inventory, and their analysis.
- Required computer program suites etc.

Stage 2:
The second stage was the collection of information, and review of existing transport scenario. In order to collect various travel information following surveys were conducted.
- Household interviews
- Roadside interview surveys
- Public transport surveys
- Traffic surveys
- Road network inventory
- Speed and delay studies

The data so collected was analyzed and validated to the existing traffic scenario which forms an input to the transport models.

Stage 3:
Development of detailed operational model forms the fourth stage of the study, this included
- Development of observed trip matrices
- Calibrate and validate trip end models
- Formulation of projects necessary to fulfill the requirement of master plan using forecast models
- Calibration and validation of trip distribution – modal split model
- Validation of Assignment models and running them for different schemes / combination of facilities
- Formulation of management policies

Stage 4:

The fourth stage involved development of Transport Strategy for Bangalore

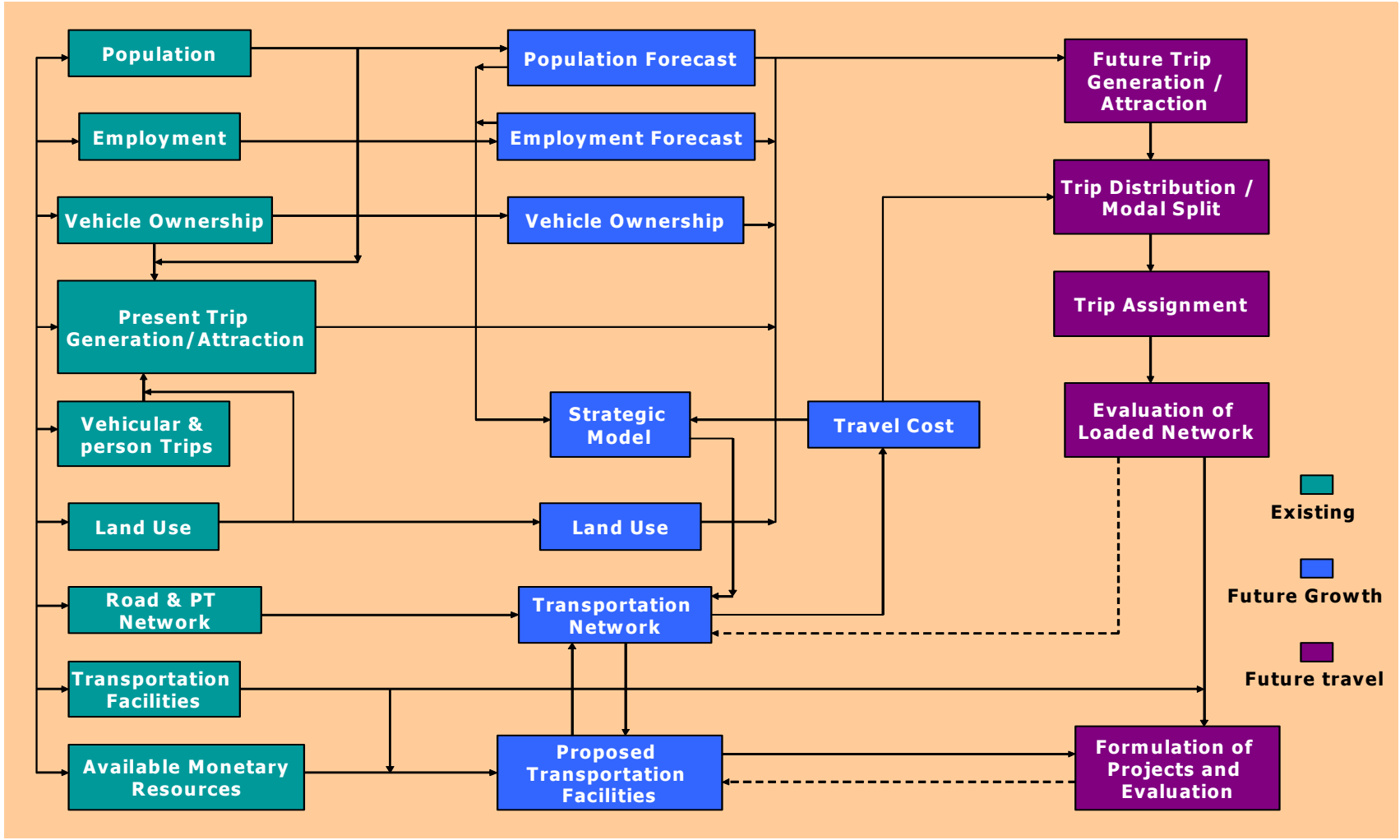
- Taking stock of current situation of Bangalore – Urban Transport Policy, Economic growth, current initiative, land use plans both existing and proposed etc.,
- Analyzing the traffic situation in terms of present situation and constraints and future growth.
- Proposed land use based on the newly prepared Master Plan.
- Analyzing the transportation demand vis-à-vis the supply and the constraints.
- Analyzing the present institutional arrangement and future requirement.

Stage 5:

The fifth and the final stage of CTTS study involve the following:

- Development of various strategies to address the transport requirements
- Evaluation of strategies based on selected criteria (mobility, congestion, safety, environmental and economic) and recommendation of suitable strategy
- Drawing up a Transport Plan for BMA and investment requirements
- Preparation of investment program for various schemes in operational plan,
- Carrying out a financial analysis of the proposals identified for Implementation in regard to implementing agencies with funding options
- Carrying out economic analysis for the recommended strategy to establish viability
- Recommending Organizational set up and institutional arrangement for implementation of plan.

Figure: 2.1 Methodology for Preparing Comprehensive Traffic and Transportation Plan for Bangalore



CHAPTER – 3

EXISTING TRAFFIC AND TRAVEL CHARACTERISTICS

3.1 INTRODUCTION

The first and foremost step to be initiated in the development of any Comprehensive Transportation Plan for a city is the collection of data relevant to the travel pattern of the residents of the city and the factors which influence the travel pattern. Transportation studies have revealed that the travel pattern in any urban agglomeration is strikingly regular and a definite pattern develops in the movement of people which can be anticipated for the future years also. This in turn helps in developing a transportation plan with a reasonable level of confidence. This data collection is done through secondary sources and conduct of primary surveys. Some of the data collected through secondary sources has already been given in Chapter 1. This chapter gives account of primary traffic and travel surveys conducted as a part of this study and emerging traffic, socio-economic and travel characteristics. This database will help in identifying issues and in travel demand modeling and forecasting exercise.

3.2 PRIMARY TRAFFIC AND TRAVEL SURVEYS

3.2.1 A study of this nature requires a number of primary surveys in order to understand the problems, demographic characteristics and travel habits of the people, which have a direct bearing on their demand for travel. Under-mentioned surveys have been conducted.

- House Hold Interview Survey (HHI)
- Business Interview Survey (BIS)
- Mid Block Volume Count Survey
- Road Side Interview (RSI) or O – D Survey
- Screen line Survey
- Parking Survey
- Pedestrian Survey
- Speed & Delay Study
- Terminal Survey
- Public Transport Survey
- Road Network Inventory

This chapter presents major results and analysis of the different surveys.

3.3 TRAFFIC ZONE DELINEATION

3.3.1 The Bangalore Metropolitan Area covers 1307 sq. km. as per Revised Master Plan-2015. Delineation of traffic zones has been made based on ward boundaries within the Municipal Corporation areas and village / TMC / CMC boundaries outside the corporation area, also taking into account homogeneity of land use. **Figure 3.1** shows the traffic zone boundaries in BMP, outside BMP but within BMA areas. It will be seen that the size of the zones are smaller in inner areas and they become larger in outer areas. The detail of the zoning adopted within BMA is furnished below:

• Within Corporation limits (1 to 128)	128 zones
• Covering CMC & TMCs (201 to 234)	34 zones
• Covering villages outside CMCs & TMCs (301 to 312)	12 zones
Total	**174 zones**

3.3.2 Thus the BMA has been delineated into 174 zones. Of this, 128 zones lie within the corporation area and 46 zones in the rest of metropolitan area. These zones have been coded adopting a simple three digit numbering system, which also helps in identifying zone locations.

3.4 ZONAL POPULATION

The area and population of the individual administrative wards within Bangalore city limits for the years 1981, 1991, and 2001 have been collected from primary census abstracts of the Directorate of Census Operations, Karnataka. The growth rate of population for each of wards has been calculated. The city and rest of BMA were subdivided wherever necessary to ensure that the population of the modified zone in the horizon year (2025) is around 50,000. Based on other consideration such as the area of zone, travel distances, density of population and land use, certain zones with population in excess of 50,000 are sub-divided. Utilizing the population figures of BMA based on the census carried out in 2001, the figures for the base year 2005 was estimated. The zonal population has been further projected to the horizon years. The population for the horizon years of 2015 and 2025 was projected so that the figures tally with those projected in the Revised Master Plan prepared by BDA for 2015 and using the growth trend as well as proposed land use details for 2025.

3.5 TRAFFIC CHARACTERISTICS

3.5.1 Traffic Surveys

Traffic surveys form an integral part of the study to assess the present day traffic situation, which in turn helps in evolving the short, medium and long term strategies to ameliorate the traffic problems of the city. Accordingly, classified traffic volume surveys mainly comprising of volume counts at 24 mid block

Figure 3.1 Traffic Zone Boundaries in BMP, outside BMP but within BMA areas

locations, 16 screen line surveys and 10 outer cordon O-D surveys have been conducted, the details of which are described in the subsequent paragraphs. Locations of traffic surveys are shown in **Figure 3.2**.

3.5.2 Mid-Block Location Volume Counts

Traffic volume count at mid-block locations give a clear picture about the density of traffic volume along different stretches of roads within the study area, which helps in assessing the V/C ratio of the road stretches. This in turn helps in assessing the current strategies to be adopted to ease the prevailing congestion as also in evolving future long term strategies. 24 mid-blocks were identified for carrying out the volume count survey covering some of the major and important roads of the city as shown in **Figure 3.2**. Mid-block volume counts were carried out for 12 hours continuously from 8 AM in the morning upto 8 PM in the evening. The volume counts were carried out on typical week days only and not on holidays and week ends.

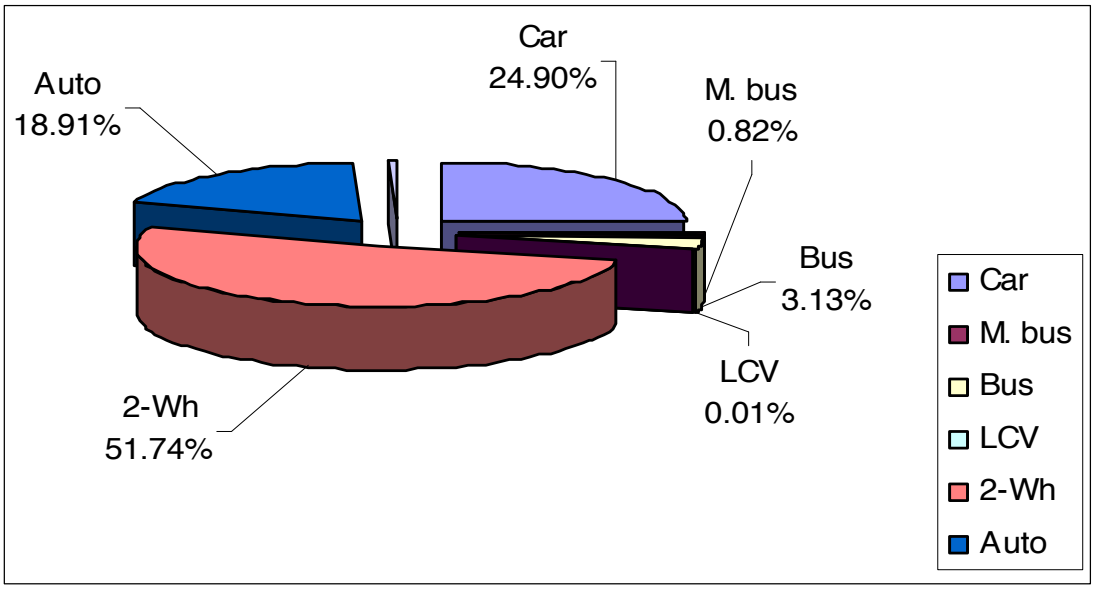
The total vehicles per day, the corresponding PCUs and the peak hour timings during morning and evening are given in **Table 3.1**. It is observed that the traffic volume is of the order of 18000 to 19000 PCUs on Sankey Road (T. Chowdaiah Road) followed by 15200 PCUs on Rajajinagar Link Road near Sujatha Theatre during peak hour. From the analysed data, is observed that the intensity of 2-wheelers is predominant on most of the roads with the composition varying between 40% & 60%, while that of cars vary between 20% and 33%. The morning peak hour is generally observed between 9 AM and 10 AM, while the evening peak hour is between 6 PM and 7 PM. However, there is slight variation in the peak hours in some of the corridors. It can therefore be concluded that the morning peak hour generally varies between 9 AM and 11 AM while the evening peak hour varies between 5 PM and 7 PM. Peak hour factor is generally about 10% of 12 hour traffic. Traffic composition and hourly traffic variation for typical locations are shown in **Figures 3.3 and 3.4**. Peak hour traffic volumes on these roads suggest that V/C ratios on most of these roads are >1.

Figure 3.2 Locations of Volume Count Surveys (Midblock, Screenline and Outer Cordon)

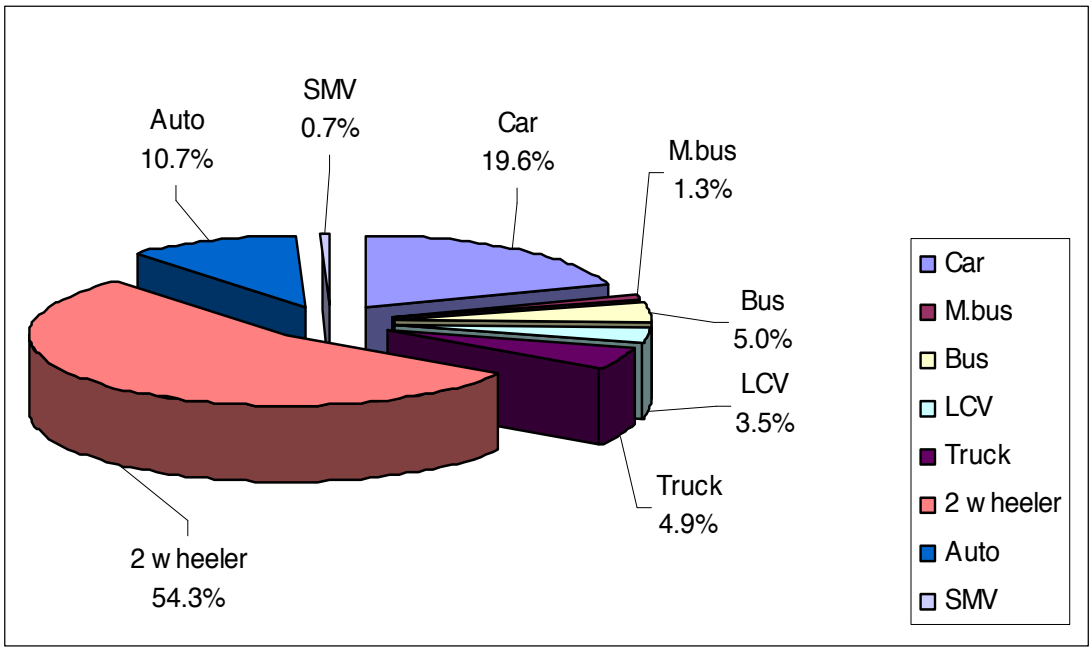
Table – 3.1 Traffic Volume at Mid-Block Locations

Sl. No.	Road Name	Total Traffic Volume (12 Hour count)		Peak Hour	
		Vehicles	PCUs	AM	PM
1.	Chord Road near Toll gate	67015	76556	9 – 10	5 – 6
2.	Magadi Road near Prasanna Theatre	14596	14724	9 – 10	6 – 7
3.	R.V. Road near Vijaya College (South End Circle)	56770	60236	9 – 10	7 – 8
4.	Hosur Road (NH-7) near Wipro- CSB Junction	62514	66116	9 – 10	6 – 7
5.	Airport Road near Kemp Fort	30146	29589	9 – 10	6 – 7
6.	Rajajinagar Link Road near Sujatha Theatre	127741	146209	10 – 11	5 – 6
7.	Sampige Road near Sampige Theatre	57547	68045	11 – 12 Noon	6 – 7
8.	M.G. Road near Trinity Circle (Big Kids Kemp)	99404	109114	9.45 – 10.45	6 – 7
9.	Richmond Road / Gen. Timmaiah Road near Masjid (Richmond Circle)	59866	69452	10 – 11	6 – 7
10.	Residency Road / F.M. Cariappa Road near St. Joseph's College (Richmond Circle)	38510	45024	10 – 11	5 – 6
11.	K.G. Road near Cauvery Bhavan	69896	100455	10.15 – 11.15	6 – 7
12.	Mahakavi Kuvempu Road near Varalakshmi Nursing Home	36684	43720	10 – 11	6 – 7
13.	Outer Ring Road near Kamakya	37467	38026	9 –10	5.15 – 6.15
15.	Bannerghatta Road near Mantri Apartments	55529	59087	9 – 10	6 – 7
16.	Mysore Road near KIMCO	33097	36667	9 – 10	5 – 6
17.	J.C.Road near BMP Parking Lot (Bharat Theatre Jn.)	99821	106048	10 – 11	6 – 7
18.	Lal Bagh Road near Urvashi Theatre	52944	58226	11 – 12 Noon	5 – 6
19.	K. R. Road near National High School	49536	56291	10.15 – 11.15	5 – 6
20.	Old Madras Road / Swami Vivekananda Road near NGEF	68781	70039	9 – 10	6 – 7
21.	Sankey Road (T.Chowdaiah Road) near NTI	179067	182047	9 – 10	5.15 – 6.15
22.	Sankey Road (T.Chowdaiah Road) after Cauvery Theatre	183194	185057	9 – 10	5 – 6
23.	Bellary Road (Ramana Maharshi Road) near Mekhri Intersection Underpass	95424	100973	9 – 10	5 – 6
24.	Dr. Raj Kumar Road near Navarang Theatre	81116	97489	10 – 11	5 – 6

Figure 3.3 Traffic Composition at Typical Mid Block/Screenline Locations

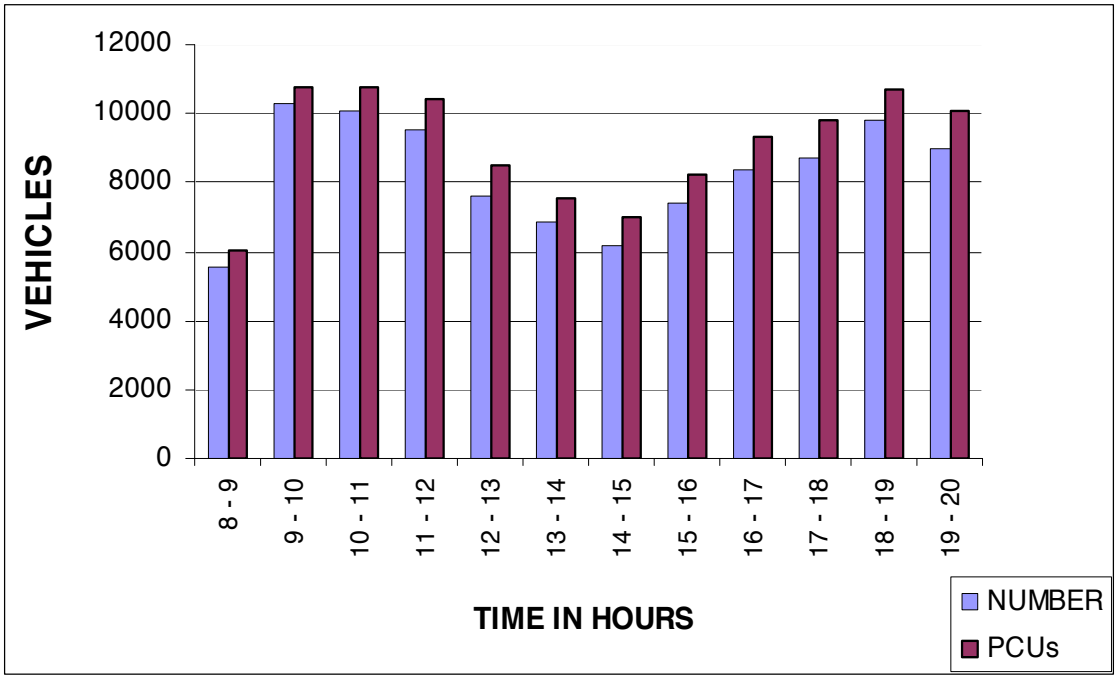


At M G Road (Mid Block)

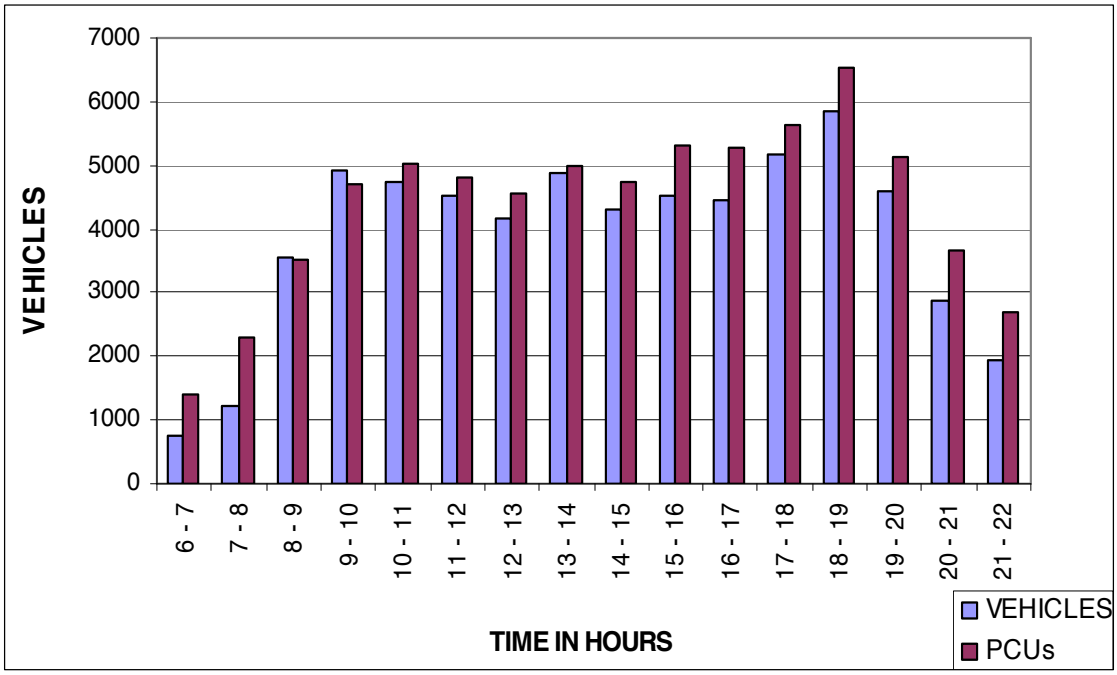


At ROB on Chord Road near Mysore Road Intersection (Screen line)

Figure 3.4 Hourly Traffic Variation at Typical Mid Block/Screen line Locations



At M G Road (Mid Block)



At ROB on Chord Road near Mysore Road Intersection (Screen line)

3.5.3 Screen Line Traffic Volume Counts

Screen line survey is the typical traffic volume count conducted at different road stretches within the study area limits preferably along the natural barriers like rivers, canals, bridges, railway lines etc. As no natural barriers exist in Bangalore, the existing railway lines and the ROBs / RUBs constructed across / along these railway lines have been taken for conducting screen line surveys. For the BMA, the screen lines considered are railway lines to Mysore, Tumkur, Yelahanka, White Field / Chennai and loop from Hebbal to Baiyyappanahalli and Salem line. Screen line surveys give an idea about the movement pattern of people in the city and helps in cross checking the movement pattern. The basic purpose of screen line surveys is validation of the model developed. The trip and movement pattern of residents of the area to different parts of the city are obtained through house hold survey and the direction of movement of different modes of vehicles is collected through traffic volume count survey. Based on the information collected through house hold survey, the trip assignment is run which gives the assignment values along different routes. This is cross checked with the traffic census as also the household survey data and the model is then validated so that the errors are minimized or nullified and the trip assignments for the horizon years reflects almost a true picture.

Screen line surveys were conducted for a period of 16 hours duration from 6 AM in the morning upto 10 PM in the evening at 16 locations as shown in **Figure 3.2**. The total vehicles per day and the corresponding PCUs plying on the locations identified for screen line volume count is given in **Table 3.2**.

It is observed that the traffic volume is of the order of 18000 PCUs during peak hour at RUB on Sankey Road near Windsor Manor followed by 15000 PCUs during peak hour at RUBs near Binny Mill and Dhanvantari Road and 13000 to 14000 PCUs at RUBs near Okalipuram and Millers Road.

Table – 3.2 Traffic Volumes at Screen Line Locations

Sl. No.	Location	Total Traffic volume (16 Hour count)		Peak Hour	
		Vehicles	PCUs	AM	PM
1.	RUB near Cantonment Railway Station on Millers Road	128528	151910	8.30 – 9.30	5.45 – 6.45
2.	Level Crossing near ITC on Wheelers Road	53850	60469	10.00 – 11.00	6.00 – 7.00
3.	ROB near BHEL on Chord Road	62515	70264	10.00 – 11.00	6.00 – 7.00
4.	ROB near Devaiah Park on Mahakavi Kuvempu Road	128136	133638	9.00 – 10.00	5.30 – 6.30
5.	ROB near Yeshwanthpur on Tumkur Rd (NH4)	61218	68620	9.00 – 10.00	6.00 – 7.00
6.	RUB near Benniganahalli on NH – 4	80876	83078	9.00 – 10.00	6.00 – 7.00
7.	RUB near Binny Mill on Tank Bund Road	132795	157592	9.00 – 10.00	5.00 – 6.00
8.	RUB near Platform Road junction Dhanvantari Road	119240	141294	11.00 – 12.00 Noon	6.00 – 7.00
9.	RUB near Khodays Factory	108918	142815	9.00 – 10.00	5.30 – 6.30
10.	RUB near Okalipuram	113608	147112	9.00 – 10.00	5.30 – 6.30
11.	RUB near Marathahalli on Ring Road	71678	83183	9.00 – 10.00	5.15 – 6.15
12.	RUB near Kino Theatre on S.C. Road	36934	45743	10.00 – 11.00	5.45 – 6.45
13.	RUB near Windsor Manor on Sankey Road	188394	192547	9.00 – 10.00	5.15 – 6.15
14.	RUB near Shivananda on Hare Krishna Road	79404	86615	9.00 – 10.00	5.00 – 6.00
15.	RUB near Coles Park on Millers Road	123055	148966	8.30 – 9.30	6.00 – 7.00
16.	RUB near Fraser Town Police Stn. on Pottery Rd.	25199	28186	9.00 – 10.00	6.00 – 7.00

3.5.4 Road Side Interview Survey (Outer Cordon O - D Survey)

The O-D surveys were conducted to get an idea about the traffic pattern of inter-city traffic entering/leaving Bangalore. The survey is basically conducted to collect information on trips (origin, destination, mode, purpose, time and vehicle occupancy) actually performed at different points. O-D survey was conducted in the BMA at 10 outer cordon locations as shown in **Figure 3.2**. Random sampling has been adopted as it was not feasible to stop all the vehicles plying on the road. It was ensured that at least 10% sampling was done. However, as per the conditions prevailing at site at the time of survey, more samples were collected, wherever possible. The O-D survey was carried out for 24 hours on a typical week day. The survey was started at 8 AM and concluded at 8 AM the next day. The vehicles entering the city or leaving the city to different destinations were stopped at random and the vehicle users were asked certain questions and the answers were duly recorded by the enumerators. Police assistance was taken for stopping the vehicles.

Daily traffic at the outer cordon locations is given in **Table 3.3**. It shows that Hosur Road carries maximum volume of traffic followed by Tumkur Road and Old Madras Road. **Figure 3.5** shows the traffic desire for through traffic. It indicates that there is substantial through traffic particularly between both the legs of NH4 and NH7 pointing to the need of road bypass so that this traffic need not enter the city.

Figure 3.5 Desire Line Diagram for Through Traffic – Base Year (PCU/day)

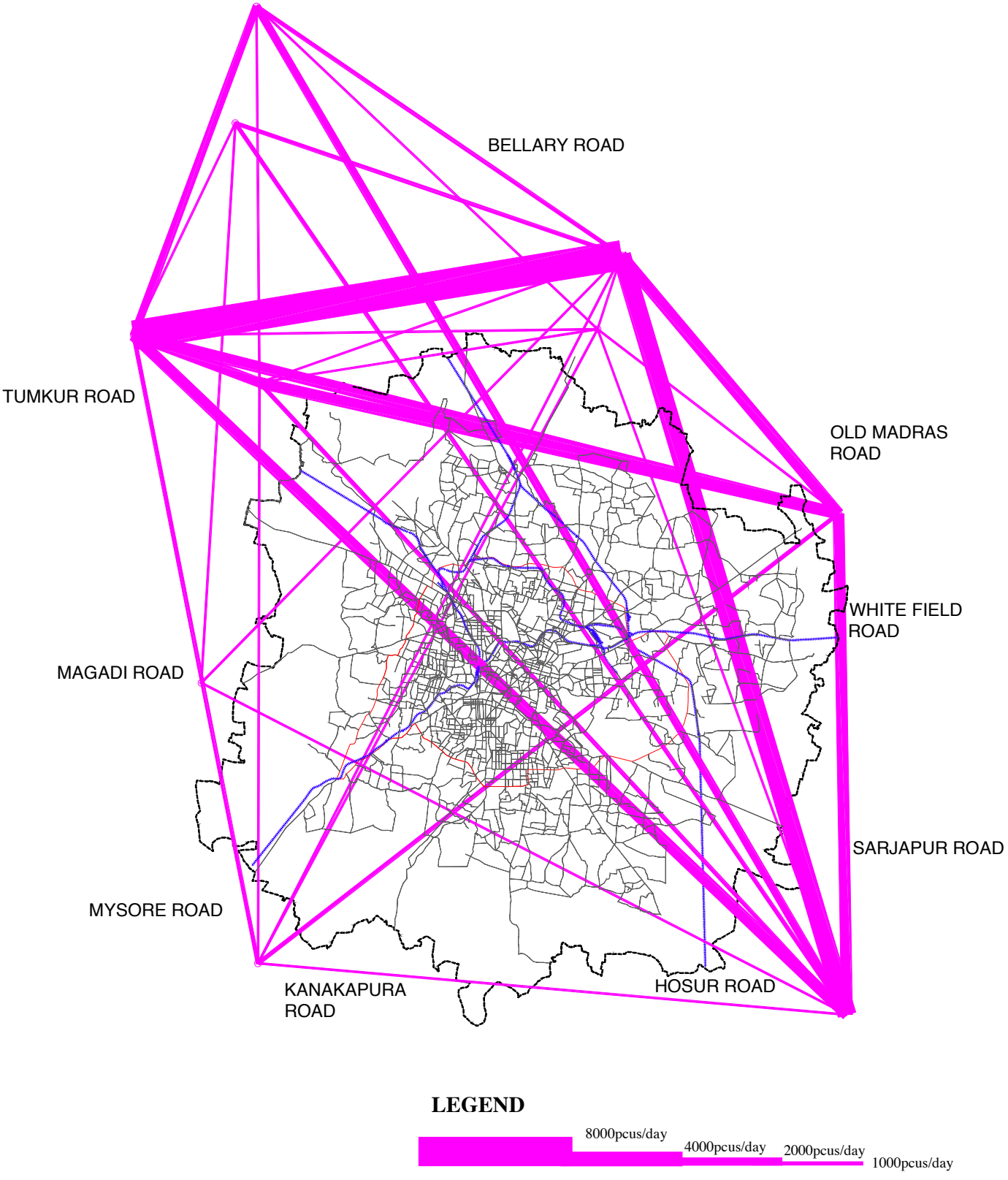


Table 3.3 Daily Traffic Volume at Outer Cordon Survey Locations

S.No.	Road	Daily Traffic Volume (24 hours)					
		Direction 1		Direction 2		Total	
		Vehicle	PCU's	Vehicle	PCU's	Vehicle	PCU's
1	Sarjapur Road	3876	5247	4749	6686	8625	11933
2	Old Madras Road	11287	18503	12060	21496	23347	39999
3	Bellary Road	7651	13651	8252	13817	15903	27468
4	Doddballapura Road	7049	11611	5794	9829	12843	21440
5	Tumkur Road	16900	29129	19357	33272	36257	62401
6	Magadi Road	5239	6969	5563	7183	10802	14152
7	Mysore Road	2511	2655	2524	2717	5035	5372
8	Kanakapura Road	9455	16093	7012	11688	16467	27781
9	Bannerghatta Road	7455	9857	6473	9482	13928	19339
10	Hosur Road	18525	37539	20200	40467	38725	78006

Source –RITES Primary Surveys, 2006

3.6 SOCIO-ECONOMIC AND TRAVEL CHARACTERISTICS

3.6.1 Household Interview surveys

The HHI survey is a part of the CTTP for BMA. Household Interview Survey is one of the main surveys conducted as part of Comprehensive Traffic & Transportation Plan for Bangalore. The main aim of the survey is to collect the socio-economic and travel characteristics of residents in BMA. The survey is intended to collect the details about the number of residents of the household, their income range and their travel pattern. The entire BMA was divided into four categories viz., Inner Ring, Middle Ring, TMC / CMC and Villages. The sample size adopted and the number of households selected for interview is given in the **Table 3.4**.

Table 3.4 Area wise Sample size adopted for the HHI survey

Area	Sample Size	No. of House Holds	Population	No. of House holds surveyed
Inner Ring	1.589%	110101	556331	1749
Middle Ring	1.80%	837068	3744995	15067
TMC / CMC	2.00%	272103	1147297	5442
Villages	2.40%	155897	700600	3742
Total		1375169	6149223	26000

3.6.2 Socio – Economic Characteristics

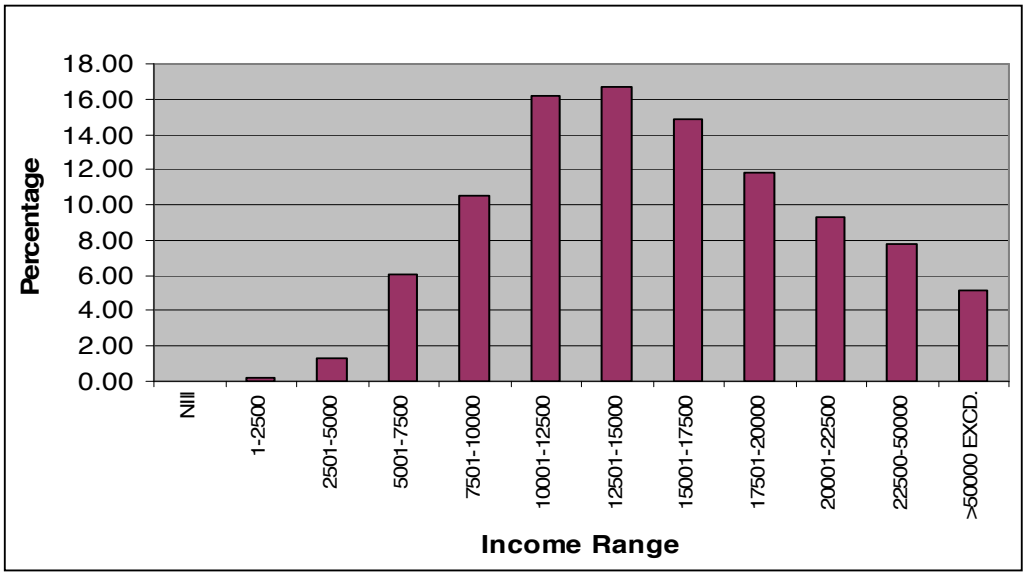
It is observed that the average household size as per survey is 3.88 while the same as per census 2001 is 3.95. The details are furnished in the **Table 3.5**.

Table 3.5 Distribution of Households by Family Size

Zone Group	Household size (Persons)							Average Household size	Actual Household size as per census
	1	2	3	4	5	6	Total		
BMC	56	1595	3889	5692	3122	2461	16815	4.04	4.12
	0.33%	9.49%	23.13%	33.85%	18.57%	14.63%	100%		
TMC	15	645	1741	1741	796	505	5443	3.77	3.72
	0.28%	11.85%	31.99%	31.99%	14.62%	9.27%	100.00%		
VILLAGE	11	489	1148	1223	553	319	3743	3.74	3.77
	0.29%	13.07%	30.68%	32.68%	14.77%	8.51%	100.00%		
Total	82	2729	6778	8656	4471	3284	26000	3.88	3.95
	0.32%	10.50%	26.07%	33.29%	17.19%	12.63%	100.00%		

Household Income: The distribution of households by income level in BMA (**Figure 3.6**) indicates that the highest proportion of households (16 – 17%) belong to income category Rs.10,000 – 12,500 p.m. followed by 15% in the category of Rs.15,000 – 17,500, 12% in the category Rs. 17,500 – 20,000 and 9% in Rs. 20,000 category.

Figure 3.6 Distribution of Households by Income Range



Thus, the average household income is found to be between Rs. 14500 and 15500 per month.

3.6.3 Travel Characteristics

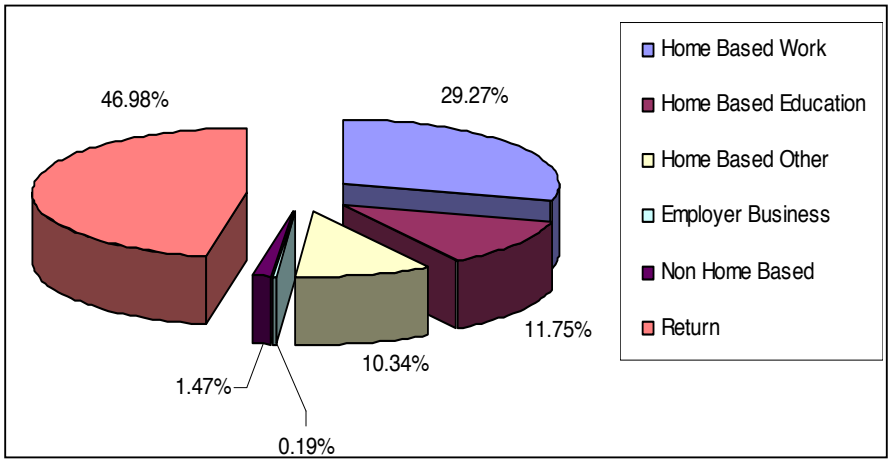
Trip Purpose

The distribution of trips by purpose indicates that out of 61.79 Lakh daily trips performed home based work trips account for (28.79%) share followed by home based education trips (11.86%) and home-based other trips (10.28%) respectively. Non-home based trips account for only 1.42% share while return trips account for 47.46%. **Table 3.6** shows the distribution of trips by purpose. **Figure 3.7** shows the graphical presentation of trips by purpose.

Table 3.6 Distribution of Trips by Purpose

Purpose Home Based	No.	% Share
Work	1839819	29.27
Education	738799	11.75
Others	649737	10.34
Non-home based	92347	1.47
Employer Business	11747	0.19
Return	2953229	46.98
Total	**6285678**	**100.00**

Figure 3.7 Trips by Purpose



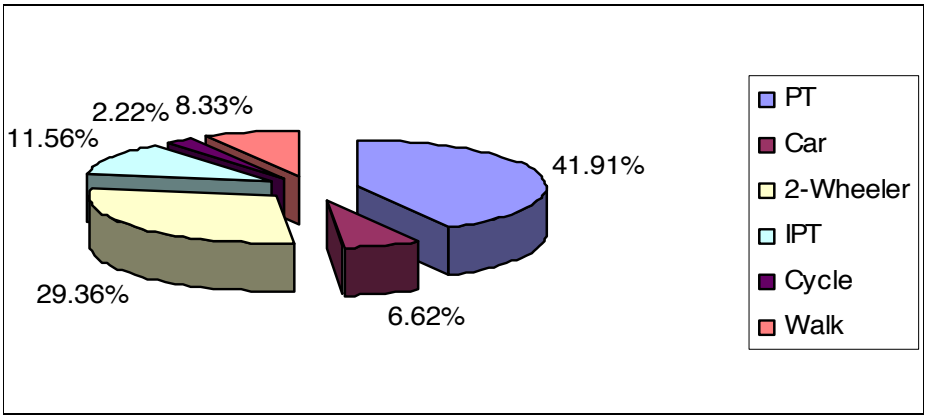
Trips by Mode of Travel

An analysis of trips by mode of travel indicate that majority of the trips (41 to 45%) are performed by bus followed by two-wheeler (29 to 32%). **Table 3.7** shows the distribution of trips by mode of travel. **Figure 3.8** shows graphical presentation of modal split.

Table 3.7 Distribution of Trips by Mode of Travel

PT	Car	2-Wheeler	IPT	Cycle	Walk	Total
With Walk						
2634471	416304	1845476	726425	139407	523597	6285680
41.91%	6.62%	29.36%	11.56%	2.22%	8.33%	100.00%
Without Walk						
2634471	416304	1845476	726425	139407	0	5762083
45.72%	7.22%	32.03%	12.61%	2.42%	0.00%	100.00%

Figure 3.8 Modal Split with Walk Trips



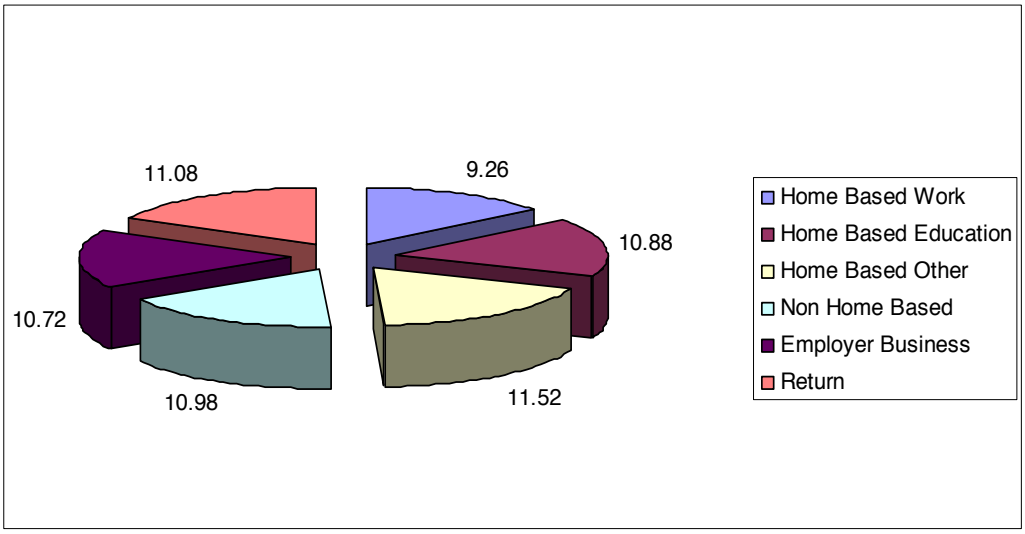
The distribution of trips by purpose & trip length indicate that 38% of home based work trips are performed within 10 – 20 km distance while 53% of education trips & 57% of other trips are performed within 10 – 20 km distance. **Table 3.8** and **Figure 3.9** shows the distribution of trips by purpose & trip length.

