



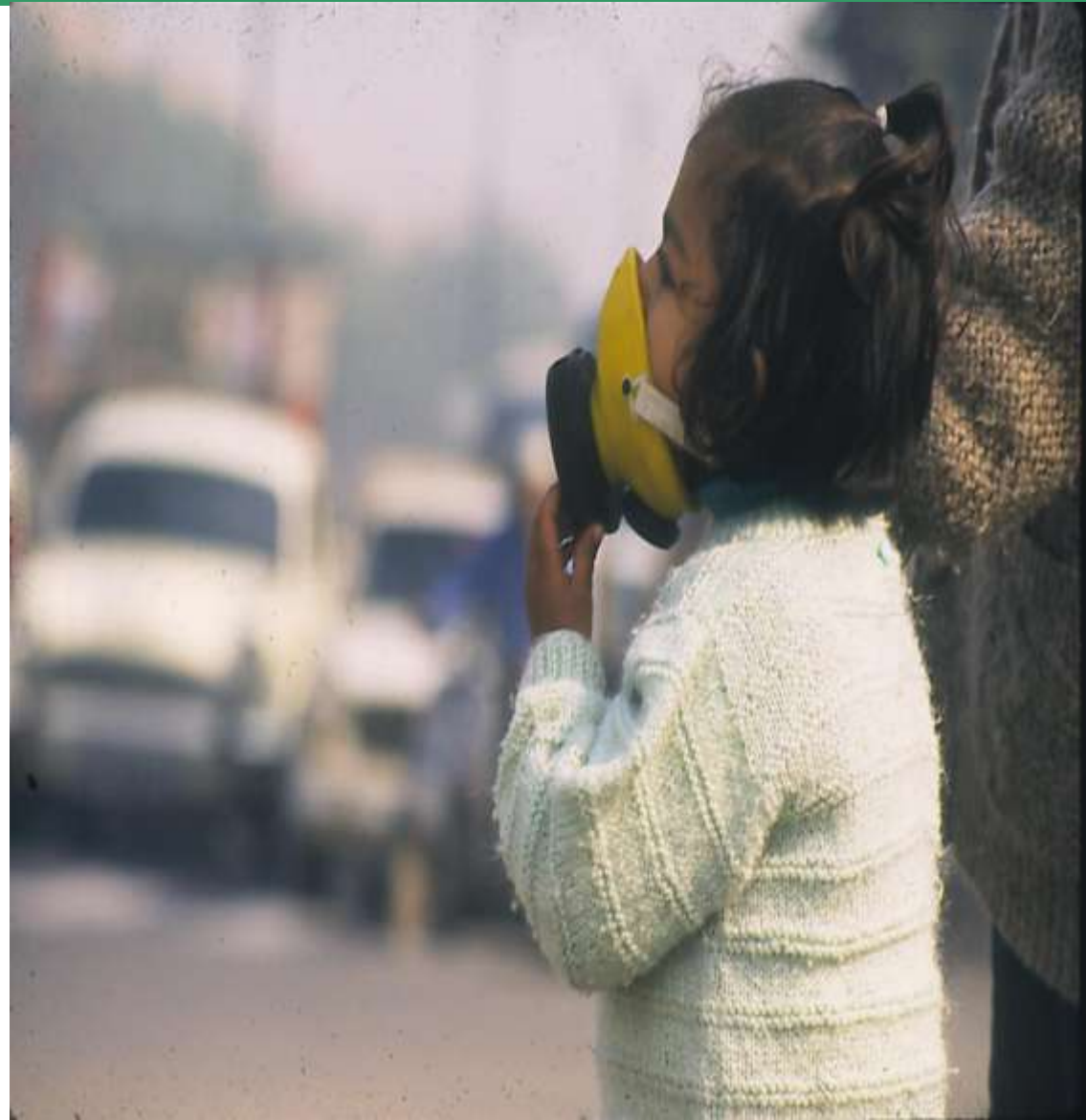
“Economic Growth and Environmental Sustainability. Are there tradeoffs? Dealing with Air Pollution Issues....”



Anumita Roychowdhury
Centre for Science and
Environment

Greening India's Growth
*ICRIER and Global Green
Growth Institute and World
Bank Conference*

New Delhi, June 12, 2014





The price of wealth

One person dies every hour in Delhi because of air pollution

In 20 years between 1975 to 1995 the GDP more than doubled in India, but...

Vehicular pollution load went up 8 times.

The industrial pollution load went up 4 times.

GDP doubled



Mounting evidences on state of air and health in India.....



2013: GBD estimates: Air pollution is the fifth largest killer in India

2013: International Agency for Research on Cancer (IARC) and WHO declare outdoor air pollution as group 1 carcinogen

2012: Reclassification of diesel exhaust as class I carcinogen by International Agency for Research on Cancer (IARC), and WHO, declares diesel exhaust as class I carcinogen for strong link with lung cancer.

