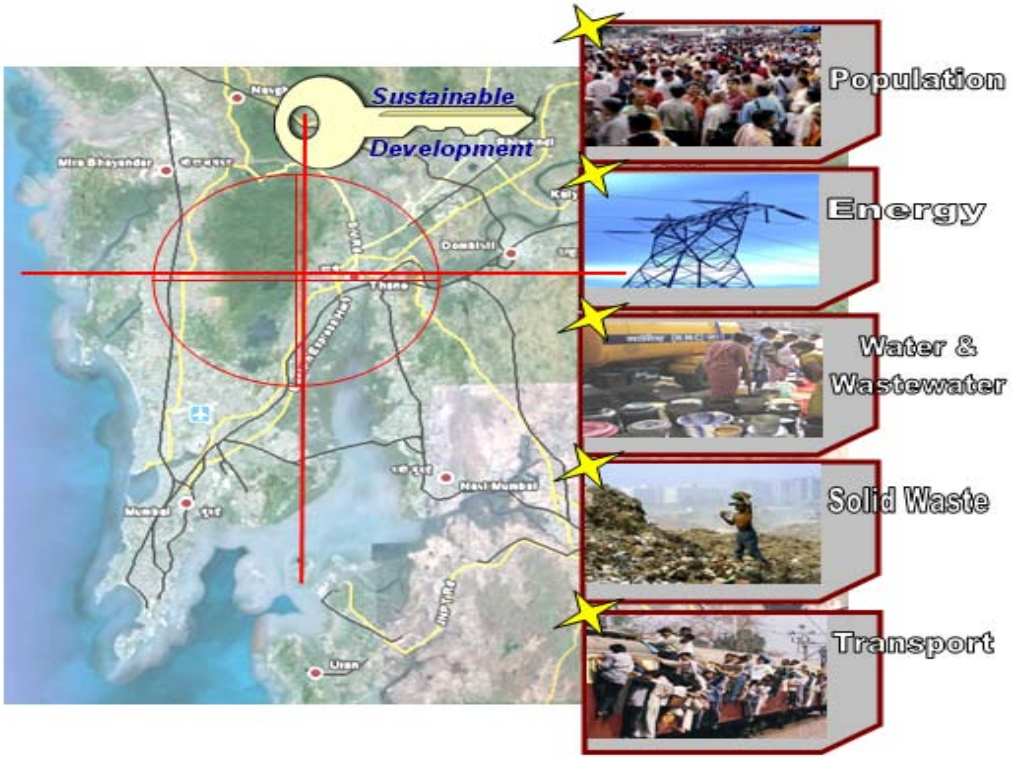
Transport Sector Dynamics and Its Contribution to Urban Health Burden in a Metropolitan Area



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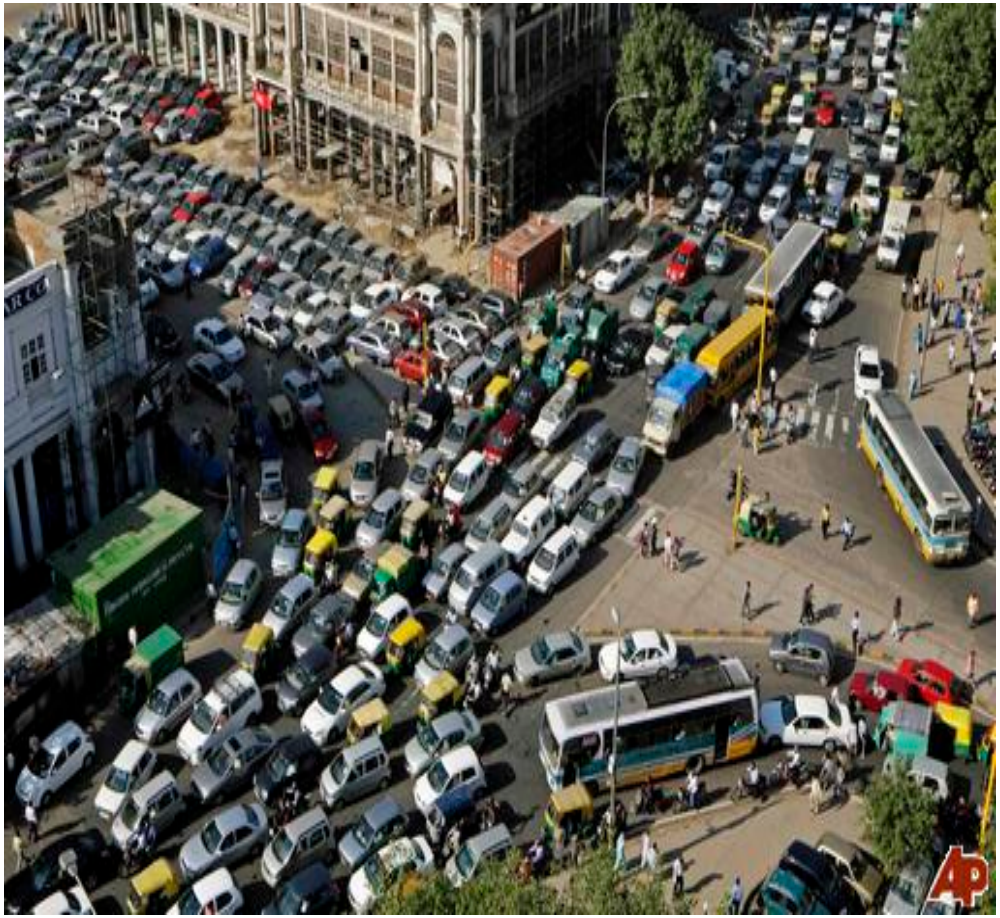
National Environmental Engineering Research Institute

September 1-2, 2011

Major Policy Issues : Transport Sector

- Public Transport facilities inadequate
- Expensive public transport
- Inadequate road space (encroachment, parking)
- Extreme Congestion and emissions
- Incentives for personal mode of transport
- High Disease Burden



Need to Study Transport Sector ?

- Limited network of roads, often narrow, poorly maintained, and unpaved.
- Rapidly increasing ownership and use of private cars and motorcycles.
- Inadequate roadway accommodations for buses and non-motorized transport.
- Primitive or non-existent traffic control and management.
- Extremely high and rapidly rising traffic fatalities, especially among pedestrians and motorcyclists.

- **Overcrowded, unreasonably expensive uncomfortable, undependable, slow, uncoordinated, inefficient, and dangerous public transport.**

- **Extremely high levels of transport-related pollution, noise and green house gas emission especially in large cities**

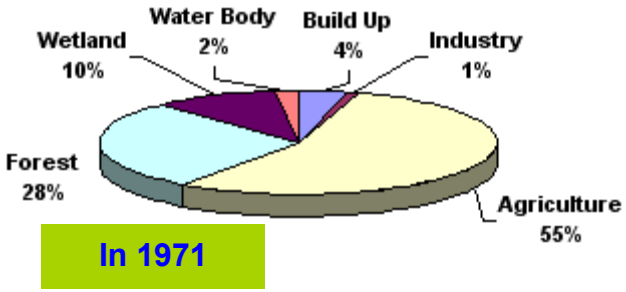
Why Transport and Health

- **Large Indian cities: Dominant Emissions earlier**
  - **Industrial sources**
  - **Domestic Burning (Bengal and Bombay Smoke Nuisance Act)**
  - **Transport for goods movement and public**
- **Emission scenario: Now**
  - **Transport**
  - **Construction & Demolition**
  - **Refuse Burning**
  - **Unorganised sector**

