Sustainability, Safety and Low Carbon Transport in Urban India

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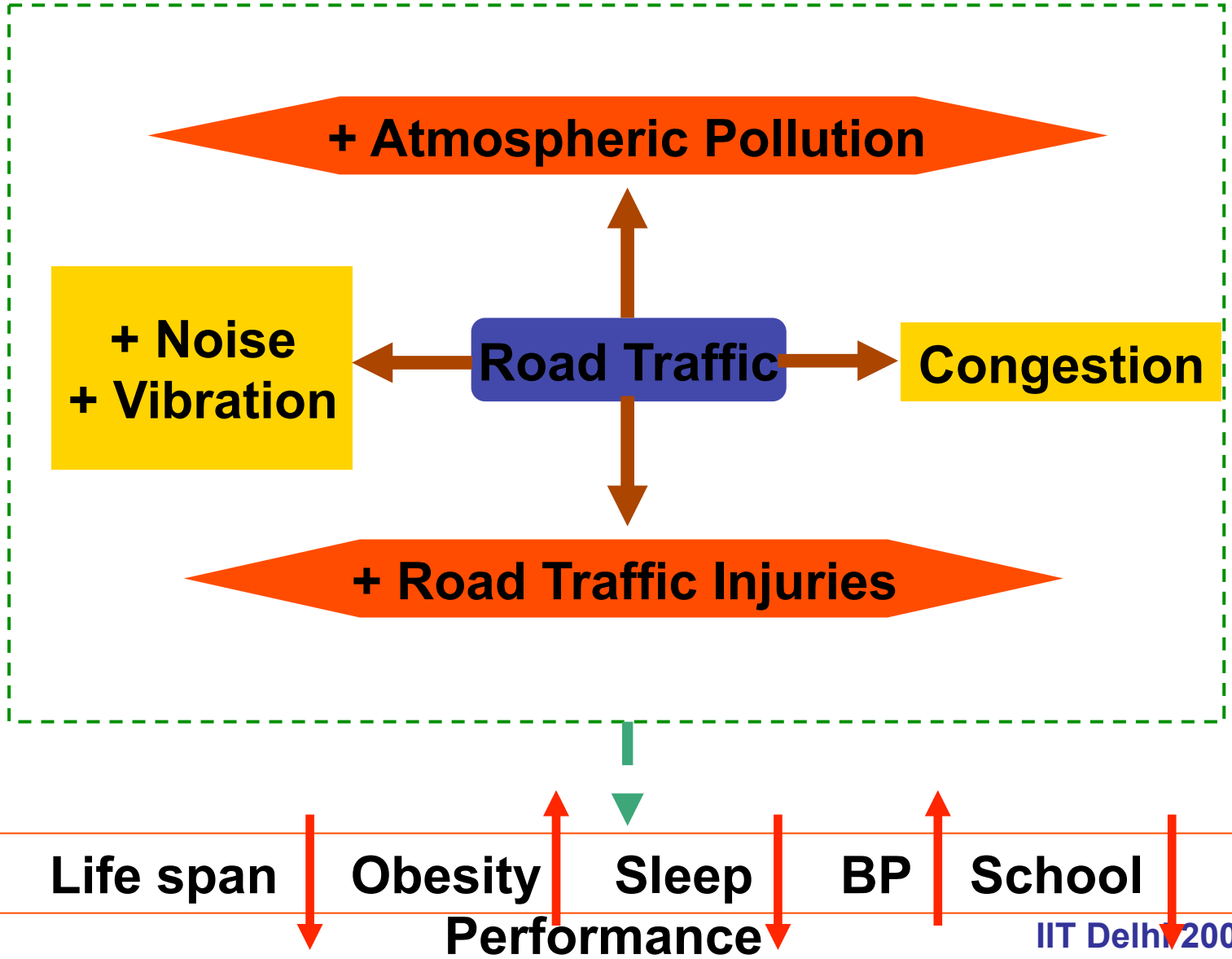
Sustainable Transport

Organising transport such that the consumption of energy , environment and land does not endanger the opportunities of future generations to reach at least the same welfare level as those living now.(Scarce resources)

Access to goods and services for all inhabitants of the urban area

Global concern of Co2 and local health concerns

Road Transport – Problem Diagnosis



Urban Transport in India
&
sustainability concerns

Urban Transpot

Patna

Rickshaw policies?

Jaipur

Three wheelers paratransit?

Hyderabad Two wheelers/three wheelers?

Lucknow Rickshaws,cycles peds?

Modal Share trends1990-2004

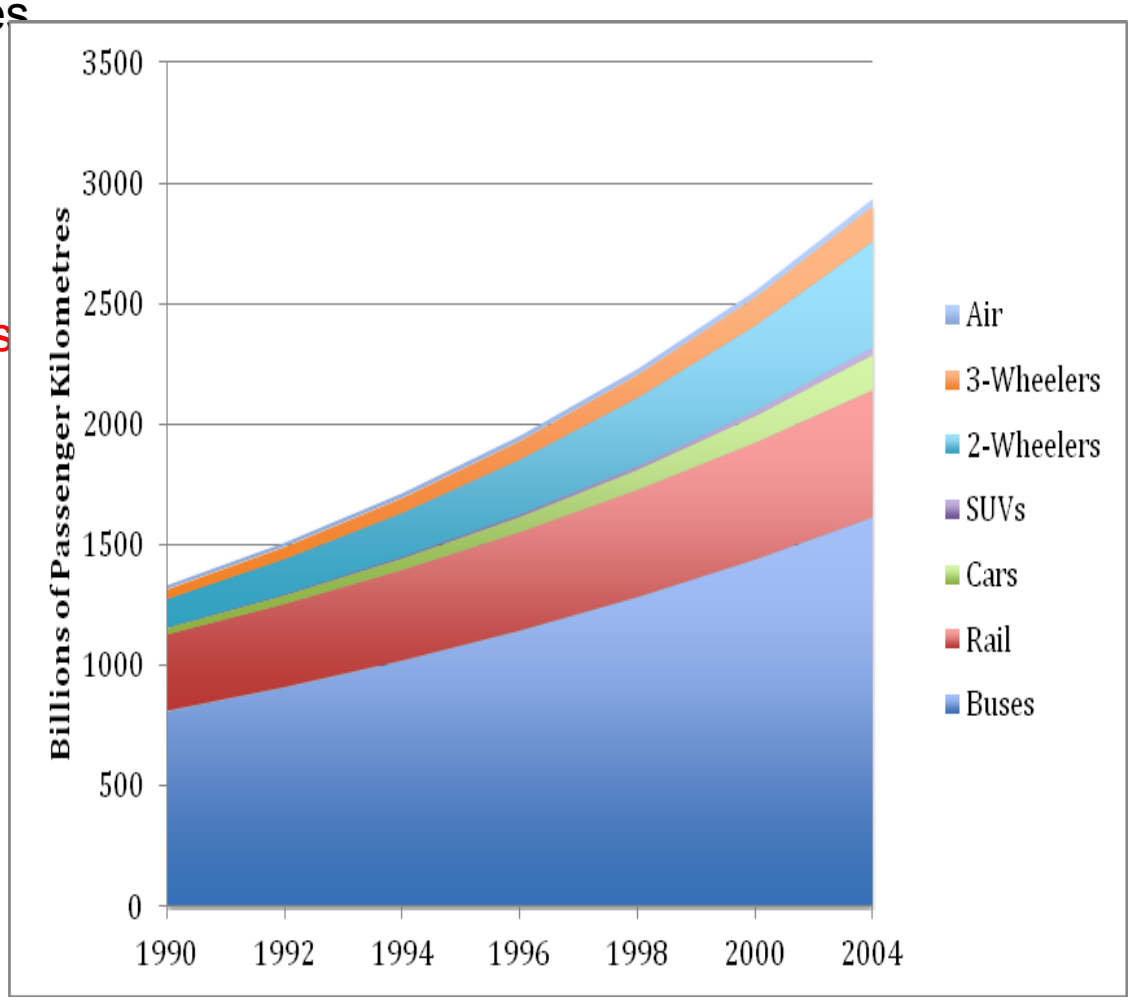
Passenger km travelled by buses dominate

Cars and two wheelers show high growth rate

MTWs and cars (including SUVs MPVs etc.) contribute between 60% and 90% of the transport GHG emissions and support about 29% of trips,

bus-based public transport supports about 27% of trips and contributes between 3% and 21% of GHG emissions

non-motorized (pedestrians, cyclists and cycle-rickshaws) modes support 39% of trips without any emissions



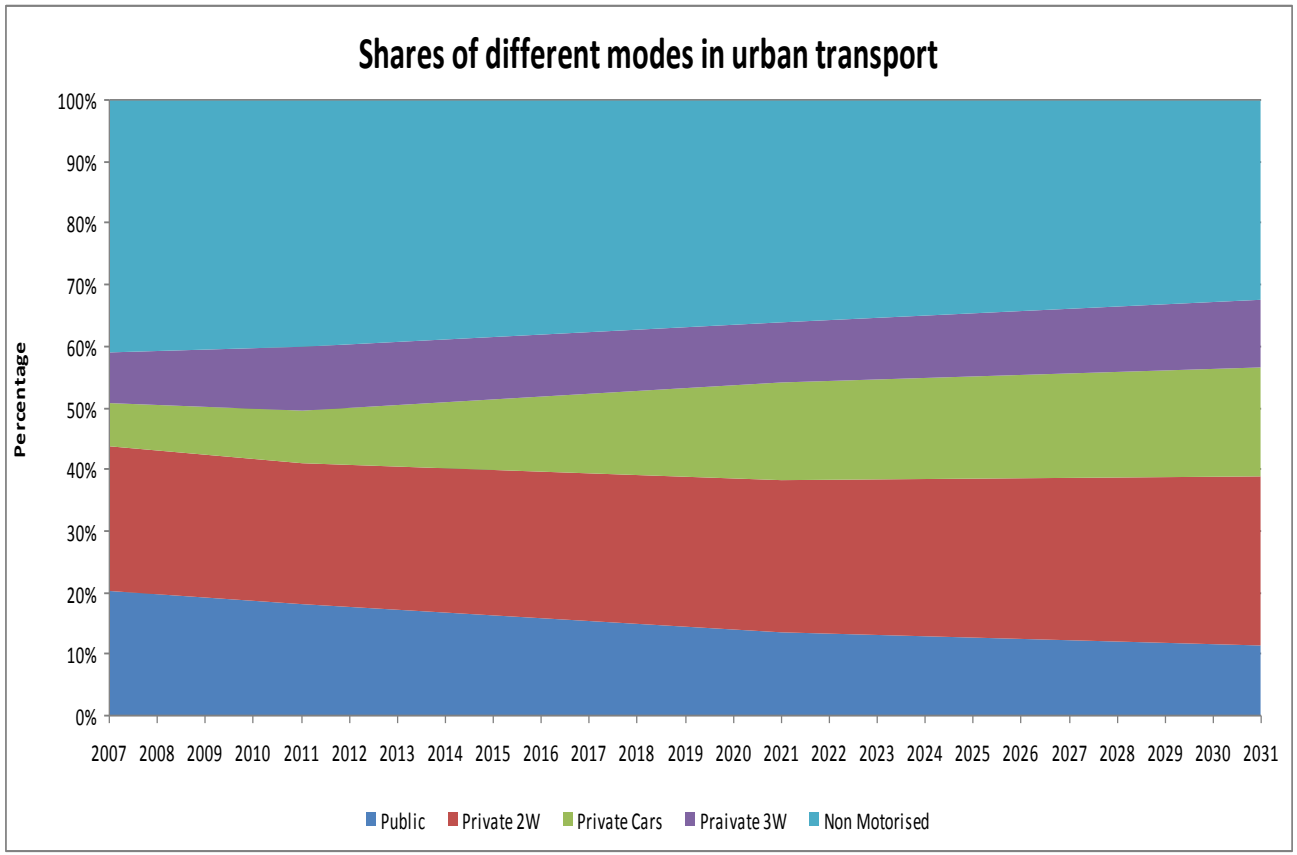
Modal share trends in BAU 2007-2031

BAU: Road expansion in cities

investment in rail based public transport

Bus and NMV share expected to decrease (~25% & 30%)

Car and two wheelers expected to increase (~20% and 25%)



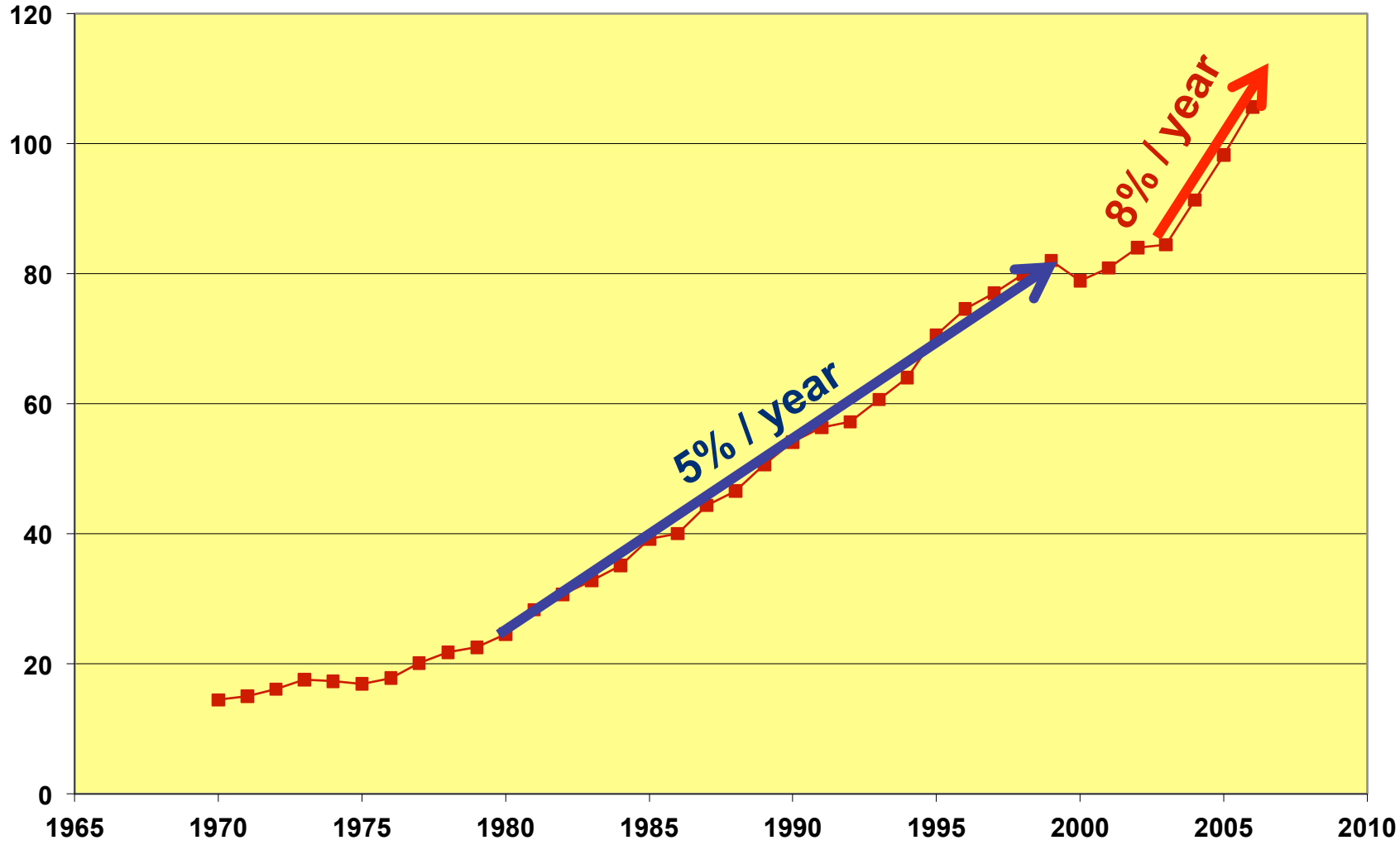
TRIP

Does the modal share trend meet sustainability criteria?

