Final Report

Study on Traffic and Transportation Policies And Strategies in Urban Areas in India

Private Limited
ENGINEERS & PLANNERS
Wilbur Smith Associates

Ministry of Urban Development

May 2008

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LIST OF ABBREVATIONS

AFR	Accident Fatality Risk
AMTS	Ahmedabad Municipal Transport Services
AR	Auto Rickshaw
ASTC	Assam State Transport Corporation
Avg	Average
BEST	Bombay Electric Supply and Transport company
BMTC	Bangalore Metropolitan Transport Corporation
Bn.	Billion
BOT	Build Operate Transfer
BRTS	Bus Rapid Transit System
CDP	City Development Plan
CIRT	Central Institute of Road Transport
CMA	Chennai Metropolitan Area
CSTC	Calcutta State Transport Corporation
CTU	Chandigarh Transport Undertaking
DTC	Delhi Transport Corporation
Eg.	Example
Ext - Int	External – Internal
FY	Financial Year
GIS	Geographic Information System
GMA	Guwahati Metropolitan Area
GMCA	Guwahati Municipal Corporation Area
Govt.	Government
GR	Growth Rate
Ha	Hectare
HHI	House Hold Interview Survey
HRTC	Himachal Pradesh Road Transport Corporation
ICTSL	Indore City Transport Services Limited
IDA	Indore Development Authority
IMC	Indore Municipal Corporation
Int - Ext	Internal – External
IPT	Intermediate Public Transit
IT	Information Technology
ITS	Intelligent Transport System
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
km	Kilometer
KMA	Kolkata Metropolitan Area
KMPH	Kilometers Per Hour

LCV	Light Commercial Vehicle
LRTS	Light Rail Transit System
MAV	Multi Axle Vehicles
min.	Minutes
MMR	Mumbai Metropolitan Region
MoUD	Ministry of Urban Development
MRT	Mass Rapid Transit
NH	National Highway
NHAI	National Highway Authority of India
NIUA	National Institute of Urban Affairs
NMT	Non Motorised Transport
No	Number
NUTP	National Urban Transport Policy
O-D	Origin Destination
PCE	Parking Car Equivalent
PCTR	Per Capita Trip Rate
PCU	Passenger Car Unit
PCU/Hr	Passenger Car Unit per Hour
PKM	Per capita travel – Kilometer
PMA	Pune Metropolitan Area
PMT	Pune Municipal Transport
Pop/Sq. km	Population per Square kilometer
PPP	Public Private Partnership
PRTC	Pondicherry Road Transport Corporation
PT	Public Transport
PV	Personal Vehicle
PWD	Public Works Department
RITES	Rail India Technical and Economic Services
ROB	Rail Over Bridge
Rs.	Rupees
RUB	Rail Under Bridge
SMV	Slow Moving Vehicle
SPA	Shimla Planning Area
SPV	Special Purpose Vehicle
Sq. kms	Square kilometers
STC	State Transport Corporation
STU	State Transport Undertaking
TA	Trip Attraction
TAZ	Traffic Analysis Zone

TOD	Transit Oriented Development
TP	Trip Production
TRIDA	Thiruvananthapuram Development Authority
TSM	Traffic System Management
TW	Two Wheeler
UA	Urban Agglomeration
ULB	Urban Local Body
UMTA	Unified Metropolitan Transport Authority
V/C ratio	Volume – Capacity ratio
WSA	Wilbur Smith Associates

TABLE OF CONTENTS

LIST OF TABLES

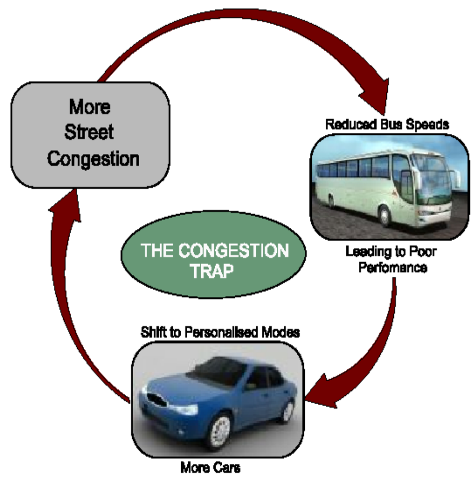
LIST OF FIGURES

LIST OF ANNEXURES

Executive Summary

The Urban Transport Environment in India

Although circumstances differ across cities in India, certain basic trends which determine transport demand (such as substantial increase in urban population, household incomes, and industrial and commercial activities) are the same. These changes have exacerbated the demand for transport – a demand that most Indian cities have been unable to meet. The main reason for this is the prevailing imbalance in modal split besides inadequate transport infrastructure and its sub-optimal use.



Public transport systems have not been able to keep pace with the rapid and substantial increases in demand over the past few decades. Bus services in particular have deteriorated and their relative output has been further reduced as passengers have turned to personalised modes and intermediate public transport (such as three-wheelers and taxis), adding to traffic congestion which has had its impact on bus operations.

The worrying factor is car ownership in India is still significantly lower than what is in a developed city. The Indian economic boom has in its wake provided a great opportunity for an urban dweller to acquire personalized modes which he has taken to with glee given that the public transport system in every city without an exception has fallen short of meeting the increasing demand and expectation level. The urban road chaos is increasing day by day with ever increasing car ownership. Infrastructure shortages are increasingly showing their ugly arm with traffic snarls and grid locks.

Unless problems are remedied, poor mobility can become a major dampener to economic growth and also cause quality of life to deteriorate. If we let things lie as they are, the future of the urban area in India looks bleak. Streets could well become parking lots. The dent this may have on the econimics of India is unthinkable. The National Urban Transport Policy (April 2006) has been set out to tackle urban mobility issues to ensure a safe and sustainable urban mobility in the coming decades.

Need for the Present Study

A similar transport study, " Traffic and Transportation Policies and Strategies in Urban Areas in India" was conducted in 1994 to establish the urban transport scenario and forecast the anticipated issues that would most likely crop up in the future. Further to this, a National Urban Transport Policy was approved in 2006 to help in addressing the unprecedented increase in transport problems that the major cities in the country are facing. The present study is aimed at updating the transportation information and projections made from the previous study in order to review the National Urban Transport Policy in light of the new and comprehensive data that this study is likely to provide.

Objectives of the Study

The objective of the study is to:

- Establish a comprehensive baseline of the traffic and transport scenario in urban areas in India, separately for all million plus cities and for a second level of cities with a population range of 0.5 to one million (including all the State Capitals that are not covered under the one million plus category of cities).

- Validate and refine the projections made in the previous study of similar nature, the report of which was submitted in 1998, under the title "Traffic and Transportation Policies and Strategies in Urban Areas in India".

- Establish an independent and reliable basis for the formulation of future polices and programs for the management of urban transport in India.

- Form a reliable database for future research and academic work in the area of urban transport.

Study Approach

The study approach may be summarised as follows. The first step has been to short list the cities that qualify for this study purpose and to obtain a sample that is truly representative of these cities. The following factors were considered in the selection process.

- Size of city
- Shape of city
- Availability of Public Transport
- Economic Activity level of the city
- Congestion
- Geographical locations

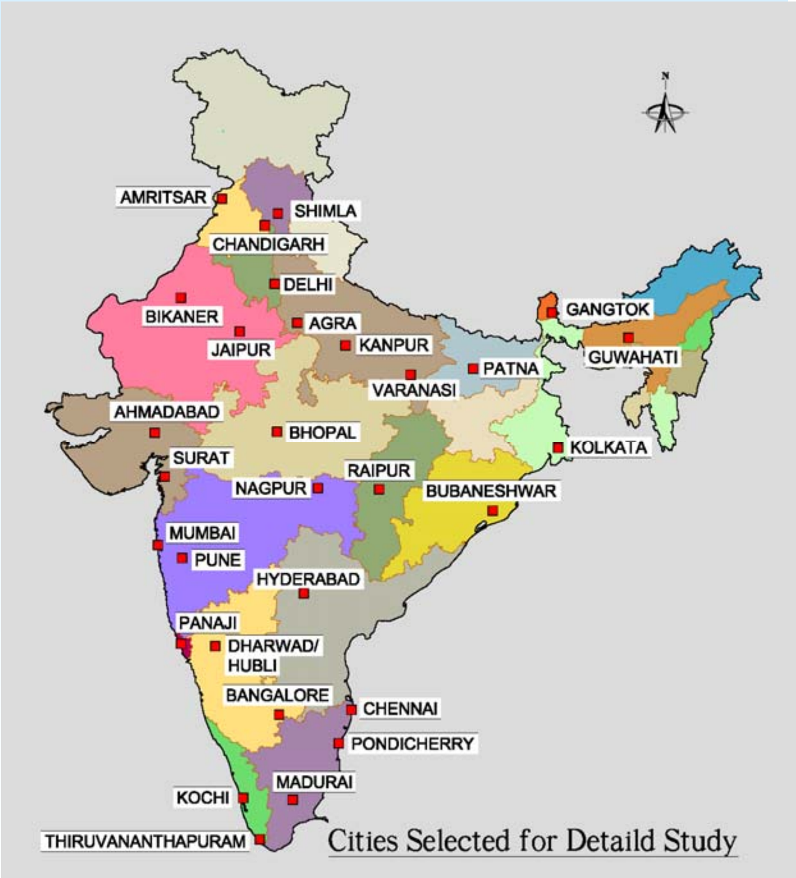
There are 87 cities that qualify for the present study (all State capital cities and with population above 0.5 million). Thirty representative cities have been selected for detailed study.

The second step has been a data collection through primary and secondary surveys for the 30 sample cities to understand the existing urban transport scenario. A Limited House hold interview survey, Cordon survey, Terminal Survey, Speed studies, Parking studies, etc, was some of the primary data that was collected.

The third step has been the development of strategic transport models for the selected 30 cities in order to establish the future urban transport scenerio. This model has been developed using state - of - the art softwares TRANSCAD/ CUBE.

The above three steps provide the data for evolving policies and strategies. In order to compare transportation parameters across cities, indices have been developed/ evolved as part of this study. The present travel characteristics have been compared with the RITES projections made in the earlier study to refine the predictions for the future. Based on transport goals in the future, the study attempts to estimate transport needs including a broad estimate of costs and phasing. An estimate of what component of these can be privatized is also made.

Selection of Study Cities: Out of the 87 cities that qualified for the study, 30 cities were selected as study cities, based on certain criteria such as size and shape, geological location, mportance, etc.   The selected cities are presented in the Figure given below.



Cities Selected for Detaild Study

Study Findings:

The share of personalized modes especially of two wheelers have gone up leaps and bounds clocking 12% per annum in the past two decades, while public transport has generally dwindled. Some public transport services have been even pushed out of business. Consequently street congestion has dramatically increased and overall speeds on major corridors have dropped.

Operating bus services in congested streets have become increasinghly difficult in congested networks with turn around times increasing by the day. Fleet sizes in nearly all public undertakings have declined rather than grow to meet the demand .

Another important observation is the decline of NMT especially cycling. Congestion, increase in trip lengths due to urban sprawl, increase in purchase power of people and totally inadequate facilities for cycling have all contributed to reducing cycling to less than 11% of the mode share which is down from nearly 30% in 1994. And for pedestrians our city roads have simply forgotten they exist. The percentage of roads with pedestrian footpaths runs to hardly 30% in most cities.

Mode Share/Composition: The present day mode share for the 6 city categories is given in the table given below. When this is compared with the 1994 values one can see a significant change in the public transport share.

Mode Share (%)-2007

City Category	Population	Walk	Cycle	Two Wheeler	Public Transport	Car	IPT
Category-1 a	<5 lakhs with plain terrain	34	3	26	5	27	5
Category-1b	<5 lakhs with hilly terrain	57	1	6	8	28	0
Category-2	5-10 lakhs	32	20	24	9	12	3
Category-3	10-20 lakhs	24	19	24	13	12	8
Category-4	20-40 lakhs	25	18	29	10	12	6
Category-5	40-80 lakhs	25	11	26	21	10	7
Category-6	> 80 lakhs	22	8	9	44	10	7
National		**28**	**11**	**16**	**27**	**13**	**6**

The decline in the share of public transport over the past 14 years is given in the table presented below.

Public Transport share Comparison with 1994 Study

City Category	City Population Range in lakhs	WSA, 2007 (%)	RITES, 1994 (%)
1	< 5.0	0.0 -15.6	14.9-22.7
2	5.0 -10.0	0.0 - 22.5	22.7-29.1
3	10.0 -20.0	0.0 - 50.8	28.1-35.6
4	20.0 – 40.0	0.2 - 22.2	35.6-45.8
5	40.0 - 80.0	11.2 – 32.1	45.8-59.7
6	Above 80.0	35.2 - 54.0	59.7-78.7

Note: Present study included 30 cities, while RITES study had only 21 cities and a number of cities selected in the present study have no public transport facility. In the present study, a high percentage of PT share (50.8%) is observed in category- 3, as Kochi falls in this category, which is supplied with very good public transport).

Trip Rate: The trip rate in almost all city categories have increased as expected. The increase of trip rate from 1994 to 2007 is presented below.

Comparison of PCTR by city category- 2007 & 1994

City Category	Population Range in lakhs	WSA, 2007	RITES, 1994
1	< 5.0	0.76	0.77-0.89
2	5.0 -10.0	0.81 - 1.02	0.57-1.00
3	10.0 -20.0	0.98 - 1.25	0.89-1.10
4	20.0 – 40.0	1.20 - 1.29	1.10-1.20
5	40.0 - 80.0	1.3 - 1.50	1.20-1.35
6	Above 80.0	1.41 - 1.67	1.25-1.40

Trip Length: With the increase in the sprawl of the city, average trip lenghts would naturally increase. The average trip length for travel in each of the city categories is presented below.

Trip length (in KMs) by city category

City Category	Population	Average Trip Length (Km)
Category-1 a	<5 lakhs with plain terrain	2.4
Category-1b	<5 lakhs with hilly terrain	2.5
Category-2	5-10 lakhs	3.5
Category-3	10-20 lakhs	4.7
Category-4	20-40 lakhs	5.7
Category-5	40-80 lakhs	7.2
Category-6	> 80 lakhs	10.4
National		**7.7**

Journey Speeds: Our journey speed surveys were focused only on the main roads of a city. The average speeds in our city roads is presented in Table 5.6.

Forecast Scenario

Transport models developed have been used to forecast traffic. Some of the salients of the do-nothing run is presented below.

Estimated trips in the future: The daily trips in the 87 urban centres are anticipated to double from 2286 lakhs to 4819 lakhs during the next 24 years . Details are presented below.

Category-wise projected daily trips of 87 Cities (including NMT)

City Category	Population	Passenger trips/day (in Lakhs)			
		2007	2011	2021	2031
Category-1 a	<5 lakhs with plain terrain	8.5	10.0	13.4	17.2
Category-1b	<5 lakhs with hilly terrain	7.5	8.8	12.0	15.6
Category-2	5-10 lakhs	263.1	308.3	423.0	558.3
Category-3	10-20 lakhs	427.7	498.2	675.6	871.9
Category-4	20-40 lakhs	183.6	210.4	309.6	433.5
Category-5	40-80 lakhs	403.6	469.8	675.2	868.0
Category-6	> 80 lakhs	992.1	1124.9	1552.4	2054.7
Total		**2286.0**	**2630.4**	**3661.2**	**4819.2**

Per Capita Trip Rate: The city category-wise average per capita trip rate estimated for all modes including NMT is presented below.

Projected Per capita Trip Rate (all modes)

City Category	Population	2007	2011	2021	2031
Category-1 a	<5 lakhs with plain terrain	0.8	0.8	0.9	1.0
Category-1 b	<5 lakhs with hilly terrain	0.8	0.9	1.0	1.1
Category-2	5-10 lakhs	1.0	1.0	1.1	1.2
Category-3	10-20 lakhs	1.1	1.2	1.3	1.4
Category-4	20-40 lakhs	1.3	1.3	1.4	1.6
Category-5	40-80 lakhs	1.4	1.5	1.6	1.8
Category-6	> 80 lakhs	1.5	1.6	1.8	2.0

Mode Share: The future mode share including NMT is presented in the table given below. A significant decrease in public transport and a very high increase in private mode share for all city categories is predicted.

Estimated Mode Share for the selected Cities for future (%)

City Category	Population	2007			2011			2021			2031		
		PT	PV+ IPT	NMT	PT	PV+ IPT	NMT	PT	PV+ IPT	NMT	PT	PV+ IPT	NMT
Category-1 a	<5 lakhs with plain terrain	5	57	38	4	59	36	3	66	31	2	72	26
Category-1b	<5 lakhs with hilly terrain	8	34	58	7	37	56	5	47	48	3	57	40
Category-2	5-10 lakhs	9	39	53	8	42	50	6	51	43	5	58	36
Category-3	10-20 lakhs	13	43	44	12	46	43	10	52	38	9	57	34
Category-4	20-40 lakhs	10	47	43	9	49	42	8	51	41	8	52	40
Category-5	40-80 lakhs	22	42	36	21	45	35	15	51	34	12	54	34
Category-6	> 80 lakhs	46	24	30	42	28	30	31	40	29	26	46	28

Note: PT- Public Transport, PV- Personal vehicles, IPT- Auto rickshaw, NMT- Non motorised transport including walk and cycles

Speeds: Expected avegrage journey speeds on major corridors in future for various city categories are presented below. With higher share of cars on the roads, severe traffic congestion will be the order of the day.

Anticipated Average Journey Speed (KMPH) on major corridors by City Category

Sl. No	City Category	Population	2007	2011	2021	2031
1	Category-1	<5 lakhs	26	22	15	8
2	Category-2	5-10 lakhs	22	18	13	9
3	Category-3	10-20 lakhs	18	13	10	7
4	Category-4	20-40 lakhs	22	18	12	9
5	Category-5	40-80 lakhs	19	15	10	7
6	Category-6	> 80 lakhs	17	12	9	6

Note: Speeds in KMPH

Transport Indices

Several indices have been developed for each selected city to evaluate the performance of the transportation system reflecting different perspectives. They are:

- **Accessibility Index (Public Transport and Service)**: **Public Transport Accessibility Index** is formulated as the inverse of the average distance (in km) to the nearest bus stop/railway station (suburban/metro). **Service accessibility index** is computed as the percentage of work trips accessible within 15 minute time and 30 minute time for each city.

- **Congestion Index**: is defined as

  Mobility Index = 1- (A/M), where

  A- Average journey speed observed on major corridors of the city during peak hours and

  M- Desirable Average journey speed on major road networks of a city during peak hour, which is assumed as 30 KMPH.

- **Walkability Index:** is calculated as [(W1 x Availability of footpath)+ (w2 x Pedestrian Facility rating)]

  Where, w1 and w2: Parametric weights (assumed 50% for both)

  Availability of footpath: Footpath length / Length of major roads in the city and

  Pedestrian Facility Rating: Score estimated based on opinion on available pedestrian facility

- **City bus supply index:** is formulated as**, Index** = City Bus fleet (public + private agency operations) for 1, 00,000 population)

- **Safety Index**: is defined as

Safety Index = 1/ Accident Fatality Index

Accident Fatality Index is defined as the number of road accident deaths per lakh of population.

- **Para Transit Index** is estimated as:

  Para Transit Index = Number of para transit vehicles for 10,000 population

- **Slow Moving Vehicles Index**: The index is computed as:

  Slow Moving Vehicle Index = [(W1 x Availability of cycle tracks)+ (w2 x SMV share in trips)]

  Where,

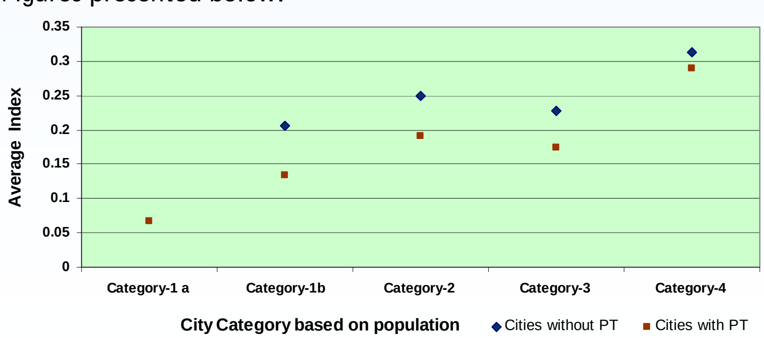
  w1 and w2: Parametric weights (assumed 50% for both)

- **On- street Parking Interference Index**:

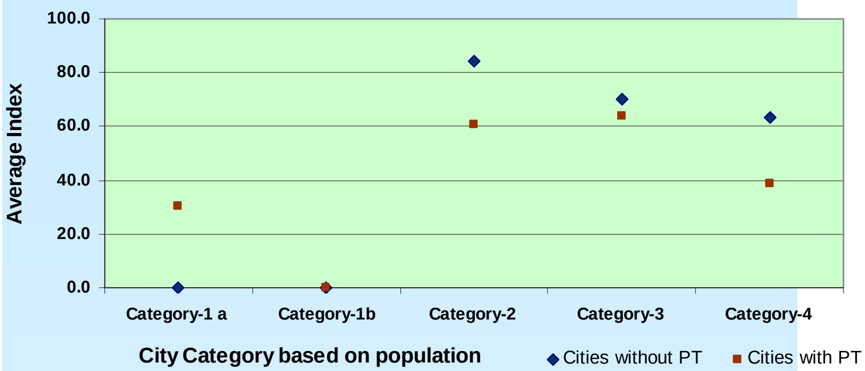
  Parking Interference Index = 1/ (w1 x % of major road length used for on-street parking + w2 x on-street parking demand on major roads)

  Where, w1 & w2 are the weightages, assumed 50% for both parameters

The index values computed for the selected 30 cities are presented in the table given below. Impact of availability of public transport on various indices are presented in the two Figures presented below.



Impact of Availability of Public Transport on Congestion Index



Impact of Availability of Public Transport on Para transit Index

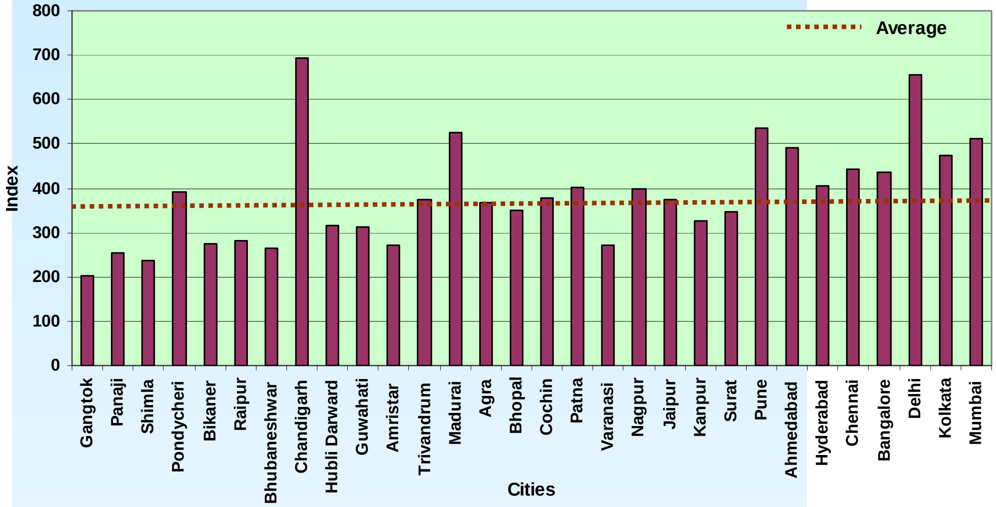
Transport Performance Index : A Transport Performance Index has been derived for each city based on the indices computed, which has been considered as an overall measure of the efficiency of the transportation system of the 30 study cities. The indices and the corresponding weightage adopted in the calculation of transport performance index are as follows.

- Public transport Accessibillity index (weightage -1)
- Service Accessibility Index (% of Work trips accessible in 15 minutes time) -(weightage -1)
- Congestion Index (weightage -2)
- Walkability Index (weightage -2)
- City Bus Transport Supply index (weightage -2)
- Safety Index (weightage -1.5)
- Slow Moving Vehicle Index (weightage -2)
- On- street Parking Interference Index (weightage -1)

Indices computed for the selected 30 cities

Sl. No.	City Name	Public Transport Accessibility Index	Service Accessibility Index (% of Work trips accessible in 15 minutes time)	Congestion Index	Walkability Index	City Bus Transport Supply index	Safety Index	Para Transit Index	Slow Moving Vehicle Index	On- street Parking Interference Index
1	Gangtok	0.00	94.12	0.21	0.30	0.00	0.04	0.00	0.00	0.59
2	Panaji	0.88	73.47	0.07	0.32	7.64	0.02	30.20	0.02	0.47
3	Shimla	0.70	76.84	0.13	0.22	8.66	0.06	0.00	0.00	0.54
4	Pondicherry	2.12	85.68	0.20	0.37	8.62	0.04	39.70	0.07	1.80
5	Bikaner	0.00	77.00	0.20	0.43	0.00	0.04	64.50	0.08	0.75
6	Raipur	0.00	93.27	0.30	0.41	0.00	0.02	104.00	0.10	0.67
7	Bhubaneswar	1.27	31.72	0.33	0.28	2.93	0.05	40.50	0.10	1.14
8	Chandigarh	1.64	83.13	0.00	0.91	17.54	0.08	75.10	0.08	0.66
9	Hubli Dharward	0.97	43.68	0.23	0.39	15.15	0.04	86.85	0.09	0.63
10	Guwahati	1.22	56.00	0.33	0.39	5.55	0.03	52.50	0.09	1.37
11	Amritsar	0.00	68.85	0.20	0.31	0.00	0.06	91.30	0.09	1.24
12	Trivandrum	1.71	54.00	0.23	0.34	20.03	0.06	63.70	0.09	0.74
13	Madurai	2.13	69.50	0.10	0.40	42.77	0.11	53.70	0.08	0.69
14	Agra	0.00	57.30	0.07	0.38	0.00	0.14	35.70	0.10	2.42
15	Bhopal	0.95	45.00	0.20	0.47	12.82	0.08	79.70	0.08	1.09
16	Kochi	1.47	57.30	0.17	0.57	16.07	0.09	70.10	0.03	1.00
17	Patna	0.00	48.00	0.23	0.65	0.00	0.19	88.80	0.14	1.21
18	Varanasi	0.00	46.00	0.41	0.33	0.00	0.16	64.49	0.08	0.98
19	Nagpur	1.06	34.45	0.30	0.66	10.21	0.10	50.50	0.11	1.13
20	Jaipur	1.38	51.00	0.30	0.64	11.11	0.06	46.70	0.05	1.33
21	Kanpur	0.71	42.86	0.33	0.59	5.64	0.05	19.30	0.09	1.14
22	Surat	0.00	53.95	0.31	0.62	2.87	0.15	63.15	0.07	1.31
23	Pune	3.15	54.35	0.20	0.81	16.43	0.22	106.20	0.04	0.98
24	Ahmedabad	2.49	21.54	0.30	0.85	12.99	0.14	73.90	0.06	2.03
25	Hyderabad	1.62	6.08	0.37	0.68	31.88	0.06	76.60	0.03	1.24
26	Chennai	1.38	12.00	0.37	0.77	33.39	0.07	64.18	0.04	1.26
27	Bangalore	1.01	13.00	0.40	0.63	39.22	0.11	89.70	0.02	1.28
28	Delhi	1.09	16.36	0.47	0.87	43.86	0.32	75.60	0.04	2.82
29	Kolkata	1.12	14.00	0.40	0.81	26.20	0.08	28.50	0.03	3.00
30	Mumbai	1.34	17.00	0.47	0.85	16.66	0.25	88.30	0.03	2.80

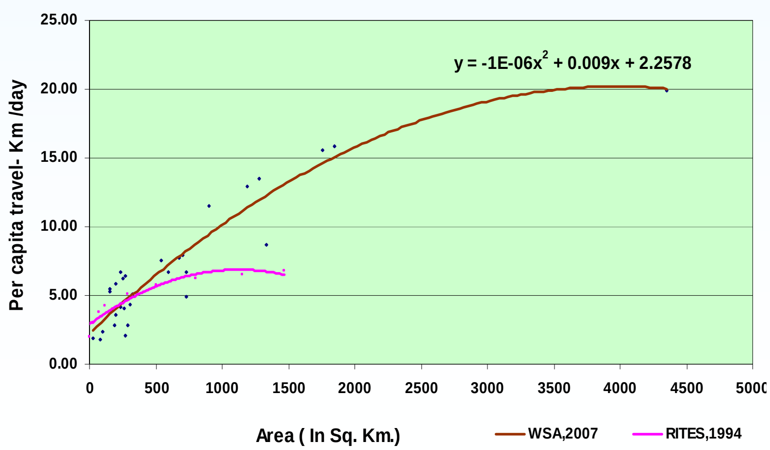
Initially all the transportation indices were converted to a scale of 100. The values corresponding to various indices for a city after multiplying with corresponding weightage are summed up to obtain the index for that city. *(Note: The inverse of congestion index is taken in the calculation of the transport performance index).* The transport performance index computed for each city is presented below.



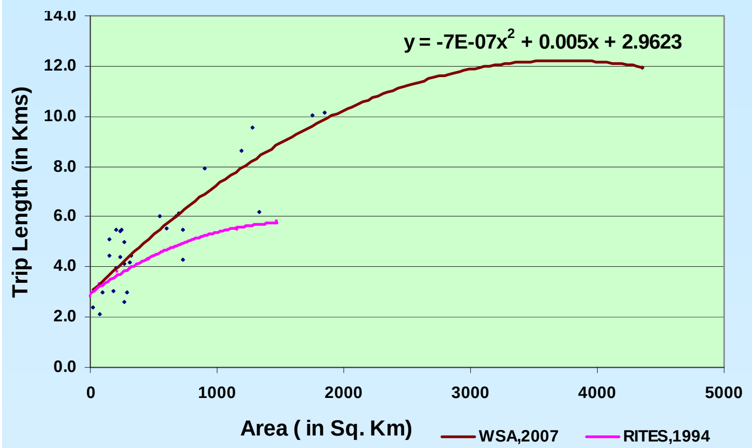
Transport Performance Index

Trends and Relationships

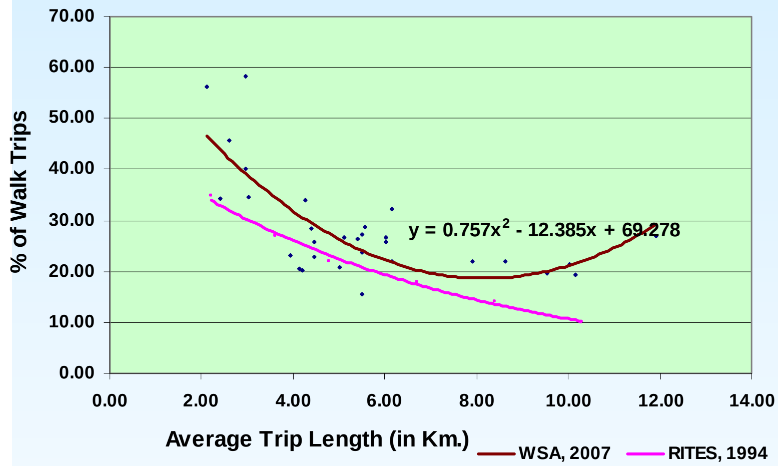
Various relationships between traffic characteristics such as per capita travel demand, trip length etc are compared with the city parameters and a comparison is made with RITES observations for similar relationships. These are presented below.