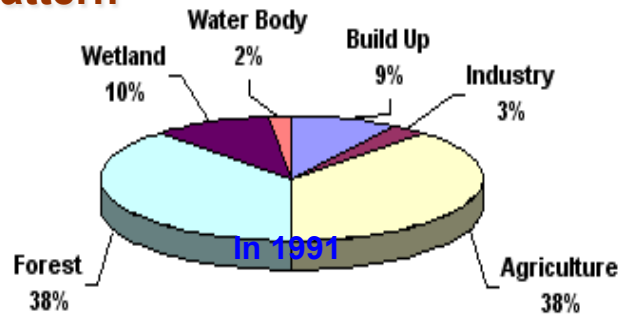
Study Area

- MMR is one of the fastest growing metropolitan regions in India. With geographical spread of about 4,335 sq. km
- MMR comprises eight Municipal Corporations *(Navi Mumbai, Mumbai, Kalyan –Dombivali, Ulhasnagar, Thane, Bhiwandi, Virar-Vasai and Mira-Bhayander)*
- Nine Municipal Councils *(Alibag, Pen, Navghar –Manikpur, Karjat, Khopoli, Matheran, Panvel, Ambernath and Uran)*
- With a population of approx. 19 million (census 2001), it is ranked as the sixth largest metropolitan region in the World

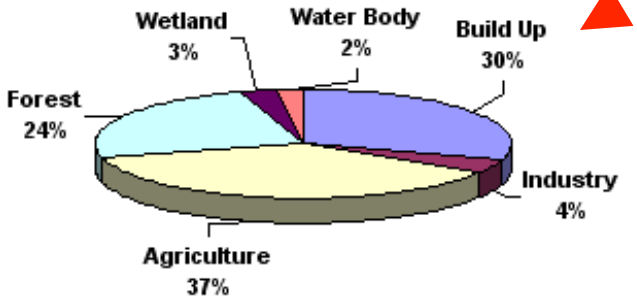
Land Use Pattern



In 1971



In 1991

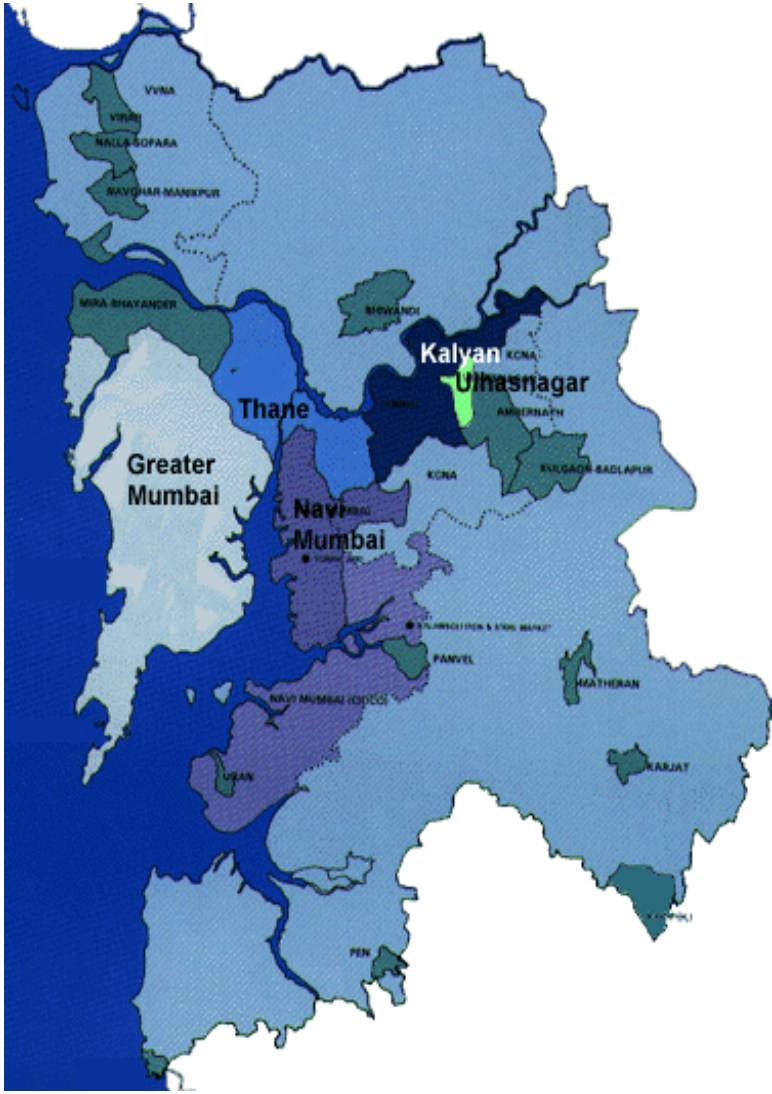


In 2011

- Significance to Study Approach
  - ✓ Rapid Urbanization and developmental activities
  - ✓ High population density
  - ✓ Employment opportunities leading to infiltration
  - ✓ Living pattern leading to burden on Environment

City Transformation Goal

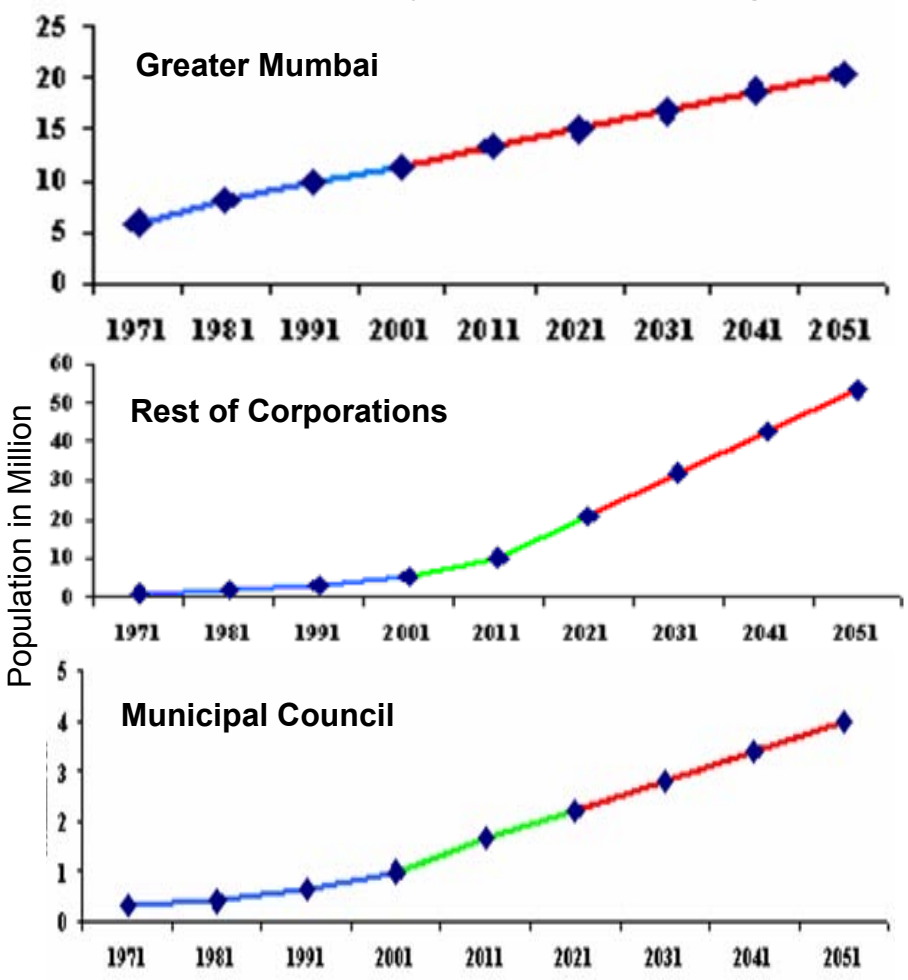
- **Population growth: linked with two major factors**
  - **Housing**
  - **Transport**
- **Development of sustainable environment along with impact mitigation and transformation of the city.**
- **Integration of air pollution & climate change based changes during developmental processes.**