Local Health concerns?

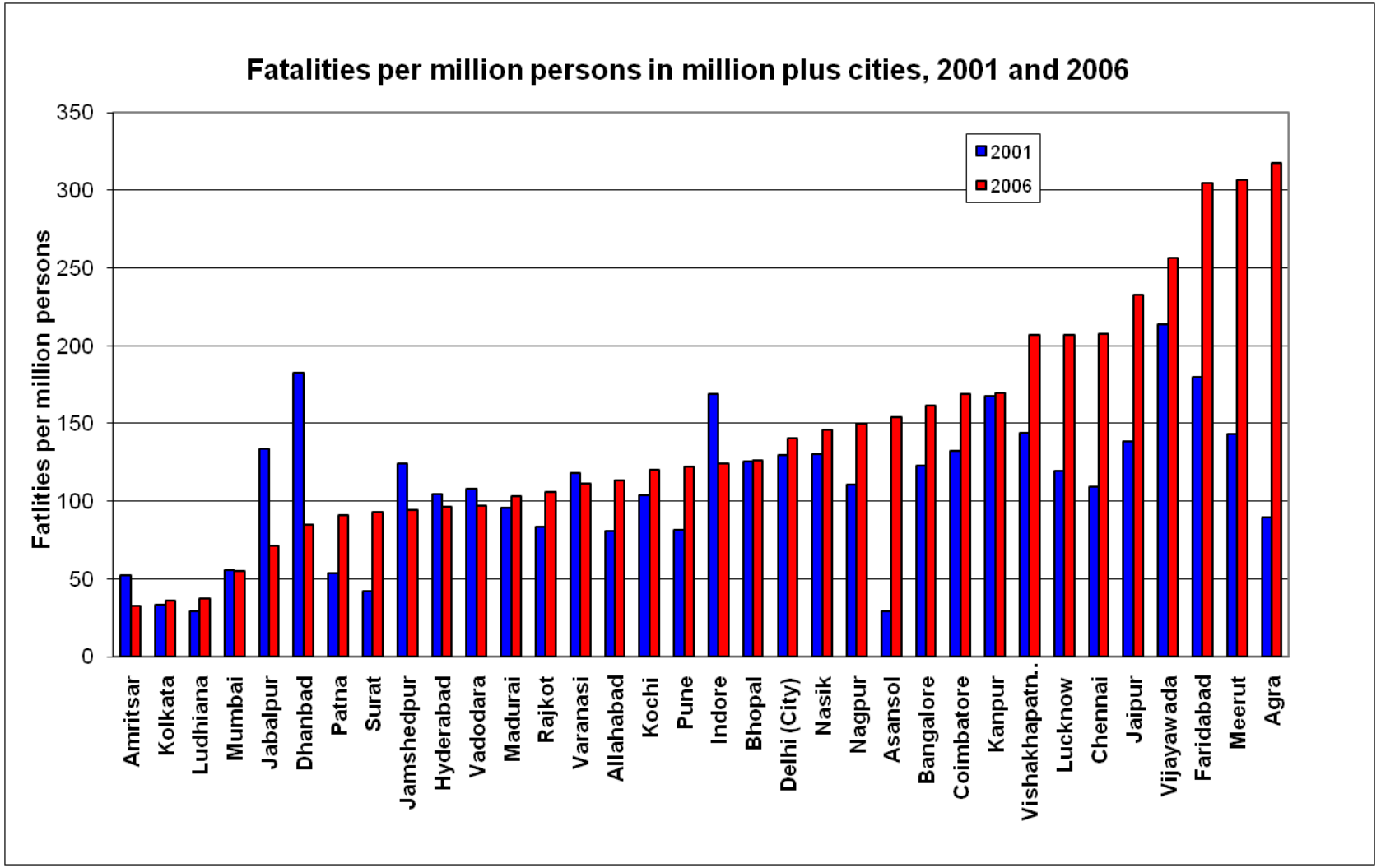
Global CO_2 Concerns?

Persons killed in road traffic crashes in India, thousand

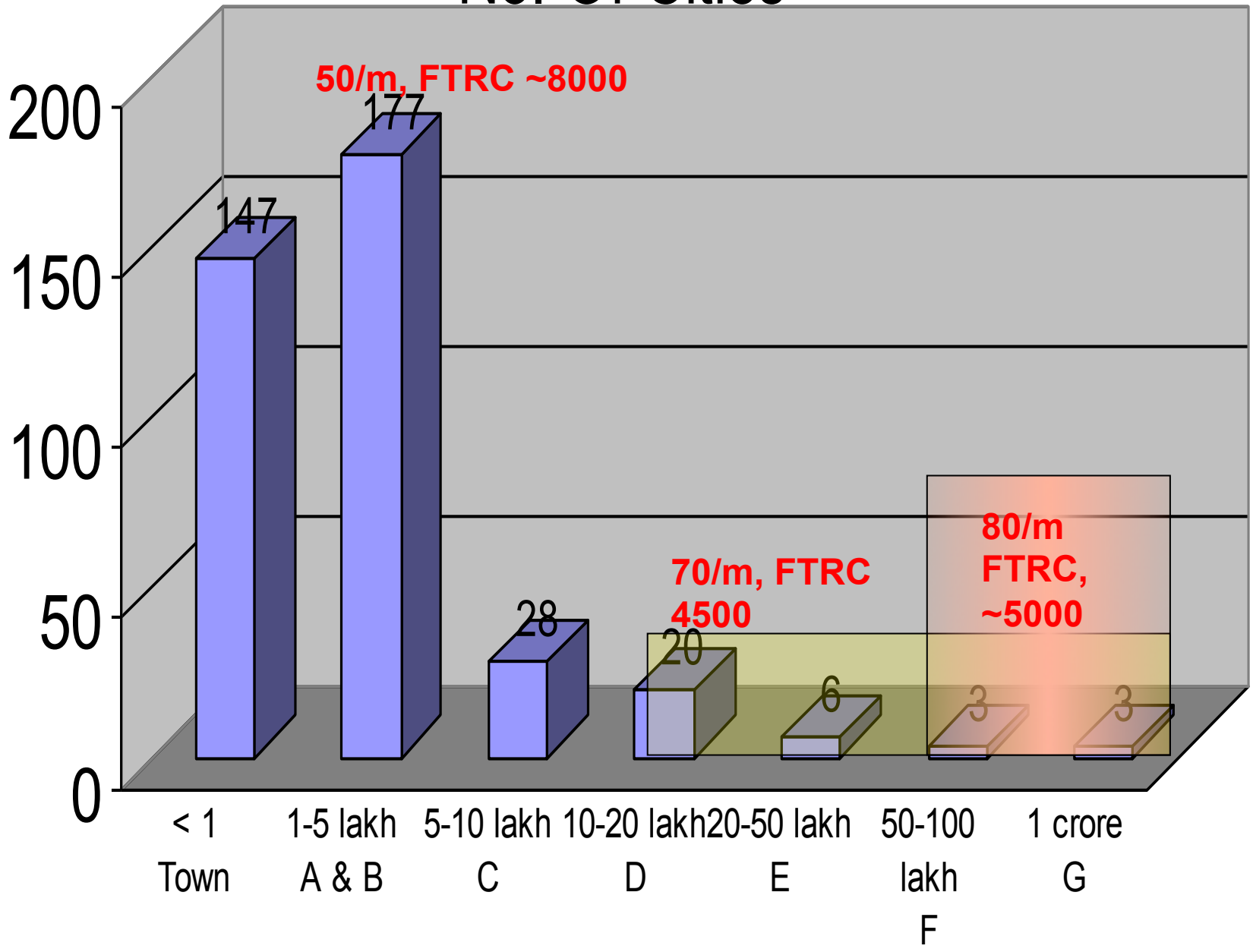


Source: NCRB, 2007

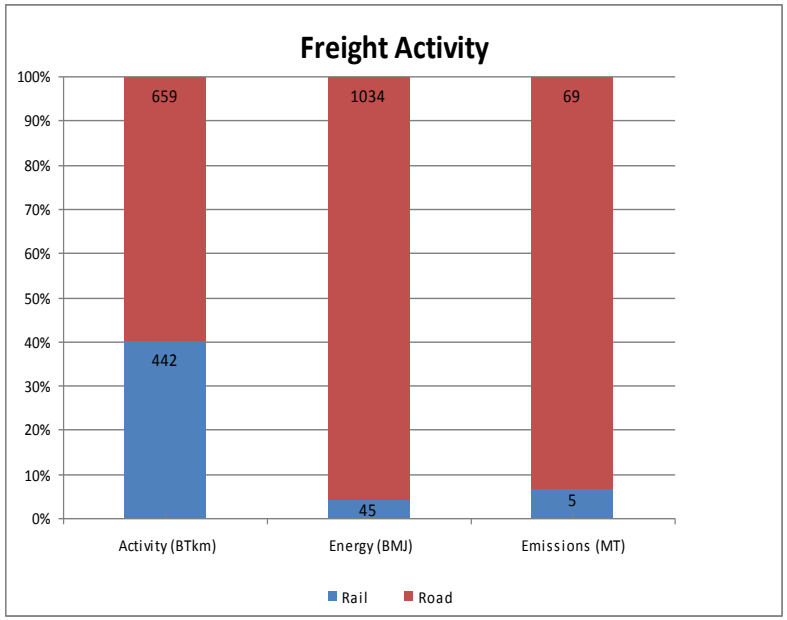
Estimated 1,650,000 hospitalised in 2006

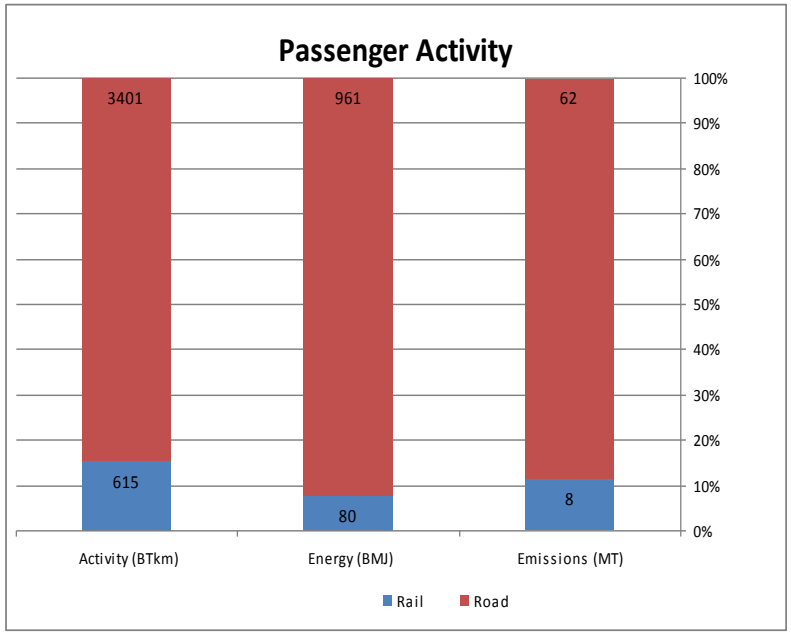

Fatalities per million persons in million plus cities, 2001 and 2006
Fatlities per million persons
350
300
250
200
150
100
50
0
2001
2006
Amritsar
Kolkata
Ludhiana
Mumbai
Jabalpur
Dhanbad
Patna
Surat
Jamshedpur
Hyderabad
Vadodara
Madurai
Rajkot
Varanasi
Allahabad
Kochi
Pune
Indore
Bhopal
Delhi (City)
Nasik
Nagpur
Asansol
Bangalore
Coimbatore
Kanpur
Vishakhapatn..
Lucknow
Chennai
Jaipur
Vijayawada
Faridabad
Meerut
Agra

Fatalities in Indian Cities(~ 18000/year)



GHG from Transport sector in India





- Transport is one of the largest contributors to GHG emissions and it is increasing
- Road transport dominates carrying 60% freight and 85% passenger

Heterogeneity within Urban Areas

City category (population in million)	CO_2 tons/ person/ year	ratio of CO_2 tons/ person/ year wrt megacities	Total no. of cities	% of Total population in different cities	CO_2 tons/ year	% of total CO2 emission in different cities
1(<.5)	0	1073.5	4208	53	3983350	0.2
2(.5-1)	0.05	6.5	39	10	1575900	6.4
3(1-2)	0.09	3.5	22	10	2196706	11.7
4(2-4)	0.07	4.6	6	6	1456916	5.2
5(4-8)	0.12	2.8	4	8	2634193	12.3
6(>8)	0.34	1	3	15	11218937	64.2

Large cities(> 8 mill.) have 15% population and contribute 64% of CO2 emissions, .34 tons/person/year, 1000 times more than the smallest category cities (53% population)

Medium size cities(2-4 mill.) have 14% population, CO2 emission 3-4 times less, high growth rate in private motorised trips

Small cities(.5-2 mill) are dependent on paratransit modes (motorised and non motorised)

Comparison with sustainable city

	car	Motor cycle	Public Transport	Walk Bicycle	Taxis
Delhi	8	14	38	40	6
Stockholm county	52	NA	45	4	3
Indian cities 2031	20	25	15	30	10

Use of personal vehicles in stockholm is 2.4 times of Delhi
NMV is 10 times more in Delhi
PT is 15% less in Delhi, taxis 2 times more than Stockholm

2031 BAU in Indian cities will produce lower CO2 emissions/ person than Stockholm county

What can Delhi learn from Stockholm?

