BANGALORE MOBILITY INDICATORS 2010-11

Draft Final Report

Submitted to

Directorate of Urban Land Transport (DULT)

By

Urban Mass Transit Company Limited

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Chapter - 1

Introduction

1.1 Preamble

In any urban area, mobility forms one of the key functionalities in the field of transportation. Attempts to improve mobility appears to be negligent of pedestrians, non-motorized and local area travel. Improvements are generally supply-driven; overly accommodating to individual motor vehicles; conservative in public transport regulations; non-protective of street based public transport modes; and overly focused on large-scale investments like widening roads and building elevated corridors, in apparent belief that these visible structures will increase the image of competitiveness of the city. This has been due to a lack of comprehensive information on the issue of the different facets of mobility in the City. In this regard, the Directorate of Urban Land Transport (DULT) in the year 2008 initiated a study to identify a set of transportation indicators towards assessing mobility in Bangalore. These indicators will help in policy decision making.

The indicators can serve many purposes. They will provide trend information from which implications for transportation can be drawn or from which transportation policy and investment decisions are made. They can provide a basis for comparisons among metropolitan sub-areas. They can provide the public with a sense of whether system performance is improving or getting worse over time.

This study is an effort in this direction in making a comparative statement of present and past indicator levels.

1.2 Need for the Study

The Bangalore Mobility Indicators 2008 study was the first study initiated in Bangalore to identify a series of indicators that are essential to track the

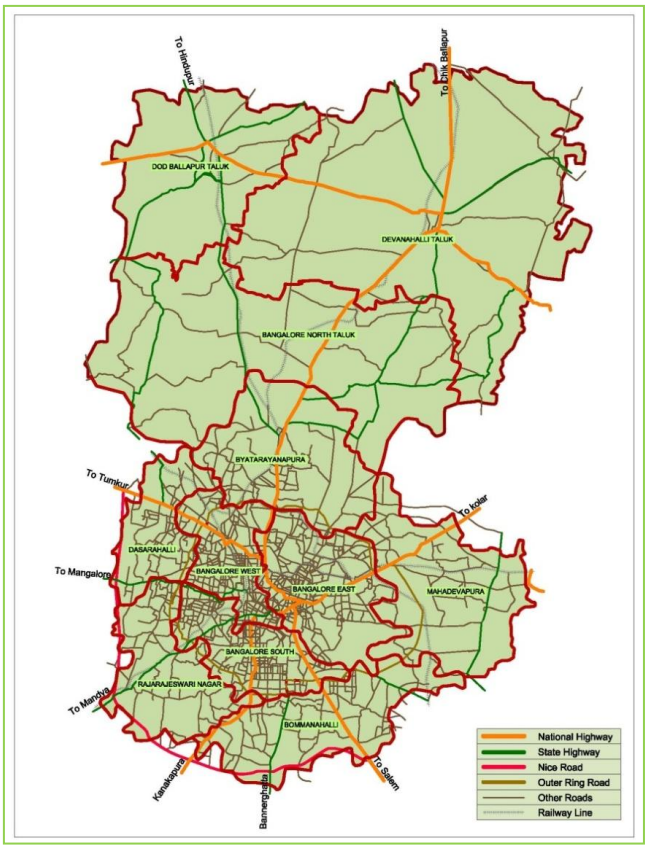
progress of various interventions towards addressing mobility. The study showcased several issues like congestion and accessibility at different locations of the city. The results had necessitated the need to take up development measures from concerned agencies in the next couple of years. Hence, it is now the time to assess the performance of these developmental measures undertaken during the last two years. Consequently, DULT has awarded this project to Urban Mass Transit Company Limited (UMTC) to re-establish the earlier indicators and do a comparison over the years.

1.3 Study Area Profile

The study area for the proposed work includes the limits of Bruhat Bangalore Mahanagara Palike (BBMP) and Bangalore International Airport Area Planning Authority (BIAAPA). The earlier study was limited to BBMP area alone. This study includes the BIAAP area in addition to the 8 zones of BBMP. Hence, the entire study area is divided in to 11 zones. The area is shown in Figure 1.1. The total area of the study area is 1831.23 sq. km.

The zone map is presented in Figure 1.2

Figure 1.1: Study Area



The zone details are as follows:

Zone 1 : Bangalore West
Zone 2 : Bangalore East
Zone 3 : Bangalore South
Zone 4 : Byatarayanapura
Zone 5 : Mahadevapura
Zone 6 : Bommanahalli
Zone 7 : Rajarajeshwari Nagara
Zone 8 : Dasarahalli
Zone 9 : Bangalore North Taluk
Zone 10: Devanahalli Taluk
Zone 11: Doddaballapura Taluk

1.2: Zone map

1.4 Scope of work

The current study would be a comprehensive study establishing Service Level Benchmarks initiated by the MoUD and also recompiling the Mobility Indicators for 2010-11 (comparison with earlier study) for Bangalore City.

The Consultant, would establish the specified SLBs for the assessment of overall level of service in the following areas:

- Quality and financial sustainability of public transport
- Pedestrian and NMT safety and infrastructure facilities
- ITS facilities in Bangalore
- Land use and transport integration
- Parking system
- Pollution levels
- Road safety

Typically, four levels of service (LoS) have been specified (LoS 1, LoS 2, LoS 3 and LoS 4) with LoS 1 being the highest and LoS 4 being the lowest to measure each identified performance benchmark. The goal is to attain the service level 1.

The other part of the study would involve updating the mobility indicators developed in the 2008 study. The updated indicators would provide the public with a sense of whether system performance is improving or getting worse. The following indicators grouped under congestion, mobility and accessibility measures will be updated:

Bangalore Mobility Indicators		
Congestion Measures	**Mobility Measures**	**Accessibility Measures**
Vehicle Kilometers Travelled Person Kilometers Travelled Average Travel Speed Travel Time Travel Time Index Total Delay (vehicle-hours and person-hours) Bottleneck Delay (vehicle-hours) Delay per Person Delay per Vehicle %age of VKT with Avg speed < 30kmph %age of VKT with Avg speed < 15kmph %age of roads with Avg speed < 30kmph %age of roads with Avg speed < 15kmph Congestion Index Safety Index Peak Period Congestion Burden Index	Slow Moving Vehicle Index On street Parking Interference Index Walkability Index ParaTransit Index Cycling Index Capacity Adequacy Planning Time Planning Time Index Buffer Index	Public Transport Accessibility Index Service Accessibility Index City Bus Supply Index Coverage of Services

1.5 Limitations of Earlier Study (Bangalore Mobility Indicators 2008)

It is recognized that the initiative of the 2008 study has a number of limitations. The performance indicators to be truly meaningful need extensive data collection. This would include large number of primary surveys, secondary information in usable format and in a timely manner. The 2008 study established the mobility indicators on the backdrop of a major transport study and hence had the resource of a huge house hold study data (about 50,000 samples) and a calibrated model. While this provided a very good source for computing indicators, the challenges of recompilation of the indices in the future years without the aid of such intensive database is real. The performance indicators determined in the earlier study can be further refined in the future years provided such exhaustive required data (primary and secondary data) is available.

It is important that the basic minimum standard set of performance benchmarks are commonly understood and used by all stakeholders. Also, indicators based on public opinion may have fluctuating results and hence not very reliable while these need to be reviewed.

1.6 Service Level Benchmarks – Concept and Necessity

The Ministry of Urban Development (MoUD) in the mean time has recognized the kinds of issues and challenges in developing mobility indices and hence, has come up with the development of a set of service level benchmarks (See Annexure 1 Service Level Benchmark Guidelines). DULT hence have (through this TOR aimed at establishing Service Level Benchmarks. The MoUD Benchmarks are easy to apply and are non-subjective.

1.7 Objective of the Study

The main objective of the present study as defined in the Terms of Reference (TOR) is to update the indicators from the previous study. It should analyze the consequences of the activities taken place following the earlier study. The study should identify the impact of the developmental activities such as widening of roads, construction of grade separators, foot paths, bus stands and bus bays. The analysis of the impacts should lead to guiding further mobility improvements

1.8 Report Layout

This report considers the significance of service level benchmarks for the Bangalore city in this introduction Chapter.

Clear understanding of what is a performance indicator, its definition & usage; its components are represented in the Chapter 2.

Chapter 3 describes abour the city profile of bangalore.
Chapter 4 describes various surveys that have been conducted and their results. These surveys provide insight in the social, economic and transportation dimensions of the entire Bangalore City.

The computation of indices procedure is described in Chapter 5 along with a comparison table of 2008 study with 2011 study

Chapter 6 ends with a conclusion on performance of the city.

Chapter - 2

Performance Measures

2.1 Mobility Indicators

The Mobility Indicators formulated to measure the performance of the transportation system are listed below

- Road Safety Index
- Congestion Index
- Travel Time Index
- Slow Moving Vehicle Index
- City Bus Supply Index
- Para transit Index
- Cycling Index
- Walkability Index
- On-street parking interference Index
- Vehicle kilometers Traveled
- Passenger kilometers Traveled
- Total Delay (vehicle-hours and person-hours)
- Public Transport Accesibility Index
- Service Accessibilty Index

2.2 Service Level Benchmarks

Service level performance indicators have been identified for the following areas by the Ministry of Urban Development (MoUD), they include:

1. Public transport facilities
    - Presence of organized public transport system in urban area (%)
    - Extent of supply availability of public transport
    - Service coverage of public transport in the city
    - Average waiting time for public transport users (mins)
    - Level of comfort in public transport
    - % of fleet as per urban bus specification

2. Pedestrian infrastructure facilities

- Signalized intersection delay (%)
- Street Lighting (Lux)
- % of city covered

3. Non Motorized Transport (NMT)facilities
    - % of network covered
    - Encroachment on NMT roads by vehicle parking (%)
    - NMT parking facilities at interchanges (%)

4. Level of usage of Intelligent Transport System (ITS) facilities
    - Availability of traffic surveillance (%)
    - Passenger Information System (PIS) (%)
    - Global Positioning System (GPS)/ General Pocket Radio Service (GPRS) (%)
    - Signal Synchronization (%)
    - Integrated ticketing System (%)

5. Travel speed (Motorized and Mass Transit) along major corridors
    - Average travel speed of personal vehicles (Kmph)
    - Average travel speed of public transport (Kmph)

6. Availability of parking spaces
    - Availability of on street paid public parking spaces (%)
    - Ratio of maximum and minimum parking fee in the city

7. Road safety
    - Fatality rate per lakhs population
    - Fatality rate for pedestrian and NMT (%)

8. Pollution levels
    - SO2
    - Oxides of Nitrogen
    - SPM
    - RSPM (Size less than 10 microns)

9. Integrated land use transport system
    - Financial Population Density – Gross (Persons/Developed area in hectare)
    - Mixed Land-use on Major Transit Corridors / Network (% area under non residential use)

- Intensity of Development – City wide (FSI)
- Intensity of development along transit corridor (FSI transit corridor/FSI)
- Clear Pattern and Completeness of the network
- % of area under Roads
- %age network having exclusive ROW for Transit network

10. sustainability of public transport
    - Extent of Non fare Revenue (%)
    - Staff /bus ratio
    - Operating Ratio

2.3 Output from the Study

The key outputs from the study are

1. Service level benchmarks which define the Level of service for different areas of transportation system for the study area
2. Performance indicators

Chapter - 3

Bangalore Today

3.1 Background

Bangalore, the Capital of Karnataka, is the fifth largest metropolitan city in the country. It is well known nationally and internationally as a destination of choice for high-technology industries, particularly in the IT/ITES and Biotechnology sectors. The high-tech industries such as Aerospace, Electronics and Computers have made Bangalore their home due to easy access to a vast pool of scientists and engineers in the city. It is a city that has transformed itself from a "pensioners' paradise" to a modern thriving cosmopolitan metropolis. Situated at about 960 meters above sea level, Bangalore is known for its salubrious climate where temperatures remain moderate throughout the year with temperatures ranging between 33°C and 16°C, with an average of 24°C. Bangalore receives adequate rainfall of about 860 mm from the Northeast Monsoon as well as the Southwest Monsoon.

3.2 Road Network

NH7 and NH4 (part of North South Corridor and Golden Quadrilateral, respectively) and NH209 pass through Bangalore forming five important radial roads within the Bangalore Metropolitan Area. State Highways linking Bangalore with Mysore, Bangalore with Bannerghatta, and Bangalore with Magadi form other major radial corridors. Developed as a radial town, Bangalore does not have a strong circumferential road system, except for the Outer Ring Road, despite the intervening space between the corridors developed. The main highways include:

- NH4 (National Highway 4) running from Mumbai to Chennai;
- NH7 from Varanasi to Kanyakumari;
- NH209 connecting Kanakapura and Kerala; and
- SH17 connecting Bangalore to Mysore.

3.3 Demographics

A. Population Trends

The City experienced rapid growth in the last decades and is the sixth largest city in India. Employment opportunities - initially in the public sector, and then in textile and information technology resulted in migration of people to Bangalore. The 2001 census population of Bangalore was 65.37 lakh, the new provisional population shows the population in 2011 was about 95.88 lakhs which includes the surrounding villages. The Annual exponential growth rate in 2001 was about 3.01 whereas, the growth rate in 2011 is about 3.91 which is more than the 10% decadal growth.