Table 3.8 Distribution of Trip Length by Purpose of Travel

Trip Length (KMS)	Home Based Work	Home Based Education	Home Based Other	Non Home Based	Employer Business	Return	Total
0-2	327907	137356	28133	4852	1681	223144	723074
2-5	278904	78626	120412	17595	1712	458116	955365
5-10	433673	73612	87537	26870	1371	579279	1202342
10-15	422495	235376	222539	21646	3759	891636	1797451
15-20	281664	156917	148359	14431	2506	594424	1198301
20-35	95176	55422	41802	2939	675	200621	396636
>35	0	1490	954	4013	43	6011	12511
Total	1839819	738800	649737	92346	11747	2953230	6285680
Avg. Trip Length	**9.26**	**10.88**	**11.52**	**10.98**	**10.72**	**11.08**	**10.57**

It will be seen that the trip lengths for education is unusually high, even higher than that of work trips. This can be attributed to the probability that most of the education trips captured are for higher education and more of such institutions including Bangalore University lying on the periphery of the city. The percentage of education trips is comparatively low indicating that lot of education trips at primary and secondary level are intra zonal, due to availability such schools within most zones. Overall, the average trip length observed is 10.57 Km.

Figure 3.9 Trip Length by Purpose



Trips by Mode & Trip Length

The distribution of trips by mode & trip length as shown in **Table 3.9** reveals that 68% of bus trips are made for covering distance varying from 10 Km to 20 Km while it is 47% in case of car trips & 33.5% in case of two-wheeler trips for the same distance. Nearly 30% of cycle trips are performed for a travel distance of upto 5 Km while it is 43% for distance of upto 2 Km by cycles.

Table 3.9 Distribution of Trips by Mode & Trip Length

Trip Length (Km.)	Bus	Car	Two Wheeler	Three Wheeler	Cycle	Walk	Total
0-2	197	46	142633	0	59137	521061	723074
2-5	117434	27809	482306	279891	45390	2536	955365
5-10	134333	151603	725082	165814	25509	0	1202342
10-15	1429620	152409	316173	192265	6560	0	2097026
15-20	612694	65318	135503	82399	2811	0	898725
20-35	329555	17627	43779	5675	0	0	396636
>35	10639	1492	0	381	0	0	12511
Total	2634471	416304	1845476	726425	139407	523597	6285680
Average Trip Length	**14.99**	**11.59**	**8.02**	**8.59**	**3.88**	**1.01**	**10.57**

Travel Cost by Purpose of Travel

The average travel cost for various purpose of travel (**Table 3.10**) reveals that the costs for non home based trips are higher compared to work trips. The Employee Business trips cost Rs. 5.74 per Km.

Table 3.10 Average Travel Cost by Purpose of Travel

Purpose	Average travel cost (Rs.)
Work / Business	7.49
Education	2.73
Employee Business	5.74
Others	6.04
Return	6.12
Non Home Based	8.74

Per Capita Trip Rate (PCTR)

PCTR refers to the number of inter zonal trips made by an individual per day. Accordingly, PCTR has been calculated purpose wise for the BMA and the same is presented in **Table 3.11**.

Table 3.11 per - Capita Trip Rates by Purpose in BMA

Trip Purpose	Trips	Percentage	PCTR
Work	1839818	29	0.271
Education	738799	12	0.109
Others	649737	10	0.096
Non-Home Based	92347	1	0.014
Employer Business	11748	0	0.002
Return	2953228	47	0.434
Total	6285677	100	0.924
Total Population	**6800000**		**0.924**

3.7 PEDESTRIAN TRAFFIC CHARACTERISTICS

3.7.1 Bangalore city is witnessing considerable pedestrian traffic especially in the CBD areas. With the increase in the commercial activity in some of the important areas like Koramangala, M G Road, Shivajinagar, K G Road etc., there is an increased demand for better pedestrian facilities. The increase in vehicular traffic has given rise to widening the carriageway width to accommodate the vehicles resulting in reduction in the size of the foot paths. This in turn has given room for pedestrians to spill over to the carriageway, thereby affecting the flow of vehicles.

3.7.2 In order to safe guard the interests of the pedestrians in particular, it was decided to carry out pedestrian survey at some important locations where there is heavy

inflow of pedestrians. This would give us an idea about the volume of pedestrian traffic which in turn would help us in developing some facilities for the pedestrian traffic. Pedestrian surveys were conducted for 12 hours at 8 mid block and 9 junction locations (locations shown in **Figure 3.10**). The survey was conducted from 8 AM to 8 PM on typical week days. **Table 3.12 and 3.13** give the peak hour pedestrian at major locations. From the analysed data, it is observed that the pedestrian traffic is highest along 9th Main Road (Jayanagar 4th Block) followed by M G Road. It is also observed that the pedestrian traffic is at its peak during holidays / weekends at 9th Main Road (Jayanagar 4th Block), M G Road, Brigade Road and Gandhi Bazaar Road. The volume of pedestrian traffic is maximum between 10 AM and 11 AM in the morning and between 5 PM and 6 PM in the evening.

Table 3.12 Volume of Pedestrian Traffic at Mid Block Locations

Sl. No.	Road Name	Pedestrian Volume (12 Hours)
1.	Along Brigade Road (Near Rex Theatre)	5198
2.	Along M G Road (Near Plaza Theatre)	5366
3.	Along Hosur Road (Near Madiwala Police Station)	3426
4.	Along Gandhi Bazaar Road (Near Roti Ghar)	2578
5.	Along CMH Road (Near HDFC Bank)	2273
6.	Along Kuvempu Road (Near Varalakshmi Nursing Home)	1203
7.	Along Hare Krishna Road (Near Shivananda Bus Stop)	1787
8.	Along 9th Main Road (Jayanagar 4th Block near Janata Bazaar)	5797
9.	Mysore Bank Circle	19168

Table 3.13 Pedestrian Traffic Volume on Major Junctions

Sl. No.	Name of the junction	Peak Hour Pedestrian Traffic
1.	Mysore Bank Circle	19168
2.	K G Circle	10761
3.	Ananda Rao Circle	9002
4.	Yeshwantpur Circle	5475
5.	South End Circle	4870
6.	Malleswaram Circle	3579
7.	Toll Gate Junction	2937
8.	K R Circle	2778
9.	Prof. Shivashankar Circle	2114

Figure 3.10 Pedestrian, Parking and Terminal Survey Locations

3.7.3 Footpath facilities have been provided by BMP. However, the footpaths in many locations, especially in the commercial areas are occupied or encroached upon by vendors and hawkers resulting in spilling over of the pedestrians on to the road. This in turn results in vehicle-pedestrian conflicts. At many places the footpaths are narrow. Most of the footpaths do not have proper surface which forces pedestrians to walk on roads. Zebra crossings have generally not been provided on busy roads. Heavy pedestrian traffic is observed in the core areas of the city. However sufficient facilities, particularly for crossing, have not been provided for pedestrians. At some locations, foot over bridges have been constructed. However, these are not being effectively utilised by the pedestrians. This is an aspect which will need priority consideration. Facilities like subways or sky-walks with lift facilities may be a better option.

3.8 PARKING CHARACTERISTCS

3.8.1 Parking is assuming critical dimensions in Bangalore. Demand for parking is increasing with increasing vehicles and on-street parking is almost exhausted in the city centre. Parking surveys done at some important locations (shown in **Figure 3.10**) like bus terminals and commercial areas have indicated large parking demand as given in **Table 3.14**. Most parking requirements are of short duration upto two hours. Some of the roads like J C Road, Sampige Road, M G road, Brigade Road, Commercial Street, CMH Road, Jayanagar 4th Block, Shivajinagar and K G Circle attract huge volume of vehicles especially during peak hours, week ends and holidays. Sufficient provision has been made for parking at KSRTC Bus Terminal and Railway Station. Parking lots have been constructed on J C Road and K G Road. However, the demand for parking is so heavy that the parking lots have not been able to cater to the increased demand.

Table 3.14 Parking Characteristics at Selected Locations

Sl. No.	Road Name	Peak Accumulation		Avg. duration in Hrs	
		Cars	Two wheelers	Cars	Two wheelers
1.	Jayanagar 4th Block- nr. Arya Bhavan	48	301	1.562	1.785
2.	Sampige Road / Margosa Road (Malleswaram Circle upto 18th Cross)	63	299	1.681	1.825
3.	M.G. Road (Brigade d to Mayo Hall)	155	45	1.710	1.843
4.	(Brigade Rd to Kumble circle)	84	331	1.738	2.287
5.	Commercial Street	39	7	1.544	4.000
6.	Gandhi Bazaar Road	88	350	1.840	1.711
7.	J.C. Road	97	391	2.441	1.763
8.	KSRTC Bus Stand	-	482	-	2.998
9.	City Railway Station	121 +23	339	2.120	1.718
	City Railway Station- second entry	48 +26	260	2.033	2.008
10.	Banashankari Temple	8	22	1.836	1.924

11.	Banashankari BDA Complex	58 +5	327	1.661	1.969
12.	Rajajinagar RTO Complex	34 +13	66	0.838	2.575
13.	Koramangala BDA Complex	44	329	1.443	1.982
14.	CMH Road	98 +3*	335+21@	1.984	1.595
15.	Russel Market	226 +4*	236+47@	1.759	2.033

* Auto rickshaws @ Cycles

3.8.2 Measures in force

- Pay & Park for on street parking
- Conservancy parking
- Parking lots by BMP – Market, J.C.Road, Jayanagar, PUB etc.,
- BMTC parking lots at Shivajinagar, BSK etc.,

3.8.3 Future plans

The future plans on the anvil initiated by the ULBs are listed below:

- Increased Pay & Park systems
- New MS Parking lots by BMP, BMTC
- More conservancy parking

Parking is causing traffic obstruction. A comprehensive parking survey needs to be taken covering the entire city and parking plan prepared indicating on-street and off-street parking locations. A suitable parking policy needs to be devised for the city.

3.9 SPEED & DELAY STUDY

3.9.1 Average network travel time and journey speed provides an insight into the road traffic performance. This in turn helps in identification of specific traffic congestion spots. Moving car method is the general method used for establishing the speed flow relationship for different types of road categories. This method was adopted to measure the network speeds and delays occurring at junctions which in turn is used for developing the speed flow relationship.

3.9.2 The moving car survey was conducted on 16 selected routes. The routes selected for the speed and delay study is given in **Table 3.15**.

Table 3.15 Speed & Delay Survey Routes

SN.	Road Name	Type of Road
1.	South End Road – From Jayadeva Hospital to R V Road	4L, 2W
2.	R V Road – Rajalakshmi Nursing Home to Minerva Circle	4L, 2W, D
3.	KR Road – Krishna Rao Park to Banashankari Temple Bus Stand	2L, 2W, UD
4.	Airport Road – Trinity – Marathahalli Bridge	4L, 2W, D
5.	M G Road – Kumble Circle to Brigade Road	4L, 2W, UD
6.	M G Road – Brigade Road to Trinity Circle	4L, 2W, D
7.	Dr. Rajkumar Road (Sujatha Theatre to Prasanna Theatre)	4L, 2W, UD
8.	Palace Road (Mysore Bank Circle to Basaweshwara Circle) a) Mysore Bank Circle to Kantharaj Urs Circle b) Kantharaj Urs Circle to Basaweshwara Circle	 2L, 1W, UD 4L, 2W, UD
9.	Bellary Road – Cauvery Theatre to Ganganagar	4L, 2W, D
10.	Ring Road – Hebbal Flyover to Banaswadi	6L, 2W, D
11.	Mysore Road – Sirsi Circle to Ring Road	4L, 2W, D
12.	District Office Road – Police Corner to Mysore Bank Circle	6L, 1W, UD
13.	ASC Junction to Richmond Circle via Victoria Road	4L, 1W
14.	Magadi Road – Leprosarium to Prasanna theatre	2L, 2W, UD
15.	Sampige Road and Margosa Road – Malleswaram Circle to 18th Cross	2L, 1W, UD
16.	CMH Road – Adarsha to CMH Road Junction	2L, 2W, UD

Note: 6L : 6 Lanes 2W : 2 – Way D : Divided
4L : 4 lanes 1W : 1 – Way UD : Undivided
2L : 2 lanes

The road stretches were so selected that it covers all the categories of roads like 2 lane roads 1 way and 2 way, 4 lane roads divided and undivided, 6 lane roads divided and undivided, 4 lane road one way and 6 lane road one way. This helps in arriving at a proper relationship of the speed-flow diagram.

3.9.3 Seven runs were made along each route, three each in the morning & evening peak hours and one run in the afternoon off-peak hour. Morning peak hour is generally observed between 9 AM and 11 AM while the evening peak hour is between 5 PM and 7 PM. The time taken to travel from one node to the next node along the identified routes was noted down in the data sheets. Whenever queuing was encountered, the time of delay was noted down as this helps in isolation of delay form the running time.

3.9.4 Classified traffic volume count was also conducted on the link on which the moving car survey was conducted. Volume counts were taken to cover two peak periods of morning and evening as also the afternoon off-peak period of the day.

3.9.5 The speed data by moving car, the network inventory data and the volume counts have been made use of to derive the speed flow relations in the form

$Y = a - bx^n$ Where

Y = Speed

a = constant (speed at free flow)

b = Coefficient of x

x = Flow in PCUs / hour / lane

n = Power of x

This is the form of equation which can be directly fed as an input into the SATURN network. For the development of speed flow relationship, data for each peak and off peak period has been averaged on each link. The links have then been classified into 8 categories based on the number of lanes. Accordingly, the following categories have been identified viz,

- 2 Lane, Undivided, One-way
- 2 Lane, Undivided, Two-way
- 3 Lane, Undivided, One-way
- 3 Lane, Undivided, Two-way
- 4 Lane, Undivided, One-way
- 4 Lane, Undivided, Two-way
- 4 Lane, Divided
- 6 Lane, Divided
- 6 Lane, Undivided, One-way

The curves so developed have been presented in **Table 3.16**.

Table 3.16 Results of Speed & Delay Study

Lane Category	Speed at Free Flow (Kmph)	Assumed Directional Capacity in PCU / Hr	Power Term n	Speed at Capacity (Kmph)	R^2
2 Lane, Undivided, One-way	35.59	3600	0.58	13.13	0.926
2 Lane, Undivided, Two-way	27.59	1800	1.20	10.91	0.856
4 Lane, Undivided, One-way	40.72	5800	0.52	17.35	0.722
4 Lane, Divided	41.82	3600	0.78	13.70	0.701
6 Lane, Divided	42.82	3600	0.55	17.02	0.712
6 Lane, Undivided, One-way	48.92	7000	0.60	19.25	0.576

The average peak hour speed is found to be 13.2 Kmph.

3.10 PUBLIC TRANSPORT SURVEY

3.10.1 Public transport survey was conducted along selected 10 bus routes. The routes were so identified and selected such that the survey covers the North-South and East-West corridors of the study area Bus route survey was done in order to

assess loading pattern and running time. The shortest route was 14.6 km and the longest route 76 km. Analysed results for the ten routes are tabulated in **Table 3.17**.

Table 3.17 Public Transport Survey on some Bus Routes

Route No	Route-from-to	Distance Km	Maximum passengers	Booked time	Actual Time	
					Minimum	Maximum
500	Banasankari to Banasankari	76	88	2:55	2:40	3:29
202	Yeshwantpur B.S to Kumaraswamy layout	24.2	47	1:20	1:32	1:45
287 M	Hebbal to Konankute Cross	20.0	69	1:20	0;50	1:12
TR-7	Banashankari III s II Ph to Jeevanahalli	17.0	78	1 ;05	1:10	1:35
MBS 4	K.R.Puram to Sunkadakatte	28.0	86	1 ;10	0:56.	1:34
TR 2	Basaweshwara Nagar to Koramangala	22.5	47	1:10	0:56	1:34
210 H	Shivajinagar to Uttarahalli	17.1	66	0:55	0.56	1:34
311 D	K.R.Puram to Shivajinagar	14.6	57	0:55	0:57	1:20
259	Shivajinagar to Jalahalli East 7th Cross	21.5	46	0:55	0:55	1:20
164	Shivajinagar to BTM Layout	14.5	89	0:45	0:43	1:05

3.10.2 It is seen that average journey speed goes down to below 15 Kmph on some routes. Overcrowding does not seem to be a problem in 80 % of routes.

3.10.3 Opinion survey for Bus and Rail passengers was conducted at 7 bus and rail terminals to study the existing travel characteristics and also to find out the intention of the passengers in modal shift. In spite of a fairly good route network, the bus service cannot provide direct home to work service for many commuters. In many users perception as ascertained from the opinion survey the services the expectation of the commuters is summed up below:

I) Over 70 % of commuters feel that (a) buses are delayed resulting long waiting times; (b) the frequency is not adequate; (c) distance to bus stops should be less

ii) For 52 %, access distance at origin should be less than 250 m and 32 % will accept half mile access distance at origin and the corresponding percentages at destination end are 45 % and 37 % respectively

iii) 69 % feel the numbers of routes are not adequate.

iv) 98 % of respondents are in favour of MRTS in city

v) 81 % would like feeder bus service to MRTS stations

vi) 89 % would like to have parking facilities at MRTS stations

vii) 43 % want MRTS fares to be same as in us for comparative distance and 32 % are prepared to pay only 25 % extra over bus fare for same distance.

viii) 90 % of respondents prefer single ticketing system between bus and MRTS

3.10.4 The longer access distance, low frequency and high travel time combined with longer waiting times have caused lower patronage of bus transport. Majority of commuters are reluctant to walk more than a quarter kilometer to the bus stop or from bus stop to destination. All these have caused a number of commuters who would have otherwise traveled by bus to prefer a two wheeler for travel. Thus, over the years, the numbers of private vehicles on roads have gone up causing congestion, which in turn has further reduced average speed of buses making them less attractive. This trend can be seen from **Table 3.18** which gives the change in modal split over the last 24 years. This table shows that over the years share of trips by cars has increasing due to rising car ownership levels, inadequate and unattractive public transport system. Share of trips by two wheelers has also gone up significantly. Of late two wheeler users have been switching over to cars due to rising income levels. Share of public transport has declined to some extent although in terms of absolute numbers it has increased. Share of trips by cycles has declined.

Table 3.18 Trend in Modal Split in Bangalore Metropolitan Area

Year	Modal Share (%)					
	Car	Two wheeler	Public Transport	IPT	Cycle	Total
1982	3.5	12.1	55.0	13.3	16.1	100.0
2003	5.4	36.3	48.9	7.3	2.0	100.0
2006	7.2	32.0	45.7	12.6	2.4	100.0

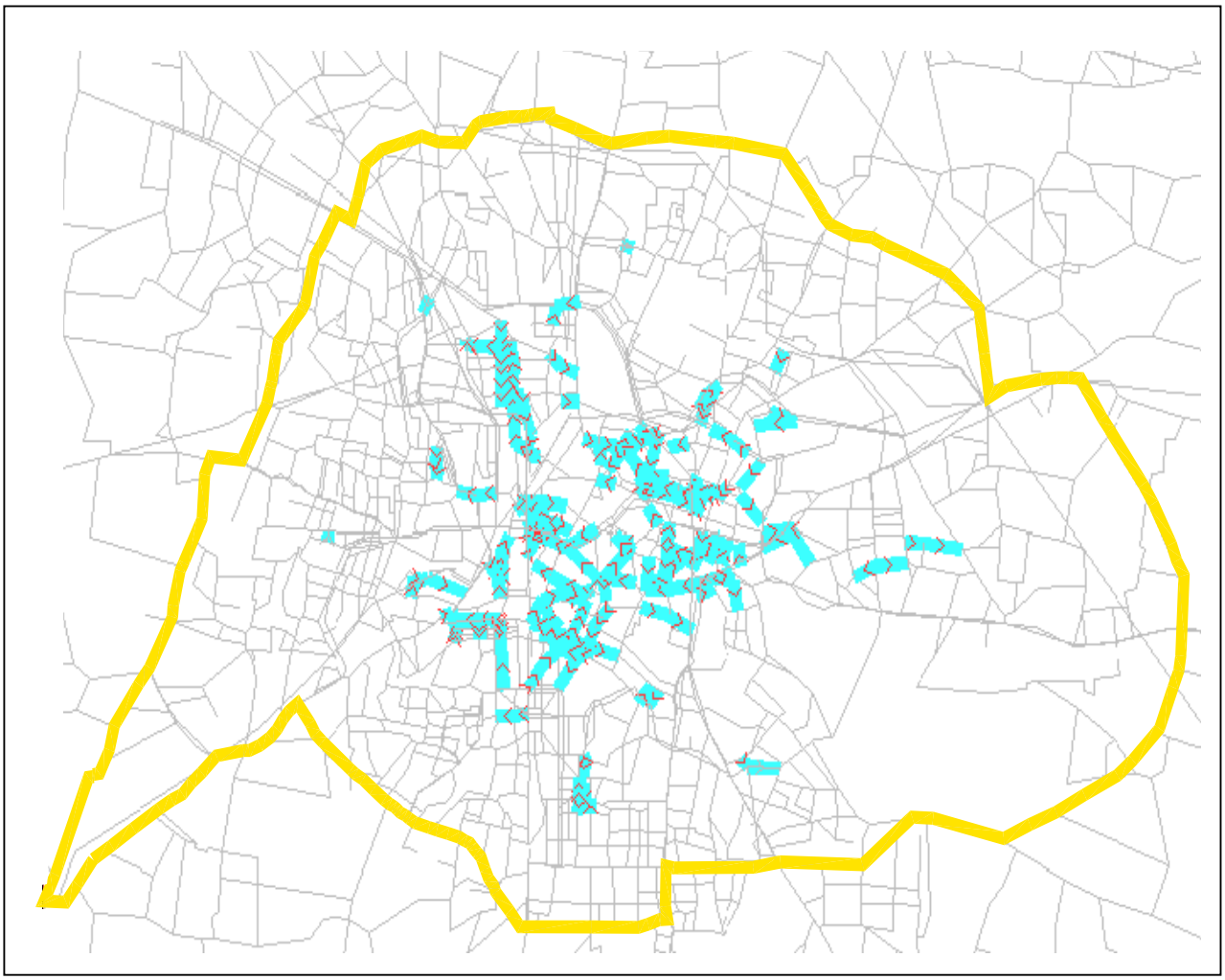
3.11 TRAFFIC MANAGEMENT

3.11.1 With nine radial corridors and a number of orbital roads, some of which are not continuous, there are a large number of intersections in the city. With the rapidly growing traffic, delays at junctions increase causing difficulty in controlling and regulating them. Traffic police who are in charge of enforcement also do the planning required for such regulation. The Policy that the Traffic Police has been emphasizing has been a multi-layered approach:

- Traffic Management – through regulations and restructure
- Traffic Infrastructure – in terms of grade separators and sub-ways
- Intelligent Transportation Systems (ITS) – use of Automated Traffic Control Systems
- Synchronised Signal Systems
- Automated Enforcement – through PDAs

3.11.2 As part of this strategy the Bangalore City Police has been undertaking the management by introducing one way systems in central areas. Over the past thirty years, about 260 km of roads have been converted as one way streets, of which 87 km were converted in the last two years only (shown in **Figure 3.11**).

Figure 3.11 Existing One Way Streets



The Police has launched the AECs and is in the process of installing synchronised signals in phases. The City Police has drawn up plans to undertake the Intelligent Transport Systems (ITS) in the near future.

3.11.3 Bangalore is characterised by the presence of numerous junctions at short distances. The distance between two junctions is hardly about 300 to 400m. BMP has 162 signalised and 600 manual intersections. Intersection management often constitutes a major chunk of traffic management. Intersections invariably delay traffic since all the arms of the junction share the same space for proceeding and turning. In view of this, the vehicles pile up at the junctions. The traffic is however being managed by installation of traffic signals at major junctions and the minor junctions are being controlled by traffic police. The traffic is being controlled by the traffic police and depending on the quantum of vehicles plying on the road network, the traffic management measures are being implemented which include one way roads, ban on entry of certain type of vehicles, exclusive lanes for IPT vehicles etc.

3.11.4 **Medians**: Most of the multi lane roads are provided with medians and where there is no provision for the same, the medians are being implemented in phases. However, the dimensions of the medians erected are not as per standard IRC norms. This is basically due to non availability of land to widen the road. BMP has plans to widen some of the roads.

3.11.4 **Parking**: Parking is a major problem in the city. Parking Demand is increasing with increasing vehicles and on-street parking is almost exhausted in the city centre. Enforcing parking restrictions on roads will require provision of alternatives in from of multi storeyed lots and alternative pricing mechanism as a disincentive.

3.12 ROAD ACCIDENTS

3.12.1 Accident data for the past 6 years has been collected from the traffic police department i.e. from 2001 upto November 2006 and is given in **Table 3.19**. The data pertains to Bangalore Corporation area only. The table shows that a large number of road accidents take place and claim many lives every year. The table also shows that the numbers of accidents have stabilized. This may be due to high congestion and declining speeds on roads.

Table 3.19 Road Accident Scenario of Bangalore City

Year	Fatal	Killed	Non-Fatal	Injured	Total
2001	668	703	8358	6929	9026
2002	783	820	9073	7577	9856
2003	843	883	9662	7980	10505
2004	875	903	8226	6921	9101
2005	793	833	6782	5899	7575
upto 30.11.06)	776	809	6051	5457	6827

Source: Traffic Police Department, B'lore

3.12.2 Most traffic accidents result from the careless behaviour of road users viz., drivers or pedestrians. The probability of accident occurrence and the severity of the accidents can be reduced by proper application of traffic control devices, good road way design features and traffic road management measures.

3.13 PROBLEMS AND ISSUES

3.13.1 The analysis of collected data from primary and secondary sources has brought the following major issues regarding the transport system of Bangalore.

1. Road network capacity is grossly inadequate. Most of the major roads are with four lane or less with small scope of their widening. This indicates the need for judicious use of available road space.

2. The junction spacings are with small length on many roads. Many junctions in core are with 5 legs. This makes traffic circulation difficult. There is need to optimise the available capacity by adopting transport system management measures and by making use of intelligent transportation systems.

3. Traffic composition on roads indicates very high share of two wheelers. The share of cars is also growing. This indicates inadequate public transport system.

4. V/C ratios on most of the roads are more than 1. Overall average traffic speed is about 13.5 kmph in peak hour. This not only indicates the need of widening of the roads but the also the need to plan high capacity mass transport systems on many corridors.

5. Outer cordon surveys indicate high through traffic to the city. This points to the need of road bypasses not only for BMA but also for BMRDA area. High goods traffic also indicates the need of truck terminals at the periphery of the city.

6. Household surveys indicate high household incomes. So the vehicle ownership levels are increasing. In the absence of adequate and comfortable public transport system, people are using their personal modes creating not only congestion problems but also environmental pollution.

7. The household surveys indicate high share of work trips. This segment of travel demand needs to be mostly satisfied by public transport system. Considering the large employment centres being planned in the BMA, the public/mass transport system needs to be upgraded substantially.

8. Modal split in favour of public transport is about 46%. The trends show a decline in this share over the last two decades. This is further expected to fall

unless adequate and quality public transport system is provided to the people of Bangalore. Share of two wheelers and cars in travel demand is disturbingly high. This trend needs to be arrested.

9. There is high pedestrian traffic in core area and some other areas in Bangalore. Footpath facilities are generally not adequate and their condition is deteriorating. Therefore up gradation of their facilities is very important.

10. Parking is assuming critical dimensions in Bangalore. Parking facilities need to be augmented substantially. In the long run, city-wide public transport system needs to provide not only to reduce congestion on roads but also to reduce parking demand.

11. Share of cycle traffic has declined over the years. This mode of transport needs to be promoted by providing cycle tracks along the roads.

12. Area of the BMA has been increased as per Revised Master Plan-2015. This plan has provided for densification of existing areas, Mutation corridors, hi-tech areas etc in various parts of the city. This likely to have a major impact on traffic demand. The transport network including mass transport system needs to be planned taking the proposed development in to consideration.

13. Large areas are planned being planned by BMRDA in the BMR. This is likely to increase interaction between Bangalore and suburban towns. There will be need to provide commuter rail services to these towns from Bangalore.

14. Opinion surveys indicate most of respondents will prefer to Metro system. They will also be willing to pay slightly extra for the improved services.

3.13.2 Thus while planning for the transport system of Bangalore, the above problems and issues need to be kept in consideration.

CHAPTER – 4

DEVELOPMENT OF OPERATIONAL TRAVEL DEMAND MODEL

4.1 INTRODUCTION

4.1.1 A Detailed operational model is required to enable estimation of future travel demand which will help in identifying transport requirements. A number of sub-models have to be developed as follows

- Trip end model
- Trip distribution model
- Modal split model
- Assignment model

4.1.2 India is one of the developing country having heterogeneous type of vehicles on road starting from slow moving vehicles such as cycles to medium speed auto rickshaws to fast moving two-wheelers, cars, buses, trucks etc. It is necessary to select appropriate travel demand software which can model multi modal transport system. Various soft-wares are available such as EMME2, SATURN, TRIPS/CUBE etc. An effort has been made in **Table 4.1** to compare these three popular soft-wares as mentioned above to select a best suited to Bangalore city.

Table 4.1 Comparative Capability Statement of three popular transportation planning software

S. No.	Particulars	EMME2	SATURN	TRIPS/CUBE
1	Network Scenario	Network consists of modes, nodes, links, turns and transit lines(up to 1,50,000 links, 60,000 nodes and 6000 zones) - up to 30 modes (such as car, truck, bus, train, walk etc.) - Possible to model the interaction between the modes. - A data bank can contain several scenarios – base year, alternatives to future years etc.	Network consist of modes, nodes, links, turns and transit lines (up to 2,00,000 links, 1,00,000 nodes and 8,250 zones) - Up to 32 modes - Possible to model the interaction between modes - Data bank contains all scenarios.	Network with links, nodes and transit links.
2	Matrices	Matrices contain results as well as in-put data – demand and travel time by O-D pair. - Zone grouping can be defined to allow the production of aggregate matrices.	Matrices contain results as well as in-put data – demand and travel time by O-D pair. - zone grouping can be defined to allow the production of aggregate matrices	Matrices contain input data – demand and travel time by O-D pair.
3	Functions	Functions are defined by the	Functions are defined by	Flexible command

		user.	the user.	language for implementing demand modals. - Advanced, built in functions for implementing standard modeling processes. - User interface in multiple languages
4	Matrix manipulation tools	Can be used to implement any travel demand forecasting model from the classical 4-step model to multi-modal assignment with direct demand functions as well as modes based on trip chains.	Provides facilities to build and modify trip matrices with options for factoring, combining, transposing, Furnessing, compressing / Disaggregating zones.	Matrix estimation functions for private and public transportation.
5	Assignment	Provides an equilibrium road assignment procedure.	Supports a wide range of assignment options, equilibrium, stochastic user equilibrium, All or nothing, stochastic, - Full demand responsive options available (elastic assignment)	Dynamic traffic assignment Multi-path public transit assignment
6	Transit assignment	Provides a multi-path transit assignment for modelling and analyzing.	Solution towards integrated transport - evaluate PT networks & service levels - examine routing options - determines route loading - skim public transport cost - Bus priority measure, LRT & guided bus system, park & ride and Traffic restraint.	Innovative multi-path and multimode approach for modeling public transit path building and assignment.
7	Graphic tools	All elements of the data bank may be displayed using various tools – interactive graphic editor, matrix histogram, shortest path builder, scenario comparison etc.	A vast range of display options - multiple network - analysis option - link and junction annotation - network comparison - turning movement annotation - GIS backgrounds - individual junction plot - lane allocations and speed - identification of problem junctions - journey time plots - bus route information	- Power of GIS -Capability to build, compare and spatially analyze transportation system.

8	Wide variety of application	Can be used to address wide variety of transportation planning problems from inter-urban highway studies to urban road, public transport and multi-modal studies.	Traffic congestion solution, revised traffic management arrangements by-pass or town center relief, development impact, local junction improvement, forecasting the impacts of traffic growth, assessing induced traffic, impact of capacity reduction economic or environmental assessment. From tolling to traffic management, from handful of junctions to full regional studies.	- Simulation of personal travel -Freight -Environmental impact
9	International user base	Supports international character sets, plot titles in several languages and representation of left-hand traffic.	Has over 300 users' world wide in 30 countries and also widely used for research projects. Has been used in Santiago, Cambridge, Kuwait, Dublin, Leeds, Chennai and Mumbai.	Used in many countries by various consultants.
10	Use in India	Information not available	Used in Chennai and Mumbai and the software is customized to Indian conditions	Information not available

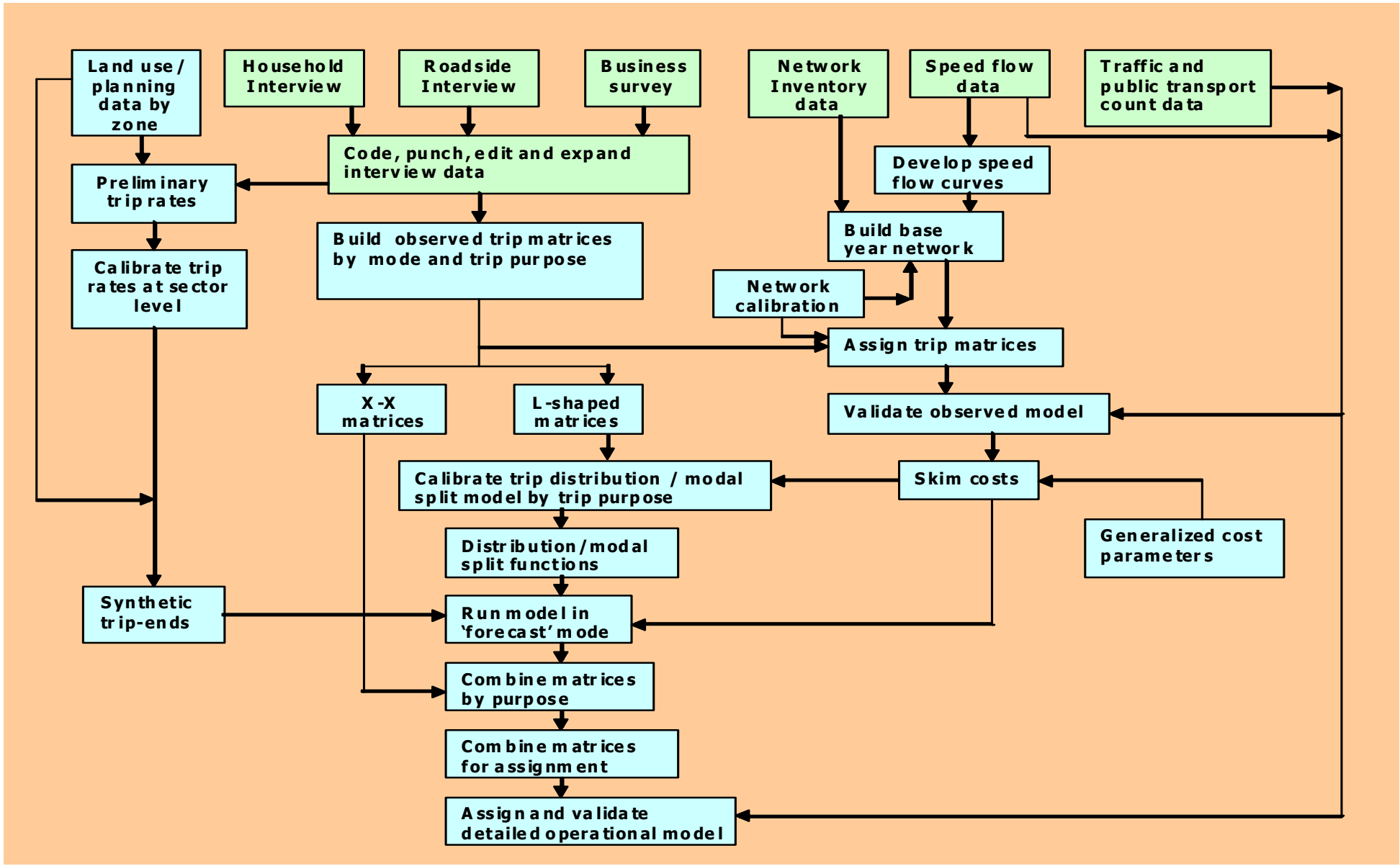
4.1.3 The comparison of the above three software infers that the software PT-SATURN developed by University of Leeds and M/s WSATKINS has been customized to Indian conditions while being used in Chennai and Mumbai. It will be prudent to mention here that the software at Chennai has been used by M/s RITES Ltd during the preparation of Comprehensive Traffic and Transportation Plan for Chennai Metropolitan Area in 1992-95. Hence SATURN was found the appropriate one to use for Bangalore.

4.2 METHODOLOGY FOR MODEL DEVELOPMENT

4.2.1 The steps involved in model development are indicated in **Figure 4.1**. Trip end models have been developed using multiple linear regression. SATURN /PT-SATURN packages have been used for the other three steps.

4.2.2 The model developed has been used for traffic forecasting for the horizon year at the strategic level including public transport corridor system. The extensive data base that was established as a result of the traffic surveys in 2006 provided the base for the model development, calibrated and validation.

Figure 4.1 Development of Detailed Operational Model



4.3 TRIP GENERATION

4.3.1 The first step is to derive the models for trip generation / production in different zones. The trip generation models can be obtained either by using Multiple Linear Regression (MLR) technique or simple linear regression techniques. The models are based on the premises that;

(i) a linear relationship exists between the trip generation and the other various independent variables which influence the trip production; and

(ii) The influence of each such independent variable on trip production is additive i.e. addition of each variable in the model contributes in a positive or negative way towards the value of dependent variable.

4.3.2 In case of MLR it takes the form

$$To = ao + a1\,x1 + a22x22 + \ldots\ldots\ldots + an, xn$$

ao is a constant;
a1, a2, ……. an are coefficients;
x1, x2, ……. xn are influencing variables

which include one or more planning factors, socio-economic characteristics and trip characteristics. They should normally cover the factors like

(i) The land use pattern and development in study area
(ii) the user characteristics like household size, income, vehicle availability; and
(iii) the nature, extent and capacities of the transportation system

In case of simple linear regression equation the equation takes the form of:

$$Y = a + bX$$

Where, a is a constant, b is the coefficient and X is the independent variable.

4.3.3 Since number of households is highly correlated to either number of workers, number of students, or number of households as a variable would take a negative coefficient and it was not desirable to be included.

4.3.4 As the projection of vehicle ownership or number of vehicles in zone is difficult especially because of non availability of zone-wise economic data this variable has not been considered. But the variables which were decided to be included is as follows:-

For Work :'Zonal population'.
For Educ : 'Zonal population'.
For Other :'Zonal Population'.

The trip generation models developed for peak and off peak period for full BMA are given below:

WHOLE DAY MODELS

Work trips	=	**7092.014 + 0.230406 P**	**R2= 0.829**
Educ. trips	=	**3287.878 + 0.088129 P**	**R2= 0.759**
Other trips	=	**2734.769 + 0.108239 P**	**R2= 0.722**

Where
P = Population
R2 = Coefficient of Multiple Correlation

4.4 TRIP ATTRACTION

4.4.1 Trip attraction can be done only at zonal level. The trip attraction models are mostly derived using regression approach. The data availability at zonal levels, which could be forecasted were checked first. But the relevant data's like number of work places, student enrolment for future years and also land use in terms of commercial area for future years were not available neither in Master Plan prepared by BDA nor else where. In absence of such data effort was made to forecast work places and student enrollment based on information like population and future activity shifting as per the Master Plan. The equation for other trips were developed based on available data like area of commercial areas at planning district levels as data was not available at traffic zonal level. Based on the above the variables used were

Work Trips : Number of work places.
School Trips : Number of school enrolment
Other trips : Commercial area

WHOLE DAY MODELS

Work trips	=	**4904.793+0.68661*WP**	**R2= 0.768**
Educ. trips	=	**2469.983+0.415853*SE**	**R2= 0.700**
Other trips	=	**8989.15+ 401.10 * CA**	**R2= 0.7267**

Where
WP = Work places
SE = Students enrollment
CA = Commercial Area
R2 = Coefficient of Multiple Correlation

4.5 BASE YEAR NETWORK DEVELOPMENT

4.5.1 Introduction – SATURN / PT SATURN

Having identified the study area and traffic zones, the base road network (in SATURN) and public transport network (in PT-SAT) were defined.

4.5.2 SATURN (Simulation and Assignment of Traffic on Urban Road Networks)

4.5.2.1 SATURN is a suite of computer program which has four basic functions

- As a network database and analysis systems
- As a combined traffic and simulation and assignment model for the analysis of traffic management schemes over relatively localized networks
- As a conventional traffic assignment model for the analysis of larger network
- As a simulation model of individual junctions

4.5.2.2 The basic SATURN model has the following six components programs

- The Network build program
- Assignment program
- Simulation program
- Analysis program
- Network editing program
- Network plot program

4.5.2.3 **For the network build program SATNET, data required are the link data like** distance, free and capacity speed capacity, power of speed – flow curve, bans on links coordinates of nodes, public transport routes etc.

4.5.3 PT-SATCHMO (SATURN Travel Choice Model)

4.5.3.1 SATCHMO is a multi-modal transport package to complement SATURN and provide facilities to model the new measures and responses. The public transport programs are used to

- Build Network (SAT10)
- Build paths
- Skim trees
- Evaluate inter zonal costs
- Assign a trip matrix to network

4.5.3.2 To build network, link speed will be read from SATURN network factored for allowing slowing at stoppages. The bus route is also read from the SATURN private network.