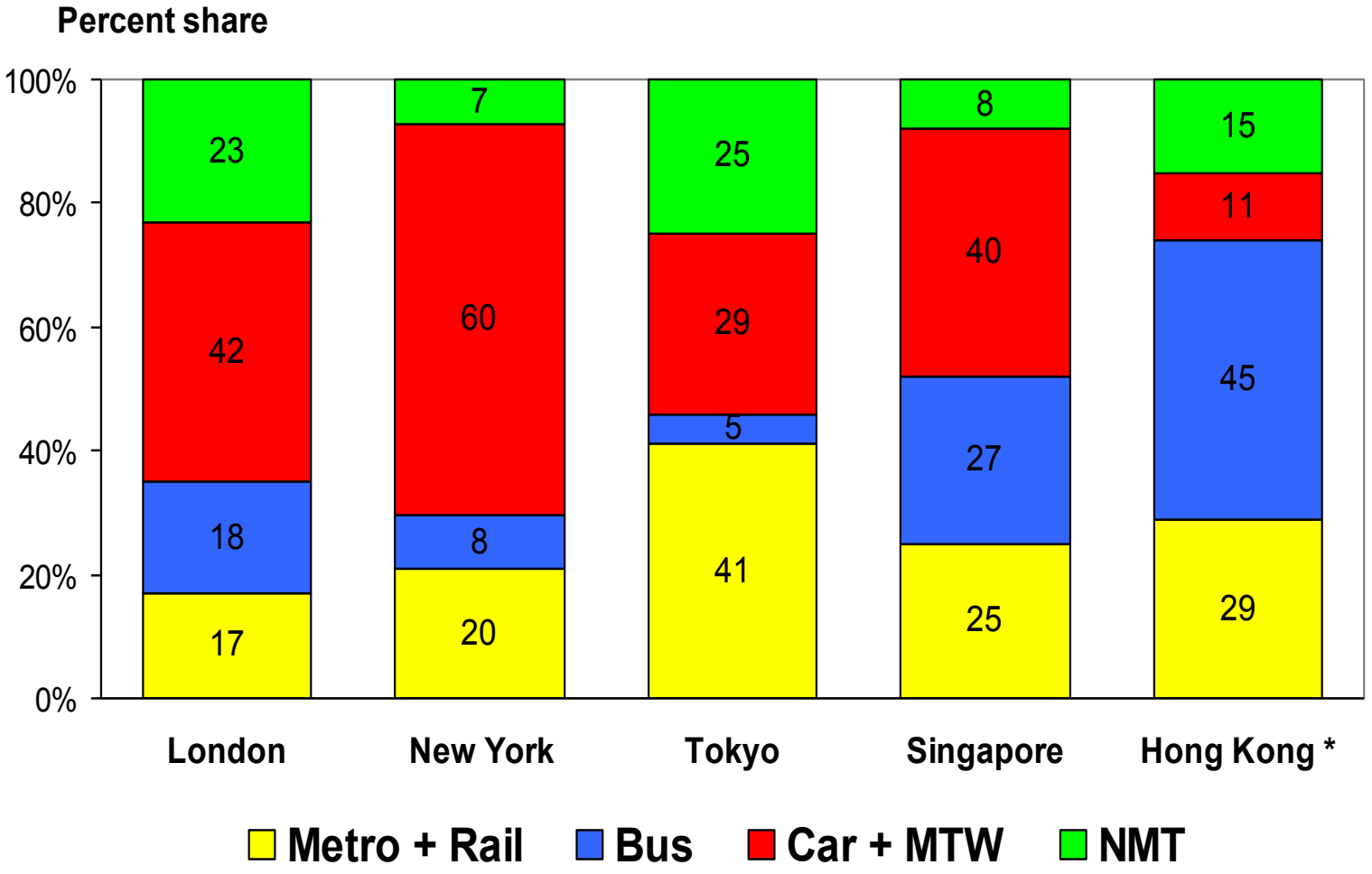
ISSUES

- **"Sustainable" cities in Europe have high car use**

	Modal share, percent		
City	Car + MTW	PT	W&C
Bristol, UK	65	12	23
Leeds, UK	61	36	3
Nantes, France	58	14	28
Helsinki, Finland	54	20	26
Marseille, France	53	12	35
Edinburgh, UK	52	29	19
Newcastle, UK	48	19	33
Brussels, Belgium	44	18	38
Frankfurt, Germany	42	21	37
Stuttgart, Germany	36	25	39
Amsterdam, Neth's	32	16	52

NO INDIAN CITY HAS CAR USE MORE THAN 15%

Travel patterns – old world cities



Improving health worldwide

THE LANCET

Impact on Public Health of Reducing Greenhouse Gas Emissions from Urban Land Transport

Based on :

Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. Woodcock J, Edwards P, Tonne C. et al.

The Lancet: Published Online November 25, 2009DOI:10.1016/ S0140-6736(09)61714-1

Possible Impact on CO2

(woodcock J et al, Lancet, 2009)

London Population 2006 = 7.5m 2030 = 9.0m Delhi Population 2004 = 14.8m 2030 = 26.0m	**London**			**Delhi**		
	Aggregate Transport CO2 Emissions (tonnes)	Transport CO2 Emissions Per Person (tCO2/ person)	CO2 Emissions Reduction on 1990 (%)	Aggregate Transport CO2 Emissions	Transport CO2 Emissions Per Person (tCO2/ person)	CO2 Emissions Increase on 1990 (%)
2006 London 2004 Delhi	9,647,900	1.3	-2.50%	6,146,651	0.4	97%
2010 BAU	9,935,897	1.3	0%	8,268,298	0.5	165%
2030 Scenario 1 BAU	10,381,318	1.2	4.80%	19,550,693	0.8	526%
2030 Scenario 2 LCD	6,480,565	0.7	-39%	17,069,668	0.7	447%
2030 Scenario 3 AT	6,120,306	0.7	-43%	10,458,736	0.4	235%
2030 Scenario 4 ST	3,608,226	0.4	-65%	9,327,207	0.4	199%

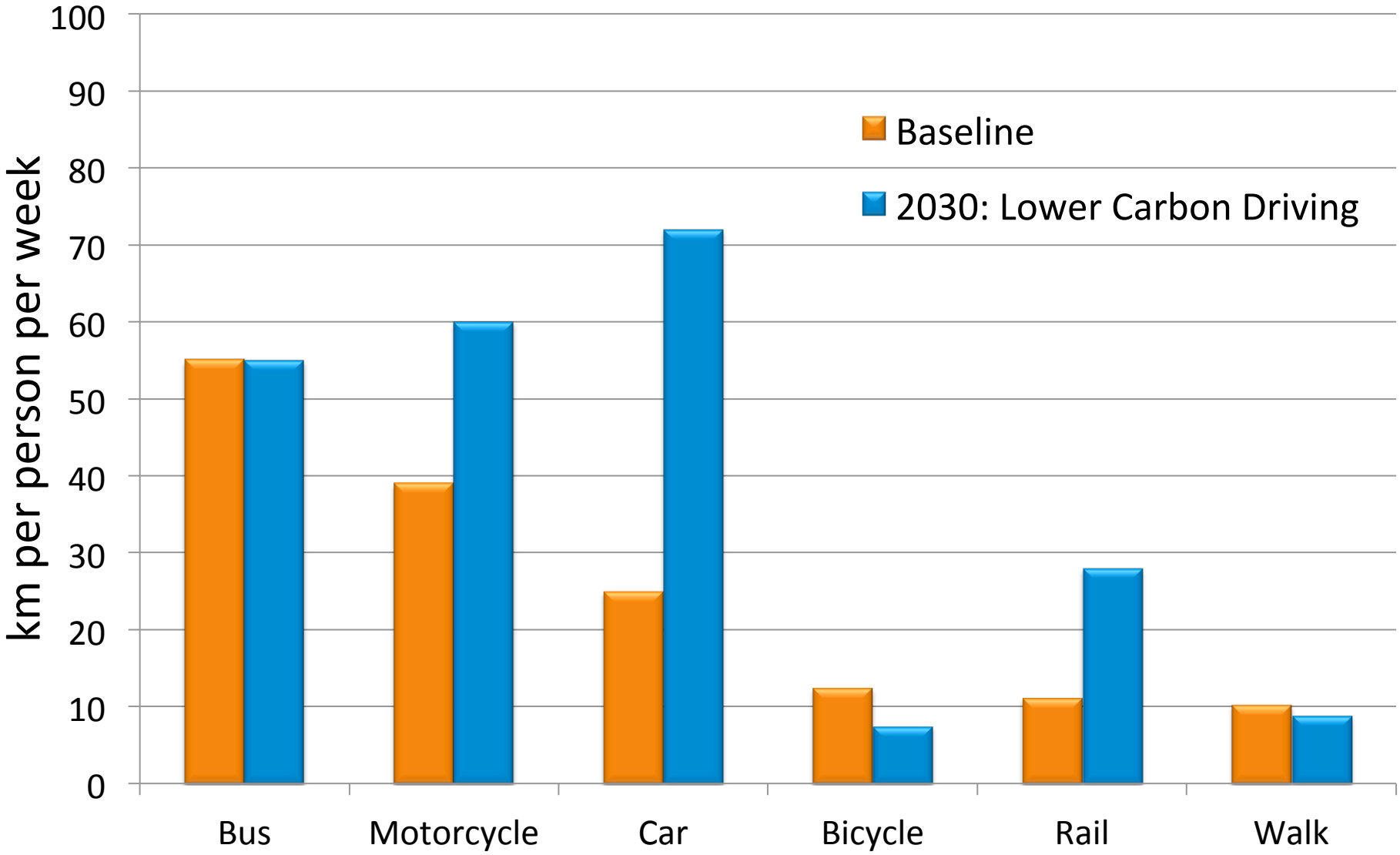
Possible scenarios for Delhi

- **Business as usual scenario:** Projection of existing trends and no coherent strategy to reduce the increase in the use of cars, but ***includes an anticipated increase in rail use***.

- **Lower-carbon-emitting vehicle scenario:** relies on implementation of vehicle technologies along with alternative fuel usage and ***an anticipated increase in rail use.***

- **Increased active travel scenario (walk and cycle):** a reversal of present trends is assumed with a small increase in the distance walked and more than double increase in distance cycled, ***a large increase in rail use*** and small increase in bus use. Policy interventions include substantial investment in infrastructure designed for pedestrians and cyclists rather than for cars, carbon rationing, road pricing, traffic demand management, restrictions for car parking and access, reduced speed limits

Delhi travel patterns

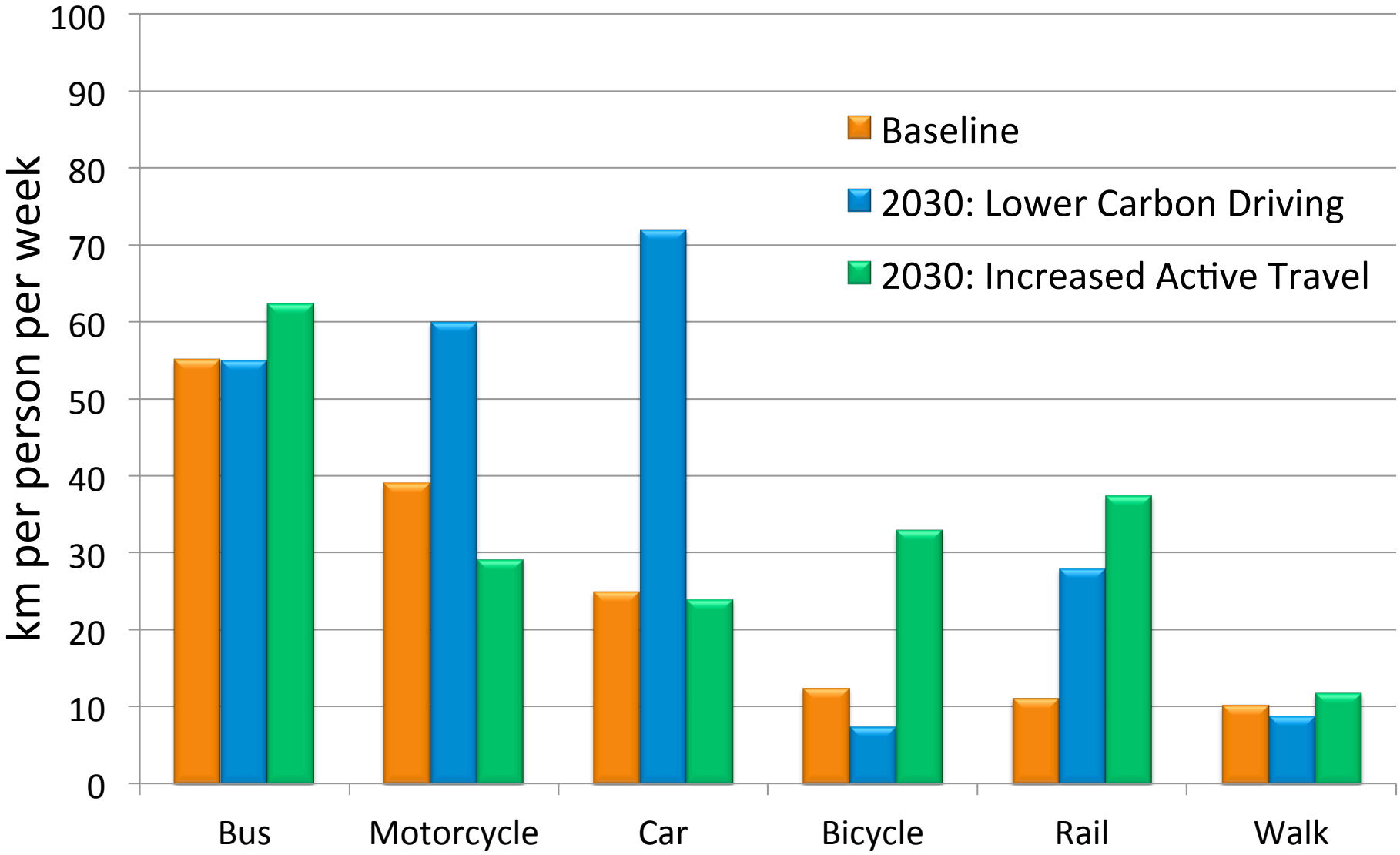


Possible scenario for Delhi cont.