Population Status for Major Urban Centers

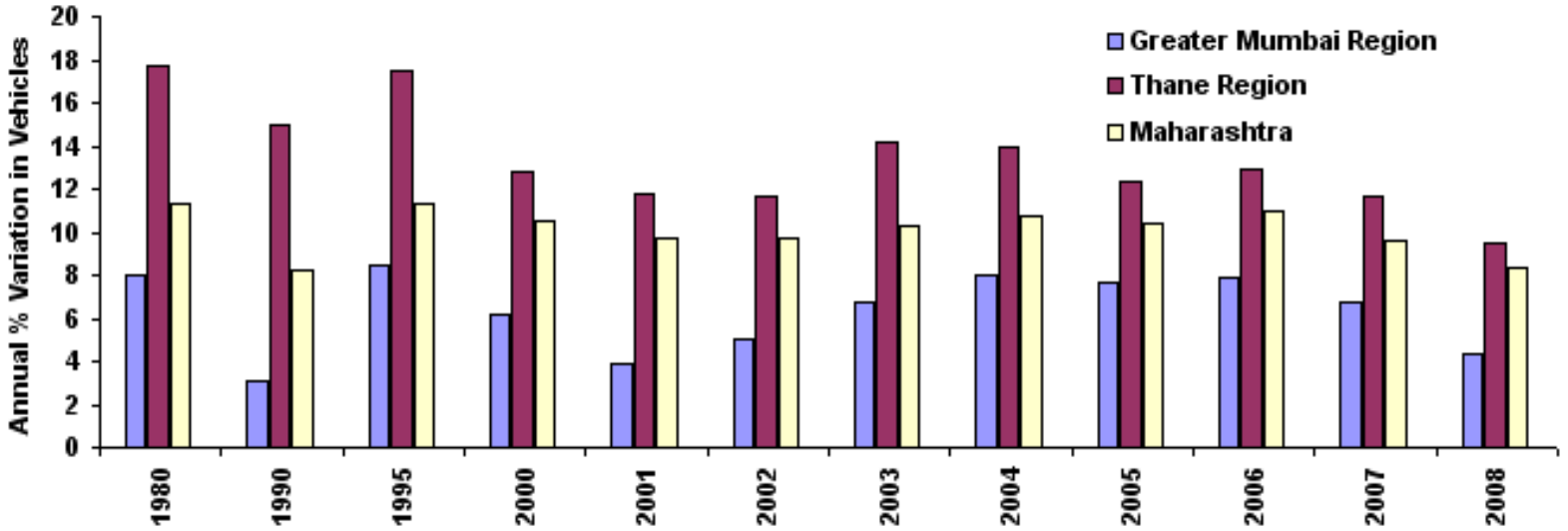
- Although India occupies only 2.4% of the world's land area, it supports over 15% of the world's population.
- Decentralization of economic activities and population by developing other parts of the Mumbai Metropolitan Region would be useful to study the trends in population.
- Mumbai is likely to grow at arithmetic scale provided current policy does not change
- Other corporations and councils are growing at faster rate since 2001 and is likely to continue till 2021. Later it will grow at arithmetic rate.