B. Decadal Growth

For the year 1991-2001, the decadal growth of population (absolute) in Bangalore Urban was about 16,97,962 Lakhs with a decadel growth rate of 21.57%, whereas, in 2001-2011, the decadal growth of population has been 30,51,786 Lakhs which is about 36.86%. This has made Bangalore one of the fastest-growing Indian metropolises, after New Delhi. The decadal growth of Bangalore rural is shown in the Figure 3.1

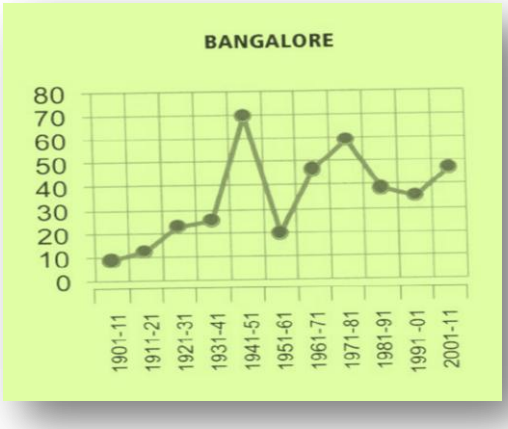


Figure 3.1: Decadal growth of Bangalore

C. Zone-wise population

Growth rate was taken as per the provisional results compiled from the Census of India 2011 for the outer zones 9, 10 and 11. The inner zones are growing at a lower rate. The zone wise projected population for the year 2001 and 2011 is presented in Table 3.1 and shown in Figure 3.2.

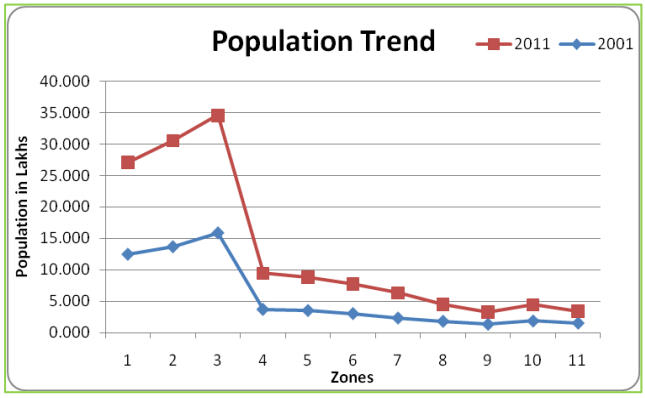


Figure 3.2: Zone-wise Population

The zone map is shown in Figure 1.2 in Chapter 1.

In order to get the whole city- wise indicator the current population for the year 2011 was derived by considering the past census figures and the present provisional annual growth rate for Bangalore.

Table 3.1: Population

ZONES	Population Year 2001	Population Year 2011
1	1245548	1465613
2	1364197	1695183
3	1584552	1877024
4	369679	578773
5	351732	534797
6	303126	473205
7	231891	404924
8	180523	273622
9	133818	193058
10	185326	256787
11	151611	193915

Population census for the year 2001 for the study area was around 61 lakhs. After applying an annual growth rate of 3.91% for the ten years the current population is around 88 Lakhs.

D. Population Densities (2011)

It is observed that the highest density is in zones 1 and 2, followed by 3. Zone 1 includes areas like Malleshwaram, Rajajinagar, Peenya, Yeshwantpur, etc. Most of the areas in Zone 2 fall under the CBD. It is the most important commercial, educational and business area in the city. Zone 3 includes well developed areas like Jayanagar, JP Nagar, BTM Layout, HSR Layout etc. Majority of the IT working population reside in these areas. The Zone-wise population density is presented in Table 3.2 and shown in Figure 3.3

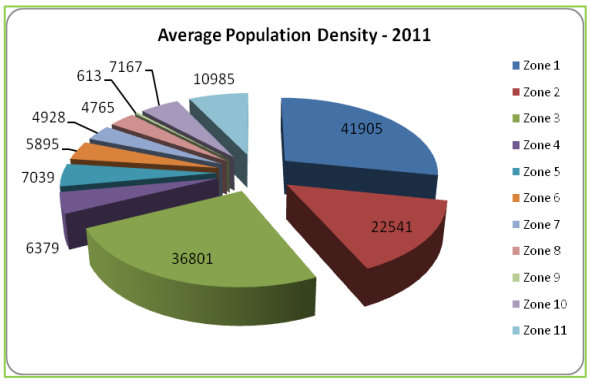


Figure 3.3: Zone-wise Population Density

Table 3.2: Population Density

ZONES	2008 Study Average Density	2011 Average Density
Zone 1	26479	41905
Zone 2	15974	22541
Zone 3	26580	36801
Zone 4	3738	6379
Zone 5	4221	7039
Zone 6	6404	5895
Zone 7	709	4928
Zone 8	5816	4765
Zone 9	---	613
Zone 10	---	7167
Zone 11	---	10985

The average density of Bangalore in 2001 was about 2985 which has increased to 4378 in 2011. It means on an average 1300 more people have inhabited every square Kilometer area in the city.

E. Employment Trends

The average employment density(zone-wise) for the year 2011 is compared with the values in 2008, and the same is presented in Table 3.3.

Table 3.3: Employment Projection

ZONES	Area (in Sq. Kms)	2011 Average Employment density	2008 Average Employment density
Zone 1	52	14917	10468
Zone 2	101	6035	4503
Zone 3	65	9380	7209
Zone 4	151	1182	1239
Zone 5	132	2391	2227
Zone 6	141	1784	2727
Zone 7	126	986	377
Zone 8	61	565	1347
Zone 9	296	351	---
Zone 10	457	274	---
Zone 11	249	269	---

3.4 Land Use Distribution

Bangalore City had developed spatially in a concentric manner. Five major zones can be distinguished in the existing land occupation.

1. The core area consists of the traditional business areas, the administrative centre, and the Central Business District.
2. The Peri-central area has older, planned residential areas, surrounding the core area.
3. The Recent extensions of the City on both sides of the Outer Ring Road were termed as a shadow area.
4. The new layouts have developed in the peripheries of the city.
5. The zone is the green belt zone which is the agricultural area on the outskirts of the city.

Table 3.4: Land Distribution

Category	Area (in Sq. Kms)	% use
Residential	16,042	14.95
Commercial	1,708	1.59
Industrial	5,746	5.36
Park and open spaces	1,635	1.52
Public semi-public	4,641	4.33
Transportation	9,014	8.40
Public utility	192	0.18
Water sheet	4,066	3.79
Agricultural	64,243	59.88
Total	107,287	100%

(Source: Land use details in CDP)

3.5 Transportation Trends

A. Vehicular growth

The number of registered vehicles in Bangalore has increased rapidly from 4 lakh (1987) to 37 lakh (2010). Two wheelers contributes about 69% of total vehicle population and cars/jeeps contributes about 19% of total vehicle population.

B. Composition of mode share

About 35% of the daily trips are Non Motorised Transport (NMT) trips, 27% of the trips are caaried by Public transport, 31% of the trips by private vehicles and 7% of the daily trips by Intermediate Public Transport(IPT).

C. Public Transport

The public transport in bangalore is operated by Bangalore Metropolitan Transport Corporation(BMTC). At present BMTC is operating 2400 bus routes with a fleet size of 6,111 buses. About 43 lakh daily passengers trips are carried by BMTC.

Apart from the bus operations, Two cooridors of Metro rail is under construction. One is North-south corridor and the other is second is East-West corridor. The North-south corridor starts at Nagasandra and ends at Puttenahalli. The East-west corridor starts at Baiyappanahalli and ends at Mysore road. The total length of the Metro rail network is 42.30 km.

D. NMT Initiatives

In the recent past years Directorate of Urban Land Transport(DULT) has taken initiatives to improve the NMT facilities in Bangalore. As part of this, A Datailed Project Report and Feasibility study report has been prepared for different areas in Bangalore are listed below

Details Project Report

1. Madiwala
2. MG Road and visinity

Feasibility study for

1. Indira Nagar
2. Koramangala/BTM
3. R.T Nagar
4. Jayamahal II stage

Chapter - 4

Data Collection and Results

4.1 Primary Data Collection

The present study involves both primary and secondary data collection. Primary survey includes,

- Household survey
- Road Network Inventory
- Speed & Delay
- Bus Passenger Occupancy Survey
- Bus Stop Waiting Time Survey
- Light Meter Survey

The survey locations were same as the Bangalore Mobility Indicators 2008 study with some additional roads & locations on the BIAPP area. The following sections will explain the surveys conducted, analysis and the output for the same.

4.2 Household Interview Survey

A. Introduction

Household interview (HHI) survey is considered as one of the most reliable type of surveys for collection of data on travel pattern of the residents of the household and other general characteristics. The minimum sample needed for such a survey is normally 2% which amounts to 40,000 samples. Since the study will be repeated every year, a sample size of around 2000 is felt to be adequate.

B. Survey Methodology

The Household interview survey is concerned with the collection of basic facts relating to the socio-economic characteristics of the population and trip movements that are made on a typical day within the study area through a questionnaire format. The survey questionnaire comprises three sections, a) Socio-economic datasheet, b) Household member characteristic datasheet, and c) the travel diary of each individual member

of the household. Experienced enumerators are sent to the individual households for collecting information by asking different questions. For this study around 200 samples were collected from each zone making a total of 2200 samples for 11 zones. The survey format is given in the Annexure.

C. Socio-Economic Characteristics

The data from the HHI survey revealed the size of household in terms of total members which would have a significant influence on the quantum of trip made by the household. The average household size in the Bangalore city is about 3.5 and the average income level of the people is about Rs 7400/- month. The zone wise details are presented in the Figure 4.1 and 4.2.

Figure 4.1 Average HH Size

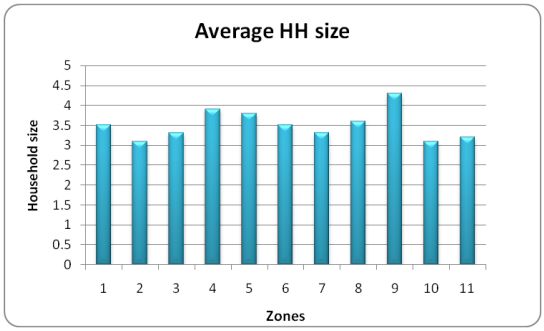
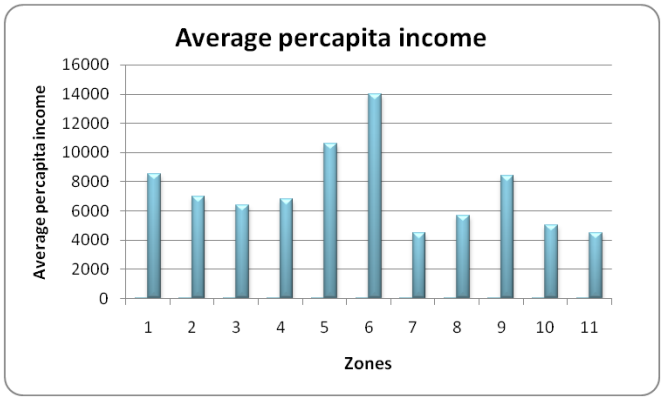


Figure 4.2 Average Income Level



D. Travel Characteristics

The data obtained from HHI was analyzed to establish criteria of variation in trip purposes, trip length, mode and other travel characteristics. Analysis of travel characteristics are presented in Tables 4.1 to 4.3

Table 4.1: Zone Wise Mode share

Mode	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11	Average
Walk	18%	21%	21%	25%	29%	35%	36%	37%	43%	45%	47%	32%
Bicycle	2%	2%	2%	1%	3%	1%	2%	3%	4%	5%	4%	3%
Taxi/Maxi Cab	0.2%	1%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%
Auto	12%	13%	11%	10%	7%	5%	6%	4%	2%	1%	1%	7%
Two wheeler	25%	23%	24%	26%	25%	26%	27%	25%	25%	26%	28%	25%
Car/Van	11%	10%	11%	7%	6%	5%	3%	3%	2%	3%	1%	6%
Public Transport	32%	30%	30%	31%	30%	27%	26%	28%	23%	20%	19%	27%

Table 4.2: Zone Wise Per Capita Trip Rate

Zone No	Zone1	Zone 2	Zone3	Zone4	Zone5	Zone6	Zone7	Zone8	Zone 9	Zone 10	Zone 11
PCTR	1.52	1.19	1.52	1.48	1.35	1.51	1.27	1.48	1.09	1.06	1.04

Table 4.3 Zone Wise Average Trip Length

Zone No	Zone1	Zone 2	Zone3	Zone4	Zone5	Zone6	Zone7	Zone8	Zone 9	Zone 10	Zone 11
Average trip length (All Modes)	7.59	6.92	6.47	6.64	6.14	5.77	6.50	6.33	7.13	7.03	4.75

4.3 Road Network Inventory

The characteristics of the road network include the width of the roadway, divided or undivided, existence of on street parking, any traffic management system like one way etc. All the arterial, sub arterial roads and major roads of about 700 Km have been covered in the study. The road details are given in the ANNEXURE

A. Carriageway Type

Of the total roads covered in the inventory, nearly 50% roads are combination of two lane two way divided and four lane two way divided. Six lane roads account to only 7% of the total road network. The carriageway width details are given in figure 4.3 and Table 4.4.