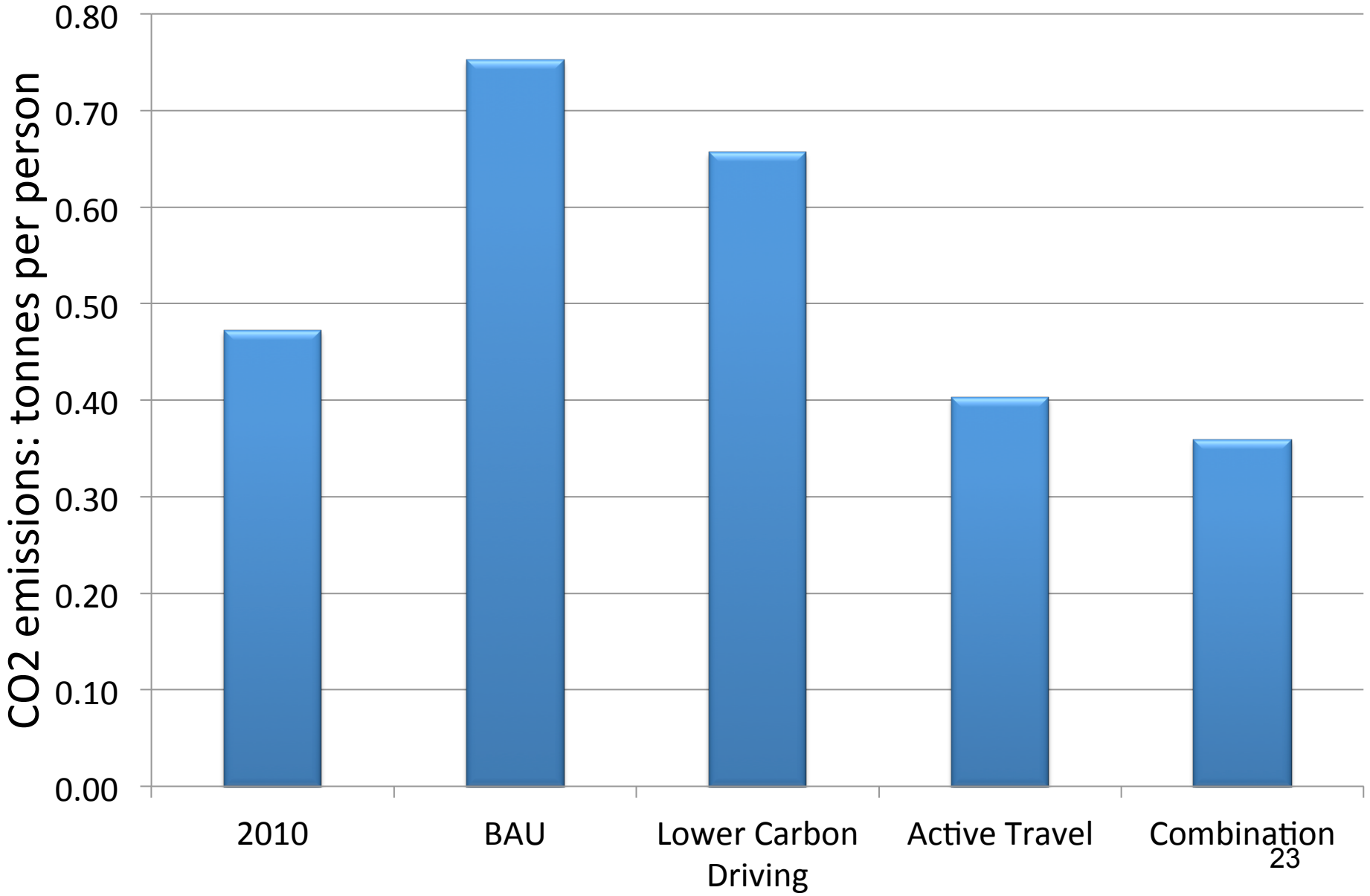
- **Sustainable transport scenario:** lower emissions from motorized vehicle and low car use from active travel scenario. Policy change would require high-intensity implementation and effectiveness of all measures. Further reduction could occur through use of electric vehicles with energy from low-carbon sources; shorter-distance trips; and continued shift from car use to walking or cycling.

- **Short distance active travel scenario**: In this scenario, it is assumed that the same motor vehicle distances are travelled as in the sustainable transport scenario but only half the increase in distances walked and cycled. This scenario represents less travel and shorter travel distances than in the other scenarios.

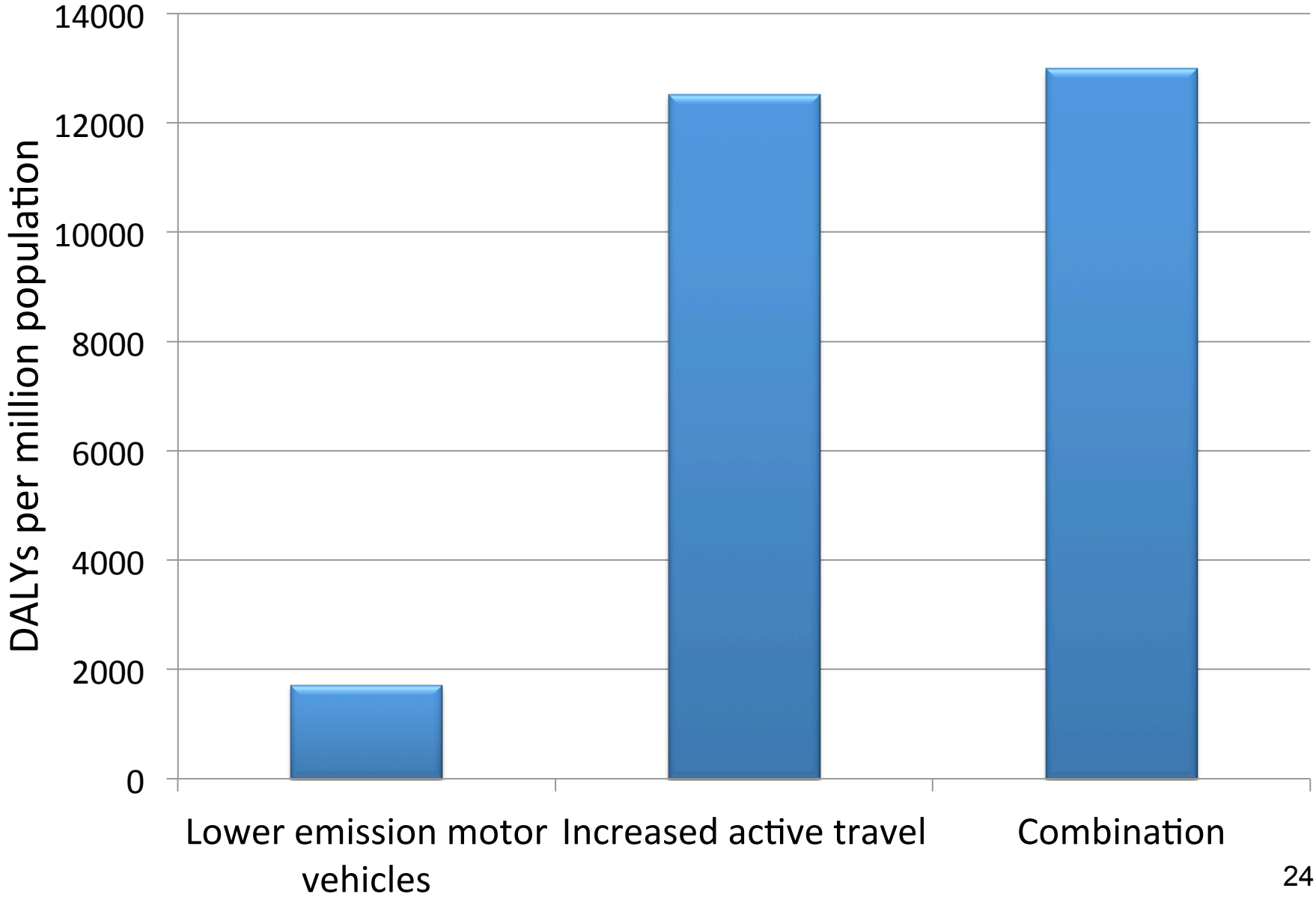
Delhi travel patterns



Delhi CO2 emissions transport



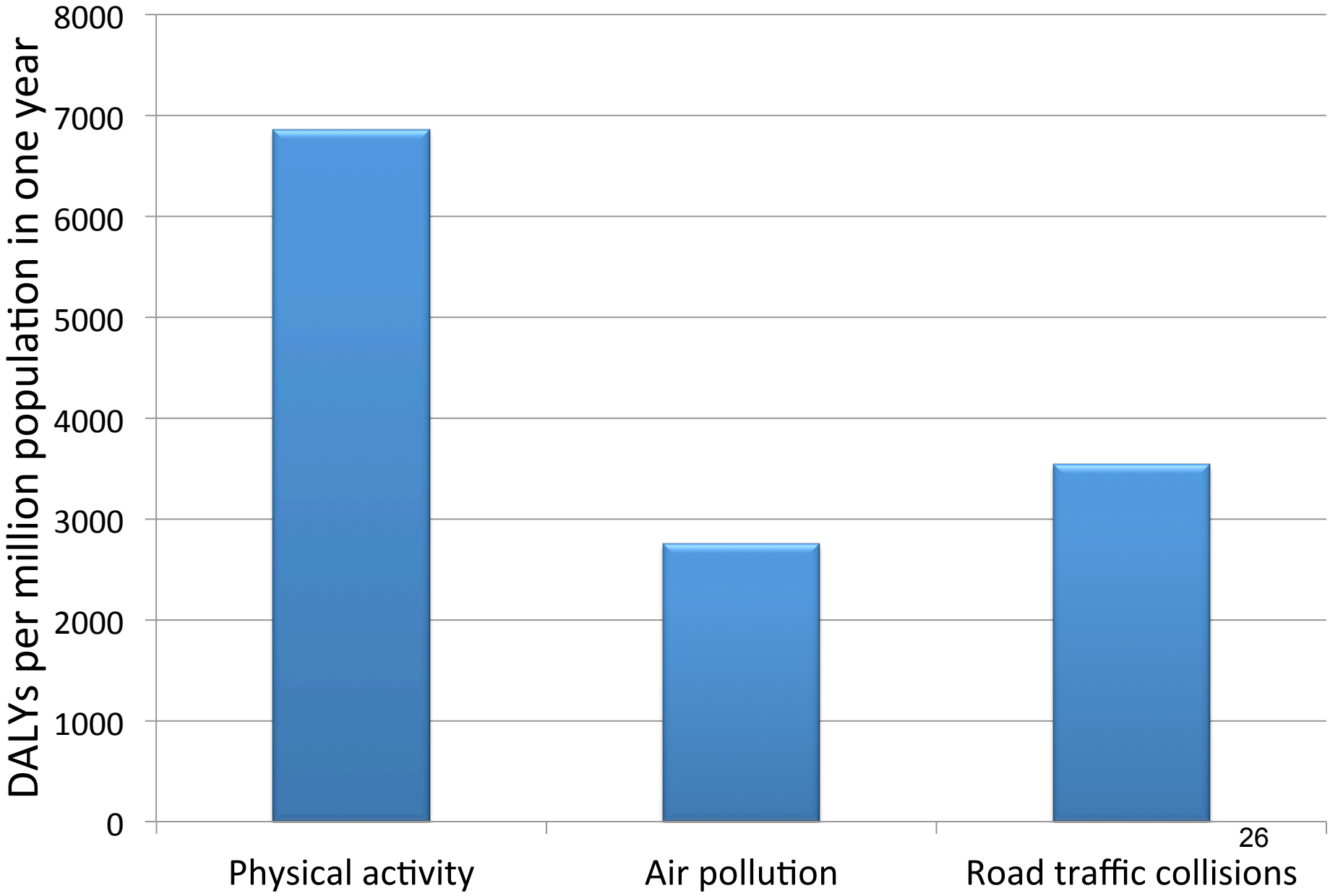
Delhi: Alternative scenarios



Delhi: Health impacts by cause

	Change in disease burden	Change in premature deaths
Ischaemic heart disease	11-25% ↓	2490-7140
Cerebrovascular disease	11-25% ↓	1270-3650
Road traffic crashes	27-69% ↓	1170-2990
Diabetes	6-17% ↓	180-460
Depression	2-7% ↓	NA

Delhi: Health impacts by pathway



Conclusions

- Replacing motor vehicle trips with walking or cycling is a win-win in both developed & developing countries

- Pedestrians and cyclists have the right to direct, pleasant and safe routes

- Restrict motor vehicles:

– speed, road space and convenience

Sustainable cities & transport

- Interaction at three levels:
  - ❑Landuse planning
  - ❑Transport infrastructure
  - ❑Urban design

TRIP

Urban Poor in India

	No. (millions)	%
1987-88	75.17	38.20
1993-94	76.34	32.36
2004-05**	80.80	25.70

Source: Estimates of the Modified Expert Group (Planning Commission 1997).
* Planning Commission's estimates, using the consumption data with 30 days recall period.
** Planning Commission's estimates, using the consumption data with Uniform Reference Period (30 days recall period)