Population Projections of MMR region

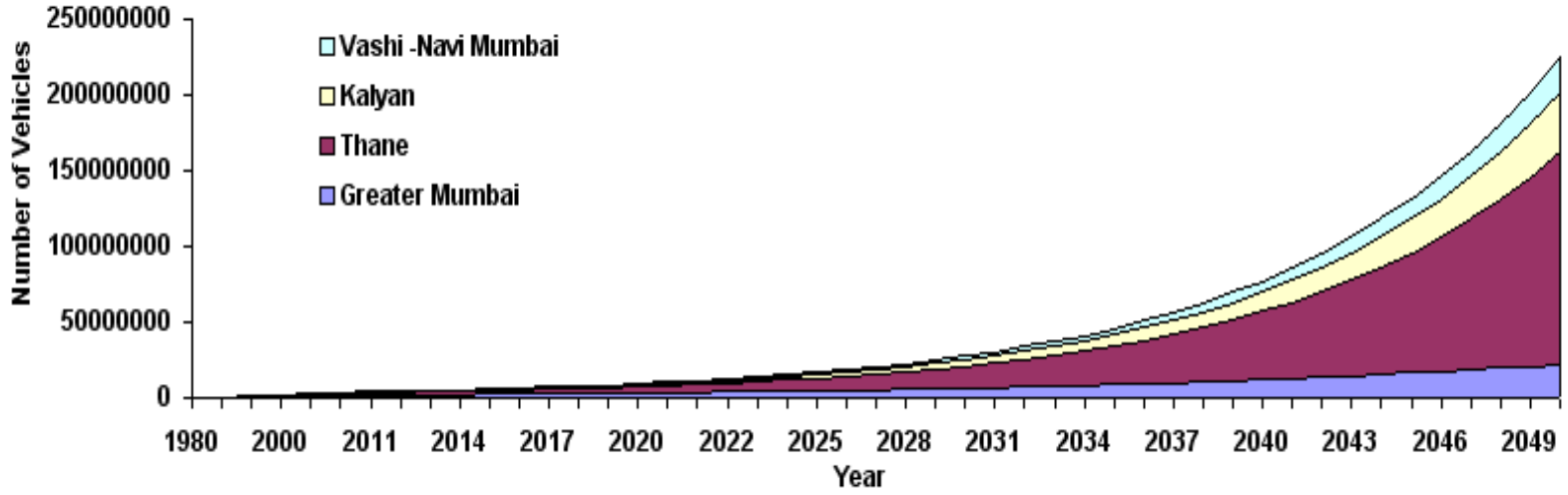


Rest of the corporations > Greater Mumbai Corporation> Municipal Councils

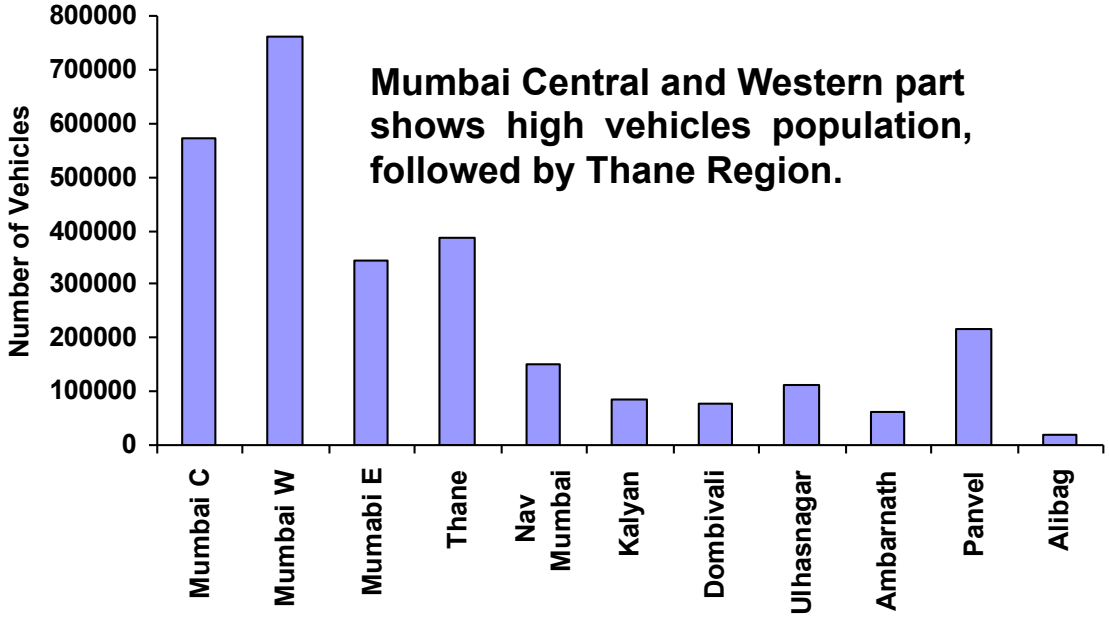
Transport Network of MMR



Annual Percent Growth Variation in Vehicles for Maharashtra

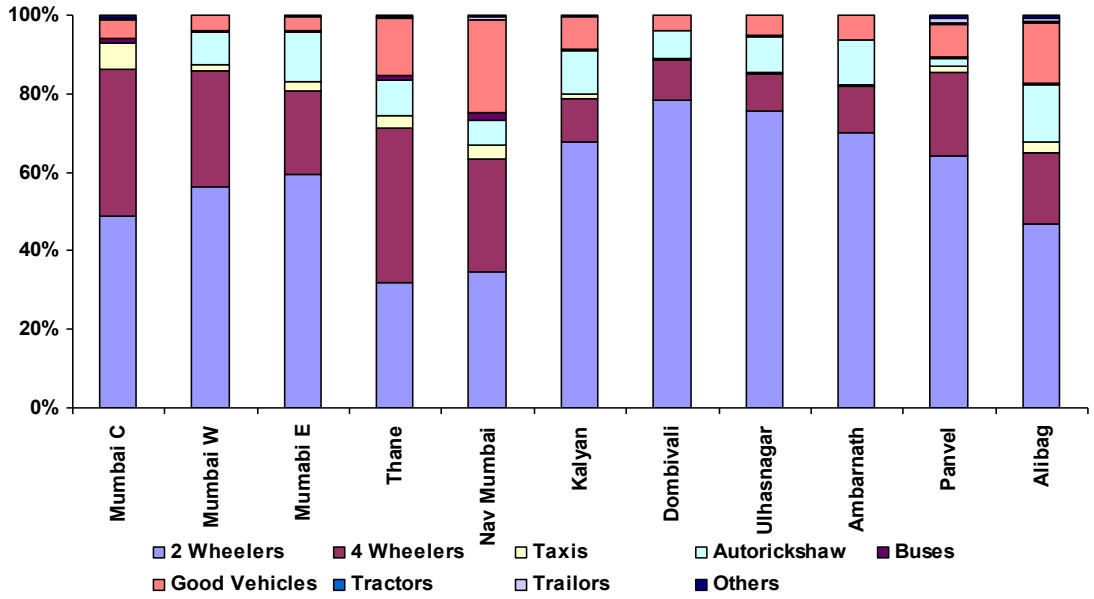


Growth of Registered Vehicles in MMR Region (1980-2050)



Mumbai Central and Western part shows high vehicles population, followed by Thane Region.

Percent distribution of category wise Motor vehicles population in MMR region



Baseline Emission Load Estimation for Mumbai

- **Emissions estimation includes data collection on vehicle counts, vehicle kilometer traveled, secondary data on vehicle registered, types of vehicles, age of vehicles, fuel used etc.**
- **Vehicle counts at representative major traffic junctions**
- **Estimation of grid-wise road length with major nodes/traffic junctions.**
- **Estimation of VKT (Vehicle Kilometers Traveled) for different categories of vehicles.**
- **Selection of appropriate emission factors from the ARAI vehicle emission study *(CPCB, 2008)*.**
- **Preparation of vehicle emission inventory and Emission growth projections.**

Vehicle Km Travel in a Day for MMR (2009-10)

Region	2 Wheelers	Auto rickshaw	Car Diesel	Car Petrol	Heavy Duty Diesel Vehicles	Taxis
G.Mumbai	3512886	5244740	4775819	7161046	2025342	3555128
Thane	3943456	3871688	1452346	2178518	1834950	1046430
Nav_Mum	1662080	1059075	415526	623290	1156980	424710
Kalyan	1852096	1068413	91382	137074	221220	79035
Dombivali	1896672	609075	73987	110981	85890	28050
Ulhasnagar	2703360	1162013	101962	152942	172440	51150
Ambarnath	1376256	796163	69120	103680	110940	13778
Panvel	4429472	511650	443558	665338	557760	306653
Alibag	317632	351563	36163	54245	98400	50078

Emission Factors Calculated by Automotive Research Association of India, (ARAI), 2007

Type of Vehicle	Vintage	Capacity	Emission Factors (g/km)				
			CO	HC	NOx	PM	CO2
Motor cycle (2 stroke)	1996-2000	>80cc	2.96	2.44	0.05	--	--
	Post 2000 #	<1000cc	1.65	0.61	0.27	0.035	24.97
Three wheeler (CNG retro)	post 2000 #	<200cc	0.69	2.06	0.19	0.118	57.71
Car (petrol)	post 2000 #	1000-1400cc	3.01	0.19	0.12	0.006	126.5
Car (diesel)	1996- 2000#	1600 -2400 cc	0.66	0.25	0.61	0.180	155.66
	post 2000	<1600cc	0.51	0.2	0.67	0.12	--
Taxis (CNG)	post 2000#	1000-1400cc	0.60	0.36	0.01	0.002	131.19
Bus-1 (Diesel)	1991-2000	>6000cc	19.3	2.63	13.84	1.965	
Bus-2 (Diesel & CNG)	post 2000#	>6000cc	6.00	0.37	9.30	1.240	837.5

 # Factors used for emission load calculation
Source: Air Quality Monitoring Project-Indian Clean Air Programme (ICAP), The Automotive Research Association of India, 2008

Category wise Emission Load in MMR (2009)