Relationship Developed for Per capita travel- Km per day (PKM) Vs Area of city



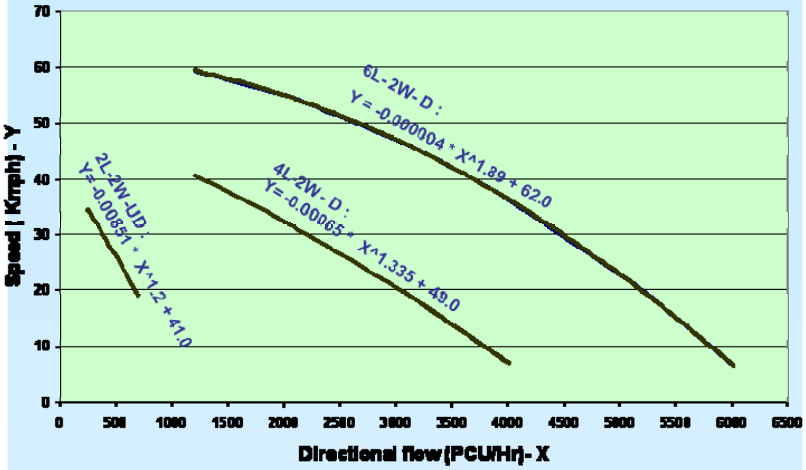
Relationship Developed for Average Trip Length Vs Area of city



Relationship Developed for Share of Walk Trips Vs Trip Length

Generic Relationships

Speed- flow curves on relationships between traffic flow and speed have been establised for different link types. These curves have been developed with data across cities and hence can be used for any urban area in India. The curves are presented below. These relationships are for running speed (not for journey time) and directional flow.



Speed- Flow Curves

Attempt has been made to develop a relation between various trip parameters and variables such as population, shape factor, slum population, available bus fleet, etc.

Eqn. (1): Trip length (Kms) = 0.0476* X1 + 4.7726* X2

Where,

X1- Population in lakhs and

X2- Shape factor of the city, which is calculated as the ratio of Minimum Spread of the city (in Kms) and Maximum Spread (in Kms)

Eqn. (2): PT Share (%) = 0.00949* X1 + 0.18218* X2

Where,

X1- Bus supply/ lakh Population and

X2- Slum population in % (a proxy variable for lower income households)

Eqn. (3): IPT Share (%) = 0.000088 * X1

Where,

X1- IPT vehicle population/ lakh Population

Eqn. (4): Walk Share (%) = -0.0025* X1 + 0.3961*

Where,

X1- Trip length (km) and

X2- Shape factor

Eqn. (5): Cycle Share (%) = 0.200* X1 + 0.150* X2,

Where,

X1- Slum population in % (a proxy variable for lower income households) and
X2- Shape factor

Urban transport Investment needs

An assessment of investment for urban transport sector of the country is made. The 87 cities identified in the study is classified into four categories for the investment requirements.

Transport infrastructure requirement for the next 20 years for each city categoty is derived separately. The objective of the interventions in small and medium cities is to enable smooth and safe traffic flow and prevent a decline in the use of non-motorised modes in the next 20 years. This could be possible by ensuring that travel by non- motorised modes to continue to be safe by proper NMT management, improvement/development of urban roads, various traffic management measures, implementation of bus transport along major corridors for cities without PT currently and augmentation of bus services for cities having PT in the next 20 years is essential. Larger cities would need largely the same interventions as small/medium cities with the diference that these cities have to plan for medium to high capacity mass transport systems and terminals.

Total Investment Requirement: The total urban transport investment requirements for the 87 cities is estimated as Rs. 4, 35, 380 Crores. The summary of the investment is given below.

Total Urban Transport Investment Requirements for the identified 87 cities

Category	Rs. in Crores
Cities in the population range of <5 lakhs	9,800
Cities in the population range of 5- 10 lakhs	70,700
Cities in the population range of 10- 40 lakhs	2,17,200
Cities in the population range of >40 lakhs	1,37,680
Total	**4,35,380**

Investment Phasing: The estimated investment of the urban transport sector is phased in four equal periods of five years. The phasing of the proposed investments is presented in the table given below.

Phasing of Urban Transport Investment

Category	Rs. in Crores	%
2008-2012	1,57,020	36
2013-2017	1,34,880	31
2018-2022	80,050	18
2023-2027	63,430	15
Total	**4,35,380**	**100**

Institutional Framework

The proposed heavy urban transport infrastructure investments needs proper guidance, planning, sustainability, adequate provisions for their maintenance and safeguard. Apart from the required fund, adequate expertise and proper institutional mechanism to implement the urban transport infrastructure is the basic requirement. The following suggestions are made for the proposed institutional framework:

- Priority for UMTA implementation
- Developemnt and management of Central Urban Transport Database
- Strengthening of Institutional setup
- Development of urban transport software library
- Clearing house for new technologies / major projects / projects involving different agencies in urban transportation:

Key Policy Suggestions

The central policy suggestions that have emerged from the present study are;

- **Focus transport Supply in the Mass transport domain:** There are a number of pointers in the data and analysis that we have carrried out that indicate that Mass Transport will be the only way forward. Be it in the form of Buses, BRT's, Monorails, LRT or Metro Systems. A few transport indices such as Congestion Index and Safety Index have performed better in cities with Public Transport Services. It must be noted that many cities in India have no public transport. Before we embark on the implementation of larger mass transport systems, there must be an effort to first ensure that bus systems are in place and the city bus index stands satisfied.

- **Serious attention is to be given to NMT:** With the environment friendly NMT declining, our cities are losing sustainability and it is imperative that this trend is reversed. 40% of todays trips in cities are by NMT and 25% of all fatal accidents involve NMT. Yet we have not focused on the much needed infrastructure to aid these modes.

- **Set up a Dedicated Transport Fund:** This study has established that urban transport needs a huge investment. It would be important to consider a dedicated transport fund to be established to meet this demand.

- **Give a thrust to TSM/ITS:** The accident information collected at the city level clearly indicate very unsafe conditions in our cities. In almost all cities, traffic is mismanaged and road networks are being put to suboptimal use.

    - To optimise the present infrastructure, traffic system management to be given immediate priority as this yields very high benefits with relatively low costs and will improve safety.

    - Wherever possible efforts on Transport Demand Management have to be pursued to ensure that optimal use of infrastructure is made.

    - There is ample evidence in other parts of the world that ITS brings about significant improvement in network efficiency. ITS must be seen as a way forward in improving traffic conditions in our cities.

- **Create a National level Database:** The virtual lack of a database on urban transport statistics has severely constrained the ability to formulate sound urban transport plans and reliably assess the impact of the different initiatives that have been taken. As a part of this study most of the data had to be recreated. It is essential to develop a Central Urban Transport Database. Necessity of creating a national level institute that would build up a database for use in planning, research, training, etc in the field of urban transport is brought out in the National Urban Transport Policy also.

- **The Institutional setup needs to be strengthened:** If the identified investment has to be utilised properly, a Transportation Authority needs to be set up at the city level and a Clearing house for new technologies / major projects needs to be in place at a central level.

- **Develop transportation plans in conjunction with the Land use Development Plans:**

    - A demonstration of the benefits of this has been carried out as part of this study which clearly shows the importance of Transit Oriented Development. We must post haste start the process of conducting land use plans along with transport plans. The terms of reference for both these components should be one.

    - The transportation scenario witnessed in urban areas is changing drastically. The differences between the 1994 study and this study suggests that if proper tracking of these changes have to be made to take suitable remedial action in time, it would be necessary to conduct updates once in 5 years atleast. It would be suitable to carry out Comprehensive Mobility plans at a city level once in 5 years so that the data from these can be used to update the overall transport strategy also once in 5 years.

Way Forward

Tremendous amount of data has been collected which has to be continued to be put to good use. This data can be used for other transportation projects and research.

Transportation models calibrated under this study can be used for preparation of CMPs with little additional inputs which will then cut down duration of CMP preparation for the 30 selected cities.

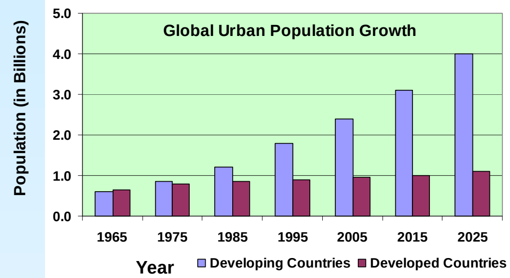
Relationships developed for modeling including speed-flow curves, can be used to obtain strategic results for any city in India.

For the equitable allocation of funds, one could use the transportation indices effectively as they serve as comparative measures between cities. Also cities can be asked to improve a certain index before they can obtain or apply for a particular fund.

1 INTRODUCTION

1.1 Global Urbanization

Between 1950 and 2000 the global urban population has more than tripled to reach 2.86 billion. More people are residing in urban areas than in rural areas today. The urban population is further forecasted to increase by 80 million new city dwellers every year. While urbanization has considerably slowed down in developed countries, developing cities are getting urbanised the most; accounting for 68% of the urban population in 2000. By 2020, 77% of the global urban population (3.26 billion) is expected to be in developing countries.

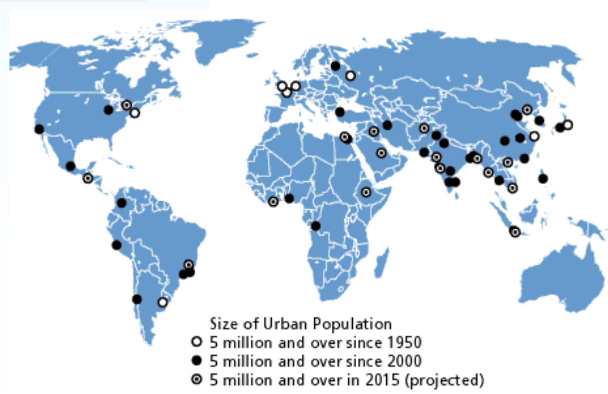


Source: World Development report. 1999/2000

Rapid growth of urban areas can be attributed to two factors: a natural increase in population (excess of births over deaths); and migration to urban areas. Today the movement of people from rural to urban areas (internal migration) is most significant. Although smaller than internal migration, international migration is also increasing.

Most of the urban population will be in developing countries

1.2 Urbanization in India



Source: U. N., World Urbanization Prospects, 1999 Revision.

The 2001 census of India shows that out of the total population of 1027 million, about 742 million (72.2%) live in rural areas and 285 million (27.8%) in urban areas. The percentage decadal growth of population in rural and urban areas during the last decade is 17.9 and 31.2 percent respectively. The census shows that there are 4378 urban centers (refer Table1.1). Nearly 63% of the Class I city population (about 108 million) lived in the 35 million-plus cities (about 39% of total urban population). Three cities have a population of more than 10 million. Four others cities have crossed the four million mark.

Amongst the mega-cities, the top three – Greater Mumbai, Kolkata and Delhi – accommodated over 65% (about 42 million) of the mega-city population (about 15% of the total urban population).

Table 1.1: Urban Agglomerations/Towns by Class/Category

Class	Population Size	No. of UAs/Towns
Class I	1,00,000 and above	393
Class II	50,000 - 99,999	401
Class III	20,000 - 49,999	1,151
Class IV	10,000 - 19,999	1,344
Class V	5,000 - 9,999	888
Class VI	Less than 5,000	191
Unclassified		10
All classes		**4378**

Source: Census of India, 2001

While the number of urban centres doubled between 1901 and 1991, the urban population increased eight-fold in the same period. Future demographic and economic growth is likely to concentrate in and around 60 to 70 large cities in the country having a population of a million people or more. (The urban population in India has increased significantly from 62 million in 1951 to 285 million in 2001 and is estimated to grow to 540 million by the year 2021. In terms of percentage of total population, the urban population has gone up from 17% in 1951 to 29% in 2001 and is expected to increase up to around 37% by the year 2021).

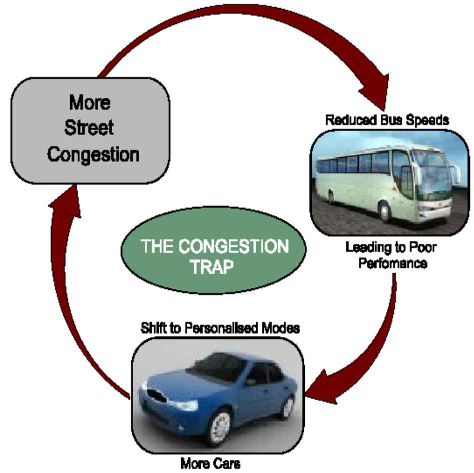
The number of metropolitan cities with a population exceeding one million has increased from 5 in 1951 to 23 in 1991. This is expected to increase further to 51 by the year 2021.

1.3 The Urban Transport Environment

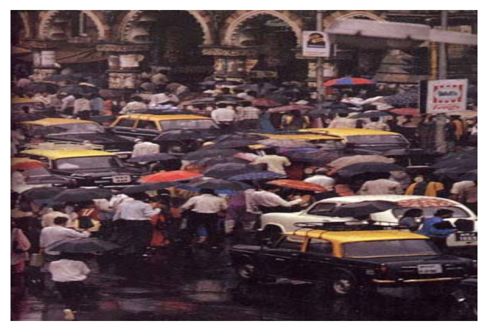
Economic efficiency of cities and well-being of urban inhabitants are directly influenced by mobility.

Although circumstances differ across cities in India, certain basic trends which determine transport demand (such as substantial increase in urban population, household incomes, and industrial and commercial activities) are the same. These changes have exacerbated the demand for transport – a demand that most Indian cities have been unable to meet. The main reason for this is the prevailing imbalance in modal split besides inadequate transport infrastructure and its sub-optimal use.

Public transport systems have not been able to keep pace with the rapid and substantial increases in demand over the past few decades. Bus services in particular have deteriorated and their relative output has been further reduced as passengers have turned to personalised modes and intermediate public transport (such as three-wheelers and taxis), adding to traffic congestion which has had its impact on bus operations.



The worrying factor is car ownership in India is still significantly lower than what is in a developed city. The Indian economic boom has in its wake provided a great opportunity for an urban dweller to acquire personalized modes which he has taken to with glee given that the public transport system in every city without an exception has fallen short of meeting the increasing demand. The urban road chaos is increasing day by day with ever increasing car ownership. Infrastructure shortages are increasingly showing their ugly arm with traffic snarls and grid locks.



Unless problems are remedied, poor mobility can become a major dampener to economic growth and also cause quality of life to deteriorate. If we let things lie as they are,the future of the urban area in India looks bleak. Streets could well become parking lots. The dent this may have on the econimics of India is unthinkable. The National Urban Transport Policy (April 2006) has been set out to tackle Urban Mobility issues and take India into the coming decade's ensuring a safe and sustainable urban mobility.

The urban transport scenario in India today is falling short in nearly every score and needs attention.

1.4 National Urban Transport Policy (NUTP) – April 2006

The objective of evolving a National Urban Transport Policy has been to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and such other needs within our cities. This is sought to be achieved by:

1. Incorporating urban transportation as an important parameter at the urban planning stage rather than being a consequential requirement
2. Encouraging integrated land use and transport planning in all cities so that travel distances are minimized and access to livelihoods, education, and other social needs, especially for the marginal segments of the urban population is improved
3. Bringing about a more equitable allocation of road space with people, rather than vehicles, as its main focus
4. Encourage greater use of public transport and non-motorized modes by offering Central financial assistance for this purpose
5. Enabling the establishment of quality focused multi-modal public transport systems that are well integrated, providing seamless travel across modes
6. Establishing effective regulatory and enforcement mechanisms that allow a level playing field for all operators of transport services and enhanced safety for the transport system users
7. Establishing institutional mechanisms for enhanced coordination in the planning and management of transport systems.
8. Introducing Intelligent Transport Systems for traffic management.
9. Addressing concerns of road safety and trauma response
10. Reducing pollution levels through changes in travelling practices, better enforcement, stricter norms, technological improvements, etc.
11. Building capacity (institutional and manpower) to plan for sustainable urban transport and establishing knowledge management system that would service the needs of all urban transport professionals, such as planners, researchers, teachers, students, etc
12. Promoting the use of cleaner technologies

The objective of evolving a National Urban Transport Policy has been to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and such other needs within our cities.

13. Raising finances, through innovative mechanisms that tap land as a resource, for investments in urban transport infrastructure
14. Associating the private sector in activities where their strengths can be beneficially tapped
15. Taking up pilot projects that demonstrate the potential of possible best practices in sustainable urban transport.

1.5 Need for the Present Study

A similar transport study, " Traffic and Transportation Policies and Strategies in Urban Areas in India" was conducted in 1994 to establish the urban transport scenario and forecast the anticipated issues that would most likely crop up in the future. Further to this, a National Urban Transport Policy was issued in 2006 to help in addressing the unprecedented increase in transport problems that the major cities in the country are facing. The present study is aimed at updating the transportation information and projections made from the previous study in order to review the National Urban Transport Policy in light of the new and comprehensive data that this study is likely to provide.

1.6 Objective and Scope of Work

1.6.1 Objectives of the Study

The objective of the study is to:

- Establish a comprehensive baseline of the traffic and transport scenario in urban areas in India, separately for all million plus cities and for a second level of cities with a population range of 0.5 to one million (including all the State Capitals that are not covered under the one million plus category of cities).

- Validate and refine the projections made in the previous study of similar nature, the report of which was submitted in 1998, under the title "Traffic and Transportation Policies and Strategies in Urban Areas in India".

- Establish an independent and reliable basis for the formulation of future policies and programs for the management of urban transport in India.

- Form a reliable database for future research and academic work in the area of urban transport.

1.6.2 Scope of the Study

Given the above background, the scope of the study is as follows:-

- To establish a rational classification of the entire range of cities proposed to be covered for the purposes of the study.

- To survey the traffic and travel characteristics of an appropriate sample of cities in each category within this classification.

- To identify travel and traffic problems faced in these cities.

- To identify the patterns of investment in transport infrastructure required in classification of cities.

- To study the inter-relationships between land use and transport and develop simplified land use transport models for studying the implications of a wide variety of policy options.

- To evolve alternative urban transport development policies and strategies covering road development, traffic management and public transport etc. with a 20 – 25 year time horizon.

- To assess the environmental implications of transport development under different scenarios of urban transport policies.

- To assess the financial implications of transport development in the cities in the light of different scenarios of urban transport policies and to suggest financing options including potential of property development at sites of various transport infrastructural facilities such as bus terminals, depots, railway stations, etc.

- To project the likely urban transport scenario in different classifications of cities in the next 20 - 25 years and suggest measures that would help in mitigating the adverse impacts, if any, in the short, medium, and long term.
- To identify the areas in which public – private – partnerships can be effective and areas that require purely government interventions.
- To compare the projections made in the report on Traffic and Transportation Policies and Strategies submitted in 1998 with the actual position as of now and suggest changes, if any, in the calibration / structure of the models used in making the earlier projections.

1.7 Study Approach

The study approach may be summarised as follows. The first step has been to short list the cities that qualify for this study purpose and to obtain a sample that is truly representative of these cities. The following factors were considered in the selection process.

- Size of city
- Shape of city
- Availability of Public Transport
- Economic Activity level of the city
- Congestion
- Geographical locations

There are 87 cities that qualify for the present study. Database for all the 87 cities is given in Annexure 1.1. Thirty representative cities have been selected for detailed study.

The second step has been a data collection through primary and secondary surveys for the 30 sample cities to understand the existing urban transport scenario. A Limited House hold interview survey, Cordon survey, Terminal Survey, Speed studies, Parking studies, etc, was some of the primary data that was collected.

The third step has been the development of strategic transport models for the selected 30 cities in order to establish the future urban transport scenerio. This model has been developed using state of- the art softwares TRANSCAD/ CUBE.

The above three steps provide the data for evolving policies and strategies. In order to compare transportation parameters across cities, indices have been developed/ evolved as part of this study. The present travel characteristics have been compared with the RITES projections made in the earlier study to refine the predictions for the future. Based on transport goals in the future, the study attempts to estimate transport needs including a broad estimate of costs and phasing. An estimate of what component of these can be privatized is also made.

1.8 Selection of Study Cities

Out of the 87 cities that qualified for the study, which includes all State capital cities and with population above 0.5 million (see Annexure 1.1), 30 cities were selected as study cities, based on certain criteria such as size and shape, geological location, mportance, etc. The selected cities are listed in Table 1.2. An over view of the selected cities are presented in Annexure 3.1.

Cities Selected for Detaild Study

1.9 Categorization of cities

To generalise the existing and forecasted urban transport parameters to all the eighty seven cities, the cities have been classified into 7 categories based on population. For the population estimates, the planning area/metropolitan area including the city and urban agglomerations around the city is considered.Based on population, the city categories are presented in Table 1.3. The category of each selected city is presented in Table 1.4.

Table 1.2: List of cities selected for the study

Sl. No	City Name	Sl. No	City Name
1	Gangtok	16	Kochi
2	Panaji	17	Patna
3	Shimla	18	Varanasi
4	Pondicherry	19	Nagpur
5	Bikaner	20	Jaipur
6	Raipur	21	Kanpur
7	Bhubaneswar	22	Surat
8	Chandigarh	23	Pune
9	Hubli Dharward	24	Ahmedabad
10	Guwahati	25	Hyderabad
11	Amritsar	26	Chennai
12	Trivandrum	27	Bangalore
13	Madurai	28	Delhi
14	Agra	29	Kolkata
15	Bhopal	30	Mumbai

Table 1.3: City Categories adopted for the study

Sl. No.	City Category	Population
1	Category-1(a)	<5 lakhs with plain terrain
2	Category-1(b)	<5 lakhs with hilly terrain
3	Category-2	5-10 lakhs
4	Category-3	10-20 lakhs
5	Category-4	20-40 lakhs
6	Category-5	40-80 lakhs
7	Category-6	> 80 lakhs

Table 1.4: Category of the cities selected for the study

Sl. No.	City Name	Population of Study area in Lakhs (2001)*	Category
1	Gangtok	0.92	1 (a)
2	Panaji	0.97	1 (b)
3	Shimla	1.73	1 (a)
4	Pondicherry	5.08	Category 2
5	Bikaner	6.40	
6	Raipur	7.19	
7	Bhubaneswar	8.44	
8	Chandigarh	9.66	
9	Hubli Dharward	9.68	
10	Guwahati	10.60	Category 3
11	Amritsar	10.85	
12	Trivandrum	11.22	
13	Madurai	11.85	
14	Agra	13.69	
15	Bhopal	14.58	
16	Kochi	18.18	
17	Patna	18.36	
18	Varanasi	18.95	
19	Nagpur	21.13	Category 4
20	Jaipur	26.80	
21	Kanpur	27.16	
22	Surat	30.90	
23	Pune	42.00	Category 5
24	Ahmedabad	59.34	
25	Hyderabad	63.83	
26	Chennai	70.14	
27	Bangalore	86.25	Category 6
28	Delhi	138.50	
29	Kolkata	147.38	
30	Mumbai	177.02	

*Note: *- Study area includes municipal area and surrounding planning area*

City Shape Assumption: The spread of the city in the horizontal and vertical direction is measured to decide the shape of the city. Based on the shape of the city, they are classified in three groups. They are (1) Circular, (2) Semi-circular and (3) Linear. Details are presented in Annexure 1.2.

1.10 Report Layout

This report has 5 chapters, including this Introductory Chapter.

The present transport characteristics are presented in **Chapter 2: Present Urban Transport Characteristics,** which is an analysis of secondary & primary data.

The urban transport forecast, transport trends and various generic relationships developed as part of the study are presented in **Chapter 3: Transport Trends and Relationships**.

Some aspects of institutional needs and an estimate of investment needs for the future is brought out in **Chapter 4: Urban Transport Institutional and Investment Needs**.

The salient findings of the study have been listed out in **Chapter 5: Summary Findings**

2. PRESENT URBAN TRANSPORT CHARACTERISTICS

2.1 Introduction

This chapter describes the present urban transport characteristics of varous city categories through a detailed analysis of the secondary and primary data collected for the selected 30 cities. Various transport indicators for cities have been proposed and the chapter also discusses about various transport indices developed in an effort to compare cities on performance. Finally the data is generallised into various city categories for subsequent use.

2.2 Secondary Data Collection

The secondary data required for the study has been collected from various sources, primarily from the following Government/Planning organizations.

- Census of India
- Directorate of Economics and Statistics
- City Municipal Corporations
- Railways
- City Bus Transport Corporations
- Urban Development Authorities
- Public Transport service providers
- Traffic Police Departments
- Transport Commissioners' Office

The data includes information regarding population and employment distribution, land use information, road network details, bus transportation data, accident data, etc. The collected data fall under the following data types:

- Socio- Economic Data
- Motor vehicle registration details
- Traffic accident history
- Public transportation system
- Traffic characteristics
- Road network and land use
- Past traffic, transportation and feasibility reports, etc

The data has also been used in urban transport demand forecasting, formulating transport indices, etc. The data collected through secondary sources is presented below.

2.2.1 Population Growth

The past and present demographic details of selected cities was collected from census of India documents. The present census population, population density and the growth trends in the population for the selected cities are presented in Table 2.1.

2.2.2 Vehicle Population Growth

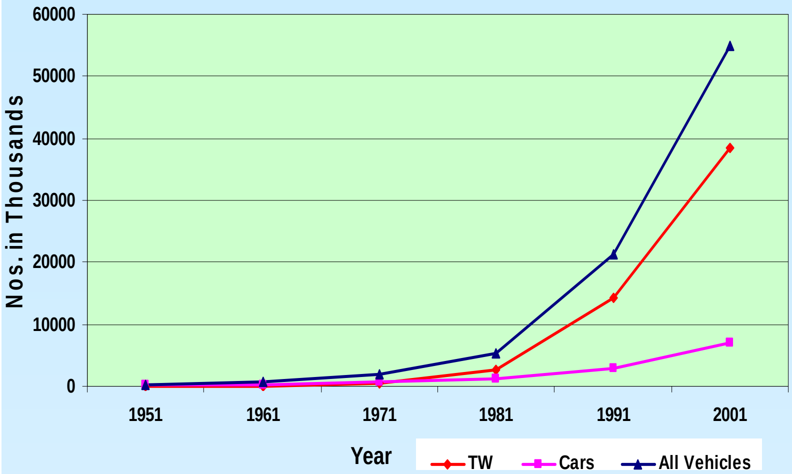
As shown in Figure 2.1, about 55 million vehicles were plying on Indian roads in 2001. The annual rate of growth of motor vehicle population in India has been about 10% during the decade (1991-2001), It is seen that two wheelers are growing faster than cars.

The unprecedented rise in vehicle population has hit our cities hard. Most city authorities today are scampering about to keep traffic flowing.

Table 2.1: Demographic Details of the Study cities*

Sl. No.	Study City	Area (sq. kms) *	Population in Lakhs		Decadal Growth Rate (%)	Population Density (Pop/sq km)
			1991	2001		
1	Gangtok	77	0.78	0.92	18	1195
2	Panaji	23	0.72	0.97	34	4217
3	Shimla	100	1.30	1.73	33	1730
4	Pondicherry	290	3.99	5.08	27	1752
5	Bikaner	270	4.96	6.40	29	2370
6	Raipur	188	4.91	7.19	46	3824
7	Bhuvaneshwar	233	6.43	8.44	31	3622
8	Guwahati	264	7.16	10.60	48	4015
9	Chandigarh	150	6.42	9.66	50	6440
10	Hubli - Dharward	200	7.28	9.68	33	4840
11	Amritsar	150	7.09	10.85	53	7233
12	Trivandrum	310	10.35	11.22	8	3619
13	Madurai	732	9.41	11.85	26	1619
14	Agra	200	10.28	13.69	33	6845
15	Bhopal	320	10.62	14.58	37	4556
16	Kochi	730	16.60	18.18	10	2490
17	Patna	235	12.86	18.36	43	7813
18	Varanasi	250	15.31	18.95	24	7580
19	Nagpur	270	16.21	21.13	30	7826
20	Jaipur	544	18.00	26.80	49	4926
21	Kanpur	597	19.74	27.16	38	4549
22	Surat	680	17.17	30.90	80	4544
23	Pune	700	30.66	42.00	37	6000
24	Ahmedabad	1330	43.46	59.34	37	4462
25	Hyderabad	900	46.70	63.83	37	7092
26	Chennai	1189	58.18	70.14	21	5899
27	Bangalore	1279	63.30	86.25	36	6744
28	Delhi	1758	94.20	138.50	47	7878
29	Kolkata	1851	126.40	147.38	17	7962
30	Mumbai	4355	145.30	177.02	22	4065

*Note: *-includes Municipal area as well as the surrounding planning area*

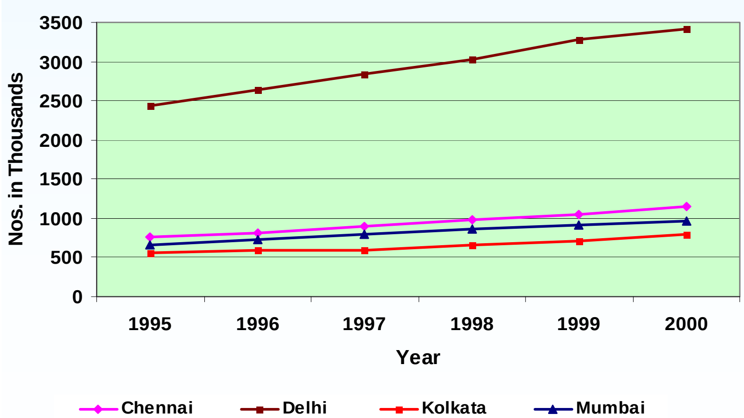


Source: Ministry of Road Transport and Highways, Govt. of India

Figure 2.1 Growth of Vehicles in India (in Thousands)

The basic problem is not the number of vehicles in the country but their concentration in a few selected cities, particularly in metropolitan cities. It is alarming to note that 32 percent of all vehicles are plying in metropolitan cities alone, these cities constitute about 11 percent of country's total urban population. The trend of automobile growth of a few cities are indicated in Table 2.2. During the year 2000, more than 6.3 million vehicles were plying in mega cities, which constitute more than 13 percent of all motor vehicles

Two wheelers constitute nearly 60-70% of registered vehicles in most of the cities.



Source: Ministry of Road Transport and Highways, Govt. of India

Figure 2.2 Growth of Vehicles in four Metros

in the country. Mumbai is carrying the highest vehicles compared with other mega cities. The growth trend of vehicles in the four mega cities is presented in Figure 2.2.

Cities like Bangalore, Hyderabad, Jaipur, Nagpur, Pune show a vehicle growth higher than the mega cities like Delhi, Kolkata etc., presently.