- **Urban population increased at 2.9 percent p.a. (1981 to 2001), & number of urban poor at 0.6 percent p.a (1983 to 2004/05).**
- **85% of the 80.80 million in non-metros**

Urban poor in Delhi

→ Symbiosis between formal and informal sectors

~90% people are employed in unorganised sector(2002)

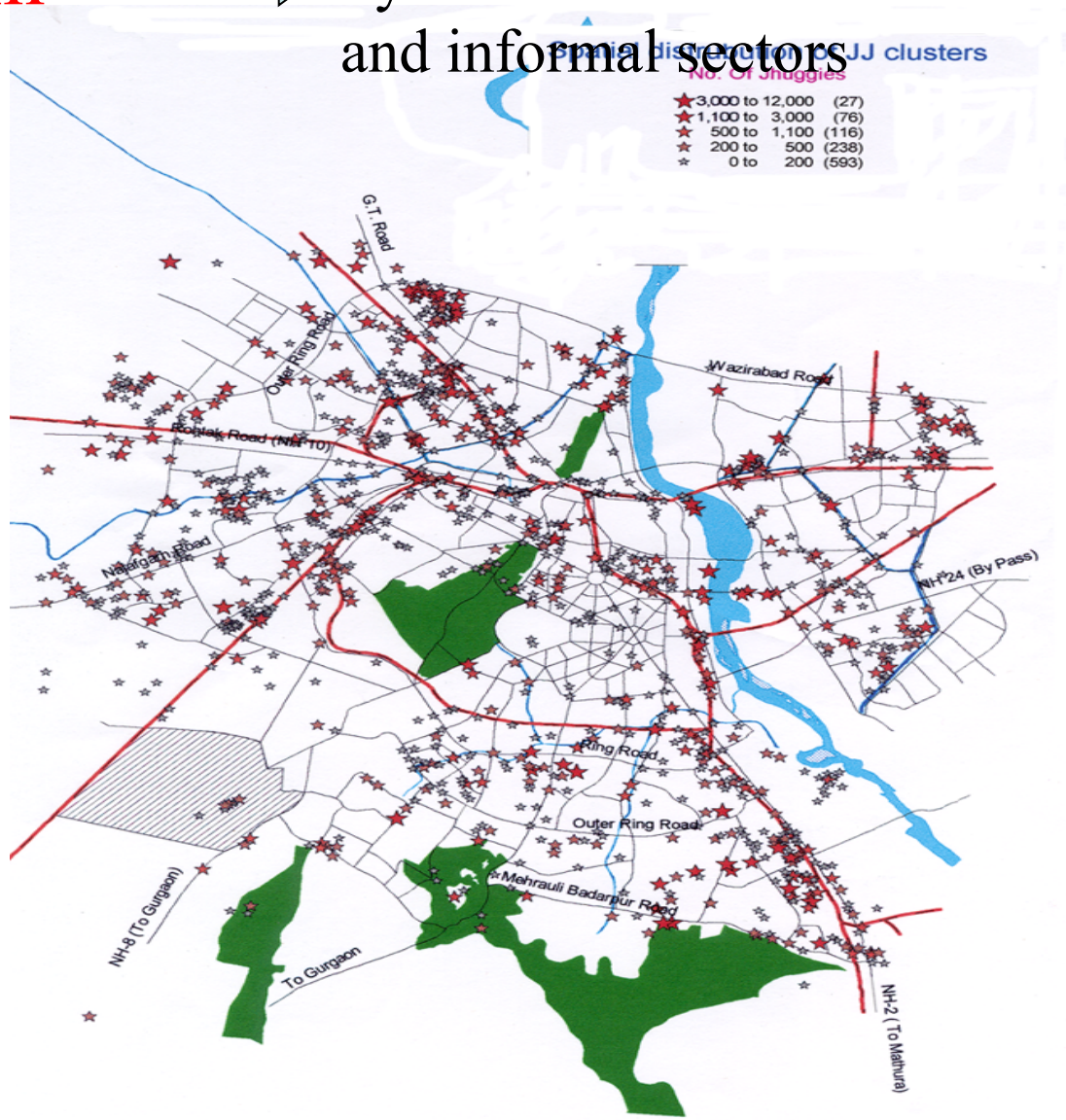
48% unorganised sector is dependent on “own business”- vendors etc.

50% women have daily wage jobs

Women are either domestic workers, self employed, or street vendors.

52% women walk to work

Women have longer work days than men



Distribution of Jhuggi Jhopri Clusters in Delhi

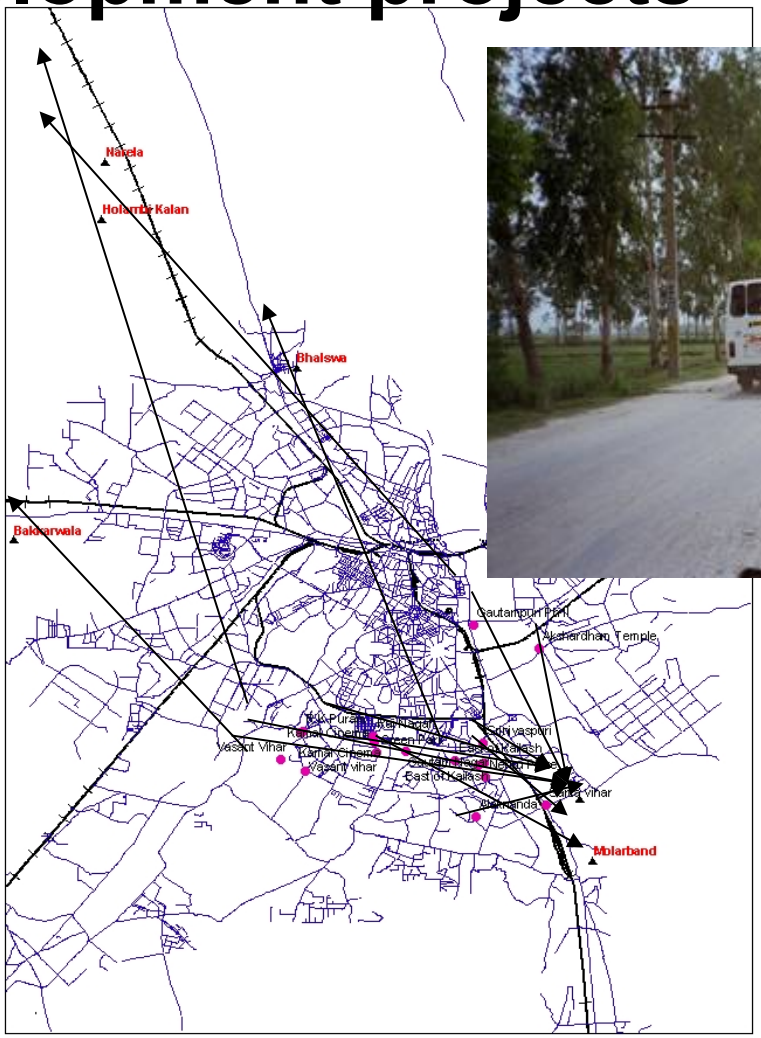
Characteristics of Informal settlements (Urban Poor)

- Location
  - wrt access to employment(formal and informal)
- Activity Planning
  - Combining production and consumption activities
- Space usage
  - High intensity of space usage through multiple use

Large numer of people relocated for metro and other development projects

Converting walking trips tp motorised trips- buses, RTVs, LCVs

Long cycling trips



Time poverty of women increases

Opportunity for “self employed” business reduces

Self planned vs Expert planned

There is significant impact on Accessibility, Mobility and SEWB

The land-use accessibility has deteriorated as distance to education, health services and other urban services has increased for 52%, 63% and 52% of the households respectively.

The transport accessibility has deteriorated even more as distance to bus stop has increased for 72% of the households and the bus frequency has seen an average decrease from 5 min to 63 min (almost 13 times)

Landuse policy can influence the following dimensions to influence urban air pollution (Gwilliam, Kojma. Johnson, 2004):

- **Density** : *policy that increases or maintains the population density*
- **Structure** :*policies that favour the concentration of employment and retail activity*
- **Diversity**:*traditional separation of landuses has become a net source of airpollution*
- **Local Design***: Cities can reduce pollution from short car trips by good design of local facilities for nonmotorized transport*

These address the 'formal'/'planned' sector in cities.

30%-70% urban population remains outside this discussion.

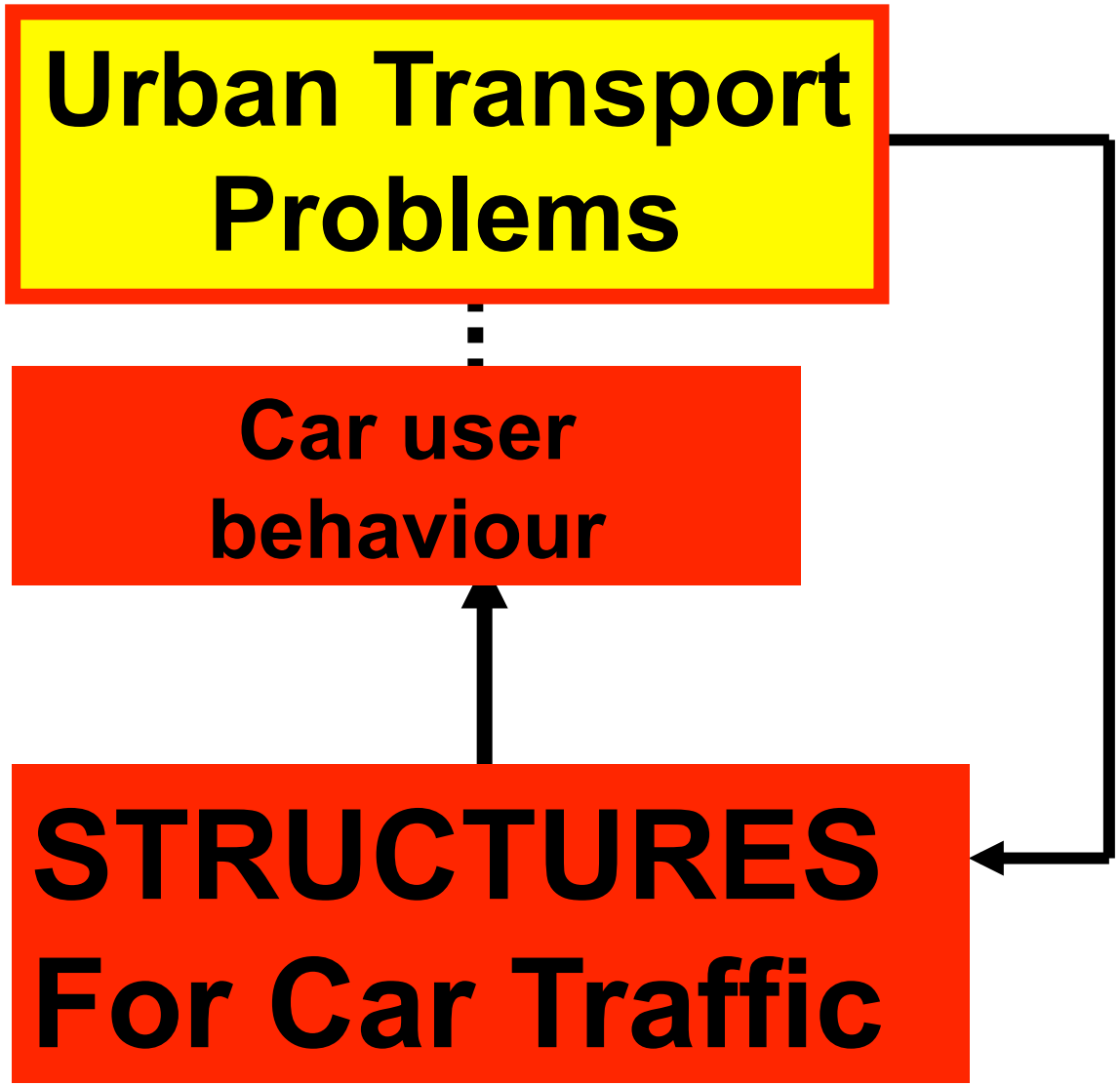
Landuse –transport integration for ‘unplanned’ sector implies:

- **Density** : High rise buildings vs small houses (12-18sqm)
- **Structure** :Monocentric/polycentric vs street vendors
- **Diversity**:mixed landuse vs informal markets
- **Local Design***:* short car trips vs walking/ bicycling trips