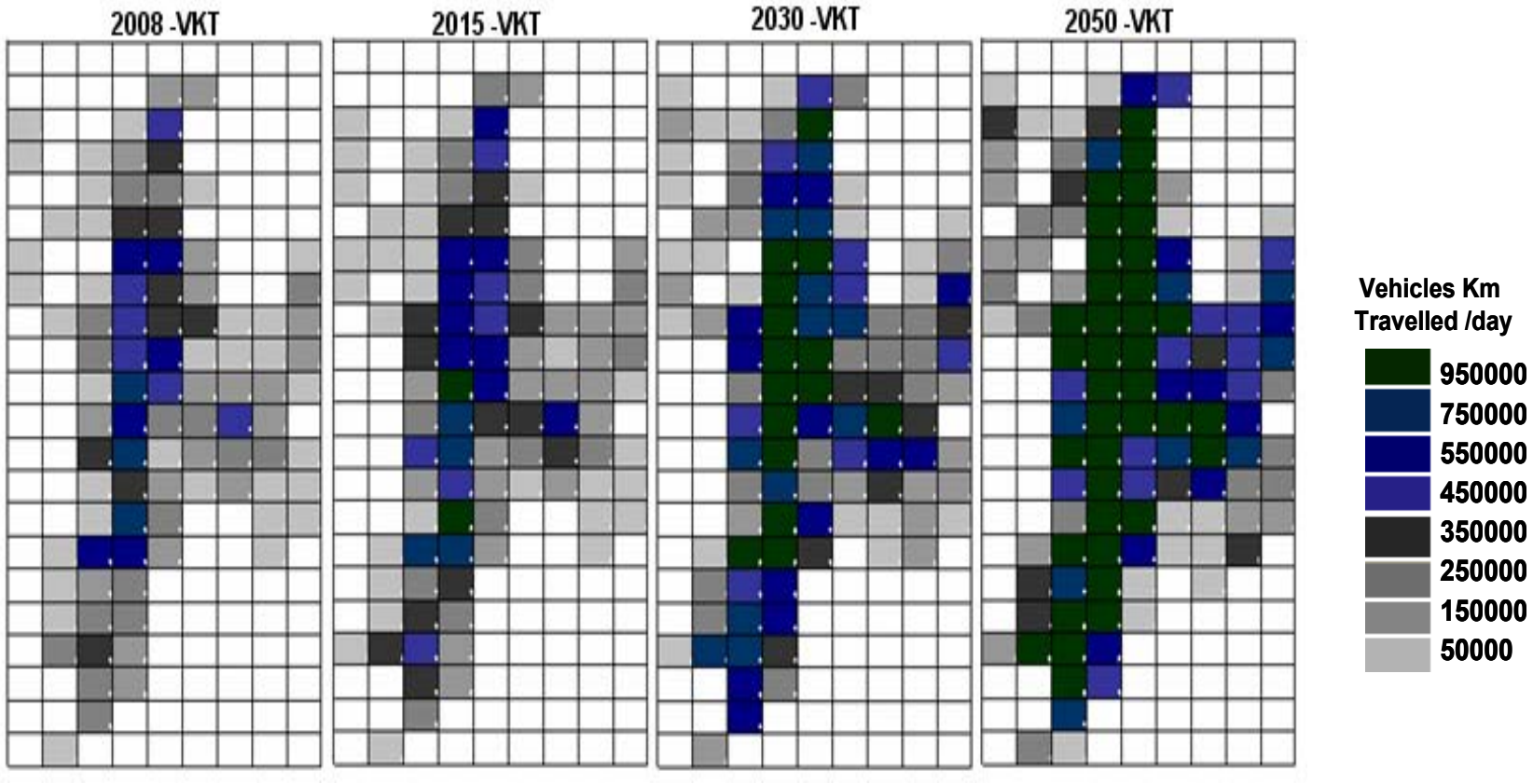
	PM	NOx	HC	SO_2	CO	CO_2
2W Emissions (T/y)						
Thane	50.4	388.6	878.0	5.3	2374.9	35940.9
New Mumbai	21.2	163.8	370.1	2.2	1001.0	15148.3
Kalyan	23.7	182.5	412.4	2.5	1115.4	16880.1
Dombivali	24.2	186.9	422.3	2.5	1142.3	17286.4
Ulhasnagar	34.5	266.4	601.9	3.6	1628.1	24638.6
Ambarnath	17.6	135.6	306.4	1.8	828.9	12543.3
Panvel	56.6	436.5	986.2	5.9	2667.6	40370.4
Alibag	4.1	31.3	70.7	0.4	191.3	2894.9
Mumbai	46.7	360.0	813.4	4.9	2200.3	33297.3
3W Emissions (T/y)						
Thane	166.8	268.5	2911.1	--	975.1	81553.8
New Mumbai	45.6	73.4	796.3	--	266.7	22308.5
Kalyan	46.0	74.1	803.3	--	269.1	22505.2
Dombivali	26.2	42.2	458.0	--	153.4	12829.6
Ulhasnagar	50.0	80.6	873.7	--	292.7	24476.8
Ambarnath	34.3	55.2	598.6	--	200.5	16770.5
Panvel	22.0	35.5	384.7	--	128.9	10777.5
Alibag	15.1	24.4	264.3	--	88.5	7405.4
Mumbai	230.4	371.0	4022.4	--	1347.3	112685.5

Category wise Emission Load in MMR (2009) (Contd..)

Car Diesel Emissions (T/y)						
Thane	95.4	323.4	132.5	72.6	349.9	82516.3
New Mumbai	27.3	92.5	37.9	20.8	100.1	23608.5
Kalyan	6.0	20.3	8.3	4.6	22.0	5192.0
Dombivali	4.9	16.5	6.8	3.7	17.8	4203.6
Ulhasnagar	6.7	22.7	9.3	5.1	24.6	5793.0
Ambarnath	4.5	15.4	6.3	3.5	16.7	3927.1
Panvel	29.1	98.8	40.5	22.2	106.9	25201.2
Alibag	2.4	8.1	3.3	1.8	8.7	2054.6
Mumbai	320.0	1084.6	444.5	243.6	1173.5	276769.3
Car Petrol Emissions (T/y)						
Thane	4.8	95.4	151.1	10.9	2393.4	100587.6
New Mumbai	1.4	27.3	43.2	3.1	684.8	28778.8
Kalyan	0.3	6.0	9.5	0.7	150.6	6329.0
Dombivali	0.2	4.9	7.7	0.6	121.9	5124.3
Ulhasnagar	0.3	6.7	10.6	0.8	168.0	7061.7
Ambarnath	0.2	4.5	7.2	0.5	113.9	4787.2
Panvel	1.5	29.1	46.1	3.3	731.0	30720.3
Alibag	0.1	2.4	3.8	0.3	59.6	2504.6
Mumbai	16.3	326.2	516.5	37.2	8182.2	343869.2

Category wise Emission Load in MMR (2009) (Contd..)

	PM	NOx	HC	SO_2	CO	CO_2
HDDV Emissions (T/y)						
Thane	830.5	6228.7	247.8	314.6	4018.5	560921.3
New Mumbai	523.6	3927.4	156.3	198.3	2533.8	353674.3
Kalyan	100.1	750.9	29.9	37.9	484.5	67624.2
Dombivali	38.9	291.6	11.6	14.7	188.1	26255.5
Ulhasnagar	78.0	585.3	23.3	29.6	377.6	52712.8
Ambarnath	50.2	376.6	15.0	19.0	243.0	33913.0
Panel	252.4	1893.3	75.3	95.6	1221.5	170500.3
Alibag	44.5	334.0	13.3	16.9	215.5	30079.7
Mumbai	935.0	7012.5	279.0	354.1	4524.2	631504.4
Taxi Emissions (T/y)						
Thane	0.8	3.8	137.5	--	229.2	50107.6
New Mumbai	0.3	1.6	55.8	--	93.0	20337.0
Kalyan	0.1	0.3	10.4	--	17.3	3784.5
Dombivali	0.0	0.1	3.7	--	6.1	1343.2
Ulhasnagar	0.0	0.2	6.7	--	11.2	2449.3
Ambarnath	0.0	0.1	1.8	--	3.0	659.7
Panel	0.2	1.1	40.3	--	67.2	14683.9
Alibag	0.0	0.2	6.6	--	11.0	2397.9
Mumbai	2.6	13.2	476.5	--	794.1	173639.7



VKT (Vehicle Kilometers Traveled) for different categories of vehicles was estimated using primary method (actual vehicle counting) for Greater Mumbai and secondary method for rest of the MMR.

The highest VKT share is by Cars Petrol- 27%, Car Diesel-18%, 3 Wheelers-20%, Taxies-14%, 2 Wheelers-13% and HDDV-8%. Projected VKT estimation for Greater Mumbai upto 2050

Congestion Impact in Mumbai City

Sr.	Fuel	Type	From	To	Km	Litre	Minute	Engine size (L)
1	Petrol	Normal Traffic	Worli	Bandra	9	1	22	> 3
		Peak Traffic	Bandra	Worli	9	1.5	25	
2	Petrol	Normal Traffic	Chembur	Worli	11	1.5	30	> 3
		Peak Traffic	Worli	Chembur	11	3	45	
3	Petrol	Normal Traffic	Worli	CST	10	1.5	35	> 3
		Peak Traffic	Worli	CST	10	2.5	50	
4	Petrol	Normal Traffic	Worli	Hajiali	3	0.5	5	> 3
		Peak Traffic	Worli	Hajiali	3	2	20	
5	Diesel	Normal Traffic	CST	Parel	6	0.78	8	> 1.9
		Peak Traffic	CST	Parel	6	2.5	30	

The key findings of the test show that both fuel and journey time increase in peak traffic. Emissions increase by 33% to 75%

Whereas travel time increase by 5min to 30min for the same route.

Denser traffic condition leads to higher emissions, slow moving traffic (stop-start vehicle movement), increased journey times and higher vehicle operating costs.