Table 2.2: Growth Trend in Vehicle Population (in Thousands)

City Name	1995	1996	1997	1998	1999	2000	Annual Growth Rate (1995-'00) (%)
Ahmedabad	510	572	631	686	739	799	9
Bangalore	796	900	972	1130	1332	1550	14
Chennai	768	812	890	975	1056	1150	8
Delhi	2432	2630	2848	3033	3277	3423	7
Hyderabad	557	764	769	887	951	991	12
Jaipur	368	405	449	492	542	598	10
Kolkata	561	588	588	664	702	799	7
Mumbai	667	724	797	860	911	970	8
Nagpur	198	213	239	270	298	331	11
Pune	358	412	468	527	568	593	11

Source: Ministry of Road Transport and Highways & RTOs

2.2.3 City Bus Transport

City buses run as the principle mode in many cities while some metro cities have other public transport modes such as suburban rail or metro rail. Many cities, including a significant number of million plus cities do not have a proper bus system. In many cities, the State Transport Undertakings (STUs) take the responsibility of operating the city buses. Some of the well known city bus operation STUs are presented in Table 2.3. In several cities where there is no significant conventional bus system worthy of mention, private bus operators are permitted to provide public transport services. Availability of public transport in selected cities is presented in Table 2.4. Cities such as Gangtok, Bikaner, Raipur, Amritsar, Patna, Agra and Varanasi do not have standard bus services. Public transport need in these cities is met with mini- buses and by IPT.

The decline in public transport share is against the wishes of the NUTP.

It is seen that metro cities are in a better position in bus fleet size, compared with other medium and small size cities.

Table 2.3 Cities with STU Run bus services

Sl. No.	City	STU
1	Mumbai	BEST
2	Delhi	DTC
3	Chennai	CHI-I
4	Kolkata	CSTC
5	Ahmedabad	AMTS
6	Pune	PMT
7	Chandigarh	DCHNTU

2.2.3.1 Bus Fleet

The city bus fleet size growth for selected STUs is presented in Table 2.5. It is observed that for all lised cities, except Bangalore, fleet size has decreased over the past seven years.

2.2.4 Intermediate Public Transport / Para - transit

Para transit mode of travel is an intermediary facility falling in between traditional public transport and the personalized automobile. It is also referred to as Intermediary Public Transport (IPT) emphasizing that it is more of a public transport than not. In India, this type of travel is more synonymous with “auto rickshaw” travel because of its predominance. However, other modes of IPT are also avaiable in smaller proportions. Except in a few cities, most of the cities selected in the study have this mode of travel.

IPT has a potential to over play its role and rather than being useful, can become a nuisance.

The auto rickshaw population in selected cities is presented in Table 2.6. Cities such as Gangtok and Shimla do not have auto rickshaws. For other cities, the number of auto rickshaws per lakh population ranges between 190 and 1060. Pune has the highest number of auto rikshaws/lakh population. Major metro cities generally have higher number of auto rickshaws compared to smaller cities. It is observed that cities without public transport have higher number of IPT vehicles.

Cities without public transport facility have higher number of IPT vehicles.

Table 2.4: Availability of Bus Transport

Sl. No	City	Total No of City Buses- 2007 (Govt. + Private)*
1	Gangtok	Nil
2	Panaji	8
3	Shimla	16
4	Pondicherry	49
5	Bikaner	Nil
6	Raipur	Nil
7	Bhuvaneshwar	32
8	Chandigarh	209
9	Hubli-Dharwad	170
10	Guwahati	62
11	Amritsar	Nil
12	Trivandrum	242
13	Madurai	609
14	Agra	20
15	Bhopal	240
16	Kochi	350
17	Patna	Nil
18	Varanasi	Nil
19	Nagpur	241
20	Jaipur	327
21	Kanpur	176
22	Surat	106**
23	Pune	824
24	Ahmedabad	886
25	Hyderabad	2546
26	Chennai	2816
27	Bangalore	4185
28	Delhi	6906
29	Kolkata	4256
30	Mumbai	3430

*Source: Various STUs and private operators- 2007, *- includes only standard buses, **- Surat updated with latest information*

Table 2.5: Growth of STU Bus Fleet

City	STU	Year								
		2000	2001	2002	2003	2004	2005	2006	2007	Annual Avg GR (%) - (2000- '07)
Mumbai	BEST	3269	3155	3075	3075	3074	3069	3075	3081	-0.8%
Delhi	DTC	4916	4330	4466	2496	2905	3010	3143	2814	-7.7%
Chennai	CHI-I	2353	2314	2211	2270	2251	2187	2176	2087	-1.7%
Kolkata	CSTC	814	821	856	800	769	707	659	635	-3.5%
Ahmedabad	AMTS	752	729	630	410	382	371	545	727	-0.5%
Pune	PMT	657	664	647	662	697	764	784	752	1.9%
Chandigarh	DCHNTU	393	395	404	-	-	-	405	404	0.4%
Bangalore	BMTC	2110	2250	2446	2656	3062	3533	3802	3967	9.4%

Source: Various STUs

Table 2.6: Number of Auto rickshaws in the selected cities

Sl. No	City	Number of IPT vehicles (2005)	No. of IPT Vehicles/ Lakh Population
1	Gangtok	Nil	0
2	Panaji	293	302
3	Shimla	Nil	0
4	Pondicherry	2017	397
5	Bikaner	4125	645
6	Raipur	7478	1040
7	Bhuvaneshwar	3421	405
8	Chandigarh	7256	751
9	Hubli-Dharwad	8407	868
10	Guwahati	5567	525
11	Amritsar	9903	913
12	Trivandrum	7152	637
13	Madurai	6361	537
14	Agra	4884	357
15	Bhopal	11620	797
16	Kochi	12742	701
17	Patna	16302	888
18	Varanasi	12221	645
19	Nagpur	10666	505
20	Jaipur	12513	467
21	Kanpur	5252	193
22	Surat	19512	631
23	Pune	44590	1062
24	Ahmedabad	43865	739
25	Hyderabad	48898	766
26	Chennai	45016	642
27	Bangalore	77375	897
28	Delhi	104747	756
29	Kolkata	41946	285
30	Mumbai	156261	883

Source: Vehicle registration data from Various RTOs, 2005

2.2.5 Accidents

Road accident information collected for various cities for the year 2005 is presented in Table 2.7. Maximum number of road accidents are recorded in Mumbai followed by Delhi. Total accidents / Lakh population is also presented in the same table. It is seen that Panaji has the highest number of road accidents/ Lakh population.

Accident fatalities in our cities is a far cry than what is observed in cities in developed countries.

Table 2.7: Road Accident Statistics (2005) for the selected cities

Sl. No	City	No of Fatalities	Total Road Accidents	% of fatal accidents	Total Accidents / Lakh population *
1	Gangtok	24	180	13	177
2	Panaji	68	892	8	832
3	Shimla	33	171	19	90
4	Pondicherry	136	780	17	139
5	Bikaner	159	367	43	52
6	Raipur	364	2059	18	259
7	Bhubaneswar	200	2000	10	215
8	Chandigarh	131	529	25	50
9	Hubli-Dharwad	250	1000	25	94
10	Guwahati	436	784	56	67
11	Amritsar	192	255	75	21
12	Trivandrum	202	3258	6	263
13	Madurai	116	836	14	64
14	Agra	109	349	31	23
15	Bhopal	205	2690	8	167
16	Kochi	234	3053	8	152
17	Patna	108	241	45	12
18	Varanasi	130	169	77	8
19	Nagpur	246	1628	15	70
20	Jaipur	495	2681	18	91
21	Kanpur	598	884	68	29
22	Surat	230	1129	20	33
23	Pune	216	1477	15	32
24	Ahmedabad	467	2460	19	38
25	Hyderabad	1196	6149	19	87
26	Chennai	1055	4499	23	58
27	Bangalore	833	7575	11	80
28	Kolkata	484	3751	13	25
29	Delhi	2023	9351	22	57
30	Mumbai	787	21678	4	111

*(Source: Road accident history from traffic police records of various cities, *- Estimated population)*

Involvement of bicycles and pedestrians in road accidents for some of the selected cities for the year 2005 is presented in Table 2.8. Pedestrian related accidents are higher compared to bicycle related accidents across all cities. Pedestrian involvement on road accidents range average 20%, while bicycles are involved in 5% of the road accidents. This highlights the absolute lack of pedestrian facilities in our country. We must recognise that the pedestiran is also a road user .

20% of road accidents involve pedestrians. "The pedestrian is also a road user".

Table 2.8: Share of Bicycles and pedestrians in road accidents (2005)

Sl. No	Name of the city	Bicycle (%) accidents	Pedestrian (%) accidents
1	Agra	4	6
2	Bhopal	2	4
3	Kochi	11	14
4	Nagpur	14	25
5	Jaipur	2	7
6	Kanpur	10	7
7	Surat	4	43
8	Pune	3	13
9	Bangalore	5	44
10	Ahmedabad	10	0
11	Chennai	2	5
12	Hyderabad	5	19
13	Kolkata	5	64
14	Delhi	6	24
15	Mumbai	3	35

Note: % of total accidents. Source: Road accident history from traffic police records of various cities

2.3 Primary Surveys

Various traffic surveys conducted as part of the study are described below. The surveys are;

- Classified volume counts
- Road Side Interview surveys
- Speed delay surveys

- Road network inventory surveys
- On-street parking surveys
- Pedestrian facility opinion surveys
- House hold interview surveys

Detailed description of these surveys and results are presented in the sections given below. Results of various primary surveys are presented in Annexure 2.1.

2.3.1 Classified Volume Count

Classified Volume Count surveys have been conducted for 8 hours duration on a normal working day covering four hours during morning peak and four hours during evening peak hours. The volume counts were located on " Screen lines" which are imaginary lines cutting across cities. At each identified station, counts in both directions were carried out and classified traffic volumes in 15 minute intervals were recorded for cars, jeeps, vans, buses, trucks, MAVs, LCVs, tractors, motorized two wheelers, three wheelers and slow moving vehicles.

Share of slow moving traffic is dwindling. NUTP seeks to reverse this condition.

Peak Hour Traffic Composition: The share of fast moving and slow moving traffic (SMVs) observed at various count locations is presented in Figure 2.3. Cities such as Patna, Raipur, Varanasi, Amritsar, Agra, etc have higher share of slow moving vehicles. It is observed that generally there is a reduction in the share of slow moving traffic in the peak hour as city size increases. City category-wise details are presented in Table 2.9. It is found that for category 6 cities, the share is found to be minimal with only 4% constituting SMV. Slow moving vehicles for cities in hilly terrain are nil.

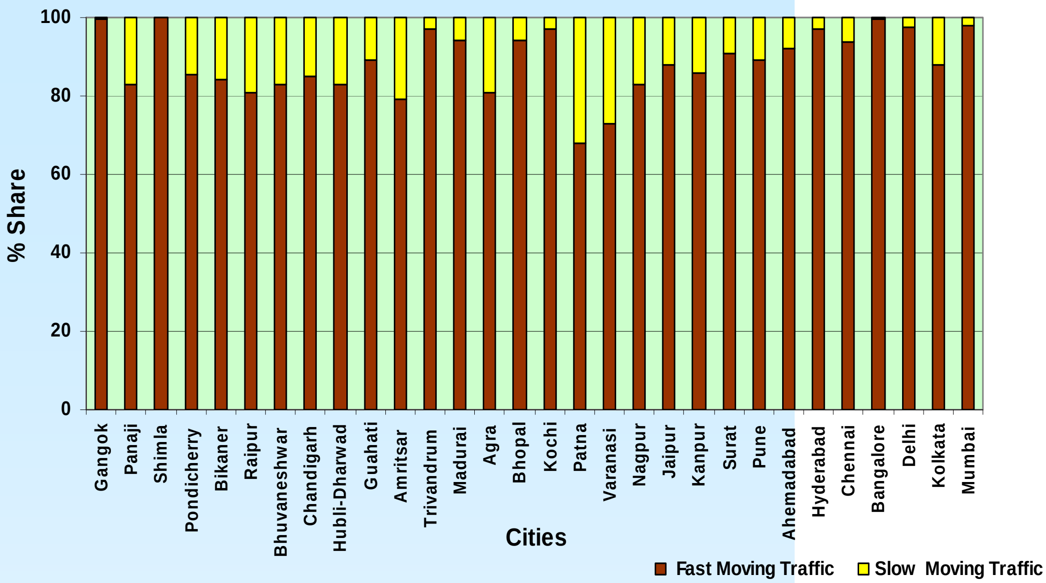


Figure 2.3 Share of Slow Moving Traffic observed in peak hour traffic for study cities

Table 2.9 Peak hour volume composition at locations within city

City Category	Average Share of Fast Traffic (%)	Average Share of Slow Traffic (%)
Category-1a	83	17
Category-1b	100	0
Category-2	84	16
Category-3	86	14
Category-4	87	13
Category-5	93	7
Category-6	96	4

Other observations made from the traffic survey results are as follows:

- Personal vehicles are high across all cities compared with other vehicle types. They range from 40% to 60%.
- Gangtok has the highest share of personal vehicles (more than 80% of the total traffic) may be explained by the absence of public transport (bus), auto rickshaws and Slow Moving Vehicles.

Personalized modes and auto rickshaws are high in cities without public transport.

- The bus traffic observed for the cities without public transport mainly constitute educational/company and tourist buses.
- Share of auto rickshaws is high for cities without public transport.

Composition of traffic during peak hour for each city by city category is presented in Table 2.10. The data indicates that the share of bus and auto rickshaws increases as the size of the city increases. The share of commercial vehicles during day is very low in all cities. This is probably due to restriction of commercial vehicles inside cities during day time.

Table 2.10 Average Peak hour vehicle composition at locations within city (%)

City Category	Std Bus	Mini bus	Cars/ Jeep/ Van	Two Wheelers	Auto Rickshaws	Commercial Vehicles	SMVs	Total
Category-1a	9	4	17	30	14	9	17	**100**
Category-1b	6	15	40	33	0	5	0	**100**
Category-2	7	2	17	32	20	6	16	**100**
Category-3	6	4	19	33	20	5	14	**100**
Category-4	6	2	23	36	16	4	13	**100**
Category-5	9	2	20	37	21	4	7	**100**
Category-6	12	3	31	23	23	3	4	**100**

*Note: *-including tourist and educational buses also*

2.3.2 Roadside Interview Surveys

The survey was carried out at outer cordon points for 8 hours during day time. Interviews were carried out on a sample basis on a typical working day by stopping vehicles with the help of police. Classified volume counts carried out along with the interviews are used to expand the sample data. The data collected include, origin and destination of trip, occupancy, trip purpose and in the case of goods vehicles the commodity that they are carrying.

OD matrices were prepared for car, Two wheelers, Auto rickshaws and goods vehicles separately, after expanding the data colelcted to total traffic obtained from volume counts.

The expanded OD has been used for developing urban transport demand model.

Commercial vehicle OD data at the cordon points provide the external- external and external- internal truck movements. City-wise share of the External - External and Internal-External commercial vehicle movements are shown in Figure 2.4. The share of internal - external movement is high for industrial/port cities such as Surat, Kochi, Bhopal, Pune, Chennai, Kolkata, Mumbai, etc. Category- wise details are given in Table 2.11. On an average, at least 40% of commercial vehicles crossing the cordon points have no business in the city.

On an average, at least 40% of commercial vehicles entering the city have no business in the city.

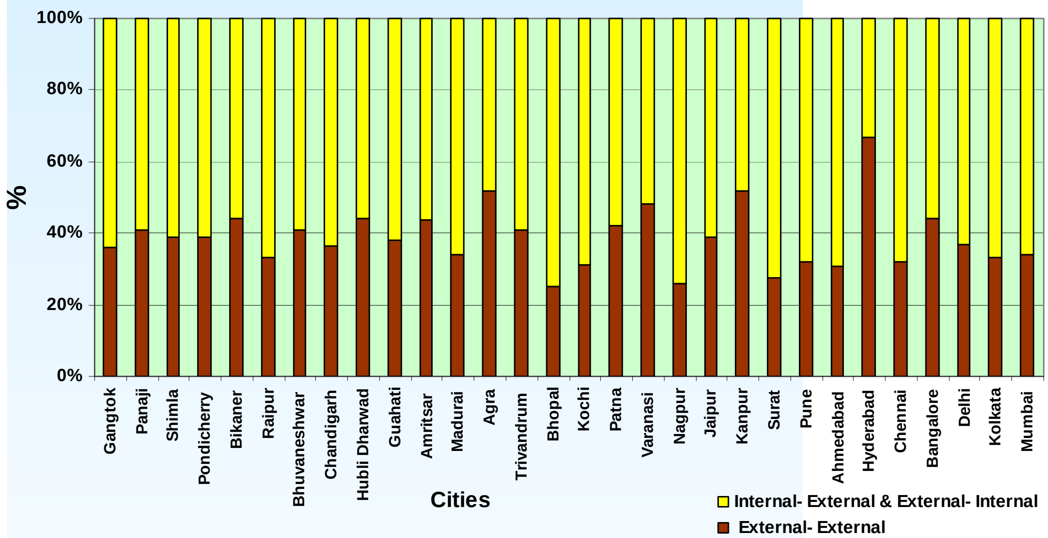


Figure 2.4 Share of External - External and Internal-External commercial traffic through cordon points for the selected cities (8 hrs during Daytime)

Share of internal- external commercial traffic out of the total traffic crossing cordon points are shown in Table 2.12. About 11% of the total vehicles constitute internal – external commercial vehicles. In most cities, commercial vehicles are not allowed within city corridors during day time.

Parking of trucks bound from/to city during day time in the city fringes due to restrictions in the city is a concern.

Table 2.11: Share of External - External and Internal-External commercial traffic through cordon points for various city categories

City Categories	External - External (%) (8 hrs)	Internal-External (%) (8 hrs)	Total (%)
Category-1 a	41	59	100
Category-1b	37	63	100
Category-2	40	60	100
Category-3	39	61	100
Category-4	36	64	100
Category-5	38	62	100
Category-6	37	63	100

Table 2.12: Share of Internal- External commercial vehicles

City Categories	Total Vehicle	Total Commercial Vehicles		Ext- Ext Commercial		Int- Ext & Ext- Int Commercial	
	Nos.	Nos.	% of Total Veh.	Nos.	% of Total Veh.	Nos.	% of Total Veh.
Category-1 a	37905	3650	10	1497	4	2154	6
Category-1b	26347	2443	9	935	3	1508	6
Category-2	58567	9833	17	3866	7	5967	10
Category-3	62512	11657	18	4526	7	7131	11
Category-4	76070	19139	26	6837	9	12302	17
Category-5	122847	26368	23	9756	8	16612	15
Category-6	193229	41907	22	15385	8	26521	14

Note: Survey duration is 8 hrs during day time

2.3.3 Road Network Inventory

Inventory survey was undertaken on the major road network in the city, covering arterials, sub- arterials and major collectors. Following information was collected as part of the survey:

- Effective road width
- Length between intersections
- Median availability

- Intersection facilities
- Pedestrian facility details
- On-street parking lengths observed
- Traffic Control Measures

Enumerators traversed the road network with a datasheet to record details listed above. Road network data is used in developing the base year network facilitating both qualitative and quantitative evaluation of the present sufficiency of road networks vis-à-vis existing standards and usage pattern.

Journey speeds are lower in cities with high slow moving vehicles in the traffic composition.

The lane configuration of various types of roads is presented in Table 2.13. Among the small and medium size cities, Chandigarh has wide roads. As the city size increases the % of roads with less number of lanes decreases and roads with higher number of lanes increases.

Table 2.13 Distribution of major roads by lanes *

City Category	2 Lane (%)	4 Lane (%)	6 lane and above (%)
Category-1a	59	41	0
Category-1b	88	12	0
Category-2	62	36	1
Category-3	64	34	2
Category-4	58	37	6
Category-5	57	37	6
Category-6	27	64	8
Average	**59**	**37**	**3**

*Note *- excluding single lane roads*

2.3.4 Speed and Delay Surveys

The objective of the survey is to estimate the journey speeds and running speeds on major roads in the city. The survey was conducted by moving car observer method. The data has been used in developing speed flow relationships as part of model development and to validate journey speeds predicted by the transport model. The survey was conducted along prominent corridors/ roads in each city.

While there is lesser parking happening on major roads in bigger cities - the parking is only being pushed into minor streets and interior areas.

The average journey speed for major corridors of the study cities is presented in Figure 2.5. Results indicate that the average speed on major corridors of larger cities is lower than the speeds observed in smaller sized cities. Among all cities, corridors in Chandigarh have the highest journey speed. Wider roads, well planned grid network and better pedestrian facilities of Chandigarh play a role in the higher speeds. It is also observed that within a specific city category, journey speed is low in cities having high slow moving vehicle composition in the traffic (eg; Varanasi, Bhubaneswar).

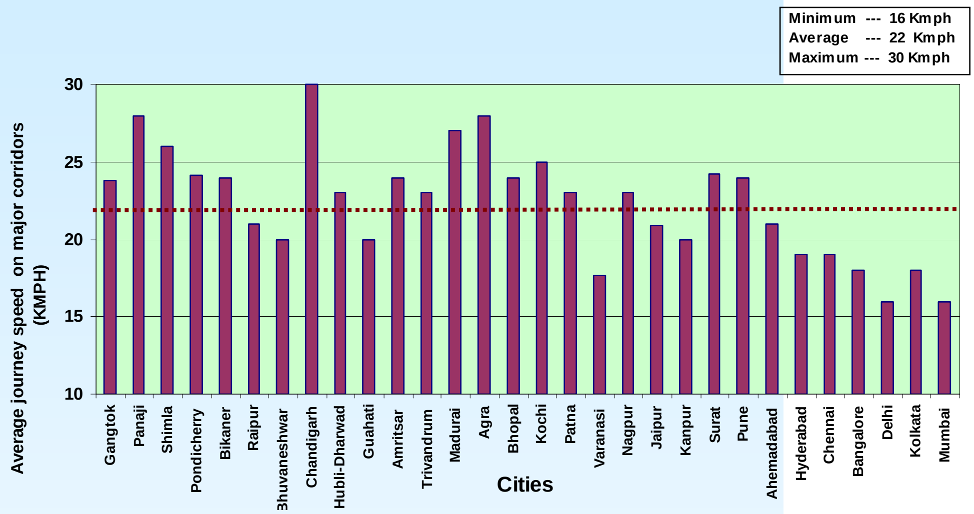


Figure 2.5 Average Journey speed on major corridors during peak hour for study cities

The average speed for various categories of cities is presented in Table 2.14. Smaller cities have higher network speeds. Journey speed for cities in plain terrain is higher than cities in the hilly terrain in the same city category.

Table 2.14 Average Journey Speed for various categories of cities

Category of cities	Average journey speed on major corridors during peak hour (KMPH)
Category-1 a	28
Category-1b	25
Category-2	24
Category-3	24
Category-4	22
Category-5	21
Category-6	17

2.3.5 On-street Parking Inventory Surveys

The road length used for on- street parking on major road network of each city has been estimated and is presented in Figure 2.6. Category wise details are presented in Table 2.15. Based on the road length used for parking, larger cities have lesser on-street parking on major roads, compared to small/medium size cities. This may be due to better enforcement present in larger cities. It is also found that within the smaller cities, on- street parking is high in tourist cities.

There is a need to revise car parking requirements set out in the Developement Control Rules of cities.

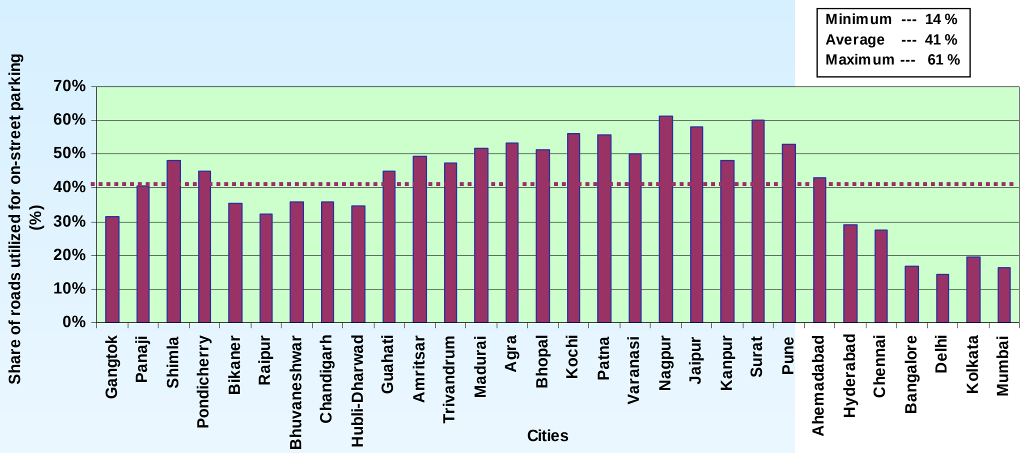


Figure 2.6 Share of Major Roads utilized for on-street parking for study cities

Table 2.15 Share of major roads used for parking

City Categories	% of Major roads used for on-street parking
Category-1 a	41
Category-1b	40
Category-2	36
Category-3	51
Category-4	57
Category-5	42
Category-6	17

2.3.6 Pedestrian Opinion Surveys

To evaluate current conditions and assess requirements for pedestrian facilities, opinion of pedestrians on the available facility is collected. Pedestrian opinion/ranking on the following parameters were collected:

1. Availability of foot path
2. Foot way width
3. Presence of obstruction
4. Maintenance of Footpath
5. Street lights & other amenities
6. Security from crime
7. Walking path conflicts
8. Availability of Pedestrian crossing
9. Safety in crossing

Within each city, several important corridors with high pedestrian intensities were selected for the survey. Opinion of pedestrians on the listed nine parameters were ranked on a 1 - 5 scale, where 1 indicates the worst and 5 the best. To normalize Level of Services inputs, each Level of Services is multiplied by the length of the surveyed road and the pedestrian count. The results are summed up across the rows and average by the number of the stretches surveyed. A final average is derived from the sum of the unweighted averages for each survey area, divided by the total number of survey areas. A final average is calculated and used in the derivation of the final rank. A low rank indicates inadequate and substandard pedestrian facilities. The results are presented in Figure 2.7. Chandigarh scored the highest rank (4.1) as it has well planned pedestrain facilities compared with any other city, while cities such as Raipur, Patna, Kanpur, Surat, etc score low ranks. The average for various categories of cities is presented in Table 2.16. In general, higher the city category better is the rank.

Pedestrian is still the neglected road user. 20% of road accidents involve pedestrians! Walking constitutse a significant mode of travel (31%).

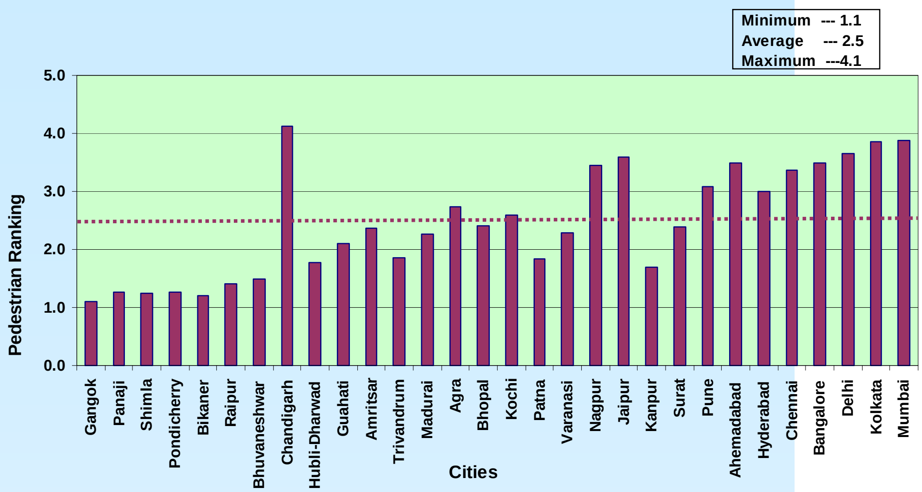


Figure 2.7 Pedestrian Facility ranking for selected cities

Table 2.16 Average Pedestrian Facility Rank for various categories of cities

City Category	Average Rank
Category-1a	1.3
Category-1b	1.2
Category-2	1.9
Category-3	2.3
Category-4	2.8
Category-5	3.1
Category-6	3.7

Note: Rank 1- poor and 5- best

2.3.7 Household Interview Surveys

The survey questionnaire comprises of three sections, a) Socio-economic datasheet, b) Household member characteristic datasheet and c) the travel diary of each individual member of the household. The travel diary section has information for all trips made by each person in the household for the previous day. This information includes the time of the trip, the trip purpose, the address of the trip starting, ending place and the mode of travel for each stage of journey.

Definition of Trip: For the purpose of the study, a trip is assumed as a complete journey through stages from origin to final destination. In case more than one mode is used for a single trip, the predominant mode used among all the stages is considered as the mode of travel.

Expansion of the data: The household travel survey sample data collected is expanded to represent the entire population. A bi-proportional fitting method is used to correct the socio-demographic characteristics of the sample to the known distributions in the 2001 Census. Imputation methods that preserve the distribution of missing data elements is used wherever appropriate to fill in important pieces of missing information in the survey responses. Samples collected vary from 1000 to 4000 households for various cities.

Average household size is the number of persons living in a house.

Per Capita Trip Rate: is defined as a one- way trip made by a person from an origin to destination by a single mode. The average per capita trip rate observed from the HHI data is presented in Figure 2.8 and in Table 2.17. It is found that trip rate increases with city size. Mumbai has the highest trip rate (1.67) among all cities, while, Panaji has the lowest (0.76). Motorised trip rate is more than one trip/person for larger cities.

Trip rates are increasing, household sizes are decreasing.

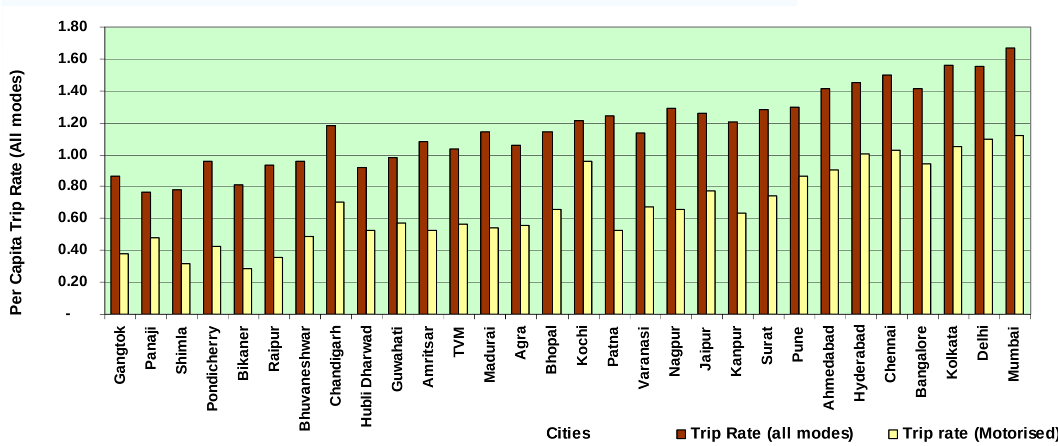


Figure 2.8 Average per capita trip rate observed for study

Table 2.17 Per capita trip rate observed for various cities (All modes)

Sl. No.	City	Trip Rate	Sl. No.	City	Trip Rate
1	Gangtok	0.87	16	Kochi	1.21
2	Panaji	0.76	17	Patna	1.25
3	Shimla	0.78	18	Varanasi	1.13
4	Pondicherry	0.96	19	Nagpur	1.29
5	Bikaner	0.81	20	Jaipur	1.26
6	Raipur	0.94	21	Kanpur	1.20
7	Bhuvaneshwar	0.96	22	Surat	1.28
8	Chandigarh	1.18	23	Pune	1.30
9	Hubli Dharward	0.92	24	Ahmedabad	1.41
10	Guwahati	0.98	25	Hyderabad	1.45
11	Amritsar	1.08	26	Chennai	1.50
12	TVM	1.03	27	Bangalore	1.41
13	Madurai	1.14	28	Kolkata	1.56
14	Agra	1.06	29	Delhi	1.55
15	Bhopal	1.14	30	Mumbai	1.67

The category-wise per capita trip rate is presented in Table 2.18. The Average trip rate for all cities is 1.13.