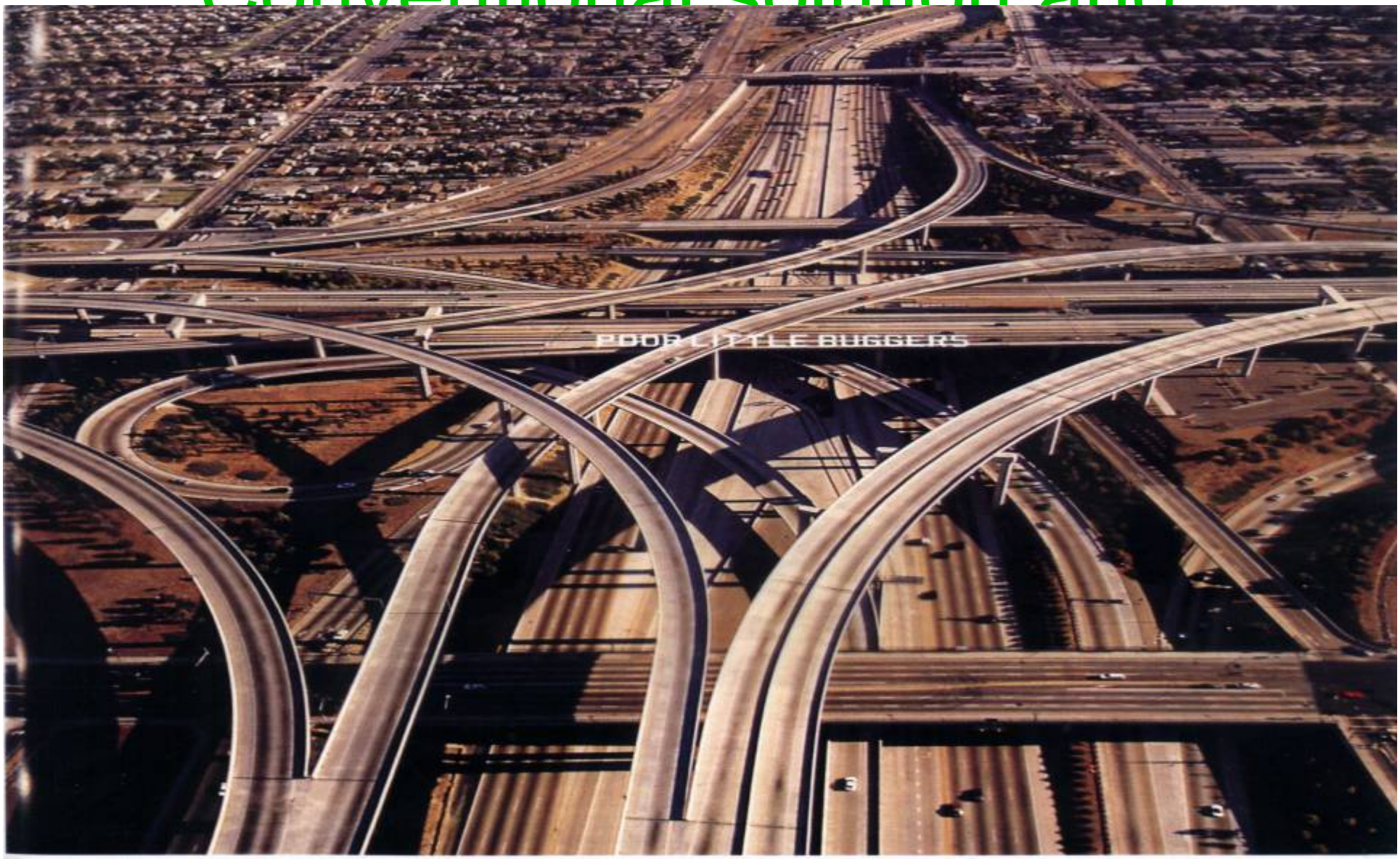
Landuse-Transport integration for sustainable cities

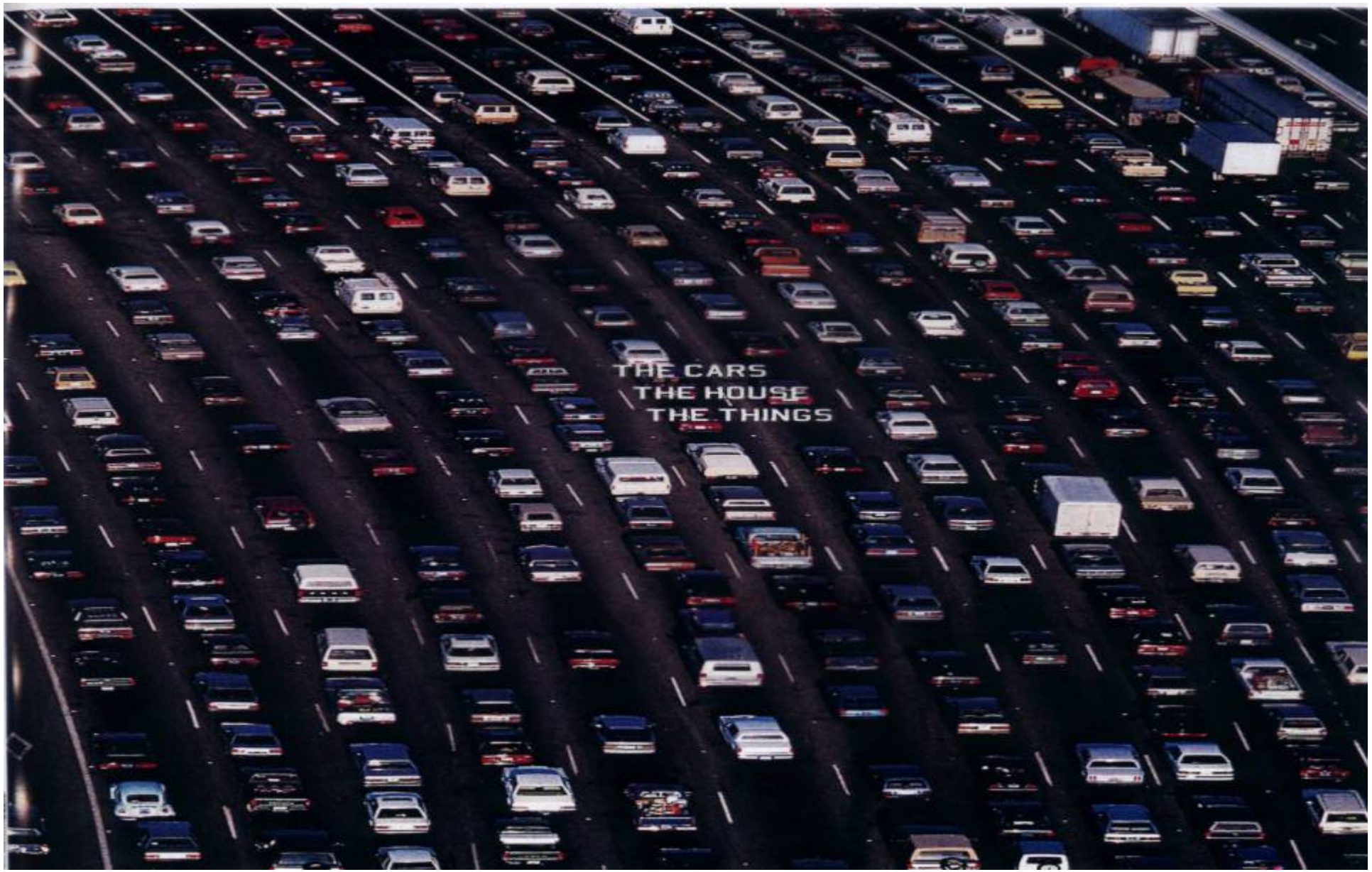
- Integrating diverse socio economic households in master plan
- Street designs and transport system to ensure current and potential walking and bicycling trips
- Lessons- indicators and methods from self organising cities.

HOW TRAFFIC PROBLEMS OF TODAY ARE PRODUCED



Conventional solution and

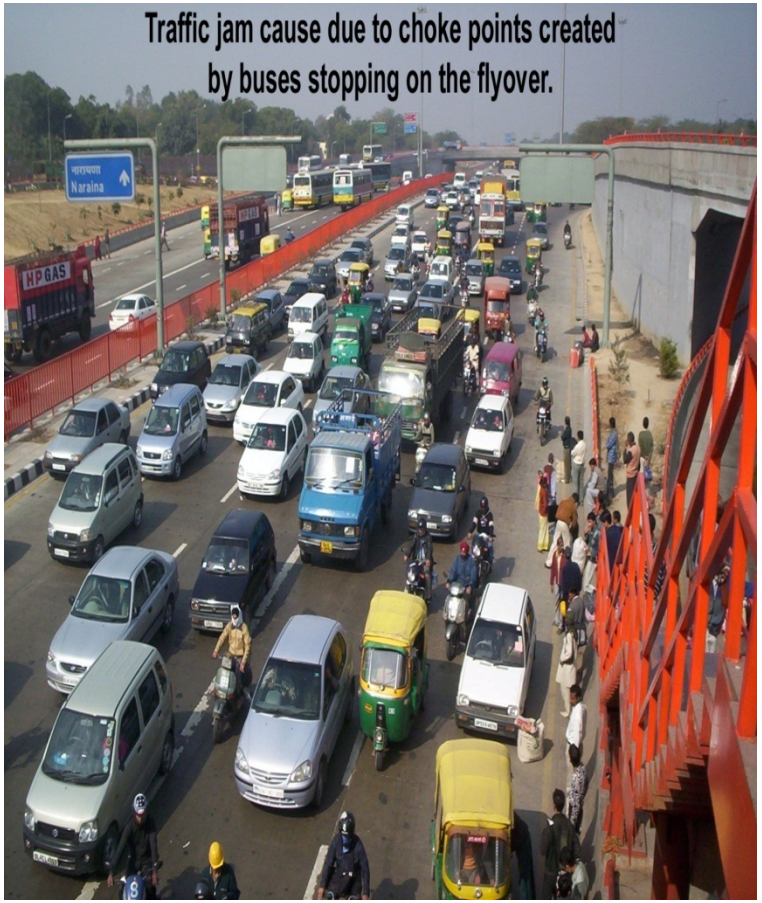



THE CARS
THE HOUSE
THE THINGS

Contrasting Approaches to Transport Planning

The Conventional Approach: Transport Planning and Engineering

- Physical dimensions
- Mobility
- Traffic focus, particularly on the car
- Large in scale
- Street as a road
- Motorised transport
- Forecasting traffic
- Modelling approaches
- Economic evaluation
- Travel as a derived demand
- Demand based
- Speeding up traffic
- Travel time minimisation



An Alternative Approach

Sustainable Mobility

- Social dimensions
- Accessibility
- People focus, either in (or on) a vehicle or on foot
- Local in scale
- Street as a space
- All modes of transport often in a hierarchy with pedestrian and cyclist at the top and car users at the bottom
- Visioning on cities
- Scenario development and modelling
- Multicriteria analysis to take account of environmental and social concerns
- Travel as a valued activity as well as a derived demand
- Management based
- Slowing movement down
- Reasonable travel times and travel time reliability
- Integration of people and traffic

Seoul

Restoration of Cheonggyecheon

Decrease of car-traffic volume : 125,000 veh/day

Before

After(Sep. 2005)

Congestion Solution: Bus exclusive lane

Traffic Condition in Delhi

Only a quarter of city's population own cars; cars and two-wheelers together drive less than 20% of its people -- and yet roads are choked. (Source: CSE)

Courtesy: Flickers

Short term:

Congestion free movement to majority people

Improve safety and convenience of PT users, pedestrians and bicyclists

Move out buses from congestion

Current modal shares can be maintained

(~30:30:30, NMV:PT:PRSVEH)

long term

increase in PT, pedestrians and bicyclists is possible

Guiding Principles

- Road geometric standards from Buses/ VRUs perspective
- Traffic management policies that enable safe mobility of VRUs
- Road side vendors/ informal sector to be viewed as service providers

Components of Infrastructure Design

- Bus lanes
- Bus Shelters
- Intersection Design
- Car or MV lanes
- Cycle tracks and related infrastructure
- Pedestrian infrastructure
- Multi Utility Zone - Spaces for support functions like hawkers
- Provision for services

Pedestrian Bridge ~ 6-8 m high

- increases walking
- distance by 100-200 m
- Discourages use of
- Public transport
- More motorcycles and
- cars leading to
- congestion and high
- risk in off peak hours

Slopes and tactile flooring at the entrance of bus shelters

NON arterial roads and small cities

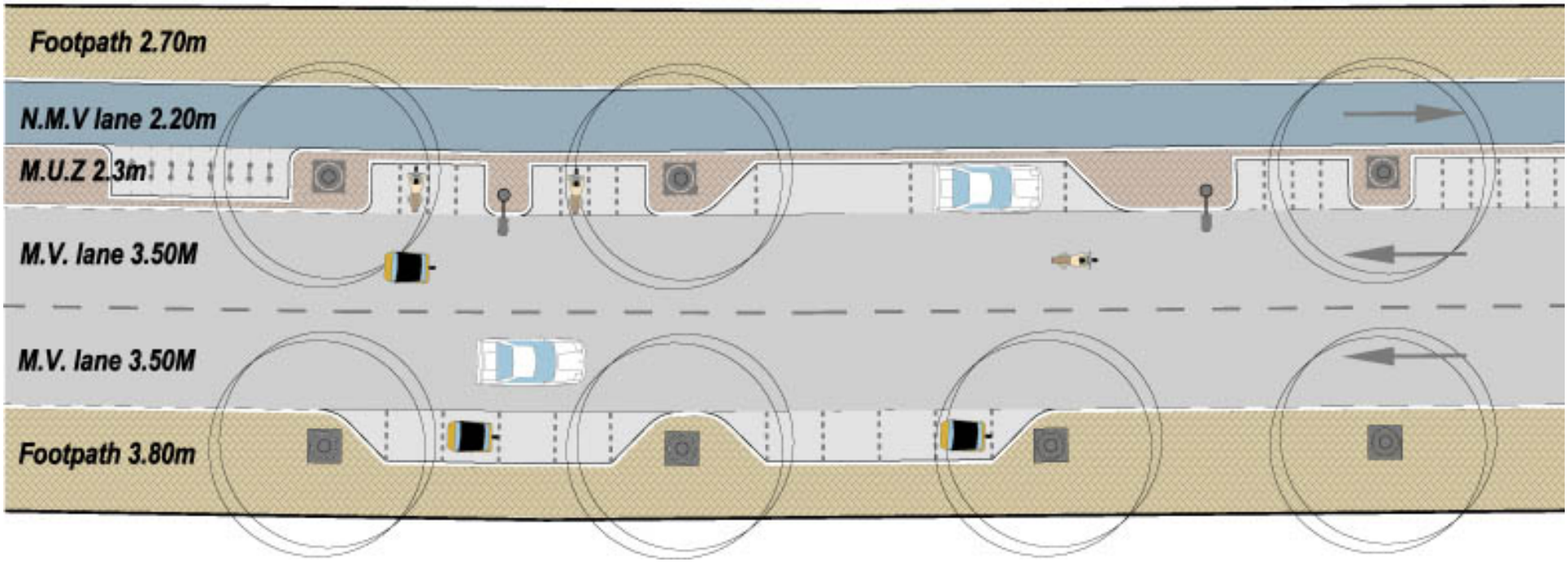
Pedestrians on grade separated junctions

Bus commuters running across the foot of the flyover.

Design- where is the space?