4.5.4 Private Vehicle Network

4.5.4.1 The Bangalore Metropolitan Area is served by a network of roads and railways to facilitate travel within the area by both private and public transport. But the network within the area is not well defined on scientific basis and also it doe not have proper well defined hierarchy of roads. Depending on the characteristics of some of the roads it is possible to broadly divide them into 4 categories like

- Arterial roads
- Sub-Arterial roads
- Collector-distributors roads
- Local Streets

4.5.4.2 It was assumed that all trips generated within zone will emanate from zone centroid. In order to load the trips on to the network they are connected to the network with the help of zone centroid connector. The travel characteristics of a centroid connector will represent the zonal average of trips starting and ending at that zone. For any centroid there may be more than one centroid connector depending on the local conditions of a traffic zone, and network links in the zone. The base road network, centroid and centroid connectors are shown in **Figure 4.2** and **4.3**. Centroid connectors linking zones with nodes were assigned with speeds of 15 Kmph in the city, 20 Kmph in outer regions. Distance is measured from each loading point to the theoretical centre of gravity.

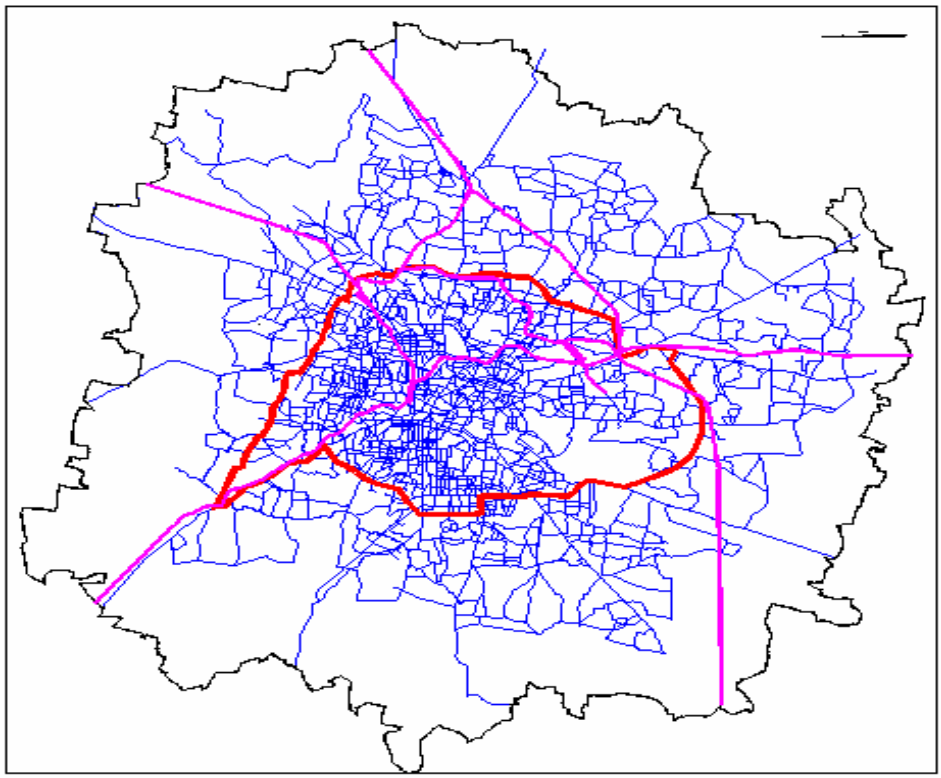


Figure 4.2: Base Road Network

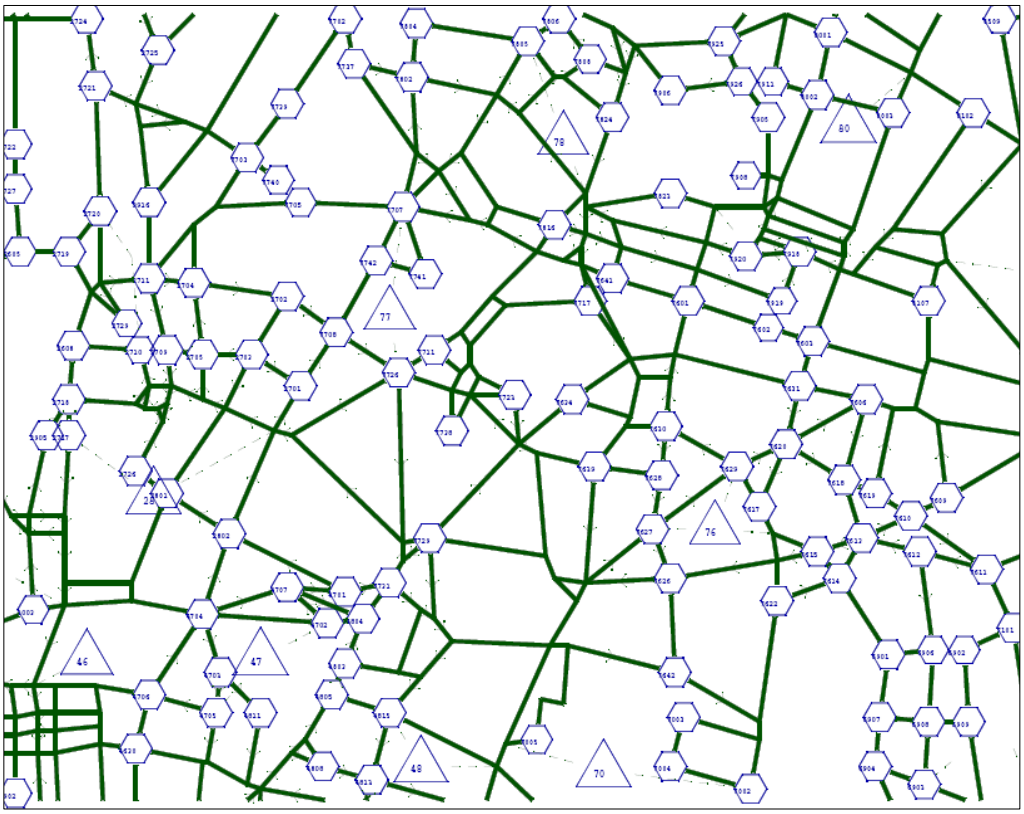


Figure 4.3: Road Node and Centroid and their Connectors

4.5.4.3 Link lengths were measured from the plans and checked at random by measuring at sites. Each link was also allocated a speed flow curve according to the speed flow study mentioned earlier and depending on category of the link in which it is falling.

4.5.4.4 Bus services of BMTC were coded with more details. The frequency of buses operating on each route was coded so as to preload the same to the private vehicle network. A bus PCU value of 3.0 was assumed.

4.5.5 Public Transport Network

4.5.5.1 The public transport network developed in PT-SAT is a composite network consisting of both bus and rail services. This helps in passenger interchange between the two. The composite network allows greater flexibility in route choice and helps in realistic assignment of trips from the combined public transport matrix.

4.5.5.2 PT SATURN extracts the bus routes and frequencies from SATURN network file. An extensive system of both bus and rail routes were modeled. This include all the intra city bus services run by BMTC and suburban rail service and exclude the intercity bus and rail services.

4.5.5.3 Bus speeds are read directly from SATURN network file which includes the effect of congestion due to private vehicles. A factor of 1.2 was used on these speeds to reflect time lost at bus stops.

4.5.5.4 Centroid connectors link centroids to the bus and rail network at major nodes and appropriate stations. The Centroid connectors represent overall walking time from Centroid to the public transport system. The mean walking speed was considered as 5 Kmph.

4.5.5.5 Transport links represent connections between bus to bus routes and railway stations. They are considered as walk links.

4.5.5.6 Important assumptions which were made whiling building public transport network are :

- Private Vehicle link times are factored by 1.2 to allow time lost at bus stops enroute
- Actual walk time is factored by 2.0 to represent perceived walk times.
- Waiting time is calculated as half the service head way. This is factored by 2.0 as for walking time.
- Bus transfers at a node accrue an additional 2 minute penalty.
- Bus fares calculated as Rs.1.00 as fixed fare, taking in to account the sale of monthly, weekly and daily passes, plus Rs.0.50 per Km. The fixed fare is charged every time a transfer is made.

4.5.6 Network Calibration

Both private and public transport networks were checked thoroughly and corrected wherever necessary in order to achieve reliability and accuracy. The rests included

- Private road network link lengths, bus and rail link lengths in PT network were checked.
- Test tree builds from selected zones to ensure logical routing pattern
- Modelled and observed journey time comparison
- Comparison of modeled and observed vehicles across screen lines in private network and passenger counts in public transport network.
- Assignment checks.

4.6 GENERALIZED COST

4.6.1 The generalized cost of travel is the sum total cost of a traveler's out of pocket expense and the perceived cost of his time of travel by the mode. Generalized cost may therefore differ not just by the mode of travel, but also according to the characteristics of the traveler and of the particular trip that he is making.

4.6.2 Value of Travel Time

4.6.2.1 In order to apply this approach to the valuation of travel time it is necessary to estimate average income and complete travel time cost. Based on the statistical data available the per capita income (per annum) has grown from Rs. 28305 during 1998-99 to Rs. 53625 by 2004-05 at constant prices. The average income per employed resident using a particular mode was extracted from 2% household data collected during HHI. The results are summarized in **Table 4.2**. Assuming full time employees work for 176 hours per month, the time cost was worked out per minute.

Table 4.2 Average per Capita Income per month of Persons Using Different Modes

Mode	Average individual income / month	Rs / hour
2-Wheeler	4469	25.39
Car	7388	41.98
IPT	3611	20.52
PT	2110	11.99

NOTE: 1. Extracted from household survey data.
2. Hourly incomes assume monthly working hours of 176.
3. Income is in Indian rupees

4.6.2.2 Business travel time is valued approximately at the person's wage rate, non-business travel or other trips like leisure, shopping, education etc., is valued at 25% of person's wage rate. In education and other leisure trips it is usually assumed as everyone in household behaves as if his/her income is equal to that of the head of the household, trip to or from work is valued as 50% of person's wage rate.

4.6.2.3 The value of time for peak and off-peak for different modes like car, two wheeler, IPT and public transport is shown in **Table 4.3**.

Table 4.3 Value of Time – Mode wise, Purpose wise and Period wise

Mode	AV Occu	Income/ Month (Rs)	Time Cost per minute	Value of Time / Minute		
				HBW	HBE/O	EB
2-Wheeler	1.53	4469	0.42 per person	0.21	0.11	0.42
			0.65 per mode	0.32	0.16	0.65
Car	2.59	7388	0.70 per person	0.35	0.18	0.70
			1.81 per mode	0.91	0.17	1.81
IPT	2.49	3611	0.34 per person	0.17	0.08	0.34
			0.85 per mode	0.43	0.21	0.85
PT		2110	0.20	0.10	0.05	0.20

NOTE: 1. Income of IPT user is weighted average of both auto rickshaw user and taxi user.
2. HBW cost = time cost per person * 0.5
HBO cost = time cost per person * 0.25
EB cost = time cost per person * 1.00
3. Income and time cost is in Indian rupees

4.6.3 Operational Cost

4.6.3.1 Car users:

This will include car operation in terms of fuel and oil. The break up of cars of various makes can be considered as Small cars 55%, big and SUV cars 30% and Rest: 15%. Accordingly the average operating costs will be worked out.

Also it is proposed to take in to account the type of fuel used by various cars and they are given in **Table 4.4**.

Table 4.4 Mileage by various Cars

CARS	Total	Km / Lt	Petrol	Diesel
Small Cars	55 %	16	35 %	20%
Big cars	30 %	10	20 %	10 %
Others	15 %	8	5 %	10 %

Average Vehicle Mileage - 13.35 Km/Lt
Cost of fuel - Rs. 50.40 for petrol and Rs. 35.26 for diesel as on 2006
Average Fuel cost per Km - Rs 3.31 per Vehicle.

4.6.3.2 **Two Wheelers**

Depending on the type & make of Two Wheelers available on road it is proposed adopt the breakup as given in **Table 4.5**.

Table 4.5 Mileage by Various Two wheelers

Mode	Total	Km/ Lt
Scooters	35%	35
Motor cycles	40%	50
Mopeds	35%	60

Average vehicle mileage – 48.5 Km/ Lt
Cost of petrol – Rs. 54.50 as on 2006
Average fuel cost per Km – Rs. 1.12

4.6.3.3 Public Transport

The out of pocket expense consists of fare paid by the passenger. The fare is minimum for the first few kilometers and increased on a per kilometer basis or depending on stages. For buses the average fare per km is Rs. 0.50 for ordinary bus with Rs. 3.00 as minimum and Rs.0.75 for pushpak buses with a minimum fare of Rs.4.00. The weighted average of minimum fare was worked out taking in to account the sale of daily passes, weekly passes and monthly passes and it is Rs.1.00

4.6.3.4 IPT

For Auto & Taxi the fare depends upon per km rate. At present min auto fare is Rs. 12.00 for 2.0 Kms & for Taxi it is Rs. 30.00 for 3 Kms. The weighted average fare for IPT per km works out to Rs. 7.50 / km and the same has been proposed to use in model.

4.6.3.5 Commercial vehicles

It is assumed that on an average the salary of driver and the helper works out to Rs.12000/- per month. It was also found that they work for about 20 days in a month and for a period of about 12 hrs in a day. Similarly on analysis of fuel consumption it was found that HTV give 3.84 km/ltr of diesel and LCV give 8.73 km/Lt. A combined weighted average for the commercial vehicles gives 5.13 km/Lt of diesel.

Time cost for Driver/helper – Rs.0.83/min
Expenditure on fuel – Rs.6.87/km (at 2005 price)

4.6.7 The determined time costs and operation costs goes as input in the assignment and distribution model to extract cost matrices for various modes and purpose.

4.7 CALIBRATION AND VALIDATION OF OBSERVED MODELS

4.7.1 There are two clear links between private vehicle and public transport assignments and the subsequent development of cost matrices – SATURN takes route and frequency data from the PT-SAT network takes link speed data from the SATURN assignment.

The private vehicle cost matrices were produced in three steps:

* Matrix development
* Network calibration/assignment validation
* Cost skims

4.7.2 Matrix Development

4.7.2.1 A total of 21 observed private vehicle trip matrices were produced as follows for the whole day.

*	Light vehicles	–	5 purposes (HBW, HBE, HBO, NHB, EB) 3 modes (car, 2-wheeler, IPT)
*	Commercial vehicles	–	(all employees business)
*	Cycle	–	5 purposes (HBW, HBE, HBO, NHB, EB)

4.7.2.2 Private vehicle passenger matrices and Public Transport passenger matrices both purpose wise and mode wise was built for distribution and modal split and the Private Vehicle (PV) matrices in terms of PCUs was built for assignment purposes. The heavy vehicles, private vehicles and cycle matrices were in PCUs and have been derived by converting person trips matrices from corresponding purpose wise occupancy figures and PCU values.

4.7.2.3 The private vehicle – car, IPT and two wheelers were combined for assignment to the private vehicle network (See **Table – 4.6**).

Table 4.6 Total number of Vehicles and trips Assigned

Vehicle type	Peak Period
Cycle	10233 PCU's
Commercial vehicles	10199 PCU's
Private modes – cars, 2-w and IPT	189569 PCU's
Public Transport	338195 person trips

Note: PCU values Car : 1.00, Cycle : 0.50, Truck : 3.00, 2-W: 0.75 and Auto : 1.20

4.7.3 Network Calibration / Assignment Validation

4.7.3.1 Private Vehicles

Approach to assignment in SATURN is to allow different vehicle types or road users to follow different routes through network up to 20 iterations for each ij pair. The basis for route choice was also varied and tested in each case in order to produce an assignment which best fitted observed behavior. BMTC scheduled bus routes were incorporated as fixed flows. Commercial vehicles and cycles were

assigned to the network first as preloads. Here the trees were based on minimum distance paths for cycles and minimum cost paths using free-flow speeds for commercial vehicles.

4.7.3.2 The private vehicles – car, IPT and two-wheelers matrices were then assigned to minimize generalized costs.

4.7.3.3 An "Equilibrium" assignment technique was followed whereby traffic arranges itself across network in such a way that all routes used for any origin and destination movement have equal and minimum costs, while all unused routes have greater costs. The algorithm employed in SATASS uses an iterative sequence.

- The complete matrix are assigned to minimum cost trees to produce a set of link flows.
- A new set of link costs are calculated as a result of first assignment and used to define new minimum cost routes.
- The matrix is reassigned to produce a newest of link flows.
- An improved set of link flows are calculated from a combination of the first two, the proportion of each being calculated on the basis of the need to minimize overall costs on all links across the network.
- A new set of link costs are then calculated and so on.

4.7.3.4 This procedure provided for satisfactory convergence after 20 iterations, convergences was defined as a situation where sum of link costs across the network, is within 1% of the costs where all trips properly assigned to equal minimum cost routes. Thus in an un-convergent assignment, the above equilibrium condition is not satisfied because different routes carrying traffic between the same destination pairs are not all of equal cost.

4.7.3.5 **Calibration of Private Vehicle Network**

The resulting assignment flows and journey times were compared with the ground count (observed flows and observed journey times). These checks on validation led to a sequence of minor network corrections, followed by assignment and further validation checks. Particular attention was placed on.

- checks on link capacity throughout the network especially at level crossing, bridges across rivers, causeways, roads with encroachment etc. by comparing journey times with observed values.
- revision to some zone centroid connectors to load traffic on to the network at more appropriate locations.

Generalized cost and time only assignment were tested using the Wardrop equilibrium assignment in SATURN. The principle behind this technique is traffic arranges itself on congested network in such a way that the cost of travel on all routes used between each O-D pair is equal to the minimum cost of travel and all unused routes have equal or greater cost (i.e. same as above). The finally selected assignment methodology was all or nothing for cycles, stochastic user equilibrium (SUE) assignment for commercial vehicles. In SUE technique, the traffic arranges itself on congested network such that the routes chosen by individual drivers are those with the minimum perceived cost; routes with perceived costs in excess of the minimum are not used. The main difference is that SUE goes through a fixed number of all-or-nothing assignments randomizing costs (within a range) each time.

4.7.4 Public Transport Network

4.7.4.1 The public transport network develop in PT-SATURN consists of both bus and rail services, so that passenger may interchange between the two. Bus routes are read into PT SATURN directly from SATURN network file. Bus speeds are read directly from the SATURN loaded network file so that journey times by bus include the effect of highway congestion. Before it is being assigned with PT trips the network was thoroughly checked and amended where necessary.

- Numbers of assumptions were made while building PT network.
- Private vehicles link times are factored by 1.2 to allow stoppages of buses at bus stops.
- Actual walk times doubled to represent perceived walk time, a common assumption.
- Waiting time will be half the service headway.
- Bus transfer will mean additional 2 minutes penalty.
- Bus fares calculated on the basis of Rs.1.00 fixed fare and Rs.0.50 per km.
- Fixed fare is charged to Bus passengers every time a transfer is made.

4.7.4.2 PT-SAT assigns the public transport matrix of both bus and rail to single all or noting trees based on minimum cost. All passengers between any two zones are assumed to travel along the same route. Each route may contain various elements of travel including

- Walk to bus stop or Railway station
- Bus or Rail options for major travel
- Transfer between bus and train / bus & bus.
- Waiting time at bus stops & Railway stations.

4.7.5 Validation Statistics for Assignment of the Observed Matrices

Screen line Comparison

Validation was assessed on the basis of comparison of observed counts against corresponding model forecasts. Traffic counts were those carried out at each of the screen line survey sites.

Total modelled flows across screen line, are within 0.12% of counts for morning peak hour. Individual directional screen line totals are generally within 10%. **Table 4.7** shows comparison of observed and assigned flows across screen line.

Table 4.7 Comparison of Observed and Assigned flows

Direction	Assigned	Observed	Difference	% difference
UP	47972	43953	4019	9.15%
Down	35762	36153	-391	1.81%
TOTAL	83734	80106	7714	9.63%

4.7.6 Travel Cost Extraction

The trees output by the final assignment from the SATURN for whole day were extracted to provide cost matrices for all modes and purposes, the bus passenger costs were obtained from extraction of the PT-SATURN assignments. Since a converged assignment by definition may contain a number of different but equal cost routes between pair of zones, it was necessary only to skim the final set of trees. The total cost for each zone pair was incorporated in a set of cost matrices.

4.7.7 Calibration and Validation of Gravity and Modal Split Model

4.7.7.1 The purpose of trip distribution modeling is to find equations that reproduce intra-zonal patterns of surveyed traffic. It should function to fill any unobserved cells of a partially observed trip matrix or to forecast the effects of changes in the transport system on the choice of trip destination used to predict changes in patterns of movement resulting from new infrastructure, changed land-use etc.

4.7.7.2 Modal split or modal choice modeling attempts to estimate the total amount of patronage on the different transport modes. Trip distribution indicates the spatial pattern of this demand. Modal split is the allocation of the total surveyed traffic to separate modes as normally used in the bi-partition of traffic in to private and public mode. For this study we have adopted joint distribution / modal split model based on gravity modeling as this option is available in SATURN / PT-SAT suite.

4.7.7.3 **The process of trip distribution and modal split is shown in Figure 4.4**

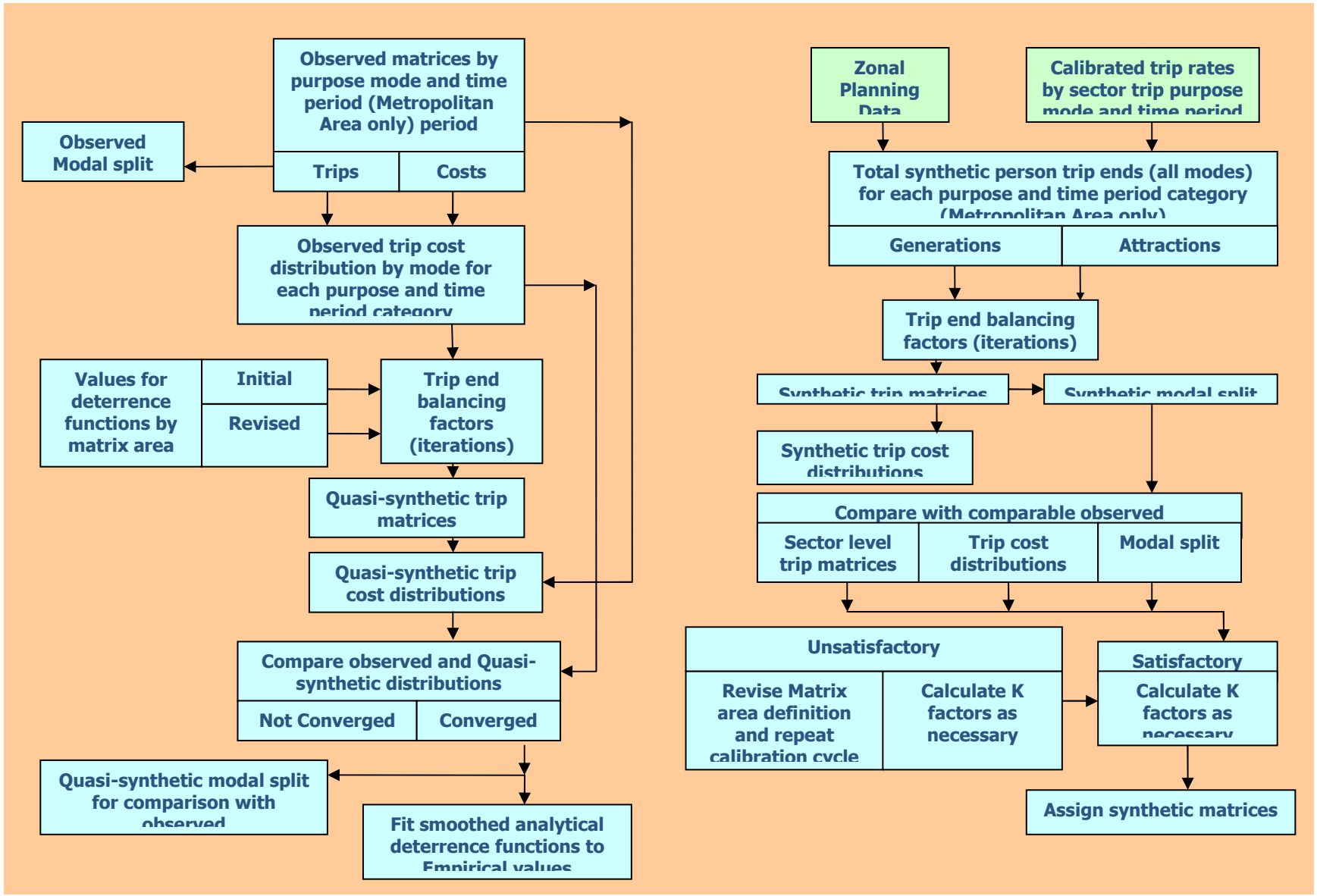


Figure 4.4 PROCESS OF TRIP DISTRIBUTION AND MODAL SPLIT

4.7.8 Approach

4.7.8.1 After successful completion of calibration and validation of observed models, the trip distribution and modal split phase were carried out jointly using a conventional doubly constrained gravity model of the form.

$T_{ijm} = r_i G_i S_j A_j F_{ijm}$

Where = T = number of interzonal trips by mode m
G = Total generation trip ends by zone
A = Total attraction trip ends by zone
i = Generation zone
j = attraction zone
r, s = balancing factors (constant)
F_{ij} = deterrence function for mode m
= $Km\ e^{-Bc_{ijm}}\ C_{Jim}$

Where K = constant factor
C = generalized cost of travel
= Calibration constant – exponential function
= Calibration constant – power function

Double constraints are imposed by ensuring that

$\sum_{Jm} T_{im} = Gi$ $\sum_{im} T_{im} = A_j$

The form of the model in such that exponential (α = o) or power (β= o) functions may be used for the deterrence function. The inclusion of both α and β represents a gamma function, sometimes called a Tanner function.

4.7.8.2 Given a matrix of intra-zonal costs and a set of generation and attraction trip ends, a gravity distribution model estimates the factor r and s automatically, leaving the calculation of the deterrence function as the main feature of the models calibration. The cost of travel between zones is associated with a deterrence function whereby the higher the intra-zonal cost, the greater the deterrence to trip making, and therefore the lower the number of trips between zones. This is the principle of the gravity distribution model.

4.7.8.3 Trip distribution models are generally run subsequently for a number of different trip purposes time periods or modes. A joint distribution and modal split model carries out this same process but for a number of different modes simultaneously. Calibration of a joint model is achieved by calculating deterrence functions for each mode as for a normal distribution model, but weighting these functions in accordance with observed modal split. The proportion of trips made by each mode is a function of the cost of travel on that mode compared with the

costs by all other modes. It is these weights which represent the different characteristics of each mode, the effects of which are not adequately determined by generalized cost variables.

4.7.8.4 Calibration constants defined by mode for each purpose and time period category are used to forecast the distribution and modal split of trip ends in conditions of changing inter-zonal costs.

4.7.8.5 This is conventional, calibrating the model on the basis of observed trip and cost matrices, and building synthetic matrices by applying the calibrated constants in forecast mode.

4.7.8.6 **Model inputs**

Trip matrices

The following observed trip matrices were input to the distribution/modal split model calibration:

- HBW, HBE & HBO trip purposes
- Whole day
- Car, two wheeler, IPT and PT passenger modes

This provides a total of 14 matrices.

Employers business and Non home based trips were not distributed, as these trips will make calibration of deterrence functions unreliable. Since small number of trips relationship between trip ends and planning data are difficult to establish. Cycles, Commercial vehicles were also excluded form distribution / modal split as these will be assigned as observed.

4.7.8.7 **Software**

The computer programme which is part of SATURN / PT-SAT is for distribution & modal split, and it includes four programs.

D1 – builds observed trip cost distribution
- Calculates trip end balancing factors
- Calculates empirical deterrence functions
- Builds quasi – synthetic trip cost distribution

DFIT – Fits smoothed analytical deterrence functions to empirical functions

M5 – Compares matrices form zone to sector level

M2 – Compares observed and synthesized matrices at the sector Level.

Calibration Statistics

Area definition

The deterrence function includes a factor K which allows different functions to be calculated, even with the same calibration constant, for different areas of the matrix that is different local areas within the study area. Here the model used a single area definition that is Bangalore Metropolitan Area, because results of a single area definition were adequate. This simplifies the forecasting procedure and makes the model more robust. The external trip ends were not distributed. This 'L' shaped portion of matrix consisting of external trips was input directly into the final synthetic matrix in different mode / purpose matrices.

Generation / Attraction

The distribution of trip ends is based on generation and attraction, rather than origins and destinations.

4.7.8.8 **Input Values**

Initial input values for α & β were provided as 0.07 and 0.001. This provided a starting point for distributing observed trip ends which led to convergence after 18 – 19 iterations. Within these, the cycle of calculating balancing factors generally involved between 2 – 6 iterations. An initial value of 1.0 was input for the K factors.

4.7.8.9 **Intra-zonal costs**

In order to ensure that complete trip cost distributions are used in the estimation of deterrence functions, intra zonal costs are required by the distribution model. These do not appear in the cost skim matrices since intra zonal trips are not assigned to the model networks. Private vehicle costs were estimated using the generalized costs, average intra zonal speeds of 15 kph for the zones in the BMA and average intra zonal trip length based on the area of the each zone.

Average intra-zonal trip length = SQRT (7 / 22) * zone area

* Zone areas were calculated as part of the dis-aggregation of planning data to CTTS zonal level.

The intra zonal costs for cars, 2W, IPT and public transport for whole day were.

Cars: Travel time * Time cost
2-W: Travel time * Time cost

IPT: (Distance * Time cost) + Min. fare

PT: Less than 2 km –

(fixed fare / km) + (Waiting time + travel time) * Time cost

More than 2 km –

(Distance * fare / km) + Fixed fare + (Waiting + travel time) * time cost.

4.7.9 Calibration Statistics

The single set of calibration constants were used for distributions over the complete matrix for mode / purpose categories.

4.7.9.1 Deterrence Functions

Deterrence functions (power functions, exponential function and constant) values were identified for different purpose, mode and period. The final analytical function outputs are given in **Table 4.8**.

Table 4.8 Calibrated Deterrence Functions for both Peak and Off Peak Periods

Purpose	Mode	Whole Day		
		Power Function	Exponential Function	Constant
Work	Car	-0.55279	-0.02618	0.79802E-01
	2-Wheeler	-1.02436	-0.02280-	0.74206E+00
	IPT	-1.08434	-0.05119	0.54307E+00
	PT	-1.72920	-0.02498	0.34888E+01
Education	Car	-1.48284	-0.03640	0.12916E+00
	2-Wheeler	-1.60020	-0.01896	0.12781E+00
	IPT	-1.27244	-0.07009	0.29600E+00
	PT	-2.05416	-0.02477	0.42883E+00
Others	Car	-0.93514	-0.02995	0.64678E-02
	2-Wheeler	-1.16506	-0.04154	0.67888E-01
	IPT	-0.51559	-0.09502	0.43992E+00
	PT	-1.79569	-0.04521	0.38062E+01

Note: 1. Observed = Observed matrices

2. Synthetic = Synthetic matrices from gravity model

4.7.10 Comparison of Total Trips

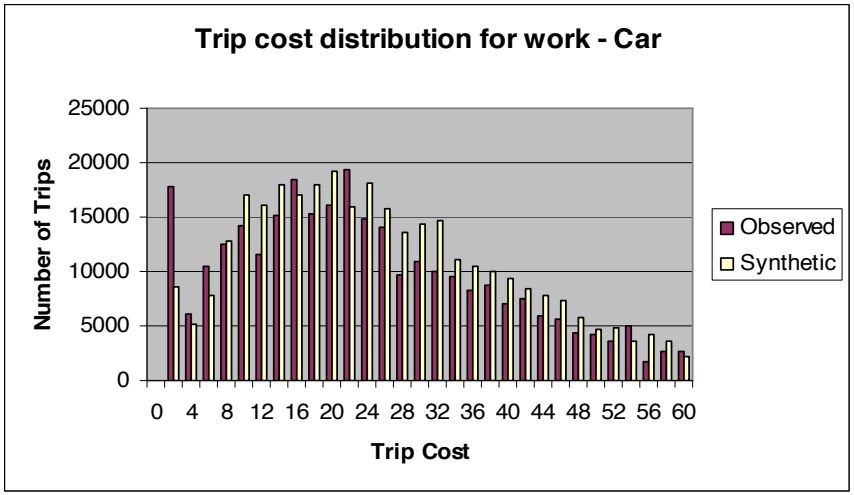
4.7.10.1 **Table 4.9** shows corresponding comparison of total trips in each purpose and mode for both observed and synthetic trips. **Figure 4.5(a) to 4.5(c)** shows the comparison of trip cost distribution for different purposes for peak period. This guarantees the close fit shown in distribution model both in total number of observed and synthesized trips and also trip cost distribution.

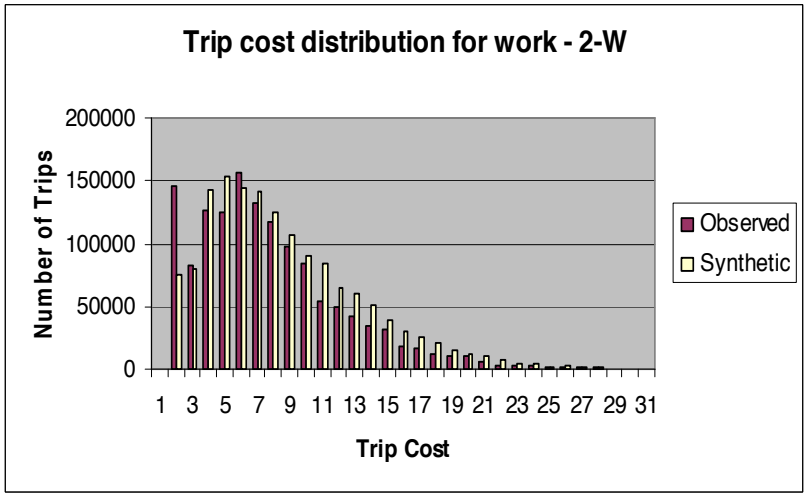
Table – 4.9 Comparison of Total trips by Purpose, Mode and Time Period

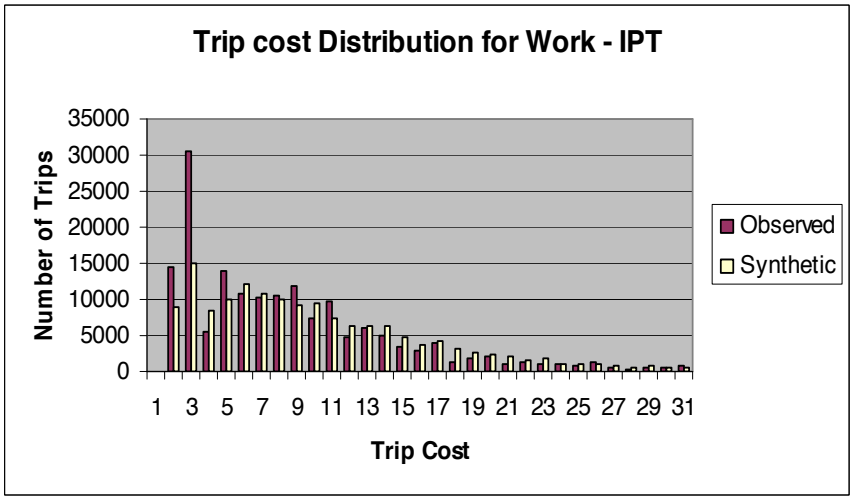
Purpose	Mode	Peak Period		
		Observed	Synthesised	Difference
Work	Car	303274	303865	-591
	2-wheeler	1367549	1369695	-2146
	IPT	170541	171599	-1058
	PT	840104	836409	3695
	TOTAL	2681468	2681468	0
Education	Car	76784	76991	-207
	2-wheeler	159171	157869	1302
	IPT	77663	77620	43
	PT	784871	786058	-1187
	TOTAL	1098490	1098490	0
Others	Car	9812	10196	-384
	2-wheeler	112840	112469	371
	IPT	358600	359553	-953
	PT	659697	658755	942
	TOTAL	1140949	1140949	0

Note: 1. Observed = Observed matrices
2. Synthetic = Synthetic matrices from gravity model

4.7.10.2 **Table 4.10** also shows the comparison of observed modal split with synthesized modal split. It depicts that both the values are within 5% for each purpose and mode. Synthesized average trip costs were also close to observed values.


Trip cost distribution for work - Car
Number of Trips
25000
20000
15000
10000
5000
0
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60
Trip Cost
Observed
Synthetic


Trip cost distribution for work - 2-W
Number of Trips
200000
150000
100000
50000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Trip Cost
Observed
Synthetic


Trip cost Distribution for Work - IPT
Number of Trips
35000
30000
25000
20000
15000
10000
5000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Trip Cost
Observed
Synthetic

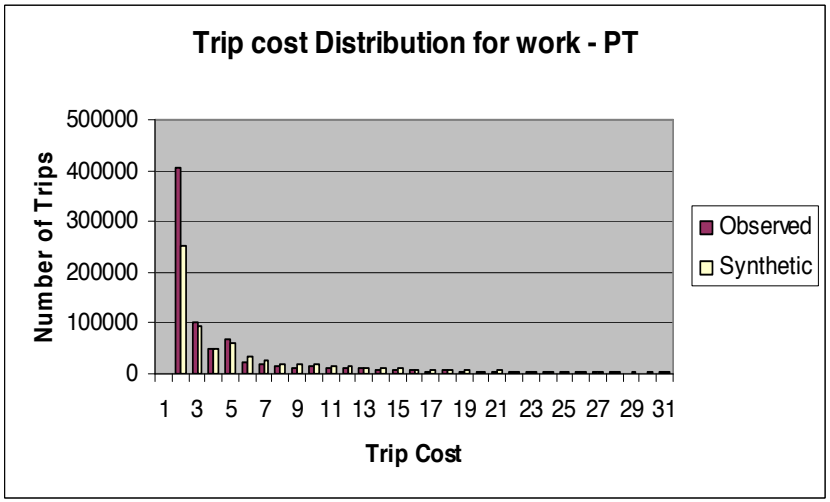
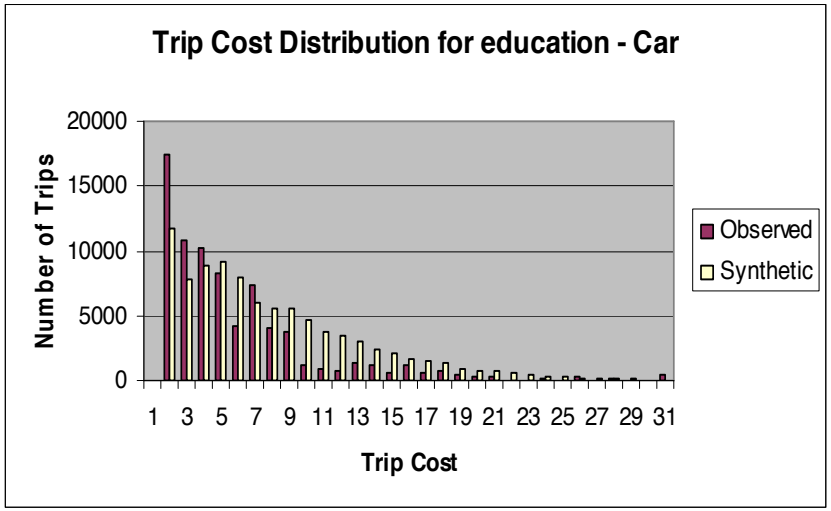
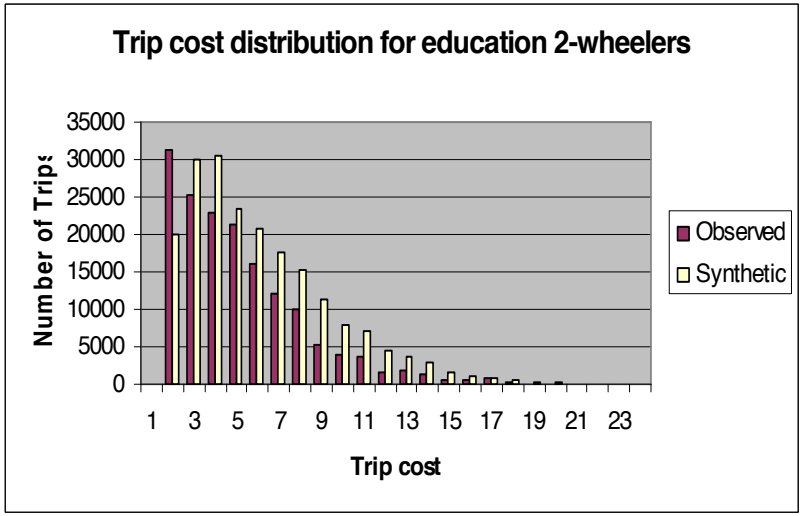
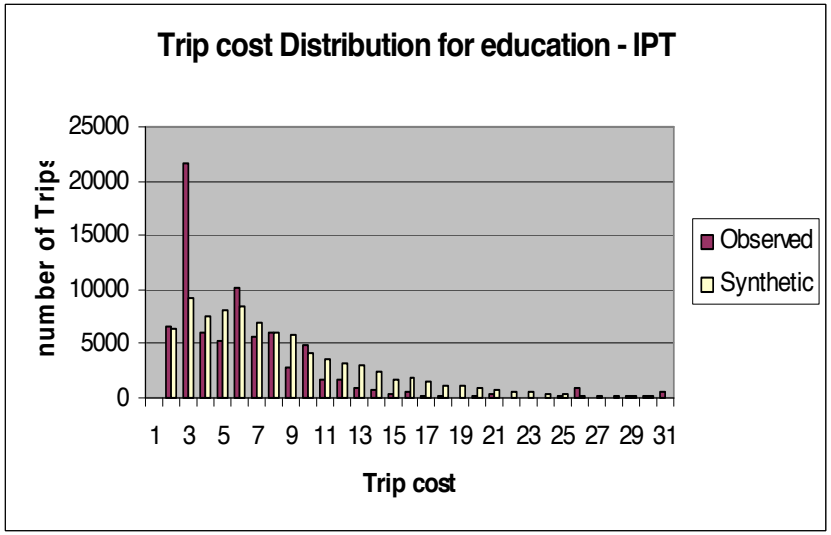

Trip cost Distribution for work - PT
Number of Trips
500000
400000
300000
200000
100000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Trip Cost
Observed
Synthetic

FIGURE 4.5 (a)


Trip Cost Distribution for education - Car
Number of Trips
20000
15000
10000
5000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Trip Cost
Observed
Synthetic


Trip cost distribution for education 2-wheelers
Number of Trips
35000
30000
25000
20000
15000
10000
5000
0
1 3 5 7 9 11 13 15 17 19 21 23
Trip cost
Observed
Synthetic


Trip cost Distribution for education - IPT
number of Trips
25000
20000
15000
10000
5000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Trip cost
Observed
Synthetic