Travel Pattern: MMR Region

- **In MMR region, the convenient mode of transport is train (85%) followed by Bus (10%) and 5% other viz. autorikshaw, walking and motor bike.**
- **Minimum Distance travel in MMR region include 10-30 km and time required is 1-2 hours.**
- **They do not face congestion situation similar to Mumbai**
- **Large scale heavy duty vehicle movements hamper general traffic and also create unsafe situation.**

Travel Pattern: Mumbai Region

- **Low and Middle income group category people travel mainly by train (68%), Bus (22%) and 8% by other mode of transport like auto rickshaw and walk.**
- **High income group people prefer to travel by cars (42%), train (28%), 20% bus and 10% motor bike and other mode of transport.**
- **The survey also indicated that most number of people use dual mode transport like train and bus.**
- **69% of High Income group people normally travel up to 20 Km and its take around 30-40 minutes approx. Low group traveling more than 10-15 kms in 45 minutes to 1 hour.**

- Highest VKT by personal mode: 61%
- Next are taxies and Autos : 32%

- Most of he HC emissions from three wheelers
- The highest pollutants from 2 wheelers:Panvel, Thane, Mumbai and Ulhasnagar

- Highest Occupancy on the road : Cars
- Highest movement of people : Buses

Impact of Diesel Price Increase

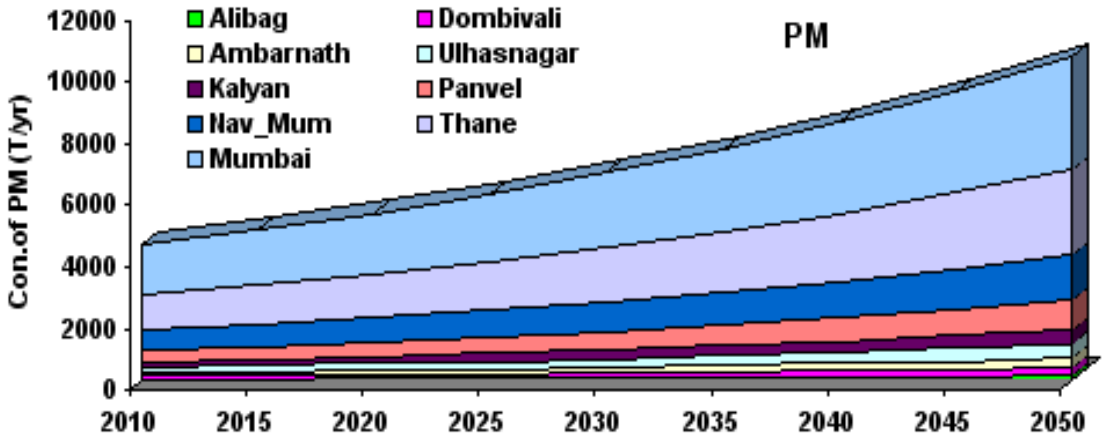
- For 1 km of travel a car consumes nearly 5 times more energy than a 52 seater bus with an average load factor of 82%.
- The car occupying 38 times more space compare to a bus for a km of a travel.
- The emission from a 2 wheeler equivalent to a bus could add 27% more pollution

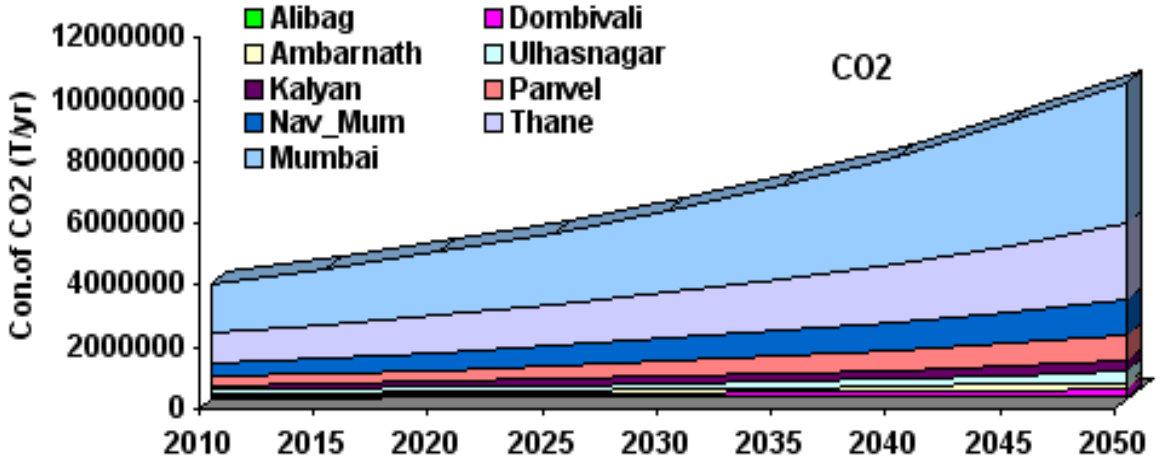
(Ref. Report on Expert committee on Auto Fuel Policy, Chapter 15, GoI, 2002 and document on ESMAP – How can Urban Bus Policy Reduce Air Pollution ? Urban Air Pollution, Briefing Note No. 3, 2001)

- As per new bus fare cost is Rs 3-4 per Km and for a two wheeler it works out to be less than one rupee/Km

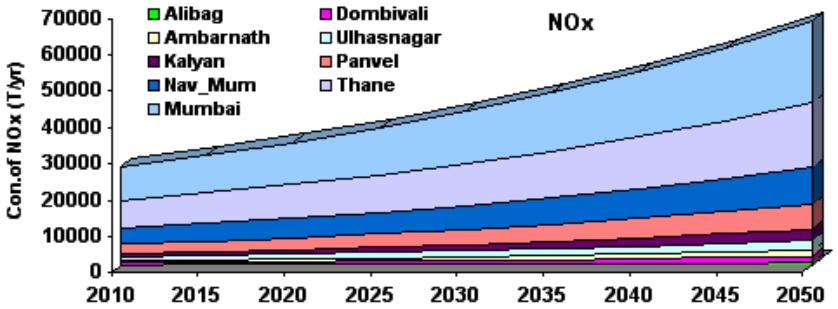
- **Recent Report shows that passenger loads have come down in Mumbai after last fare increase.**
- **The congestion due to increased private vehicles have led to increase of about 15-18% emission [mainly gaseous pollution]**
- **Price Increase is anti poor as also against environment**

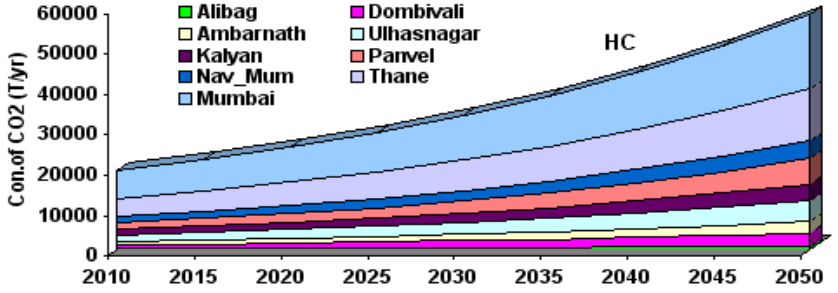
Projected Emission Loads from 2010 to 2050 for Different Pollutants