Table 2.18 Category-wise trip rate Observed (all modes)

Category	Trip Rate
Category-1 a	0.76
Category-1b	0.83
Category-2	0.96
Category-3	1.11
Category-4	1.26
Category-5	1.41
Category-6	1.55

Mode Share: The mode share observed for selected 30 cities is presented in Table 2.19 and in Figure 2.9. Following observations could be made:

- Cycle trips are minimal in hilly cites.
- Walk trips are high in smaller cities. Only two cities (Kolakata and Kochi) have walk share <20%, may be due to higher patronage of public transport (PT) in these two cities. Walk trips range between 19- 25% in all metros.
- Public Transport (standard city bus transport) trips are absent in cities such as Gangtok, Bikaner, Raipur, Agra, Amritsar, Patna, Varanasi and Surat. In general, IPT trips are more in those cities.
- High public transport share is observed in all metro cities. Among other cities, Kochi has the highest share of public transport trips.
- Kolkata has the highest public transport share (54%), followed by Kochi (51%). Both the cities have public transport share above 50%. Delhi and Mumbai have almost same public transport share.
- Kolkata and Mumbai record the lowest two wheeler share of trips.

Walk trips are significant in all cities

Trip Length: is the average distance travelled during a trip. This has been estimated as the ratio of total passenger- kilo meters to the total number of trips. The average trip length of trips performed in a day is presented in Table 2.21 and in Figure 2.10. Trip length is directly related with the city size. As city size increases, trip length increases. Average minimum trip length is for Gangtok (2.1km), while the maximum maximum trip length is for Mumbai (11.9Km). All metros have trip length around 10 Kms. About 20 cities have trip length between 3- 6 kms. The trip length distribution for each city is presented in Annexure 2.2.

A number of cities have no public transport trips and in all these cities IPT play a very significant role.

Table 2.19 Mode Share for selected study cities (%)

Sl. No.	City	Wa lk	Cycle	Two Wheeler	Public Transport	Car	IPT	Total
1	Gangtok	56	0	4	0	40	0	100
2	Panaji	34	3	26	5	27	5	100
3	Shimla	58	1	8	16	17	0	100
4	Pondicherry	40	15	30	7	4	4	100
5	Bikaner	46	19	22	0	8	5	100
6	Raipur	35	28	25	0	9	4	100
7	Bhuvaneshwar	28	21	30	4	12	4	100
8	Chandigarh	23	18	10	18	28	3	100
9	Hubli Dharward	23	19	25	22	10	0	100
10	Guwahati	21	21	20	8	18	12	100
11	Amritsar	27	25	31	0	14	4	100
12	TVM	26	19	14	21	10	10	100
13	Madurai	34	18	15	16	7	9	100
14	Agra	27	21	31	2	17	3	100
15	Bhopal	26	17	31	15	9	3	100
16	Kochi	16	5	14	51	9	6	100
17	Patna	26	31	20	0	12	10	100
18	Varanasi	24	17	34	0	10	15	100
19	Nagpur	21	28	35	12	3	2	100
20	Jaipur	26	13	26	22	8	4	100
21	Kanpur	29	19	21	9	16	7	100
22	Surat	27	16	34	0	16	7	100
23	Pune	22	11	35	12	12	7	100
24	Ahmedabad	22	14	25	16	17	6	100
25	Hyderabad	22	9	19	35	9	7	100
26	Chennai	22	9	20	31	10	8	100
27	Bangalore	26	7	17	35	8	7	100
28	Delhi	21	12	5	43	14	6	100
29	Kolkata	19	11	4	54	8	4	100
30	Mumbai	27	6	7	45	8	7	100

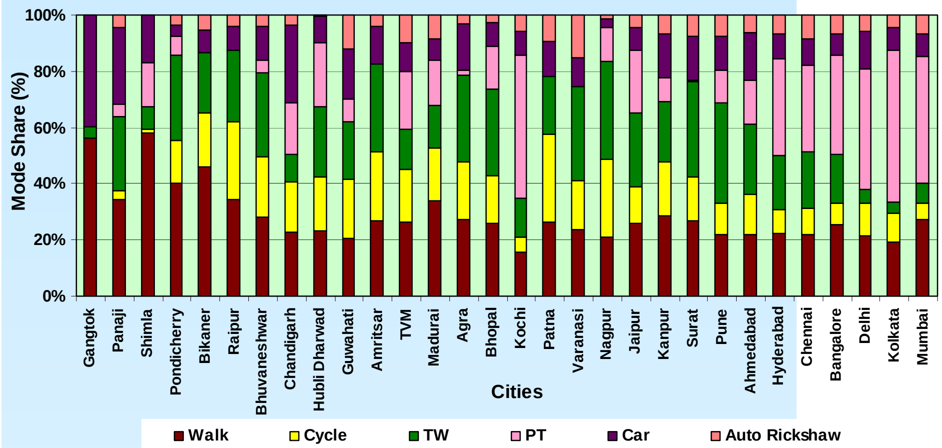


Figure 2.9 Mode share observed for study cities

The category-wise mode share is presented in Table 2.20.

Table 2.20 Category-wise mode share observed (in %)

Category	Walk	Cycle	Two Wheeler	Public Transport	Car	IPT
Category-1 a	34	3	26	5	27	5
Category-1b	57	1	6	8	28	0
Category-2	32	20	24	9	12	3
Category-3	24	19	24	13	12	8
Category-4	25	18	29	10	12	6
Category-5	25	11	26	21	10	7
Category-6	22	8	9	44	10	7

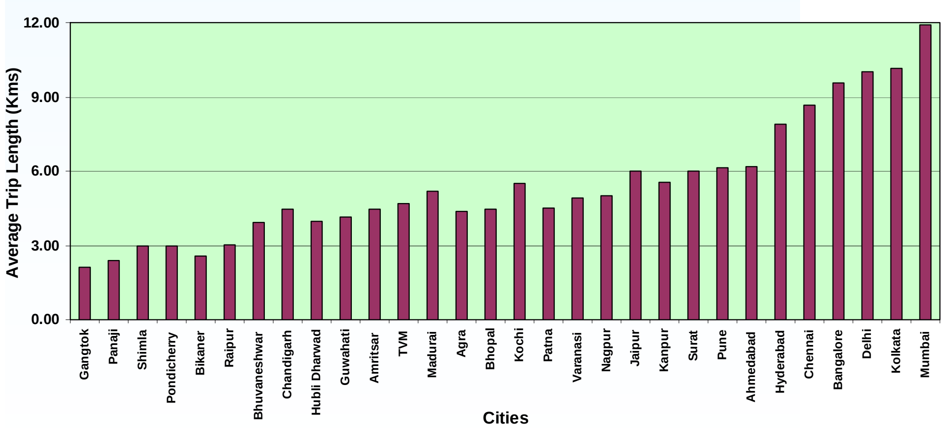


Figure 2.10 Average trip length observed for study Cities

Table 2.21 Average trip length for various study cities

Sl. No.	City	Trip Length (Km)	Sl. No.	City	Trip Length (Km)
1	Gangtok	2.1	16	Kochi	5.5
2	Panaji	2.4	17	Patna	4.5
3	Shimla	3.0	18	Varanasi	4.9
4	Pondicherry	3.0	19	Nagpur	5.0
5	Bikaner	2.6	20	Jaipur	6.0
6	Raipur	3.0	21	Kanpur	5.6
7	Bhubaneswar	3.9	22	Surat	6.0
8	Chandigarh	4.5	23	Pune	6.1
9	Hubli Dharward	3.9	24	Ahmedabad	6.2
10	Guwahati	4.1	25	Hyderabad	7.9
11	Amritsar	4.5	26	Chennai	8.6
12	TVM	4.7	27	Bangalore	9.6
13	Madurai	5.2	28	Kolkata	10.0
14	Agra	4.4	29	Delhi	10.2
15	Bhopal	4.4	30	Mumbai	11.9

The city category-wise average trip length is presented in Table 2.22.

Table 2.22 Average Trip length (in KMs) by city category

Category	Average Trip Length (Km)
Category-1 a	2.4
Category-1b	2.5
Category-2	3.5
Category-3	4.7
Category-4	5.7
Category-5	7.2
Category-6	10.4

2.4 Transportation Indices

Performance of the transportation system if measured at a city level can help in efficient resource allocation on transport investment. One of the simplest methods that is available to measure transportation performance that is convenient and comprehensive is through indicators/ indices.

Several indices have been developed for each selected city to evaluate the performance of the transportation system reflecting different perspectives. They are:

- Accessibility
- Congestion
- Walkability
- City Bus Transport Supply
- Safety
- Para Transit
- Slow moving vehicles
- On- street Parking Interference

Separate indicators have been developed for individual categories of vehicles and user groups. Some indicators such as Bus Transport Index is formulated with only secondary data while some indices use primary traffic data. For the sake of ease of computation and usability, most of the indicators are developed for the city level urban transport scenario. Thresholds can be developed for each index that can be used to compare city level transport performance.

2.4.1 Accessibility Index

Conventional approaches often assume that transportation means motor vehicle traffic, measured in terms of per capita vehicle ownership and vehicle-kilometres, average traffic speed, roadway, level of service, etc. From this perspective, projects that increase traffic speed and volume are considered desirable and projects that reduces traffic speed and volume are considered harmful.

The most comprehensive approach evaluates transportation in terms of accessibility the ability to reach desired goods, services and activities. It recognises the value of more accessible land use patterns and mobility substitutes as ways to improve transportation while reducing total physical travel.

Two types of Accessibility indices have been developed as part of this study . They are (1) Public Transport Accessibility Index and (2) Service Accessibility Index.

Public Transport Accessibility Index is formulated as the inverse of the average distance (in km) to the nearest bus stop/railway station (suburban/metro). Higher the index, better is the public transport accessibility.

Service accessibility index is computed as the percentage of work trips accessible within 15 minute time and 30 minute time for each city. Higher the index, better is the Service accessibility.

These two indices are derived from house hold interview survey data.

Public Transport Accessibility Index derived for the selected 30 cities is presented in Figure 2.11. Cities such as Gangtok, Bikaner, Raipur, Amritsar, Agra, Patna, Varanasi and Surat do not have public transport services, For cities with public transport; the average distance to bus stop varies from 400m to 1500m. In general, large cites are with a better index, indicating more accessibility to public transport. Among metro cities, Bangalore has a comparetively high index, as other metros are served by suburban train/metro services in addition to bus transport and thereby having a better accessibility to bus stop/railway station and also are linear cities. The average index for the study cities is found to be about 1.05.

Figure 2.11: Public Transport Accessibility Index

The city category-wise Public Transport Accessibility Index is presented in Figure 2.12. It is found that medium category cities have better index compared with low and high categories, indicate that medium cities are more accessible to public transport.

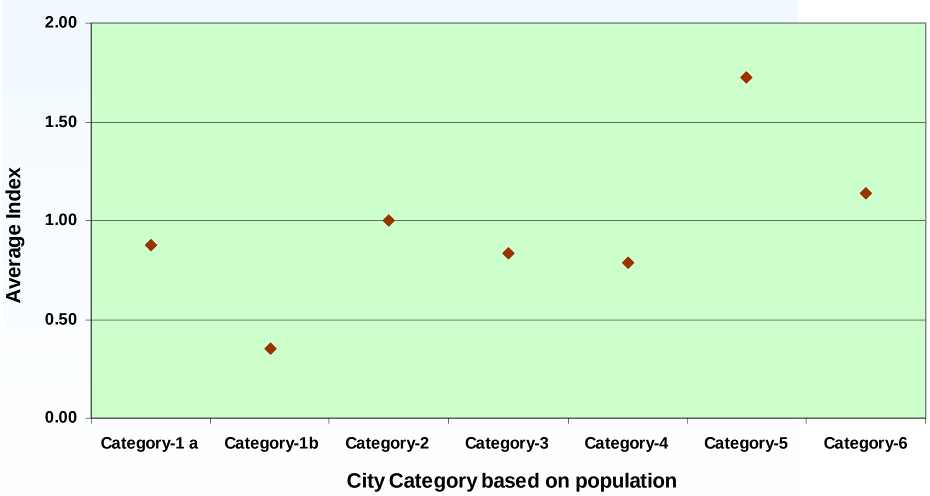


Figure 2.12: City Category- wise Public Transport Accessibility Index

The service accessibility index developed for the selected cities is presented in Figure 2.13. In general, smaller cities have a higher index value for both the 15 minute duration and the 30 minute duration indices. This is obviously as a result of lower trip lengths due to small city size. But then again congestion is also less in smaller cities. (The following index- the congestion index- suggests this). City category-wise index is presented in Figure 2.14.

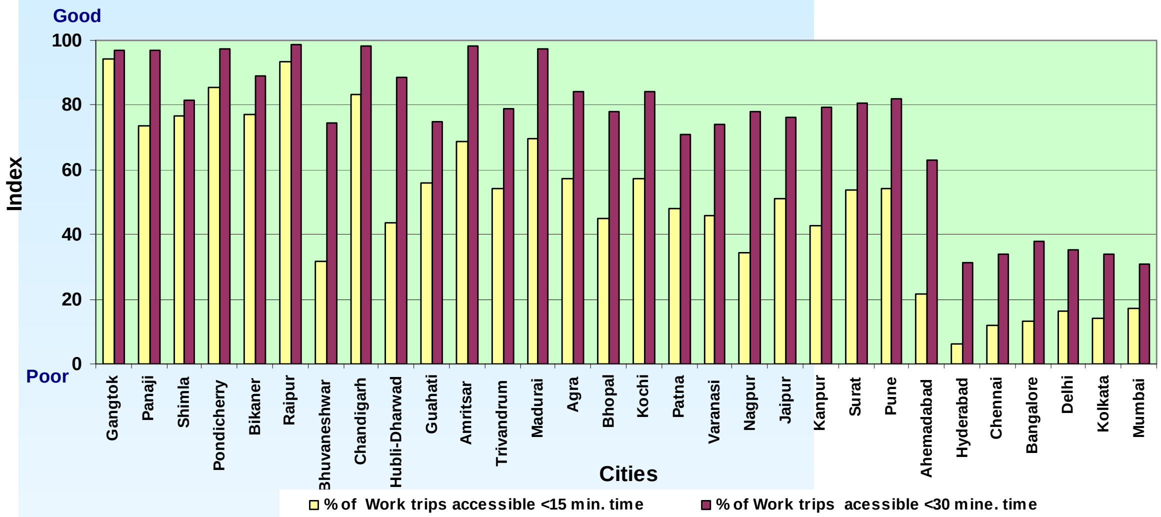


Figure 2.13: Service Accessibility Index

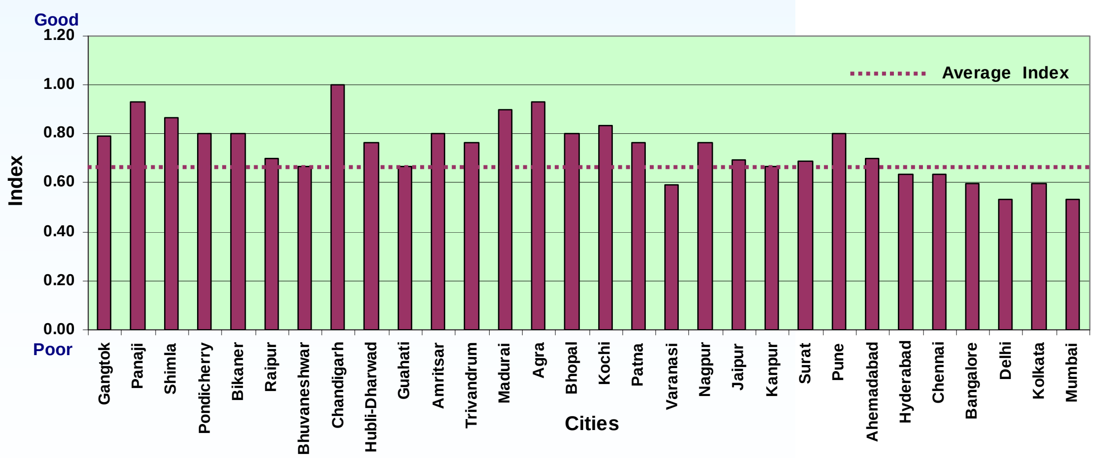


Figure 2.14: Service Accessibility Index by city category

2.4.2 Congestion Index

Congestion may be described as the existing travel condition of the roadway facility, while mobility may be interpreted as how effectively users can perform trips. It is normally considered that safety, environment, economic developments are degraded by increasing levels of roadway congestion. Congestion and mobility are closely related to each other and most often the same measures of effectiveness can be used to monitor both of them.

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 Average journey speed on major road networks of a city during peak hour, which is assumed as 30 KMPH, and

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

The index for the selected 30 cities is presented in Figure 2.15. The index is formulated such that lower the index, better the city performance (lower congestion).

It is found that among 30 cities selected, smaller and medium cities generally have lower index indicating less congestion. Cities such as Bhubaneswar, Guwahati, Varanasi, Kanpur, etc have higher index, probably because of slow moving traffic inerference with the main traffic stream. Among all cities, Chandigarh has the lowest congestion index (value- 0), reflecting the very good road network that it has.

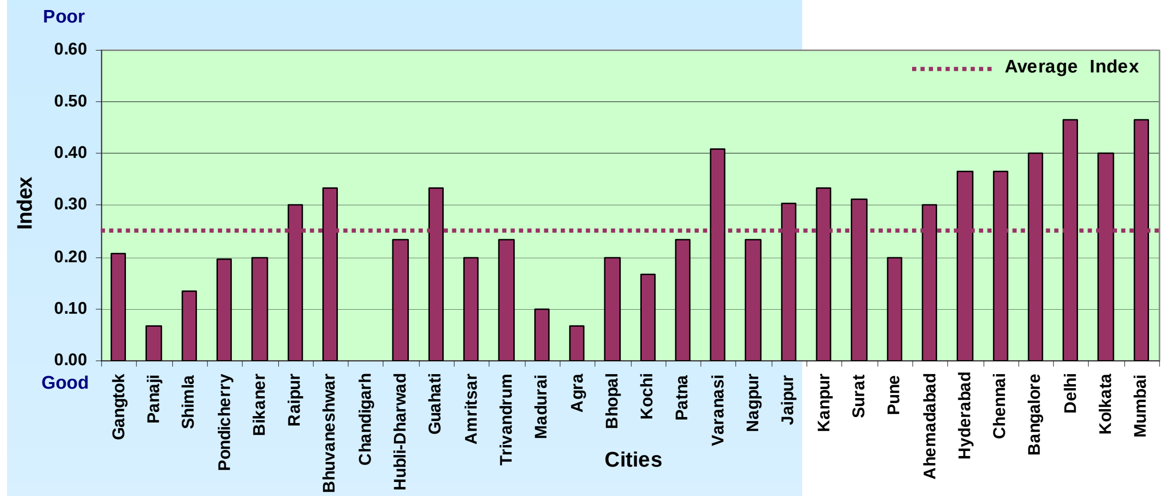


Figure 2.15: Congestion Index developed for the study cities

City category-wise congestion index is presented in Figure 2.16. All large cities have higher index, indicating high congestion on the roads.

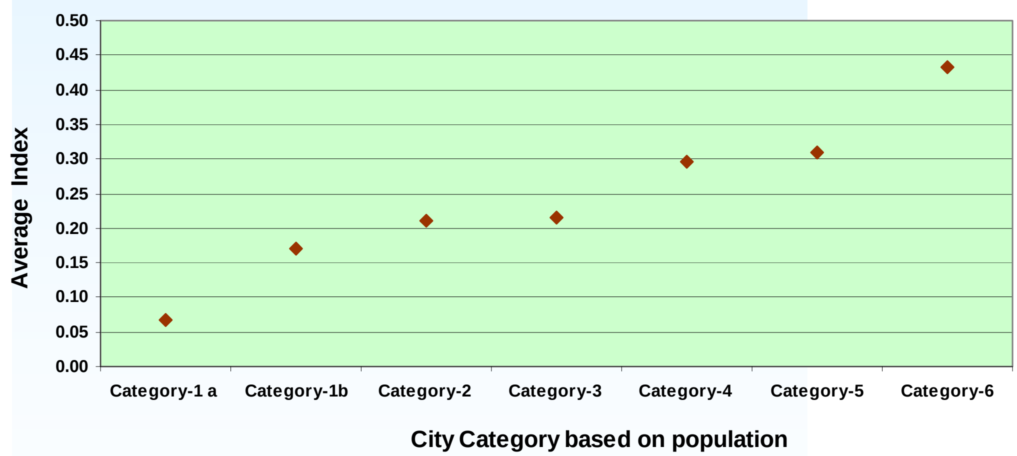


Figure 2.16: Average Congestion Index for various categories of cities

A very important finding (refer Figure 2.17) shows that cities with good public transport are performing better with higher congestion index within the same city category.

It is clear that cities with public transport have better journey speed, when comparing with cities without public transport.

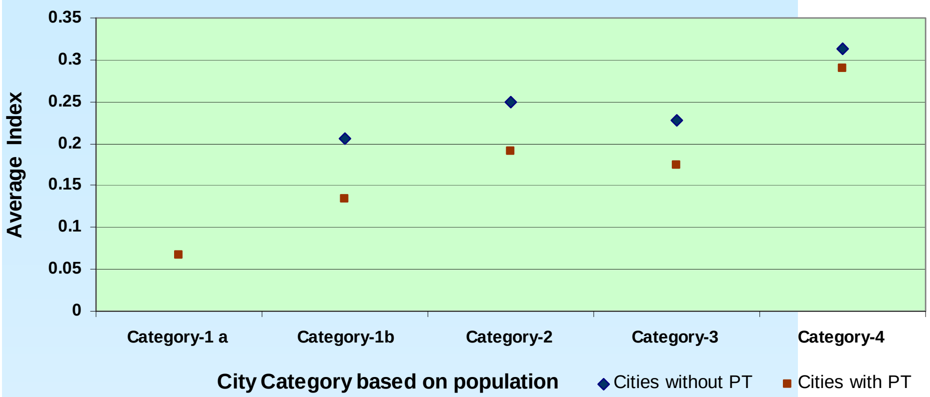


Figure 2.17: Impact of Public Transport on Congestion Index

2.4.3 Walkability Index

Significant number of trips in Indian cities is made by foot (16% - 58%), but pedestrian infrastructure, amenities and services are neglected and not given adequate focus. A walkability index has been developed for evaluating performance of pedestrian infrastructure taking into consideration the following factors,

- Availability of foot path on major corridors,
- Overall facility rating by pedestrians

From the facility rating and footpath availability, the index is formulated as follows:

Walkability Index = [(W1 x Availability)+(w2 x Facility rating)]

Where,

w1 and w2: Parametric weights (assumed 50% for both)

Availability: Footpath length / Length of major roads in the city (refer section 2.3.5) and

Facility Rating: Score estimated based on opinion on available pedestrian facility (refer section 2.3.6)

Walkability index calculated for the 30 cities is shown in Figure 2.18. The index is higher the index, the city is with better pedestrian facilities. It is observed from the figure that Chandigarh has the highest index among all selected cities, reflecting its better pedestrian facilities. All larger cities have scored a higher index. Tourist cities such as Varanasi, Shimla, etc. scored low values, indicating the poor condition/availability of pedestrian facilities.

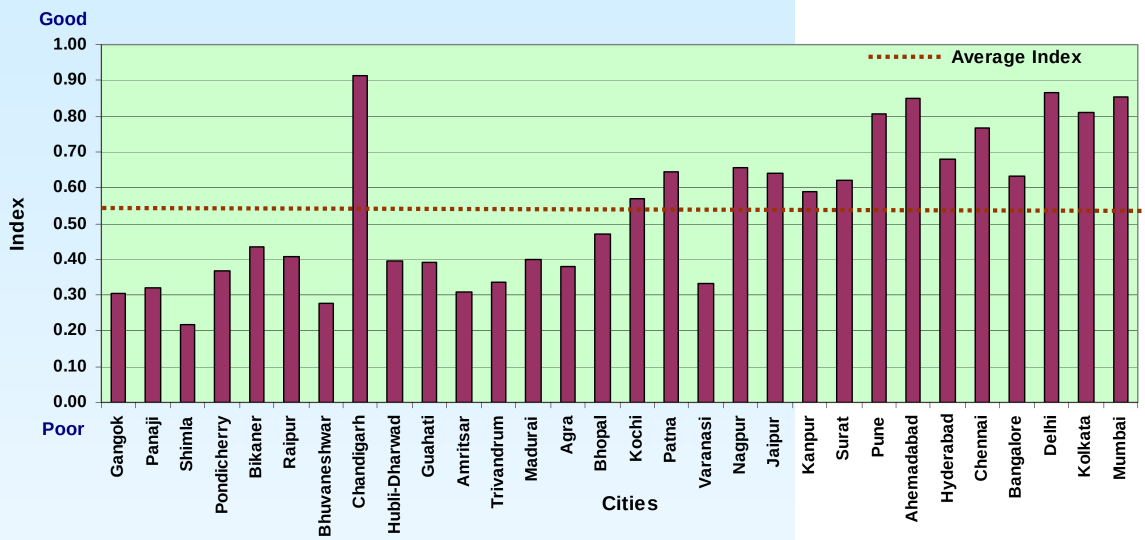


Figure 2.18: Walkability Index for study cities

Average index for all cities made together is found to be 0.52. It is clear from the figure that cities with values lesser than the average are more in small and medium size cities, indicating the importance of developing better pedestrian facilities in these cities.

Average index for each city category is presented in Figure 2.19. City categories 4 - 6 have better pedestrian facilities. Among the selected cities, cities located in hilly terrain have very poor pedestrian index.

However, if we compare this with a city in a developed country, this will be falling embarassingly short (one rough estimates indicate that the index for London is between 1.5 to 1.7).

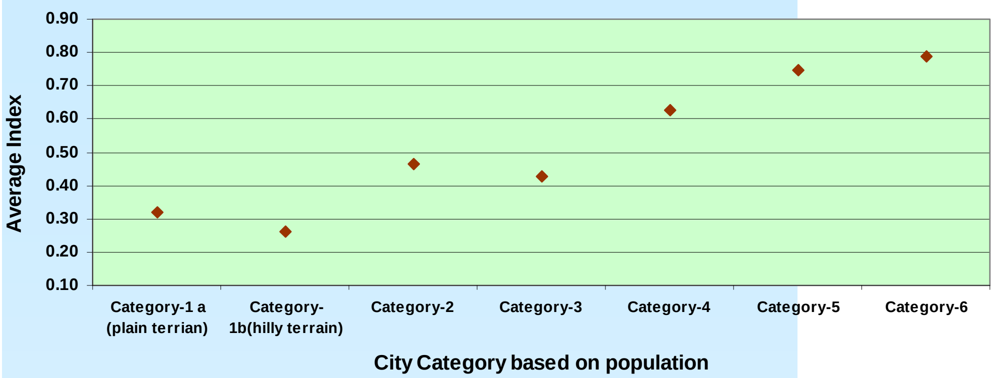


Figure 2.19: Average Walkability Index for various categories of cities

2.4.4 City Bus Supply Index

City Bus Transport is the most common and predominant form of public transport in a city and plays an important role in the urban transportation system of India. Currently several cities including some million plus cities do not even have a minimal public transport system.

A City Bus Supply Index is formulated as follows:

City bus supply index = City Bus fleet (public + private agency operations) for 1, 00,000 population)

Only standard buses are considered for the purpose of computing the index (mini bus services are excluded). The index calculated for each city is shown in Figure 2.20. Higher index value refers better city bus supply. Cities such as Gangtok, Bikaner, Raipur, Amritsar, Varanasi, Agra and Patna have no standard bus transport system and hence the index value is not shown (zero values).

It is imperative that bus transport is encouraged and it is important that, every city in India should immediately be provided with adequate public transport.

Among the selected 30 cities, Delhi has the highest index, followed by Madurai, Bangalore and Chennai. When compared with small and medium sized cities, large cities have better bus supply, except Mumbai and Ahmedabad. Public transport need for Mumbai is served by efficient commuter rail system. Among smaller cities, Madurai has the highest index with a fleet of more than 600 buses.

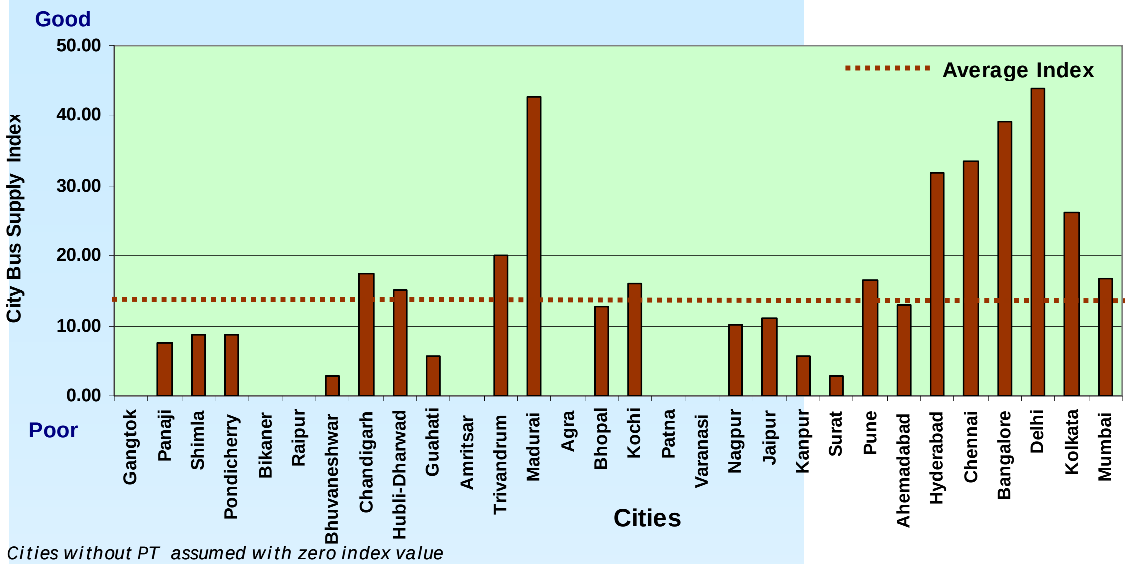


Figure 2.20: City Bus Supply Index developed for the study cities

As per available CIRT (Central Institute of Road Transport) recommendation, the minimum number of buses supplied/ lakh population should be 40. All small and medium sized cities except Madurai, do not have the minimum bus fleet.