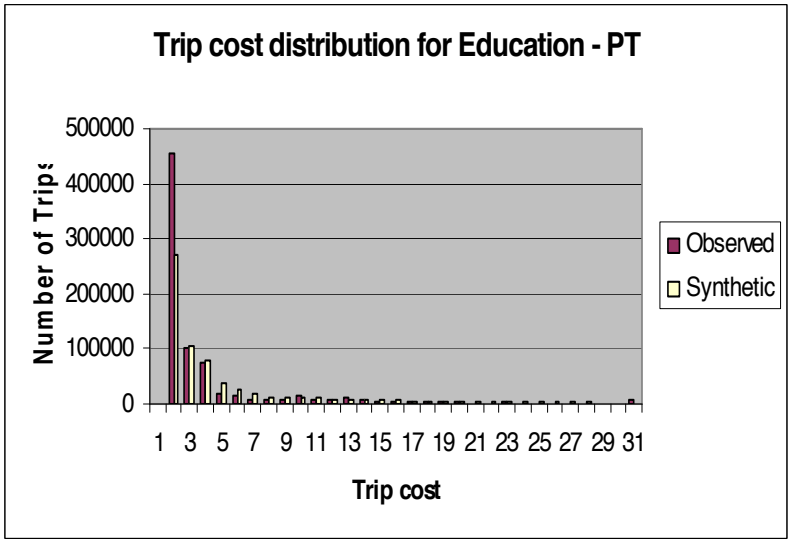
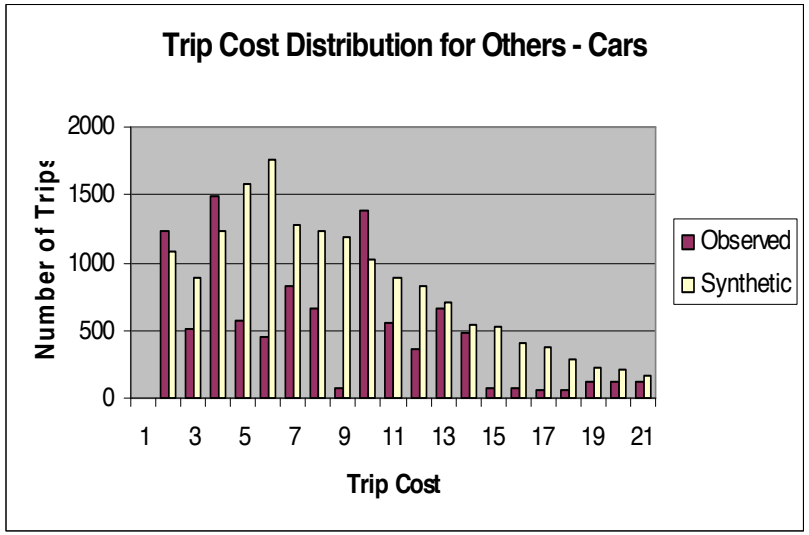
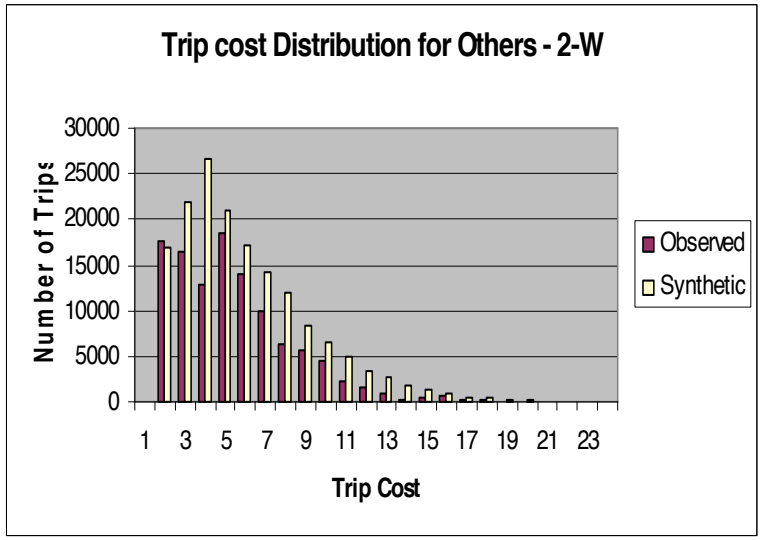
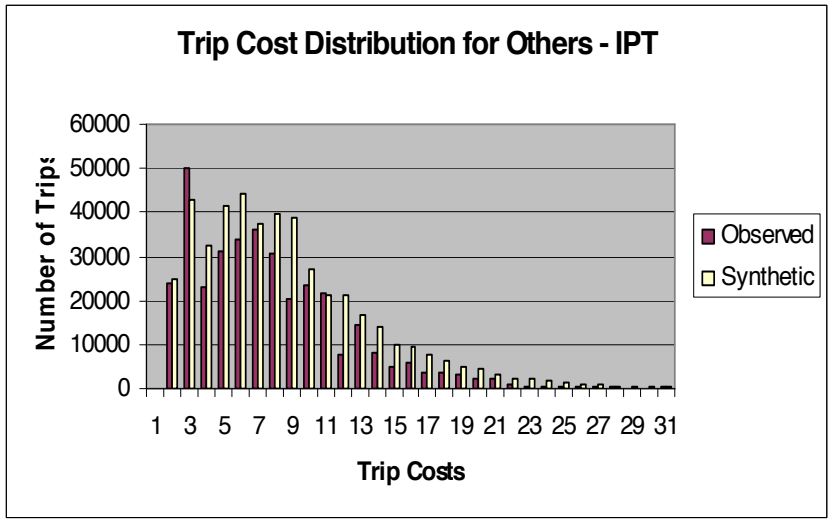

Trip cost distribution for Education - PT
Number of Trips
500000
400000
300000
200000
100000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Trip cost
Observed
Synthetic

FIGURE 4.5 (b)


Trip Cost Distribution for Others - Cars
Number of Trips
2000
1500
1000
500
0
1 3 5 7 9 11 13 15 17 19 21
Trip Cost
Observed
Synthetic


Trip cost Distribution for Others - 2-W
Number of Trips
30000
25000
20000
15000
10000
5000
0
1 3 5 7 9 11 13 15 17 19 21 23
Trip Cost
Observed
Synthetic


Trip Cost Distribution for Others - IPT
Number of Trips
60000
50000
40000
30000
20000
10000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Trip Costs
Observed
Synthetic

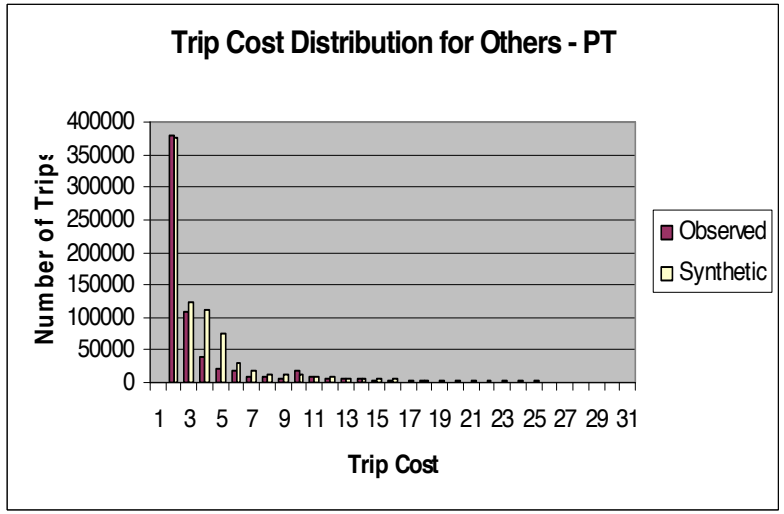

Trip Cost Distribution for Others - PT
Number of Trips
400000
350000
300000
250000
200000
150000
100000
50000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Trip Cost
Observed
Synthetic

FIGURE 4.5(C)

Table 4.10 Comparison of Modal Split by Purpose and Time Period

Purpose	Mode	Peak Period	
		Observed	Synthesized
Work	Car	11.31	11.33
	2-wheeler	51.00	51.08
	IPT	6.36	6.40
	PT	31.33	31.19
Education	Car	6.99	7.01
	2-wheeler	14.49	14.37
	IPT	7.07	7.07
	PT	71.45	71.56
Others	Car	0.86	0.89
	2-wheeler	9.89	9.86
	IPT	31.43	31.51
	PT	57.82	57.74

Note: 1. Observed = Observed matrices
2. Synthetic = Synthetic matrices from gravity model

4.7.10.3 These test results led to the following observations

i) The detailed operational model is able to synthesize trip movements during peak and off peak period on the basis of travel costs. The travel costs are based on both value of time and out of pocket expenses. The model considers 4 different modes (cars, 2-wheelers, IPT, and public transport)

ii) The model has been calibrated from the existing data and validated at various stages by comparing modeled and counts of traffic and passengers using public transport across screen lines. Journey times both modeled and observed are compared very well.

iii) The model is sufficiently robust at strategic level to use for forecasting. The model has performed well at screen line levels and speeds.

4.8 CONCLUSIONS

4.8.1 Operational transport of CTTS as developed using SATURN and PT-SATURN is able to synthesize patterns of trip movement during the whole day on the basis of travel costs. The model includes 4 modes (cars, two wheelers, IPT and public transport) and travel cost is based on value travel time and out of pocket expenses.

4.8.2 Patterns of movements and choice of mode are determined by a joint trip distribution / modal split model of gravity type. All other things being equal, the number of trips between any two zones will decrease as the cost of travel increases, and the number of people selecting a particular mode will decrease as its cost relative to other modes increases.

4.8.3 The model has been calibrated and validated from existing data by comparing modeled and counted flows of traffic and public transport passengers across screen lines.

4.8.4 Now the Model can be used for forecast with confidence.

CHAPTER – 5

STRATEGY FOR TRANSPORT DEVELOPMENT

5.1 NATIONAL URBAN TRANSPORT POLICY

5.1.1 The Government of India has evolved a policy to overcome the problem of poor mobility which dampens the economic growth and deterioration in the quality of life. The approach is to deal with this rapidly growing problem as also it can offer a clear direction and a framework for future action.

The vision of this policy is:

- To recognize that people occupy center-stage in our cities and all plans would be for their common benefit and well being
- To make our cities the most livable in the world and enable them to become the "engines of economic growth" that power India's development in the 21st century
- To allow our cities to evolve into an urban form that is best suited for the unique geography of their locations and is best placed to support the main social and economic activities that take place in the city.

5.1.2 The objective of this policy is to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and such other needs within our cities. This is sought to be achieved by:

- Incorporating urban transportation as an important parameter at the urban planning stage rather than being a consequential requirement
- Encouraging integrated land use and transport planning in all cities so that travel distances are minimized and access to livelihoods, education, and other social needs, especially for the marginal segments of the urban population is improved
- Improving access of business to markets and the various factors of production
- Bringing about a more equitable allocation of road space with people, rather than vehicles, as its main focus
- Encourage greater use of public transport and non- motorized modes by offering Central financial assistance for this purpose
- Enabling the establishment of quality focused multi-modal public transport systems that are well integrated, providing seamless travel across modes
- Establishing effective regulatory and enforcement mechanisms that allow a level playing field for all operators of transport services and enhanced safety for the transport system users
- Establishing institutional mechanisms for enhanced coordination in the planning and management of transport systems
- Introducing Intelligent Transport Systems for traffic management

- Addressing concerns of road safety and trauma response
- Reducing pollution levels through changes in traveling practices, better enforcement, stricter norms, technological improvements, etc.
- Building capacity (institutional and manpower) to plan for sustainable urban transport and establishing knowledge management system that would service the needs of all urban transport professionals, such as planners, researchers, teachers, students, etc
- Promoting the use of cleaner technologies
- Raising finances, through innovative mechanisms that tap land as a resource, for investments in urban transport infrastructure
- Associating the private sector in activities where their strengths can be beneficially tapped
- Taking up pilot projects that demonstrate the potential of possible best practices in sustainable urban transport

5.2 GROUND REALITIES VS URBAN TRANSPORT POLICY

i) The urban planners do consider the transportation as an important parameter, but the growth of the city has been so fast that the inadequacy sets in too fast to enable any possible review and taking remedial measure.

ii) It is very much essential to carry out integrated land use transportation planning. However, as part of the study, the possible implications of the proposals on land use in some areas and recommendations for necessary changes in policy have been included. It is also proposed to test impact of densifying measures around MRTS stations. But such measures will require major policy change and practicability and implications of same will need to be studied.

iii) Transport planning in the last two decades in BMA has been oriented towards developing a mix of public transport but funds have been a constraint. Despite same, a 36 km metro line has been taken up and the bus transport has been providing more and more services, which is indicated by the fleet growth and increased passenger trips.

iv) Share of walk and cycle trips in Bangalore have been comparatively low in Bangalore even earlier. Non motorized trips share has been going down. Apart from non availability of cycle tracks on roads, increased trip lengths for almost all purposes may have caused this fall.

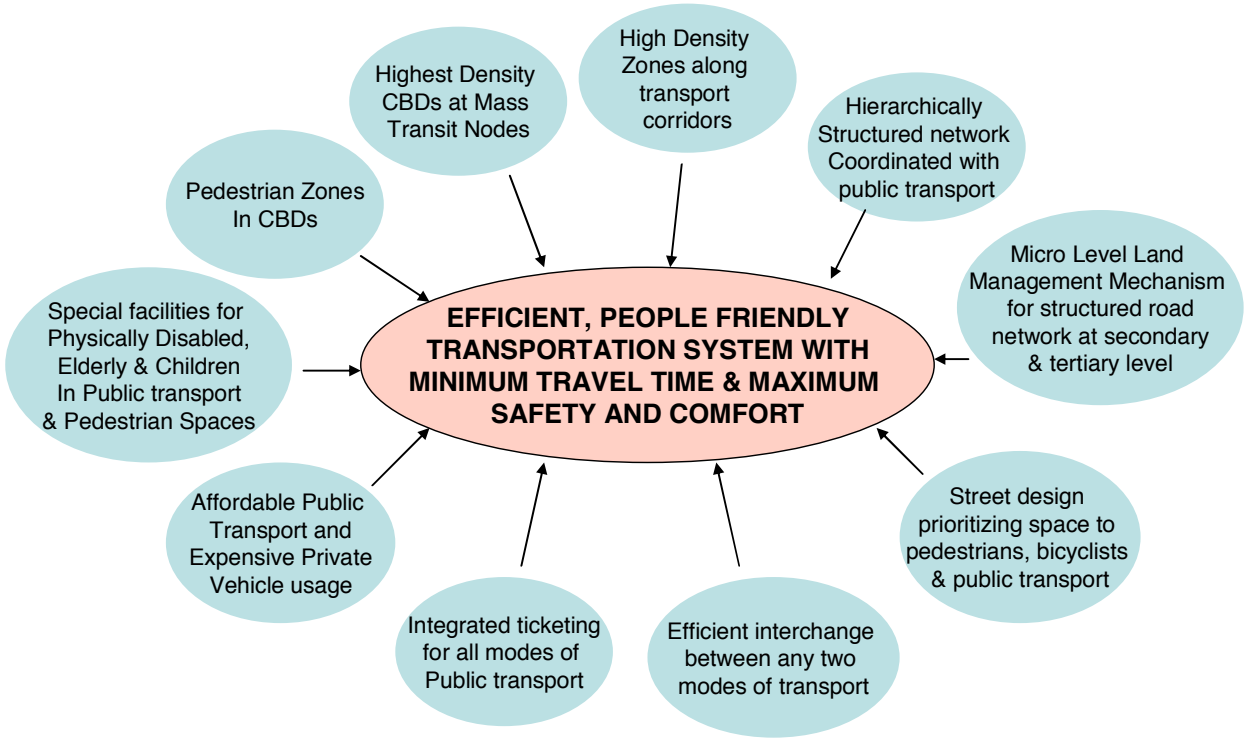
v) The current policy has been more road oriented. The fast growing economy and higher per capita income has resulted in high vehicle ownership and usage. The roads in the core area getting congested and land cost mechanism has encouraged more of peripheral growth, increasing urban sprawl. This has resulted in longer trip lengths for all purposes.

5.3 VISION

5.3.1 With this background, it is desirable to have a vision be developed before considering different alternative strategies. A vision by definition is 'a vivid image produced by the imagination'. A Transport Planner's vision for the city and

metropolitan area is to see 'a well contained city with efficient people-friendly transport system with minimum travel time & maximum safety and comfort'. At the same time the facility provided should be optimally used. The different actions which have to contribute to this vision are diagrammatically represented in **Figure 5.1**.

Figure 5.1 Vision for Transportation and Associated Actions



The diagram above paraphrases what we would like to see when we look at Bangalore ten years from now. In order to achieve this, an integrated land use-transport strategy is called for. Preparation of such a step is diagrammatically indicated in **Figure 5.2** below.

Figure 5.2 Integrated Landuse Transport Strategy for Bangalore

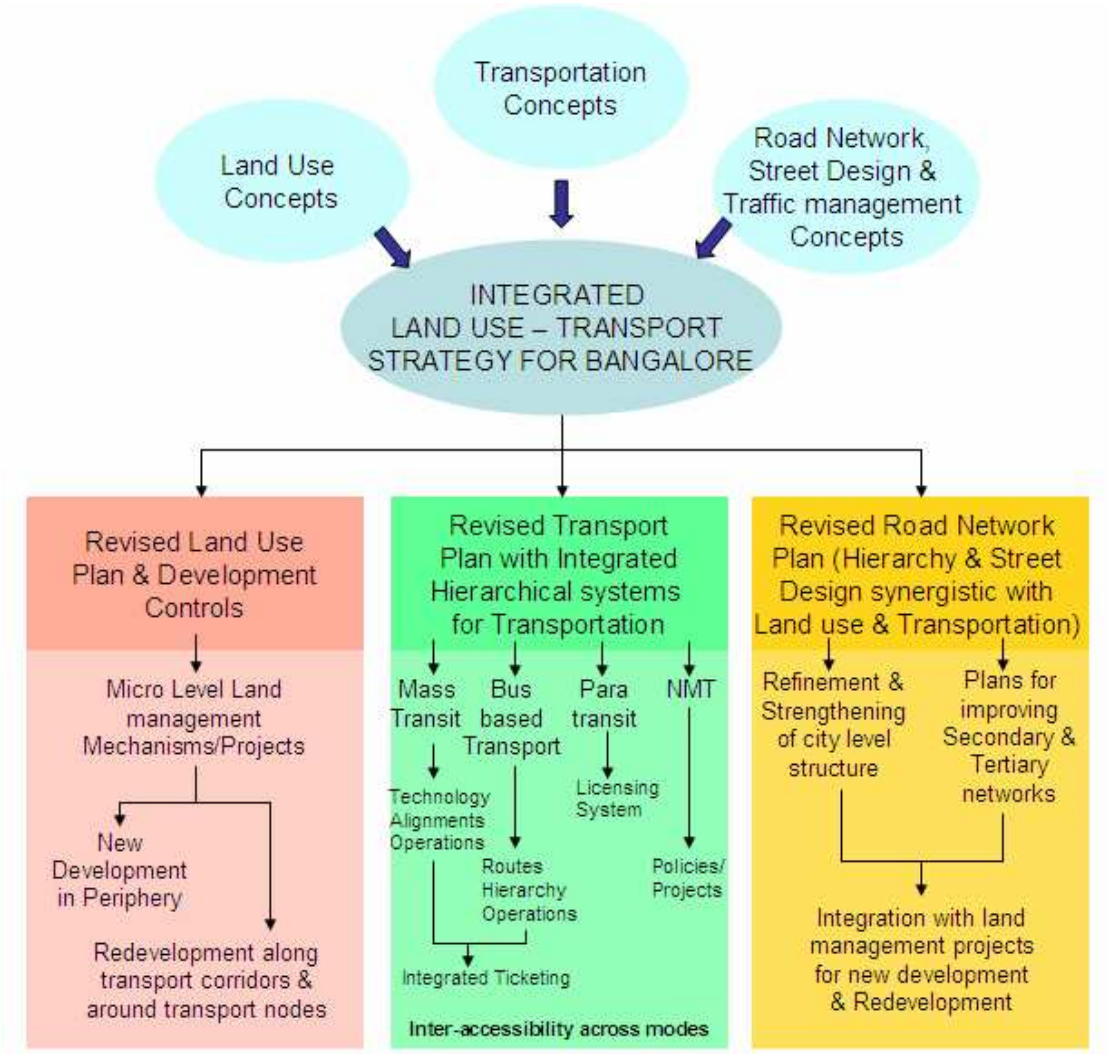


Diagram source: Balachandran and Sowmya Haran

5.3.2 The Road Map (Strategies)

Considering the status of progress in various fronts that have already been initiated in Bangalore, the road to an integrated urban transportation strategy is fraught with difficulties. The process is bound to be messy and will appear costly in terms of time, money and effort to be invested in such an exercise. However, the COST OF NOT DOING THE INTEGRATION is far higher than that of doing it and the resultant situation, if the integration is not done, will be far more messy than the process of doing it. Therefore the following initiatives are recommended.

5.3.2.1 Integrated land use – transport strategy

A team consisting of both urban planners and transportation planners and preferably led by an urban planner with a holistic understanding of urban

transport issues should put together an integrated land use – transport strategy for Bangalore. This strategy should incorporate modern concepts in land use planning, urban transportation planning road network planning and street design in a mutually complementary manner. Such an approach necessarily means that the team should review the city's Master Plan as well as plans relating to mass transport and road network improvements.

A strategy such as this will have no statutory backing as such. Therefore if this strategy is to be taken seriously then it should be mandated by an overarching body which has sway over all the stakeholder organizations. No such body exists as of today. A Unified Metropolitan Transport Authority has been mooted on many occasions. Even such a body would leave out land use planning. Therefore the possibility of an **Integrated Land and Transport Management Authority for Bangalore** may be considered to mandate the preparation and operationalization of this strategy.

5.3.2.2 Revised Land Use Plan and Development Controls

The land use and density component of the above strategy can be operationalized only through revisions in the Master Plan. High traffic generating activities and high density (high FSI) zones should be realigned around mass transport nodes and along major transportation corridors.

Such a reorganization of land use and density cannot be realized only through the modifications in the Master plan. In already developed areas, this needs to be translated into projects for planned redevelopment, ensuring that the high density and high intensity of activities are supported by appropriating land for improvements in the road network, street design and supporting infrastructure. The energy for redevelopment already exists in the real estate market in Bangalore, and will receive further impetus from the implementation of mass transport projects.

In new growth areas, a mechanism for micro-level planning (such as Town Planning Schemes in Gujarat) will need to be introduced to ensure that all new development is adequately served by primary, tertiary and secondary road network with provision for public transport facilities. These would also essentially have to be translated into land management projects.

5.3.2.3 Road network and street design

Having articulated the approach to road network planning and street design in the Strategy document, the primary road network proposals in the Master Plan should be modified appropriately. In many places, particularly in the already developed areas, these modifications can be realized only through carefully structured redevelopment projects as the missing links in the primary road network will have to go through existing development.

In the case of the secondary and tertiary level roads, as explained in the previous section, the improvements in developed areas, in many cases, will have to be achieved through planned redevelopment. In the new growth areas these have to be part of proactive land management initiatives.

Street design has to be standardized according to the hierarchical level and function of a street and customized according to local conditions. On all BRTS roads, the street design of extremely high importance. In the areas surrounding a mass transport node also, street design has to enable easy access of pedestrians, bicyclists and para transit passengers to the mass transport facility.

5.4 OBSERVATIONS

The important observations are as following, which will now guide the strategy for development.

1. The City though claimed to be compact in the basic premise, is actually quite wide spread – The development area of more then 800 sq km, to accommodate around 1 Crore persons by 2015/20 as per Master Plan 2015. Thus, a multi-modal system with a fairly large coverage will be required.

2. Pockets of economic activities like Hi-Tech & Electronic city having very large employment potential are planned. Of course a large part of the human resources to be engaged in these activities is expected to come from with in BMA but quite a large no. is also to the expected from the Bangalore Metropolitan Region & even from towns like Hosur, Tumkur, etc. This will require special High capacity mass transport system connecting these work centres with the living areas within Bangalore as well as meeting the needs of the long distance / suburban commuters, especially along the corridors leading to these centers.

3. The present radial network is bringing the entire load of traffic to the ORR & core areas causing congestion. The trend needs to be stopped through :

    - Dispersal of traffic at the periphery by completing the PRR, & the other Ring Roads planned at the Regional level like the Intermediate Ring Road & Satellite Town Ring Road.
    - Creating Transport Hubs for goods traffic and the junctions of PRR & selected Radials
    - Banning the entry of Heavy vehicles at the Transport hubs & allowing only LCV to transport the goods from the Transport Hubs to the inner city areas and that too during the non-peak hours (i.e. No Entry between 9 A.M. to 9 P.M.)

4. The master plan proposal of having Mutation Zones along practically all the radial corridors would require some sort of mass transport system along them.

5. The core areas inside the core ring road are proposed to be fully traversed by the Metro. Therefore the vehicular movement inside this area should be minimized & if possible completely avoided during working hours for 9am to 9pm through:

   - Complete pedestrianisation of narrow commercial streets.
   - Providing adequate parking along the CRR and running dedicated BRT on the lower level of the CRR and restricting all private vehicles on the elevated portion thereof.
   - Smooth & free flow of emergency vehicles like Ambulance, Fire Engines etc in side the core area.
   - The goods feeder services like LCV be allowed to come in only doing 9PM to 9AM to unload materials etc.
   - Attempts may be made to decentralize certain trades requiring bulk carriage like heavy machinery, hardware, building material etc in organized markets beyond the ORR and preferably near the PRR.
   - On a few of the wide roads inside the core area the feasibility of running BRT etc. may be examined.

5.5 THE PREFERRED STRATEGY FOR TRANSPORT DEVELOPMENT

Based on the above observations it is clear that the already planned network will be insufficient to cope up with the future requirements especially after the target year of 2015. As such in order to prepare the Comprehensive Transport Plan the following policy measures are required to be taken based on which the CTTP will be finalized.

1. Extension of mass transport system to provide wide coverage and interchange facilities with other modes of transport.
2. Provide substantially large network of medium level mass transport system such as BRT to cover the areas beyond the Metro network and on over loaded corridors.
3. Landuse adjustments and densification of corridors along mass transport corridors where possible.
4. Extension of commuter rail system upto the BMRDA's New Townships & beyond upto Tumkur, Hosur etc. to act as sub-urban services.
5. Introducing BRT and wherever possible dedicated bus lanes
6. Rationalisation of Local Bus system and its augmentation.
7. Improvement in traffic management through TSM measures.
8. Special facilities for pedestrians within the entire network specially in the core areas ; pedestrianisation of selected shopping streets in side the core area

going to be served by Underground sections of Metro. Provision of pedestrian sky walks, under passes, footpaths and other road furniture along the roads where necessary.

9. Diverting through traffic on Peripheral Ring Road. Providing transport hubs at the junctions of Peripheral Ring Road with important radials such as; the National Highways and other heavily loaded roads.
10. Improving Primary, Arterial and other important roads by providing grade separation, junction improvements, adding missing links, widening and other road side facilities wherever necessary. The Arterial roads outside the PRR need to be improved upto the New BMRDA townships in order to take the increased load of commuters.
11. Transport integration of various modes.

CHAPTER – 6

FUTURE DEMAND ANALYSIS AND SYSTEM SELECTION

6.1 FUTURE GROWTH SCENARIO

6.1.1 Revised Master Plan-2015 for the BMA has been published. This document gives the likely growth to take place in various areas of the BMA. The population of the BMA is expected to grow from 61 lakh in 2001 (70 lakh in 2006) to 88 lakh in 2015 and 122 lakh in 2025. The plan also gives locations of various land uses such as residential, commercial, industrial, IT uses etc. This has already been explained in Chapter 1.

6.1.2 The proposed growth of population and economy is expected to generate high travel demand. As per travel demand modeling exercise, daily travel demand is expected to grow from 57.2 lakh person trips in year 2006 to 127 lakh in year 2025. Thus while population is expected to become 1.74 times in 19 years, the travel demand is likely to become 2.25 times. Similarly inter-city travel demand from/ to Bangalore and through traffic are also expected to more than double of present levels. Transport network will also need to be augmented to cater to the expected travel demand. The present chapter examines some transport scenarios to meet the travel demand and recommends the best scenario.

6.2 DO MINIMUM SCENARIO

6.2.1 The conventional approach is to assume a 'Do nothing' scenario in respect of transport facility development and asses what the problems would be with the expected growth of population and trip generation towards horizon year. But this is not considered realistic since some committed and sanctioned schemes of road-widening, provision of grade-separators etc would nevertheless be carried out as is being done at present. Otherwise dynamism of growth will be lost. The scenario that will be available by the horizon year therefore would be a 'Do minimum' situation with some of the committed schemes of road capacity augmentation implemented. The base year network was updated by including identified committed road and public transport schemes to form the forecast Do minimum network which includes

a. Base year network with proposed road capacity augmentation.
b. Changes to bus frequencies to keep up with increase in demand generally

6.2.2 Having achieved satisfactory validation of base year transport model, forecast year model for 2025 was set up with changes in population and other changed scale economic factors and also minimum network changes for peak and off peak. In each case, iterative procedure goes through a series of network skims, trip distribution / modal split runs to produce synthetic trip matrices, subsequent

assignments (followed by skims for next iteration). It was found that to achieve convergence, eight iterations were required.

6.2.3 The Do-minimum assignment was carried out to identify the bottlenecks, over capacity links etc. With this it is possible to identify the major constraints in the network. Once the constraints are identified it is easy to formulate schemes to overcome the problems. New infrastructure, traffic management plans, and policy controls can be worked out with the help of identified schemes. The calibrated deterrence functions for various modes and various purposes have been adopted. Forecast test of each scheme will be assessed against the Do-Minimum assignment.

6.2.4 For the Do Minimum Scenario, the expected modal split for the year 2025 is given in **Table 6.1**. This table shows that the modal split in favour of public/mass transport will fall to about 29% by 2025 against base year modal split of 47%. Share of trips by personalized motor vehicles such as car and two wheelers is expected to increase from 40% to 60%. This is expected to increase the traffic volumes on the most of the road network beyond its capacity. The desireline diagram for private vehicles for 2025 is shown in **Figure 6.1**. Peak hour traffic assignment on the road network is shown in **Figure 6.2**. These figures indicate heavy radial movements to the core of the city and also circumferential movements. Heavy traffic is likely to be experienced on all radial roads, Outer Ring Road and various roads in core area. V/C ratio will be more than 0.8 on most of the roads. Travel speeds will fall to 6-7 kmph. Environmental pollution from motor vehicles will assume critical dimensions.

Table 6.1 Expected Modal Split – Do Minimum Scenario (Scenario –I)

Modes	Modal Split			
	Base Year Scenario – 2006		Scenario –1 (Do Minimum) – 2025	
	Daily Trips (lakhs)	%age	Daily Trips (lakhs)	%age
Car	4.2	7.5	15.5	12.2
2W	18.4	32.8	60.4	47.5
IPT	7.3	12.9	14.9	11.7
BUS	26.3	46.8	36.3	28.6
Total	**56.2**	**100.0**	**127.2**	**100.0**

6.3 SCENARIO 2

6.3.1 Considering the evaluation of the above scenario, the most important issue to reduce road traffic will be to increase the share of trips by public/mass transport. This will mean providing high capacity mass transport system on many corridors. Revised Master Plan-2015 has proposed the following public transport system and major roads.

Figure 6.1 Desireline Diagram for Private Vehicles for 2025 (Do Minimum)

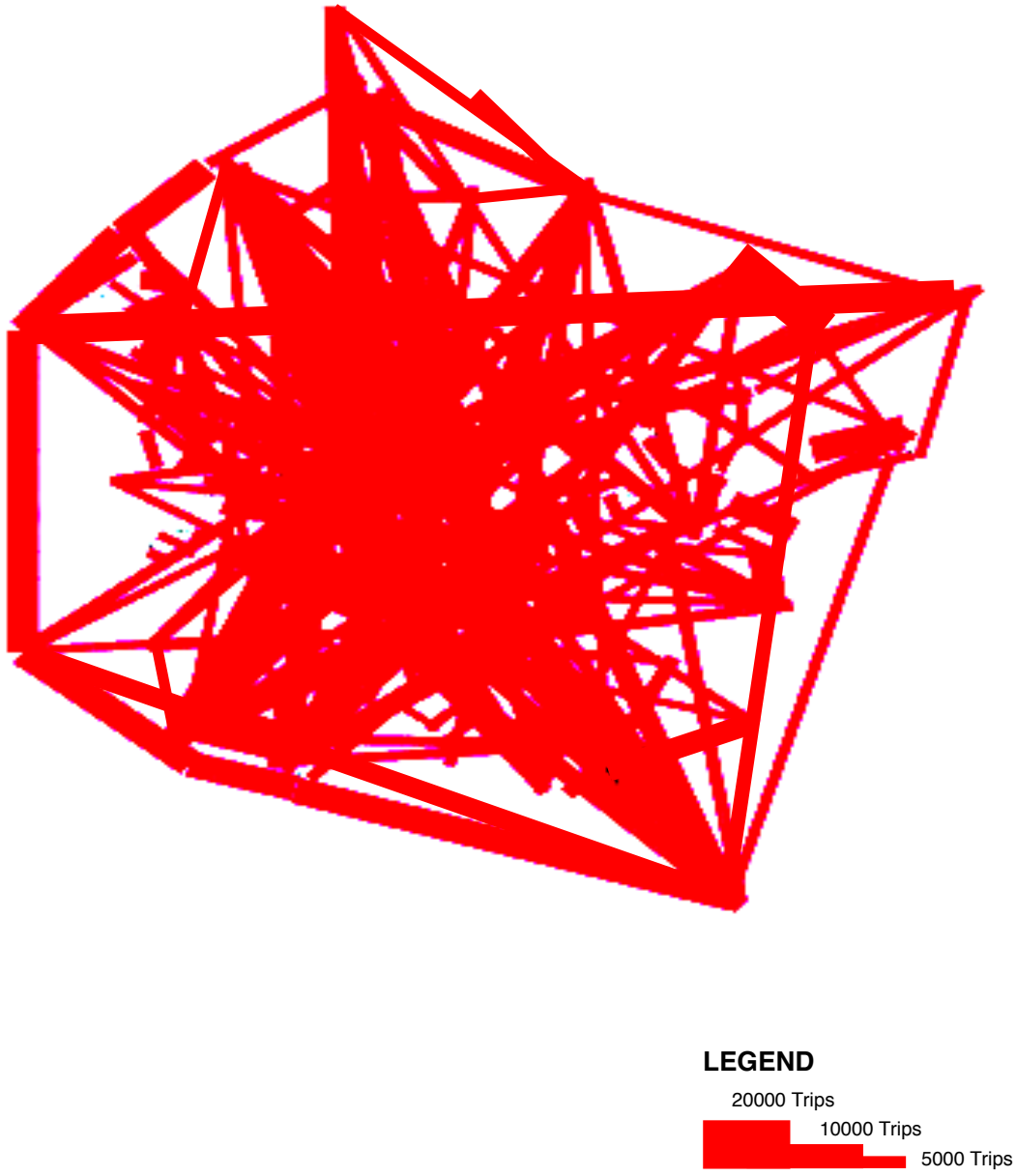


Figure 6.2 Peak Hour Traffic Assignment on Road Network (Do minimum)

i. Metro System (36.8 km) (Mysore Road-Baiyyappanahalli and Peenya-RV Terminal corridors)
ii. Monorail system (47km) (from Kanakapura Road to Bellary Road along ORR, Kathriguppe to National College, Bannerghatta-Adugodi along Bannerghatta and ORR to Toll Gate junction along Magadi Road)
iii. BRT (30km) (on ORR)
iv. Commuter Rail Service in Bangalore (Kangeri-Whitefield, Bangalore City Satation-Baiyyappanahalli via Lottagolahalli (60 km)
v. Elevated Core Ring Road (30 km)
vi. Peripheral Ring Road (114 km)
vii. New Airport Expressway (26 km)

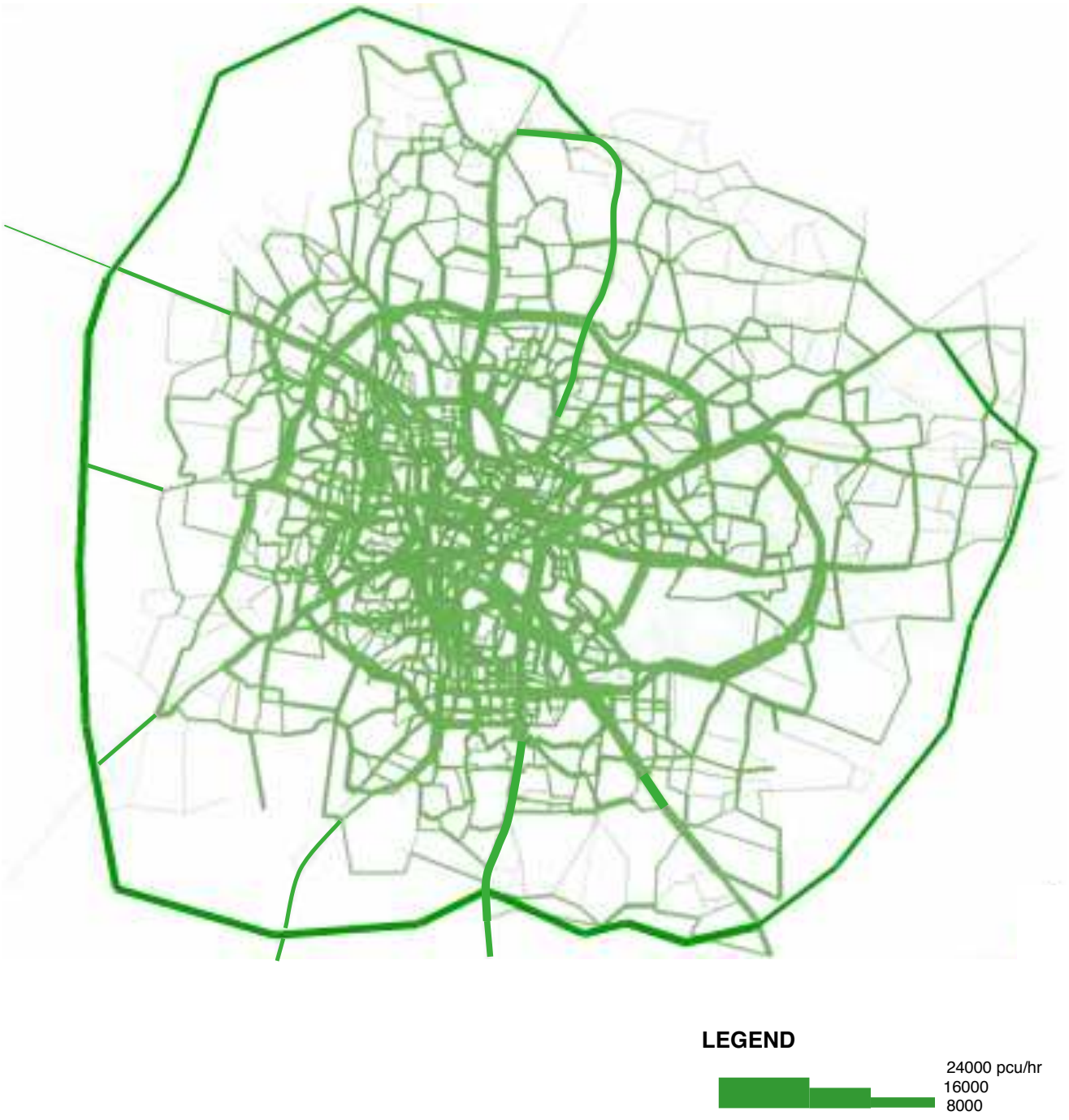
6.3.2 Considering above, another network Scenario (termed as Scenario 2) was developed, travel demand modeling and forecasting carried out and results evaluated. For this Scenario, the expected modal split for the year 2025 is given in **Table 6.2**. This table shows that the modal split in favour of public/mass transport will increase marginally to about 50% by 2025 against base year modal split of 47%. Share of trips by personalized motor vehicles such as car and two wheelers is expected to increase from 40% to 44%, although in absolute numbers their demand will increase from 23 lakh (2006) to 55 lakh (2025) daily trips. This is also expected to increase the traffic volumes on the many of the road network beyond its capacity, although, the traffic levels will be much less as compared to Do Minimum Scenario. This can be seen in traffic assignment figures. Peak hour peak direction trips (phpdt) on mass transport network for this scenario is shown in **Figure 6.3**. Peak hour traffic assignment on the road network for 2025 for this scenario is shown in **Figure 6.4**. These figures indicate significant traffic on mass transport network and reduced traffic on many roads. However, many roads such as Hosur Road, Kanakapura Road, Airport Road, Mysore Road, ORR, many roads in core area and outer areas will continue to be overloaded. Thus share of public/mass transport in total demand will still need to be increased substantially.

Table 6.2 Expected Modal Split –Scenario 2

Modes	Modal Split			
	Base Year Scenario (2006)		Scenario 2 (2025)	
	Daily Trips (lakhs)	% age	Daily Trips (lakhs)	% age
Car	4.2	7.5	9.7	7.6
2W	18.4	32.8	45.6	35.9
IPT	7.3	12.9	8.9	7.0
Public/Mass Transport	26.3	46.8	50.0	49.5
Total	**56.2**	**100.0**	**127.2**	**100.0**

Figure 6.3 Peak Hour Peak Direction Trips (PHPDT) on Mass Transport Network (Scenario 2)

Figure 6.4 Peak Hour Traffic Assignment on the Road Network for 2025 (Scenario 2)



6.4 SCENARIO 3

6.4.1 Considering that many of the road corridors will still be overloaded in Scenario 2, the public/mass transport network and road network has been extended on the following corridors and the alternative termed as Scenario 3.

1. Mass transport network and Major Road Network as in Scenario 2
2. Additional Mass Transport Corridors
   i. Baiyyappanahalli to Benaiganahalli
   ii. R.V. Terminal to PRR along Kanakapura Road
   iii. Yelahanka Road to PRR via Nagavara, Electronic City
   iv. Indiranagar to Whitefield along Airport Road
   v. Devenahalli Airport to MG Road via Bellary Road (New Airport)
   vi. Kanakapura Road to Bannerghatta Road along ORR
   vii. PRR to ORR along Magadi Road
   viii. Benaiganahalli (ORR) to PRR along old Madras Road
   ix. From ORR to Hosur Rd along Hitech Corridor Jn.
   x. Hosur Rd-PRR Junction to Tumkur Rd along PRR (western part)
   xi. Tumkur Road-PRR Jn. to Hosur Rd along PRR via Tirumanahalli, Old Madras Road, Whitefield (eastern part of PRR)
   xii. Along Core Ring Road
   xiii. Vidyaranyapura to Nagavarapalya Via Hebbal, Jayamahal Road, Queens Road, M.G. Road, Ulsoor, Indranagar, CV Raman Nagar
   xiv. Kengeri Sattelite Town to J.P. Nagar along Uttarahalli Road, Kodipur
   xv. Banshankari III stage to Banshankari VI stage Ext. along Ittamadu Road, Turahalli, Thalaghattapura.
   xvi. Domlur Ext. to Kormangala along inner ring road
   xvii. PRR (Mulur) to Maruti Nagar (up to Hitech corridor) along Sarjapur Road
   xviii. Peenya to PRR along Tumkur Road
   xix. Old Madras Road near Indranagar to ORR near Banaswadi along Baiyyappanahali Road -Banaswadi Road
   xx. Commuter Rail Corridors
      - Lottegollahalli to Yelahanka
      - Banaswadi -Hosur
      - Kangeri- Ramnagaram
      - Yeshwantpur to Tumkur

6.4.2 Expected modal split for Scenario 3 for 2025 is shown in **Table 6.3**. It is seen that share of person trips for public/mass transport is expected to increase to 73%. This share in favour of public/mass transport is desirable for the city of size of population more than one crore as recommended by the Committee for the Report on 'Alternative Systems of Urban Transport' set up by the Government of India.