Figure 4.3: Carriageway Width Details

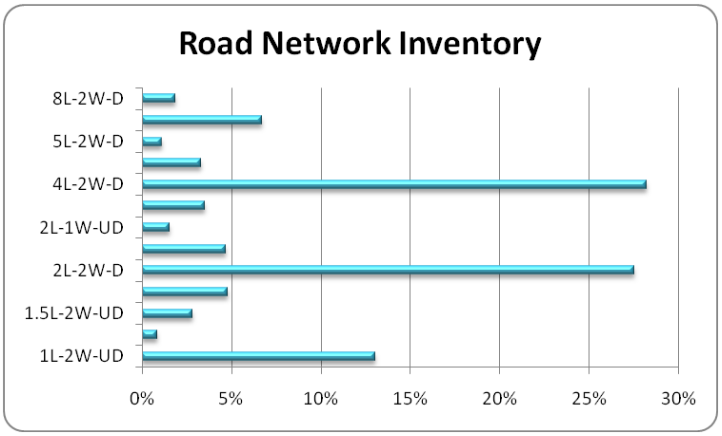


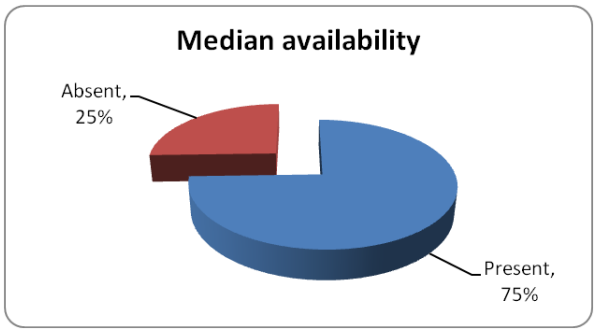
Table 4.4: Carriageway Width Details

Sl. No	lane Configuration	%
1	1L-2W-UD	13%
2	1L-2W-D	1%
3	1.5L-2W-UD	3%
4	1.5L-2W-D	5%
5	2L-2W-D	28%
6	2L-2W-UD	5%
7	2L-1W-UD	2%
8	3L-2W-D	4%
10	4L-2W-D	28%
12	4L-2W-UD	3%
13	5L-2W-D	1%
14	6L-2W-D	7%
15	8L-2W-D	2%

B. Availability of Median

Majority of roads in the study area have medians. Details of the same is shown in Figure 4.4.

Figure 4.4 Median Availability



C. Availability of Footpath

The road inventory study also revealed the presence/absence of the footpaths along with the type, if existed. From the analysis, it is identified that in Bangalore City around 60% of footpath is paved and around 18% of footpath is unpaved despite its present conditions of usage. See Table 4.5.

Table 4.5: Footpath Details

Footpath availability	LHS %	RHS %
Paved	61%	59%
Unpaved	18%	19%
Not present	20%	22%
	100%	**100%**

D. Presence of On-street Parking

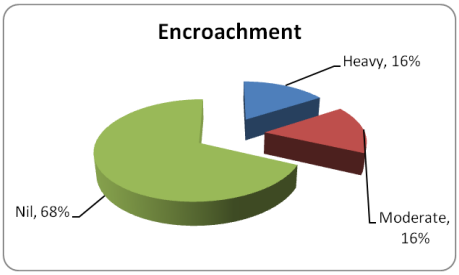
Out of the total road network, On-street parking is present in about 41% of roads in the study area limits. The same is presented in Figure 4.5.

Figure 4.5 Parking Availability

Figure 4.6: Encroachment

E. Encroachment

The extent of encroachment in Bangalore roads has been identified as heavy in some 16% of the roads shown in Figure 4.6



F. Road Markings and Signages

Availability and quality of markings has been classified into three categories such as good, fair and poor. Out of to total road network, good quality marking is available for 60% of roads in Bangalore city. Observed road marking details are presented in Figure 4.7. Similarly data on the availability of proper signage board is presented below in Figure 4.8

Figure 4.7 Road Markings

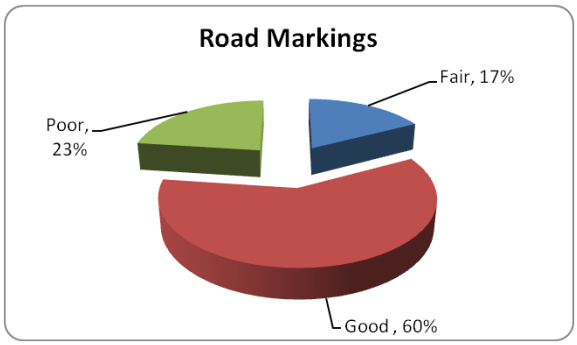
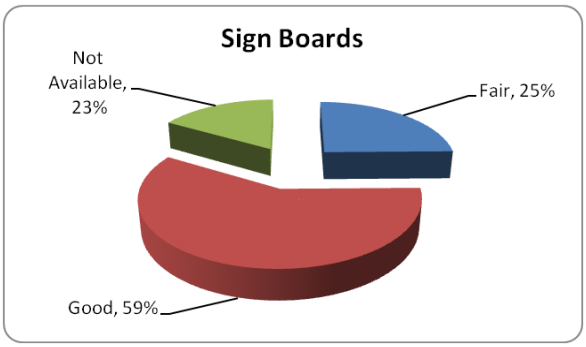


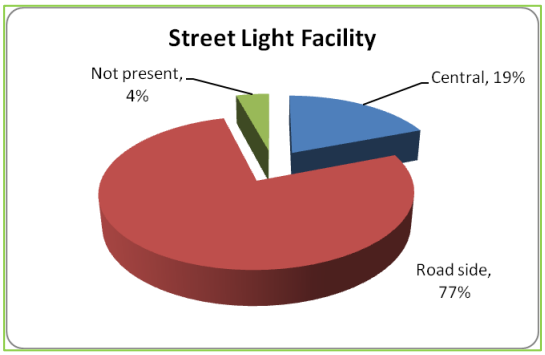
Figure 4.8 Signages



G. Street Lights

Street light facilities have been classified into central, road side and not present based on its availability and location of poles. Details are presented Figure 4.9

Figure 4.9: Street light facility



4.4 Light Meter Survey

A light meter is a device used to measure the amount of light. This survey attempts to analyse the quality of road lightings in the entire Bangalore city by measuring the lighting levels using an illuminance (lux) meter. Illuminance is the amount of light falling on a surface. The unit of measurement is lux (or lumens per square metre = 10.76 foot candles, fc). Readings are taken from several angles and positions from the street light.

A. Method of conducting survey

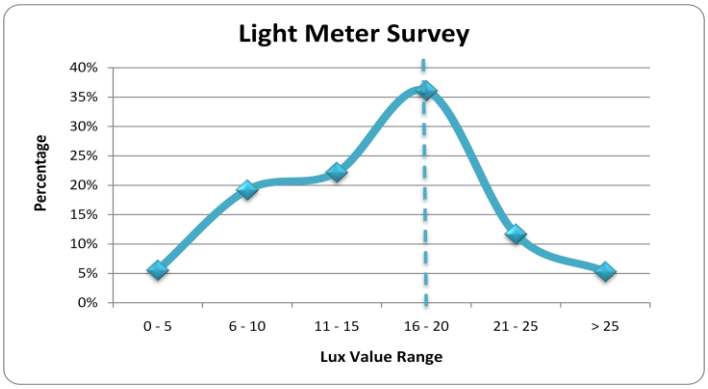
The light sensor was placed on the surface of the road and illuminance (lux) was read off the attached meter. The methodology adopted was

- Divide the section between two light poles into 4 quadrants of equal size
- Measure the lux levels at four corners of each quadrant
- Take the average of each quadrant
- Find the average of all the four quadrants

Care was taken to ensure that the accuracy of reading is not affected by stray shadows. Since pedestrian intrusion (residential access, pedestrian crossing, park/vehicular access etc) and vehicle intrusion (Head Light from vehicles) are the factors affecting the lux meter. The assessment of road lighting adequacy utilizing illuminance measurement is therefore not an accurate indicator

Despite the technical impediment of the measurements, the following conclusion can be drawn from the survey:

Figure 4.10: Lux Meter Survey



As per the MoUD guidelines lines 10 samples were taken per km along the selected arterial/sub arterial roads. Frequency distribution of all the lux levels was observed for the LOS categories as mentioned in the indicators. The cumulative frequency crosses 50% at a lux range of 16-20 as shown in Figure 4.10.

4.5 Speed and Delay Survey

Speed and delay survey on road network in Bangalore metropolis is used to evaluate the travel speed and the travel delays. The overall travel speed is referred to as journey speed while the running speed is the speed maintained by the vehicle over the stretch while in motion and not including delays.

The journey speed and the variation between running speed and journey speed is indicative of level of service and a measure of congestion. Most of the roads in the road network inventory have been taken for speed and delay survey which is about 500 Km each by public transport and private vehicles.

A. Method of conducting survey

For this study, speed and delay by both private and public transport vehicles were conducted using the floating car technique. The enumerator travels along the traffic stream by noting down stop and start time of the vehicle in bus stops and intersections which includes mainly signal delays and traffic delays. Also time of delays caused by other reasons is also noted happened during the survey if it did occur. The same procedure is followed by the enumerator by sitting inside a bus to identify speed and delay by public transport.

Two runs are made on either direction during peak periods (8.00 AM to 11.00 AM & 4.30 PM to 7.30 PM) and off-peak period (11 AM -4PM) and average journey speeds are worked out.

B. Analysis Output

The abstract of overall analysis of journey speed and travel time both by private vehicles and public transport is shown in the Figure 4.11 to figure 4.14. About 42% of the public transport journey speed is in the range of 15 – 20 Kmph.

Figure 4.11 Journey Speed – Public Transport

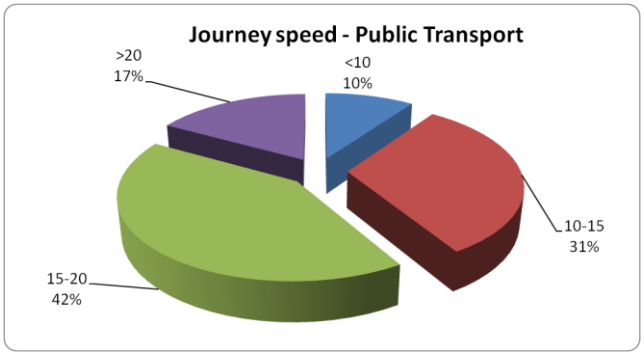
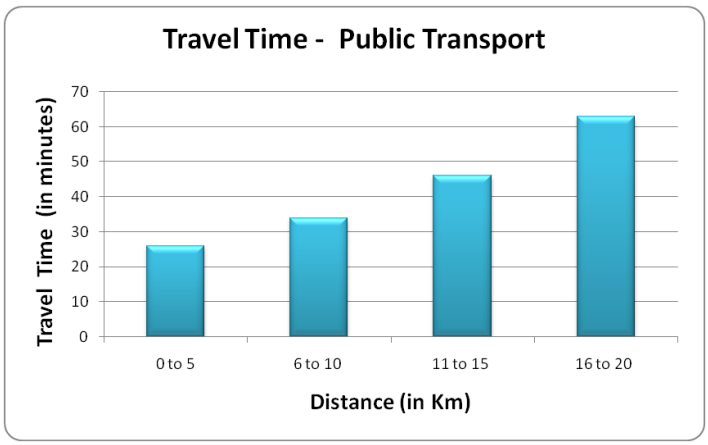


Figure 4.12 Travel Time – Public Transport



Similarly, the average journey speed of the private vehicles lies between 15 – 25 Kmph.

Figure 4.13 Journey Speed – Private Vehicles

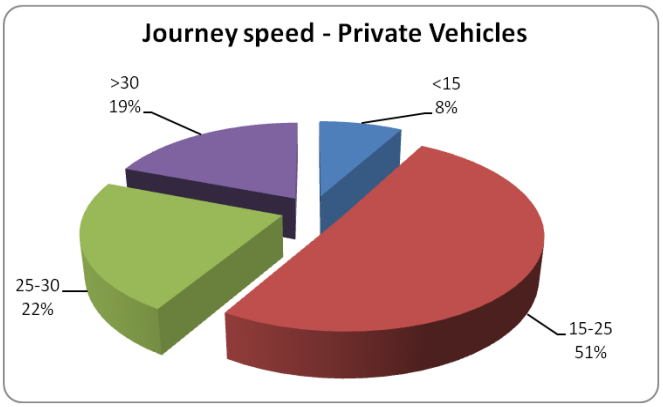
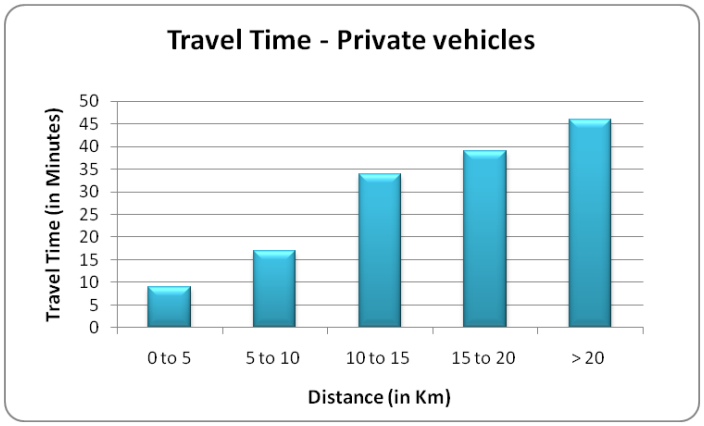


Figure 4.13 Journey Speed – Private Vehicles



Comparison is made on the percentage difference between the public transport and private vehicle travel time and presented in Table 4.6. Thus for a distance of 9 Km the travel time by Public transport is about 1.5 times that of the private vehicle.

Table 4.6: Comparison between Public Transport & private Vehicles

Bangalore City	Average Distance (in Km)	Average Journey Speed (in Kmph)	Average Travel Time (in min)
Public Transport	9	14	35
Private Vehicle	9	23	22

For the major roads, the overall data in respect of major roads furnishing the name of road, length surveyed, overall travel time, journey speed and running speed is furnished in the ANNEXURE

4.6 Bus Passenger Count & Waiting Time Survey

The occupancy count and waiting time is used to evaluate the extent of public transport usage and their comfort levels are. This survey is as per the MoUD guide lines on service levels. A number of bus stops for the entire Bangalore city for this survey were selected on a random basis.

A. Method of conducting survey

For waiting time survey, the enumerators were asked to sit at the selected bus stops both in the peak and off peak hour (8.00 AM to 11.00 AM & 5.00 PM to 8.00 PM and off-peak period 11 AM - 4PM) to note down the arrival and departure time of the buses at the specified stops.

For Bus passenger occupancy count for the same time period, the enumerators were asked to note down the number of people present in the bus on a percentage manner (100% sitting and 25% standing) and the seat availability for that bus type (Volvo, Big10 etc).