2.4.5 Safety Index

Traffic accidents happen for various reasons. Our cities have witnessed an increasing number of road accidents. Road accidents may be caused due to the interplay of a number of other factors such as driver/user behavior, interaction between traffic modes, vehicle design, geometric features, environmental features etc. Consequently a high incidence of road accidents may be conjectured to be a result of suboptimal performance of the overall transportation system and warrants remedial interventions.

Accident data was collected from respective Traffic Police Departments of the 30 cities for the year 2005, through personal enquiry and from published reports. The data obtained has been used to develop a road safety index that represents the safety of transport system of the city. The most widely used accident index, Accident Fatality Index has been adopted for developing the Road Safety index.

Accident Fatality Index: The accident fatality index is defined as the number of road accident deaths per lakh of population.

Road safety index for the selected cities is formulated as follows:

ROAD SAFETY INDEX = 1/AFR

Safety index calculated for each city is shown in Figure 2.21.

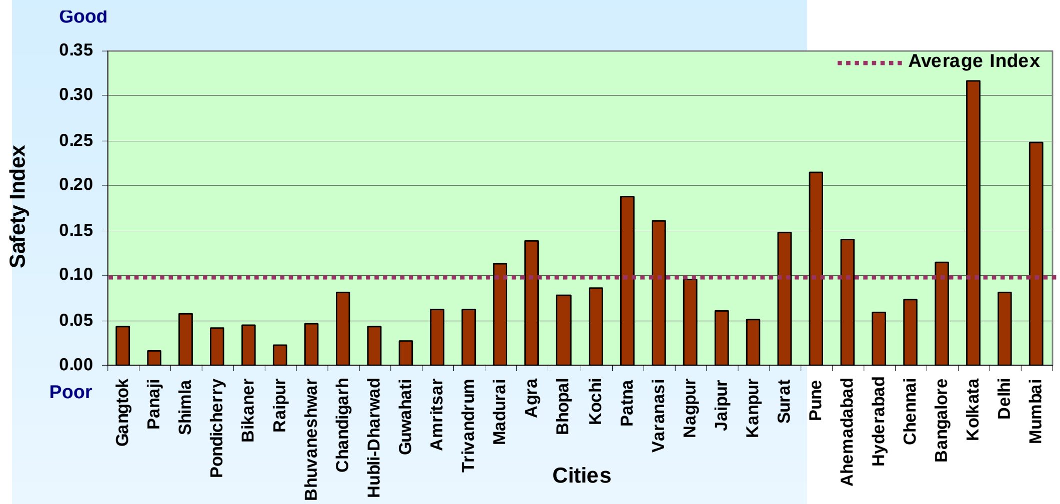


Figure 2.21: Safety Index developed for the study cities

It could be inferred that cities with higher slow moving vehicles in the traffic stream such as Guwahati, Kanpur, Raipur, Amritsar, have a poor safety index and hence unsafe. Due to the absence of separate lanes for slow moving vehicles, are forced to share the right of way with fast moving vehicles, leading unsafe roads.

Our cities are unsafe. An immediate focus on road safety is imperetive.

Average index value estimated for each city category is presented in Figure 2.22. Larger cities are safer than smaller and medium cities, as it is observed that the city size/population increases the index value also increase. Larger cities have lesser speeds, public transport, better traffic management measures, etc than smaller cities.

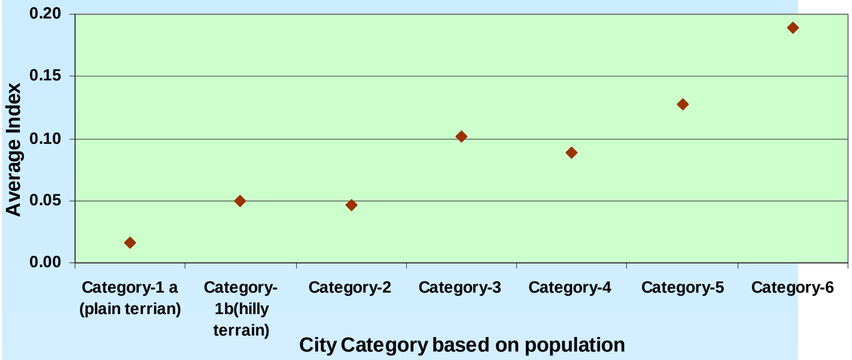


Figure 2.22: Average Safety Index by city categories

A very important observation (see Figure 2.23) has been made for cities with and without public transport system. Cities 'with public transport' have a better safety index than cities 'without public transport'. This indicates that enhancing public transport also improve traffic safety.

Cities with PT are safer!

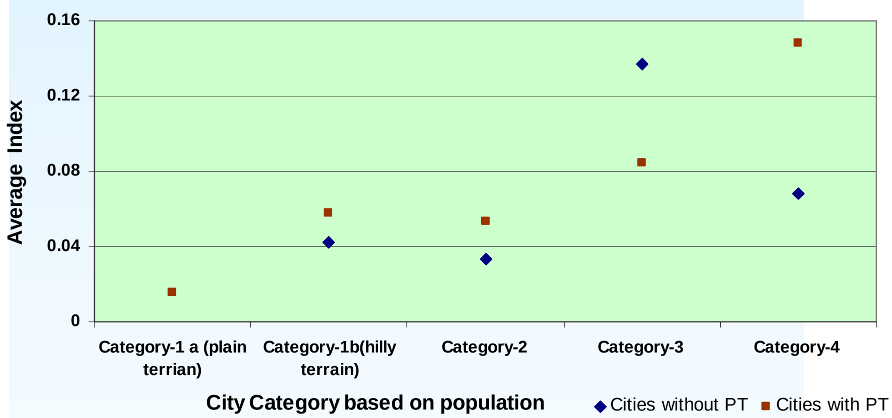


Figure 2.23: Impact of PT on Safety Index

2.4.6 Para Transit Index

Intermediate Public Transit (IPT) also known as Para Transit refers mainly to the auto- rickshaw. IPT plays an important and unique role in the urban transportation system of India. They play an intermediary role between a private vehicle and a public transit. In the case of India it provides substantial source of employment. It is the only alternative to public transport system in several cities. The main disadvantage of IPT is pollution concerns. In order to compare between cities, an index is formulated as follows:

Para Transit Index = Number of para transit vehicles for 10,000 population

The index obtained for each city is shown in Figure 2.24. It is seen from the figure that Pune has the maximum index, followed by Raipur and Amritsar. IPT is not present in Shimla and Gangtok. Kolkata, Kanpur and Agra are the cities with low index value.

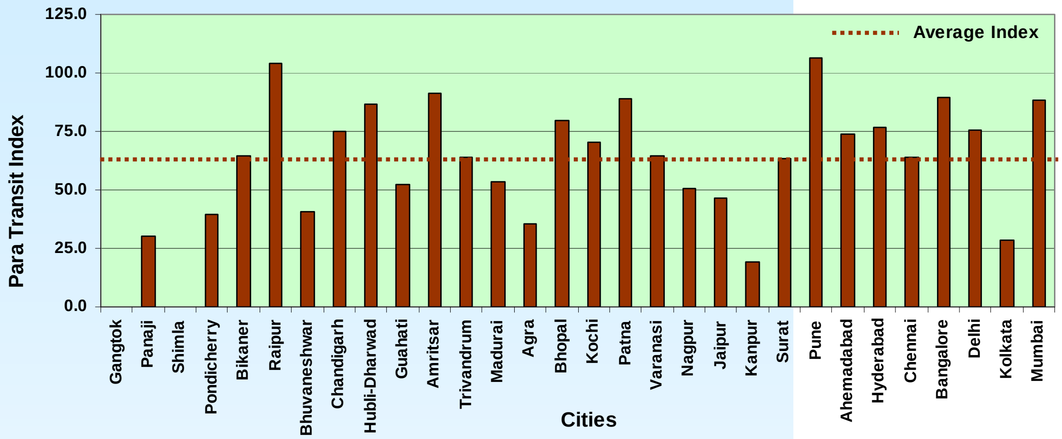


Figure 2.24 Para Transit Index developed for the study cities

A comparison of the index is made for cities 'without PT' and 'with PT' in each category and is presented in Figure 2.25. As expected, cities 'without PT' has higher index than cities 'with PT' in each category. The average IPT index index for indian cities is 61.

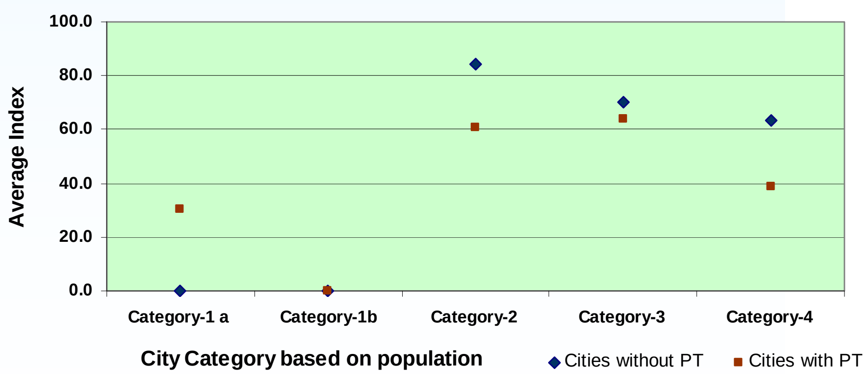


Figure 2.25: Impact of Public Transport on Para transit Index

2.4.7 Slow Moving Vehicle Index

Slow moving vehicle transport (SMV) is an integral part of the transport system of India, which consists of bi-cycles and non-motorised rickshaws. Bicycle, once a major urban transport mode in India, is gradually being marginalized by motor vehicles.

The factors which were considered for the SMV index are

1) Availability of bicycle lanes

2) Percentage of SMV trips

As most of the urban areas in India do not have dedicated bicycle lanes, hence the value is assumed as zero for all cities.

Slow Moving Vehicle Index = [(W1 x Availability of bicycle lanes)+ (w2 x Percentage of SMV trips)]

Where,

w1 and w2: Parametric weights (assumed 50% for both)

The index for the selected 30 cities is shown in Figure 2.26.

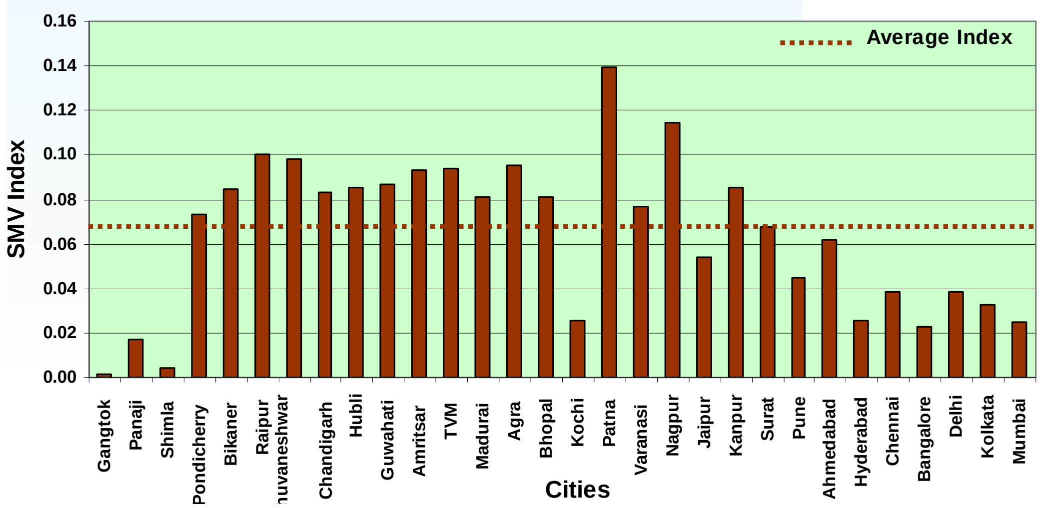


Figure 2.26: SMV Index developed for the study cities

Following observations could be made from the SMV index developed.

- Cities with hilly terrain have negligible cycle trips and hence very low index due to difficulties in riding slow moving vehicle in hilly areas.
- Smaller cities have higher share of cycle trips. As city size increase, the index decreases.
- Among thirty cities, Patna has the highest SMV index.

Our endeavour must be to encourage SMV use in cities.

The variation of index among each city category is presented in Figure 2.27.

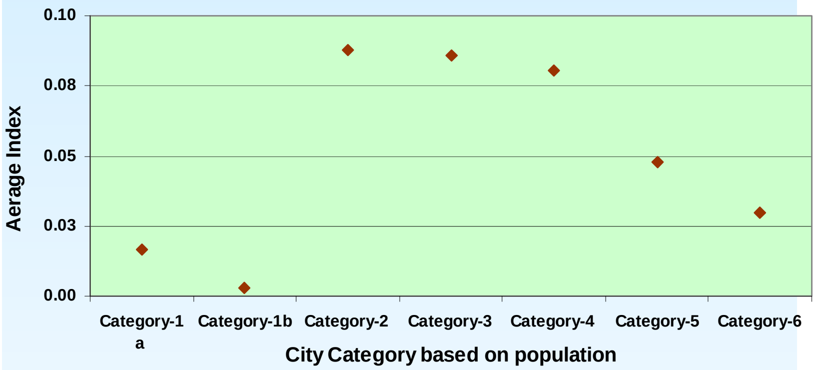


Figure 2.27: Average SMV Index for various categories of cities

2.4.8 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. On the other hand, on-street parking plays an important role in promoting businesses within cities, particularly in central business districts.

An index have been formulated that reflects the imbalances in the parking supply and demand. The index is formulated as follows:

Parking Interference Index = 1/ (w1 x % of major road length used for on-street parking + w2 x on-street parking demand on major roads)

Where,

w1 & w2- the weightages, 50% for both parameters

The first parameter, % of road length used for on- street parking, is calculated as ratio of major road length used for on-street parking in a city and total major road length of the city.

The second parameter, on-street parking demand, is estimated as the ratio of on- street parking demand (PCE) observed and total volume of personalized vehicles owned (PCE) in a city.

The index calculated for the selected 30 cities is shown in Figure 2.28. Panaji has the lowest index value. It is found that the index value is low in small and medium size cities, while larger cities have higher index. This may be due to better on-street parking management, strict enforcement and availability of off-street parking facilities in larger cities. Average index value is obtaines as 1.3.

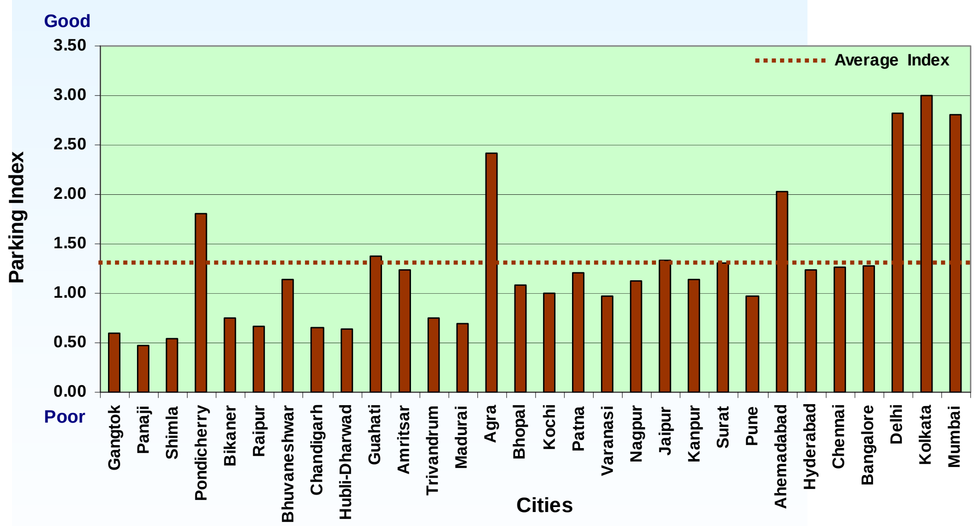


Figure 2.28: Parking Interference Index developed for study cities

Average index estimated for each city category is presented in Figure 2.29. For category 2-5 cities, the index is close to 1.

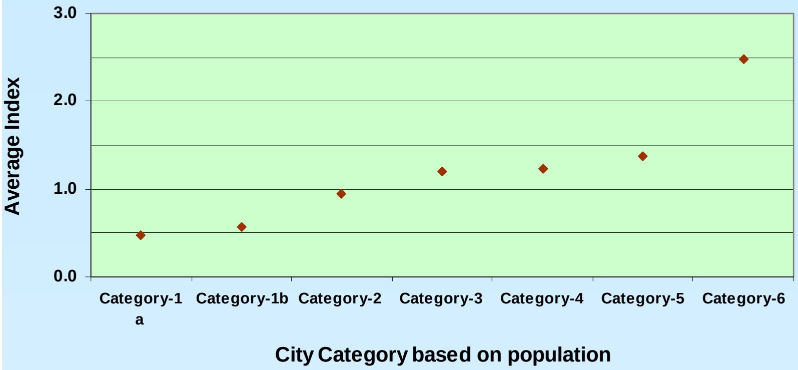


Figure 2.29: Average Parking Index by city category

2.4.9 Transport Performance Index

A Transport Performance Index has been derived for each city based on the indices computed, which has been considered as an overall measure of the efficiency of the transportation system of the 30 study cities. The following he indices were considered:

- Public transport Accessibillity index
- Service Accessibility Index (% of Work trips accessible in 15 minutes time)
- Congestion Index
- Walkability Index
- City Bus Transport Supply index
- Safety Index
- Slow Moving Vehicle Index
- On- street Parking Interference Index

(Note: The inverse of congestion index is is taken in the calculation of the transport performance index).

Initially all the selected transportation indices were converted to a scale of 100. The values corresponding to various indices for a city are summed up to obtain the index for that city. Weightages can also be given for the different transportation indices depending upon their significance. The weightages given for various indices are as given in Table 2.23.

Higher the index, better is the performance of the city. The transport performance index computed for each city is presented in Figure 2.30.

Table 2.23 Weightages given for various Transportation indices

Sl. No.	Transportation Index	Weightages
1	PT Accessibility Index	1
2	Service Accessibility Index	1
3	Congestion Index	2
4	Walkability Index	2
5	City Bus Transport Supply	2
6	Safety Index	1.5
7	Slow Moving Vehicle Index	2
8	On-street Parking Interference Index	1

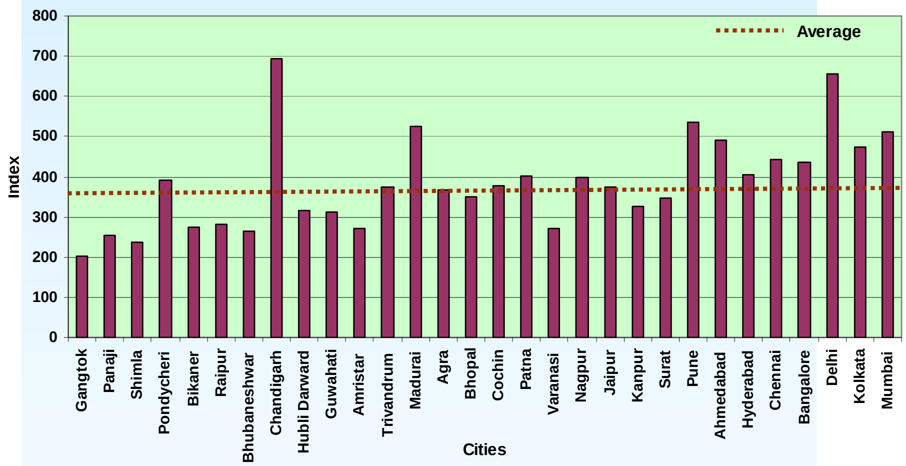


Figure 2.30: Transport Performance Index developed for the study cities

From the transport performance index, it can be observed that Chandigarh is having the highest index, followed by Delhi and Madurai. Among the 30 cities, Gangtok has the lowest index.

Table 2.24 Transport Performance Index for the study cities

Sl. No.	City Name	Transport Performance Index
1	Gangtok	202
2	Panaji	255
3	Shimla	237
4	Pondicherry	391
5	Bikaner	273
6	Raipur	281
7	Bhubaneswar	265
8	Chandigarh	695
9	Hubli Dharward	315
10	Guwahati	312
11	Amritsar	271
12	Trivandrum	373
13	Madurai	527
14	Agra	366
15	Bhopal	352
16	Cochin	377
17	Patna	401
18	Varanasi	270
19	Nagpur	399
20	Jaipur	375
21	Kanpur	326
22	Surat	348
23	Pune	537
24	Ahmedabad	490
25	Hyderabad	405
26	Chennai	443
27	Bangalore	436
28	Delhi	656
29	Kolkata	474
30	Mumbai	512

3 URBAN TRANSPORTATION TRENDS AND RELATIONSHIPS

3.1 Introduction

The Chapter is structured in six sections including this introductory section. A comparison of the study findings with RITES study is discussed in Section 3.2. To predict urban transport scenario in the future, strategic transport models have been developed and the strategic model development is explained in Section 3.3. The transport characteristics of 30 study cities that most likely will happen (do- nothing case) is also discussed in this section. This information is expanded to 87 cities (all capital cities and all other cities with population above 1 lakhs) and is presented in Section 3.4. Various generic relationships developed as part of the study is detailed in Section 3.5 and the end section outlines a model test for transit oriented land use planning, (the relationship between landuse and transport).

3.2 Trends in Traffic and Transportation Characteristics

The 1994 RITES study assessed the traffic and transportation characteristics of 21 sample cities of the country with a view to help the Ministry in developing future traffic and transportation policies for urban areas in the country. The current study compares the transportation parameters with RITES study as well as other city transportatin studies conducted in the past (wherever possible) to assess their change over time. For comparison purposes, the same city categories used in RITES study has been adopted.

3.2.1 Traffic Composition Characteristics

A comparison of traffic composition in the common cities of the two studies is presented in Table 3.1. It can be observed that composition of traffic has significantly changed across all cities between 1994 and 2007. It is clear from the table that on an average, the share of fast moving vehicles has increased from 70% to 88%, while the share of slow moving vehicles, basically cycles, has decreased from 33% to 12%.

Bi-cycle share has been declining steadily over the past decade.

Table 3.1: Traffic composition of vehicles within the common study cities

Sl No	Traffic Composition (2007)				RITES (1994)		
	City*	Population (2007) (Lakhs)**	Average Share of Fast Traffic (%)	Average Share of Slow Traffic (%)	Population (1994) (Lakhs)	Average Share of Fast Traffic (%)	Average Share of Slow Traffic (%)
1	Shimla	1.85	100	0	1.1	100	0
2	Guwahati	11.92	89	11	5.84	71	29
3	Varanasi	21.37	73	27	10.31	46	54
4	Bhopal	18.73	94	6	10.63	83	17
5	Nagpur	23.61	83	17	16.64	59	41
6	Kanpur	31.22	86	14	20.37	40	60
7	Pune	50.15	89	11	24.94	79	21
8	Ahmedabad	68.20	92	8	33.12	71	29
9	Kolkata	162.47	88	12	110.22	84	16
Average			**88**	**12**		**70**	**33**

Note:- Common cities in both the studies, **- Area includes city and surrounding area in LPA/DA*

3.2.2 Per Capita Trip Rate (PCTR)

A compendium of trip rates observed in various studies in the country in the past is presented in Table 3.2. It is observed that there is significant variation in the PCTR making them not very comparable. It is our understanding that the trip definition in each of the studies is quite different from each other.

Table 3.2: Trip rates observed in various studies

Sl. No	City	PCTR (all vehicles)			PCTR (motorized vehicles)		
		WSA 2007	RITES Study 1994	Past Reports 2006	WSA 2007	RITES Study 1994	Past Reports 2006
1	Panaji	0.76			0.48	-	0.69
2	Chandigarh	1.02	-	-	0.61	-	0.91
3	Guwahati	0.98	0.93	-	0.57	0.73	-
4	Agra	1.06	-	1.01	0.55	-	0.9
5	Trivandrum	1.03	-		0.56	-	0.91
6	Madurai	1.14	1.3	-	0.54	0.5	0.8
7	Kochi	1.21	-		0.96	-	1.03
8	Jaipur	1.26	-	0.91	0.77	-	1.02
9	Kanpur	1.20	0.81	-	0.63	0.22	-
10	Surat	1.28	-	1.15	0.74	-	-
11	Pune	1.30	1.49	2.71	0.87	1.11	1.88
12	Ahmedabad	1.41	1.34	1.11	0.90	0.81	0.53
13	Hyderabad	1.45	-	1.26	1.01	-	0.91
14	Delhi	1.55		-	1.10	-	1.16
15	Kolkata	1.56	1.19	-	1.05	1.17	-
16	Mumbai	1.67	-	1.16	1.12	-	0.54

The comparison of PCTR with RITES study is presented in Table 3.3. The PCTR estimated in both the studies shown that trip rates have increased by about 10% to 20% in cities population of above 10 lakhs.

Table 3.3: Category-wise Comparison of PCTR with RITES study

Category*	Population Range in lakhs	WSA, 2007	RITES, 1994
1	< 5.0	0.76	0.77-0.89
2	5.0 -10.0	0.81 - 1.02	0.57-1.00
3	10.0 -20.0	0.98 - 1.25	0.89-1.10
4	20.0 - 40.0	1.20 - 1.29	1.10-1.20
5	40.0 - 80.0	1.3 - 1.50	1.20-1.35
6	Above 80.0	1.41 - 1.67	1.25-1.40

(Note: - City categories as per RITES study)

3.2.3 Mode Share

The share of public transport observed in both the studies is presented in Table 3.4. Unlike RITES study, many cities selected in the present study have no public transport, hence the ranges starts from zero. For category- 3 alone a higher public transport share is observed in the present study. This higher public transport share (50.8%) is for Kochi. All other city categories show a continuous decline in the public transport share between 2007 and 1994.

Share of public transport trips is declining.

Table 3.4: Comparison of Public Transport share (%)

City Category	Population Range in lakhs	WSA, 2007*	RITES, 1994
1	< 5.0	0.0 -15.6	14.9-22.7
2	5.0 -10.0	0.0 - 22.5	22.7-29.1
3	10.0 -20.0	0.0 - 50.8	28.1-35.6
4	20.0 - 40.0	0.2 - 22.2	35.6-45.8
5	40.0 - 80.0	11.2 - 32.1	45.8-59.7
6	Above 80.0	35.2 - 54.0	59.7-78.7

*Note: *- A number of cities selected have no public transport and have the range started from zero, City categories as per RITES study*

The share of walk trips from the two studies is compared in Table 3.5. Walk trips have declined significantly for city categories 1 to 3, while for category-4, the decrease is marginal. Interestingly eventhough share of walk trips are low for city Categories 5 and 6, the walk trips have increased over the past decade.

Smaller cities have shown a decline in walk trips over the last decade.

Table 3.5: Comparison of Walk trip share (%)

City Category	Population Range in lakhs	WSA, 2007*	RITES, 1994*
1	< 5.0	46.0	57.0
	5.0 -10.0	34.5	44.0
3	10.0 -20.0	25.0	36.0
4	20.0 - 40.0	25.0	28.0
5	40.0 - 80.0	27.0	20.0
6	Above 80.0	23.0	14.5

*Note: - City categories as per RITES study, *- Mid value of the range*

3.2.4 Trip Length Characteristics

The range of average trip lengths by city categories is presented along with RITES study in Table 3.6.

Since trip length depends mainly on city size, the category-wise trip length should remain in the same range, except for bigger cities.

Table 3.6: Comparison of Trip length with RITES, 1994

City Category	Population Range in lakhs	Trip length (in Kms)	
		WSA, 2007	RITES, 1994
1	< 5.0	2.1- 3.0	3.70 - 4.38
2	5.0 -10.0	2.6 - 4.5	4.38 - 4.86
3	10.0 -20.0	4.1 - 5.5	4.86 - 5.51
4	20.0 - 40.0	5.0- 6.0	5.51- 6.40
5	40.0 - 80.0	6.1- 8.6	6.40 - 7.62
6	Above 80.0	9.6- 11.9	7.62 - 8.32

Note: City categories as per RITES study

3.2.5 Household Income

Average household income has been obtained for all cities from HHI surveys. The comparison indicates an increase in urban affluence across city categories. (This information is based on persons disclosing their income during the survey and may not be entirely reliable). The results are tabulated in Table 3.7.

Table 3.7: Comparison of House hold income with RITES study

City Category	Population Range in lakhs	WSA, 2007	RITES 1994**
1	1-5	11300*	5970
2	5-10	8360	6250
3	10-20	8950	6150
4	20-40	8630	6710
5	40-80	12690	5520
6	Above 80	14380	6790

*Note: *- selected cities in the category are major tourist cities, **- inflated to 2007 values, City categories as per RITES study*

3.3 Urban Transport Demand Forecast

Transport models were developed to forecast the future urban transport scenario. The models were developed such that they are;

- Responsive to street congestion
- Responsive to travel costs
- Responsive to Availability of Public transport
- Responsive to the growth of the City

To be responsive to street congestion, the network information of a city needs to be fairly complete (all the major roads and key minor roads), the bus system and routes and frequency, the commuter rail system, etc. A generalised cost function for this, which includes value of time (perceived), fuel costs and fares is used in the model.

The model has to be responsive to the landuse development of the city. The economic development of the city in terms of population and employment growth is translated to the model for forecasting.

3.3.1 Model Development

To suit the above requirements, we have used a conventional 4 stage gravity model. Traffic assignement has been carried out through a multi user class. The model includes trip generation and trip attraction functions that derive information from the planning data of the city (the linkage between transport and development).

The network data is assimilated from available maps and verified with network inventory surveys. The base year trip matrix is developed through the following procedure.

1. Allocate population and employment to the study area zones for the current year.

2. Trip generation and trip attractions by zones were derived based on trip-end models developed for other cities or used in past studies for the same city.

3. Trip distribution functions calibrated in other similar cities were used to estimate the trip patterns in the base year.

4. The traffic volume counts at identified screen lines were used to control the trip matrices via a procedure of trip matrix balancing from screen line counts. The Road Side Interview survey findings and limited HHI inferences were used to adjust the estimated trips across screen lines to match trip length distributions and modal shares.