Table 6.3 Expected Modal Split –Scenario 3

Modes	Modal Split			
	Base Year Scenario (2006)		Scenario 3 (2025)	
	Daily Trips (lakhs)	%age	Daily Trips (lakhs)	%age
Car	4.2	7.5	7.0	5.5
2W	18.4	32.8	20.6	16.2
IPT	7.3	12.9	6.7	5.3
Public/Mass Transport	26.3	46.8	92.9	73.0
Total	**56.2**	**100.0**	**127.2**	**100.0**

6.4.3 The desireline diagram for private vehicles for 2025 is shown in **Figure 6.5**. The traffic desire by these vehicles will be significantly reduced. Peak hour peak direction trips (phpdt) on mass transport network for this scenario are shown in **Figure 6.6**. Peak hour traffic assignment on the road network for 2025 for this scenario is shown in **Figure 6.7**. These figures indicate significant traffic on mass transport network and further reduced traffic on roads as compared to Scenario 2.

6.5 RECOMMENDED SCENARIO

6.5.1 The above evaluation of alternative scenarios shows that the public/mass transport system has to be extensive with high capacity mass transport systems on major corridors in order to achieve a modal split of more than 70% in favour of public/mass transport. Scenario 3 will not only enable the commuters to travel from one part to another of the city with good level of service, convenience and comfort but also help in the shift to public transport. This is also desirable as available ROW s of roads in Bangalore are not adequate. Provision of a city-wide extensive public/mass transport is the only way to solve mobility problem of Bangalore. Thus Scenario 3 public/mass transport network should be aimed at in order to cater to travel demand of 2025 and beyond.

6.5.2 The balance demand can generally be met by augmentation of road system in the form of new roads, road widening, provision of grade separators, pedestrian facilities, traffic management measures etc. The proposals for these are detailed in Chapter 7.

6.6 SYSTEM SELECTION

6.6.1 Criteria for Choice of Mode

Choice of mode will depend mainly on demand level on a corridor, available road right-of-way (ROW) and the capacity of the mode. Other considerations are the land-use along the corridor, the location of building lines, and the potential for

Figure 6.5 Desireline Diagram for Private Vehicles for 2025 (Scenario 3)

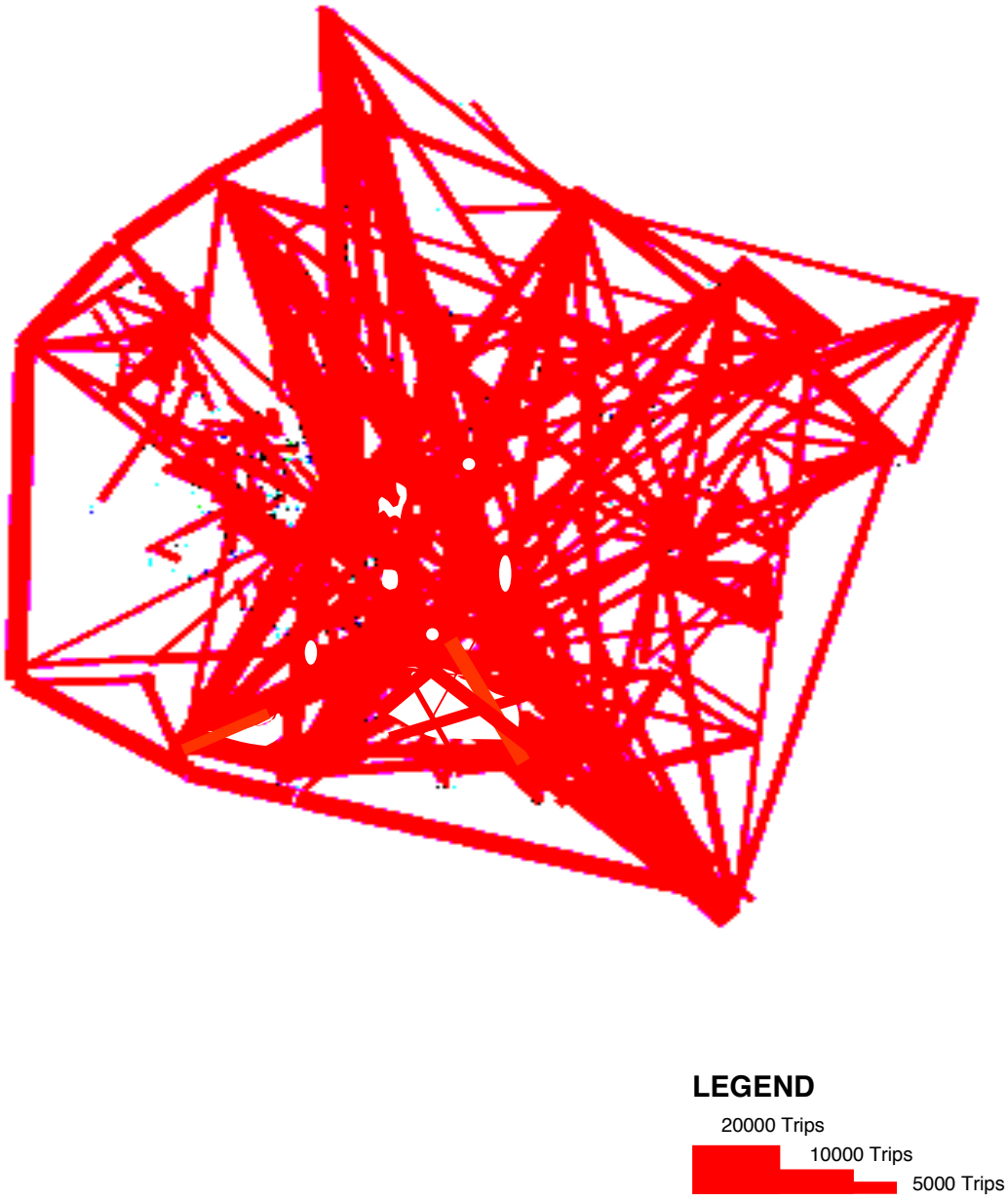
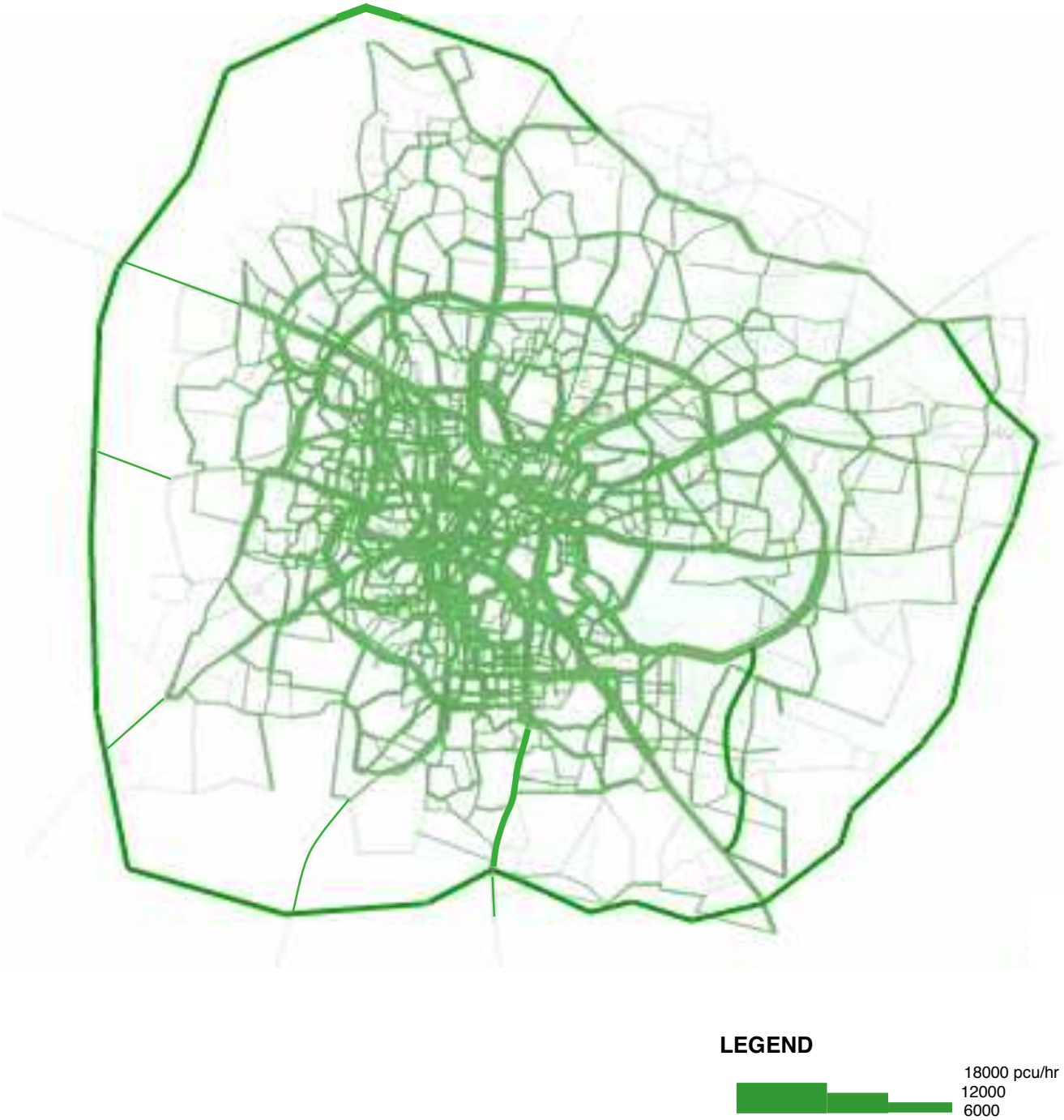


Figure 6.6 Peak Hour Peak Direction Trips (PHPDT) on Mass Transport Network (Scenario 3)

Figure 6.7 Peak Hour Traffic Assignment on Road Network for 2025 (Scenario 3)



increasing the ROW. Cost of the same mode of transport can vary at different locations depending on engineering constraints. It is therefore important that the final choice of mode is based on techno-economic considerations.

6.6.2 In choosing a mode for a corridor, first priority should be given to at-grade services and BRT. It offers convenience to commuters particularly the short distance users. Commuters do not have to walk up and down to use the services. The construction cost is low. It offers the best financial sustainability. If road ROW is inadequate and it cannot be widened, and/or the route is congested, an elevated mode needs to be proposed.

6.6.3 Capacity of Various Modes

The comparative capacity of the main transport modes used in developing cities is reported in a TRRL-UK study (1995) and World Bank study (2000). As per these studies, it appears that the capacity of various modes may be taken as follows;

BRT (HCBS) at-grade	10000 to 20000 phpdt
LRT at-grade	2000 to 20000 phpdt
Metro/ Suburban Rail	30000 to 80000 phpdt

There is no mention of the Monorail in this study, but based on information available, it appears that the mode has been used up to a demand level of 10000 phpdt and designed and used in one case up to 20000 phpdt. Thus, it appears that BRT, Monorail and LRT, can be used when the demand on a corridor is not expected to exceed 20000 phpdt. Beyond the demand level of about 20000 phpdt, a metro appears to be the only choice.

The World Bank report further states that the bus way output depend greatly on road network configuration, junction spacing and stop spacing. It typically has been demonstrated to be high at about 10,000 phpdt at 20 km/h on arterial corridors and 15-17 km/h on urban corridors for a one-lane each way bus-way. If provision for bus overtaking at stops is provided, passenger throughputs of 20,000 phpdt have been demonstrated.

6.6.4 Proposed Capacity of Various Modes for Bangalore

Based on studies by World Bank and others, the following capacity norms for various modes are proposed to be adopted for Bangalore.

Table 6.4 Proposed Capacity of Various Modes for Bangalore

Modes	Capacity (phpdt)
Metro rail	> 30000
Elevated LRT	upto 30000
Elevated Monorail	upto 20000
At grade LRT	upto 15000
At grade HCBS	upto 20000 (with overtaking facility)

6.6.5 Right of Way Requirement

All medium capacity modes normally lie within the road right of way and hence require a share in the road space. At-grade modes however require more space than elevated modes. For at-grade BRT, the desirable right of way requirement is 35 m to meet the requirements of the IRC code, but with an absolute minimum of 28 m. The latter allows for two- lane sub-standard carriageways each way and a combined cycle track and footpath. Additional 7 m space is required at stations/stops. This includes the requirement for overtaking facility as well. It may be possible to reduce the requirement further when the demand level is low such as at the periphery of the city. The above does not include service roads. It is highly unlikely that the desired ROW will be available for full length of the corridor. Elevating the corridor at tight locations could be one option.

If minimum ROW of 28m (desirably 35m) is not available, elevated modes become necessary. For elevated Monorail or LRT, desirable ROW is 30 m to meet the requirements of the IRC code, and an absolute minimum of 20 m because at ground level space is required only for a column and its protective measures. At stations, additional space will be required on the roadside.

Typical cross-sections of road with BRT, elevated LRT and Monorail are shown in **Figures 6.8 and 6.9** respectively.

6.7 SUGGESTED MASS TRANSPORT SYSTEMS FOR BANGALORE

On the basis of expected traffic demand in 2025 on the proposed mass transport corridors of Scenario 3 as explained above, available Right of Way on the corridors, capacity of various mass transport modes and already available mass transport system along a corridor, the mass transport systems on various corridors have been suggested. These are given in **Table 6.5**.

Table 6.5 - Public Transport System Selection

S. No.	CORRIDOR	Expected Maximum Traffic (PHPDT)	Available ROW (m)	System Recommended
1	Mysore Road to Baiyyappanahalli	75,000		Metro
2	Peenya to R V Road	75,000		Metro
3	Baiyyappanahalli to Benniganahalli	25,000	25	Metro
4	R.V. Terminal to PRR	25,000	25	Metro
5	Yelahanka Road to junction of Hi-tech corridor and Hosur Road via Nagavara, Electronic City	45,000	30	Metro
6	Indiranagar to Whitefield Road	35,000	25	Metro
7	Devenahalli Airport to MG Road via	20,000	24	Metro

S. No.	CORRIDOR	Expected Maximum Traffic (PHPDT)	Available ROW (m)	System Recommended
	Bellary Road (New Airport)		(within city)	
8	Hebbal to Bannerghatta Road along Western portion of ORR	20,000	20	Monorail / LRT
9	PRR to Toll Gate along Magadi Road	12,000	22	Monorail / LRT
10	Kattriguppe Road / Ring Road Junction to National College	14,000	18	Monorail / LRT
11	Hosur Road to PRR along Bannerghatta Road	18,000	22	Monorail / LRT
12	Hebbal to Bannerghatta Road along Eastern portion of ORR	15000	40	BRT
13	Benniganahalli (ORR) to PRR along Old Madras Road	10,000	30	BRT
14	From ORR to Hosur Road along Hi-tech Corridor	12,000	60	BRT
15	Hosur Road to Tumkur Road along PRR (western part)	8,000	100	BRT
16	Tumkur Road to Hosur Road along eastern side of PRR	6,000	100	BRT
17	Along Core Ring Road	12,000	25	BRT
18	Vidyaranayapura to Nagavarapalya	12,000	25	BRT
19	Kengeri Satellite Town to J.P. Nagar along Uttarahalli Road, Kodipura	12,000	30	BRT
20	Banashanakari III stage to Banshankari VI Stage Extension along Ittamadu Road, Turahalli, Thalaghattapura	9,000	35	BRT
21	Domlur Extension to Koramangala along inner Ring Road	10,000	25	BRT
22	PRR to Maruti Nagar (upto Hi-tech Corridor) along Sarjapur Road	15,000	25	BRT
23	Peenya to PRR along Tumkur Road	12,000	30	BRT
24	Old Madras Road near Indranagar to ORR near Banaswadi along Baiyyappanahalli Road – Banaswadi Road	10,000	22	BRT
25	Commuter Rail Corridors (10 corridors)	10,000	-	Commuter Rail System

Figures 6.8 Typical Cross-Sections of Road with BRT System – Mid Section (Minimum ROW – 28 m)

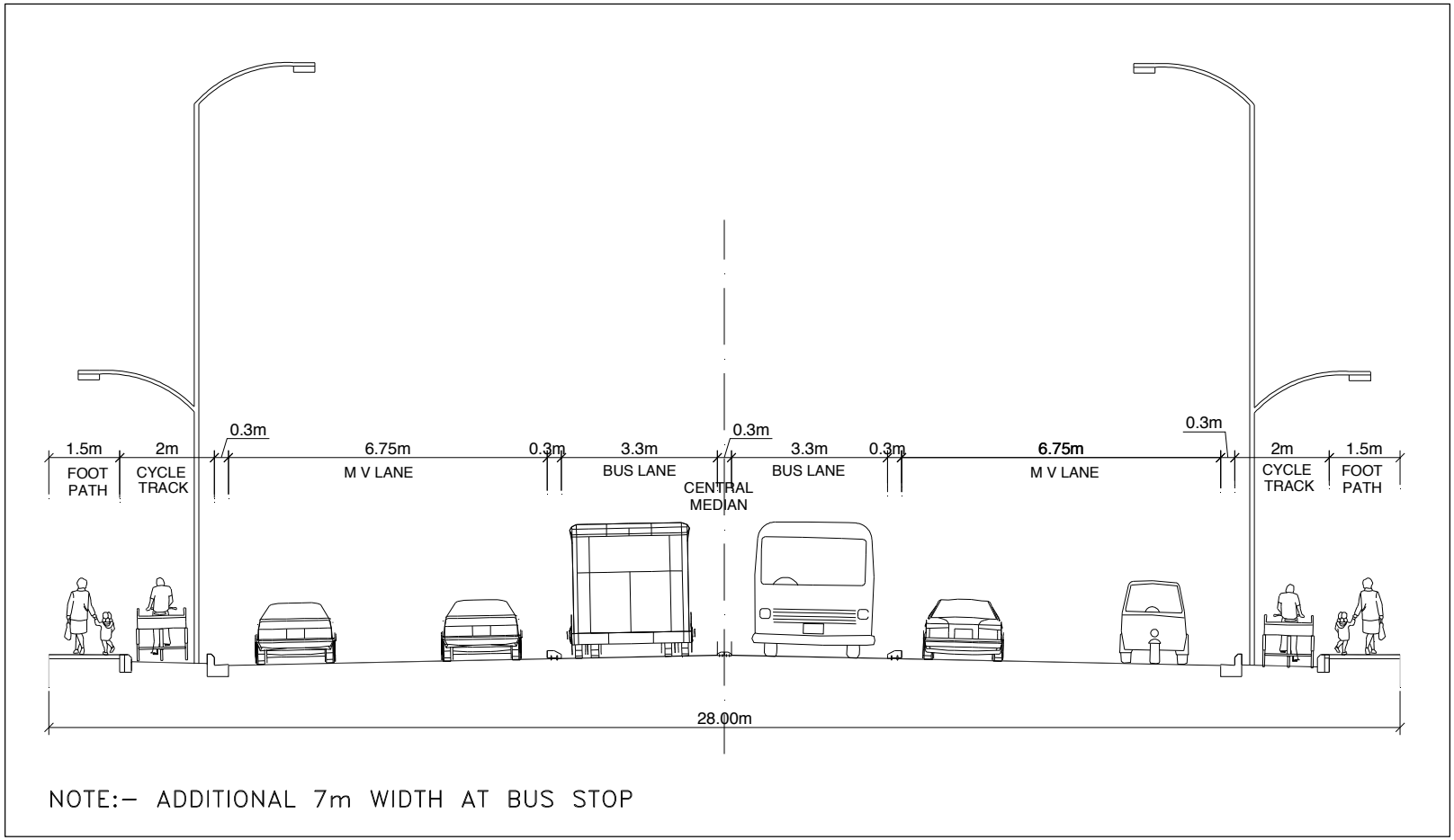
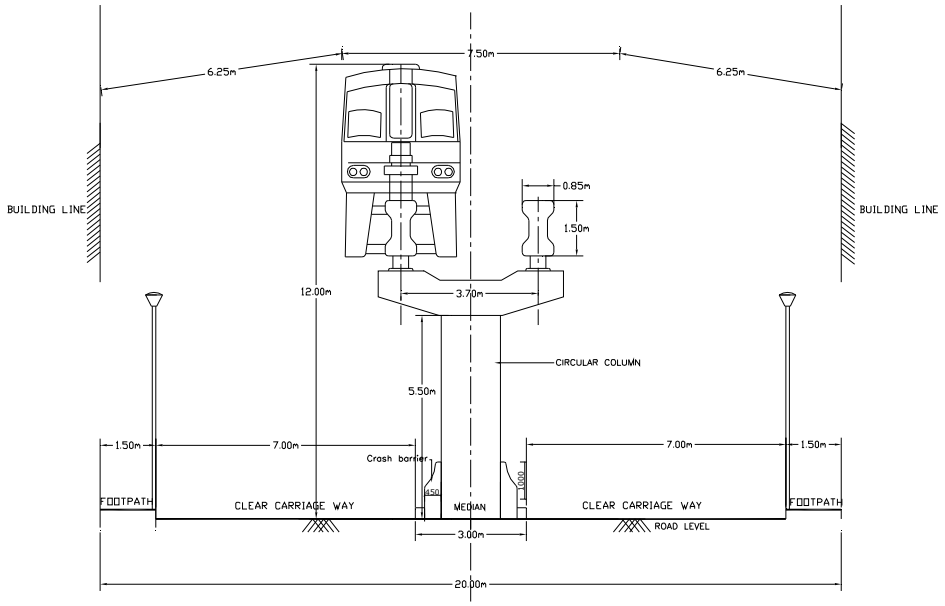
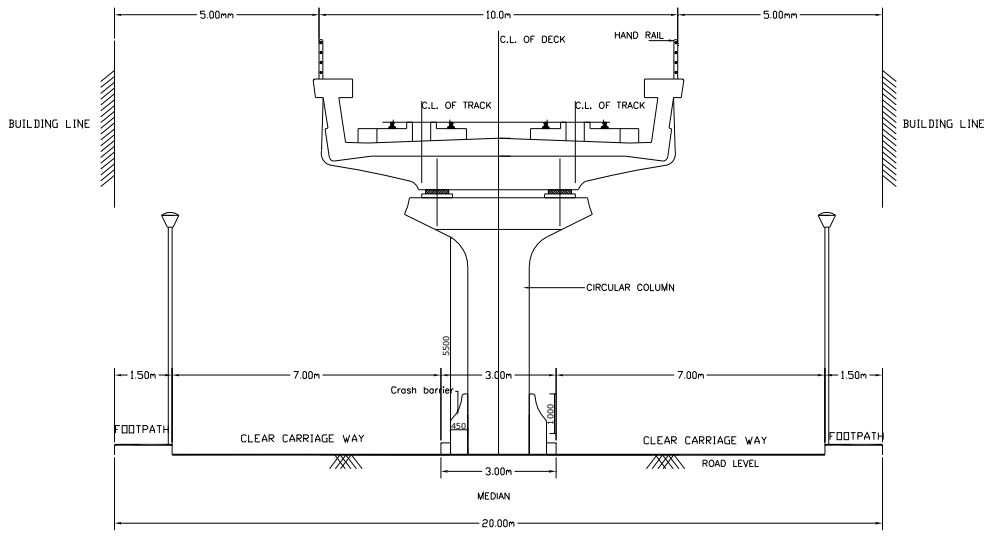


Figure 6.9 Typical Cross-Sections of Road with Elevated LRT and Monorail



NOTE:- ADDITIONAL 8m WIDTH AT STATION

TYPICAL CROSS SECTION OF ROAD WITH MONORAIL - MID SECTION (MINIMUM ROW - 20m)



NOTE:- ADDITIONAL 8m WIDTH AT STATION

TYPICAL CROSS SECTION OF ROAD WITH LRT - MID SECTION (MINIMUM ROW - 20m)

CHAPTER – 7

THE TRAFFIC AND TRANSPORTATION PLAN

7.1 COMPONENTS OF THE TRAFFIC AND TRANSPORTATION PLAN

7.1.1 The previous chapter has dealt with the future travel demand analysis on various corridors. On the basis of projected traffic, an integrated multi-modal mass transport system plan indicating different mass transport systems on various corridors has been suggested in order to cater to traffic up to the year 2025. The balance traffic should be carried by road system in order to satisfy the needs of normal bus system and other modes such as two wheelers, cars, bicycles, trucks, pedestrians etc. The proposed Traffic and Transportation plan for Bangalore contains the following types of proposals, which will cater to requirements of the projected travel demand up to the year 2025.

- Mass Transport System
  - Metro System
  - Monorail/LRT System
  - Bus Rapid Transport (BRT) System
  - Commuter Rail Services
- City Bus System
  - Augmentation of Bus Fleet
  - Grid Routes
  - Bus Terminal cum Traffic & Transit Management Centres (TTMC)
  - Volvo Depot cum Traffic & Transit centre
  - New Bus Stations/bus shelters
  - Additional Depots
  - IT Infrastructure
  - HRD Infrastructure
  - Environmental Protect Projects
- Inter-city Bus Termini
- Transport Integration
- Transport System Management Measures
- Pedestrian/NMT Facilities
  - Footpaths
  - Skywalks/Subways
  - Pedestrian zones
  - Cycle Tracks
- Road Development Plan
  - New Roads/Missing Links
  - Road Widenings
  - Grade Separators
  - Re-alignment of ORR

- Parking Facilities
- Integrated Freight Complexes

7.1.2 While framing proposals priority has been given to public transport and non-motorized transport such as pedestrian facilities. For the balance travel demand, road improvement proposals have been formulated. The details of these proposals are given in the following paragraphs.

7.2 MASS TRANSPORT SYSTEM

Public/Mass Transport System will be the backbone of the city's transport system. The basic premise of the Transport Plan in terms of the National Urban Transport Policy is to create an efficient, cost effective and extensive network of public transport which could provide comfortable, convenient and affordable means of transport to the maximum number of commuters. In this direction a number of schemes are already under implementation and quite a few on the drawing board. Infact keeping in view the observations of the scenarios in Chapter-6 there exist a large requirement for additional facilities in respect of public/mass transport system for the large area proposed to be developed in the forthcoming two decades as per the Master Plan - 2015 proposals.

7.3 THE METRO NETWORK SYSTEM

7.3.1 Metro Corridors under Implementation:

Work on implementation of 36.8 km of metro, partly underground and partly elevated, has already been initiated by Bangalore Metro Rail Corporation (BMRC) along East-West & North-South corridors crossing at Majestic. These corridors will basically cover the most congested core areas of Banglore like Peenya, Gandhinagar, M.G. Road, Vijayanagar, Indiranagar, Majestic area, K.R.Market, Jayanagar, and Basavanagudi etc. **Tables 7.1** give these Phase I Metro corridors.

Table 7.1 Phase-1 Metro Corridors

S.No.	Corridor	Length km
1	Baiyyappanahalli to Mysore Road (East-West Corridor)	18.0
2	Peenya to R.V terminal (North-South Corridor)	18.8
	Total length	**36.8**

7.3.2 Extension of Metro Corridors:

The above corridors may be able to give relief to the immediate traffic problems within the core areas and its immediate neighborhood but by the time the Master Plan proposals get implemented and development of areas beyond the outer ring road takes place in right earnest, the above system will fall short and a more extensive system will become necessary as brought out in Chapter 6. This is especially true because the Master Plan 2015 and its detailed Zonal plans propose the development of around 814.4 Sq. Kms. of area for various urban uses. This brings very large spread of area on which various urban activities will take place.

They would now be located right upto the Peripheral Ring Road in practically all directions and at a few places even beyond it. These activities include some with huge employment potential areas like the Electronic City in the east and southern portions of the BMA. It is therefore necessary that the Metro gets ultimately extended to the most of the high density centers. Therefore the following additional corridors considering the projected travel demand are proposed to be taken up as extension of the Metro in Phase 2.

7.3.2.1 **Extension of North –South corridor from R.V. Terminal upto Peripheral Ring Road**:
The area to the south of Jayanagar consisting of J.P.Nagar Banashankari, Kumaraswamy layout are fully developed and quite densely populated. Substantial commutation takes place between these areas and core areas of Bangalore. BMICAPA has plans to develop residential and commercial activities along the Bangalore Mysore Expressway corridor, the North –south commuter traffic is expected to increase substantially. It is therefore being proposed that the already approved North-South corridor between Peenya to R V Road Terminal may be extended upto the PRR along the Kanakapura Road. This extension of approximately 10 km should be taken up in the first phase itself.

7.3.2.2 **Baiyyappanahalli to Benniganahalli along Old Madras Road**
The first phase of the East West line has been proposed from Baiyyappanahalli to Mysore Road. How ever as would be seen from the plan and the subsequent proposals, Outer Ring Road (ORR) is one of the most important spines of Banglore on which large city traffic converges and keeping this in view mass transport in the form of BRT/ Mono-Rail/ LRT is proposed on it in addition to its improvement and smoothening. Benniganahalli located just on the ORR is also the Rail station for the proposed Commuter Rail Systems on the intersection of Bangalore City Station – Whitefield & Banaswadi – BMA Boundary rail corridors. Thus, since it is a very important transport node where a number of transport modes i.e. BRT, CRS etc., meet it, can act as an excellent inter-modal interchange. Therefore it is proposed the east west corridor is extended from Baiyyappanahalli to Benniganahalli through a distance of 1.5 km in the first phase itself.

7.3.2.3 **Yelahanka to Hi-tech corridor via Nagavara, Electronic City**
The singular North-South corridor planned so far will mostly be able to cater to the western part of the city between Peenya and Kanakapura Road. However the development coming up on the eastern side between Hosur Road and white field – the I.T. and the Electronic cities and in the Northern side near Thanisandra and Yelahanka need another north-south corridor. In order to meet the traffic demand of this area another 34 km long corridor from Yelahanka to PRR via Nagavara, Electronic City has been planned. This corridor will cover Nagavara, Veerannapalya, Frazer Town, the residential, commercial and industrial (IT Sector) areas along Hosur Road. This corridor will also have interchange with the airport expressway and airport metro to provide direct access from south and south east Bangalore to the airport. This will also at interchange with the East West metro corridor.

7.3.2.4 **Indira Nagar Metro Stn. to White field Railway Stn. via 100ft Indiranagar Road**

The up coming industrial areas, I.T hubs and commercial developments near the White Field area, C.V. Raman Nagar and the commercial development along most of the roads in the Indira Nagar area have totally chocked the Airport Road and the White Field Road and by the time the I.T. hub is fully functional the traffic demand will require a Metro connection of the White Field area with the heart of the City. Accordingly a 19.5 Km. Metro link between Indira Nagar Metro station and White field is proposed. This link when completed would have an inter face with the Mysore Road – Benniganahalli east west corridor at Indira Nagar.

7.3.2.5 **Proposed Devanahalli Airport to M.G.Road via Bellary Road**

A new International airport is coming up at Devanhalli about 33 Kms North of Banglore and is slated to be completed shotly. In order provide an unhindered direct approach to the Airport a Metro link between M.G. road and the new airport approximately 33 km long has proposed. In order to make the corridor truly functional, the following Terminal / checkin & pick stations have been suggested:

i. City Airport Terminal: In police grounds on M.G.Road the CAT is planned and the metro ramp structure from Mink underground section to M.G. Road elevated section will pass through the CAT structure, integrating both systems.

ii. Hebbal Check-in Station: The second check-in station has been planned at the end of the Hebbal fly-over towards left, with elevated cross-passage with escalator facility to cross-over from the bus-terminal being planned on the right side. The ease of access from the ORR will be able to attract large clientele to this Station.

iii. Yelahanka Pickup Station: It is located at the junction of the N.H. and the Yelahanka Town Road. At this station luggage checkin is not being provided but passengers with hand baggage only will be able to board and alight the train.

The above proposals of metro extensions have been consolidated and listed in the following table. These proposals would add up to about 100 Kms. of Metro to taken up in later phases.

Table 7.2 Extension of Metro Corridors

S.no.	Corridor	Length km
1	Extension of North –South corridor from R.V. Terminal upto PRR	10.2
2	Baiyyappanahalli to Benniganahalli along Old Madras Road.	1.5
3	Yelahanka R.S to PRR via Nagavara , Electronic City	36.0
4	Indira Nagar Metro Station to White field Railway Station via 100ft Indira Nagar Road	19.5
5	Proposed Devanhalli Airport to M.G.Road via Bellary Road	33.0
	Total length	**100.2**

Thus ultimately it is suggested that approx. 137 km of network of Metro will be required to effectively serve the major traffic corridors and high density use areas

to meet the travel demand up to 2025. This could be taken up in two phases. Corridors No 1 and 2 of the above **Table 7.2** may be taken up along with the corridors indicated in **Table 7.1** under implementation in Phase I, while the corridors Sr. No 3 &4 above may be taken up in the subsequent phase. In view of the pace at which the new Airport is constructed, it will be desirable to take up the Airport connection at S.No. 5 above in the first phase itself in order to make the same accessible as and when commissioned. These proposals are indicated in **Figure 7.1.**

7.4 MONO RAIL / LIGHT RAPID TRANSIT SYSTEM (LRT)

In addition to the metro, the corridors where the traffic volumes are upto 20,000 phpdt and the requirement is to cover a wide area with a large network and also to act as feeder to Metro, a medium capacity system is required. Infact upto about 15000 phpdt, a BRTS can also work reasonably well. However the limitation with it is that in order to make it really effective dedicated 10 meter wide BUS Lanes (Bus ways) are necessary at grade. However on roads where the right of way does not permit carving out the at-grade Busway, an elevated mono rail / light rail is the preferred option, since it does not impinge upon the capacity of the at grade carriageways which continue handling the vehicular traffic as explained in Chapter 6. The Master Plan 2015, while pointing out the inadequacies of the present Public Transit system and emphasizing the need for a Multi-Modal Public Transport system, has referred to mono-rail as one of the modes. It has proposed a Mono-Rail along the western crescent of the ORR from Bellary Road to Kanakapura Road along with a couple of spurs along selected radials leading to the core area. In addition an independent corridor has been proposed from Hosur Road - Bannerghatta Road Junction to National park. Considering all the factors, while basically keeping the same configuration, the proposed radial corridors along Magadi Road and Bannerghatta Road need to be extended upto the PRR and along ORR, extended up to Bannerghatta Road. Accordingly the following corridors with a total length of 60 Km. have been identified for Mono-Rail / LRT system.

Table 7.3 Mono-Rail/LRT Corridors

S.no.	Corridor	Length Km
1	Hebbal to J.P. Nagar (Bannerghatta Road) along the western portion of outer ring road	31.0
2	PRR to Toll Gate along Magadi Road	9.0
3	Kathriguppe Road / Ring Road Junction to National College	5.0
4	Hosur Road - Bannerghatta Road Junction to PRR along Bannerghatta Road	15.0
	Total	**60.0**

The option of system selection i.e. Light rail or Monorail will depend on the detailed feasibility for these corridors as and when taken up.

Figure 7.1

7.5 COMMUTER RAIL SYSTEM (CRS)

Within the BMA, approximately 120 km of rail system of the Indian Railways exists basically for long distance passengers and goods/ freight. This system currently is not being utilized for intra-urban movement with in the BMA. However RITES in its study has identified some of the Railway corridors along which it is possible to run commuter service with some additions and improvements. A similar proposal of utilizing approximately 62 km track and incurring an expenditure of Rs. 650 Crore on making the commuter service possible in two phases (2007 to 2012 & 2013 to 2018 each estimated to cost Rs. 325 Cr.) has been recommended in M.P.2015. The plan has also indicated a land requirement of 62 Ha. for this project. However it is found that the network proposed above will not be sufficient to meet requirements of the Development Area proposed in Master Plan 2015 upto the year 2025. Accordingly it has been considered necessary to extend the CRS network to approximately 119 Kms, using the existing at-grade railway system to serve intra-city needs, which is proposed along the corridors 1 to 7 in **Table 7.4**.

In addition, with the coming up of the BMRDA's planned new Town Ships at Bidadi, Ramanagaram, Solur, Sathanur & Nandagudi, high level of commutation between them and the Metropolis. Also, with the development of the huge Multiple Economic Activity Areas like Electronic City, I.T. Parks, Industrial & Commercial Areas with consequent job opportunities on the one hand and availability of comparatively cheaper accommodation in surrounding towns like Hosur, Ramanagaram and Tumkur etc. where a large number of working population is likely to live, substantial of commuter movement between these towns and the Metropolis will take place. In order to cater to this suburban commuter traffic, the CRS is proposed to be extended as corridors 8 to 10 in **Table 7.4** below.

Table 7.4 Commuter Rail Corridors

S No.	Corridor	Length Kms
1.	Kengeri – Banglore City Station	13.0
2.	Bangalore City Station – Whitefield	24.0
3.	Bangalore City Station – Baiyyappanahalli Via Lottegollahalli	23.0
4.	Lottegollahalli to Yelahanka	7.0
5.	Banaswadi upto BMA Boundary	29.0
6.	Kengeri- BMA Boundary	9.0
7.	Yeshwantpur to BMA Boundary	14.0
8.	BMA Boundary – Hosur	12.0
9.	BMA Boundary- Ramanagaram	23.0
10.	BMA Boundary to Tumkur	50.0
	Total	**204.0**

Corridors 1, 2, 6 and 9 are proposed to be taken up in the I Phase, while Sl No 3, 4, 5, 7 and 8 will be taken up in the II Phase. The Corridor at Sl No 10 upto Tumkur may be taken in III Phase.

7.6 BRT SYSTEM

BRT is one of the most cost effective public transport modes where the following two conditions can be met:

- Sufficient Right of way (30m or more) is available along the corridor to provide for exclusive carriage ways for BRT
- The peak hour commuter load is up to 20,000 phpdt.

The BRT has also the advantage of large coverage and ease of accessibility as well as simpler operational systems. Accordingly taking into consideration the Master Plan 2015 development proposals and the likely travel demand as explained in Chapter 6, BRT system along the following corridors is proposed:

Table 7.5 Bus Rapid Transit (BRT) Corridors

S.No.	Corridor	Length km
1	Hebbal to Bannerghatta Road along eastern crescent of outer ring road	33.0
2	Benniganahalli (ORR) to PRR along old Madras Road	7.0
3	From ORR to Hosur Rd along Hi-tech Corridor	8.0
4	Hosur Road to Tumkur Road along PRR (western part)	41.0
5	Tumkur Road-PRR Junction to Hosur Road along PRR via Tirumanahalli, Old Madras Road, Whitefield	76.0
6	Along Core Ring Road	30.0
7	Vidyaranyapura to Nagavarapalya via Hebbal, Jayamahal Road, Queens Road, M.G. Road, Ulsoor, Indranagar, CV Raman Nagar	29.0
8	Kengeri Sattelite Town to J.P. Nagar along Uttarahalli Road, Kodipur	13.0
9	Banashankari III stage to Banashankari VI stage Ext. along Ittumadu Road, Turahalli, Thalaghattapura	6.0
10	Domlur Ext. to Koramangala along inner ring road	5.0
11	PRR (Mulur) to Maruti Nagar (up to Hitech corridor) along Sarjapur Road	7.0
12	Peenya to PRR along Tumkur Road	6.0
13	Old Madras Road near Indiranagar to ORR near Banaswadi along Baiyyappanahalli Road -Banaswadi Road	5.5
14	Hebbal to Devanahalli Airport along Bellary Road	25
	Total	**291.5**

Thus it is proposed to have at least 569 km of mass transport system consisting of Metro, Mono Rail / LRT, BRT and CRS within the BMA supported by another 85 Kms of CRS out side BMA connecting the Metropolis to some of the BMRDA's new Townships and the Regional Towns of Tumkur and Hosur. All these proposals are shown in **Figure 7.1**. In addition to this network, the city bus system will cover a much larger area and will compliment the above systems.

7.7 AUGMENTATION AND IMPROVEMENT IN CITY BUS SYSTEM

While the high capacity BRT will be operational on selected routes where substantial right of way is available, the major areas specially the inner areas and the areas approached by the internal roads will in any case continue to be served by local bus system which will act as the most important feeder system to the Metro, Mono Rail/LRT and the CRS. For this purpose the BMTC has identified East-West, North-South & diagonal grid routes along 27 corridors as already indicated in **Figure 1.4**. In addition to improving the fleet capacity, rationalization of routes, improvement in traffic management at the junctions including priority signaling, provision of proper road side bus stops and integration points with the Metro, Mono Rail and CRS will provide effective use of the bus system. BMTC shall continue to play a vital and leading role in public transport in any scenario of the City's development. In order to meet the future challenge, BMTC has planned a number of initiatives as included in the following proposals:

Table 7.6 Proposed Improvements in the City Bus System

S. N.	Proposals	Description
1.	**Augmentation of Schedule and Fleet**	At present the BMTC is operating approximately 4500 buses at more than 1700 routes carrying approximately 35 Lakh passengers. By the year 2025, despite the fact that we are going to add Metro, Mono-rail /LRT, BRT and start CRS, still the feeder services as bus services on the other less dense corridors, will definitely be run through the city bus system only. It is expected that by 2025 at least 60 Lakh trips will be performed by buses only. For this volume of traffic at least 10000 buses will be required. However, this number may have to be increased substantially incase any of the MRT components lag behind in implementation. It is further pointed out that mere increase in fleet is not enough, its quality will also have to be of much higher standard if we want to achieve the NUTP policy of changing the passenger preference from personalized vehicles to Public Transport. Accordingly it is suggested that all the new buses to be added to fleet, either as addition or replacement should be low floor good quality buses fully considering the commuter comfort. The BMTC plans to add 2500 new vehicles and replace 1415 aged old vehicles, taking the Scheduled strength to 7000 by 2010. The financial implication towards these new vehicles is estimated as Rs 1000 Crore. In the later phases the balance 3000 buses are proposed to be added to meet the ultimate requirement of 10000 buses.