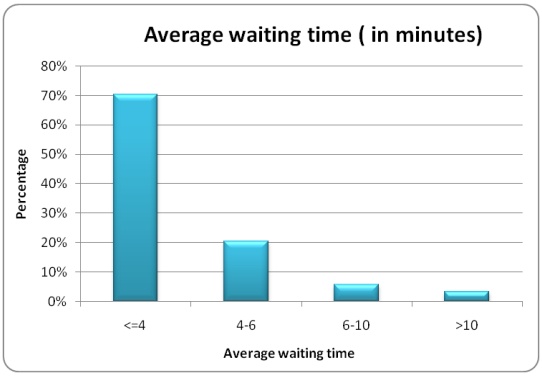
B. Analysis Output

From the waiting time survey, the headway/frequency of buses at selected stops was tabulated on an hourly basis. The waiting time is taken as half that of the frequency of arrivals. The frequency of buses at stops for both morning and evening peak hour is shown in Table 4.7. Nearly, 70% of the passengers felt that they will stay only for about five minutes in the bus stop during peak hours (refer Figure 4.15).

Table 4.7: Frequencies of Buses

Frequency of buses at bus stops	Percentage	
	Morning (per hour)	Evening (per Hour)
< 5 min	40%	36%
5 - 10 min	38%	44%
10 - 20 min	12%	8%
20 - 30 min	8%	6%
> 30 min	2%	6%

Figure 4.15: Average Waiting Time Distributions



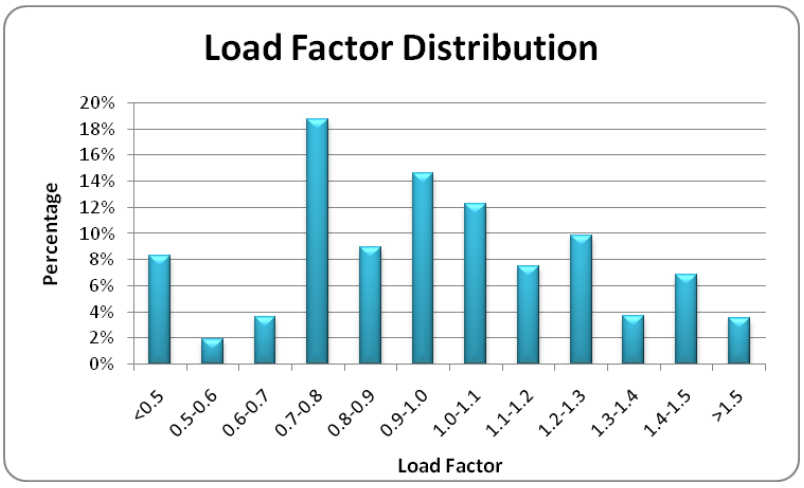
C. Results

From the passenger occupancy count survey, the load factor was calculated which is the main indication for the comfort level of passengers inside the bus. The load factor was calculated as a ratio of bus occupancy divided by the no of seats available in the same bus. Table 4.8 shows the load factor of buses observed at stops for both morning and evening peak hour. The average load factor for all is 0.93.

Table 4.8: Load Factor

Load Factor	Percentage
<0.5	8%
0.5-0.6	2%
0.6-0.7	4%
0.7-0.8	19%
0.8-0.9	9%
0.9-1.0	15%
1.0-1.1	12%
1.1-1.2	7%
1.2-1.3	10%
1.3-1.4	4%
1.4-1.5	7%
>1.5	4%

Figure 4.15 Load factor Distribution



4.7 Secondary Data Collection

The secondary data required for the development of the Mobility Indicators was collected from various sources primarily from the Government/planning organizations. The secondary data includes information regarding the population and employment distribution, land use information, vehicle registration details, pollution details, public transport operation and maintenance details, Bus route & bus stop details, City ITS facility details, Traffic regulation details accident data etc.

For the computation of indicators the secondary data collected are described in sections 2.1 to 2.5.

A. City Bus Details from BMTC

Since, BMTC is the only operator of the city bus service in the entire Bangalore city, for the computation of indices regarding the public transport facility in the city, variety of details were collected from them.

The consolidated details of all the information regarding the bus schedules, routes operated, effective Kms, daily trips, types of service, earnings per day, revenue per day, vehicle utilization, are listed down in the Table 4.9. The operative and financial performance of the bus operator BMTC details is necessary for the computation of indices.

Table 4.9: Consolidated BMTC Details

BMTC	Details (2010 -2011)
Area of operation	5130 Sq. Kms
Vehicles own	6111 buses
Schedules operated	5865 bus schedules
No of bus stops	2198
Effective Kms per day	12.80 lakh service Kms
Daily Bus Trips	8000 bus trips
Existing Routes	2400 routes
Earnings per day	Rs 3.50 Crores
Carry	over 43.50 lakh passengers
Bus Depots	35
Bus Stations	47
Bus Staff ratio	5.7
Traffic revenue per day	339.78 lakhs
Vehicle utilization	222.1

BMTC	Details (2010 -2011)
Fleet utilization	92.3
K.M.P.L (HSD)	4.01
No of accidents	556
Breakdowns/10,000 Kms	0.04

The fleet strength increased from 4000 vehicles in 2006 to 6111 vehicles in 2011 as shown in the Figure 4.17. This shows the huge growth of public transport facility in Bangalore City. The staff members also increased considerably in the years (refer Figure 4.18) arriving a bus staff ratio of about 5.7.

Figure 4.16 Fleet Strength

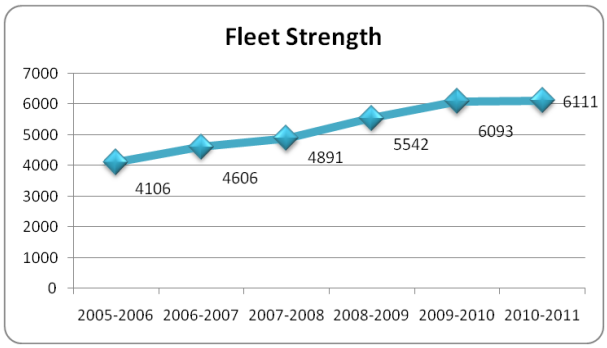
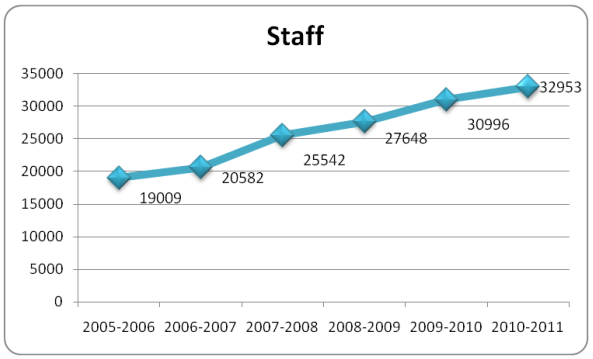


Figure 4.17: Staff (in Nos.)



The traffic revenue of the BMTC bus operations per day is approximately about 3.5 Crores and it shows a steady increase over the years. The other revenues like Government reimbursement. Revenue depends over the years as shown in the Figure 4.19 and Figure 4.20.

Figure 4.19: Traffic Revenue

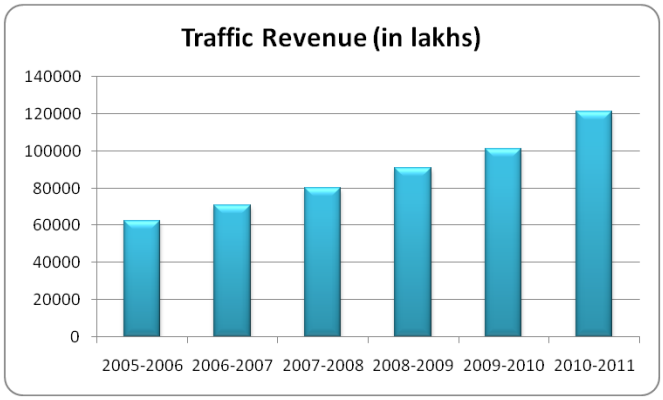
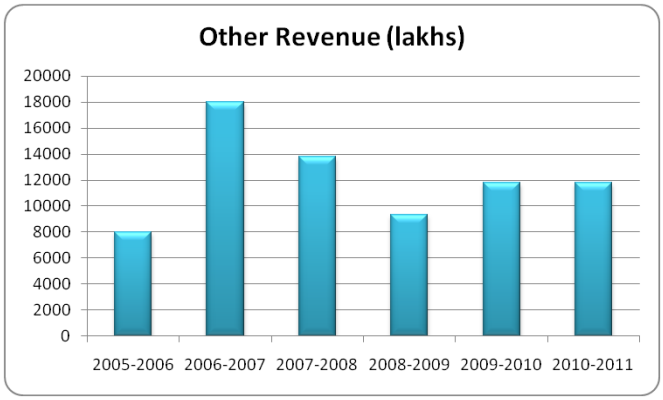
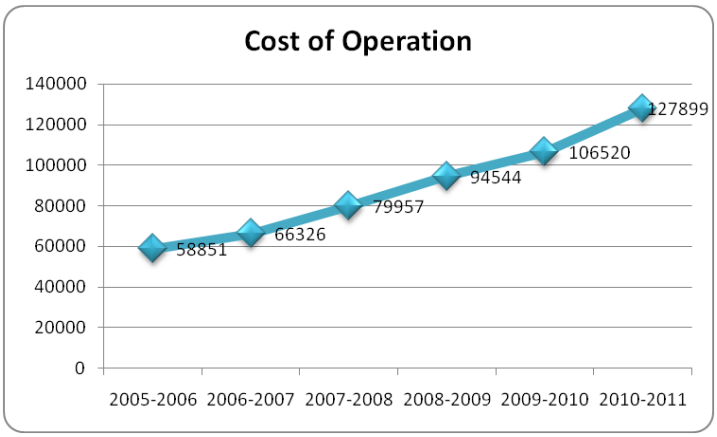


Figure 4.20: Other Revenue

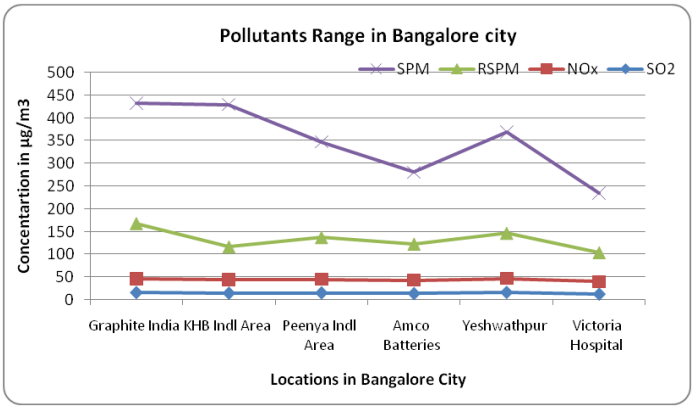


The cost of operation per kilometer (in paise) shows a growth of about 15.8 when compared with the previous years as shown in the Figure 4.21.

Figure 4.21: Cost of Operation



B. Emission Levels from Pollution Board



Karnataka State Pollution Control Board is monitoring Ambient Air Quality. They are monitored at Graphite India Limited, KHB Indl Area, Peenya Industrial area, Victoria Hospital, Amco batteries and Yeshwanthpur Police Station using 'Respirable Dust Sampler' (RDS) by Conventional method. Four air pollutants viz., Sulphur

Dioxide (SO2), Oxides of Nitrogen as NO2 and Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM/PM10), have been identified for regular monitoring at all the locations. The monitoring of pollutants is carried out for 24 hours (4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate matter) with a frequency of twice a week, to have 104 observations in a year. The split up data is given in the Annexure

The consolidated data for the year (2010 – 2011) is given in the following Table 4.10

Table 4.10: Pollutants in Bangalore City

Locations in Bangalore City	SO2	NOx	RSPM	SPM
	Concentration in µg/m^3			
Graphite India	16.1	30.4	122	264
KHB Indl Area	14.8	29.8	72	313
Peenya Indl Area	15.4	30	92	210
Amco Batteries	13.9	29	80	158
Yeshwanthpur	16.5	30.4	100	222
Victoria Hospital	12.7	27.2	64	131

C. Accidents in Bangalore City 2010-2011

With increasing road traffic growth, Bangalore city faces raised level of injuries and fatalities. Level of fatality is an indication of road safety which should be monitored. Figure 4.22 and Table 4.11 show the fatal and injured type of accidents for the year 2010-2011.

Figure 4.22: Accidents in Bangalore

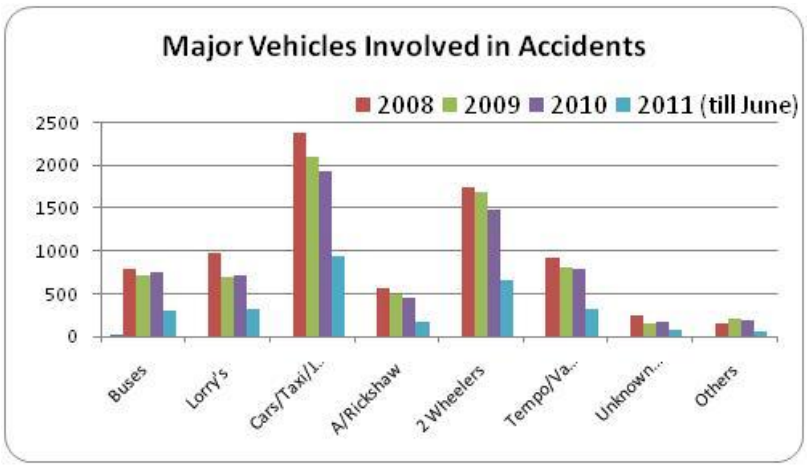


Table 4.11: Accidents in Bangalore City

FATAL AND NON-FATAL CASES REPORTED PERSONS KILLED & INJURED FROM THE YEAR 2001 TO 2011 (up to June) IN BANGALORE CITY					
YEAR	Fatal Cases		Non-Fatal		Total
	Cases	Killed	Cases	Injured	
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	796	836	6782	5899	7578
2006	880	915	6681	6048	7561
2007	957	981	7469	6591	8426
2008	864	892	6908	6150	7772
2009	737	761	6138	5668	6875
2010	816	858	5667	5343	6483
2011(up to May)	340	360	2532	2449	2872

D. Vehicle Registration in Bangalore City 2010-2011

The number of registration vehicles showed a study increase with a growth rate of about 8.62% in the last year. The growth of vehicles is responsible for the traffic congestion in the city. Figure 4.23 shows the growth trend of vehicles and Table 4.12 represents the number of vehicles registered in the current year.