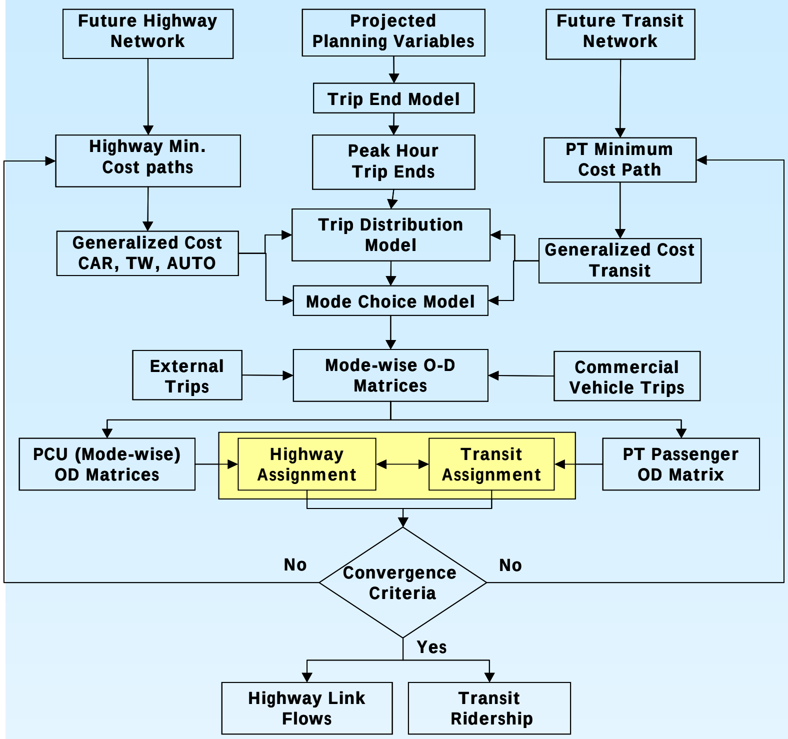
5. These adjusted trip matrices were deemed as observed trip matrices for the city. These were assigned to the network and validated.

The observed trip matrices have been then used for calibration.

3.3.2 Urban Transport Forecast

The calibrated urban transport model has been used to predict the travel patterns and mode share in the future. The methodology of travel demand forecast is provided in Figure 3.1. The estimated parameters and key outputs of the models under a do-nothing scenario is presented Annexure 3.1.

Figure 3.1: Methodology of Travel Demand Forecast



3.3.2.1 Population and Employment Projection

The population growth is forecasted considering past growth rates and CDP projetions. The projected population for the study cities are presented in Table 3.8. The projected population and employment for 2011, 2021 and 2031 were used for estimating trip ends in the corresponding years.

The methodology and projected population and employment for the study cities is detailed in Annexure 3.2.

3.3.3 Urban Transport Demand Forecast

Projected transport demand estimated from transport models are presented in Table 3.8.

The category-wise average per capita trip rate estimated for all modes including NMT is presented in Table 3.9. The motorised trip rate is derived from the model forecast and NMT trip rate is added with that to obtain the trip rate that include all modes.

Table 3.8: Projected Transport Demand in lakhs for 30 study cities (including all modes)

City Category	2011	2021	2031
Category-1 a	0.9	1.2	1.6
Category-1b	3	4	5
Category-2	63	94	139
Category-3	198	272	354
Category-4	173	258	368
Category-5	472	678	871
Category-6	1117	1543	2044

Table 3.9: Projected Per capita Trip Rate (all modes)

City Category	2007	2011	2021	2031
Category-1 a	0.8	0.8	0.9	1.0
Category-1b	0.8	0.9	1.0	1.1
Category-2	1.0	1.0	1.1	1.2
Category-3	1.1	1.2	1.3	1.4
Category-4	1.3	1.3	1.4	1.6
Category-5	1.4	1.5	1.6	1.8
Category-6	1.5	1.6	1.8	2.0

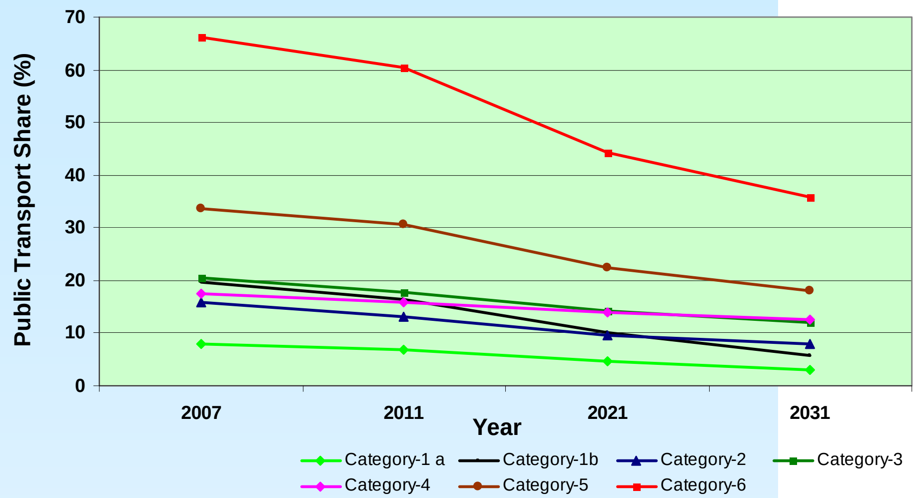
The category-wise average per capita motorised trip rate estimated is presented in Table 3.10.

Table 3.10: Projected Per capita Motorised Trip Rate

City Category	2007	2011	2021	2031
Category-1 a	0.5	0.5	0.6	0.7
Category-1b	0.4	0.4	0.5	0.6
Category-2	0.5	0.5	0.6	0.8
Category-3	0.6	0.7	0.8	0.9
Category-4	0.7	0.8	0.9	1.0
Category-5	0.9	0.9	1.0	1.2
Category-6	1.1	1.1	1.3	1.4

The motorised mode share forecast is presented in Table 3.11. On an average, public transport share decreases from 26% to 14%, while, the share of PV (personal vehicles including car and two wheelers) and IPT together increases from 74% to 86%.

It is seen that the share of private modes is more than 4 times than public transport in small and medium cities, which



is expected to increase further in future.

Figure 3.2 Future Trend of Public Transport Share under Do- Nothing Scenario

Table 3.11: Forecasted Motorised Mode Share for future (%)

City Category	2007		2011		2021		2031	
	PT	PV+ IPT	PT	PV+ IPT	PT	PV+ IPT	PT	PV+ IPT
Category-1 a	8	92	7	93	5	95	3	97
Category-1b	20	80	16	84	10	90	6	94
Category-2	16	84	13	87	10	90	8	92
Category-3	21	79	18	82	14	86	12	88
Category-4	18	82	16	84	14	86	13	87
Category-5	34	66	31	69	22	78	18	82
Category-6	66	34	60	40	44	56	36	64
Average	**26**	**74**	**23**	**77**	**17**	**83**	**14**	**86**

Note: PT- Public Transport, PV- Personal vehicles, IPT- Auto rickshaw

The trends in the share of public transport in the future is presented in Figure 3.2. It is observed that, a significant decrease in public transport and a very high increase in PV share for Category- 6 cities. A higher usage of personal vehicles resulting in severe traffic congestion in large cities in the future, unless proper measures to improve/ enhance public transport is undertaken.

Trend in public transport share from 1994 is presented in Table 3.12. The present study includes cities without public transport upto categories 1 to 4. The public transport share has been decreasing and the trend will continue in the future, under do- nothing scenario.

Table 3.12: Trend in Public Transport Share (%)

City Category *	Population Range	RITES, 1994	WSA**			
			2007	2011	2021	2031
1	1 to 5 lakhs	18.5	15.7	13.2	8.4	4.9
2	5- 10 lakhs	25.4	15.8	13.2	9.6	7.8
3	10- 20 lakhs	30.6	20.6	17.7	14.1	12.1
4	20- 50 lakhs	42.3	17.7	16.0	13.7	12.1
5	>50 lakhs	62.8	54.4	49.7	36.3	29.4

*Note: *- Category based on RITES study,**- Cites without PT is present for categories 1 to 4*

The future mode share including NMT is estimated and presented in Table 3.13. The trend in the share of various modes in the future is also presented in Figure 3.3. It is assumed that NMT trips will continue decreasing significantly in smaller and medium size cities, while the decrease will be marginal for large cities.

Table 3.13: Estimated Mode Share for the selected Cities for future (%)

City Category	2007			2011			2021			2031		
	PT	PV+ IPT	NMT	PT	PV+ IPT	NMT	PT	PV+ IPT	NMT	PT	PV+ IPT	NMT
Category-1 a	5	57	38	4	59	36	3	66	31	2	72	26
Category-1b	8	34	58	7	37	56	5	47	48	3	57	40
Category-2	9	39	53	8	42	50	6	51	43	5	58	36
Category-3	13	43	44	12	46	43	10	52	38	9	57	34
Category-4	10	47	43	9	49	42	8	51	41	8	52	40
Category-5	22	42	36	21	45	35	15	51	34	12	54	34
Category-6	46	24	30	42	28	30	31	40	29	26	46	28

Note: PT- Public Transport, PV- Personal vehicles, IPT- Auto rickshaw, NMT- Non motorised transport including walk and cycles

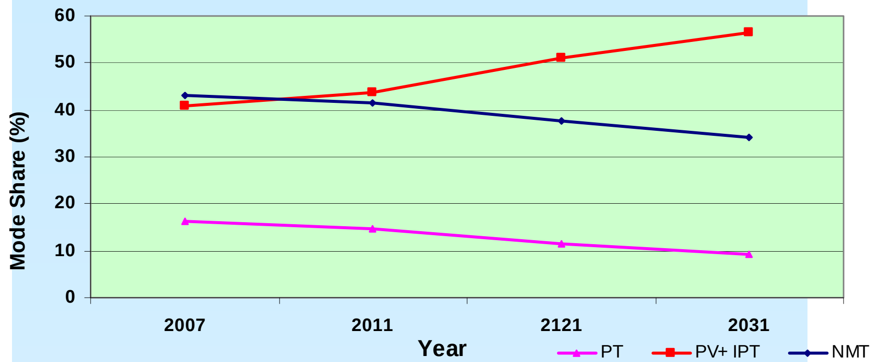


Figure 3.3 Future Trend of Mode Share

The projected average trip length in the future is presented in Table 3.14. The average trip length for all city categories is expected to be 8 km in 2031, which is presently about 5 Kms.

Table 3.14: Projected Trip length (Kms)

City Category	2007	2011	2021	2031
Category-1 a	2.5	2.7	3.3	4.0
Category-1b	2.6	2.8	3.4	4.2
Category-2	3.5	3.8	4.6	5.6
Category-3	4.9	5.3	6.5	7.9
Category-4	5.8	6.2	7.5	9.1
Category-5	7.3	7.7	9.0	10.4
Category-6	10.3	11.0	12.7	14.8

The daily transport demand in terms of passenger- km, including NMT trips, is estimated and is presented in Table 3.15. The trip length as well as trips in each city will increase and hence the passenger kilometers travelled / day is expected to increase. There will be nearly a three fold increase in trip- km by 2031.

There will be nearly a three fold increase in trip- km by 2031.

The anticipated drop in network speeds and increase in congestion is significant. Predicted congestion and speeds are presented in Table 3.16 and Table 3.17.

Table 3.15: Projected Transport Demand in Passenger-Km / Day (Lakhs)

City Category	Passenger-km in Lakhs				
	2007	2011	2021	2031	Growth (2007 - 2031) %
Category-1 a	2.0	2.4	3.9	6.3	223
Category-1b	3.3	4.1	7.0	11.5	251
Category-2	33.0	42.2	77.4	141.0	327
Category-3	96.6	120.8	203.7	325.1	237
Category-4	220.8	271.8	494.2	853.0	286
Category-5	758.6	938.6	1572.2	2344.5	209
Category-6	2583.7	3114.3	4977.6	7629.4	195

Table 3.16: Average Volume-Capacity ratio for Cities by Category under Do- Nothing Scenario

Sl. No	City Category	2007	2011	2021	2031
1	Category-1	0.24	0.33	0.69	1.48
2	Category-2	0.73	0.78	1.2	1.64
3	Category-3	0.81	1.24	1.80	1.97
4	Category-4	0.97	1.05	1.16	1.32
5	Category-5	1.12	1.51	2.01	2.54
6	Category-6	1.21	1.79	2.4	2.9

Table 3.17: Average Speed for Cities by Category under Do-nothing Scenario

Sl. No	City Category	2007	2011	2021	2031
1	Category-1	26	22	15	8
2	Category-2	22	18	13	9
3	Category-3	18	13	10	7
4	Category-4	22	18	12	9
5	Category-5	19	15	10	7
6	Category-6	17	12	9	6

Note: Speeds in KMPH

3.4 Future Transport Scenario of all Urban Centers

Network speeds will naturally decline, it would be extremely difficult to manage traffic in 2031.

The parameters derived from the model forecast were used to estimate the trip details for the identified 87 urban centres in India (all State capitals and >0.5 million population cities). Category-wise details presented above are used to expand various parameters for the 87 urban centres. Details are presented below.

3.4.1 Population Projection

The category-wise projected population for all 87 cities are presented in Table 3.18. It is expected that the total population will increase from 1735 lakhs to 2882 lakhs between 2007 and 2031.

Table 3.18: Category-wise Projected Population of 87 Cities

City Category	Population in Lakhs					
	2001	2007	2011	2021	2031	Growth Rate (2007-2031) in %
Category-1 a	9.4	10.5	11.8	14.3	16.7	78
Category-1b	8.4	9.4	10.6	13.1	15.5	84
Category-2	247.9	282.1	317.8	394.9	471.9	90
Category-3	323.8	371.2	415.4	509.8	595.5	84
Category-4	128.5	146.5	161.2	214.7	272.0	112
Category-5	235.3	282.6	316.0	410.8	478.0	103
Category-6	549.2	632.5	689.0	861.1	1032.1	88
Total	**1,502.3**	**1,734.8**	**1,921.9**	**2,418.6**	**2,881.7**	**92**

3.4.2 Travel Demand Forecast

The projected transport demand for 87 cities is presented in Table 3.19. The daily trips in the 87 urban centres are anticipated to double from 2286 lakhs to 4819 lakhs during the next 24 years. The expected growth of population and trips/day for various categories of cities are presented in Figure 3.4.

Table 3.19: Category-wise projected daily trips of 87 Cities (including NMT)

City Category	Passenger trips/day (in Lakhs)				
	2007	2011	2021	2031	Growth Rate (2007- 2031) in %
Category-1 a	8.5	10.0	13.4	17.2	103
Category-1b	7.5	8.8	12.0	15.6	108
Category-2	263.1	308.3	423.0	558.3	112
Category-3	427.7	498.2	675.6	871.9	104
Category-4	183.6	210.4	309.6	433.5	136
Category-5	403.6	469.8	675.2	868.0	115
Category-6	992.1	1124.9	1552.4	2054.7	107
Total	**2286.0**	**2630.4**	**3661.2**	**4819.2**	**111**

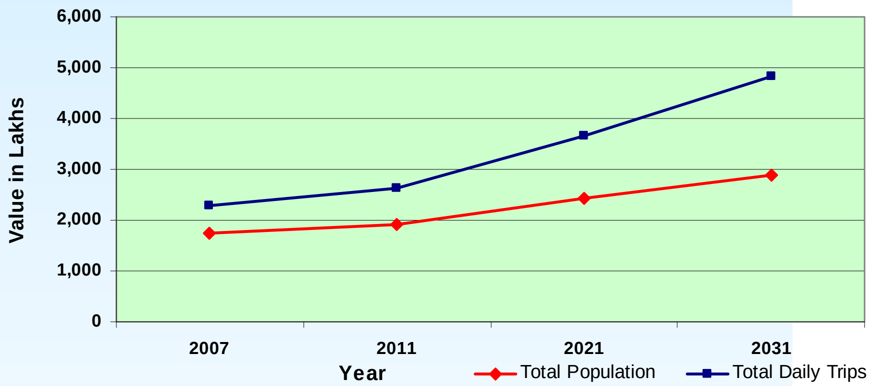


Figure 3.4 Expected Growth of Population and Daily Trips for 87 cities

Expected motorised daily trips for the 87 cities in the future is presented in Table 3.20. The growth trend of total trips, motorised trips and population is shown in Figure 3.5. Till 2021, the projected motorised trips are less than the projected population, there after it exceeds the population. It indicates on an average, a person will make more than one motorised trip in a day in the future.

Table 3.20: Category-wise Projected Motorised daily trips for 87 Cities

City Category	Motorised trips/day (in Lakhs)				
	2007	2011	2021	2031	Growth Rate (2007- 2031) in %
Category-1 a	4.9	5.8	8.2	11.0	117
Category-1b	3.3	4.1	6.5	9.8	170
Category-2	131.2	160.4	251.4	373.6	163
Category-3	234.9	280.3	406.0	592.4	151
Category-4	102.4	119.8	179.9	254.4	176
Category-5	262.7	309.6	451.1	585.4	141
Category-6	680.6	778.7	1083.5	1445.7	127
Total	**1420.0**	**1658.6**	**2386.5**	**3272.2**	**140**

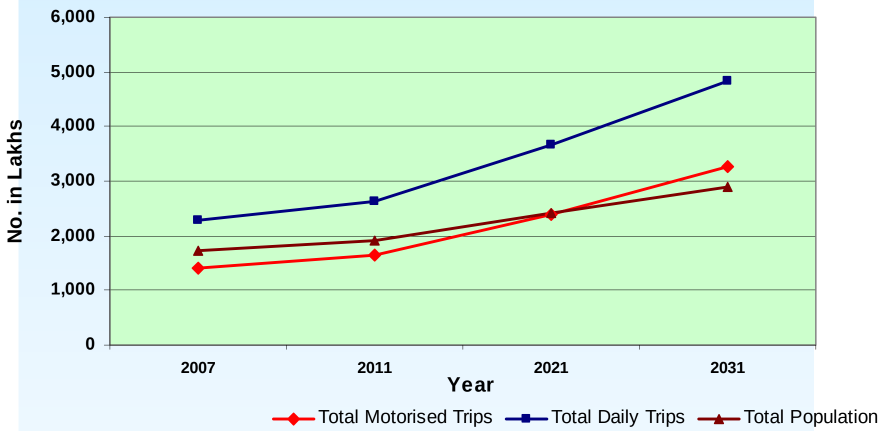


Figure 3.5: Growth of Total Trips and Motorised trips (87 urban centers)

The total transport demand in terms of Passenger-km expanded for the 87 urban centers are presented in Table 3.21. The daily trips are expected to increase from 18,000 lakhs as of now to 55,000 lakhs by 2031.

Table 3.21 Projected Passenger- Km/Day for 87 Cities

City Category	Passenger - Km /day in Lakhs			
	2007	2011	2021	2031
Category-1 a	18.4	23.5	38.5	60.1
Category-1b	19.9	25.4	42.2	66.6
Category-2	932.6	1183.1	1982.4	3198.9
Category-3	2129.7	2685.9	4451.5	7011.7
Category-4	1102.7	1362.3	2425.0	4113.8
Category-5	3020.9	3737.7	6267.2	9345.9
Category-6	10406.9	12546.2	20038.5	30697.5
Total Passenger Km	**17631.1**	**21563.9**	**35245.3**	**54494.5**

3.4.3 Fuel Consumption and Emission Levels

The fuel consumption and the consequent emissions produced by the different modes of transport in the different categories of cities in India (87 urban centers) are illustrated in Table 3.22 and Table 3.23 given below.

Table 3.22: Category wise Fuel Consumption/ day (in Kilo Litres)

City Category	Car	TW	AR	Bus	Total
1	36	8	5	6	55
2	603	414	362	280	1,659
3	1,003	1,058	602	376	3,039
4	436	393	393	140	1,362
5	921	901	553	833	3,208
6	4,782	1,605	2,869	7,442	16,697

Table 3.23: Category wise Emissions/day (in Tons)

City Category	Car	TW	AR	Bus	Total
1	6	3	0	0	10
2	90	133	24	21	268
3	158	342	125	27	652
4	64	127	37	9	238
5	143	300	143	60	647
6	556	365	451	375	1747

Based on the above tables the following conclusions could be made.

The majority of the fuel consumption by vehicles for all cities in Category 1 to 5 is contributed by cars and two-wheelers and they account to approximately 65 percent to 90 percent of the total emissions produced by all modes of transport.

In Category 6 cities, although cars and two-wheelers consume less than fifty percent of the total fuel consumption by all modes, the total emission produced by these two modes is more than 60 percent. This is due to high level of congestion in these cities resulting in slow speeds and thus higher emissions.

In Category 5 and 6 cities, Intermediate Public Transport vehicles account to 18 to 23 percent of the fuel consumption, respectively while they contribute to approximately quarter of the total emissions by all vehicles.

It could be concluded that cars and two-wheelers are the major contributors to the total emissions produced by all vehicles in all cities. In Category 5 and 6 cities IPT vehicles also contribute significantly to total emission levels. It is evident that more public transport vehicles would decrease the total emission produced on the road.

The public transport system is the most effective way to reduce the number of vehicles as well as the total emissions on the road. This is also the only way to a more equitable allocation of road space with people, rather than vehicles. The effects of incorporating adequate public transport (ranging from 30 to 70 percent) in 87 urban centers in India in the future year (2021) clearly illustrate the above. (See Tables 3.24 and Table 3.25).

Public transport will be the most effective alternative to vehicle emissions.

Table 3.24: Total Fuel Consumption/day by Vehicles With and Without Public Transport in 2021/day (in Kilo Ltrs)

City Category	Without Adequate PT			With Adequate PT			Reduction In Total Fuel Consumption (%)
	PV	PT	TOTAL	PV	PT	TOTAL	
1	16	2	18	14	3	17	6
2	445	114	559	425	77	502	10
3	2401	216	2617	1426	685	2112	19
4	2554	248	2802	1247	851	2099	25
5 & 6	23020	14144	37164	25305	13089	38395	3

Table 3.25: Total Emission Production/day by Vehicles With and Without Public Transport in 2021 (in Tons)

City Category	Without Adequate PT			With Adequate PT			Reduction in Total Emissions (%)
	PV	PT	TOTAL	PV	PT	TOTAL	
1	2	0	3	3	0	3	11
2	68	8	76	72	8	80	5
3	242	48	290	405	15	420	31
4	200	58	258	412	16	428	40
5 & 6	565	198	763	1157	103	1259	7

It is evident that the introduction of adequate public transport to the different cities in India reduces total fuel usage from 3 to 25 percent in the bigger cities and about 6-19 percent in small cities.

3.5 Generic Relationships for Urban Transport

The information collated in Chapter 2 can be generalized over the country to provide useful information across various parameters. We have segmented this information into two sections. The first one is the relationships of traffic characteristics with city level parameters. We have found interesting similarities with the study carried out in the 1994 RITES study which we have presented as well. The second is specific to the parameters of the models that we have developed which will only apply to the form of the models that have been calibrated in this report.

3.5.1 Functional Relationships of City Level Parameters and Trip Characteristics

Various traffic characteristics such as per capita travel demand, trip length etc are compared with the city parameters such as area, population, etc to establish suitable relationships between them. A comparison of the same wherever possible is made with RITES observations for similar relationships. These are presented in Figure 3.6 to Figure 3.8.

Relationship developed for per capita travel per day and Area of the city by RITES and WSA is presented in Figure 3.6. It is seen from the graph that there is a close relationship with RITES study for smaller cities, while for larger cities, the 1994 values is lower compared with the 2007 values.

The relationship between average trip length and area of the city is presented in Figure 3.7. Similar observation could be made here also. This could possibly be due to the huge two wheeler increase which has given the opportunity to travel more distance than in 1994.

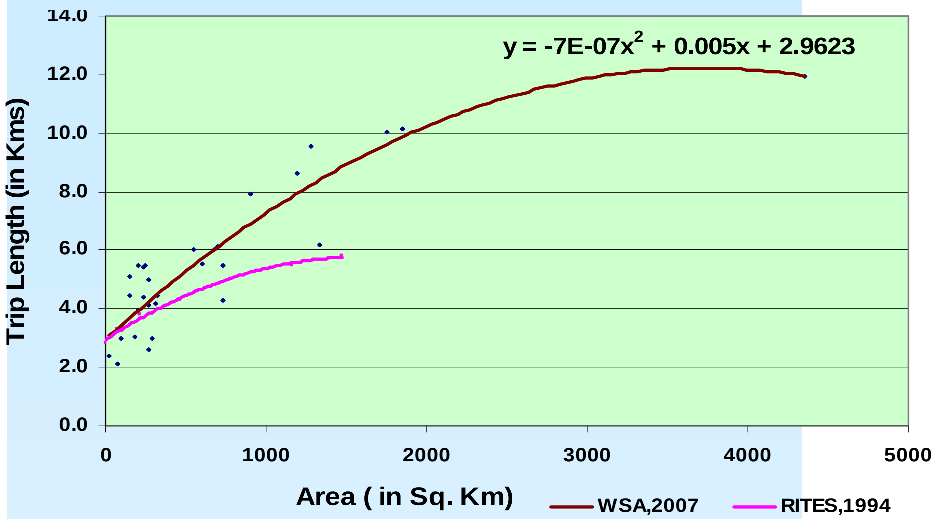


Figure 3.6: Relationship Developed for Per capita travel-Km per day (PKM) Vs Area of city

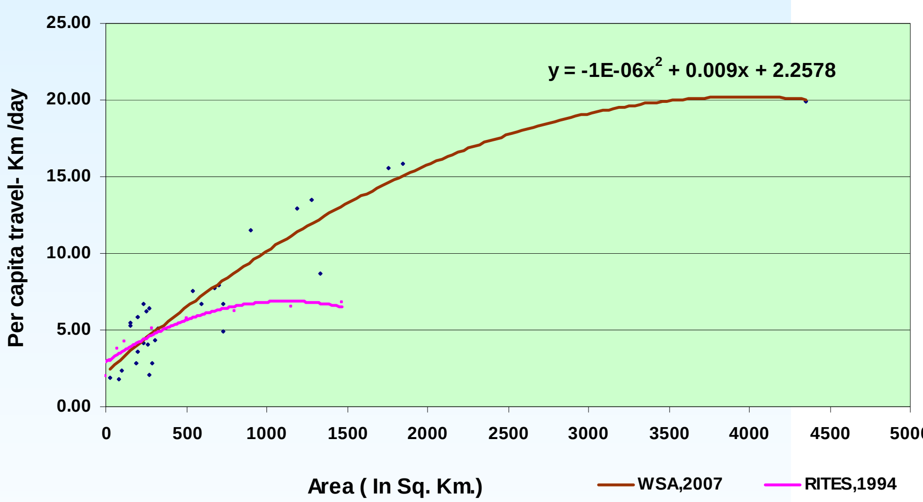


Figure 3.7: Relationship Developed for Average Trip Length Vs Area of city

The relationship between walk trips as a percentage and trip length developed by the two studies are presented in Figure 3.8. The relationships from both the studies look similar for smaller/medium size cities, while a higher walk share is observed in the present study.

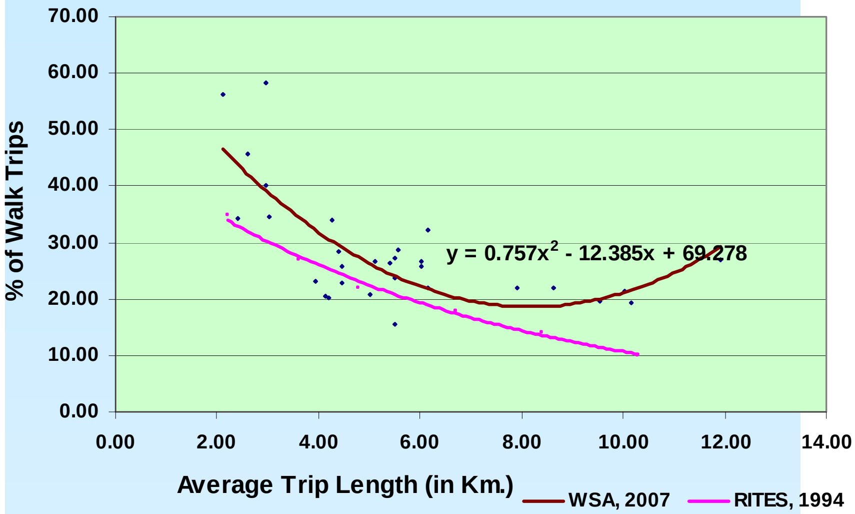


Figure 3.8: Relationship Developed for Share of Walk Trips Vs Trip Length

3.5.1.1 Other Generic Relations

Speed- flow curves on relationships between traffic flow and speed have been establised for different link types. These curves have been developed with data across cities and hence can be used for any urban area in India. The curves are presented in Figure 3.9. These relationships are for running speed (not for journey time) and directional flow.

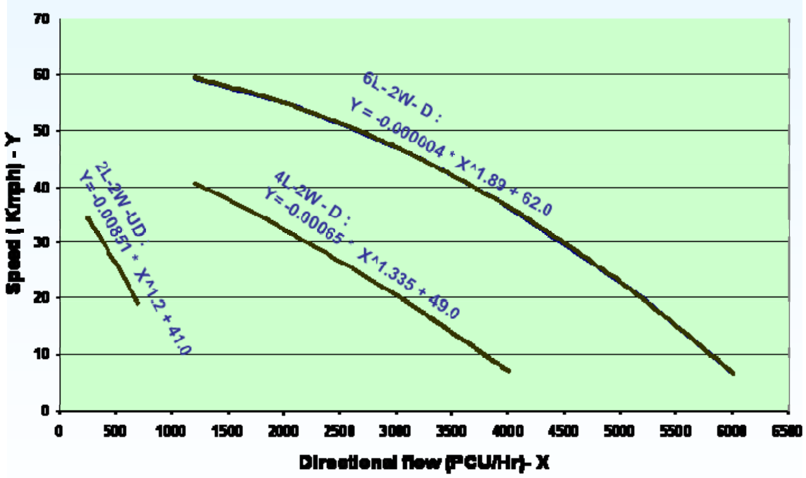


Figure 3.9: Speed -Flow Curves Developed for different road carriageways

Attempt has been made to develop a relation between various trip parameters and variables such as population, shape factor, slum population, available bus fleet, etc. The following linear equations are found to be best.

Eqn. (1): Trip length (Kms) = 0.0476* X1 + 4.7726* X2, R^2= 0.96

Where,

X1- Population in lakhs and

X2- Shape factor of the city, which is calculated as the ratio of Minimum Spread of the city (in Kms) and Maximum Spread (in Kms)

Eqn. (2): PT Share (%) = 0.00949* X1 + 0.18218* X2, R^2= 0.78

Where,

X1- Bus supply/ lakh Population and

X2- Slum population in % (a proxy variable for lower income households)

Eqn. (3): IPT Share (%) = 0.000088 * X1, R^2= 0.73

Where,

X1- IPT vehicle population/ lakh Population

Eqn. (4): Walk Share (%) = -0.0025* X1 + 0.3961* X2, R^2= 0.82

Where,

X1- Trip length (km) and

X2- Shape factor

Eqn. (5): Cycle Share (%) = 0.200* X1 + 0.150* X2, R^2= 0.74

Where,

X1- Slum population in % (a proxy variable for lower income households) and

X2- Shape factor

3.5.2 Generic Parameters of Urban Travel Demand Models

Trip Generation: Trip production and attraction equations have been developed at a city category level and is presented in Table 3.26.