Proposed section

18.0m ROW / One way street / Road no. 8



Plan

Safe accessible bicycle lanes

0 bicycle accidents since May08 (10 months)

Bicycle and pedestrian friendly marking and signage at the entrance

Safe urban road

Rumble strip before the bus platform and midblock

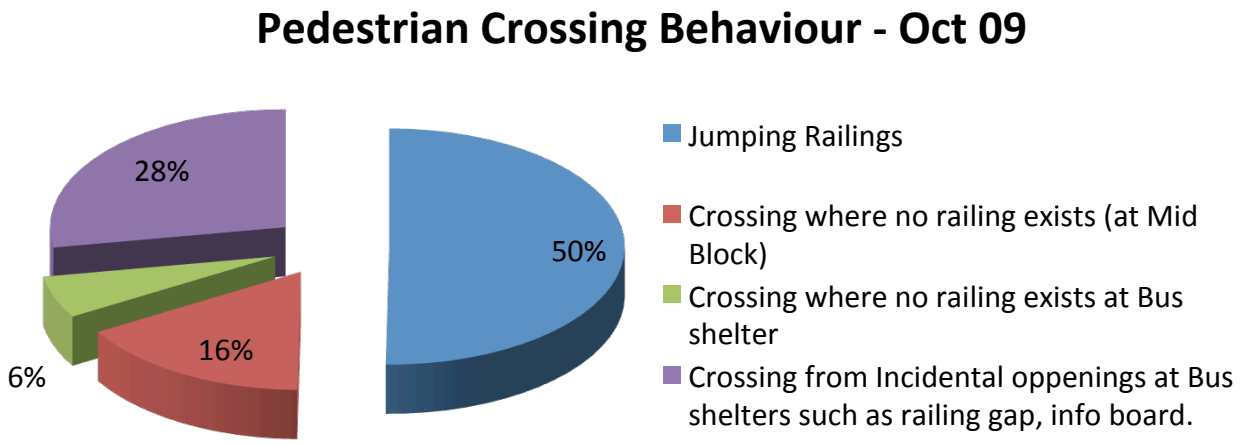
Safe road design (Delhi BRT corridor)

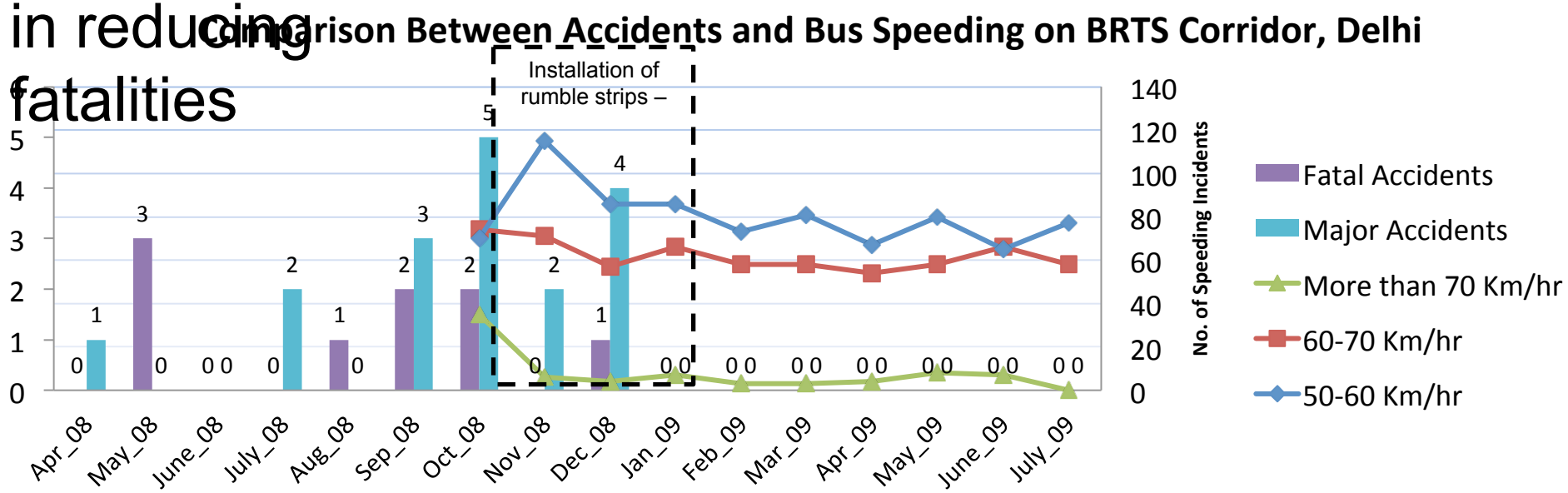
2002	9
2003	17
2004	9
2005	6
2006	8
2007	2
2008	7
2009	0
2010	2

RAISED CROSSINGS :PRIORITY TO PEDESTRIANS AT JUNCTIONS

BRTS Corridor Delhi - Results

- Provision of Railing had little impact
- Rumble Bars had maximum impact in reducing fatalities





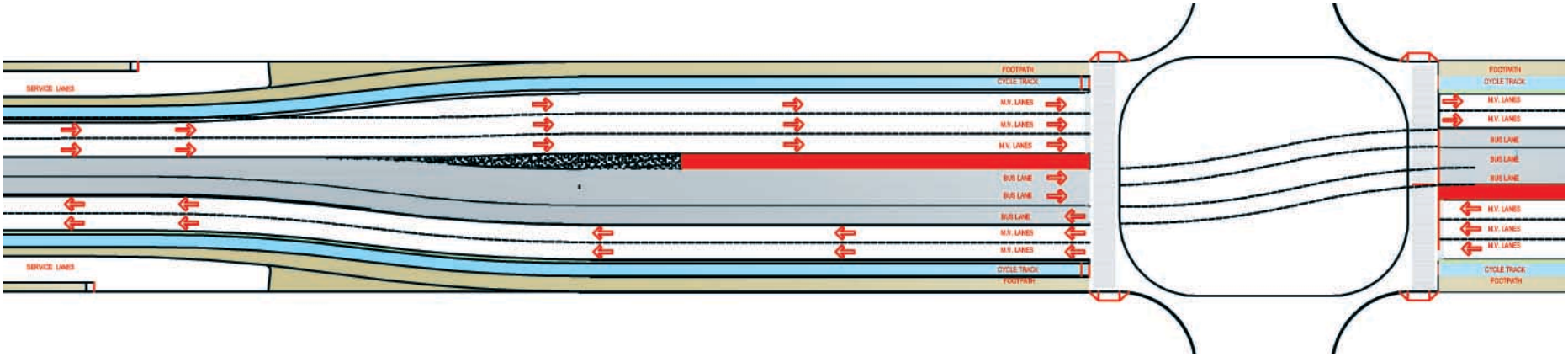
No. of Accidents post installation of rumble strips in bus lane – "ZERO"

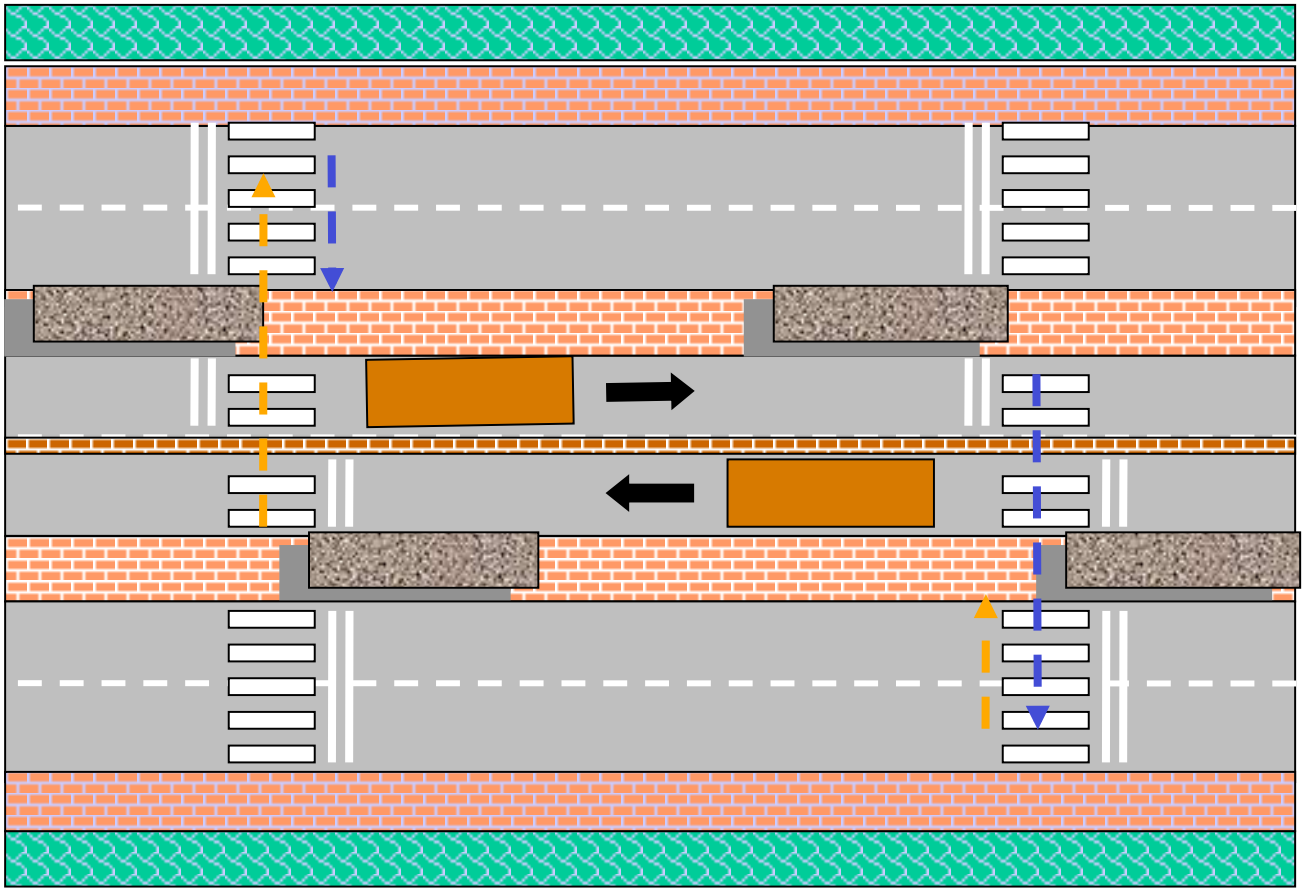
Pedestrian and bicycle lane occupied by parked cars (design or enforcement issue?)

Road Engineering / Geometric Design

Following three aspects of geometric design are essential for system efficiency:

- Creating exclusive lanes for buses :
- Location and design of bus stops :
- Non motorized vehicle lane :

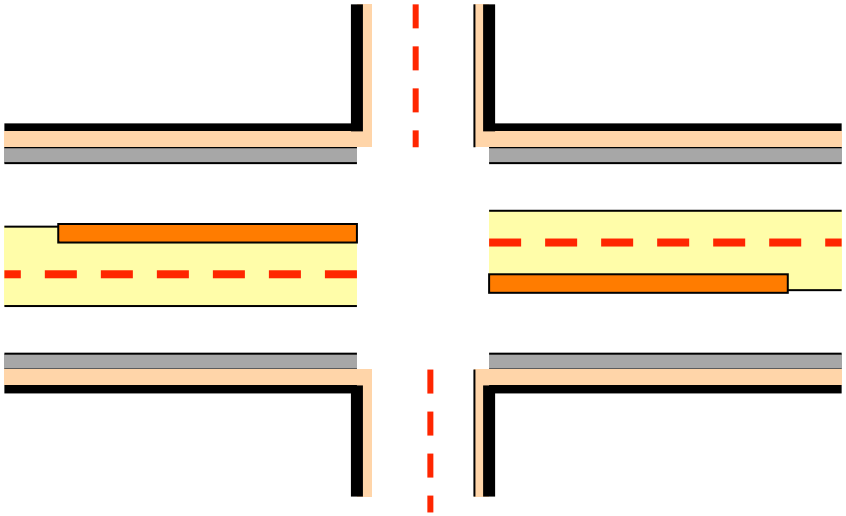




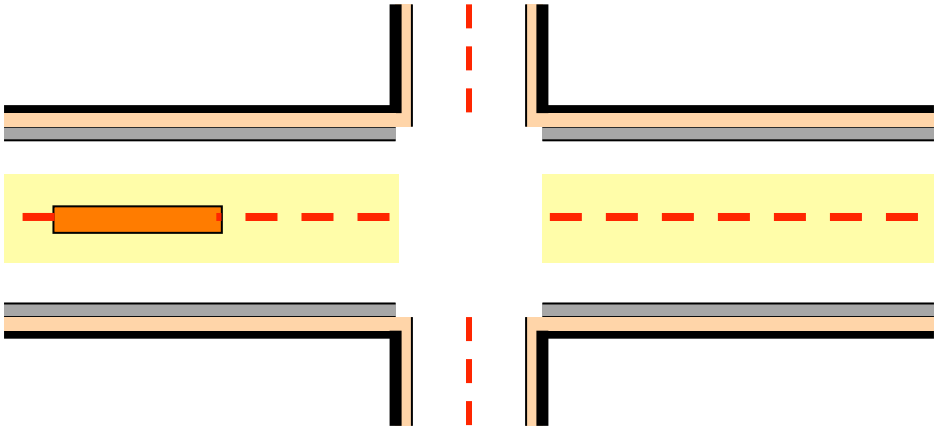
Total of 12 lanes are crossed - 2 at a time