Figure 4.23 Non-Transport Vehicles

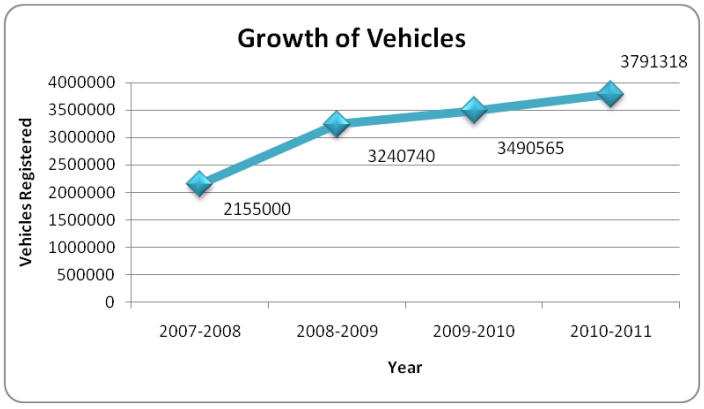


Table 4.12: Registered Vehicles for the Year 2010-2011

Category of Vehicles Registered	2010-2011
Transport	
Trucks/MAV	71983
LMV (goods)	69758
Buses	28261
Taxis	41190
LMV (passengers)	121241
Others	36520
Total Transport	368953
Non-Transport	
Two Wheelers	2624707
Cars/Jeeps	718106
Omni buses	46344
Others	33208
Total Non-Transport	3422365
Total	**3791318**

E. Intelligent Transport System in Bangalore City 2010-2011

Intelligent Transportation System (ITS) refers to the application of information technology in the field of traffic to manage factors like traffic management, safety, vehicle wear, fuel consumption etc. Table 4.13 shows the ITS system operating in Bangalore.

Table 4.13: ITS in Bangalore

Sl. No	Bangalore City - Traffic Details	
1	No of Intersections	40,000 Intersections
2	Signalized Intersections	330 Locations
3	Surveillance Cameras	175 Intersections
4	Enforcement Cameras	5 Locations
5	Variable Message Signs	20 Locations
6	Passenger Information System	14 Bus shelters
7	E-GPS online vehicle tracking	699 vehicles
8	E - Ticketing	1689 electronic machines

Chapter - 5

Computation of Benchmarks and Indices

5.1 Introduction

Transportation systems provide access, mobility and other benefits, while at the same time putting pressures on the human and natural environment. Making progress towards more sustainable transportation systems and mobility patterns, while at the same time increasing the economic prosperity and quality of life, are policy aims shared by the country. The county's transportation system is inextricably linked to its growth and development. This linkage means that growth trends may be evaluated through transportation system performance.

The tools or indicators describe the levels of transport performance in the cities, its safety and access, air pollution, accidents, congestion and also economic aspects of transportation division in the city. Finally, a group of indicators describe the state of governance. Above all, these indicators allow stakeholders to quantify the past and present changes in transport and its sustainability.

All the indices and their derivative methods are discussed below. The level of service table for all of the indicators and data reliable measures for all the indicators are given in the ANNEXURE.

5.2 Service level Benchmarks

Service level performance indicators have been identified for the following areas by the Ministry of Urban Development (MoUD), they are discussed in detail in the following sections.

5.2.1 Public transport facilities -

The parameters include:

1. Presence of organized public transport system in urban area (%)
2. Extent of supply availability of public transport
3. Service coverage of public transport in the city
4. Average waiting time for public transport users (mins)

5. Level of comfort in public transport
6. % of fleet as per urban bus specification

Presence of organized public transport system in urban area (%)

In Bangalore city, 6111 vehicles are operated by the Bangalore Metropolitan Transport Corporation (BMTC) on 5849 schedules.

Los 1	Presence of Organized Public Transport System
1	>= 60
2	40 - 60
3	20 - 40
4	< 20

A = Total Number of Buses in the City – 6111 buses (till May 2011)

B = Total Number if Buses under the ownership of STU/SPV - 6111 buses

Presence of Public Transport System in Urban Area (%)

= (B/A)*100

=100%, Therefore **LOS 1 = 1**

Extent of Supply Availability of Public Transport

In Bangalore the sub urban train facility is absent. The train service is for interstate and intercity only. Hence only the buses operating inside the city are taken into consideration.

Los 2	Extent of Supply Availability of Public Transport
1	>= 0.6
2	0.4 - 0.6
3	0.2 - 0.4
4	< 0.2

The 2011 population of Bangalore has an average annual growth rate of 3.91 when compared to the 2001 population. For Bangalore, the rural growth rate is about 1.50%. The population of Bangalore is taken as 89, 54,594 Lakhs.

A = Total Number of Buses in the City – 6111 buses (till May 2011)

B = Total Population of the city (2011 Census) - 89, 54,594 Lakhs.

Availability of Public Transport / 1000 Population

= A/ (B/1000)

= 0.68255, Therefore LOS 2 = 1

Service coverage of public transport in the city

In Bangalore city, as per the road inventory survey the public transport corridors are present for about 1321 Kilometers with nearly 525 city routes and 1866 sub urban routes.

Los 3	Service coverage of public transport in the city
1	>= 1
2	0.7 - 1.0
3	0.3 – 0.7
4	< 0.3

A = Total length of road Kms of the corridors on which the PT systems ply in the city = 1321 (in Road Kilometers)

B = Area of the Urban Limits of the City = 1831.23 (in Square Kilometers)

Service Coverage = (A/B)
= 0.721373, Therefore **LOS 3 = 2**

Average waiting time for public transport users (mins)

From the bus stop survey as per the MoUD guidelines (Given in Annexure) the average headway was calculated for each bus stop both at the morning and evening peak hour. The waiting time is taken as half of the average headway for that particular route.

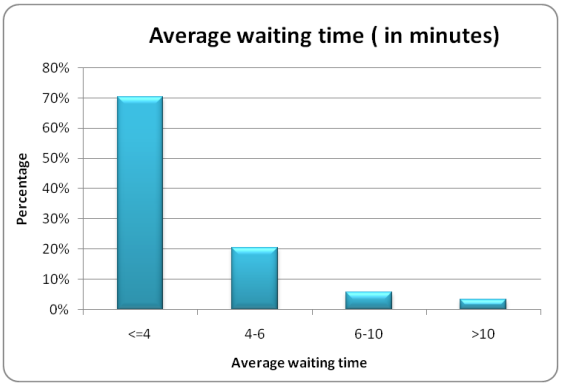
Los 4	Average waiting time for public transport users (mins)
1	<=4
2	4 - 6
3	6 - 10
4	> 10

A = Identify bus stops for survey within the city = 2198 (in Road Kilometers)

B = Average headway of buses / route

Average waiting time for public transport users is identified from the frequency distribution curve and corresponding LOS from the table

Figure 5.1: Average waiting time



According to the MoUD Service Level Benchmarks the median of the frequency distribution defines the average waiting time which lies in between 4 - 6 minutes. Therefore LOS 4 = 2

Level of comfort in public transport

A = Key public transport corridors are identified through the Google map and Bus passenger occupancy survey were done at that selected bus stops.

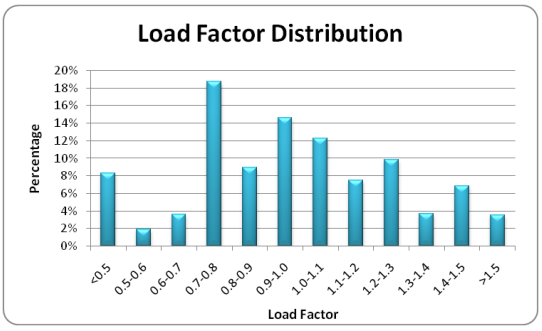
B = Passenger count on bus at key identified routes.

C = Seats available in the bus is taken based on its type. The different type of buses available in BMTC was shown in the figure.

Los 5	Level of Comfort of public transport in the city
1	<=1.5
2	1.5 – 2.0
3	2.0 – 2.5
4	>2.5

Passenger comfort - Load factor (passengers per seat) = B/C

Figure 5.2: Load Factor Distribution



Load factor was calculated for different routes. From the calculated load factor distribution table was prepared. The average value obtained from the distribution is 0.94. Therefore LOS 5 = 1

Percentage of Fleet as per Urban Bus Specification

In Bangalore, it has become mandatory that all buses have sliding doors, sliding windows, emergency exists, destination boards etc. Mostly the newly introduced buses like Volvo, Vajira, Pushpak, Jnnurm, Marcopolo satisfies the specification. The long time buses like old work horse, vestibule, Big 10 are missing some requirements specified by MoUD.

Los 6	% of fleet as per urban bus specification
1	75 - 100
2	50 - 74
3	25 - 49
4	<=25

A = Total Number of Buses in the City – 6111 buses (till May 2011)
B = Total number of buses as per the Urban Bus specifications in the city – 2800 buses
% of fleet as per urban bus specification lies between 25% - 49%, Therefore **LOS 6 = 3**

Overall Level of Service of Public Transport facilities city wide = LOS 1+ LOS 2 + LOS 3 + LOS 4 + LOS 5 + LOS 6
= 1+1 +2 +2 +1 +3
= 10

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Public Transport Facilities	10	<12	The City has a good public transport system which is wide spread and easily available to the citizens. The System provided is comfortable.

Regulatory Mechanism for Periodic Revision of Fares

There would be periodic revision of fares based on changes in the prices of indices. Such periodic revision is proposed to be carried out, every year. For this study since there is no previous study existing for all these below mentioned parameters, the value of the parameters for this year alone was given useful for next year reference.

FN = 0.4 [FPN - FPO] + 0.3 [CPIN - CPIO] + 0.3 [AMCN - AMCO] + FO

Where,

FN - New Fare & FO - Old Fare, FPN - New Fuel Price & FPO - Old Fuel Price , CPIN - New Consumer Price Index & CPIO - Old Consumer Price Index and AMCN - AMC Rate/km & AMCO - Old AMC Rate/km

The exiting bus fare minimum is Rs 4. The Public Transport High Speed fuel rate ranges from Rs. 85 – 50. The average Consumer Price Index for Karnataka Urban ranges from 100 -120 (given in Annexure). The Annual Maintenance Cost for Public Transport vehicles for 2010-2011 was 127899.53 (Rs in Lakhs).

5.2.2 Pedestrian infrastructure facilities

a. Signalized intersection delay (%)
b. Street Lighting (Lux)
c. % of city covered

Signalized Intersection Delay (%)

A = Total Number of signalized intersections in the city = 324

B = No of intersections having average waiting time of pedestrian more than 45 seconds = 176

Los 1	Signalized intersection delay (%)
1	< 25
2	25 – 50
3	50 - 75
4	>= 75

(Desired average waiting time for a pedestrian is not more than 45 seconds)

Signalized intersections delay (%) = (B/A)

= 54.32% Therefore LOS 1 =3

Street Lighting (%)

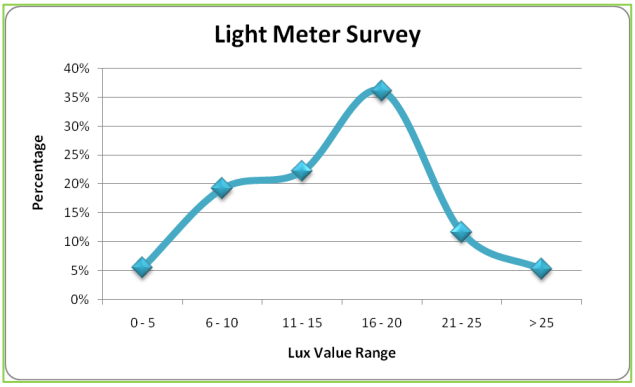
A = Total length of the road network in the study area = 1321 Kms

B = Lux level in % (taken sample wise using lux meter in the entire arterial and sub arterial routes of the city)

Los 2	Street Lighting (Lux)
1	>= 8
2	6 - 8
3	4 - 6
4	< 4

The lux range was noted at the point where the cumulative frequency distribution crosses 50% mark. From the figure it crosses 50% at a range of 16 – 20 lux which lies at the Level of service 1.

Figure 5.3: Light meter survey results



Street Lighting = 16 – 20 Lux, Therefore LOS 2 =1

Percentage of City Covered (%)

A = Total length of road network in the city and multiplied by 2.

= 5900 kilometers (referred in CDP)

B = Total length of the footpath having minimum width of 1.2 m and available on both sides = 3553 in Kilometers

Los 3	% of city covered
1	>= 75
2	50 - 75
3	25 - 50
4	< 25

Percentage of the city covered = (B/A)*100

= (3553/5900)*100

= 60 %, Therefore LOS 3 =2

Overall Level of Service of pedestrian Infrastructure facilities city wide = LOS 1+ LOS 2 + LOS 3

= 3+2+1

= 6

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Pedestrian infrastructure facilities	6	6-8	The city has pedestrian facilities which may need some improvements in terms of improvements in intersections, footpaths and street lighting as some parts of the city are not served by it. The footpath available need improvements. The system provided is comfortable and sustainable.