<table>
<tr><td>2.</td><td>Grid Routes and Dedicated Bus Lanes</td><td colspan="3">The BMTC has at present identified 27 grid routes in the North South, East and West and diagonal direction, which will meet the requirement till about 2010. Most of these grid routes are confined upto the ORR, and only a few at present transcend beyond it. However, by 2025 when the complete Development Area of more than 814 Sq. Kms proposed in BDA Master Plan gets fully occupied, these grid routes will both have to be extended upto the PRR and new routes added to serve this area. These routes will complement the Metro and BRT already proposed between the ORR and PRR.</td></tr>
<tr><td>3</td><td>Bus Terminal cum Traffic & Transit Management Centres (TTMC)</td><td colspan="3">TTMC's are planned to have multi-level parking lot, public utilities like mini-shopping centres and food courts. These centers in addition to providing park & ride facilities are also proposed to act as hubs for Mini – Buses planned by BMTC to transport the commuters from every major residential area to the nearest TTMC, so that commuters can board a bus of their choice. BMTC has planned such TTMC's at the following 45 locations. Of these TTMCs at Bannerghatta, Kengeri, Domlur, Yeshwantpur, Koramangala, Vijayanagar, ITPL, Banashankari and Shantinagar are planned to be taken up very shortly. In fact quite of few these center will act as Intermodal transfer nodes and will provide logistic support to MRT modes like – METRO, Mono-rail/LRT, BRT & CRS etc. through Park & Ride as well as other facilities. In fact as the MRT network grows some additional TTMC's may be required and in some case a slight relocation of some of the following TTMC's may be required.</td></tr>
<tr><td></td><td colspan="4">TRAFFIC & TRANSIT MANAGEMENT CENTERS (TTMC)</td></tr>
<tr><td></td><td>1. Yeshawantapur
2. Jayanagar Bus Stn.
3. Domlur
4. Kengeri
5. Bannerghatta
6. Shanthinagar
7. Koramangala
8. ITPL, Whitefield
9. Vijayanagara
10. Banashankari
11. Indiranagar
12. Kathriguppe
13. Hebbal.
14. Hennur
15. HSR layout</td><td>16. Kalyan Nagar
17. Nagarabhavi
18. Sriganda Kaval
19. Poorna Prajna
20. Jayanagar Depot-4
21. Peenya
22. Yelahanka
23. Rajarajeshwari Nagar
24. Hosakote
25. Bidadi
26. Vaddarahalli
27. Anjanapura
28. International Air Port
29. Venkatala
30. Bairathi</td><td>31.Avalahalli
32.Channasandra
33.Kodarhi
34.Dodda Tugur
35.Gollahalli
36.Kaggalipura
37.Challaghatta
38.Sulikere
39.Machohalli
40.Madapura
41.Harohalli
42.Soladevanahalli
43.Kambipura
44.Baiyyappanahalli
KR Pura</td></tr>
</table>

4	**Multi-Modal Transit Center**	The MMTC at Subhash Nagar has been planned at a cost of Rs. 350 Crore
5	**Volvo Depot cum Traffic & Transit centre**	Banashankari
6	**New Bus Stations/Bus Shelters**	In addition to the 4 major Bus stations located at Subhashnagar, Shivajinagar, City Market and Shanthinagar & 27 sub-nodal bus-stations commissioned at various locations, BMTC has planned another 23 bus stations and about 300 bus shelters at a cost of Rs. 279 Crore
7	**Modern Bus Depots**	Nagarabhavi Sreegandhadakaval Vaddarahalli Kothnurdinne Poornaprajna Layout
8	**New Depots**	In addition to the existing 24 bus depots, BMTC intends adding another 27 depots at a cost of Rs. 161 Crore to make the total number to 51 by 2010. However in order to cater to the 2025 proposed fleet size of 8000 buses, we may need another 20 depots for the additional fleet.
9	**Improvement of IT Infrastructure**	BMTC is the first public transport undertaking in the country to use the sophisticated GPS technology for monitoring and tracking of vehicles. This is expected to cost Rs. 33 Crore. In order to provide commuter friendly information, the corporation proposes to transfer GPS generated positional details of the buses to commuters in the form of passenger information system (PIS) through display at bus stops/ bus stations also through interactive voice response system (IVRS). This is expected to cost Rs. 84 Crore. In addition introduction of Electronic Destination Boards on buses, introduction of Electronic Ticketing System, Expansion of Computerisation activity and establishment of surveillance system at a cost of Rs. 66 Crore has been proposed.
10	**Development of HRD Infrastructure**	Training of employees of a large staff organization such as bus system is very important. Therefore 2 hitech multi disciplinary centers (Rs. 50 crore), establishment of employee training modules (Rs. 20 crore) and establishment of employee development centers (Rs. 80 crore) have been proposed.
11	**Environment Protection Projects**	Various environment protection measures at bus depots are being proposed such as Rain water harvesting, Installation of solar lighting system and other environmental initiatives costing around Rs. 49 crore.

7.8 INTEGRATED MULTI MODAL TRANSIT CENTRES –CUM- INTERCITY BUS TERMINALS

At present all the buses whether inter-city, Inter-state or Intra-city originate and terminate at the Central station in Majestic area. These not only creates congestion and heavy traffic density on all radial routes coming into the core of Bangalore but also result in substantial delay to the passengers who have to take the buses from far flung area. Though another intercity bus terminal cum integrated multi modal transit center is being contemplated at Peenya, It will not be sufficient to meet the requirements of traffic from the other direction- especially North, East & South. It is, therefore proposed that there should be at least 3 more Intercity terminals. Accordingly it is suggested that ultimately 4 intercity terminals be located at the following places:

1. Peenya
2. Hosur Road
3. Old Madras Road near ORR
4. Bellary Road near Hebbal

The above terminals are proposed to be located at the Metro and the BRT terminals and will act as Inter Modal Interchanges between regional and local traffic.
Also these would be the center for Chartered and tourist buses, with adequate parking facilities and tourist bureaus / offices etc as well as other tourist infrastructure for operation of private tour operators who are at presently located mostly around the majestic Area.

These proposals have been indicated in **Figure 7.2**.

7.9 ROAD INFRASTRUCTURE

The present road network consists of the Ring Roads and major radial corridors. A number of proposals have already been very broadly included in the Master Plan 2015. In addition quite a few proposals are being implemented by Govt. agencies like NHAI, State PWD, BMC, BDA, BMRDA and BMICAPA along with the private sector through PPP model. It is necessary to integrate / superimpose all these proposals in the light of projected travel demand for road traffic and confirm that they are in conformity with each other and there is neither conflict nor duplication. As the radial road corridors are expected to have high traffic volume, these corridors have been proposed to be strengthened instead of isolated improvements. The road improvement proposals include road widening, new roads (bypasses and other roads), ORR realignment, grade separators (road flyovers, ROBs, RUBs), Integrated Freight Complexes etc. These proposals are explained below.

Figure 7.2

7.9.1 Functional Hierarchy

In the existing road network, except for defining National Highways no other road has been specifically defined according to its functions. The Master Plan 2015 has broadly defined them as under:

- Ring Roads – Core Ring Road (CRR), Outer Ring Road (ORR), Peripheral Ring Road (PRR), Intermediate Ring Road (IRR), Satellite Township Ring Road (STRR)
- Expressways– Airport Link Road
- Highways – National Highways, State Highways
- Arterial Roads
- Sub-arterial roads
- Other link roads

It is however suggested that for new roads, we may clearly define them as shown in the **Table 7.7** below and provide them with adequate protective green belt beyond their right of way in order control direct access and avoid ribbon development:

Table 7.7 Functional Hierarchy of Roads

Road Nomenclature	Functional Characteristics	Minimum Suggested Right of Way (ROW)	Restricted green belt beyond the ROW
R-1	Access controlled Expressway with proper service roads like Peripheral Ring Road, Expressway linking the Town with New airport, Other Regional Roads like the Intermediate Ring Road and the Satellite Towns Ring Road etc.	100 Mts	30 Mts.
R-2	Arterial Roads	80 Mts	15 Mts
R-3	Secondary Roads/ Sub-Arterial Road providing main internal access in functional areas– Industrial, residential, institutional and commercial areas.	45 Mts	
R-4	Access Roads providing access to individual properties. No kerb parking is to be provided	20 Mts.	

The suggested cross-sections for the above categories of roads are shown in **Figure 7.3**. It is suggested that in order to control the development along R-1 & R-2 roads, legislation similar to the 'the Punjab Scheduled Roads and Controlled Areas Restriction of Unregulated Development Act, 1963' may be enacted.

Figure 7.3

7.9.2 Major Road Proposals

7.9.2.1 Ring Roads

The City would be looking at significantly altering the radial, "through the core" traffic pattern by improving / developing key "rings," in the BBMP, BDA, and BMRDA jurisdictions:

- **Core Ring Road (CRR)**: Of about 30 km length, around the core area, this would form the primary "bypass" to the inner core BBMP area. This road may be constructed as an elevated corridor, to minimize land acquisition. The ground level carriageways may be reserved for public transport i.e. BRT, while the private vehicles and Para transit vehicles should use the elevated deck. However this proposal will also entail improvement to the radials meeting it and their junctions with the CRR.

- **Outer Ring Road (ORR)**: Is at a radius of 7 to 10 km from the city center. The outer ring road covers a total length of 62 km and connects all major roads and highways in and around Bangalore. However, by efflux of time, the ORR has almost become a city road, with local traffic and many signaled intersections, and development all around. At present this road has a number of bottlenecks and kinks. Infact near Pantarapalya on Mysore for about 6.5 Kms the ORR follows the Mysore Road radial corridor only. The proposals consist of realigning the ORR at a couple of points and providing 2 fly-overs where the ORR has some common portions with Sarjapur Road and Bannerghatta Road. These proposals are to be carried in small lengths totaling up to about 16.6 Kms and are indicated in the Table 7.8 below. On the eastern crescent of this road, BRT corridor with exclusive segregated lanes and allied facilities for operating high capacity buses has been proposed, while on its western crescent Monorail / LRT has been proposed.

Table 7.8 Outer Ring Road Re-alignment

S. No	Stretch	Length km
1	Elevated road along Bangalore University Road	2.5
2	Realigning ORR between Magadi Road and Pipe Line Road	1.9
3	Realigning ORR at Tumkur Road through CMTI	1.2
4	Realigning ORR from Kasturi Nagar to Mahadevapura along Selam railway line	5
5	Elevating ORR along common portion with Sarjapur Road	2
6	Elevating ORR along common portion with Bannerghatta Road	1
7	PESIT to Janabharti Enterance Banglore University	3
	Total	**16.6**

- **Peripheral Ring Road (PRR)**: The Master Plan 2015 has proposed a Peripheral Ring Road of around 114 km around Bangalore at a radial distance of 2.80 to 11.50 km from the existing outer ring road. On the western side of the city just about 1 to 5 Kms inside the PRR an access-controlled expressway is already being constructed under the auspices of the Bangalore Mysore Infrastructure Corridor Area Planning Authority (BMICAPA) through Private Sector. This Expressway connects NH-7 (Hosur Road) and NH-4 (Tumkur Road) covering approx. 41 Kms. The Eastern Portion of the PRR between NH-4 & NH-7 via Old Madras Road, Airport Road should be taken up immediately to be followed by implementation of the western portion. The entire PRR should have exclusive segregated lanes and allied facilities for operating high capacity buses as BRT system. Along this Ring Road at its Junctions with Hosur Road (NH-7), White Field Road, Old Madras Road (NH-4), Bellary Road, Tumkur Road and Mysore Road, six Integrated Freight Complexes (IFC) have been proposed for handling entire freight traffic. These IFCs are indicated in **Figure 7.4**. Since it is proposed not to allow the HCV's to enter the town inside the PRR, the junctions will have to be grade separated at these points. This road should be treated as R-1 and have the 30 meters restricted belt on either side beyond the ROW.

7.9.2.2 Air Port Link Road (Expressway)

An expressway has been proposed in the Mater Plan 2015 to connect the New International Airport at Devanhalli to the city. At the moment the International airport site is only approachable through the Bellary Road which being a National Highway (NH-7) carries large interstate traffic. In order to provide uninterrupted approach to the upcoming International Airport likely to be operational next year, it will be desirable that this expressway should come up early and be commissioned simultaneous with the opening of the International Airport.

7.9.2.3 Other New Roads / Missing Links

In addition to the above roads, a few small links are required to cater to the important activity areas from the major existing Network and under implementation.

Accordingly the new roads (including elevated CRR, PRR, A.P. Link Expressway and other new links proposed to be taken up are as listed in **Table 7.9** below.

Table 7.9 New Roads / Missing Links

SNo	Corridor	Length km
1	Core Ring Road (CRR) (elevated)	30
2	Arterial Roads crossing CRR	30
3	Peenya Industrial Area To Bangalore Mysore Expressway	2.2
4	Peripheral Ring Road (PRR)	114
5	Air Port Link Road (Expressway) Upto ORR	26

SNo	Corridor	Length km
6	Link from Tigalarapalaya Main Road to Nelagadaranahalli (included in Item 42 of Parallel Ring Road (Table 7.10)	1.23
7	Link from Hesargatta Main Road to Shettihelli and Madarahelli to Mohammed Sabi Palaya (included in Item 43 of parallel ring road (Table 7.10)	4.02 (1.38 + 2.64)
8	Link from Sampigehalli to CRPF parade ground (included in Item 25 of parallel ring road (Table 7.10)	1.72
	Total	**209.17**

7.9.2.4 **Road Improvements**

The entire traffic from the BMA, the Region and even beyond converges on to the Center of Bangalore and the work areas along the radial corridors and gets dispersed through the ring roads. Most of the radials roads suffer from congestion because of their over utilization of their limited capacity. In addition the limited carriageway, the inefficiency of the junctions and their incapability to handle the volumes of traffic further reduces the capacity of the road systems. Accordingly it has found necessary that quite a few roads listed in the **Table 7.10** below will require improvement through widening 4 – 6 lane carriageway in order to cater to projected road traffic up to the year 2025. In addition at some of the critical junctions where normal signaling cannot effectively manage the traffic volumes, grade separators & flyovers will be necessary. Also at road crossings with railway lines, at some places Road Over bridges & or Road Under Bridges will be necessary. Along a few of the roads where the traffic demand far exceeds the capacity and at grade expansion is not possible due to restriction of available carriageway, elevated roads e.g. along Mysore road and Hosur Road have been provided. Accordingly the roads, both inside the ORR and out side the ORR have been identified for their improvements in terms of widening of carriageway, provision of drainage, surface improvement, footh-path etc. are listed in **Table 7.10** below. The Junctions & Road stretches requiring grade separators, ROB's and RUBs are indicated in **Table 7.11** below.

Table 7.10 Road Improvements

SNo	Name of Road	Length km
	Road Improvements (Inside ORR)	
1	Bellary Rd	7.60
2	Palace Road	1.75
3	Sheshadri Road	0.50
4	Nrupatunga Road	1.10
5	Vidhana Veedhi	0.20
6	Mission Road	1.00
7	Devanga Hostel Road	0.50
8	Sankey Road	3.40
9	Lalbagh Road	0.41

SNo	Name of Road	Length km
10	Jaymahal Road	2.80
11	Hosur Road	1.60
12	Hosur Laskar Road	4.30
13	Victoria Road	1.60
14	Lower Agaram Road	2.40
15	Sarjapur Road	3.35
16	Hosur Road	4.30
17	Bannerghatta Road	4.11
18	80' Koramangala	4.00
19	Dickenson Road	0.30
20	Ulsoor Road	0.60
21	Kensington Road	0.32
22	Murphy Road	1.70
23	Old Madras Road	1.70
24	Richmond Road	5.20
25	Airport Road	5.20
26	Goods shed Road	1.35
27	Cottonpet Main Road	1.20
28	17th Main J CNagar in ward13	1.50
29	5th cross Malleshwaram	1.00
30	Commissariat Road	0.74
31	A M Road	0.75
32	Lalbagh Fort Road	1.35
33	Race Course Road	1.66
34	Kasturba Road	0.77
35	A S char street & BVK Iyengar Road	1.21
36	Vanivilas Road	0.85
37	Suranjan Das Road	3.85
38	Mysore Road	3.90
39	Mt joy Road & Kattriguppe main Road via Vidyapeeta circle	3.00
40	Mahalakshmi Layout & Nandini Layout Road via Ayyappa Temple & Singapore Layout	2.70
41	Dinnur Main Road and Kavalbyrasandra Road (via Ganganagar Sulthan Palya)	4.50
42	Hoskerehalli main Road (via Girinagar)	2.05
43	Vasanth Nagar Main Road	0.62
44	K R Road	1.16
45	Sulthan Road	0.42
46	1st main Chamrajpet	0.15
47	3rd cross Chamrajpet & Bull temple Road	1.00
48	Link Road	0.63
49	Padarayanapura Main Road	1.86

SNo	Name of Road	Length km
50	Bull Temple Road via N R Colony, Chennamma Tank bed & 30th main BSK 3rd stage	1.10
51	Infantry Road	1.83
52	Park Road	0.50
53	Hospital Road	1.10
54	Dispensary Road	0.50
55	K Kamraj Road	1.25
56	Dharmaraj Road	0.40
57	Chandini chowk	0.45
58	Meenakshi Koil Street	0.60
59	Thimmaih Road	2.10
60	Old Poor House Road-Haine's Road	1.00
61	Millers Tank Bund Road	0.52
62	Station Road	1.30
63	Queen's Road	0.95
64	Millers Road	1.42
65	Cunningham Road	0.80
66	Road in front of Russel market	0.25
67	Dr. Ambedkar Road (Tannery Road)	4.43
68	Hennur Road	3.62
69	Banaswadi Road & Wheelers Road (via Banaswadi)	6.35
70	Hare Krishna Road	0.70
71	HMT main Road	2.10
72	Magadi Road	2.40
73	Baiyyappanahalli Main Road	3.35
74	Bapujinagar Cross Road	0.80
75	Kumaraswamy Layout Main Road	1.75
76	South Link Road	0.50
77	MTB Road	0.50
78	Kurubarahalli Main Road in ward 16	1.00
	Total	**141.73**
Road Improvements (Outside ORR)		
Radial Roads		
1	From Peenya II Stage to Andrahalli (via Peenya II Stage, Industrial area, Andrahalli)	4.00
2	Tumkur Road-NH4	8.80
3	New BEL Road	3.40
4	Jalahalli Main Road to Attur via Yelahanka	28.00
5	Yeshwantpur to Yelahanka	20.00
6	Doddaballapur Road.	6.00
7	Devanahalli - Hebbal Bellary Road	25.00
8	NH-7 Kogilu Junction to Nagavara Main Road	8.00
9	Dasarahalli Main Road	16.00

SNo	Name of Road	Length km
10	HBR Ring Road to Nagavara Main Road leading to Jakkur	20.00
11	HBR Ring Road to Hennur Main Road	16.00
12	Old Madras Road	5.25
13	ITPL Road from Ring Road to Hope farm	8.50
14	Varthur Road from Marathalli to Varthur Kodi	5.00
15	Varthur to Outer Ring Road via Belegere and Panathur	6.50
16	Kaigondanahalli to Sarjapur	10.00
17	Bannerghatta Road – ORR to National Park	8.60
18	Bannerghatta Road – National Park to PRR	2.40
19	Begur Road from Hosur Road to Begur	7.00
20	Kanakapura Road.	10.40
21	Ring Road to Kanakapura Road (via Ittumadu)	7.00
22	Rajarajeshwari Nagar Arch to PRR	10.00
Connector Roads		
23	From Magadi Road to NH 4(Via Sunkadakatte, Hegganahalli Main Road, Peenya II Stage, NTTF circle, KIADB Main Road)	6.00
24	Peenya II Stage to Ring Road (via Peeya II Stage Bus stop, Rajgopal Nagar Main Road, Peenya Industrial Area)	3.00
25	NH-7 to Nagavara Main Road through Jakkur	16.00
26	NH-7 to Nagavara Main Road	12.00
27	Hennur Main Road to Hoskote Ring Road	10.00
28	Horamavu-Agara to HBR Ring Road	4.00
29	Horamavu Road from Outer Ring Road to Kalkere	4.20
30	T C Palya main Road from ORR to Anandapura	5.50
31	Devasandra main road from NH 4 to Basavanapura Road	1.70
32	Kundalahalli Road from Devasandra main Road to Kundalahalli gate via Hoodi	7.00
33	ITPL Road to Varthur Road via Pattanadur Agrahara & Nellurahalli	4.00
34	Sarjapur Road to Ring Road(near Devarabisanahalli)	7.00
35	Nagarthapura to Matha Amruthamayee College	5.00
36	Hosur Road to Nagarthapura (Hosur Road)	4.00
37	Begur to Hosur Road (via Begur tank Bund, Chikkabegur and Manipal County)	7.00
38	Bannerghatta Road to Begur (via DoddaKammanahalli, Yelenahalli)	8.00
39	Kottur Dinne to Bannerghatta Road	5.00
40	Harinagar to Kottanur Dinne	4.00
41	Corporation Bank to Ring Road via Javaraiana doddi	4.00
Parallel Ring Road		
42	From Magadi Road to NH 4(Via Herohalli, karivobanahalli, Andrahalli, Tigalarapalya, Nelagadaranahalli, Nagasandra)	8.00

SNo	Name of Road	Length km
43	Hesaraghatta Main Road to SM Road (via Mallasandra, Shetty halli, Abbigere, Kammagondanahalli main Road, Gangammagudi Circle)	6.00
44	Vidyaranyapura Main Road to Hennur main Road	35.00
45	Nagavara Main Road to Kalkere Junction	8.00
46	Sarjapura Road to Kalkere via Chikkaballapur,Gujurpalya, Varthur, Hope farm, Kadugodi, Sadaramangala, Kodigehalli, Basavanapura, T.C.Palya	31.00
47	Matha Amruthamayee to Sarjapura Road(Kaigondanahalli)	5.00
48	Kanakapura Road-Amruthnagar to Harinagar	4.50
49	Kengeri to Konanakunte via Uttarahalli(end of Kanakapura Road)	13.50
50	Kengeri 80' Ring Road to Ullalu Main Road via Matha Mata	10.50
51	Begur Road to Hosur Road and Kudlu	6.00
52	B G Road to Begur Road(via BTM Layout, Kodichikkanahalli	5.00
53	Chunchaghatta Road to B G Road	6.00
54	GnanaBharati Circle to Magadi Road	11.00
	Total	**502.75**
	Grand Total	**644.48**

Table 7.11 List of Grade Separators

SNo	Location / Road
Grade Seperators-Roads	
1	Hudson Circle- N.R.Road Under pass
2	Cauvery Theatre Junction-Bellary Road Grade separator
3	Minerva circle-J.C.Road Fly over
4	Nagavara Junction Along ORR Flyover
5	Hennur Banasvadi along ORR underpass
6	Sarjapur Road & ORR Jn. Along ORR flyover near Ibbalur
7	On ORR Jn. Along ORR near Agara flyover
8	Flyover along Hosur Road near Check post
9	Hosur Road-Inner Ring Road along Hosur Road fly over
10	Additional slip road at CSB intersection
11	Hosur Road Grade separator @ Attibelle
12	Along 16 main BTM Layout underpass
13	Puttenahalli along ORR underpass
14	Kanakapura Road & ORR Jn. Along ORR flyover
15	Kadirenahalli Road & ORR Jn. along ORR flyover
16	Flyover on RV road near RV Teacher College

SNo	Location / Road
17	Tagore Circle underpass on Gandhi Bazaar Main Road
18	Tumkur Road & ORR Junction along ORR Grade separator
19	Flyover along NH 4 at Jalahalli Cross
20	Underpass along pipeline road near Ayyappa Temple
21	Grade separator along Guttahalli Main Road near Guttahalli Circle
22	Grade separator at Yeshwantpur Circle near Bus Station
23	Bridge at Gali Anjaneya Junction
24	Grade separator at Malleshwaram Circle
25	Underpass at Prof. CN Rao Circle
26	Underpass along Chord Road at Magadi Road & Chord Road Junction
27	Underpass along ORR at ORR and Banaswadi Ramamurthy Nagar Road Junction
28	Grade separator at ORR & Magadi Road Junction
Road Over Bridges / RUBs-Rail	
29	ROB along MES Road near Jalahalli
30	Underpass along Link Road Connecting D Rajagopal Road & Kodigehalli Road
31	Ashoka Theatre – Pottery Road
32	Nagavara–Arabic College Road
33	Kasturinagar–Chikka–Banaswadi Road
34	Baiyyappanahalli Road
35	Kadugondanahalli Railway line along Nagavara Main Road
36	Hudi Main Road near Whitefield Railway Station
37	Construction of ORR connecting Mysore Road to Magadi Road including underpass across Bangalore Mysore Rly Line
38	Along settihalli main Road
39	Along S M Road near Gurudwara
40	Along Koigehalli Main Road near Kodigehalli Rly Stn
41	Along Hesaraghatta Main Road
42	Near Tanisandra Rly Stn
43	Along Kundalahalli Road at Kundalahalli gate.
44	Along Varthur Road near Lakshmi Layout
45	Along Panathur Main Road near Bellandur Rly Stn
46	Along Sarjapur Road
Elevated Roads	
47	Elevated Road From Sirsi Circle to ORR on Mysore Road (6.0 Km)
48	Elevated Road on Hosur Road (10.5 Km)

The above proposals are shown in **Figure 7.4**

Figure 7.4

7.10 INTER-MODAL INTERCHANGES

7.10.1 Proper integration of modes

Integration between Bus, MRTS, and railway is a vital need for the future. The city is planning two such major inter-modal interchanges.

- The first such interchange is already under bid – the Kempegowda bus terminus at Subhashnagar is proposed to be converted into an interchange that accommodates the BMTC, KSRTC, BMRC, and a "city center" complex.
- The second interchange is proposed at Baiyyappanahalli, which will have the BMTC, KSRTC, Railways, BMRC, and the Airport Rail Link.

In addition to the above major 47 interchanges as indicated in Figure 7.1 are proposed at required intersections of mass transport corridors.

7.11 NON- MOTORISED MODES

7.11.1 Cycle Facilities

Their use in Bangalore is not significant but still this needs to be encouraged on environmental considerations. Provision for safer and better section of road or cycle track is the best way to keep them on roads. This is necessitates more on roads in the periphery of city and in many areas in BMA. In CBD some side roads and lanes can be exclusively reserved for cyclists and pedestrians in peak periods. In the new cross sections for major roads in **Figure 7.3**, reservation for cycle tracks has especially been incorporated.

7.11.2 Pedestrian Facilities

Pedestrians form a major proportion of commuters. Not only trips are conducted by walk in its entirety but every public transport trip will also have component of walk at its both ends. Though they are short distance travelers, they are spread all over the city. As facilities furnished for them are encroached upon by vendors or for road space, they have to spill on roads. These contribute to accidents also. One alternative for their facility and controlling their spill on roads is to provide good footpath with railings covering about one to one half meters width on either side of the road with openings at desired crossing points. Another alternative is to develop some narrow roads especially adjacent to major arterials as "pedestrians only" roads. Bus bays and foot paths at bus stops can also help in restraining their spill on to carriageways and reducing accidents. Pedestrian subways at important location on all 6 lane roads and at busy inter sections/junctions on 4 lane roads are to be planned on a programmed basis.

7.11.2.1 Pedestrian Cross-Over Walk-ways facilities

The proposed skywalks/pedestrian subways are given in **Table 7.12**.

Table 7.12 Sky Walks / Sub-Ways

S No.	Locations of Sky Walks / Sub-Ways
1.	Cauvery Bhavan to Education Department Building and to Law College to Mysore Bank crossing KG Road on State Bank Junction
2.	Opposite NTI connecting Guttahalli Road and Palace (opposite Bus Stop) on Sankey Road
3.	Arya Bhavan Sweets to Kanthi Sweet to Himalaya Theatre, crossing KG Road
4.	Lalbagh Main Gate (Javaraiah Circle)
5.	Bannerghatta Road near Jayadeva Hospital
6.	BMTC Main Bus Stand to Amar Lodge Building in Majestic Area
7.	KSRTC Kempegowda Bus Station to BMTC Main Bus Station
8.	At Kengeri Bus Stand, Mysore Road
9.	At Byatarayanapura on Bellary Road (near Junction of BBMP office complex)
10.	BMTC Main Bus Station to Railway Station Premises
11.	Shanthala Silk House to KSRTC Main Bus Station and to Good-Shed Road
12.	RNS Motors, Tumkur road
13.	Jalahalli Circle, Tumkur Road
14.	Near Webb junction
15.	Near Kamakhya, Kathriguppe Ring Road
16.	Gandhi Bazaar Main Road
17.	On Vittal Mallya Road near Mallya Hospital
18.	Sheshadri Road near Maharani College
19.	On JC Road near Ravindra Kala Kshetra
20.	On Hosur Main Road near Madivala Check post
21.	On Raja Ram Mohan Roy Road, near Pallavi theatre
22.	On Richmond Road near D'Souza Circle
23.	On Race Course Road near Chalukya Hotel
24.	On Commissariat Street near Garuda Mall
25.	On Residency Road near Mayo Hall
26.	On Kamaraj Road near Commercial Street
27.	Near Indira Nagar 100 feet Road & Water Tank junction on Airport Road
28.	On Hosur Road(Near Forum)
29.	On Tumkur Road, near SMS Railway Junction
30.	On Air Port Road, Marath Halli at Village Road.
31.	On Air Port Road, Marath Halli at Junction of Under Pass ORR
32.	K.R. Puram Bus Stand
33.	Bharatiya Vidya Bhavan, Devaraj Urs Road
34.	On Hosur Road "T" Junction with Tavarekere Main Road (Opposite Sai Sadan & Prestige Acropolis) (High Rise Apartments Condominium)
35.	Mission Road at the foot of Fly over
36.	Vidhana Veedhi near M S Building
37.	Tumkur Road near Yeshwantpur Circle
38.	At South End Circle
39.	Malleshwaram 5th cross

S No.	Locations of Sky Walks / Sub-Ways
40.	Double Road opposite Shanthi Nagar bus station
41.	City Market additional arm to be added to existing underpass
42.	30 no. Sky –walks / Sub-Ways along the eastern crescent of the ORR

The choice between lift/escalator operated skywalks and underpasses will depend upon the specific site conditions and the quantum of pedestrian traffic while undertaking the detailed feasibility studies. Location of these facilities is indicated in **Figure 7.5**.

7.11.2.2 **Foot paths**

It has been observed that most of the footpaths along the major arterial and sub arterial roads need extensive repairs and up gradations. The major problems observed are:

- Insufficient widths (< 1.5 mts.)
- Uneven surface because of settlement of base course, improper covering of service lines, manholes etc.
- Obstruction due to encroachments, unwanted garbage, unused building materials, fallen/ half cut trunks of trees and full grown trees, cable stays of electric poles etc.
- Level difference and steep risers with junctions of roads.

For this purpose tentatively it has been estimated that footpaths along 350 km of roads are required to be taken up. The basic principles for construction of new footpaths and improvement of existing ones are as under:

- Footpaths along existing roads should be widened and the minimum width be kept at least 2.0 mts.
- Proper leveling of footpath surface – with a stable base course fully compacted and safe guarded against any settlement before laying the top surface. In addition the cover for the underground services and man holes, if any, located below the footpaths or crossing should be properly designed to maintain a proper level with the surface of the footpath and no subsidence occurs.
- Continuity of footpaths
- Adequate ramp facilities for physically challenged people at junctions and cross overs.
- Proper merger of footpaths with skywalks/ underpasses/zebra crossings and junctions be provided with pedestrian priority signaling.

Figure 7.5

7.11.2.3 Pedestrian Zones

Substantial areas inside the core ring road has quite a few streets which are either fully commercial or majority of whose frontage is being used as shopping. The commercial activities on these roads can broadly be divided into the following two categories:

i. Retail and general Shopping like general merchandise, clothing garments and allied products, household white goods, consumer electronics, groceries & kitchen ware, Food & sweet shops etc., which are more or less regularly visited by shoppers.

ii. Wholesale and specialised shops dealing in machinery, building materials, Hardware etc. which are occasionally visited by customers with specific requirements and need bulk handling through Trucks and MCV's As far as these commercial activities are concerned attempt should be made to shift them out side the ORR along wide corridors where adequate loading / unloading facilities can be provided along with required parking facilities for visitors / shoppers. For shifting of these wholesale activities both strong measures against their functioning in their present locations in the core areas and incentives for shifting to the new locations will have to be provided.

The majority of the customers visit the core area to meet their retail needs through first type of establishments. As per the plan, this central area is going to be very well served by:

- 3 Metro Links namely
  i. Baiyyappanahalli to Mysore Road (East-West Corridor)
  ii. Peenya to Banashankari (North-South Corridor)
  iii. Yelahanka R.S to PRR via Nagavara and Electronic City

- An elevated core ring road surrounding this area with provision for BRT
- Adequate park & ride facilities out side the core area at Bus Terminal cum Traffic & Transit Management centres, Metro Termini & important metro Stations, BRT stations, along side Core Ring Road and Monorail Termini & Stations.

Thus the entire core area will be fully covered by elaborate public transport network and as such the entry of all private vehicles, especially during the shopping hours 10 A.M. to 9 P.M. should be minimised.

7.11.2.4 Proposed Pedestrian Zones

To start with following two areas are being suggested for pedestrianisation:

1. Gandhi Nagar & Chickpet Areas- The area surrounded by Seshadri Road, Kalidas Marg, K.G.Road, Distt. Offices Road, N.R.Road, Mysore Road and Bhashyam Road, Tank Bund Road & Dhanvantri Road can be converted into two pedestrian zones I & II on either side of K.G.Road. The two Zones can be inter connected through a semi depressed under pass near Alankar Plaza and Jantha Bazar. All the private vehicles will be required to move on Seshadri Road, Kasturba Road, NR Road and Bhashyam Road, while K.G.Road and District Offices Road be used by Public Transport –Busses & Trams. In the surrounding areas 5 mechanical parking spaces with a capacity of 500 vehicles each will be provided at;

- P13- Behind Sagar
- P14- Kanteerava Stadium
- P15-Near City Market
- P16-Near Bakshi Gardens
- P17 – KSRTC Bus Depot

2. Commercial Street - To be designated as 'CLOSED FOR VEHICLES FROM 10 A.M TO 9 P.M.' and supported by parking P-2 near Kamaraj Road
3. Brigade Road - To be designated as 'CLOSED FOR VEHICLES FROM 10 A.M TO 9 P.M.' and supported by parking P-1 near M.G.Road

These proposals are indicated in **Figure 7.6.**

7.12 PARKING

7.12.1 The parking demand is growing with growth of vehicles in the city. The multistoried buildings in busy/commercial areas are major attractors. Though the building regulations specify a minimum provision of parking area, there can be many defaulters and some who later convert the spaces for other purposes. This results in the vehicle parking spilling to streets (main road or side streets). A practical solution is to provide off street multistoried parking lots in this areas. As funds will be constraint consultants suggest a policy in this regard. The Owner who fails to provide required parking spaces as per the regulations should be charged an annual levy equivalent to market rental value for the short fall in parking area provided. Subsequently the market value will rise every year. Amount so collected plus parking charges collected will be substantially enough to meet the repayment installments of loans which were taken to construct multistoried parking lots. Once such facility is provided it is possible to prevent the on Street parking of vehicles or otherwise road space can be utilized for traffic. The development control regulations and TCP act may be suitably amended to provide for such levies.

Figure 7.6

7.12.2 Parking demand can also be controlled by implementing transport management measures like staggering office and school working hours and banning on-Street parking of private vehicles in CBD and on major arterials.

However it must be realized that mere regulatory measures are not enough and positive steps are required to meet the parking demand and provide safe parking outside the congested areas. It is suggested that for proper parking management and control, to start with we may divide the city into three zones.

7.12.2.1 Zone A – Central areas inside the core ring road where only short term parking on hourly basis should be provided between 9 AM to 9PM with high telescopic charges increasing with every hour of parking. These areas will invariably be provided with automatic mechanical parking (AMPs). Beyond 9PM and upto 9AM they can offer lower tariff rates for long term night parking.

7.12.2.2 Zone B – between the CRR and ORR – in these areas a combination of AMPs and Conventional Multi level Parking (CMPs) can be provided at selected interchanges, especially at the TTMCs and other identified locations closer to public transport corridors. Parking in these areas will also be short term time based but at a slightly lower tariff as compared to Zone A.

7.12.2.3 Zone C – outside the ORR – large CMPs may be provided at the TTMC s and other locations adjoining the public transport stations of Metro, Monorail/LRT, BRT etc. these will be long term parking lots of 8 to 12 hour duration at a nominal tariff to encourage the vehicle owners to park at these facilities and ride the public transport system to their destination and back.

7.12.3 To begin with parking for about 10000 vehicles has been suggested at the following sites in **Table 7.13**.

Table 7.13 Proposed Parking Sites

S. No.	Location	Phase	Type
1	M G Road	P-1	AMP
2	Near Kamraj Road	P-1	AMP
3	Gandhi Nagar	P-1	AMP
4	Jayanagar Shopping Complex	P-1	CMP
5	Koramangala near Raheja Tower	P-1	CMP
6	Rajajinagar BDA Complex	P-1	CMP
7	Banashankari BDA Complex	P-1	CMP
8	Gandhi Bazaar	P-1	CMP
9	Malleshwaram	P-1	AMP
10	Fire Station, Residency Road	P-1	AMP
11	Dhobi Ghat, Cunningham Road	P-1	AMP

S. No.	Location	Phase	Type
12	SP Office, Miller Road, Cunningham Road crossing	P-1	AMP
13	Near Sagar & States	P-1	AMP
14	Kanteerava Stadium	P-1	AMP
15	City Market	P-1	AMP
16	Bakshi Gardens	P-1	AMP
17	KSRTC Bus Depot	P-1	AMP

Of these sites, where the availability of land is limited and the land values very high, automatic mechanical parking (AMP) which can provide 500 parking lots in approx. 1000 sqm of space have been suggested. In the outer areas, conventional multistory parking (CMP) has been proposed.

In addition, since most of the TTMC's are proposed to be adequately served by Public Transport like Metro, Mono Rail/LRT, BRT etc, substantial Park and ride facilities should be provided from where the commuters can switch over from private to public transport. These proposals are indicated in **Figure 7.2**.

Similarly at all the termini of Metro, Mono rail/LRT, BRT,CRS and their major stations out side the Core Ring Road should be provided with adequate park and ride facilities are to be provided.

Within the core area where the land is scarce and very expensive, mechanical automatic & semi automatic parking may be provided with heavy time based parking Charges.

In the long run, when the mass transport system is city-wide and adequate, parking demand will stabilize. Therefore it is important that adequate and convenient mass transport system as recommended above is provided.

7.13 FREIGHT MOVEMENT

7.13.1 The freight movement through the city particularly on some of the arterials is already restricted in CBD area. Many orbital corridors cannot be easily restrained till such time the wholesale activities are concentrated in the CBD. The strategy already followed is to decongest the CBD by shifting the wholesale market to outer areas or proposed IFCs along the PRR. In order to facilitate the shifting of the wholesale activity from the core areas, both harsh measures in terms of restriction on the activities at their present location and incentives for relocation in the new areas will have to be followed. The restrictions in the central areas could be in the form of banning the entry of HCVs completely and permitting only LCVs between 10 PM and 9 AM; treating these properties as engaged in misuse activities and charge a very hefty misuse charge on a daily basis and a substantial increase in the property tax. All private vehicles should be banned from entering

these areas between 9 AM to 10PM. simultaneously well developed wholesale markets may be created along side the IFCs with modern transport, loading and unloading, parking and ancillary facilities. These sites can be allotted to the persons relocating their business on no profit no loss basis on priority.

The provision of PRR is itself going to help diversion of through freight traffic. Nearly 80% of the ORR has lost the sole identity of ring road, the PRR being thought of in this connection will be a boon to the city. Development of another orbital ring road as proposed by BMRDA would also help in diversion of the freight traffic. So far there is no though regarding the shifting of the goods shed. If a ring railway is formed over the outer ring road, shifting of the goods shed to the periphery of the city can also be thought of. But this will take longer time. However, future planning of the rail facilities in and around Bangalore will need to be kept this in mind. Such shifts will have some adverse effect i.e. HCV/LCV movement from the goods sheds on the periphery and any wholesale complexes, into the city will develop. By suitable management measures like restricting these movements during particular timings of the day, problem can be suitably managed.

7.13.2 Integrated Freight Complexes (IFC)

Near the junctions of the PRR with the following radial corridors, six IFC's are proposed as indicated in **Figure 7.4**:

1. Hosur Road
2. White Field Road
3. Old Madras Road
4. Bellary Road
5. Tumkur Road
6. Mysore Road

In addition to acting as nodes for handling the HCVs traffic and diverting it on the PRR they will also act as center for wholesale trade. Quite a few wholesale markets to be shifted outside the central area can be located as part of the IFC for efficient handling for bulk goods.

7.14 DEMAND CONTROL

7.14.1 Reducing Private Vehicle Use

There are two ways to restraint the growth of private vehicles on road to either by pricing policy or by providing better level of service on public transport. Road pricing is difficult to achieve in a city like Bangalore particularly since its enforcement would be very difficult. It should be possible to put constraints in some areas by restricting private vehicles entering into the congested roads particularly during the peak hours. Providing good public transport with feeder

IPT modes like Mini buses for facilitating the commuters to reach their destinations from Train/Bus stations would also induce many private vehicle users to shift from private vehicles. In fact with the coming up of the Core Ring Road, proposed improvements in the alignment of the ORR, Coming up of the various Mass Rapid Transit (MRT) Modes like Metro, Mono-Rail / LRT & BRT we can substantially achieve the objectives through the following measures:

- Enough parking lots be provided outside the ORR & CRR easily accessible from the radials reaching the ORR & CRR
- Proper park & ride facilities for long term parking at the stations / termini of the MRT modes out side the ORR.
- Providing comfortable, environmentally friendly transport (Electrically operated / CNG mini busses) between MRT stations and the core areas.
- The parking facilities provided / planned in side the CRR should only be for Short term parking with high hourly charges.
- Congestion Charges be imposed on slab-scale from private vehicles entering first the ORR and then the CRR.
- Private vehicles be completely banned from entering the pedestrian zones between the shopping hours i.e. 10 AM to 9 PM.

The above measures can help in reducing private vehicles in busy areas.

7.14.2 Land use for demand optimization

The land use and density component of the above strategy can be operationalized only through revisions in the Master Plan. High traffic generating activities and high density (high FSI) zones should be realigned around mass transport nodes and along major transportation corridors.

Such a reorganization of land use and density cannot be realized only through the modifications in the Master plan. In already developed areas, this needs to be translated into projects for planned redevelopment, ensuring that the high density and high intensity of activities are supported by appropriating land for improvements in the road network, street design and supporting infrastructure. The energy for redevelopment already exists in the real estate market in Bangalore, and will receive further impetus from the implementation of mass transport projects.