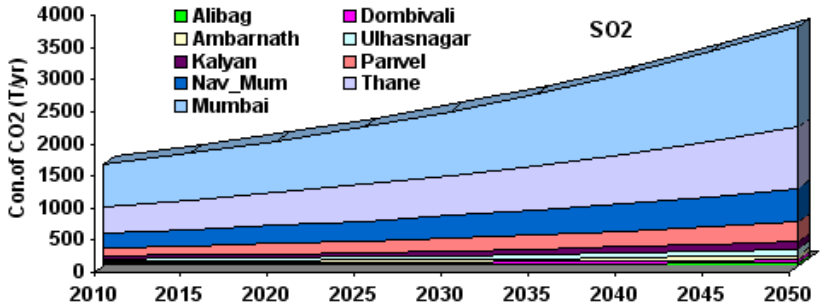


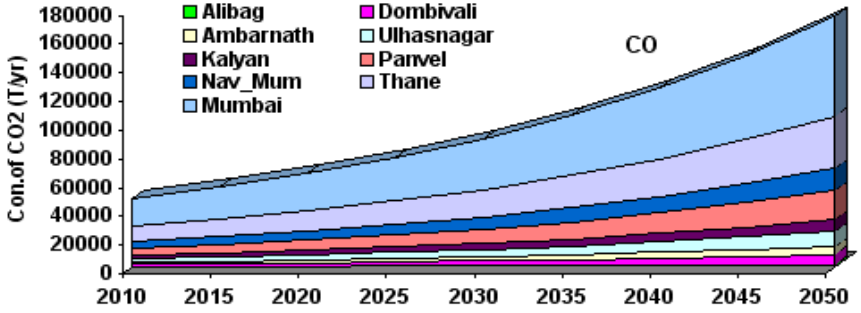


Projected Emission Load Different Pollutant at MMR Region (T/Yr)







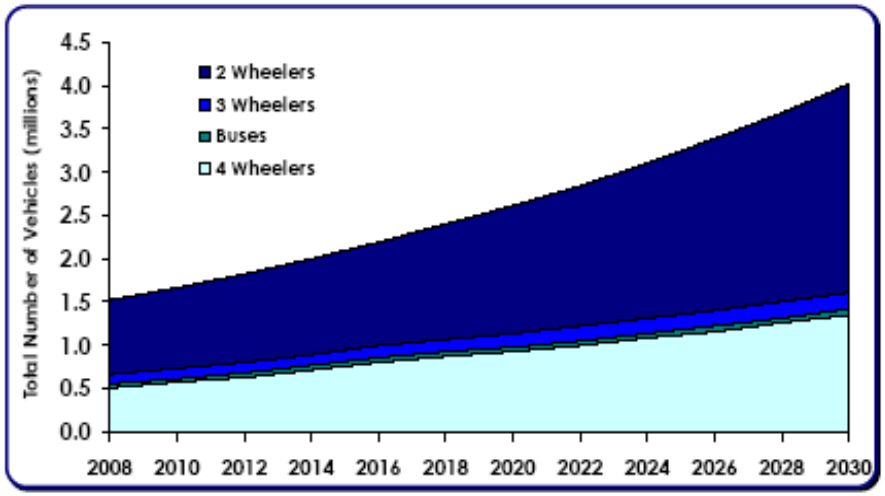


Scenario of CO_2 and other Emissions Reduction : Control Options

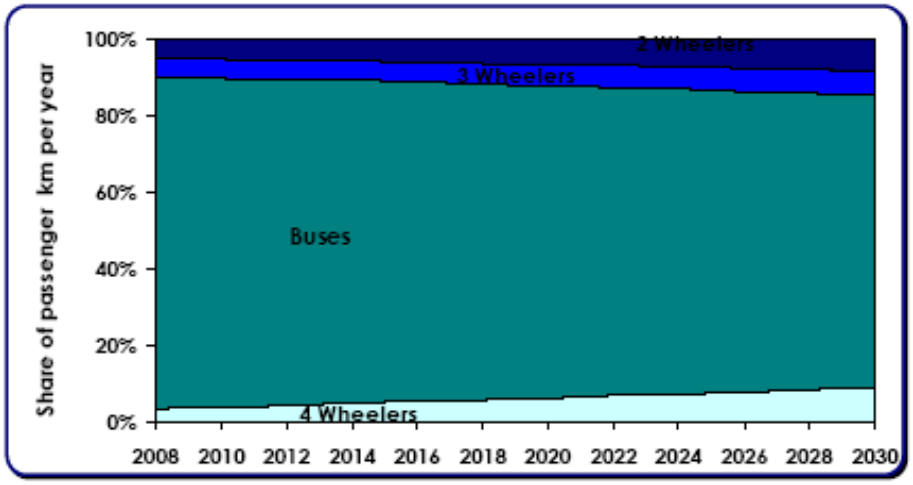
- Mumbai and Delhi as two mega cities
- Pattern of vehicle types and use is different
- Analysis of CO_2 emission reduction from this sectors based on
  - Synchronization of signals
  - Fuel Shift
  - Preference of Public transport