5.2.3 Non Motorized Transport (NMT) Facilities

a. % of network covered
b. Encroachment on NMT roads by vehicle parking (%)
c. NMT parking facilities at interchanges (%)

Jnnurm recommends that cities should have NMT tracks on all major roads within a year. In view of the above this indicator reflects the availability of dedicated cycle track along all the arterial, sub arterial roads and public transport corridors, its encroachment and parking facilities.

In Bangalore, feasibility studies for dedicated NMT tracks are in progress. In future construction of roads, cycle tracks / lanes become mandatory. UMTC have also done a feasibility study for cycle track in and around Madiwala Lake Bangalore which is now in DPR stage.

In Bangalore, the NMT parking facility is absent but for a few places such as railway stations. As an overall percentage this value is negligible and is taken as zero.

Los	% of network covered	Encroachment on NMV roads by vehicle parking (%)	NMT parking facilities at Interchanges (%)
1	>= 50	<= 10	>= 75
2	50 - 25	10 – 20	50 - 75
3	25 - 15	20 – 30	25 - 50
4	< 15	>30	< 25

Overall Level of Service of NMT facilities city wide = LOS 1+ LOS 2 + LOS 3

= 4+4+4

= 12

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Non Motorised Transport Facilities	12	11-12	The city lacks adequate NMT facilities.

5.2.4 Level of usage of Intelligent Transport System (ITS) facilities

a. Availability of Traffic Surveillance (%)
b. Passenger Information System (%)
c. Global Positioning System (GPS)/ General Pocket Radio Service (GPRS) (%)
d. Signal Synchronization (%)
e. Integrated ticketing System (%)

Availability of Traffic Surveillance (%)

A = Total no of bus stations on BRTS, major bus stops, terminals, metro stations and signalized intersection having CCTVs = 175 (in No)

B = Total no of bus stations on BRTS, major bus stops, terminals, metro stations and signalized intersections = 2569(in No) (Total no. of bus stops – 2198, Terminals – 47, Signalised intersection - 324)

Los 1	Availability of Traffic Surveillance (%)
1	>= 75
2	50 - 75
3	25 - 50
4	< 25

Availability of traffic surveillance (%) = (A/B)*100
= (175/2569)*100
=7%, Therefore LOS 1 = 4

Passenger Information System (%)

A = Total no of bus stops, terminals, metro stations having Passenger Information System facility = 61 (in No) (Bus stops-14, Terminals-47)

B = Total no of bus stops, terminals, metro stations = 2245 (in No)

Los 2	Passenger Information System (PIS)
1	>= 75
2	50 - 75
3	25 - 50
4	< 25

Passenger Information System =(A/B)*100
=(61/2245)*100
= 3 %, Therefore LOS 2 = 4

Global Positioning System (GPS)/ General Pocket Radio Service (GPRS) (%)

A = No of public transport vehicles and IPT with functional on board GPS/GPRS and connected to common control center = 699 (in No)

B = Total no of public transport vehicles and IPT = 168542 (in No)(Three/Four seaters -1212242, taxi and Cabs – 41190, Bus – 6111)

Los 3	Global Positioning System / GPRS
1	>= 75
2	50 - 75
3	25 - 50
4	< 25

Global Positioning System = (A/B)*100

= (699/16842)*100

=0.41 %, Therefore LOS 3 = 4

Signal Synchronization (%)

In Bangalore city, so far no signals have been synchronized.

A = No of signals synchronized = 0 (in No.)

B = Total number of signalized intersections = 324 (in No.)

Los 4	Signal Synchronization (%)
1	>= 75
2	50 - 75
3	25 - 50
4	< 25

Signal Synchronization (%) = (A/B)*100

= (0/324)*100

=0 %, Therefore LOS 4 = 4

Integrated ticketing System (%)

Integrated Ticketing System is absent in Bangalore. **The level of service for this benchmark is 4.**

Overall Level of Service of ITS facilities city wide = LOS 1+ LOS 2 + LOS 3 + LOS 4 + LOS 5

= 4+4+4+4+4

= 20

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Level of usage of Intelligent Transport System(ITS) Facilities	20	16-20	The city lacks adequate ITS facilities.

5.2.5 Travel speed (Motorized and Mass Transit) along major corridors

a. Average travel speed of personal vehicles (Kmph)

b. Average travel speed of public transport (Kmph)

Average travel speed of personal vehicles (Kmph)

Los 1	Average travel Speed of personal vehicles (Kmph)
1	>=30
2	25 - 30
3	15 - 25
4	<15

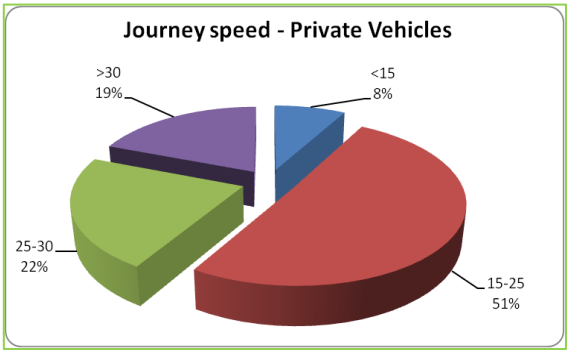
A = Delineate the key corridors of the road traffic (personal vehicle) in the city

B = Compute average speed on the key corridors

From the speed and delay survey for private vehicles, the average journey speed for private vehicles = 22 Kmph.

C= Level of service for personal vehicle along each corridor.

Figure 5.4: Journey speed - Private vehicles



For each corridor, based on its journey speed the level of service is noted down. For example for the corridor 1, suppose its journey speed is 40 kmph then that corridor will fall under LOS 1.

Similarly, the percentage of LOS on corridors based on travel speeds with private vehicles for the Bangalore city is given in the table

Level of Service with	Percentage (personal vehicles) of LOS on Corridors
1 (>=30 Kmph)	12 %
2 (25 – 30 Kmph)	18 %
3 (15 -25 Kmph)	53 %
4 (<15 Kmph)	18 %

Around 53 % of the corridors in the city have a journey speed of about 15 – 25 Kmph.

D = Weights of each corridor based on volume of personal traffic

Weight age of the nth corridor (Wn) = Length for nth corridor / Total length

Based on the above, the weightages of all the corridors as a share of total length has been calculated for both the directions.

City-wide Level of Service of motorized vehicles = (W1*LOS1) + (W2 * LOS2) + (W3 * LOS3) +…. (Wn * LOSn)

= 2.337

=3 (Rounded off to the next whole number)

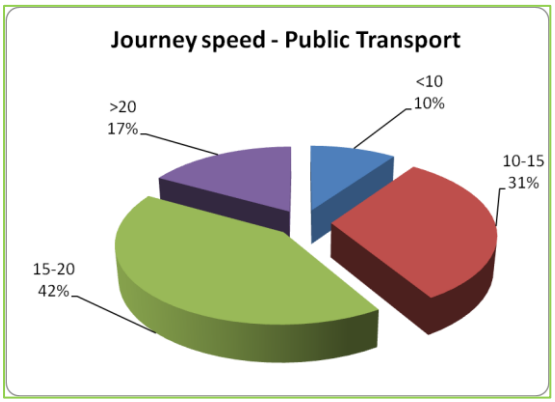
Average travel speed of Public Transport vehicles (Kmph)

A = Delineate the key corridors of the road traffic (personal vehicle) in the city

B = Compute average speed on the key corridors

Los 2	Average travel Speed of Public Transport vehicles (Kmph)
1	>=20
2	15 – 20
3	10 – 15
4	<10

Figure 5.5: Journey speed –Public Transport



From the speed and delay survey for private vehicles, the average journey speed for the private vehicles = 15 Kmph

C= Level of service for personal vehicle along each corridor.

The percentage of LOS on corridors based on its travel speed with public transport vehicles for Bangalore is given in the table below:

Level of Service with	Percentage (personal vehicles) of LOS on Corridors
1 (>=20 Kmph)	15%
2 (15 – 20 Kmph)	37%
3 (10 -15 Kmph)	38%
4 (<10 Kmph)	10%

Around 37 % of the corridors in the city have a journey speed of about 15 – 20 Kmph and around 38 % of the corridors have a journey speed of about 10 – 15 Kmph.

D = Weights of each corridor based on volume of personal traffic

Based on the above said formula, the weightages of all the corridors as share of total length will get calculated for both the directions. The minimum distance taken in the speed & delay survey is about 2 Km to the maximum distance of about 18 Km.

City-wide Level of Service of motorized vehicles = (W1*LOS1) + (W2 * LOS2) + (W3 * LOS3) +…. (Wn * LOSn)

= 2.168

=3 (Rounded off to the next whole number)

Overall Level of Service of Travel Speed facilities city wide = LOS 1+ LOS 2 = 3+3
= 6

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Travel speed (Motorized and Mass transit)	6	5-6	Significant approach delays and average travel speed of 1/3 of free flow speed or lower. Such operations are caused by some combination or adverse progression, high signal density, extensive queuing at critical intersections and inappropriate signal timing

5.2.6 Availability of parking spaces

a. Availability of on street paid public parking spaces (%)
b. Ratio of maximum and minimum parking fee in the city

This indicator represents the availability of free parking spaces for all the vehicles in the entire Bangalore city. Free on-street parking is available on about 60% of the roads- which is a significant number.

The paid parking facility is introduced only at two places in Bangalore by BBMP one is at Brigade road and the other one is at Commercial Street. In the remaining places like Malls, Markets, etc. parking is maintained by private people.

Los	Availability of on street public parking spaces (%)	Ratio of Maximum and Minimum parking Fee in the City
1	>= 75	>4
2	50 – 75	2 – 4
3	25 – 50	1 – 2
4	< 25	1

The fee collected by BBMP is also very limited with a range of 5 rupees to 10 rupees per hour. Hence, the ratio of maximum and minimum parking fees lies in the range of 1-2 with a level of service 3.

Hence, overall Level of Service of Parking Facilities city wide = LOS 1+ LOS 2
= 4+3
= 7

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Availability of Parking places	7	7-8	The city authorities need to initiate immediate actions with respect of providing paid parking spaces and demand management for parking

5.2.7 Road safety

a. Fatality rate per lakhs population
b. Fatality rate for pedestrian and NMT (%)

Fatality Rate per Lakh of Population (%)

Accident Data for the entire city was collected from Traffic police and BMTC for the year 2010. Calculation is done on 2010 data using the 2010 population.

A = Total number of fatalities recorded in road accidents within city limits in the given calendar year = 858 (in nos.)

B = Population of the urban agglomeration 2010 year – 8617644 (in Lakhs)

Los 1	Fatality rate Per Lakh of Population
1	<=2 persons
2	2 – 4 persons
3	4 – 6 persons
4	>6 persons

Fatality rate per 100000 Population (ratio)

= (A * 100000)/B
= 9.95

Approximately 10 persons, Therefore LOS 1 = 4

Fatality Rate for Pedestrian and NMT

A = Total number of fatalities recorded of persons who were pedestrians /cyclists in road accidents for the year 2010 = 420 (in nos.)

B = Total no of fatalities recorded in road accidents within city limits in the given year = 858 (in nos.)

Los 2	Fatality rate Per Lakh of Population
1	<=20
2	20 - 40
3	40 - 60
4	>60

Fatality rate for pedestrian and NMT (%)

= (A/B)*100

= 48.95%, Therefore LOS 2 = 3

Overall Level of Service of Road Safety = LOS 1+ LOS 2

= 4+3

= 7

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Road safety	7	7-8	Level of Fatality rate in the city is very high

5.2.8 Pollution levels

a. SO2
b. Oxides of Nitrogen
c. SPM
d. RSPM (Size less than 10 microns)

In Bangalore, Ambient Air Quality is monitored at six locations. Four air pollutants viz., Sulphur Dioxide (SO2), Oxides of Nitrogen as NO2 and Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM/PM10), have been identified for regular monitoring. As per Central Pollution Control Board (CPCB) guidelines, the monitoring of pollutants has been measured as the Annual Arithmetic Mean of minimum 104 measurements in a year taken twice a week 24 – hourly at uniform interval. (Data source by Pollution Control Board Bangalore, Karnataka)

Location	SO_2	NOx	RSPM	SPM
	(Unit – Concentration range in µg/m^3)			
Graphite India	16.1	30.4	122	264
KHB Indl Area	14.8	29.8	72	313
Peenya Indl Area	15.4	30	92	210
Amco Batteries	13.9	29	80	158
Yeshwanthpur	16.5	30.4	100	222
Victoria Hospital	12.7	27.2	64	131
Average	**14.90**	**29.47**	**88.33**	**216.33**

The level of service for the pollutants is divided into four categories low, moderate, high and critical. From the available data for the year 2010 to 2011the LOS pollutants are given below in the table.

Sl. No	Level of Service	SO_2	NO_x	RSPM	SPM
1	Low	14.9	29.47		
2	Moderate				216.33
3	High			88.33	
4	Critical				

Overall Level of Service of Pollution city wide = LOS 1+ LOS 2 + LOS 3+ LOS 4 = 1+1+3+2
= 7

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Pollution levels	7	6-9	Need some improvements in emission standards, checking pollution etc.

5.2.9 Integrated land use transport system

a. Financial Population Density – Gross (Persons/Developed area in hectare)
b. Mixed Land-use on Major Transit Corridors / Network (% area under non residential use)
c. Intensity of Development – City wide (FSI)
d. Intensity of development along transit corridor (FSI transit corridor/FSI)
e. Clear Pattern and Completeness of the network
f. % of area under Roads
g. %age network having exclusive ROW for Transit network

Financial Population Density - Gross (Persons/Developed area in hectare)

A = Developed area (in Hectare) computed from the satelite image and City Development Plan CDP = 38978

B = Population of the current year for which data is available = 8954594

Population density (No.) = B/A

= 229.73, Therefore LOS 1 = 1

Los 1	Population density / Gross
1	>= 175
2	150 – 175
3	125 – 150
4	< 125

Mixed Land Use Zoning (Proportion of non residential area)

Metro work construction (phase 1) for about 42.3 Km covering the entire city in East-West and North-South directions is in progress. So, the zoning will be determined actually once transit corridor starts operating. For this study, the mixed land use is taken as 0. Thus the level of service for the inventory of land use along major transit corridors is very least taken as <5%. Therefore LOS 2 = 4

Los 2	Mixed Land Use Zoning
1	>= 30
2	15 - 30
3	5 – 15
4	<5

Intensity of Development Citywide - FSI

As per the Development plan Floor Space Index (FSI) as applicable to the developed area lies in the range of 1.00 - 3.25. Normally, FSI varies due to plot size, ground coverage and road width.