HCBS SYSTEM – Central Bus lanes

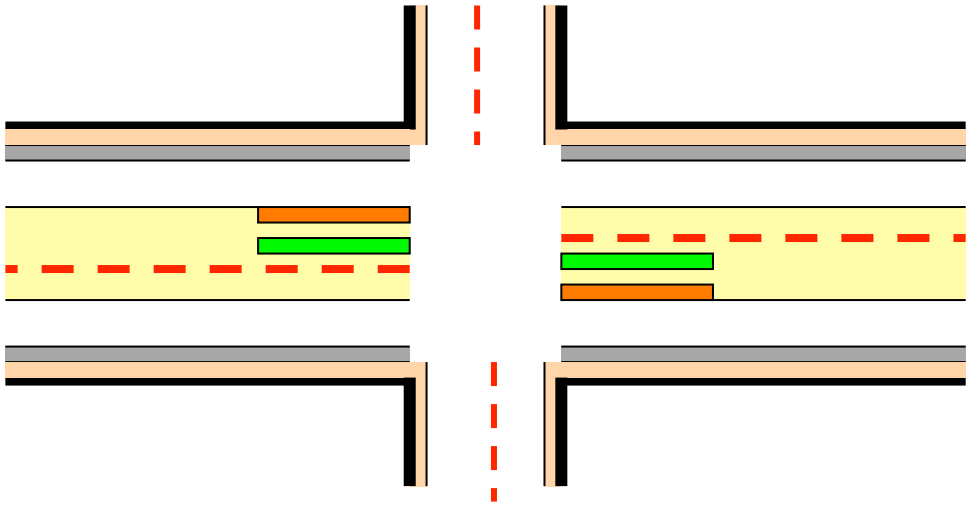
Central Bus lanes – Intersections



Central Staggered at **Intersection**



Island Shelter at **Intersection**



Central Staggered – parallel at **Intersection**

LEGEND

Bus shelter

Median

Central bus lanes

Cycle track

Pedestrian footpath

ROW

Bus stops

Bus Stop – Delhi BRT

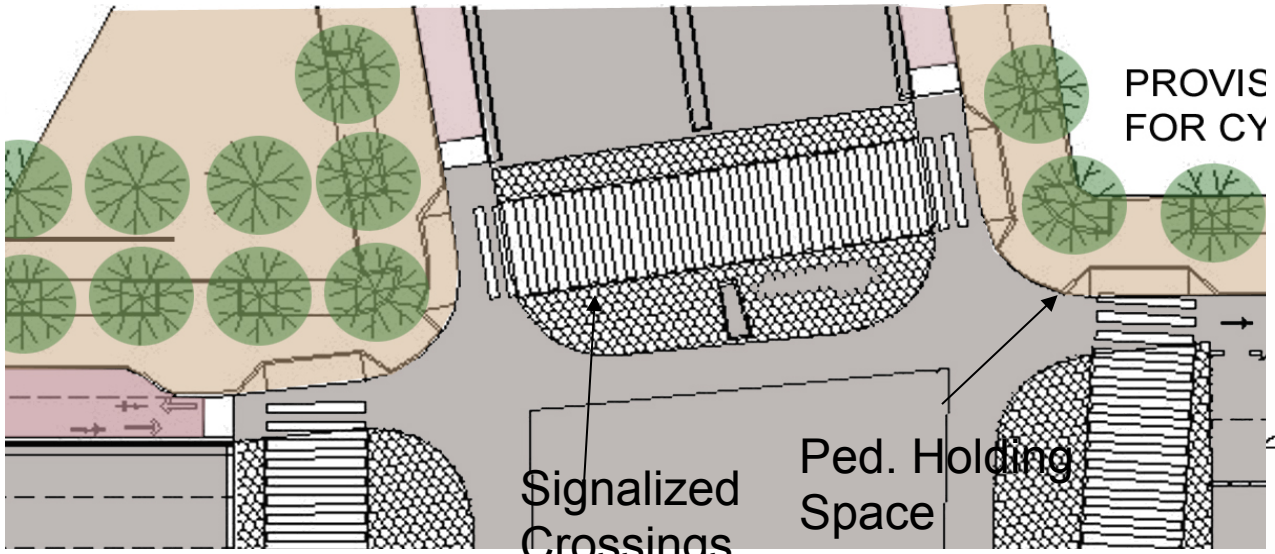
Seating and tactile on BRT Bus shelters Delhi

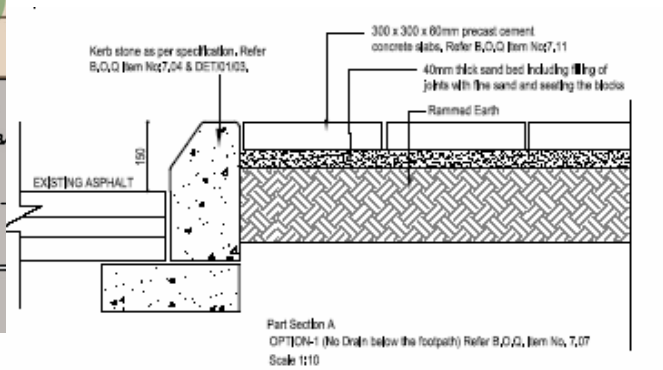
Bus Stop – Ahmadabad BRT

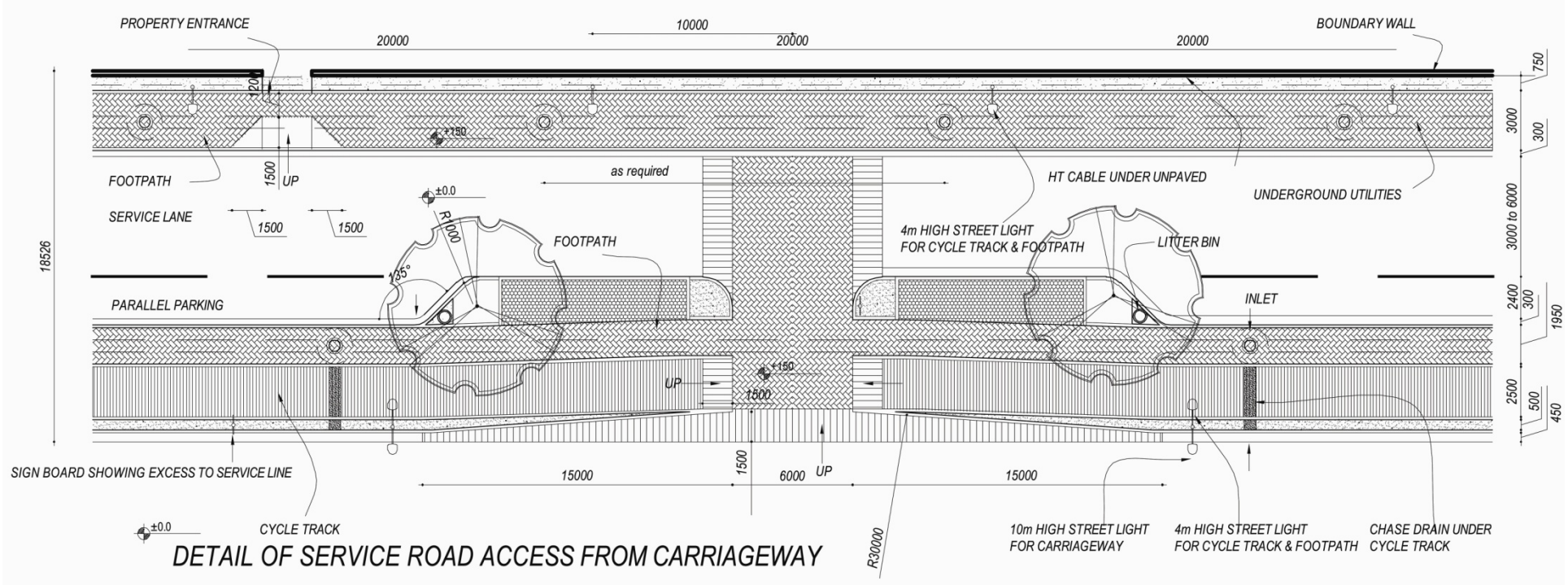
NMV Infrastructure

Title	Specifications
Size of lanes	
Width	Each motor vehicular lane shall be 3.0m in width. An additional 0.3m to 0.75m (depending on speed of the corridor) shy away distance should be provided on one or both edges of the motor vehicle carriageway.
Length	The length should be continuous unless at places where weaving with buses is required like at the foot of flyovers in which case physical segregation from bus lanes should be replaced with pavement markings.
Slopes	MV lane slopes should be in accordance with the roadway design on bends. It should also comply with overall slope requirement of the roadway to drain surface water. The advisable cross slope for the bus lanes is 2 percent.

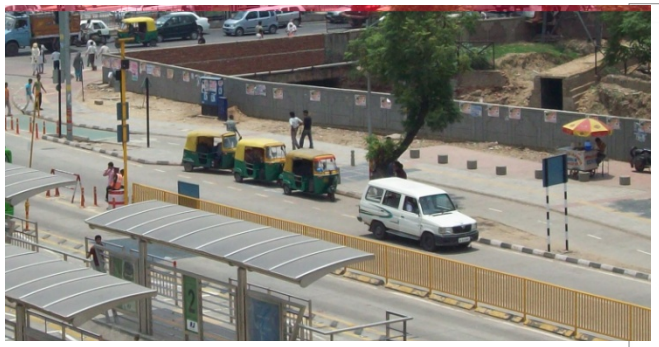
Pedestrian Infrastructure

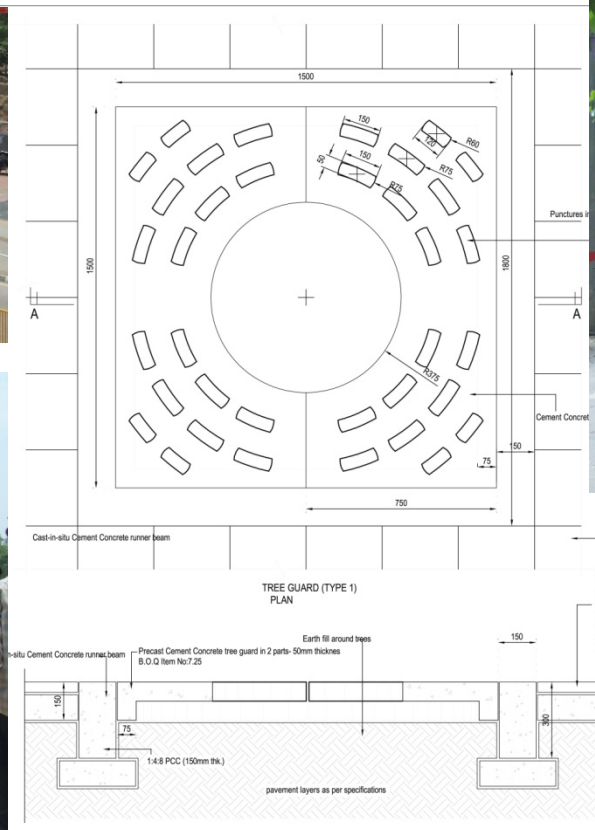


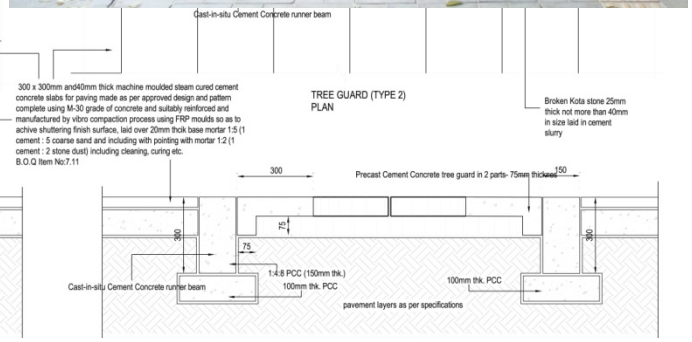




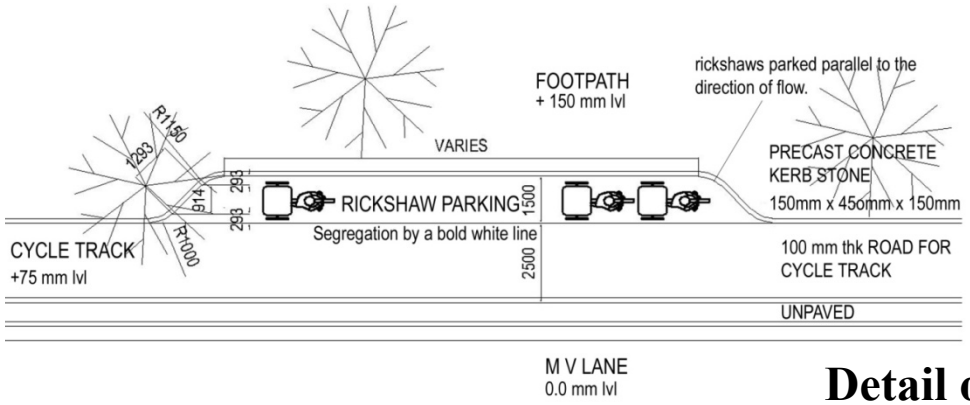
Tree Guards and NMV Parking

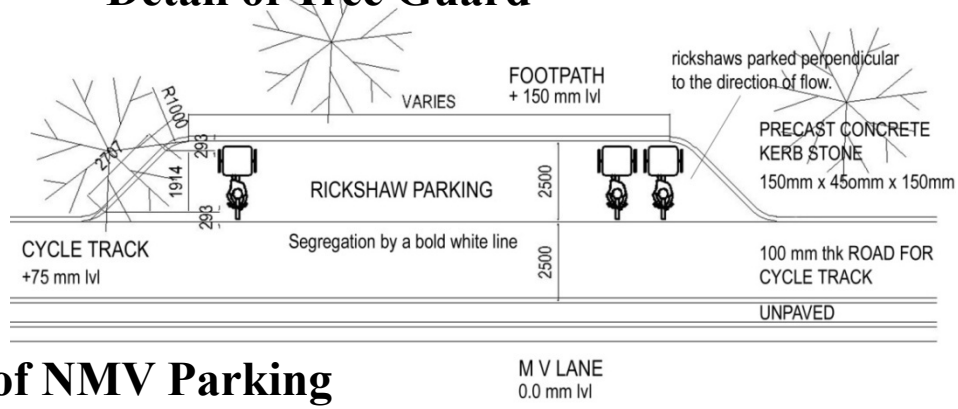






Detail of Tree Guard





Detail of NMV Parking

ROUNDABOUTS REDUCE DEATHS BY 50 -80% AND POLLUTION BY ~30%

Bicycle lane and Midblock bus shelter (single platform)

At grade pedestrian crossing

Low Carbon Transport & GHG challenges in Urban India

Development and modernity is associated with technology (fuel, automobile, metro rail)

External financing favours large construction projects (metro vs buses)

Zero emission modes, walking and cycling have no "market value" i.e. financing through land development or loans not possible, hence no takers!

Successful public transport projects are those which do not affect the cars adversely not just benefiting the bus commuters!

TRIPP