In new growth areas, a mechanism for micro-level planning (such as Town Planning Schemes in Gujarat) will need to be introduced to ensure that all new development is adequately served by primary, tertiary and secondary road network with provision for public transport facilities. These would also essentially have to be translated into land management projects.

7.14.3 Development of Integrated Facilities

As already pointed out, Bangalore has a good network of rail system, which can be converted by adding a few facilities like parallel lines, electrification, additional stations etc to serve as a commuter rail system also. Detailed studies have been completed already. CRS along with the Metro system under construction and the Bus transport can be integrated with good interchange and parking facilities at stations to form an Integrated Transport System.

7.15 TRANSPORT SYSTEM MANAGEMENT – B-TRAC 2010

7.15.1 Background

Bangalore City, has witnessed a phenomenal growth in vehicle population. As a result, many of the arterial roads and intersections are operation over the capacity (i.e., v/c is more than 1) and average Journey speeds on some of the key roads in the Central Area are lower than 10 Kmph in the peak hour. Therefore, it has become necessary to establish plans for efficient traffic management in Bangalore. In this regard, Bangalore City Police have envisaged the "Bangalore Traffic Improvement Project – B- TRAC 2010"

7.15.2 Goal and Objectives

The objectives of B-TRAC 2010 would be two-fold:

1. Operational Objectives: (a) Reduce traffic congestion by 30% in the Central Area of Bangalore City; (b) Reduce accidents by 30% in the city of Bangalore; (c) Achieve significant reduction in pollution; (d) Achieve substantial compliance of Traffic Laws and Rules; and (e) Set up an effective Trauma Care System.

2. Institutional Objectives: (a) Coordinated traffic management by developing mechanisms for the same, like institutionalizing Traffic Task Force, Road Safety Committee, Traffic Action Committee etc; (b) Robust Revenue Model (traffic funds to pay for traffic management infrastructure and maintenance); (c) Legal and Institutional reforms; (d) Capacity Building (Modernization and up gradation of Traffic Training Institute etc.); and (e) Strengthening of Traffic police by augmenting officers and staff; construction of buildings and provision of modern communication and mobility.

7.15.3 Approach

The city of Bangalore needs a traffic management that addresses not just supply aspects, but also demand and B-TRAC – 2010 adopts this very same approach.

7.15.4 Strategy

B-TRAC-2010 framework would be as follows: (a) Land use development controls; (b) Primacy to Public Transport; (c) Parking controls and management; (d) Automated Control and Enforcement (ITS/ATC); (e) Entry Restriction to the Central Area; and (F) Road safety plan for accident reduction. Specific components of the strategy are: (a) Central Area – Area Traffic Control System; One way systems; dedicated bys lance and signal priority for buses; Parking controls; creation of no-auto zones; restricted entry of traffic in to the core area

(b) Core ring road development for unhindered movement of traffic thereby avoiding the central area (c) Corridor Traffic Control System (as in ATC) for the several radial roads (d) up gradation of intermediate and outer ring roads and development of the peripheral ring road (e) Traffic police modernization with improved communication, computerization, mobility, capacity building and automated enforcement systems.

7.15.5 Components

The various components of B-TRAC are as under:

- Junction Improvements
- Street Furniture and Road Marking
- Intelligent Transport System including. ATC, VMS etc for 250 intersections
- Surveillance / monitoring and enforcement cameras etc
- Education and Training / Others

7.15.6 Benefits

(a) Traffic congestion will be reduced by 30% in the Central Area of Bangalore City
(b) Accidents will be reduced by 30% in the city of Bangalore
(c) There will be significant reduction in pollution
(d) Substantial compliance of Traffic Laws and Rules will be achieved
(e) Effective Trauma Care System will be set up
(f) Coordinated traffic management will be achieved
(g) Level of traffic and road safety awareness will be enhanced and
(h) State of the art traffic policing and regulation will lead to substantial compliance.

7.15.7 Summary

B-TRAC 2010 will be first of its kind project in the country to address the issues of traffic congestion, safety etc by utilizing the latest traffic management technology and techniques, which are appropriate to our context. This will give the much-needed scope for larger infrastructure projects to be planned and implemented for improving the transportation system in Bangalore city.

CHAPTER – 8

TRANSPORT INTEGRATION

8. 1 NEED

A multi-modal public transport network for the BMA has been proposed to be developed to meet expected commuter's travel needs. Integration of various modes of transport is vital to evolution of a least-cost and viable transport system. Objective of an integrated transport system is to offer maximum advantage from economic, traffic and planning considerations. Various transport modes are to be integrated in such a way that each mode supplements the other. For effective integration, total transport system has to be planned, implemented and operated under common policies. Depending upon the forecast transport demand and other parameters along various corridors, an appropriate transport system giving least-cost option has been proposed.

8.2 INTEGRATION OF MODES

8.2.1 It is not possible to provide direct origin to destination service and vice a versa for all commuters. The need to interchange modes and or corridors is an essential feature of any public transport system. The planning objective as stated earlier is to minimize the need to change and when change is essential to make it as convenient as possible and with minimum time loss.

8.2.2 The proposed network includes corridors that are collector routes to serve areas at some distance from the mass transport routes. Another corridors are radial that normally would be direct origin to destination routes and hence will meet the objective of minimum interchanges. There are circular routes that will interchange with the radial routes. On these routes, one interchange should meet the needs of most commuters. The overall network of radials and circular corridors has formed a grid and hence most commuters should not need more than one or two interchanges.

8.3 FEEDER SERVICES

Feeder services to the proposed network will also be important in order to provide convenient and quick transfer of passengers from one mode of transport to other. As all commuters will not be living within walking distance of the proposed network, proper planning for feeder services will be necessary to ensure the forecast passenger demand on the system. For catchment area of about 0.5-1 km from the proposed network, commuter can easily access it by walk. People residing in next 1-km can reach station by cycles, scooters, auto-rickshaws and mini-buses. Areas outside the 2-km catchment area will require

regular feeder bus services to important terminals/stations. Feeder services can also be provided by Para-transit modes. However, choice of a particular mode will depend upon passenger demand, road cross-section, road gradient, etc.

8.4 INTER-CHANGE FACILITIES

8.4.1 One of the most important elements of transport integration is the provision of inter-change facilities. Required inter-changes will be between the proposed mass transit systems such Metro, CRS, LRT/Monorail, BRTS and with other feeder services. Integration facilities at stations would depend upon expected station load to ensure proper system utilization. This will also include approach roads to stations, circulation facilities, pedestrian ways and adequate parking areas for various modes that are likely to come to important stations including feeder, bus/mini-bus routes. The provision will have to be made for peak demand at each station. At either stations, proper road based integration is to be ensured.

8.4.2 **Figure 7.1** shows the interchange points in the mass transport network. There are 49 locations of interchange with high capacity mass transport modes.

8.4.3 The main issue is to make these interchanges convenient with minimum time penalty. Facilitates for interchange between modes/corridors should be planned for convenience and minimum loss of time. Side by side or vertical interchange that involves minimum walking is the best and hence has to be the norm in planning. It is proposed that planning and design of convenient interchanges and safe access from the area up to stations and stops forms the subject of a special study devoted to achieve the objective.

8.5 OPERATIONAL INTEGRATION

Integration at operational level will be required to synchronize the timings of mass transit and feeder services. For efficient inter-change, walking/waiting time at these stations will need to be minimized. Introduction of common ticketing and their availability at convenient places will be necessary to ensure forecast patronage of the system. An integrated passenger information system covering all modes through publication of common route guides, time-table, information boards at terminals for providing up-to-date information for the system users will also be important.

CHAPTER – 9

COST ESTIMATES, PHASING AND FINANCING PLAN

9.1 UNIT RATES

9.1.1 The Traffic and Transportation Plan comprising proposals for public/mass transport system, inter-city bus terminals, pedestrian facilities, parking facilities, road infrastructure, integrated freight complexes, transport system management measures etc has been prepared for the BMA to cater to travel demand up to the year 2025 at an acceptable level of service as explained in Chapter 7. In order to know the financial implications of these proposals, block cost estimates have been worked out in this chapter. Unit rates adopted for items at 2007 prices are given in **Table 9.1**.

Table 9.1 Unit Rates

S.No.	Item	Unit	Rate (Rs Cr.)
1	Metro Elevated Section	per Km	130
2	Metro Underground Section	per Km	250
3	Mono Rail/ Light Rail Transport System	per Km	85
4	Commuter Rail System inc. dedicated line, signalling systems, improvement of stations etc.	per Km	15
5	BRT	per Km	12
6	Low floor urban commuter buses	Each	0.4
7	Bus terminal cum Traffic & Transit Management Centres (TTMC)	Each	45
8	Bus station	Each	12
9	Bus depot	Each	6
10	Bus shelter	Each	0.03
11	Inter-city bus terminal	Each	45
12	Elevated Road	per lane/ Km	10.0
13	New dual carriage way road	per lane / Km	1.66
14	Widening of roads	per lane/Km	0.5
15	Grade separators 6 lane dual CW 700 mts long	each	30
16	Improvements of Foot paths	per Km	0.2
17	Sky walks	Each	2
18	Automatic Mechanical Parking	per parking space	0.05
19	Conventional Multi Storey Parking	per parking space	0.02
20	Integrated Freight Complex	Each	45

9.2 COST ESTIMATES OF PROPOSALS AND PHASING OF IMPLEMENTATION

9.2.1 Considering the various proposed schemes and unit rates, cost estimates of these schemes have been worked out at 2007 prices and are given for Proposed Mass Transport Corridors, City Bus System, Road Infrastructure, Grade Separators, Pedestrian Facilities, Parking Facilities, Integrated Freight Complexes and Transport System Management Measures in **Tables 9.2 to 9.9** respectively. The entire transport development plan is not required to be implemented in one go. Considering the existing problems, expected traffic demand levels and schemes already under implementation/ active consideration of the Government, phasing of implementation of various projects has been suggested in three phases (2007-12, 2013-18 and 2019-24) and is also given in these tables. Cost estimates for each project to be implemented in the three phases have also been given in the tables.

Table 9.2 Cost Estimates of Proposed Mass Transport Corridors (Rs Crore)

S.No.	Corridor	Length km	Unit Cost per Km	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
Metro System							
1	Baiyyappanahalli to Mysore Road East-West Corridor	18		5605	5605		
2	Peenya to R.V terminal North-South Corridor	18.8					
3	R.V .Terminal to PRR	10.2	130	1326	1326		
4	Baiyyappanahalli to Benniganahalli along Old Madras Road	1.5	130	195	195		
5	Yelahanka R.S. to PRR via Nagavara , Electronic City	36	175	6300		6300	
6	Indiranagar Metro Stn. to White field Railway Station via 100ft Indiranagar Road	19.5	130	2535		2535	
7	Proposed Devanahalli Airport to M.G.Road via Bellary Road	33	120	3960	3960		
	Total	**137**		**19921**	**11086**	**8835**	

S.No.	Corridor	Length km	Unit Cost per Km	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
Mono Rail / LRT System							
1	Hebbal to J.P.Nagar (Bannerghatta Road) along the western crescent of outer ring road	31	85	2635	2635		
2	PRR to Toll gate along Magadi Road	9	85	765	765		
3	Kathriguppe Road / Ring Road Junction to National College	5	85	425	425		
4	Hosur Road – Bannerghatta Road Junction to PRR along Bannerghatta Road	15	85	1275		1275	
	Total	**60**		**5100**	**3825**	**1275**	
Commuter Rail System							
1	Kengeri – Bangalore City Station.	13	15	195	195		
2	Bangalore City Station – Whitefield	24	15	360	360		
3	Bangalore City Station – Baiyyappanahalli Via Lottegollahalli	23	15	345		345	
4	Lottegollahalli to Yelahanka	7	15	105		105	
5	Banaswadi upto BMA Boundary	29	15	435		435	
6	Kengeri- BMA Boundary	9	15	135	135		
7	Yeshwantpur to BMA Boundary	14	15	210		210	
8	BMA Boundary – Hosur	12	15	180		180	
9	BMA Boundary- Ramanagaram	23	15	345		345	
10	BMA Boundary to Tumkur	50	15	750			750
	Total	**204**		**3060**	**690**	**1620**	**750**
BRT System							
1	Hebbal to Bannerghatta Road along Eastern portion of the ORR	33	12	396	396		

S.No.	Corridor	Length km	Unit Cost per Km	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
2	Benniganahalli (ORR) to PRR along Old Madras Rd.	7	12	84	84		
3	From ORR to Hosur Road along Hitech Corridor	8	12	96	96		
4	Hosur Rd. to Tumkur Road along PRR (western part)	41	12	492		492	
5	Tumkur Road-PRR Junction to Hosur Road along PRR via Tirumanahalli, Old Madras Road, Whitefield	76	12	912		912	
6	Along Core Ring Road	30	12	360	360		
7	Vidyaranyapura to Nagavarapalya via Hebbal, Jayamahal Road, Queens Road, M.G. Road, Ulsoor, Ind1ranagar, CV Raman Nagar	29	12	348	348		
8	Kengeri Sattelite Town to J.P. Nagar along Uttarahalli Road, Kodipur	13	12	156		156	
9	Banashankari III stage to Banashankari VI stage Ext. along Ittumadu Road, Turahalli, Thalaghattapura	6	12	72		72	
10	Domlur Ext. to Koramangala along inner ring road	5	12	60	60		
11	Mulur to Maruti Nagar (up to Hitech corridor) along Sarjapur Road	7	12	84	84		
12	Peenya to PRR along Tumkur Road	6	12	72	72		
13	Old Madras Road near Indiranagar to ORR near Banaswadi along Baiyyappanahalli Road – Banaswadi Road	5.5	12	66	66		
14	Hebbal to Devanahalli Airport along Bellary Road	25.0	12	300	300		
	Total	**291.5**		**3498**	**1866**	**1632**	

Table 9.3 Cost Estimates for Proposed Improvement in City Bus System and Intercity Bus terminals / IMTCs (Rs Crore)

SNo.	Proposals	Phase	Units	Qty/Nos.	Unit Cost (Rs Cr)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
City Bus System									
1	New Buses to be added by 2010	P-1		2500	0.4	1000	1000		
	Addl. Buses to be added by 2018	P-2	1500	3000	0.4	1200		600	
	Addl. Buses to be added by 2025	P-3	1500		0.4				600
2	Bus Terminal cum Traffic & Transit Management Centres (TTMC)	P-1	45	45	45	2025	2025		
3	New Bus Stations	P-1	23	23	12	276	276		
4	New Bus Shelters	P-1		300	0.03	10	10		
5	New Depots								
	Upto 2010	P-1	27	27	6	162	162		
	Addl. Depots required by 2018	P-2	10	20	6	120.00		60	
	Addl. Depots required by 2024	P-3	10						60
6	Improvement of IT Infrastructure	P-1				184.00	184		
7	Multimodal Transit Centre at Subhashnagar	P-1	1	1	350	350	350		
8	Development of HRD Infrastructure	P-1				150	150		
9	Environment Protection Projects	P-1				49	49		
Intercity Bus Terminals / IMTCs									
10	Intermodal Transit Centres cum Intercity Bus Terminal-Peenya	P-1	1	1	60	60	60		
11	Intermodal Transit Centres cum intercity Bus terminals- Hosur Rd, Bellary Rd, NGEF at Old Madras Road	P-1	3	3	45	135	135		
	Total					**5721.0**	**4401**	**660**	**660**

Table 9.4 Cost Estimates for Proposed Road Infrastructure Development Plan (Rs Crore)

S. No.	Corridor	Length km	Unit Cost per Km (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
New Roads							
1	Core Ring Road (CRR) (elevated)	30	40	1200	1200		
2	Arterial Roads crossing CRR	30	1	30	30		
3	Peenya Industrial Area To Bangalore Mysore Expressway	2.2	10	22	22		
4	Peripheral Ring Road (PRR)	114	30	3420	3420		
5	Air Port Link Road (Expressway)	26	20	520	520		
6	Link from Tigalarapalaya main road to Nelagadaranahalli (Cost included in Item 42 of parallel ring road)	1.23					
7	Link from Hesarghatta main road to Shettihalli and Madarahelli to Mohammed Sabi Palya (Cost included in Item 43 of parallel ring road)	4.02					
8	Link from Sampigehalli to CRPF parade ground (Cost included in Item 25 of parallel ring road)	1.72					
	Total	**209.17**		**5192**	**5192**		
Outer Ring Road Re Alignment							
1	Elevated road along Bang. University Road (excluding cost of Construction of ORR connecting Mysore Road to Magadi Road including underpass across Bangalore Mysore Rly Line accounted for at item no. 9 of RUB/ROB List)	2.5	20	50	50		

S. No.	Corridor	Length km	Unit Cost per Km (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
2	Realigning ORR between Magadi Rd. and Pipe Line Rd	1.9	10	19	19		
3	Realigning ORR at Tumkur Rd through CMTI	1.2	10	12	12		
4	Realigning ORR from Kasturi Nagar to Mahadevapura along Salem railway line	5	10	50	50		
5	Elevating ORR along common portion with Sarjapur Rd (excluding cost of grade separators at Agara & Ibbalur at item no. 6 & 7 of list of Grade separators)	2	10	20	20		
6	Elevating ORR along common portion with Bannerghatta Road	1	40	40	40		
7	PESIT to Janabharti Enterance Banglore University	3	40	120	120		
	Total	**16.6**		**311**	**311**		
Road Improvements (Inside ORR)							
1	Bellary Rd	7.60	1	7.6	7.6		
2	Palace Road	1.75	1	1.75	1.75		
3	Seshadri Road	0.50	1	0.5	0.5		
4	Nrupatunga Road	1.10	1	1.1	1.1		
5	Vidhana Veedhi	0.20	1	0.2	0.2		
6	Mission Road	1.00	1	1	1		
7	Devanga Hostel Road	0.50	1	0.5	0.5		
8	Sankey Road	3.40	1	3.4	3.4		
9	Lalbagh Road	0.41	1	0.41	0.41		
10	Jaymahal Road	2.80	1	2.8	2.8		
11	Hosur Road	1.60	1	1.6	1.6		
12	Hosur Laskar Road	4.30	1	4.3	4.3		
13	Victoria Road	1.60	1	1.6	1.6		
14	Lower Agaram Road	2.40	1	2.4	2.4		
15	Sarjapur Road	3.35	1	3.35	3.35		
16	Hosur Road	4.30	1	4.3	4.3		

S. No.	Corridor	Length km	Unit Cost per Km (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
17	Bannerghatta Road	4.11	1	4.11	4.11		
18	80' Koramangala	4.00	1	4	4		
19	Dickenson Road	0.30	1	0.3	0.3		
20	Ulsoor Road	0.60	1	0.6	0.6		
21	Kensington Road	0.32	1	0.32	0.32		
22	Murphy Road	1.70	1	1.7	1.7		
23	Old madras Road	1.70	1	1.7	1.7		
24	Richmond Road	5.20	1	5.2	5.2		
25	Airport Road	5.20	1	5.2	5.2		
26	Goods shed Road	1.35	1	1.35	1.35		
27	Cottonpet main Road	1.20	1	1.2	1.2		
28	17th main J CNagar in ward13	1.50	1	1.5	1.5		
29	5th cross Malleshwaram	1.00	1	1	1		
30	Commissariat Road	0.74	1	0.74	0.74		
31	A M Road	0.75	1	0.75	0.75		
32	Lalbagh fort Road	1.35	1	1.35	1.35		
33	Race Course Road	1.66	1	1.66	1.66		
34	Kasturba Road	0.77	1	0.77	0.77		
35	A S char street & BVK Iyengar Road	1.21	1	1.21	1.21		
36	Vanivilas Road	0.85	1	0.85	0.85		
37	Suranjan Das Road	3.85	1	3.85	3.85		
38	Mysore Road	3.90	1	3.9	3.9		
39	Mt joy Road & Kattriguppe main Road via vidyapeeta Circle	3.00	1	3	3		
40	Mahalakshmi layout & Nandini Layout road via Ayyappa temple & Singapore layout	2.70	1	2.7	2.7		
41	Dinnur main Road and kavalbyrasandra Road (via ganganagar sulthan palya)	4.50	1	4.5	4.5		
42	Hoskerehalli main Road(via girinagar)	2.05	1	2.05	2.05		
43	Vasanth nagar main Road	0.62	1	0.62	0.62		
44	K R Road	1.16	1	1.16	1.16		
45	Sulthan Road	0.42	1	0.42	0.42		
46	1st main Chamarajpet	0.15	1	0.15	0.15		
47	3rd cross Chamarajpet & Bull temple Road	1.00	1	1	1		
48	Link Road	0.63	1	0.63	0.63		
49	Padarayanapura main Road	1.86	1	1.86	1.86		

S. No.	Corridor	Length km	Unit Cost per Km (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
50	Bull temple Road via N R Colony, Chennamma tank bed & 30th main BSK 3rd stage	1.10	1	1.1	1.1		
51	Infantry Road	1.83	1	1.83	1.83		
52	Park Road	0.50	1	0.5	0.5		
53	Hospital Road	1.10	1	1.1	1.1		
54	Dispensary Road	0.50	1	0.5	0.5		
55	K Kamaraj Road	1.25	1	1.25	1.25		
56	Dharmaraj Road	0.40	1	0.4	0.4		
57	Chandini chowk	0.45	1	0.45	0.45		
58	Meenakshi koil street	0.60	1	0.6	0.6		
59	Thimmaih Road	2.10	1	2.1	2.1		
60	Old poor house Road-Haine's Road	1.00	1	1	1		
61	Millers tank bund Road	0.52	1	0.52	0.52		
62	Station Road	1.30	1	1.3	1.3		
63	Queen's Road	0.95	1	0.95	0.95		
64	Millers Road	1.42	1	1.42	1.42		
65	Cunningham Road	0.80	1	0.8	0.8		
66	Road in front of Russel market	0.25	1	0.25	0.25		
67	Dr. Ambedkar Road (tannery Road)	4.43	1	4.43	4.43		
68	Hennur Road	3.62	1	3.62	3.62		
69	Banaswadi Road & Wheelers Road (via Banaswadi)	6.35	1	6.35	6.35		
70	Hare Krishna Road	0.70	1	0.7	0.7		
71	HMT main Road	2.10	1	2.1	2.1		
72	Magadi Road	2.40	1	2.4	2.4		
73	Baiyyappanahalli main Road	3.35	1	3.35	3.35		
74	Bapujinagar cross Road	0.80	1	0.8	0.8		
75	Kumaraswamy layout main Road	1.75	1	1.75	1.75		
76	South link Road	0.50	1	0.5	0.5		
77	MTB Road	0.50	1	0.5	0.5		
78	Kurubarahalli main Road in ward 16	1.00	1	1	1		
	Total	**141.73**		**141.73**	141.73		

S. No.	Corridor	Length km	Unit Cost per Km (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
Road Improvements (Outside ORR)							
Radial Roads							
1	From Peenya II Stage to Andrahalli (via Peenya II Stage, Industrial area, Andrahalli)	4.00	0.75	3.00	3.00		
2	Tumkur Road-NH4	8.80	0.75	6.60	6.60		
3	New BEL Road	3.40	0.75	2.55	2.55		
4	Jalahalli Main Road to Attur via Yelahanka	28.00	0.75	21.00	21.00		
5	Yeshwantpur to Yelahanka	20.00	0.75	15.00	15.00		
6	Doddaballapur Road.	6.00	0.75	4.50	4.50		
7	Devanahalli - Hebbal Bellary Road	25.00	3.0	75.0	75.00		
8	NH-7 Kogilu Junction to Nagavara Main Road	8.00	0.75	6.00	6.00		
9	Dasarahalli Main Road	16.00	0.75	12.00	12.00		
10	HBR Ring Road to Nagavara Main Road leading to Jakkur	20.00	0.75	15.00	15.00		
11	HBR Ring Road to Hennur Main Road	16.00	0.75	12.00	12.00		
12	Old Madras Road	5.25	0.75	3.94	3.94		
13	ITPL Road from Ring Road to Hope farm	8.50	0.75	6.38	6.38		
14	Varthur Road from Marathalli to Varthur Kodi	5.00	0.75	3.75	3.75		
15	Varthur to Outer Ring Road via Belegere and Panathur	6.50	0.75	4.88	4.88		
16	Kaigondanahalli to Sarjapur	10.00	0.75	7.50	7.50		
17	Bannerghatta Road - ORR to National Park	8.60	0.75	6.45	6.45		
18	Bannerghatta Road - National Park to PRR	2.40	0.75	1.80	1.80		
19	Begur Road from Hosur Road to Begur	7.00	0.75	5.25	5.25		
20	Kanakapura Road.	10.40	0.75	7.80	7.80		
21	Ring Road to Kanakapura Road (via Ittumadu)	7.00	0.75	5.25	5.25		
22	Rajarajeshwari Nagar Arch to PRR	10.00	0.75	7.50	7.50		

S. No.	Corridor	Length km	Unit Cost per Km (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
Connector Roads							
23	From Magadi Road to NH 4(Via Sunkadakatte, Hegganahalli Main Road, Peenya II Stage, NTTF circle, KIADB Main Road)	6.00	0.75	4.50	4.50		
24	Peenya II Stage to Ring Road (via Peeya II Stage Bus stop, Rajgopal Nagar Main Road, Peenya Industrial Area)	3.00	0.75	2.25	2.25		
25	NH-7 to Nagavara Main Road through Jakkur	16.00	0.75	12.00	12.00		
26	NH-7 to Nagavara Main Road	12.00	0.75	9.00	9.00		
27	Hennur Main Road to Hoskote Ring Road	10.00	0.75	7.50	7.50		
28	Horamavu-Agara to HBR Ring Road	4.00	0.75	3.00	3.00		
29	Horamavu Road from Outer Ring Road to Kalkere	4.20	0.75	3.15	3.15		
30	T C Palya main Road from ORR to Anandapura	5.50	0.75	4.13	4.13		
31	Devasandra main road from NH 4 to Basavanapura Road	1.70	0.75	1.28	1.28		
32	Kundalahalli Road from Devasandra main Road to Kundalahalli gate via Hoodi	7.00	0.75	5.25	5.25		
33	ITPL Road to Varthur Road via Pattanadur Agrahara & Nellurahalli	4.00	0.75	3.00	3.00		
34	Sarjapur Road to Ring Road(near Devarabisanahalli)	7.00	0.75	5.25	5.25		
35	Nagarthapura to Matha Amruthamayee College	5.00	0.75	3.75	3.75		
36	Hosur Road to Nagarthapura (Hosur Road)	4.00	0.75	3.00	3.00		
37	Begur to Hosur Road (via Begur tank Bund, Chikkabegur and Manipal County)	7.00	0.75	5.25	5.25		
38	Bannerghatta Road to Begur (via DoddaKammanahalli, Yelenahalli)	8.00	0.75	6.00	6.00		

S. No.	Corridor	Length km	Unit Cost per Km (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
39	Kottur Dinne to Bannerghatta Road	5.00	0.75	3.75	3.75		
40	Harinagar to Kottanur Dinne	4.00	0.75	3.00	3.00		
41	Corporation Bank to Ring Road via Javaraiana doddi	4.00	0.75	3.00	3.00		
Parallel Ring Road							
42	From Magadi Road to NH 4(Via Herohalli, karivobanahalli, Andrahalli, Tigalarapalya, Nelagadaranahalli, Nagasandra)	8.00	0.75	6.00	6.00		
43	Hesaraghatta Main Road to SM Road (via Mallasandra, Shetty halli, Abbigere, Kammagondanahalli main Road, Gangammagudi Circle)	6.00	0.75	4.50	4.50		
44	Vidyaranyapura Main Road to Hennur main Road	35.00	0.75	26.25	26.25		
45	Nagavara Main Road to Kalkere Junction	8.00	0.75	6.00	6.00		
46	Sarjapura Road to Kalkere via chikkaballapur,Gujurpalya, Varthur, Hope farm, Kadugodi, Sadaramangala, Kodigehalli, Basavanapura, T.C.Palya	31.00	0.75	23.25	23.25		
47	Matha Amruthamayee to Sarjapura Road(Kaigondanahalli)	5.00	0.75	3.75	3.75		
48	Kanakapura Road-Amruthnagar to Harinagar	4.50	0.75	3.38	3.38		
49	Kengeri to Konanakunte via Uttarahalli(end of Kanakapura Road)	13.50	0.75	10.13	10.13		
50	Kengeri 80' Ring Road to Ullalu Main Road via Matha Mata	10.50	0.75	7.88	7.88		
51	Begur Road to Hosur Road and Kudlu	6.00	0.75	4.50	4.50		

S. No.	Corridor	Length km	Unit Cost per Km (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
52	B G Road to Begur Road(via BTM Layout, Kodichikkanahalli	5.00	0.75	3.75	3.75		
53	Chunchaghatta Road to B G Road	6.00	0.75	4.50	4.50		
54	GnanaBharati Circle to Magadi Road	11.00	0.75	8.25	8.25		
	Total	**502.75**		**433.31**	**433.31**		

Table 9.5 Cost Estimates for Proposed Grade Separators (Rs Crore)

SNo	Location / Road	Nos.	Unit Cost per G.S (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
Grade Seperators-Roads							
1	Hudson Circle-N.R.Road Under pass	1	30	30	30		
2	Cauvery Theatre Junction-Bellary Road Grade separator	1	10	10	10		
3	Minerva circle-J.C.Road Fly over	1	25	25	25		
4	Nagavara Junction Along ORR Flyover	1	22	22	22		
5	Hennur Banasvadi along ORR underpass	1	25	25	25		
6	Sarjapur Road & ORR Jn. Along ORR flyover near Ibbalur	1	23	23	23		
7	On ORR Jn. Along ORR near Agara flyover	1	40	40	40		
8	Flyover along Hosur Road near Check post	1	25	25	25		
9	Hosur Road-Inner Ring Road along Hosur Road fly over	1	25	25	25		
10	Additional slip road at CSB intersection	1	25	25	25		
11	Hosur Road Grade separator @ Attibelle	1	25	25	25		

SNo	Location / Road	Nos.	Unit Cost per G.S (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
12	Along 16 main BTM Layout underpass	1	25	25	25		
13	Puttenahalli along ORR underpass	1	23	23	23		
14	Kanakapura Road & ORR Jn. Along ORR flyover	1	30	30	30		
15	Kadirenahalli Road & ORR Jn. along ORR flyover	1	30	30	30		
16	Flyover on RV road near RV Teacher College	1	14	14	14		
17	Tagore Circle underpass on Gandhi Bazaar Main Road	1	25	25	25		
18	Tumkur Road & ORR Junction along ORR Grade separator	1	40	40	40		
19	Flyover along NH 4 at Jalahalli Cross	1	25	25	25		
20	Underpass along pipeline road near Ayyappa Temple	1	25	25	25		
21	Grade separator along Guttahalli Main Road near Guttahalli Circle	1	25	25	25		
22	Grade separator at Yeshwantpur Circle near Bus Station	1	22	22	22		
23	Bridge at Gali Anjaneya Junction	1	32	32	32		
24	Grade separator at Malleshwaram Circle	1	12.5	12.5	12.5		
25	Underpass at Prof. CN Rao Circle	1	27.5	27.5	27.5		
26	Underpass along Chord Road at Magadi Road & Chord Road Junction	1	31.5	31.5	31.5		

SNo	Location / Road	Nos.	Unit Cost per G.S (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
27	Underpass along ORR at ORR and Banaswadi Ramamurthy Nagar Road Junction	1	21.5	21.5	21.5		
28	Grade separator at ORR & Magadi Road Junction	1	29	29	29		
	Total	**28**		**713**	**713**		
Road Over Bridges / RUBs-Rail							
29	ROB along MES Road near Jalahalli	1	20	20	20		
30	Underpass along Link Road Connecting D Rajagopal Road & Kodigehalli Road	1	20	20	20		
31	Ashoka Theatre - Pottery Road	1	20	20	20		
32	Nagavara-Arabic College Road	1	20	20	20		
33	Kasturinagar-Chikka-Banaswadi Road	1	20	20	20		
34	Baiyyappanahalli Road	1	20	20	20		
35	Kadugondanahalli Railway line along Nagavara Main Road	1	20	20	20		
36	Hudi Main Road near Whitefield Railway Station	1	20	20	20		
37	Construction of ORR connecting Mysore Road to Magadi Road including underpass across Bangalore Mysore Rly Line	1	87	87	87		
38	along Settihalli main Rd.	1	20	20	20		
39	along S M Road near Gurudwara	1	20	20	20		
40	Along Koigehalli Main Road near Kodigehalli Rly Stn	1	20	20	20		
41	Along Hesaraghatta Main Road	1	20	20	20		
42	Near Tanisandra Rly Stn	1	20	20	20		
43	Along Kundalahalli Road at Kundalahalli gate.	1	20	20	20		

SNo	Location / Road	Nos.	Unit Cost per G.S (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
44	Along Varthur Road near Lakshmi Layout	1	20	20	20		
45	Along Panathur Main Road near Bellandur Rly Stn	1	20	20	20		
46	Along Sarjapur Road	1	25	25	25		
	Total	**18**		**432**	**432**		
Elevated Roads							
47	Elevated Road From Sirsi Circle to ORR on Mysore Road	**6**	**60**	**360**	**360**		
48	Elevated Road on Hosur Road	**10.5**	**60**	**630**	**630**		
	Total	**16.5**		**990**	**990**		

Table 9.6 Cost Estimates for Proposed Pedestrian Facilities (Rs Crore)

Sl No	Name of Road	Length (km)/No.	Unit Cost per Km	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
1	Improvement & augmentation of foot paths	350	0.2	70	70		
Skywalks/subways							
2	Cauvery Bhavan to KG circle crossing across KG Road and Distt. Office Road	1	10	10	10		
3	Opposite NTI connecting Guttahalli Road and Palace (opposite Bus Stop) on Sankey Road.	1	3	3	3		
4	Arya Bhavan Sweets to Kanthi Sweet to Himalaya Theatre, crossing KG Road	1	3	3	3		
5	Lalbagh Main Gate (Javaraiah Circle)	1	3	3	3		
6	Bannergatta Road near Jayadeva Hospital	1	3	3	3		
7	BMTC Main Bus Stand to Amar Lodge Building in Majestic Area	1	3	3	3		

Sl No	Name of Road	Length (km)/No.	Unit Cost per Km	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
8	KSRTC Kempegowda Bus Station to BMTC Main Bus Station.	1	3	3	3		
9	At Kengeri Bus Stand, Mysore Road	1	3	3	3		
10	At Byatarayanapura on Bellary Road (near Junction of BBMP office complex).	1	3	3	3		
11	BMTC Main Bus Station to Railway Station Premises	1	3	3	3		
12	Shanthala Silk House to KSRTC Main Bus Station and to Good-Shed Road	1	3	3	3		
13	RNS Motors, Tumkur road	1	3	3	3		
14	Jalahalli Circle, Tumkur Road	1	3	3	3		
15	Near Webb junction	1	3	3	3		
16	Near Kamakhya, Kathriguppe Ring Road	1	3	3	3		
17	Gandhi Bazaar Main Road	1	3	3	3		
18	On Vittal Mallya Road near Mallya Hospital	1	3	3	3		
19	Seshadri Road near Maharani College	1	3	3	3		
20	On JC Road near Ravindra Kala Kshetra	1	3	3	3		
21	On Hosur Main Road near Madivala Check post	1	3	3	3		
22	On Raja Ram Mohan Roy Road, near Pallavi theatre	1	3	3	3		
23	On Richmond Road near D'Souza Circle.	1	3	3	3		
24	On Race Course Road near Chalukya Hotel	1	3	3	3		
25	On Commissariat Street near Garuda Mall	1	3	3	3		
26	On Residency Road near Mayo Hall.	1	3	3	3		
27	On Kamaraj Road near Commercial Street	1	3	3	3		

Sl No	Name of Road	Length (km)/No.	Unit Cost per Km	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
28	Near Indira Nagar 100 feet Road & Water Tank junction on Airport Road	1	3	3	3		
29.	On Hosur Road (Near Forum)	1	3	3	3		
30.	On Tumkur Road, near SMS Railway Junction	1	3	3	3		
31.	On Air Port Road, Marath Halli at Village Road	1	3	3	3		
32.	On Air Port Road, Marath Halli at Junction of ORR Under Pass	1	3	3	3		
33.	K.R. Pura Bus Stand	1	3	3	3		
34.	Bharatiya Vidya Bhavan, Devaraj Urs Road	1	3	3	3		
35.	On Hosur Road "T" Junction with Tavarekere Main Road (Opposite Sai Sadan & Prestige Acropolis) (High Rise Apartments Condominium)	1	3	3	3		
36.	Mission Road at the foot of Fly over	1	3	3	3		
37.	Vidhana Veedhi near M S Building	1	3	3	3		
38.	Tumkur Road near Yeshwantpur Circle	1	3	3	3		
39.	At South End Circle	1	3	3	3		
40.	30 no. Sky –walks / Sub-Ways along the eastern crescent of the ORR	30	3	90	90		
	Sub-Total	68		211	211		
	TOTAL			**281**	**281**		

Table 9.7 Cost Estimates for Proposed Parking Facilities (Rs Crore)

S.No	Location	Type	Capacity	Cost per Parking Space (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013-18	Phase-III 2019-24
1	M G Road	AMP	500	0.05	25	25		
2	Kamraj Road	AMP	500	0.05	25	25		

S.No	Location	Type	Capacity	Cost per Parking Space (Rs. Cr.)	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013-18	Phase-III 2019-24
3	Gandhi Nagar	AMP	500	0.05	25	25		
4	Jayanagar Shopping Complex	CMP	1000	0.02	20	20		
5	Koramangala near Raheja Tower	CMP	1000	0.02	20	20		
6	Rajaji nagar BDA Complex	CMP	500	0.02	10	10		
7	Banashankari BDA Complex	CMP	1000	0.02	20	20		
8	Gandhi Bazaar	CMP	500	0.02	10	10		
9	Malleshwaram	AMP	500	0.05	25	25		
10	Fire Station, Residency Road	AMP	500	0.05	25	25		
11	Dhobi Ghat, Cunningham Road	AMP	500	0.05	25	25		
12	SP Office, Miller Road, Cunningham Road crossing	AMP	500	0.05	25	25		
13	Near Sagar & States	AMP	500	0.05	25	25		
14	Kanteerava Stadium	AMP	500	0.05	25	25		
15	City Market	AMP	500	0.05	25	25		
16	Bakshi Garden	AMP	500	0.05	25	25		
17	Majestic	AMP	500	0.05	25	25		
	Total		**10000**		**380**	**380**		

Table 9.8 Cost Estimates for Proposed Integrated Freight Complexes (Rs Crore)

S.No.	Location	No.	Cost per Unit	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
1	Hosur Road	1	45	45	45		
2	White Field Road	1	45	45		45	
3	Old Madras Road	1	45	45		45	
4	Bellary Road	1	45	45		45	
5	Tumkur Road	1	45	45	45		
6	Mysore Road	1	45	45	45		
	Total	**6**		**270**	**135**	**135**	

Table 9.9 Cost Estimates for Transport System Management Measures (B-TRAC) (Rs Crore)

SNo	Component	Nos	Unit Cost Crs	Total Cost (Rs. Cr.)	Phase-I 2007-12
1	Junction Improvements	250	0.7	175	175
2	Street Furniture and Road Marking			100	100
3	Intelligent Transport System including. ATC, VMS etc for 250 intersections			150	150
4	Surveillance / monitoring and enforcement cameras etc			50	50
5	Education and Training / Others			25	25
	Total			**500**	**500**

9.2.2 Summary of the cost estimates for various projects is given in **Table 9.10.** Overall cost of the entire plan is estimated as Rs 46,944 crore of which Rs 31,377 crore is proposed for Phase I (2007-12). Cost of the projects proposed in Phase II is Rs 14,157 crore.

Table 9.10 Summary of Cost Estimates for the Entire T&T Plan (2007 prices)(Rs Crore)

ITEM	Length kms/Nos	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
MASS TRANSPORT CORRIDORS					
Metro System	137	19921	11086	8835	0
Mono Rail / LRT System	60	5100	3825	1275	0
Commutor Rail System	204	3060	690	1620	750
BRT System	291.5	3498	1866	1632	0
IMPROVEMENT IN CITY BUS SYSTEM					
Improvement in City Bus System		5721	4401	660	660
ROAD INFRASTRUCTURE					
New Roads	209.2	5192	5192	0	0
Outer Ring Road Realignment	17	311	311	0	0
Road Improvements (Inside ORR)	142	142	142	0	0
Road Improvements (Outside ORR)	503	433	433	0.00	0.00
GRADE SEPARATORS					
Grade Separators-Road (Nos.)	28	713.0	713.0	0.0	0.0
Rail Over Bridges / RUBs-Rail (Nos)	18	432	432	0	0
Elavated Roads (Kms)	16.5	990	990	0	0

ITEM	Length kms/Nos	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
PEDESTRIAN FACILITIES		**281**	**281**	**0**	**0**
PARKING FACILITIES (No. of car spaces)	10000	380	380	0	0
Integrated Freight Complexes (IFC):	6	270	135	135	0
B-TRAC		**500**	**500**	**0**	**0**
GRAND TOTAL		**46944**	**31377**	**14157**	**1410**

9.3 BROAD FINANCING OF TRANSPORTATION PROJECTS

9.3.1 The estimated investment for the entire T &T Plan based on public transport oriented system for the period till 2025 is estimated to be Rs 46944 crore at 2007 prices as given in **Table 9.10**. More than two-thirds of this investment is proposed during the period 2007-12 which coincides with the JNNURM mission period. The proposed Implementing Agency (given in **Table 9.11**) and tentative financing structure for each of the major investments proposed is dealt with briefly below:

Table 9.11 Implementing Agencies for Various Projects

S.No	ITEM	Implementing Agency
1.	Metro	BMRCL
2.	Mono Rail / LRT	BMRCL/New Company
3.	Commuter Rail System	Railways/Govt of Karnataka /BMRDA
4.	BRT	BMTC / BBMP/BDA
5.	City Bus System (including Inter City Bus Terminals)	BMTC/KSRTC
6.	New Roads	BBMP/BDA
7.	Road Improvements (Inside ORR)	BBMP
8.	Road Improvements (ORR & Outside ORR)	BBMP,BDA/NHAI
9.	Grade Seperators	BBMP/NHAI/ BDA
10.	Rail Over Bridges / RUBs	Railways / BBMP
11.	Improvement & augmentation of foot paths	BBMP
12.	Pedestrian Sky Walks / Sub-Ways	BBMP
13	Parking Facilities	BBMP
14	Integrated Freight Complexes (IFC)	BDA
15	B-TRAC	BBMP/Traffic Police

9.3.2 Metro

Out of Rs 19,921 crore of investment for the 137 km of Metro, financing for Rs 5605 crore corresponding to the present phase I corridors under implementation now (about 34 km) has already been arranged and the project is implemented by BMRCL, a company incorporated for the purpose. Balance investment for Metro would also be mobilized by the company through a combination of contributions from Government of India, Government of Karnataka and debt financing. It is also

recommended that JNNURM funding from Government of India to an extent of Rs 532 crores be sought to finance the balance Rs 1521 crores for the Phase I. The recommended funding pattern for Rs 1521 crores for Phase I is as follows:

- Government of India (JNNURM) funding: Rs 532 Cr
- Government of Karnataka (JNNURM) funding: Rs 228 Cr
- BMRCL / Debt funding: Rs 761 Cr

The Airport Metro Project may be implemented on BOT basis with viability gap funding from the Government.