Table 3.26: Trip Generation Equations developed at a city category level

Sl. no	Category	Trip Production	Trip Attraction
1	Category 1	TP = 0.0303 * Population + 15.86	TA = 0.0711 * Employment + 35
2	Category 2	TP = 0.05 * Population +294.51	TA = 0.022 * Employment + 411.11
3	Category 3	TP = 0.08109 * Population	TA = 0.066447 * Employment
4	Category 4	TP = 0.168 * Population +557.33	TA = 0.67 * Employment + 233.33
5	Category 5	TP = 0.03789 * Population	TA = 0.153726 * Employment
6	Category 6	TP = 0.070023 * Population + 236.36	TA = 0.189388 * Employment + 195.867

Friction factor coefficients (a, b, c) : Relationships have been developed for impedence function parameters or friction factor coefficients for calibratation of the gravity model. The equation for the impedence function is as follows:

Fij = aCbij e - cCij

Where,

'F' is the Deterrence/Friction Function and

'a b, c' are the Friction factor coefficients

Mode choice utility function coefficients (α, β): The relationships developed for mode choice utility function coefficients (α, β) in terms of various parameters for various modes are presented in Table 3.26.

The relationships developed are presented in Figure 3.10 to Figure 3.12.

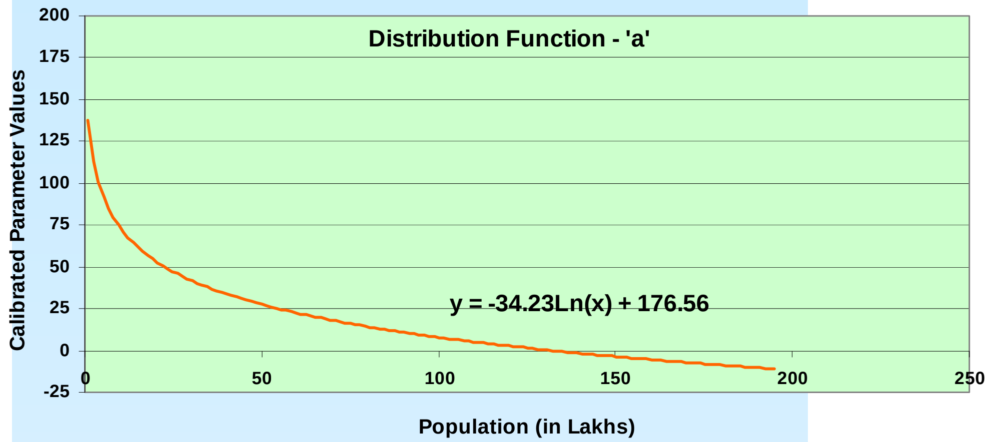


Figure 3.10: Relationship Developed for Distribution function 'a' Vs Population of city

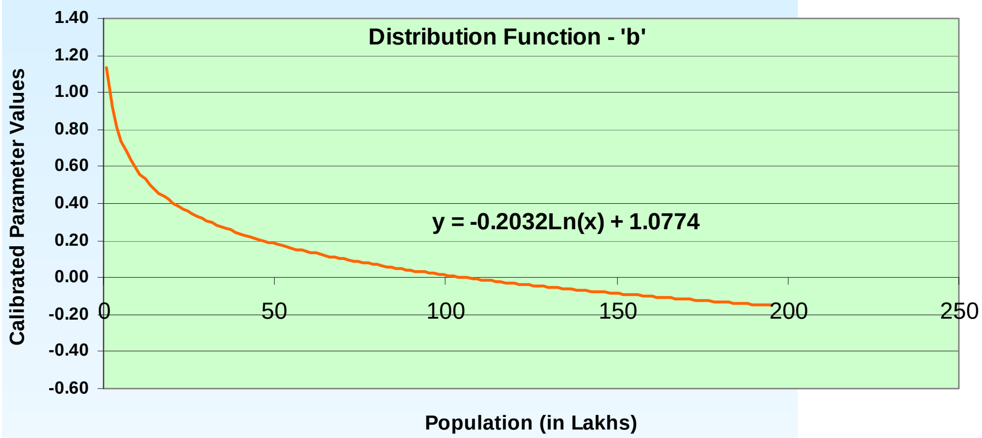


Figure 3.11: Relationship Developed for Distribution function 'b' Vs Population of city

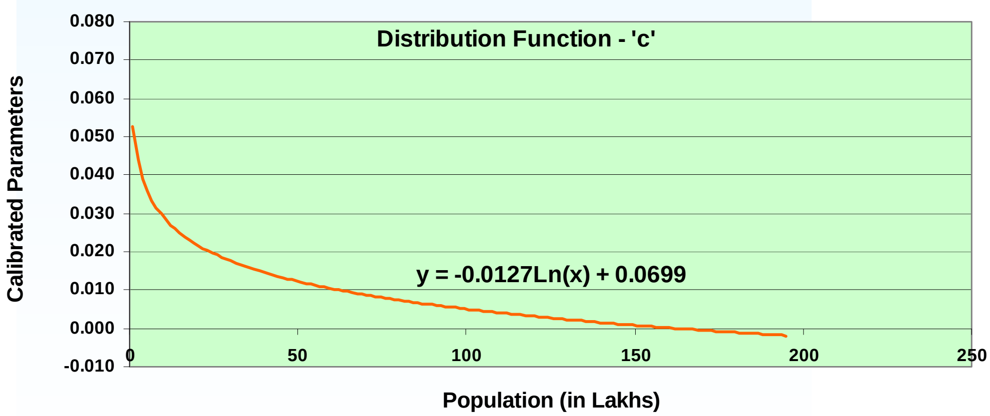


Figure 3.12: Relationship Developed for Distribution function 'c' Vs Population of city

Table 3.26 Relationships developed for mode choice utility function coefficients

Mode	Relationship
PT	α = 1.891E-04*Population (in lakh)^2+-5.799E-03*Population (in lakh)
	β = -1.466E-04*Population (in lakh)^2+2.319E-02*Population (in lakh)
Auto Rickshaw	α = 9.1208E-07*IPT / lakh of population ^2+-5.955E-04*IPT / lakh of population
	β = 9.825E-05*buses/ lakh of population ^2+-5.103E-03*buses/ lakh of population
Two Wheelers	α = 0.6855*Shape Factor^2+-0.327*Shape Factor
	β = 3.1036E-06*IPT / lakh of population ^2+-2.3195E-03*IPT / lakh of population
Car	α = 5.978E-07*IPT / lakh of population ^2+-2.8523E-04*IPT / lakh of population
	β = -0.1273*Shape Factor^2+4.923E-02*Shape Factor

3.6 Model Test on Transit Oriented Development (TOD)

The City Development Plans (CDP) when developed, should incorporate a balanced transport system serving these landuses to enhance the regional mobility. That requires an integration of landuse patterns and transport systems during the development of the CDP itself. This is a common practice elsewhere in the world.

However, in India, most of the City Development Plans developed have not integrated the transport system plans into them. All these years, the transport system planning is not been considered as a vital component of the overall planning of cities. As a result, the transport planners have to fit in a transport system into the already planned or developed landuse patterns.

This has resulted in contributing a not so efficient transport system that serves the urban population to the maximum extent.

A Transit Oriented Development plan would bring out the relationship between the landuse and public transport more clearly and efficiently. A Transit Oriented Development would allow the growth and redevelopment to take place along the transit corridors. In other words, the densities would be higher and aligned along the corridors of transit systems. Conversely, the transit corridors would pass through high density patterns.

In this regard, a case study was taken up where the density pattern was redistributed to be centered on the planned transit corridor. Since the travel generated in an urban area is a function of landuse, by having high density patterns spread around a transit corridor (which is a TOD itself), a significant impact on travel characteristics is observed.

There is a need to integrate urban and transport planning.

The city selected as the case study for applying the TOD principles is Thiruvananthapuram. The travel demand model developed to forecast the travel patterns and mode shares under different landuse scenarios for Thiruvananthapuram is used for the study. Based on the travel pattern and the centers of attraction in the city, a Mass Transit corridor is proposed from Sreekaryam to Pappanamcodu. Most of the work centers and the CBD area are served by the corridor. To bring in the concept of Transit Oriented Development into the case study, the land use densities are redistributed and high density patterns are applied along the proposed transit corridor. About 50% of the population and 70% of the employment were distributed along the corridor. The impact observed by doing so is significant enough to demonstrate the importance of following TOD principles in our urban areas.

The redistribution of densities to bring out the concept of TOD in Trivandrum is shown in the Figure 3.12.

The most significant impact of having TOD is the increase in the public transport mode share. In the absence of any TOD, the public transport mode share is found to be around 28% for the year 2021. However, under the TOD scenario, the same mode share jumped to about 42%.

With the National Urban Transport Policy (NUTP) advocating the importance of public transport in cities, incorporating landuse and transport in the form TOD will immensely contribute towards achieving the vision of NUTP. The change in the mode shares of different categories of vehicles before and after applying TOD principles is shown in Table 3.27.

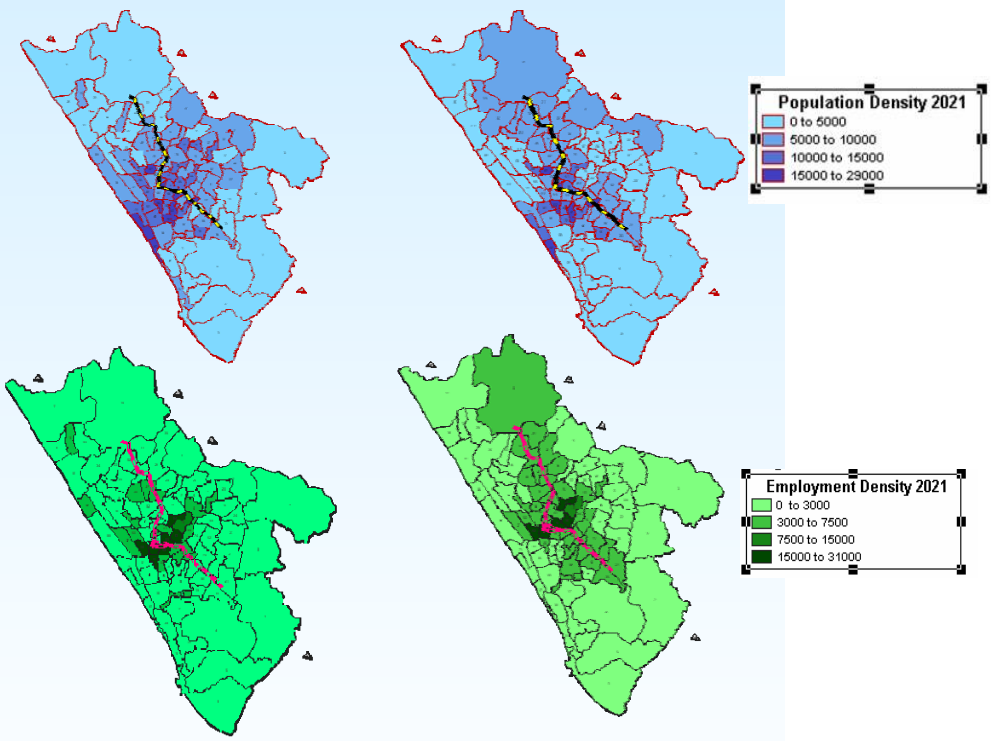


Figure 3.12: Redistribution of densities in Trivandrum

Table 3.27: Mode-shares

Mode	2021 - Do Nothing Without Mass Transit		2021 - Do Nothing With Mass Transit using TOD	
Two Wheelers	77011	43%	64261	36%
Car	14328	8%	13192	7%
Auto rickshaw	37610	21%	25692	14%
PT	50147	28%	75951	42%

Other important positive impacts of introducing TOD in an urban area are on the congestion ratios and the speeds.

Ten different locations along the transit corridor are identified and the impact of TOD is observed at these locations.

The reductions in the volume-capacity ratios and the increase in speeds are shown in Table 3.28.

Table 3.28: V/C Ratios and Speeds

Sl. no	Major road	V/C Ratio		Speed km/hr	
		Do nothing	With TOD	Do nothing	With TOD
1	MG Road	2.34	1.29	13.45	19.86
2	NH - 47 to Nagercoil	4.24	3.86	8.13	9.16
3	NH - 47 to Ernakulam	3.58	2.46	8.71	10.61
4	NH - Bypass	3.93	3.52	12.10	14.83
5	SH - 2	4.34	2.87	6.48	9.73
6	MC Road	0.87	0.45	22.58	23.00
7	Mahilamandiram Road	3.17	2.9	6.85	8.83
8	Pipeline Road	2.81	2.61	5.73	6.82
9	Airport Road	2.6	1.95	7.88	10.88
10	Kovalam Road	3.28	2.84	11.43	13.15

It can be concluded from the case study, that a successful Transit Oriented Development can significantly increase the public transport mode share. It would hence imply that the private vehicle ownership will be reduced in areas where TOD is implemented. The study also reveals that TOD relieves congestion along major corridors and thereby increases speeds on these corridors.

4 URBAN TRANSPORTATION INVESTMENT NEEDS AND INSTITUTIONAL FRAMEWORK

4.1 Urban Transport Investment Needs

4.1.1 Present Urban Transport Investment Record

Accurate estimation of urban transportation expenditure is a difficult task as the transportation infrastructure for urban area is implemented by various agencies such as Local Planning Authorities/ Development Authorities, Urban local bodies, NHAI/State Highways/PWDs, Traffic Police etc.

As per, 'Municipal Finance and Municipal Services in India: Present Status and Future Prospects' a paper published by Dr. Mukesh P. Mathur (Professor and Coordinator Indo-USAID FIRE(D) Project, National Institute of Urban Affairs (NIUA), New Delhi, India) in 2001, on an average, municipalities are spending Rs. 747/- per capita annually on various municipal activities and functions. Out of Rs. 747/-, Rs. 70.19/- is spent on urban roads, which is about 9% of the total expenditure, by the Municipalities. Multiplying this per capita expenditure with the urban population of India (about 29 crores), it could be estimated that approximately Rs. 2,035 Crores is spent annually on urban roads by the local bodies itself. As explained above, this amount forms only a part of the total expenditure on urban transportation as a number of other agencies are also involved in implementation of urban transport projects.

Several other authoritative studies have been undertaken to estimate the quantum of funds required for the upgradation of urban infrastructure. The India Infrastructure Report, 1996 estimates the annual investment need for urban water supply, sanitation and roads at about 28,035 crores per year for the next ten years. The estimates made in the India Infrastructure

Report, 1996 (also known as the Rakesh Mohan Committee Report) [1] for various urban sectors is given in Table 4.1.

Table 4.1 Investment Requirements - 1996-2005

Sector	Gross Investment in Rs. in Bn. (FY 1996 - FY 2005)
Power	6,244
Urban Infrastructure	2,878
Roads	950
Ports	250
Other transport	2,046
Communications	1,915
Total	**14,283**

Estimates by Rail India Technical and Economic Services (RITES) indicate that the amount required for urban transport infrastructure investment in cities with population 100,000 or more during the next 20 years would be of the order of Rs.207,000 crore.

According to the Eleventh Five Year Plan Working Group Estimates[2], the total financial requirements come to Rs. 57,400 crores as summarized in Table 4.2.

Table 4.2 Urban Transport Requirement of funds according to Eleventh Five Year Plan

Details	Rs in Crores
Capacity Building	100
0.1 - 0.5 million cities	3,700
0.5 - 1 million cities	4,000
1 - 4 million cities	11,600
4 million plus cities	6,000
MRT for mega-cities	32,000
Total	**57,400**

It may be noticed from the above that out of the proposed allocation of Rs 57,400 crores, as much as Rs. 32,000 crores is only for MRT systems. This disproportionately high outlay proposed for MRT systems is primarily because many cities have come up with proposals for very high cost metro rail systems. There is a need to rigorously evaluate all such proposals and compel a complete and thorough evaluation of

[1] These requirements were derived from growth assumptions for the Indian economy. Some of these assumptions were quite high (primarily in the manufacturing sector - 11% annual growth) and have not matched actual performance of the economy. Hence, the requirements could be lower in reality.

[2] Report of the Working Group for the 11th Five Year Plan on Urban Transport

other technological alternatives (Alternate Analysis). If this is done, the required outlays may come down significantly.

In view of the higher anticipated economic growth and the projected requirement of BRTS, Working Group Report, 11th Five year plan, has been revised the estiamte of Rs, 57,400 Crores to a total requirement of Rs. 1,32,590 crores.

4.1.2 Urban Transportation Investment Needs for the future

To meet the transport needs of the future, investment requirements will increase to levels three to four times higher in real terms from the present levels. The financing of this level will be a massive task. While the government will continue to be a major source of funds for infrastructure, internal generation of resources by the sector itself will have to increase. Pricing of transport services and reduction in the costs will have to play a much bigger role than in the past. A larger role of the private sector is also visualized.

In a maze of subsidies and social service obligations public sector transport has lost the importance of commercial operations.

Urban transport Policy of the Ministry of Urban development clearly indicates the areas and levels of possible government support in 'planning to implementation of urban transport components'.

4.1.2.1 Urban Transport Components

Demand for urban transport components will be city specific to suit their requirements. However, the common requirements are listed below:

i. Urban Roads

1. Intra-city road network (capacity augmentation, new links)
2. Inter-city roads (Bypasses, Development of major arterials in the outer-city area)
3. Corridor development for major arterials within city
4. Bridges, Flyovers, ROB/RUB, underpasses, etc

ii. Traffic improvements
   1. Junction improvements
   2. Parking (Off-street / On-street)
   3. Road Information System
   4. Intelligent Transport System

iii. NMT management
   1. Pedestrian foot path and safe crossing facilities
   2. Pedestrian subways
   3. Pedestrian zones
   4. Cycle tracks & terminals

iv. Road Safety
   1. Signage
   2. Training & education
   3. Accident information system
   4. Trauma care facilities
   5. Management of accident prone areas
   6. Street lighting

v. Mass transport system
   1. Commuter rails/LRTS/ Metro
   2. BRTS
   3. Bus transport system (intra-city / inter-city)
   4. Terminals
   5. Inter modal transfer facilities
   6. Inland water facilities

vi. IPT
   1. Regulations (licensing, parking, routings etc)
   2. Terminals

vii. Urban Transport Planning & Operation Data
   1. Urban Road Information System
   2. Data Collection
   3. Collation & Management
   4. Planning & research activities

viii. Terminals
   1. Rail
   2. Bus (Inter-city/intra-city/Tourist etc)
   3. Truck terminals
   4. Circulation pattern

4.1.2.2 Investment Requirements: Assessment Methodology

An assessment of investment for urban transport sector of the country is made. The 87 cities identified in the study is classified into four categories for the investment requirements. They are:

- Cities in the population range of <5 lakhs
- Cities in the population range of 5- 10 lakhs
- Cities in the population range of 10- 40 lakhs
- Cities in the population range of >40 lakhs

Number of cities in each category is presented in Table 4.3.

Table 4.3 City categorization for Urban Transport Requirement in the future

Category	No. of Cities
Cities in the population range of <5 lakhs	14
Cities in the population range of 5- 10 lakhs	35
Cities in the population range of 10- 40 lakhs	30
Cities in the population range of >40 lakhs	8
Total no. of Cities	**87**

Transport infrastructure requirement for the next 20 years for each city categoty is derived separately and the basis is explained below. The assumptions made in computing category-wise rate is detailed in Annexure 4.1.

Urban Transport Infrastructure needs of cities in the population of <5 lakhs: These small and medium cities do not face any kind of mobility problems that are faced by larger cities. The objective of the interventions in this category of cities is to enable smooth traffic flow and prevent a decline in the use of non- motorised modes. This could be possible by ensuring that travel by non- motorised modes to continue to be safe by providing separate slow moving vehilcle lanes, etc. Though these small cities would not require a mass rapid transit system in the future, implementation of bus transport along major corridors for cities without PT currently and augmentation of bus services for cities having PT in the next 20 years is essential. Following interventions are considered in the transport investment.

Adequate Investments in traffic engineering and pedestrian management are required.

- Urban roads
    - New and improvement of intra- city road network,
    - Bypasses and ring roads,
    - RoBs/RuBs
- Traffic improvement
    - Junction improvements
    - On- street parking management
    - Signages and other traffic management measures
- NMT management
    - Pedestrian foot path, safe crossing facilities, subways,
    - Cycle tracks
- Implementation/Augmentation of buses including terminals and bays
- Inland water transport
- Creation of parking spaces for IPT
- Road safety measures
- Urban Transport Planning and Operation data

It is estimated that every city in this category require an average of Rs. 700 Crores to satisfy the transport needs for next 20 years. The total requirement for the 14 cities in this category is estimated as Rs. 9800 Crores.

Urban Transport Infrastructure needs of cities in the population of 5-10 lakhs: In this category of cities, the focus of investment would be largely similar to the previous category. Hence al the items considered in the first category is retained. In addition, flyovers/under passes, pedestrian subways, off-street parking facilities, ITS, mofussil bus terminals and truck terminals are added.

It is estimated that every city in this category would require Rs. 2,020 Crores for augmentaiton of transport infrastructure in the future. Hence the financial requirement for all the 35 cities falling in this category is estimated as Rs. 70,700 Crores.

Urban Transport Infrastructure needs of cities in the population of 10-40 lakhs: This category of cities will also need the same kind of requirements of 5-10 lakh cities would intervene, but in large quantom. In these cities, it is necessary to plan for low to medium capacity mass transit system also along some of the high density corridors. It is estimated that on an average every city in this category require Rs. 7240 Crores for the upgradation of transport infrastructure. All the 30 cities coming in this category would require a total investment of Rs. 2,17,200 Crores.

Urban Transport Infrastructure needs of cities in the population of >40 lakhs: This category of cities would need largely the same interventions as the 10 - 40 lakhs population cities with the diference that these cities have to plan for medium to high capacity mass transport systems. It is estimated that each city would require an amount of Rs. 17,210 Crores for the transport investments. The investment requirements for all 8 cities in the category would be about Rs.1,37,680 crores.

4.1.2.3 Total Investment Requirement

The total urban transport investment requirements for the identified 87 cities is estimated as Rs. 4, 35, 380 Crores. The summary of the investment is given in Table 4.4.

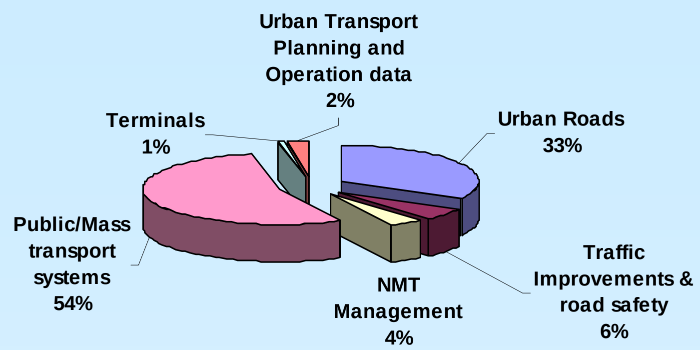
Table 4.4 Total urban transport Investment Requirements for the identified 87 cities

Category	Rs. in Crores
Cities in the population range of <5 lakhs	9,800
Cities in the population range of 5- 10 lakhs	70,700
Cities in the population range of 10- 40 lakhs	2,17,200
Cities in the population range of >40 lakhs	1,37,680
Total	**4,35,380**

4.1.2.4 Distribution of Various Components

The distribution of various components is presented in Figure 4.1. At least 54% of the total investment will be required for developing public/mass transit systems. The investment for urban roads constitutes about 33% of the total investment.

54% of the investment is to develop mass transport systems.



Transport Components
Figure 4.1 Investment Requirements of Various Urban

4.1.2.5 Investment Phasing

The estimated investment of the urban transport sector is phased in four equal periods of five years. The phasing of the proposed investments is presented in Table 4.5.

Table 4.5: Phasing of Urban Transport Investment

Category	Rs. in Crores	%
2008-2012	1,57,020	36%
2013-2017	1,34,880	31%
2018-2022	80,050	18%
2023-2027	63,430	15%
Total	**4,35,380**	**100%**

4.1.2.6 Funding Options

There are certain areas of urban transport components that different stakeholders can participate so that the required funding and responsibilities can be shared with suitable coordination and regulation mechanism.

Considering the funding pattern, legal aspects, implementation capacity, return potential, risks associated etc., urban transport components can be grouped for implementation.

Projects that can be implemented by:

- Local bodies
- Local bodies with the fund support of State and Central governments
- Local bodies with the fund/technical support of multilateral funding agencies
- State or Central governments
- Local bodies with the support of private participation
- Private participation

4.1.2.7 Areas and Forms of Private Participation

The possible areas of the urban transport projects for various implementation agencies are presented in Table 4.6. Low capital intensive with moderate technical requirements and high social responsibility projects can be taken up by ULBs. High capital intensive and more technical required projects like MRTS, LRTS, and structural projects shall be through the co-operation of State and Central governments on SPV format (eg; Metro in Delhi). Projects with overlapping responsibilities but with high return potentials with less risk and less gestation period shall be through private sector by BOT/Annuity formats. Private sector participation will be in the areas of high profitability with less/medium risks. Hence it is necessary to identify the appropriate areas for different types of private sector participation for implementing urban transport components.

Private sector involvement in urban transport component can be the following forms:

- Projects with social responsibility on sponsorship pattern (eg: improvement and maintenance of junctions).
- Annuity format of BOT projects which have less return potentials and high capital intensive (eg: Development and maintenance City Roads in Trivandrum City).

- Commercial projects BOT projects (eg: Coimbatore Bypass in Tamil Nadu, Bridge connecting Wellington Island and Mattancherry in Kochi City in Kerala).

- PPP for urban bus services: The PPP model for Indore city bus operation is presented in Annexure 4.2.

The share of various urban transport projects with respect to the possible implementation mechanism is presented in Figure 4.2. It is found that about 37% of the investment can be undertaken under private participation, in which 29% can be implemented under BOT option of the private sector participation.

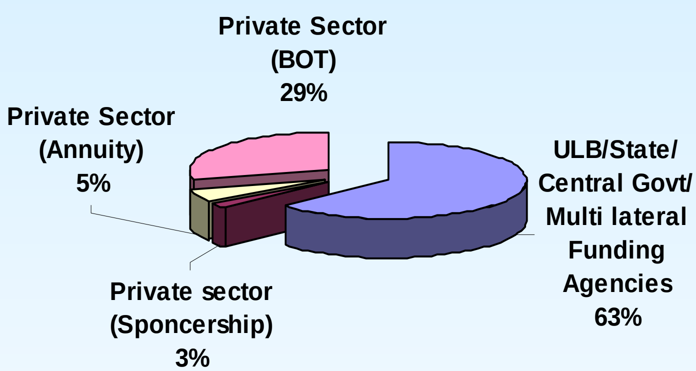


Figure 4.2 Share of Various Implementing Agencies for Implementation of Urban transport Investment

Table 4.6: Possible Areas of Urban Transport Project Components for Implementation by Various Agencies

Urban Transport Components	Potential Role Players / Agencies						
	ULB	State	Cntral Govt.	Multilateral Funding Agencies	Private Sector Sponsorship	Private Sector (Annuity)	Private Sector (BOT)
i. Urban Roads							
1. Intra-city road network (capacity augmentation, new links)		■	■	■			
2. Inter-city roads (Bypasses, Development of major arterials in the outer-city area)		■	■	■			■
3. Corridor development for major arterials within city						■	■
4. Flyovers, ROB/RUB, underpasses, pedestrian subways etc		■	■	■			
ii. Traffic improvements							
1. Junction improvements	■	■	■	■	■		
2. Parking (On-street)	■				■		
3. Parking (Off-street)							■
4. Road Information System	■			■			■
5. Bus Stops	■						■
iii. Road Safety							
1. Signage	■	■		■			
2. Training & education		■	■	■			
3. Accident information system	■	■					
4. Trauma care facilities		■	■	■			
5. Management of accident prone areas	■	■	■				
6. Street lighting	■					■	
iv. Mass transport system							
1. MRTS/LRTS	■	■	■				
2. BRTS	■	■	■				
3. Bus Transport System (Intra-city)	■	■					■
4. Bus Transport System (Inter-city)		■					■
5. Inland water transport		■					■
6. Intermodal transfer facilities		■					■
v. IPT							
1. Regulations (licensing, parking, routings etc)	■						
2. Terminals	■			■			■
vi. Non- Motorized Vehicles							
1. Regulations (licensing, parking, routings etc)							
2. Terminals							
vii. Pedestrian facilities							
1. Footpaths	■	■		■			
2. Pedestrian Zones	■	■					
3. Pedestrian crossing facilities	■	■					
viii. Urban Transport Planning & Operation Data							
1. Urban Road Information System			■			■	
2. Data Collection			■			■	
3. Collation & Management			■			■	
4. Planning & research activities		■	■	■			
ix. Road side Environment							
1. Drains	■	■				■	
2. Regulations of Advertisement/Bill boards/Posters	■						
3. Management of open spaces	■						
x. Terminals							
1. Rail			■				■
2. Bus (Inter-city/intra-city/Tourist etc)	■	■					
3. IPT	■						
4. Circulation pattern	■						

4.2 Institutional Framework

In the present context, where the importance of urban infrastructure and its relevance is recognized to improve the living conditions of urbanites who contribute maximum to the national development, the role of urban transport is more relevant. MoUD's recent thrust in urban transport projects through various schemes like JNURM explains this. Hence the proposed heavy investments in urban transport infrastructure needs proper guidance, planning, sustainability, adequate provisions for their maintenance and safeguard. Apart from the required fund, adequate expertise and proper institutional mechanism to implement the urban transport infrastructure is the basic requirement.

Based on the review of the existing institutional system and the prevalent issues, the following suggestions are formulated and they include:

Priority for UMTA implementation: The National Urban Transport Policy recognizes that the current structure of governance in the transport sector does not provide for the right co-ordination mechanisms to deal with urban transport problems. It recommends setting up of Unified Metropolitan Transport Authorities (UMTAs) in all million plus cities, to facilitate more co-ordinated planning and implementation of urban transport programs and projects and an integrated management of urban transport systems.

Central Urban Transport Database management: Creation of a centralized data base at city, district, State and central level for use by all the interested agencies. This could also be a joint venture between Ministry of Urban Development and a private agency. The data base consists of;

- Identification of available data base with different agencies and the missing areas of data base that requires frequently for planning and monitoring purpose for urban infrastructure including transport.

- A proper data collection system through primary surveys and periodical updation of the data for the missing data.
- Collation and management of all data base.
- Access to the data base to the stakeholders on appropriate 'pricing'.
- Data base can include all study projects reports, raw data, models, software etc.
- Management of the data base by a committee representing all stakeholders with adequate responsibility and budget provisions (with more representation from government through user departments).
- Use of latest technology in collection, collation, and management.
- Ensuring private participation by entrusting the responsibility to suitable private sector firms with adequate control and supervision provision under the stake holder committee.
- Details of the data and their items including updating provisions etc will be decided by the Committee with the support of a technical advisory forum.
- Pricing mechanism with 'no profit – no loss' objective along with the minimum return requirement to the private sector investment should be introduced for the efficient operation of the system.