Los 3	Intensity of development citywide FSI
1	>= 2
2	1.5 – 2.0
3	1.0 – 1.5
4	<1

Floor Space Index (Applicable to most part of the city as per master plan /CDP is around 2.5 (> 2), Therefore **LOS 3 = 1**

Intensity of Development Citywide - FSI

A = Floor Space Index (Applicable to most part of the city as per master plan /CDP is around 2.

B = FSI for the proposed transit (Metro) corridor has been mentioned as 4 for a distance of 150 m around transit corridor (Information given by BMRCL). These areas have yet to be developed.

Los 4	Intensity of development along transit corridor
1	>= 2
2	1.5 – 2.0
3	1.0 – 1.5
4	<1

Intensity of development along transit corridor = B/A

= 2/2 = 1, Therefore LOS 4 = 3

Clear pattern and completeness of network

The entire Local Planning Area of Bangalore city is conceptually organized into three main Rings for consideration of zoning and regulations.

a. Areas coming within the Core Ring Road: Ring I
b. Areas coming between the Core Ring road and the Outer Ring Road: Ring II
c. Areas coming beyond the Outer Ring Road and within the LPA: Ring III

The above rings are equivalent to Zone-A, Zone-B and Zone-C for TDR Purposes

Los 5	Clear pattern and completeness of network
1	Clear pattern (ring radial or grid iron)and complete network
2	Somewhat clear pattern (ring radial or grid iron) but somewhat in complete network
3	Somewhat un clear pattern and in complete network
4	No clear pattern incomplete / sparse network

A = Based on existing and proposed network the identified major roads pattern is Ring and Radial Pattern mainly of 3 rings as mentioned above.

B = Extent of clarity and completion - Medium clarity (qualitative from high to low)

Road network pattern and completeness = **somewhat clear pattern (ring radial pattern) but somewhat incomplete network, Therefore LOS 5 = 2**

% of area under roads (%)

A = Developed area (in Hectare) and City Development Plan CDP including agriculture area = 103221

B = Overall area under road network = 9014

Deisity of Roads (No.) = (B/A)*100

= 8.73%,

Therefore **LOS 6 = 4**

Los 6	% of area under roads
1	>=15
2	12 – 15
3	10 – 12
4	< 10

% network having exclusive ROW for transit network

In Bangalore, till date there are no exclusive BRT/Metro/LRT/Monorail corridors actually plying. For this indicator, the length of network is taken as 0. Therefore, the level of service for this indicator is the least < 10% and mentioned as 4.

Los 7	% network having exclusive ROW for transit network
1	>=30
2	20 - 30
3	10 – 20
4	< 10

Overall Level of Service of Integrated Land use system

= LOS 1+ LOS 2 + LOS 3 + LOS 4 + LOS 5 + LOS 6 + LOS 7

= 1+ 4 +1 +3 +2 +4 +4

For a population >= 1 million the calculated level of service = 19

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Integrated landuse Transport system	19	15-22	Faint coherence between city structure and public transport system.

5.2.10 Sustainability of public transport

a. Extent of Non fare Revenue (%)
b. Staff /bus ratio
c. Operating Ratio

Extent of Non Fare Revenue (%)

Operational performance and financial performance of BMTC had been collected from the year 2005 to 2011.

A = Revenue collections per annum from non fare related sources for the year 2010-2011 (i.e. excluding tariff box collections) - Rs. 11810.98 (in Lakhs)

B = Total revenue per annum from all the sources - Rs. 132934.5 (in Lakhs)

Los 1	Extent of non fare Revenue
1	>40
2	40 - 20
3	20 - 10
4	<=10

Extent of non-fare revenue (%)

= A/B * 100

= 8.88 %, Therefore LOS 1 = 4

Staff/Bus Ratio (%)

A = Total staff of bus operation and maintenance – 32953 (in Number)

B = Total number of buses – 6111 (in Number)

Staff / Bus Ratio (ratio) = A/B

= 5.39, Therefore **LOS 2 = 1**

Los 2	Staff / Bus Ratio
1	<=5.5
2	5.5 – 8
3	8 – 10
4	>10

Operating Ratio (%)

A = Cost/bus = Rs. 127899 (in lakhs)

B = Earning/bus = Rs. 132934 (in lakhs)

Operating Ratio (ratio) = A/B

= 0.962124, Therefore **LOS 3 = 1**

Los 3	Operating Ratio
1	<0.7
2	0.7 – 1.0
3	1.0 - 1.5
4	>=1.5

Overall Level of Service of Public Transport facilities city wide = LOS 1+ LOS 2 + LOS 3

= 4+1+1 = 6

Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
Sustainability of public transport	6	5-7	The Public Transport of a city is financial sustainable but needs some improvements.

5.2.1 Summary of Benchmarks

Sl. No	Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
1	Public Transport Facilities	10	<12	The City has a good public transport system which is wide spread and easily available to the citizens. The System provided is comfortable.
2	Pedestrian infrastructure facilities	6	6-8	The city has pedestrian facilities which may need some improvements in terms of improvements in intersections, footpaths and street lighting as some parts of the city are not served by it. The footpath available need improvements. The system provided is comfortable and sustainable.
3	Non Motorised Transport Facilities	12	11-12	The city lacks adequate NMT facilities.
4	Level of usage of Intelligent Transport System(ITS) Facilities	20	16-20	The city lacks adequate ITS facilities.
5	Travel speed (Motorized and Mass transit)	6	5-6	Significant approach delays and average travel speed of 1/3 of free flow speed or lower. Such operations are caused by some combination or adverse progression, high signal density, extensive queuing at critical intersections and inappropriate signal timing
6	Availability of Parking places	7	7-8	The city authorities need to initiate immediate actions with respect of providing paid parking spaces and demand management for parking

Sl. No	Bench mark	LOS calculated	LOS range suggested by MOUD	Comments
7	Road safety	7	7-8	Level of Fatality rate in the city is very high
8	Pollution levels	7	6-9	Need some improvements in emission standards, checking pollution etc.
9	Integrated landuse Transport system	19	15-22	Faint coherence between city structure and public transport system.
10	Sustainability of public transport	6	5-7	The Public Transport of a city is financial sustainable but needs some improvements.

5.3 Mobility Indicators

In the 2008 Bangalore Mobility indicators study, performance of the transportation system was measured based on measures like Congestion, Mobility and Accessibility. The various aspects considered in congestion measures were travel speed, travel time and its index, vehicle kilometers travelled, passenger kilometers travelled, congestion index, congestion burden index, percentage of speeds, accident fatality index, accident injury index and road safety index. Similarly, in Mobility measures slow moving vehicle index, city bus supply index, parking interference index, walk ability index and para transit index were formulated. In Accessibility measures features like Public transport accessibility, service accessibility were computed.

5.3.1 Road Safety Index

Safety Index

Accident Fatality Index: The accident fatality index is defined as the number of road accident deaths per lakh of population. For this computation, the accidents in the year 2010 are taken into consideration for deriving the indicators as whole accident data for 2010 is what can be available at this point in time.

Accident Injury Index: The accident injury index is defined as the number of road injury accidents per lakh of population.

Bangalore city Population in 2010 (as per the 2001 census)	8617644
Per lakh population	86.17
Number Road accident deaths	858
Accident Fatality Index	9.95
Number Road accident injuries	5343
Accident Injury Index	62.0007

Source: (Traffic Police Data, Bangalore)

Road Safety Index: The accident safety index is defined as sum product of reciprocal of AFI (Accident fatality index) times W1 (Weightage) and reciprocal of AII (Accident Injury Index) times W2 (Weightage)

Road Safety Index = W1*(1/AFI) +W2*(1/AII), where W1=0.75, W2=0.25

= 0.75 * (1/9.95) + 0.25 * (1/62.0007)

=

Road Safety Index = 0.079. In 2008 study Road Safety Index = 0.047

.

079

5.3.2 Congestion Index

The Roadway Congestion Index (RCI) is a measure of vehicle travel density on major roadways in an urban area. Congestion levels are assessed by using the prevailing measurable average journey speed observed on major corridors. Journey speeds are easily understood by public and are applicable from both user and a roadway perspective.

The congestion index is formulated as follows:

Congestion index = 1 – (A / M)

Where,

M: Desirable ideal average journey speed on major road networks of a city during peak hour, which is assumed as 40 KMPH, and

A: Average journey speed observed on major corridors of the city during peak period.

Average journey observed on major corridors (A)	22 Kmph
Desirable average journey speed on major corridors (M)	40 Kmph
A/M	0.55
1-(A/M)	0.45

In ideal condition congestion index is zero. The index is formulated such that lower the index, better the performance. Lower the speed higher the congestion index. In this study, desirable speed is considered as 40 kmph, and not higher keeping in view safety issues in an urban area. The Congestion index for the City is about 0.45, indicating during peak periods, the journey speed is reduced by 45 percent of the desired speed limit.

Congestion Index = 0.45. In 2008 study congestion Index = 0.33

5.3.3 Travel Time Index

The Travel Time Index is the ratio of peak period travel time to free flow travel time. Ideal travel speed is assumed to be 40 kmph during peak hour. This indicator expresses the average amount of extra time it takes to travel in the peak relative to free-flow travel. The travel time index for both public transport vehicles and private vehicles have been calculated. Table shows the travel time index for the City.

Travel Time Index = Actual Travel Time/Ideal (free flow) Travel Time

Average ideal travel time for a ideal speed of 40 Kmph	13.22 minutes
Average travel time along the corridors (private vehicles)	22 minutes
Travel time index (private vehicles)	1.69
Average travel time along the corridors (Public transport)	35 minutes
Travel time index (Public transport)	2.38

Source: (Speed and delay survey)

Travel time Index = 1.69. In 2008 study travel time Index = 1.57

5.3.4 Slow Moving Vehicle Index

Slow moving vehicle transport includes bi-cycles and cycle rickshaws. In India, dedicated bi cycle lanes were absent in most of the cities. Bicycle a sustainable urban transport mode in India, is gradually diminished due to motor vehicles. Now due to the government policies on improving NMV, separate lanes for NMV are being included in their future proposals.

SMV Index = SMV share in trips (percentage)

This indicator just reflects the NMV percentage share to all other modes obtained from the HHI survy analysis. The zone wise percentage of NMV trips are given in the table.

Zone	SMV Share (%)
1	2%
2	2%
3	2%
4	1%
5	3%
6	1%
7	2%
8	3%
9	4%
10	5%
11	4%

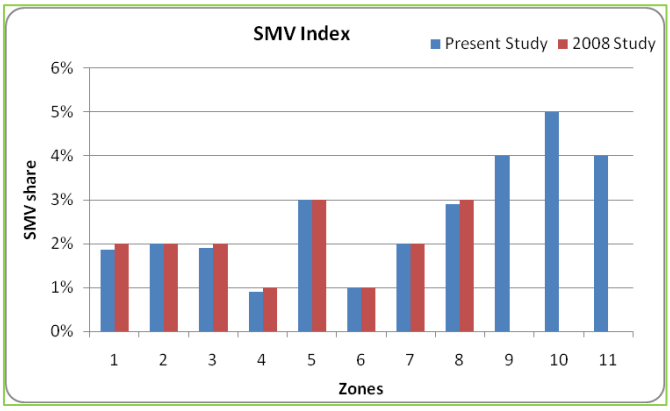


Figure 5.6: SMV Index

The average slow moving vehicles (SMV) index = 2% for the total Bangalore city which is similar to the previous study. The outlying

zones show a higher share than the city zones. The outer zones show a higher share than the city zones.

Slow moving vehicle Index = 2 %. In 2008 study slow moving vehicle Index = 2 %

5.3.5 City Bus Supply Index

City Bus Supply index represents the extent of availability of bus service for the public in the city. This index is generally expressed as the ratio of City bus fleet availability to the per lakh population.

Total number of buses held in BMTC	6112
Population in lakhs	89.545
City Bus Supply Index	69

Source: (BMTC data as on 31/3/2011)

The extent of supply of buses in Bangalore city is far above the India's average. Since, the demand is more due to the effective increase in urban population the index decreased from 80 in 2008 study to 69 in the current study.

City Bus Supply Index = 69. In 2008 study City Bus Supply Index = 80

5.3.6 Para Transit Index

In most of the metropolitan cities, informal public transport or Para transit or Intermediate Public Transport (IPT) is an important component of their overall transport services.

Para transit index is number of vehicles available per 10,000 Population

Bangalore city Population in 2011 (as per the 2001 census)	8954594
Per 10,000 population	895.45
Three wheeler (Auto rickshaw)	31793
Taxis & Cabs	41190
Three Seaters	98025
Para Transit Index	190

Source: (RTO data in Bangalore Metropolitan City as on 31/3/2011)

Para Transit Index = 190. In 2008 study Para Transit Index = 185

5.3.7 Cycling Index

Cycling Index refers to the availability of separate cycle tracks or lanes in the city. In, Bangalore so far there are no cycle tracks. Many feasibility and DPR studies are in progress to develop cycle tracks.

Cycle Index = % cycle lanes/total road length

Since there are no separate cycle tracks or lanes in Bangalore the Cycle Index is zero (0).