9.3.3 Mono Rail / LRT

The implementing agency for mono rail / LRT could either be BMRCL or a new special purpose company to be incorporated. It is recommended that funding for this project be on similar lines as Metro. The viability of the scheme should be established at the time of preparation of the detailed project report.

9.3.4 Commuter Rail System

This project involves the active participation of three principal stake holder's viz. Railways, State Government and the implementing agency. The implementing agency for the project could be BMRDA / BDA or a special purpose company. Since the proposed rail system extends beyond BBMP area it is recommended that the project promoter is BMRDA. The funding pattern is recommended to be:

- Railways – Railway related infrastructure including rolling stock and O&M approx one third of the project cost
- Government of Karnataka – One third of the project cost to cover the cost of expansion of stations, and additional tracks
- BMRDA – Access roads, parking facilities and passenger facilities to cover one third of the project cost

9.3.5 BRT System

Implementing agency for BRT system may be BMTC or a new special purpose company to be incorporated with representative from BBMP, BDA and BMRDA. The project may be implemented on PPP model.

9.3.6 All Road Improvements and New Roads

Investments to the extent of Rs 8154 crore proposed till 2012 for road related infrastructure would be implemented by Bruhat Bangalore Mahanagara Palike (BBMP), BDA etc. It is recommended that the funding for these projects be arranged under the JNNURM scheme seeking 35% grant from GOI, 15% from GOK and balance to be arranged by BBMP/BDA through debt financing and internal resources. Since this represents the core infrastructure for decongesting the city traffic system the funding should be routed through the JNNURM.

9.3.7 City Bus System/Inter-city Bus System

Out of estimated investment of Rs 5,721 crore, the cost of rolling stock requirement by the city bus transport corporation is Rs 2200 crore. This amount is proposed to be funded through internal resources and project financing structure of the corporation. The balance amount of Rs 3,521 crore represent the infrastructure support required by the transport corporations. An amount of Rs 3,401 crore is proposed to be incurred during the period 2007-12 and it is recommended that the same be funded under the JNNURM funding pattern viz:

- GOI: 35% - Rs 1,190 Crore
- GOK: 15% - Rs 510 Crore
- BMTC/KSRTC: 50% - Rs 1,701 Crore (IMTCs / Inter-city Bus Terminals could also undertaken by KSRTC on PPP model)

For the phases II and III the funding will have to be arranged by the company based on the strength of its balance sheet.

9.3.8 Footpaths/Pedestrian Sky Walks/subways and Parking facilities

An amount of Rs 661 crore is estimated towards improving and strengthening the pedestrian facilities and establishing parking facilities at identified locations across the city. The funding for the same shall be arranged though a PPP model where revenue sharing models could be explored. Viability gaps if any could be funded by BBMP the implementing agency.

9.3.9 Integrated Freight terminals

An amount of Rs 270 crore for establishing freight complexes at six locations is recommended to be funded through a PPP model involving oil companies, freight operators, industries' associations and BDA as the implementing agency.

9.3.10 Transport System Management Measures (B-TRAC)

This component represents the intelligent road system including traffic management systems to be introduced in the city to reduce the number of accidents and regulate the traffic using technological interventions. It is proposed that the amount of Rs 500 crore estimated under this head is posed under JNNURM with 50% contribution of the ULB allocated by BBMP (balance 50% from GOI and GOK as per JNNURM norms).

9.4 FUNDING OF INFRASTRUCTURE THROUGH DEVELOPMENT, CONVERSION & INFRASTRUCTURE DEVELOPMENT CHARGES

Alternatively Government can also partly finance the CTTP by imposing External Development Charges (EDC), Licence Fee, Conversion Charges of land-use and Infrastructure Development Charges (IDC) on the lines of Haryana Government for the new developing areas (about 320 sq km) in Bangalore. The estimated revenue that can be generated through these sources is given in **Table 9.12** below:

Table 9.12 Expected Recoverable Charges through Development of External Areas as per Master /Zonal Plans 2015

Landuse	Net Extension Area Sq. Kms	Rates prevalent per Sq Mts in Haryana	Suggested Avg.Rates of EDC, IDC, Conv. Charges, License Fee per Sq Km	Expected Returns Rs. Cr
Residential	255			
Plotted Dev. (60%)	153	1227	125	19125
Gr. Housing (40%)	102	3328	350	35700
Commercial	38	11297	1150	43700
Industrial	6.5	1250	125	812.5
I.T	20	2271	250	5000
Total	**319.5**			**104337.5**
Assuming 75 % of the above Returns to be used for Town Level Public Health Services (Water Supply, Sewerage, Storm Water Drainage), Power, Community Facilities etc.				Rs. 78253.125 Cr.
Balance amount that should be used for financing CTTP				Rs. 26084.375 Cr.

Thus about Rs 100,000 crore can be generated through the above charges for the planned new areas for development as per the Master Plan 2015. Out of this about Rs 20000 to 25000 crore may be used for financing transportation projects.

CHAPTER – 10

INSTITUTIONAL STRENGTHENING

10.1 REGIONAL PLANNING

10.1.1 Though the Study covers the transportation problems in the BMA, the impact of the traffic from the neighboring towns has also to be taken into consideration. The description of the BMR has already been given in Chapter 1. These towns lie in outer belt and the traffic which emanates from or bound for these come into or exit the city mostly though the major radials like Mysore Road, Magadi Road, NH-7, NH-4 and NH-209. The traffic to and from these areas have been accounted for through the outer cordon survey. Planning for these townships is being carried out independently by Bangalore Metropolitan Regional Development Authority (BMRDA). The data available individually for these towns as at present is meager. Hence, for the purpose of this study, the traffic which is passing through the outer cordon as determined by traffic counts at cordon points has been considered as the basis. The BMRDA is also involved in the development of the satellite towns and BIAPPA area.

10.1.2 As such it is presumed that any future planning in these areas will be directly controlled by the BMRDA or the BMRDA will be more actively involved in their development plans. According to the present structure, the overall planning in the BMRDA in respect of land use and transportation facilities is looked after and controlled by the BMRDA which forms the nodal agency. However the planning in respect of industries, education, commerce etc., for areas outside the city, are done by the respective Departments of the State Government at District level. They are coordinated by the District Commissioners. Within the city, it is partly coordinated by BDA and the City Corporation. The implementation of the various plans / proposals in the region is thus under different agencies as discussed below.

10.2 AGENCIES INVOLVED IN CIVIC WORKS

10.2.1 Presently day-to-day land use control and maintenance of services like drainage, roads etc., are done by Bruhut Bangalore Mahanagara Palike, BDA, TMCs and CMCs, while BDA prepares the Master Plan and development control regulations. The road infrastructure connecting the different municipalities, towns and also the National Highways and the State Highways passing through the city and these are maintained, improved and expanded by the Public Works Department/NHAI. The water supply within the city is looked after by the Bangalore Water Supply & Sewerage Board (BWSSB) and by respective municipalities in TMCs and CMCs.

10.2.2 Progress of works and flow of funds in respect of any aided projects, is watched and monitored by a Project Management Department/ Division of KUIDFC.

10.3 ROLE OF VARIOUS TRANSPORTATION AGENCIES

10.3.1 Transport Department

10.3.1.1 The Commissioner for Transport is in-charge of the licensing of the motor vehicles, issue of route permits/area of operation and monitoring condition of the vehicles by having them periodically examined and also maintaining the various statistics with regard to the transportation in the whole city. There are nine Regional Transport Officers who control the licensing and monitoring of the vehicle operations in and around BMA. While the commercial vehicles and larger passenger vehicle operations are licensed for statewide operation, the licensing for IPT modes like auto-rickshaws are confined to respective districts. There are certain constraints on their operations outside their respective areas, particularly from the district into the city, which sometimes cause problems. Even collection of the data on the vehicles operating in the metropolitan region becomes difficult in view of this.

10.3.2 Traffic Engineering & Transport Management

10.3.2.1 The traffic engineering works, design and implementation within the city is looked after by a separate division under the Engineering Department in BBMP and BDA. In parallel, the Commissioner of Police under whom there is a Traffic Division also initiates and implements certain traffic engineering proposals as part of traffic management.

10.3.2.2 The Traffic Management is considered an enforcement function and the Traffic Division under the Commissioner of Police does all the planning and implementation within the city as mentioned earlier. There is a coordinating body which is of a recommendatory nature functioning in the under Home Secretary.

10.3.3 Public Transport consisting of Road and Rail within BMA

10.3.3.1 The road transport is looked after by Bangalore Metropolitan Transport Corporations (BMTC) working under the direct control of the Secretary / Transport of the State Government. In addition, there is Karnataka State Road Transport Corporation serving peripheral areas and regional towns around BMA.

10.3.3.2 Bangalore Metro Rail Corporation Limited (BMRCL) has been entrusting with the implementation of Bangalore Metro.

10.3.3.3 The Railway transport is under the South Western Railway, which works under the Ministry of Railways of the Central Government. There is very little coordination between these agencies. The fare policies are dictated by the State Government for bus and by the Central Government under the authority of the Parliament for the Railways. The expansion of facilities and utilisation of the available facilities are done by the respective agencies depending upon the availability of funds. Their routing and services are also run, keeping in view need for maximizing their use of assets and revenues. This naturally results in development of very little inter-modal services for the benefit of the commuters.

10.3.3.4 Existing institutional arrangement for transportation in Bangalore is given in **Table 10.1**.

Table 10.1- Existing Institutional Arrangement for Transport in Bangalore

S.No.	Functions	Institution
1.	Policies and framework affecting transport sector	Departments of Urban Development and Transport
2.	Road building, road maintenance, street lighting, Construction of select ring roads and grade separators Construction of bus shelters Construction of traffic islands Issue of permission for road cutting	Bruhat Bangalore Mahanagara Palike (BBMP) the urban local body of the Bangalore City
3.	Enforcement of traffic laws and regulations, management of traffic junctions and corridors, regulation of right of ways, parking and right of ways	Bangalore City Traffic Police
4.	Public transport system – bus based – construction and maintenance of bus depots, stations and passenger centres	Bangalore Metropolitan Transport Corporation (BMTC)
5.	Public transport system – Metro Rail	Bangalore Metro Rail Corporation Limited (BMRCL)
6.	Preparation of Comprehensive Development plan (CDP) (primarily land use and zoning), formulating of regulations, construction of select ring roads and grade separators	Bangalore Development Authority (BDA)
7.	Planning of transport System in BMR	BMRDA
8.	Registration of motor vehicles, issue of licenses and enforcement of regulations	Regional Transport Office and Department of Transport, Government

S.No.	Functions	Institution
	of motor vehicle act	of Karnataka
9.	Monitoring of air quality and noise levels	Karnataka State Pollution Control Board (KSPCB)
10.	Infrastructure and finance	Karnataka Urban Infrastructure and Finance Corporation Limited (KUIDFC)
11.	Construction and Operation of rail system	Indian Railways
12.	Construction and maintenance of NH	NHAI

10.4. NEED FOR UNIFIED METROPOLITAN TRANSPORT AUTHORITY

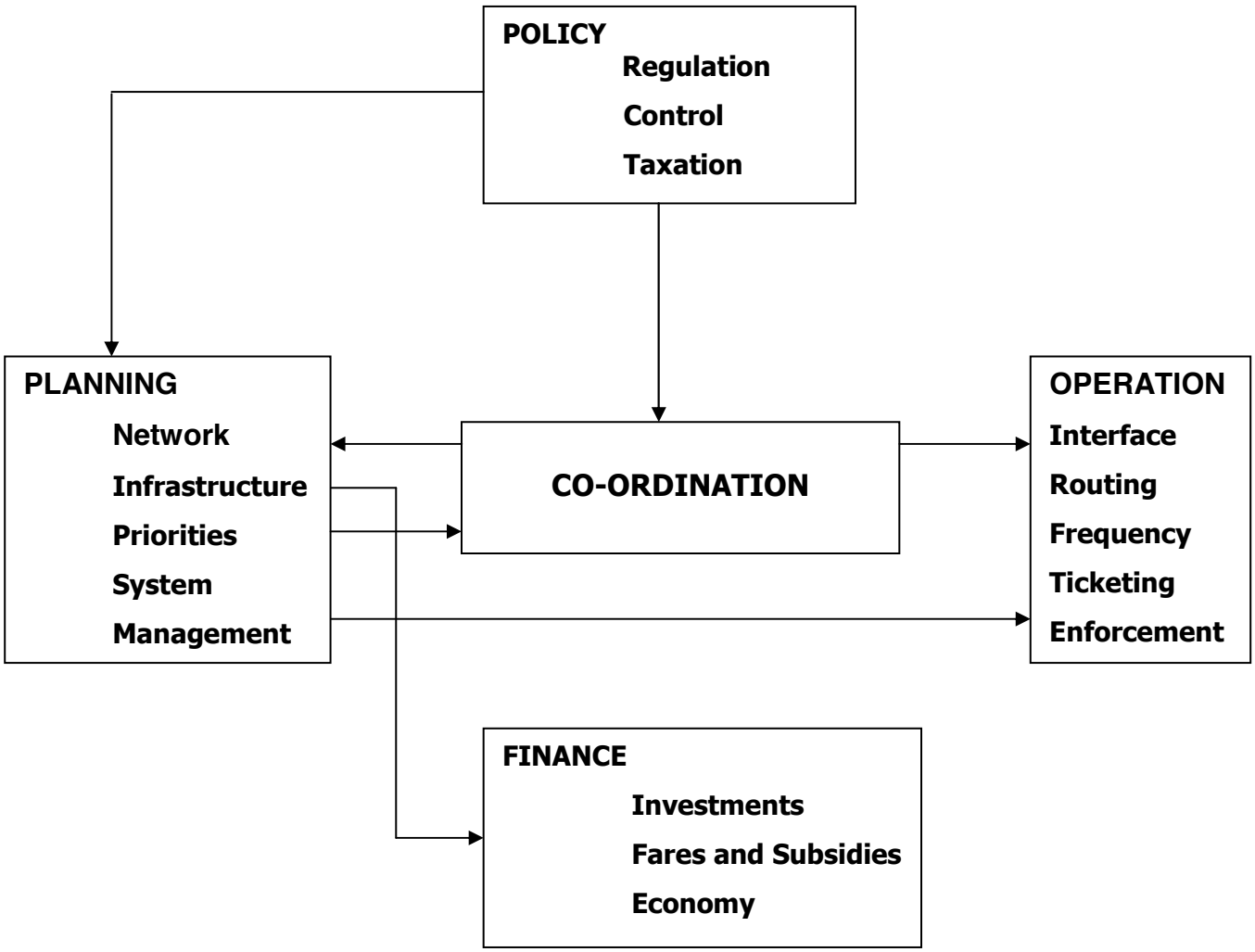
10.4.1 The above discussion suggests that there are many agencies involved in the urban transport in Bangalore. As such there is nothing wrong in multiplicity of authorities. However currently there is no mechanism to ensure coordination among various institutions which is one of the key road block affecting formulation and implementation of major schemes and initiatives to improve the traffic situation and mobility plans in the city. Close co-ordination is needed on number of factors as indicated in **Figure 10.1**.

10.4.2 Since early 1990s planners in India have been suggesting need for a unified metropolitan transport authority (UMTA)in order to ensure co-ordination, co-operation and continuity. In view of the fact that both central and state government agencies are involved in providing urban transport, such an authority will need to be created by an act in Parliament, even though the city and state governments are primarily responsible for urban planning including transport. Alternatively, it can be one of the existing authorities with full powers of planning, implementation and control. Such an authority could be an urban development authority at the third level. All departments of the authority should be manned by skilled personnel in technical jobs. The authority should ensure planning, development, co-ordination and implementation.

10.4.3 The National Urban Transport Policy has recommended setting up of Unified Urban Transport Authorities (UMTA's) in million plus cities. In the policy document it is observed as follows:

'*The current structure of governance for the transport sector is not equipped to deal with the problems of urban transport. These structures were put in place well before the problems of urban transport began to surface in India and hence do not provide for the right coordination mechanisms to deal with urban transport. The central government will, therefore, recommend the setting up of Unified Metropolitan Transport Authorities (UMTA's) in all million cities to facilitate more co-ordinated planning and implementation of urban transport programmes & projects and integrated management of urban transport systems. Such Metropolitan Transport Authorities would need statutory backing in order to be meaningful*'.

Figure 10.1 Unified Metropolitan Transport Authority



10.5 DIRECTORATE OF URBAN LAND TRANSPORT

10.5.1 Bearing in mind the National Urban Transport Policy, the Government of Karnataka felt that there is a strong case for reorganization of the administration structure dealing with urban land transport in the State by creation of a State Directorate of Urban Land Transport (DULT) under the administrative control of the Urban Development Department. Considering this, DULT has now been sanctioned by the State Government. The functions of the DULT are as follows.

1. Periodic assessment of travel demand in a given area through CTTS and other studies
2. Determination of level of public transport required on different corridors and the type of transport system required.
3. Assessment and recommendation of the new investments needed for creation of transport infrastructure
4. Apart from State owned service providers devising a system of procurem,ent of public transport services from private operators nad ensuring compliance
5. Setting policy guidelines for development of total network
6. Actively liaising with the municipal bodies/UDAs in designing and developing integrated policies and plans

10.5.2 The Directorate of Urban Land Transport (DULT) shall initially cover jurisdiction of seven Municipal Corporatioons in the State viz, Banagalore, Msore, Mangalore, Hubli-Dharwar, Belgaum Gulburga and Bellary. The integrated transport plans for these cities may extend to the local planning areas (LPAs) also. It will be gradually extended in stages to all towns / cities and urban settlements with a population of over one lakh.

10.5.3 The newly created directorate of Urban land Transport (DULT) shall take up comprehensive traffic and transportation studies (CTTS) for the six Municipal Corporations (excluding Bangalore). These studies would help assess the urban transport needs over a medium term perspective (say 25 years), identify technological and cost options, intensity of local urban economic activity and paying capacity of the average population and in short help arrive at an optimal urban transport solution. On completion of the CTTS, the existing master plan for the LPAs of these cities will be updated / revised to incorporate the necessary land use changes so that the transport and land use plan are totally integrated. A city level investment plan for creation of transport infrastructure together with sources of financing will also have to be created so as to enable posing of the projects for financing under different schemes including multilateral / bilateral assistance as also on PPP basis.

10.5.4 Other functions of the State Directorate of Urban Land Transport would include (i) road network planning in the urban areas, (ii) setting of technical standards for construction of the maintenance of urban roads, (iii) planning execution of infrastructure for pedestrians/cyclists, (iv) comprehensive drainage network to ensure road quality, (v) parking infrastructure ets. All of them will be part of the Intergrated Transport Plan at the city level and would be developed in close coordination with the local bodies who will eventually need to adopt the plan.

10.5.5 An important aspect with respect to the adopted functions of the State Directorate for Urban Land Transport is capacity building. It is necessary to develop a manpower base for good and sustainable urban transport planning and execution by creating a pool of skilled manpower. There is a need to:

1) Strengthen academic programme in the State in urban transport
2) Create systems for accreditation of specialists in urban transport
3) Ensure mechanism for continuous training at all levels.

A multi disciplinary team of experts will be constituted as an advisory board for the State Directorate of Urban Land Transport to provided inputs for:

1) Capacity building
2) Academic and educational programmes
3) Preparation of standards/manuals/codes
4) Development for Intelligent Transport System (ITS)
5) Other technical issues related to urban transport

10.5.6 The Organisation for DULT is supposed to have Commissioner (Urban Land Transport), Special Officer (Urban Planning), Traffic & Transportation Planners, Traffic Engineer etc. It is necessary that DULT is staffed with adequate numbers of transportation personnel as it will cover urban transport for all cities of Karnataka.

10.6 BANGALORE METROPOLITAN LAND TRANSPORT AUTHORITY

10.6.1 Bearing in mind the National Urban Transport Policy, the State Government considered it also necessary to create an Unified Metropolitan Transport Authority for the Bangalore Metropolitan Region (BMR) which will function as an umbrella organization to coordinate planning and implementation of urban transport programmes and projects and provide an integrated management structure. All land transport systems (excluding Railways) in the BMR may be brought under all purview of the Bangalore Metropolitan Land Transport Authority (BMLTA). The BMLTA will be created initially under an executive order and later with statutory backing.

10.6.2 Under the circumstances explained above, Government has already sanctioned creation of Bangalore Metropolitan Land Transport Authority (BMLTA) for Bangalore metropolitan Region (BMR) as per Government Order No. UDD 134BMR 2006 (2),Bangalore dated 09.03.2007. This shall be taken up as a part of the Greater Bangalore reorganization exercise so as to make it operational by 2007-08. Initially as an interim arrangement, the Government has set up this as a Committee of the BMRDA with the Chief Secretary as Chairman with the following composition.

1.	Chief Secretary to Government	Chairman
2.	Principal Secretary, Finance Department	Member
3.	Principal Secretary, UDD	Member
4.	Principal Secretary, Transport Department	Member
5.	Principal Secretary, Forest Ecology & Environment Department	Member
6.	Principal Secretary, Public Works Department	Member
7.	Commissioner, Urban Land Transport (DULT)	Member
8.	Commissioner, BMP	Member
9.	Commissioner, BDA	Member
10.	Managing Director, BMTC	Member
11	VC & Managing Director, KSRTC	Member
12	Commissioner, BMRC	Member
13.	Commissioner of Police	Member
14.	Managing Director, KUIDFC	Member
15.	Representatives from Railways, AAI etc	Member
16.	Any other experts connected with the Urban Transport found necessary	Member
17.	Commissioner, BMRDA	Member Secretary

10.6.3 The Functions of BMLTA / committee shall be as follows:

(1) To coordinate all land transport matters in the BMR

(2) To prepare detailed Master Plan for Transport Infrastructure based on the Comprehensive Traffic and Transport Study for Bangalore.

(3) To oversee implementation of all transportation projects

(4) To appraise and recommend transportation and infrastructure projects for bilateral / bilateral Central assistance.

(5) To function as empowered Committee for all Urban Transportation Projects

(6) To initiate action for a regulatory frame work for all land transport systems in BMR.

(7) To initiate steps, where feasible for common ticketing system.

(8) Take any other decision for the integrated urban transport and land use planning and implementation of the projects.

(9) Any other functions entrusted from time to time.

10.6.4 BMLTA / committee will function as an umbrella organization to coordinate planning and implementation of urban transport programmes and projects and provide an integrated management structure. All land transport systems (excluding Railways) in the Bangalore Metropolitan Region shall be brought under the purview of BMLTA / Committee.

10.6.5 It is seen from the above that the GOK has already taken the lead and has initiated steps to strengthen the institutions for urban transport. Therefore it is important that BMLTA is established at the earliest with statutory backing and adequate technical staff provided for this organization. It is also important that BMLTA is also given with the power to assign various projects to various organizations. All the finances for transportation projects to the concerned organizations should also be routed through BMLTA in order to make BMLTA effective and to ensure timely completion of projects.

10.6.6 Shifting of utilities, a key function encountered in most of the road improvement works as well construction of new roads requires very effective coordination among institutions to ensure timely completion of projects. This key function is reported to be the major contributor for project delays and cost over runs. Revamping of institutional arrangements with assignment of authority to single entity to accord approvals and sanction would enhance the efficiency of implementation of major projects proposed under the CTTS. The study recommends that this be vested with BMLTA.

10.7 TRANSPORT PLANNING UNIT (TPU)

10.7.1 The role of BDA with regard to town planning is defined within the BDA act as follows:

i) To prepare a structure plan for the development of BMA
ii) To formulate schemes for implementation the structure plan
iii) To secure and coordinate the execution of the town planning schemes for development of transport infrastructure and management of transport system in accordance with the plan.
iv) To entrust to any local authority the work of execution of the development plan and schemes
v) To coordinate the activities of the various bodies which are concerned with developmental activities.

10.7.2 Transport planning is essential ingredient of the town planning. Presently there is no proper technical body for the required transport planning inputs. It is necessary that technical expertise is created not only within BDA to undertake this task but also in BMRDA to carry out similar jobs at Bangalore Metropolitan Region Level.

10.7.3 The proposed Transport Planning Unit (TPU) will perform the following specific functions:

i) To prepare a strategic plan for long term development and utilisation of transport facilities
ii) To formulate schemes for implementing the strategic transport plan
iii) To secure and coordinate the execution of schemes for development of transport infrastructure and management of transport system in accordance with the plan.
iv) To entrust to appropriate local authorities the work of execution of transport schemes
v) To coordinate activities of the various bodies concerned with transport with BDA
vi) To define a strategic transport network for BDA / BMRDA
vii) To define a metropolitan transport policy based on strategic network demand and plan.

10.7.4 The other important responsibilities of Transport Planning Unit will include the establishment of criteria for capital investment and methods for fixing the priorities for road and transport schemes and feasibility studies. The TPU will also be responsible to prepare definite policies related to public transport, road safety, environmental protection and goods movement pattern with related agencies dealing with road planning, railways, traffic engineering, enforcement and regulation will be imperative.

10.7.5 The TPU will be headed by a Senior Transport Planner, who will be of rank of superintending Engineer. The head will be overall in charge and will give the necessary direction to the unit apart from the high level coordination with the concerned departments. He will be assisted by two transport planners, one for policy planning and other for the co-ordination and monitoring. An economist at a senior level is also proposed to be associated with the unit on a part time basis depending upon the requirements.

10.8 TRAFFIC ENGINEERING CELLS (TEC)

A large number of agencies deal with roads such as BBMP, BDA, Traffic Police, PWD, NHAI, BMRDA, Transport Department, KUIDFC, BMRCL, BMTC, BMLTA etc. There are numerous issues of proper road geometrics, traffic circulation, junction design, traffic signals, road signs/markings, street furniture etc which are properly attended to by these agencies due to lack of traffic engineering expertise. Traffic planning is a continuous affair. It is therefore important that Traffic Engineering Cells are established in these organizations with qualified and adequate staff such as traffic engineers. This will ensure that the traffic schemes are properly implemented with better results and fine tuned later, if necessary. This will go a long way to improve traffic flow in Bangalore.

EXECUTIVE SUMMARY

COMPREHENSIVE TRAFFIC AND TRANSPORTATION PLAN FOR BANGALORE

1. PROBLEMS AND ISSUES

1.1 Bangalore population has been growing at a rate of 3.25% per year in the last decade. There has been a phenomenal growth in the population of vehicles as well especially the two and four wheelers in this period due to rising household incomes. The number of motor vehicles registered has already crossed 28 lakhs. In the absence of adequate public transport system, people are using the personalized modes which is not only leading to congestion on limited road network but also increasing environmental pollution. An average Bangalorean spends more than 240 hours stuck in traffic every year. Such delays result in loss of productivity, reduced air quality, reduced quality of life, and increased costs for services and goods

1.2 The analysis of collected data from primary and secondary sources has brought the following major issues regarding the transport system of Bangalore.

1 Road network capacity is inadequate. Most of the major roads are with four lane or less with limited scope of their widening. This indicates the need for judicious use of available road space. The junctions are closely spaced on many roads. Many junctions in core area are with 5 legs. This makes traffic circulation difficult. There is need to optimise the available capacity by adopting transport system management measures and by making use of intelligent transportation systems.

2 Traffic composition on roads indicates very high share of two wheelers. The share of cars is also growing. This indicates inadequate public transport system. V/C ratios on most of the roads are more than 1. Overall average traffic speed is about 13.5 kmph in peak hour. This not only indicates the need of augmenting road capacity but the also to plan high capacity mass transport systems on many corridors.

3 Outer cordon surveys indicate high through traffic to the city. This points to the need of road bypasses not only for Bangalore Metropolitan Area (BMA) but also for Bangalore Metropolitan Region (BMR). High goods traffic also indicates the need of freight terminals at the periphery of the city.

4 The household travel surveys indicate high share of work trips. This segment of travel demand needs to be mostly satisfied by public transport system. Considering the large employment centres being planned in the BMA, the public/mass transport system needs to be upgraded/extended substantially.

5 At present, modal split in favour of public transport is about 46% (exclusive of walk trips). The trends show a decline in this share over the last two decades. This is further expected to fall unless adequate and quality public transport system is provided to the people of Bangalore. Share of two wheelers and cars in travel demand is disturbingly high. This trend needs to be arrested.

6 There is high pedestrian traffic in core area and some other areas in Bangalore. Footpath facilities are generally not adequate and their condition is deteriorating. Therefore up gradation of their facilities is very important. Share of cycle traffic has declined over the years. This mode of transport needs to be promoted by providing cycle tracks along the roads.

7 Parking is assuming critical dimensions in Bangalore. Parking facilities need to be augmented substantially. In the long run, city-wide public transport system needs to provide not only to reduce congestion on roads but also to reduce parking demand.

8 Area of the BMA has been increased as per Revised Master Plan-2015. This plan has provided for densification of existing areas, Mutation corridors, hi-tech areas etc in various parts of the city. This likely to have a major impact on traffic demand. The transport network including mass transport system needs to be planned taking the proposed development in to consideration.

9 Major developments have been proposed in the suburban towns of Bangalore by BMRDA in the BMR. This is likely to increase interaction between Bangalore and these suburban towns. There will be need to provide commuter rail services to these towns from Bangalore.

1.3 Thus while planning for the transport system of Bangalore, the above problems and issues need to be kept in consideration. The issues relating to traffic and transportation in a large and growing city like Bangalore need to be viewed in the larger perspective of urban planning and development. Issues relating to land use planning and development control, public-private transportation policy and industrial location would need to be integrated at the perspective planning level. With Metro Rail under implementation there is the need to coordinate inter modal transport issues.

2. THE PREFERRED STRATEGY FOR TRANSPORT DEVELOPMENT

In order to prepare the Comprehensive Transport Plan the following policy measures have been considered.

1 Extension of mass transport system to provide wide coverage and transport integration with other modes of transport.

2 Provide substantially large network of medium level mass transport system such as BRT to cover the areas beyond the Metro network and on over loaded corridors.

3 Landuse adjustments and densification of corridors along mass transport corridors where possible.

4 Extension of commuter rail system upto the BMRDA's New Townships & beyond upto Tumkur, Hosur etc. to act as sub-urban services.

5 Rationalisation of local bus system and its augmentation.

6 Improvement in traffic management through TSM measures.

7 Special facilities for pedestrians within the entire network specially in the core areas; pedestrianisation of selected shopping streets in side the core area going to be served by Metro. Provision of pedestrian sky walks/subways, footpaths and road furniture along the roads where necessary.

8 Diverting through traffic on Peripheral Ring Road. Providing transport hubs at the junctions of Peripheral Ring Road with important radials such as; the National Highways and other heavily loaded roads.

9 Improving primary, arterial and other important roads (particularly radial and ring roads) by providing grade separation, junction improvements, adding missing links, widening and other road side facilities wherever necessary.

3. TRANSPORT DEMAND ANALYSIS

3.1 Population of the BMA is expected to increase from 61 lakh in 2001 to 88 lakh in 2015 and 122 lakh in 2025. Considering proposed land use, transport sector requirements upto 2025 have been assessed using travel demand modeling. The transport sector recommendations contained in the Master Plan for BMA, city development plan proposed by Bruhat Bangalore Mahanagara Palike (BBMP) under the auspices of Jawaharlal Nehru National Urban Renewal Mission (JNNURM), region development plan prepared by Bangalore Metropolitan Regional Development Authority (BMRDA), development plans of Bangalore International Airport Area Planning Authority (BIAAPA) and Bangalore-Mysore Infrastructure Corridor Area Planning Authority (BMICAPA) have been examined.

3.2 For the purpose of transport demand analysis, various scenarios have been considered as follows.

Scenario 1: This scenario considers a 'do minimum' situation wherein Improvement & augmentation in existing system for the bus network and roads already proposed. The purpose of the scenario is to capture the intensity of the problem if no measures are taken to overhaul the transport system in the city

Scenario 2: in addition to what has been considered in scenario 1, scenario 2 considers the implementation of metro project as planned, a mono rail system

covering 50 km, a BRT system covering 30km, commuter rail system covering 62 km, elevated core ring road of 30 km, a peripheral ring road of 114 km and intermediate ring road of 188 km as proposed IN Master Plan.

Scenario 3: this scenario is developed to address the anticipated demand with extensive public transport system as the focus for development. It is developed upon scenario 2 with additional lines of mass transport systems (about 650 km).

3.3 127 lakh person trips by mechanical modes are estimated to be generated in 2025 against 56 lakh in 2006. Present modal split of 46% in favour of public transport is estimated to fall to 29% by 2025 for scenario 1. Thus most of the trips would be undertaken by personalised modes creating unbearable congested conditions. For scenario 2, modal split in favour of public transport is expected to improve to 50% by 2025. However, this is also not enough for the city of size of Bangalore and many roads would still be overloaded. For scenario 3, the modal split in favour of public transport is estimated as 73%. This modal split is in conformity with the desirable modal split for the city of size of Bangalore as recommended by a Study Group of Government of India. The study, thus, recommends scenario 3 that would fulfill the objectives of the transport sector development integrated with the proposed land use and giving predominance to the public transport system.

4. THE PROPOSED TRAFFIC AND TRANSPORTATION PLAN

4.1 On the basis of projected traffic, an integrated multi-modal mass transport system plan on various corridors has been suggested in order to cater to traffic up to the year 2025. The mass transport systems have been proposed on various corridors considering expected traffic demand by 2025, available road right-of-ways and system capacity. The balance traffic should be carried by road system in order to satisfy the needs of normal bus system and other modes such as two wheelers, cars, bicycles, trucks, pedestrians etc. The proposed Traffic and Transportation Plan for Bangalore contains the following types of proposals, which will cater to requirements of the projected travel demand up to the year 2025.

- Mass Transport System
  - Metro System
  - Monorail/LRT System
  - Bus Rapid Transport (BRT) System
  - Commuter Rail Services
- City Bus System
  - Augmentation of Bus Fleet
  - Grid Routes

  - Bus Terminal cum Traffic & Transit Management Centres (TTMC)
  - Volvo Depot cum Traffic & Transit centre
  - New Bus Stations/bus shelters
  - Additional Depots
  - IT Infrastructure
  - HRD Infrastructure
  - Environment Protection Projects
- Inter-city Bus Terminals
- Transport Integration
- Transport System Management Measures
- Pedestrian/NMT Facilities
  - Footpaths
  - Skywalks/Subways
  - Pedestrian zones
  - Cycle Tracks
- Road Development Plan
  - New Roads/Missing Links (Peripheral Ring Road, Core Ring Road, New Airport Expressway etc).
  - Road Widenings
  - Grade Separators
  - Re-alignment of Outer Ring Road
- Parking Facilities
- Integrated Freight Complexes

4.2 Integrated multi modal transport system has been recommended in order to ensure seamless travel. For the balance travel demand, road improvement proposals have been formulated. While making road proposals, entire corridor has been proposed to be improved instead of isolated improvements.

4.3 The proposed mass transport corridors are shown in **Table 1** and **Figure 1**. Proposals pertaining to city bus system (other than BRT), parking, pedestrian and road improvement proposals are shown in **Figures 2 -4**. Summary of proposals is given in **Table 2**.

4.4 Summary of the cost estimates for various projects is also given in Table 2. Overall cost of the entire plan is estimated as Rs 44,029 crore of which Rs 25,872 crore is proposed for Phase I (2007-12). Cost of the projects proposed in Phase II (2013-18) is Rs 17,017 crore.

Table1. Proposed Mass Transport Corridors

S.No	Corridor	Length (km)
	Metro Corridors	
1	Baiyyappanahalli to Mysore Road East-West Corridor	18.0
2	Peenya to R.V terminal North-South Corridor	18.8
3	Extension of North –South corridor from R.V. Terminal upto PRR	10.2
4	Baiyyappanahalli to Benniganahalli along Old Madras Road.	1.5
5	Yelahanka R.S to PRR via Nagavara , Electronic City	36.0
6	Indira Nagar Metro Stn to White field Railway Station via 100ft Indira Nagar Road	19.5
7	Proposed Devanhalli Airport to M.G.Road via Bellary Road	33.0
	Total length	**137.0**
	Monorail/LRT Corridors	
1	Hebbal to J.P. Nagar (Bannerghatta Road) along the western portion of outer ring road	31.0
2	PRR to Toll Gate along Magadi Road	9.0
3	Kathriguppe Road / Ring Road Junction to National College	5.0
4	Hosur Road – Bannerghatta Road Junction to PRR along Bannerghatta Road	15.0
	Total Length	**60.0**
	Commuter Rail Corridors	
1.	Kengeri – Bangalore City Station	13.0
2.	Bangalore City Station – Whitefield	24.0
3.	Bangalore City Station – Baiyyappanahalli Via Lottegollahalli	23.0
4.	Lottegollahalli to Yelahanka	7.0
5.	Banaswadi upto BMA Boundary	29.0
6.	Kengeri- BMA Boundary	9.0
7.	Yeshwantpur to BMA Boundary	14.0
8.	BMA Boundary – Hosur	12.0
9.	BMA Boundary- Ramanagaram	23.0
10	BMA Boundary to Tumkur	50.0
	Total Length	**204.0**
	Bus Rapid Transit (BRT) Corridors	
1	Hebbal to Bannerghatta Road along eastern crescent of outer ring road	33.0
2	Benniganahalli (ORR) to PRR along old Madras Road	7.0
3	From ORR to Hosur Rd along Hi-tech Corridor	8.0
4	Hosur Road to Tumkur Road along PRR (western part)	41.0
5	Tumkur Road-PRR Junction to Hosur Road along PRR via Tirumanahalli, Old Madras Road, Whitefield	76.0

S.No	Corridor	Length (km)
6	Along Core Ring Road	30.0
7	Vidyaranyapura to Nagavarapalya via Hebbal, Jayamahal Road, Queens Road, M.G. Road, Ulsoor, Indiranagar, CV Raman Nagar	29.0
8	Kengeri Sattelite Town to J.P. Nagar along Uttarahalli Road, Kodipur	13.0
9	Banashankari III stage to Banashankari VI stage Ext. along Ittumadu Road, Turahalli, Thalaghattapura	6.0
10	Domlur Ext. to Koramangala along inner ring road	5.0
11	PRR (Mulur) to Maruti Ngr. (up to Hitech corridor) along Sarjapur Road	7.0
12	Peenya to PRR along Tumkur Road	6.0
13	Old Madras Road near Indiranagar to ORR near Banaswadi along Baiyyappanahalli Road -Banaswadi Road	5.5
14	Hebbal to Devanahalli Airport along Bellary Road	25
	Total Length	**291.5**

Table 2. Summary of Proposed Projects and Cost Estimates (2007 prices) (Rs Crore)

ITEM	Length kms/Nos	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
MASS TRANSPORT CORRIDORS					
Metro System	137	19921	11086	8835	0
Mono Rail / LRT System	60	5100	3825	1275	0
Commuter Rail System	204	3060	690	1620	750
BRT System	291.5	3498	1866	1632	0
IMPROVEMENT IN CITY BUS SYSTEM					
Improvement in City Bus System		5721	4401	660	660
ROAD INFRASTRUCTURE					
New Roads	209.2	5192	5192	0	0
Outer Ring Road Realignment	17	311	311	0	0
Road Improvements (Inside ORR)	142	142	142	0	0
Road Improvements (Outside ORR)	503	433	433	0.00	0.00
GRADE SEPARATORS					
Grade Separators-Road (Nos.)	28	713.0	713.0	0.0	0.0
Rail Over Bridges / RUBs-Rail (Nos)	18	432	432	0	0
Elevated Roads (Kms)	16.5	990	990	0	0
PEDESTRIAN FACILITIES		**281**	**281**	**0**	**0**
PARKING FACILITIES (No. of car spaces)	10000	380	380	0	0
Integrated Freight Complexes (IFC):	6	270	135	135	0
B-TRAC		**500**	**500**	**0**	**0**

ITEM	Length kms/Nos	Total Cost (Rs. Cr.)	Phase-I 2007-12	Phase-II 2013- 18	Phase-III 2019- 24
GRAND TOTAL		46944	31377	14157	1410

5. INSTITUTIONAL STRENGTHENING

5.1 The current structure of governance for the transport sector is not adequately equipped to deal with the problems of urban transport. Multiplicity of organizations, independent legislations and inherent conflict in the roles and responsibilities of stakeholders actually impede in the process of planning and implementation of major schemes aimed at development. Government of Karnataka has recently accorded sanction for the creation of State Directorate of Urban Land Transport (DULT) under the Urban Development Department with the intended objective of ensuring integration of transport planning and development of transport infrastructure in urban areas. The government has also sanctioned setting up of Bangalore Metropolitan Land Transport Authority (BMLTA) for BMR. BMLTA will function as an umbrella organization to coordinate planning and implementation of urban transport programmes and projects. All land transport systems (excluding Railways) in the BMR will be brought under the purview of BMLTA. Therefore it is important that BMLTA is established at the earliest with statutory backing and adequate technical staff provided for this organization. It is also important that BMLTA is also given with the power to assign various projects to various organizations. All the finances to the concerned organizations should also be routed through BMLTA in order to make BMLTA effective and to ensure timely completion of projects.

5.2 Transport Planning is an essential component of town planning. Presently there is no proper technical body for required transport planning inputs. It is necessary that technical expertise is created within BDA and BMRDA to undertake this task. For the purpose Transport Planning Unit (TPU) is proposed to be established in BDA and BMRDA.

5.3 A large number of agencies deal with road system such as BBMP, BDA, Traffic Police, PWD, NHAI, BMRDA, Transport Department, KUIDFC, BMRCL, BMTC, BMLTA etc. There are numerous issues of proper road geometrics, traffic circulation, junction design, traffic signals, road signs/markings, street furniture etc which are not properly attended to by these agencies due to lack of traffic engineering expertise. Traffic planning is a continuous affair. It is therefore important that Traffic Engineering Cells are established in these organizations with qualified and adequate staff such as traffic engineers and transport planners. This will ensure that the traffic schemes are properly implemented with better results and fine-tuned later, if necessary. This will go a long way to improve traffic flow in Bangalore. As bus system will continue to be an important

sub-system in future also, it is also important that BMTC is adequately strengthened through its HRD initiatives.