Institutional strengthening: The capacity building of technical experts in the high level and middle level in transport planning, engineering, management and maintenance will improve the efficiency of urban transport infrastructures, rather than current situation of managing the traffic by traffic police. The recognition of specialized nature of transport functions and assigning such personnel for minimum 2-3 years, clear cut positions and authority for different ranks, provision for external/lateral entry for limited durations, capacity building through compulsory training in traffic & transport to senior and middle level officials.

Based on the functional requirements of urban transport infrastructure, additional transport planning experts should be added to the agencies responsible for planning. Suitable trainings should be made to the agencies responsible for implanting, maintaining and regulating the urban transport services.

Urban transport software library: This includes Development, commissioning, acquiring and maintaining various software packages in Transport planning, Traffic engineering, GIS packages, etc. This could b managed by the same set-up of data base management.

Clearing house for new technologies / major projects / projects involving different agencies in urban transportation: The new technologies for better traffic management for urban areas, such as area traffic control, new types of license plates, smart card for registration and driving licenses, etc, should be tested and implemented in urban areas.

A suitable permanent committee representing high level decision makers of different agencies involved in urban transport service, technical experts and representative of users can be used for this purpose that can also review and approve major urban transport projects.

5 SUMMARY FINDINGS

5.1 Present Transport Scenario

The share of personalized modes especially of two wheelers have gone up leaps and bounds clocking 12% per annum in the past two decades, while public transport has generally dwindled. Some public transport services have been even pushed out of business. Consequently street congestion has dramatically increased and overall speeds on major corridors have dropped.

Operating bus services in congested streets have become increasinghly difficult in congested networks with turn around times increasing by the day. Fleet sizes in nearly all public undertakings have declined rather than grow to meet the demand (Table 5.1).

Table 5.1: Growth of STU Bus Fleet

City	STU	Year								Annual Avg GR (%) - (2000-'07)
		2000	2001	2002	2003	2004	2005	2006	2007	
Mumbai	BEST	3269	3155	3075	3075	3074	3069	3075	3081	-0.8
Delhi	DTC	4916	4330	4466	2496	2905	3010	3143	2814	-7.7
Chennai	CHI-I	2353	2314	2211	2270	2251	2187	2176	2087	-1.7
Kolkata	CSTC	814	821	856	800	769	707	659	635	-3.5
Ahmedabad	AMTS	752	729	630	410	382	371	545	727	-0.5
Pune	PMT	657	664	647	662	697	764	784	752	1.9
Chandigarh	DCHNTU	393	395	404	-	-	-	405	404	0.4
Bangalore	BMTC	2110	2250	2446	2656	3062	3533	3802	3967	9.4

Source: Various STUs

Another important observation is the decline of NMT especially cycling. Congestion, increase in trip lengths due to urban sprawl, increase in purchase power of people and totally inadequate facilities for cycling have all contributed to reducing cycling to less than 15% of the mode share which is down from nearly 25% in 1994. And for pedestrians our city roads have simply forgotten they exist. The percentage of roads with pedestrian footpaths runs to hardly 30% in most cities.

Mode Share/Composition: The present day mode share for the 6 city categories is given in Table 5.2. When this is compared with the 1994 values one can see a significant change in the public transport share (see Table 5.3).

Table 5.2 Mode Share (%) -2007

City Category	Walk	Cycle	Two Wheeler	Public Transport	Car	IPT
Category-1 a	34	3	26	5	27	5
Category-1b	57	1	6	8	28	0
Category-2	32	20	24	9	12	3
Category-3	24	19	24	13	12	8
Category-4	25	18	29	10	12	6
Category-5	25	11	26	21	10	7
Category-6	22	8	9	44	10	7
National	**28**	**11**	**16**	**27**	**13**	**6**

Table 5.3: Public Transport share Comparison with 1994 Study

City Category	City Population Range in lakhs	WSA, 2007 (%)*	RITES, 1994 (%)
1	< 5.0	0.0 -15.6	14.9-22.7
2	5.0 -10.0	0.0 - 22.5	22.7-29.1
3	10.0 -20.0	0.0 - 50.8	28.1-35.6
4	20.0 - 40.0	0.2 - 22.2	35.6-45.8
5	40.0 - 80.0	11.2 - 32.1	45.8-59.7
6	Above 80.0	35.2 - 54.0	59.7-78.7

Note: A number of cities selected in the present study have no public transport facility. In the present study, a high percentage of PT share (50.8%) is observed in category- 3, as Kochi falls in this category, which is supplied with very good public transport).

Trip Rate: The trip rate in almost all city categories have increased as expected. The increase of trip rate from 1994 to 2007 is presented in Table 5.4.

Table 5.4: Comparison of PCTR by city category- 2007 & 1994

City Category	Population Range in lakhs	WSA, 2007	RITES, 1994
1	< 5.0	0.76	0.77-0.89
2	5.0 -10.0	0.81 - 1.02	0.57-1.00
3	10.0 -20.0	0.98 - 1.25	0.89-1.10
4	20.0 - 40.0	1.20 - 1.29	1.10-1.20
5	40.0 - 80.0	1.3 - 1.50	1.20-1.35
6	Above 80.0	1.41 - 1.67	1.25-1.40

Trip Length: With the increase in the sprawl of the city, average trip lenghts would naturally increase. The average trip length for travel in each of the city categories is presented in Table 5.5.

Table 5.5 Trip length (in KMs) by city category

City Category	Average Trip Length (Km)
Category-1 a	2.4
Category-1b	2.5
Category-2	3.5
Category-3	4.7
Category-4	5.7
Category-5	7.2
Category-6	10.4
National	**7.7**

Journey Speeds: Our journey speed surveys were focused only on the main roads of a city. The average speeds in our city roads is presented in Table 5.6.

Table 5.6 Average Journey Speed by City category

Category of cities	Average journey speed on major corridors during peak hour (KMPH)
Category-1 a	28
Category-1b	25
Category-2	24
Category-3	24
Category-4	22
Category-5	21
Category-6	17

5.2 Forecast Scenario

Transport models developed have been used to forecast traffic. Some of the salients of the do-nothing run is presented below.

Estimated trips in the future: The daily trips in the 87 urban centres are anticipated to double from 2286 lakhs to 4819 lakhs during the next 24 years (see Table 5.7).

Table 5.7: Category-wise projected daily trips of 87 Cities (including NMT)

Category	Passenger trips/day (in Lakhs)			
	2007	2011	2021	2031
Category-1 a	8.5	10.0	13.4	17.2
Category-1b	7.5	8.8	12.0	15.6
Category-2	263.1	308.3	423.0	558.3
Category-3	427.7	498.2	675.6	871.9
Category-4	183.6	210.4	309.6	433.5
Category-5	403.6	469.8	675.2	868.0
Category-6	992.1	1124.9	1552.4	2054.7
Total	**2286.0**	**2630.4**	**3661.2**	**4819.2**

Per Capita Trip Rate: The city category-wise average per capita trip rate estimated for all modes including NMT is presented in Table 5.8.

Table 5.8: Projected Per capita Trip Rate (all modes)

City Category	2007	2011	2021	2031
Category-1 a	0.8	0.8	0.9	1.0
Category-1 b	0.8	0.9	1.0	1.1
Category-2	1.0	1.0	1.1	1.2
Category-3	1.1	1.2	1.3	1.4
Category-4	1.3	1.3	1.4	1.6
Category-5	1.4	1.5	1.6	1.8
Category-6	1.5	1.6	1.8	2.0
Average	**1.1**	**1.2**	**1.3**	**1.4**

Mode Share: The future mode share including NMT is presented in Table 5.9. A significant decrease in public transport and a very high increase in private mode share for all city categories is predicted.

Table 5.9: Estimated Mode Share for the selected Cities for future (%)

City Category	2007			2011			2021			2031		
	PT	PV+ IPT	NMT	PT	PV+ IPT	NMT	PT	PV+ IPT	NMT	PT	PV+ IPT	NMT
Category-1 a	5	57	38	4	59	36	3	66	31	2	72	26
Category-1b	8	34	58	7	37	56	5	47	48	3	57	40
Category-2	9	39	53	8	42	50	6	51	43	5	58	36
Category-3	13	43	44	12	46	43	10	52	38	9	57	34
Category-4	10	47	43	9	49	42	8	51	41	8	52	40
Category-5	22	42	36	21	45	35	15	51	34	12	54	34
Category-6	46	24	30	42	28	30	31	40	29	26	46	28
Average	**16**	**41**	**43**	**15**	**44**	**42**	**11**	**51**	**38**	**9**	**57**	**34**

Note: PT- Public Transport, PV- Personal vehicles, IPT- Auto rickshaw, NMT- Non motorised transport including walk and cycles

Speeds: Expected avegrage journey speeds on major corridors in future for various city categories are presented in Table 5.10. With higher share of cars on the roads, severe traffic congestion will be the order of the day.

Table 5.10: Average Journey Speed by City Category

Sl. No	City Category	2007	2011	2021	2031
1	Category-1	26	22	15	8
2	Category-2	22	18	13	9
3	Category-3	18	13	10	7
4	Category-4	22	18	12	9
5	Category-5	19	15	10	7
6	Category-6	17	12	9	6

Note: Speeds in KMPH

5.3 Transport Indices

Several indices have been developed for each selected city to evaluate the performance of the transportation system reflecting different perspectives. They are:

- **Accessibility Index (Public Transport and Service)**: **Public Transport Accessibility Index** is formulated as the inverse of the average distance (in km) to the nearest bus stop/railway station (suburban/metro). **Service accessibility index** is computed as the percentage of work trips accessible within 15 minute time and 30 minute time for each city.

- **Congestion Index**: is defined as

  Mobility Index = 1- (A/M), where

  A- Average journey speed observed on major corridors of the city during peak hours and

  M- Desirable Average journey speed on major road networks of a city during peak hour, which is assumed as 30 KMPH.

- **Walkability Index:** is calculated as [(W1 x Availability of footpath)+ (w2 x Pedestrian Facility rating)]

  Where, w1 and w2: Parametric weights (assumed 50% for both)

  Availability of footpath: Footpath length / Length of major roads in the city and

  Pedestrian Facility Rating: Score estimated based on opinion on available pedestrian facility

- **City bus supply index:** is formulated as**, Index** = City Bus fleet (public + private agency operations) for 1, 00,000 population)

- **Safety Index**: is defined as

  Safety Index = 1/ Accident Fatality Index
  Accident Fatality Index is defined as the number of road accident deaths per lakh of population.

- **Para Transit Index** is estimated as:

  Para Transit Index = Number of para transit vehicles for 10,000 population

- **Slow Moving Vehicles Index**: The index is computed as:

Slow Moving Vehicle Index = [(W1 x Availability of cycle tracks)+ (w2 x SMV share in trips)]

Where,

w1 and w2: Parametric weights (assumed 50% for both)

- **On- street Parking Interference Index**:

Parking Interference Index = 1/ (w1 x % of major road length used for on-street parking + w2 x on-street parking demand on major roads)

Where, w1 & w2 are the weightages, assumed 50% for both parameters

The index values computed for the selected 30 cities are presented in Table 5.11. Impact of availability of public transport on various indices are presented in Figure 5.1 and Figure 5.2.

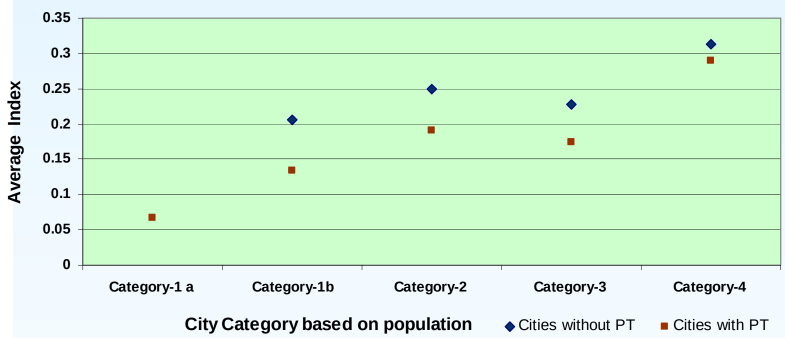


Figure 5.1: Impact of Availability of Public Transport on Congestion Index

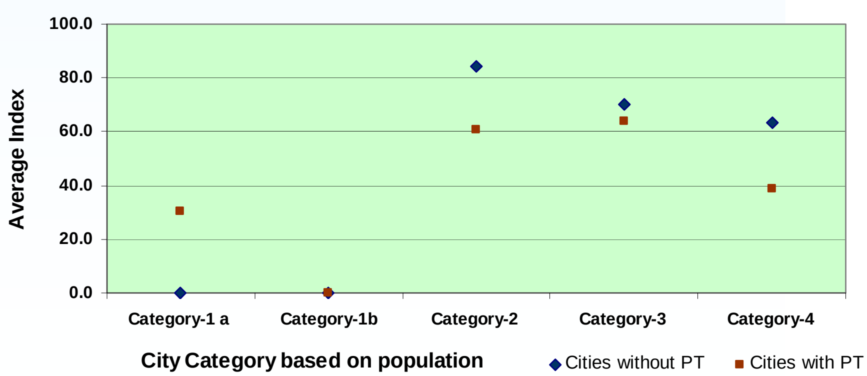


Figure 5.2: Impact of Availability of Public Transport on Para transit Index

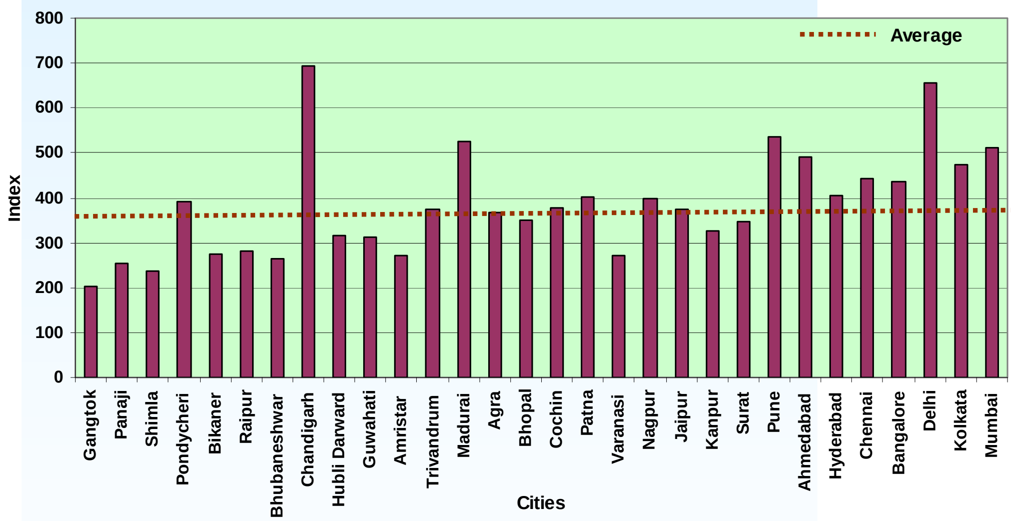
Table 5.11 Indices computed for the selected 30 cities

Sl. No.	City Name	Public Transport Accessibility Index	Service Accessibility Index (% of Work trips accessible in 15 minutes time)	Congestion Index	Walkability Index	City Bus Transport Supply index	Safety Index	Para Transit Index	Slow Moving Vehicle Index	On- street Parking Interference Index
1	Gangtok	0.00	94.12	0.21	0.30	0.00	0.04	0.00	0.00	0.59
2	Panaji	0.88	73.47	0.07	0.32	7.64	0.02	30.20	0.02	0.47
3	Shimla	0.70	76.84	0.13	0.22	8.66	0.06	0.00	0.00	0.54
4	Pondicherry	2.12	85.68	0.20	0.37	8.62	0.04	39.70	0.07	1.80
5	Bikaner	0.00	77.00	0.20	0.43	0.00	0.04	64.50	0.08	0.75
6	Raipur	0.00	93.27	0.30	0.41	0.00	0.02	104.00	0.10	0.67
7	Bhubaneswar	1.27	31.72	0.33	0.28	2.93	0.05	40.50	0.10	1.14
8	Chandigarh	1.64	83.13	0.00	0.91	17.54	0.08	75.10	0.08	0.66
9	Hubli Dharward	0.97	43.68	0.23	0.39	15.15	0.04	86.85	0.09	0.63
10	Guwahati	1.22	56.00	0.33	0.39	5.55	0.03	52.50	0.09	1.37
11	Amritsar	0.00	68.85	0.20	0.31	0.00	0.06	91.30	0.09	1.24
12	Trivandrum	1.71	54.00	0.23	0.34	20.03	0.06	63.70	0.09	0.74
13	Madurai	2.13	69.50	0.10	0.40	42.77	0.11	53.70	0.08	0.69
14	Agra	0.00	57.30	0.07	0.38	0.00	0.14	35.70	0.10	2.42
15	Bhopal	0.95	45.00	0.20	0.47	12.82	0.08	79.70	0.08	1.09
16	Kochi	1.47	57.30	0.17	0.57	16.07	0.09	70.10	0.03	1.00
17	Patna	0.00	48.00	0.23	0.65	0.00	0.19	88.80	0.14	1.21
18	Varanasi	0.00	46.00	0.41	0.33	0.00	0.16	64.49	0.08	0.98
19	Nagpur	1.06	34.45	0.30	0.66	10.21	0.10	50.50	0.11	1.13
20	Jaipur	1.38	51.00	0.30	0.64	11.11	0.06	46.70	0.05	1.33
21	Kanpur	0.71	42.86	0.33	0.59	5.64	0.05	19.30	0.09	1.14
22	Surat	0.00	53.95	0.31	0.62	2.87	0.15	63.15	0.07	1.31
23	Pune	3.15	54.35	0.20	0.81	16.43	0.22	106.20	0.04	0.98
24	Ahmedabad	2.49	21.54	0.30	0.85	12.99	0.14	73.90	0.06	2.03
25	Hyderabad	1.62	6.08	0.37	0.68	31.88	0.06	76.60	0.03	1.24
26	Chennai	1.38	12.00	0.37	0.77	33.39	0.07	64.18	0.04	1.26
27	Bangalore	1.01	13.00	0.40	0.63	39.22	0.11	89.70	0.02	1.28
28	Delhi	1.09	16.36	0.47	0.87	43.86	0.32	75.60	0.04	2.82
29	Kolkata	1.12	14.00	0.40	0.81	26.20	0.08	28.50	0.03	3.00
30	Mumbai	1.34	17.00	0.47	0.85	16.66	0.25	88.30	0.03	2.80

Transport Performance Index : A Transport Performance Index has been derived for each city based on the indices computed, which has been considered as an overall measure of the efficiency of the transportation system of the 30 study cities. The indices and the corresponding weightage adopted in the calculation of transport performance index are as follows.

- Public transport Accessibillity index (weightage -1)
- Service Accessibility Index (% of Work trips accessible in 15 minutes time) -(weightage -1)
- Congestion Index (weightage -2)
- Walkability Index (weightage -2)
- City Bus Transport Supply index (weightage -2)
- Safety Index (weightage -1.5)
- Slow Moving Vehicle Index (weightage -2)
- On- street Parking Interference Index (weightage -1)

Initially all the transportation indices were converted to a scale of 100. The values corresponding to various indices for a city after multiplying with corresponding weightage are summed up to obtain the index for that city. *(Note: the inverse of congestion index is taken in the calculation of the transport performance index).* The transport performance index computed for each city is presented below.



Transport Performance Index

5.4 Trends and Relationships

Various relationships between traffic characteristics such as per capita travel demand, trip length etc are compared with the city parameters and a comparison is made with RITES observations for similar relationships. These are presented in Figure 5.5 to Figure 5.7.

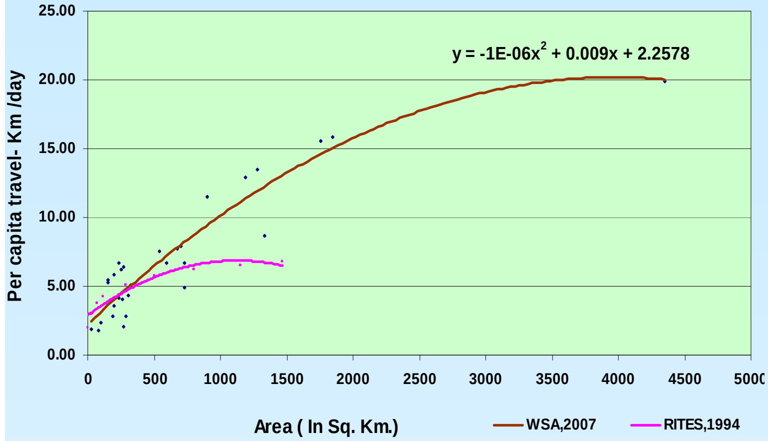


Figure 5.5: Relationship Developed for Per capita travel-Km per day (PKM) Vs Area of city

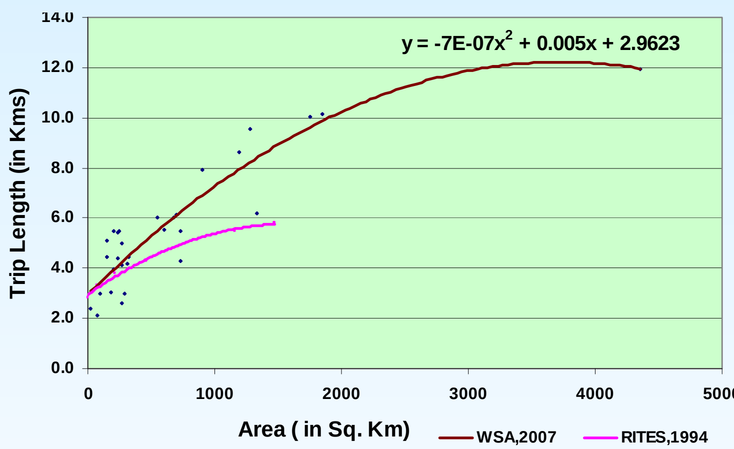


Figure 5.6: Relationship Developed for Average Trip Length Vs Area of city

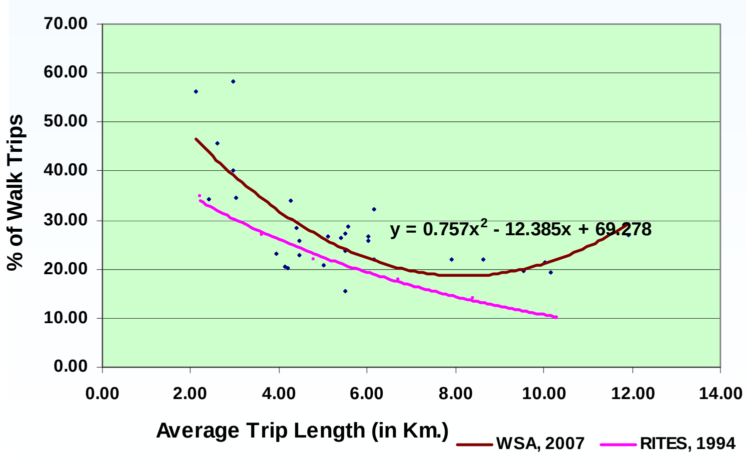


Figure 5.7: Relationship Developed for Share of Walk Trips Vs Trip Length

5.5 Generic Relationships

Speed- flow curves on relationships between traffic flow and speed have been establised for different link types. These curves have been developed with data across cities and hence can be used for any urban area in India. The curves are presented in Figure 5.8. These relationships are for running speed (not for journey time) and directional flow.

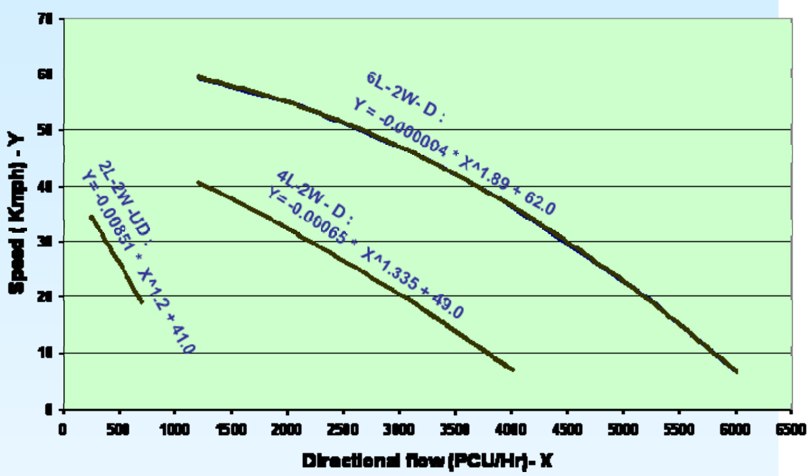


Figure 5.8: Speed- Flow Curves

Attempt has been made to develop a relation between various trip parameters and variables such as population, shape factor, slum population, available bus fleet, etc.

Eqn. (1): Trip length (Kms) = 0.0476* X1 + 4.7726* X2

Where,

X1- Population in lakhs and

X2- Shape factor of the city, which is calculated as the ratio of Minimum Spread of the city (in Kms) and Maximum Spread (in Kms)

Eqn. (2): PT Share (%) = 0.00949* X1 + 0.18218* X2

Where,

X1- Bus supply/ lakh Population and

X2- Slum population in % (a proxy variable for lower income households)

Eqn. (3): IPT Share (%) = 0.000088 * X1

Where,

X1- IPT vehicle population/ lakh Population

Eqn. (4): Walk Share (%) = -0.0025* X1 + 0.3961*

Where,

X1- Trip length (km) and

X2- Shape factor

Eqn. (5): Cycle Share (%) = 0.200* X1 + 0.150* X2,

Where,

X1- Slum population in % (a proxy variable for lower income households) and

X2- Shape factor

5.6 Urban transport Investment needs

An assessment of investment for urban transport sector of the country is made. The 87 cities identified in the study is classified into four categories for the investment requirements.

Transport infrastructure requirement for the next 20 years for each city categoty is derived separately. The objective of the interventions in small and medium cities is to enable smooth and safe traffic flow and prevent a decline in the use of non-motorised modes. This could be possible by ensuring that travel by non- motorised modes to continue to be safe by proper NMT management, improvement/development of urban roads, various traffic management measures, implementation of bus transport along major corridors for cities without PT currently and augmentation of bus services for cities having PT in the next 20 years is essential. Larger cities would need largely the same interventions as small/medium cities with the diference that these cities have to plan for medium to high capacity mass transport systems and terminals.

Total Investment Requirement: The total urban transport investment requirements for the 87 cities is estimated as Rs. 4, 35, 380 Crores. The summary of the investment is given in Table 5.2.

Table 5.2 Total Urban Transport Investment Requirements for the identified 87 cities

Category	Rs. in Crores
Cities in the population range of <5 lakhs	9,800
Cities in the population range of 5- 10 lakhs	70,700
Cities in the population range of 10- 40 lakhs	2,17,200
Cities in the population range of >40 lakhs	1,37,680
Total	**4,35,380**

Investment Phasing: The estimated investment of the urban transport sector is phased in four equal periods of five years. The phasing of the proposed investments is presented in Table 5.3.

Table 5.3: Phasing of Urban Transport Investment

Category	Rs. in Crores	%
2008-2012	1,57,020	36
2013-2017	1,34,880	31
2018-2022	80,050	18
2023-2027	63,430	15
Total	**4,35,380**	**100**

5.7 Institutional Framework

The proposed heavy urban transport infrastructure investments needs proper guidance, planning, sustainability, adequate provisions for their maintenance and safeguard. Apart from the required fund, adequate expertise and proper institutional mechanism to implement the urban transport infrastructure is the basic requirement. The following suggestions are made for the proposed institutional framework:

- Priority for UMTA implementation
- Developemnt and management of Central Urban Transport Database
- Strengthening of Institutional setup
- Development of urban transport software library
- Clearing house for new technologies / major projects / projects involving different agencies in urban transportation.

5.8 Key Policy Suggestions

The central policy suggestions that have emerged from the present study are;

- **Focus transport Supply in the Mass transport domain:** There are a number of pointers in the data and analysis that we have carrried out that indicate that Mass Transport will be the only way forward. Be it in the form of Buses, BRT's, Monorails, LRT or Metro Systems. A few transport indices such as Congestion Index and Safety Index have performed better in cities with Public Transport Services. It must be noted that many cities in India have no public transport. Before we embark on the implementation of larger mass transport systems, there must be an effort to first ensure that bus systems are in place and the city bus index stands satisfied.
- **Serious attention is to be given to NMT:** With the environment friendly NMT declining, our cities are losing sustainability and it is imperative that this trend is reversed. 40% of todays trips in cities are by NMT and 25% of all fatal accidents involve NMT. Yet we have not focused on the much needed infrastructure to aid these modes.
- **Set up a Dedicated Transport Fund:** This study has established that urban transport needs a huge investment. It would be important to consider a dedicated transport fund to be established to meet this demand.

- **Give a thrust to TSM/ITS:** The accident information collected at the city level clearly indicate very unsafe conditions in our cities. In almost all cities, traffic is mismanaged and road networks are being put to suboptimal use.
  - To optimise the present infrastructure, traffic system management to be given immediate priority as this yields very high benefits with relatively low costs and will improve safety.
  - Wherever possible efforts on Transport Demand Management have to be pursued to ensure that optimal use of infrastructure is made.
  - There is ample evidence in other parts of the world that ITS brings about significant improvement in network efficiency. ITS must be seen as a way forward in improving traffic conditions in our cities.
- **Create a National level Database:** The virtual lack of a database on urban transport statistics has severely constrained the ability to formulate sound urban transport plans and reliably assess the impact of the different initiatives that have been taken. As a part of this study most of the data had to be recreated. It is essential to develop a Central Urban Transport Database. Necessity of creating a national level institute that would build up a database for use in planning, research, training, etc in the field of urban transport is brought out in the National Urban Transport Policy also.
- **The Institutional setup needs to be strengthened:** If the identified investment has to be utilised properly, a Transportation Authority needs to be set up at the city level and a Clearing house for new technologies / major projects needs to be in place at a central level.
- **Develop transportation plans in conjunction with the Land use Development Plans:**

- A demonstration of the benefits of this has been carried out as part of this study which clearly shows the importance of Transit Oriented Development. We must post haste start the process of conducting land use plans along with transport plans. The terms of reference for both these components should be one.

- The transportation scenario witnessed in urban areas is changing drastically. The differences between the 1994 study and this study suggests that if proper tracking of these changes have to be made to take suitable remedial action in time, it would be necessary to conduct updates once in 5 years atleast. It would be suitable to carry out Comprehensive Mobility plans at a city level once in 5 years so that the data from these can be used to update the overall transport strategy also once in 5 years.

Way Forward

Tremendous amount of data has been collected which has to be continued to be put to good use. This data can be used for other transportation projects and research.

Transportation models calibrated under this study can be used for preparation of CMPs with little additional inputs which will then cut down duration of CMP preparation for the 30 selected cities.

Relationships developed for modeling including speed-flow curves, can be used to obtain strategic results for any city in India.

For the equitable allocation of funds, one could use the transportation indices effectively as they serve as comparative measures between cities. Also cities can be asked to improve a certain index before they can obtain or apply for a particular fund.