Mumbai City

Number of Vehicles

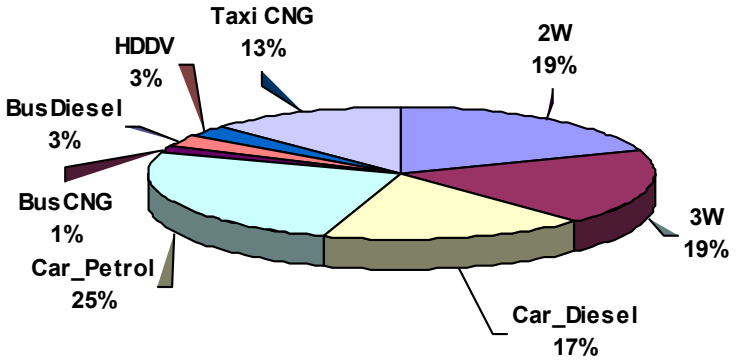


% Passenger kilometers

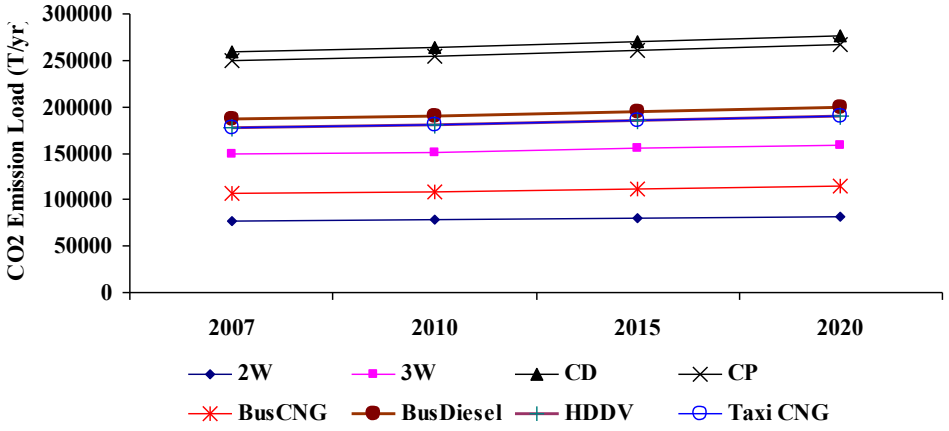


SIM-16-2009

Percent VKT Share of Vehicles : 2007-08

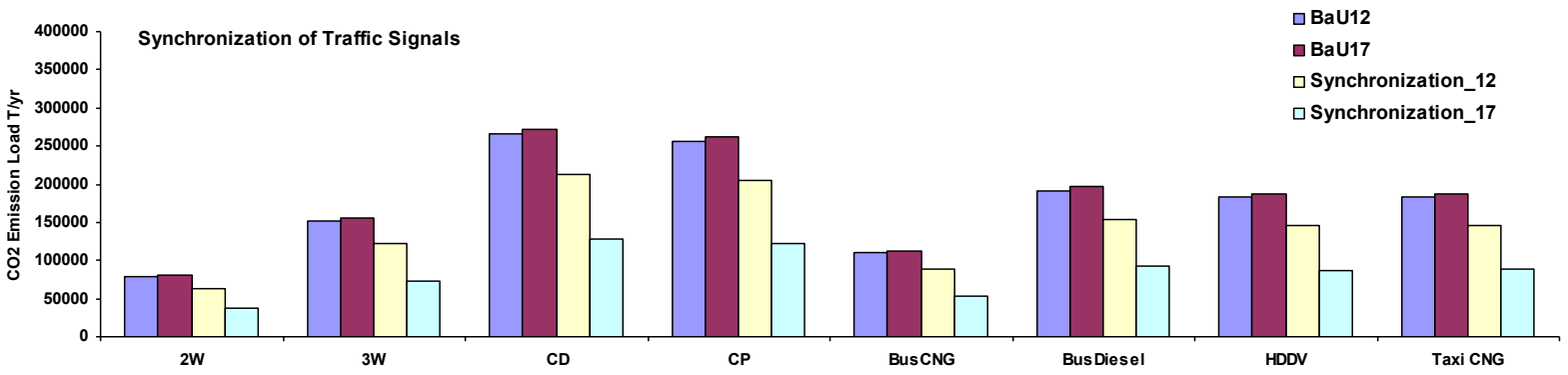


CO2 Emission

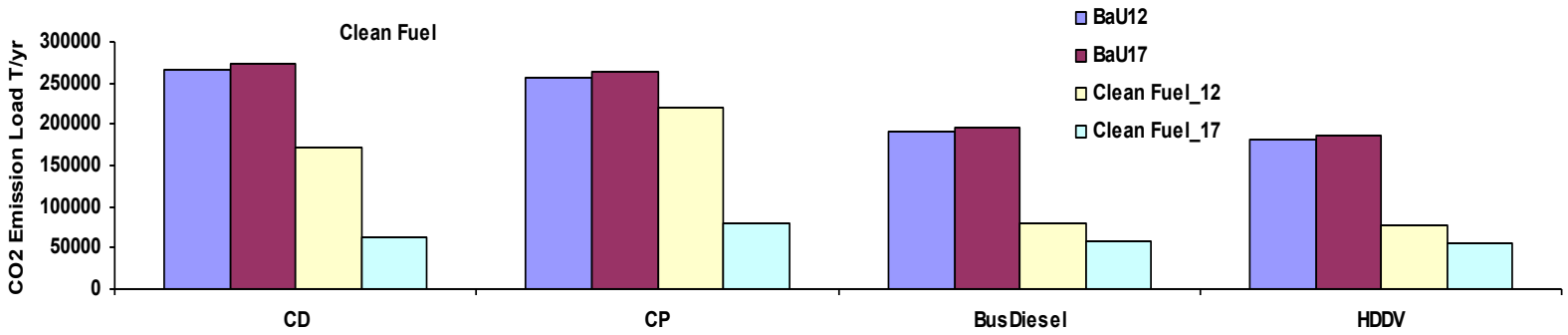


Mumbai

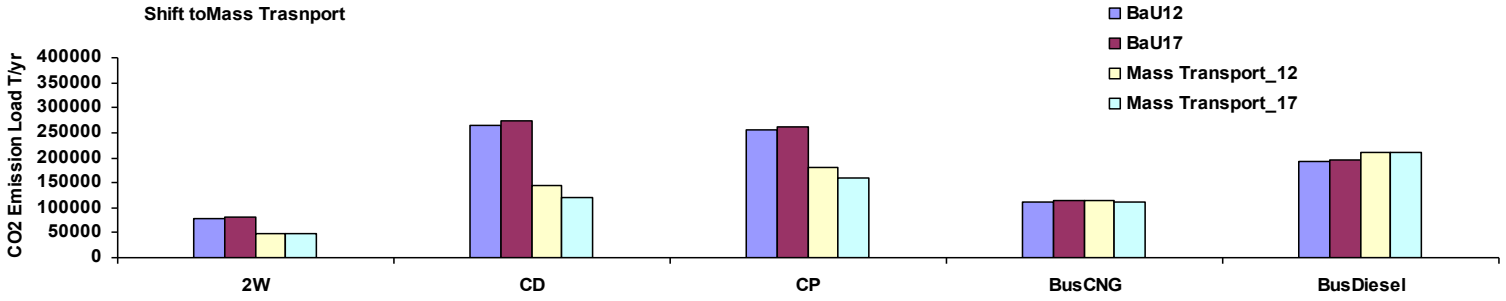
- **Synchronization of traffic signals (20% improvement in 2012 and 40% improvement in 2017)**



- **CNG/LPG to commercial (all 3 and 4-wheelers)- 25% conversion in 2012 and 40% in 2017 – Taxi & 3W already converted to CNG**



- **Improvement of public transport: as per existing plan for the city (VKT of cars, 2-wheelers and buses) Incorporated city specific proposals on public transport with respect to Metro/mono rail, BRT, large buses contingent etc. leading to percentage shift in VKT and off road personal transport : 10% shift in VKT – in 2012 and 20% shift in VKT in 2017**



Other Policies and measures

- **Enhancement of knowledgebase and capacity building**
- **Improving access and reducing transport demand**
  - **Integrate land use and transport planning**
- **Using less fuel per passenger or freight kilometre**
  - **Fiscal and control measures**
  - **Priority to good public transport**
  - **Promoting use of NMT modes**
- **Implement fuel economy standards for new vehicles**
  - **Fuel efficiency standards**
  - **Emission standards**
  - **Fuel quality standards**
- **Reducing emissions from in-use vehicles**
  - **Inspection and Certification**
  - **Retrofit programme**

Health Status and Linkages with Transport Sector

- Difficult to apportion health to a sector
- Problems of sources emissions, locations and exposures
- Methodology need to be evolved
- Population staying close to roads
- Understand exposure in a given situation and microenvironment
- Understand how much comes from transport sector
- Types of diseases,
- Background area: cohorts and control

Mumbai Case

- The number of air polluting industrial units in the year 2002 was 181 which drastically declined to less than 40 by 2007.
- It is witnessed that most of the air pollution in the city currently can be attributed to transport and construction sector.
- Of many pollutants, NOx and CO can be mainly attributed to transport sector, whereas PM contributions come from construction, refuse burning, resuspended dust and other combustion processes.
- Most of the future illnesses due to air pollution would majorly come from transport sector, not only due to its higher contribution but also due to toxics emissions.

Health Issues: Mumbai

- In recent times, City doctors are baffled with the increasing number of patients with respiratory ailments requiring hospitalisation.
- The study shows around 25-30% increase in cases of upper respiratory ailments
- 2-4% of these patients required urgent hospitalisation. In some cases, it has been found that the lungs are severely damaged.

Economic Assessment

- Environmental Pollution Research Centre at KEM Hospital in Mumbai data analysed
- Study to establish respiratory diseases and air pollution using logistic regression to investigate the link between air pollution and morbidity impacts. The monetary burden of morbidity was estimated through the cost of illness approach.
- PM and NOx emerged as the critical pollutants for a range of health impacts,
- The study developed the concentration-response coefficients for these health impacts.

The total monetary burden of these impacts, including personal burden, government expenditure and societal cost, is estimated at INR 4522.96 million or US$ 113.08 million for a 50-µg/m3 increase in PM10,

INR 8723.59 million or US$ 218.10 million for a similar increase in NO2.

Policy Options

- Appropriate policies to exploit the railways for Air Pollution reduction potential.

- China and India have currently less than five cars per 100 head of population, the US has around 90 and the UK 50. If India and china alone go ahead with fossil-fuelled cars the way the West did, the situation can be very daunting.

Policy Options

- Railways offer efficient transport
  - social equity,
  - low environmental impact
  - positive economic growth,
  - sustainable mobility and an improved quality of life.
- Fuel shift along with reduction of vehicle kilometers traveled [bio diesel, hydrogen, renewables etc or any new development]
- Public transport use of all categories.
- Lower cost of Fuel for public transport or other fare reduction options

Conclusions

- **Of many issues which can be addressed there are plenty of them for easy implementation such as improvement in vehicle technology, reduction in rate of vehicle growth, other mode of transport (buses, metro, rail, waterways etc), land use etc.**
- **Awareness about economic benefits in terms of reduced health burden**
- **Transport sector local alternatives**
- **Reduction in fare and improvement of public transport for the sole purpose of improving health**

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