Cycling Index = 0. In 2008 study Cycling Index = 0

5.3.8 Walkability Index:

Walk ability index has been developed for evaluating performance of pedestrian infrastructure taking into consideration of the availability of foot path on major corridors. For this indicator, availability of footpath has been identified from the road network inventory survey. In this study, facility rating was not included.

Footpath availability	LHS Percentage	RHS Percentage
Paved	61%	59%
Unpaved	18%	19%
Not present	20%	22%
	100%	**100%**

Walk ability Index = 0.6 for the Bangalore city

5.3.9 On-street Parking Interference Index

On-street parking occupies valuable space on the roadway which otherwise could have been used by motorized or non-motorized traffic. This indicator has been identified as the reciprocal of major road length used for on street parking.

Parking Index = 1/ (% of major road length used for on-street parking)

= 1/ (0.41) = 2.43

Parking interference Index = 2.43 for the Bangalore city. In 2008 study = 2.3

5.3.10 Vehicle Kilometers Traveled

Vehicle Kilometers Traveled (VKT) is the key data for transportation planning and management, and a common measure of roadway use. It is the total kilometers traveled by private motor vehicles on the highway system. This has been derived from the HHI survey. It is dependent on the trip lengths and the number of trips made of the passengers in each zone. The average trip length for Bangalore obtained from this study is about 7.79 Km. The vehicle kilometers traveled is about 24.9 Million.

Vehicle Kilometers Travelled in the city = 24.9 Million

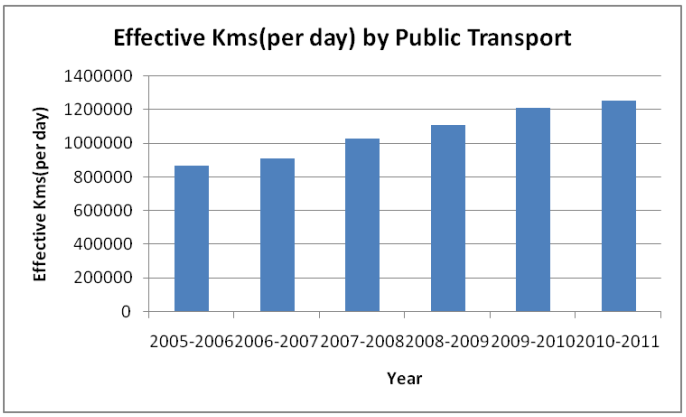
5.3.11 Passenger Kilometers Traveled

Passenger Kilometers traveled (PKT) are calculated by multiplying vehicle-kilometers of travel by the average number of occupants for each vehicle type. Average vehicle occupancy rate is as follows based on the primary and secondary data collection.

- Two wheeler – 1.5
- Car/van/taxi/maxi cab - 2
- Auto – 2.5

The passenger kilometers travelled for the public transport has been taken from the BMTC Operational performance data from the year 2005 to 2011.

Figure 5.7: Effective Kms(per day) by Public Transport



For, the 2011 year it was given as 1225000 Km/day. The passenger kilometers traveled is about 63.3 Million.

Passenger Kilometers Travelled in the city = 63.3 Million

5.3.12 Total Delay (vehicle-hours and person-hours)

Delay is the number of hours spent in traffic beyond what would normally occur if travel could be done at the ideal speed. For Bangalore, vehicle hours of delay measure the amount of time it takes to travel a distance in the City during the peak hour compared to the time it takes to travel the same distance at 40 km per hour. This measurement provides a general indication of traffic congestion. Daily person hours of delay is calculated by determining the difference between the estimated travel time under actual (peak hour) conditions and under uncongested (at 40 km per hour) conditions.

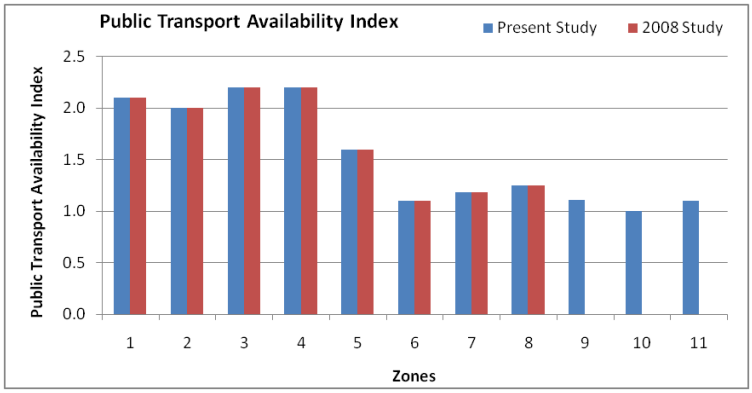
- Total delay (Vehicle – hours) – 21,47,909
- Total delay (Person – hours) – 45,30,872
- Delay per vehicle (in hours) – 0.6 (30 minutes)

5.3.13 Public Transport Accessibility Index

It is the inverse of the average distance (in km) to the nearest bus stop/railway station (suburban/metro). The desirable PT Accessibility Index is at least 2 (500 m access to nearest bus stop / railway station). In Bangalore mostly, zones 1-4 being the centre of the city have good accessibility whereas zones 5-11 lying somewhat outside have less PT accessibility. Figure shows the comparison of previous 2008 study with the present study.

Zone	PT Accessibility Index
1	2.1
2	2.0
3	2.2
4	2.2
5	1.6
6	1.1
7	1.18
8	1.25
9	1.1
10	1.0
11	1.1

Figure 5.8: Public Transport Availability Index



5.3.14 Service Accessibility Index

Service accessibility index is defined as the percentage of work trips accessible within 15 minute time and 30 minute time for a zone. This index indicates that around 40% of the people travel about 30 minutes to their work by public transport. Figure shows the comparison of 2008 study with the present study.

Percentage of people travelling less than 15 minutes or less than 30 minutes

Zones	Present Study	
	<15 min	<30 min
1	14%	24%
2	13%	32%
3	9%	24%
4	11%	17%
5	15%	22%
6	13%	20%
7	18%	33%
8	13%	22%
9	11%	20%
10	14%	26%
11	13%	23%
Average	13%	24%

Figure 5.9: Service Accessibility Index(work trips travel time <15 min)

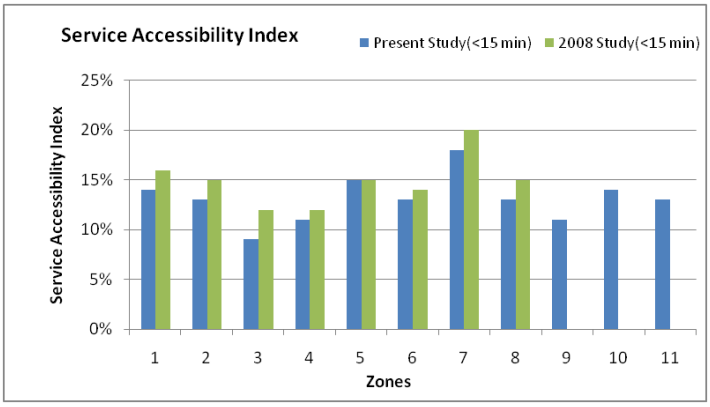
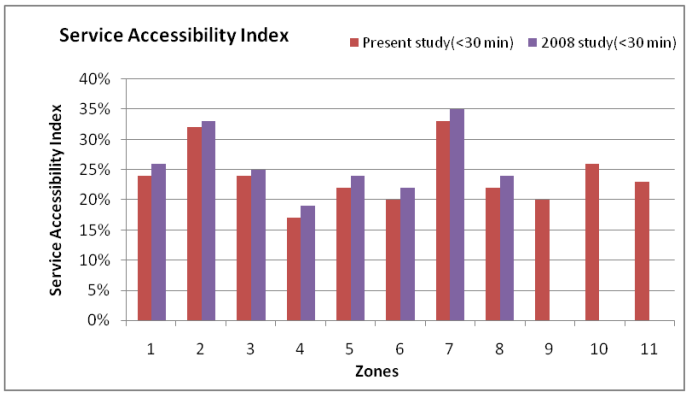


Figure 5.9: Service Accessibility Index(work trips travel time<30 min)



Comparison of present Indicators with 2008 study is presented in Table below:

Sl. No	Indicator	2008 Study	2011 Study	Comments
1.	Road Safety Index	0.047	0.079	Improvement seen in Fatal accidents
2.	Congestion Index	0.33	0.45	Journey speeds have dropped
3.	Travel Time Index	1.57	1.69	Travel time has increased
4.	Slow Moving Index	2%	2%	Remains unchanged
5.	City Bus Supply Index	80	69	Due to the increase area the bus per lakh population has decreased
6.	Para transit Index	185	190	Marginal increase seen
7.	Cycling Index	0	0	Remains unchanged
8.	On street parking interference Index	2.3	2.43	Parking space marginally reduced
9.	Public Transport Accessibility	1.7	1.7	The average distance to bus stops remains same
10.	Service accessibility Index	26%	24%	Work trips travelling <30 min marginally reduced

5.4 Data Reliability

All the performance indicators data for this study have been provided with certain reliability scale suggested by MoUD. The description of the reliability information collected ranked from lowest, intermediate to highest level. The ranking for each performance indicator is given in the following table.

Indicator	Description	Data Source	Overall Data reliability
Indicator 1	Public Transport Facilities		A
LOS 1	Presence of Organized public transport in Urban Area	Secondary Data	
LOS 2	Availability of Public Transport	Secondary Data	
LOS 3	Service Coverage of Public Transport Facility	Secondary Data	
Los 4	Average waiting time for Public Transport Users	Primary Survey	
LOS 5	Level of comfort in Public Transport	Primary Survey	
LOS 6	% of Fleet as per Urban Bus Specifications	Primary Survey	
Indicator 2	Pedestrian Infrastructure Facilities		A
	Signalized Intersection Delay	Primary Survey	
	Street Lighting	Primary Survey	
	% of City Covered	Secondary Data/Primary Survey	
Indicator 3	Non Motorized Transport Facilities		A
	% Network Covered	Secondary Data	
	Encroachments on NMV Roads	Secondary Data	
	NMT Parking facilities at Interchanges	Primary Survey/Secondary data	
Indicator 4	Level of Usage of Intelligent Transport System (ITS) facilities		C
	Availability of Traffic surveillance system	Secondary Data	
	Passenger Information System	Secondary Data	
	Global Positioning System	Secondary Data	

Indicator	Description	Data Source	Overall Data reliability
	Signal Synchronization	Secondary Data	
	Integrated Ticketing System	Secondary Data	
Indicator 5	Travel speed along major corridor		C
	Travel speed of personal vehicle along key corridor	Primary Survey	
	Travel speed of public transport vehicle along key corridor	Primary Survey	
Indicator 6	Availability of Parking space		C
	Availability of paid parking spaces	Secondary Data/Primary Survey	
	Ratio of Maximum and minimum parking fee in the city	Secondary Data	
Indicator 7	Road safety		A
	Fatality rate per lakh population	Secondary Data	
	Fatality rate for pedestrian and NMT	Secondary Data	
Indicator 8	Pollution Level		C
Indicator 9	Integrated land use transport system		A
	Population Density	Secondary Data as per SLB	
	Mixed land use zoning	Secondary Data as per SLB	
	Intensity of development citywide	Secondary Data as per SLB	
	Intensity of development along transit corridors	Secondary Data as per SLB	
	Road network pattern and completeness	Secondary Data as per SLB	
	% area under roads	Secondary Data as per SLB	
	Network with exclusive ROW for Transit	Secondary Data as per SLB	
Indicator 10	Financial sustainability of Public Transport by bus		A
	Extent of Non fare Revenue	Secondary Data as per SLB	

Indicator	Description	Data Source	Overall Data reliability
	Staff per bus Ratio	Secondary Data as per SLB	
	Operating Ratio	Secondary Data as per SLB	

Chapter - 6

Conclusions

Policy analysis and planning require accurate information for guidance. This is particularly important for transportation planning, which takes into account diverse, indirect and long-term impacts. Transportation indicators are an important tool for better transportation planning.

There is currently no standard set of transportation indicators. A variety of indicators are used, some of which are particularly appropriate and useful for planning and policy analysis. It would be highly desirable for transportation professional organizations to develop standardized, "baseline" indicator sets, with consistent definitions and collection methods, suitable for comparing impacts and trends between different organizations, jurisdictions and times. This can include some indicators suitable for all situations, and others for specific needs and conditions.

The Ministry of Urban Development, therefore, has recommended standardized sets of Service Level Benchmarks. This should build on existing efforts to improve the collection of transportation statistics, expanding these efforts to reflect key economic, social and environmental impacts.

As far as the benchmarks for Bangalore are concerned, a considerable amount of interventions are required by the authorities to improve the quality of urban transport. Except the public transport facilities, all other components of transportation have been performing at disappointing levels. The current performance measures (as per the MoUD guidelines) are summarized as follows:

- The public transport in Bangalore is good with wider coverage and easy access
- Existing public transport is financially sustainable
- Pedestrian facilities need improvements in terms of footpaths, intersections and street lighting
- NMT facilities are lacking and need major improvements
- ITS facilities are inadequate in terms of ticketing system, signal synchronization, GPS / GPRS etc.
- Significant delays and queuing of vehicles are common on major corridors
- Parking facilities are inadequate; immediate actions needed towards parking management
- Bangalore city roads are unsafe – considerable improvements needed in road design; fatality index is very high

- Needs improvement in emission standards and checking pollution
- There exists a faint coherence between land use and transport planning efforts

These trends are quite disappointing despite the fact that a number of infrastructure building activities are happening in and around Bangalore city. This shows the lack of visioning in our exercises. We have to focus less on 'supply oriented' improvements and focus more on 'mobility management' remedies to improve the quality of urban transport in Bangalore. There is also a greater need of institutional integration to achieve higher efficiency in our transportation efforts.

The 2008 study was compared on a number of indicators and in the past two years, the change has not been too drastic. It would be interesting to study the change once the Metro is fully implemented.

Annexures