2013 NASA study -- high PM 2.5 belt stretching from Delhi south-east to Kolkata.

2014: Yale University 2014 Environmental Performance Index: India among the worst performers. Worse on Air Quality

April 2014: WHO database shows 13 out 20 most polluted cities in the world are in India

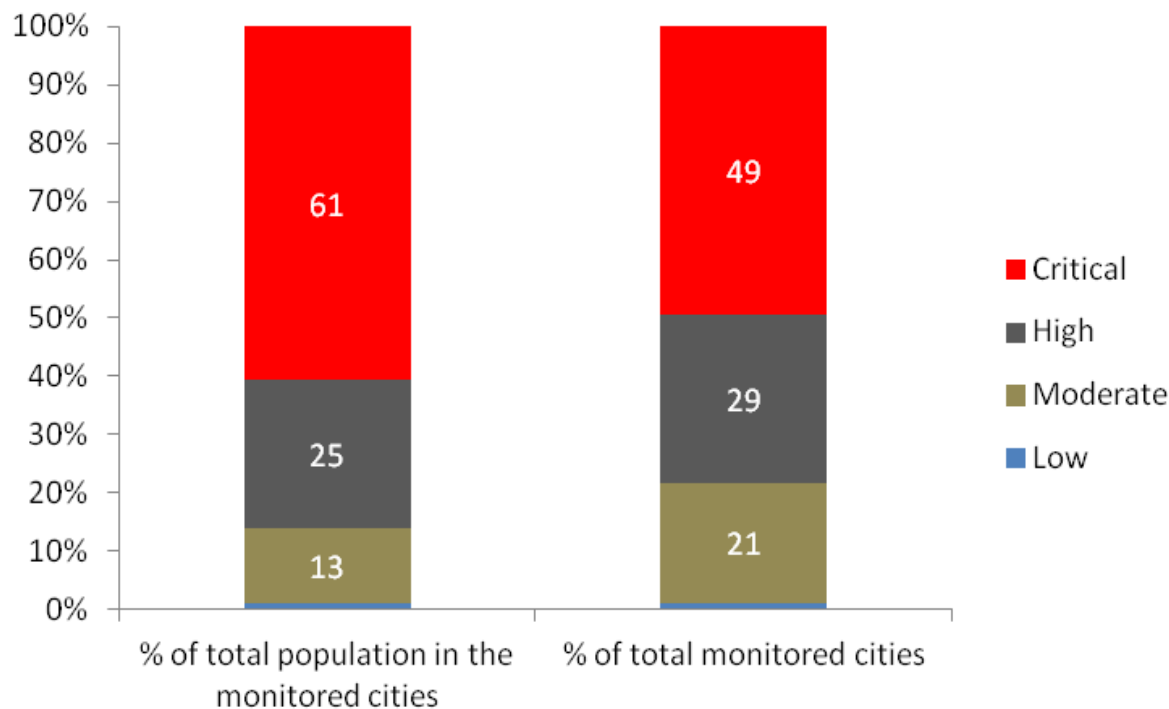
Data from air quality monitoring in India proves the risk.....



Killer particlesCities with critical pollution level increasing



Nearly half of Indian cities have critical pollution levels. This represents close to two third of urban population. WHO says particles are dangerous at any level....



Note: Cities with PM10 levels 1.5 times the standards is classified as critical
Source: Estimated on the basis of CPCB air quality database and Census data

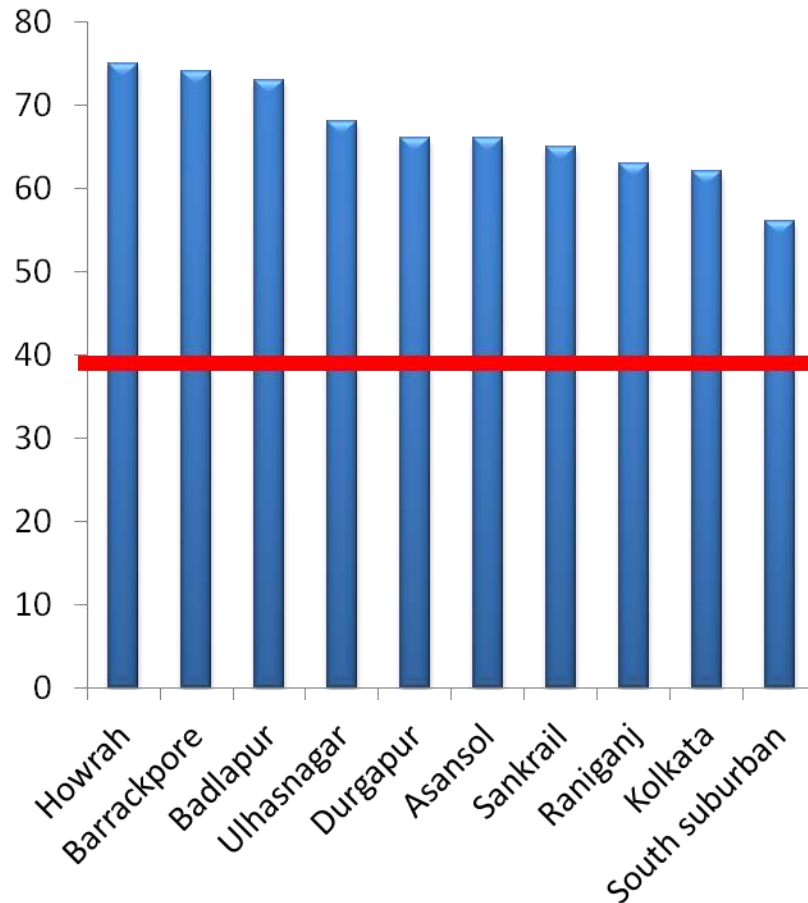


Multi pollutant crisis....

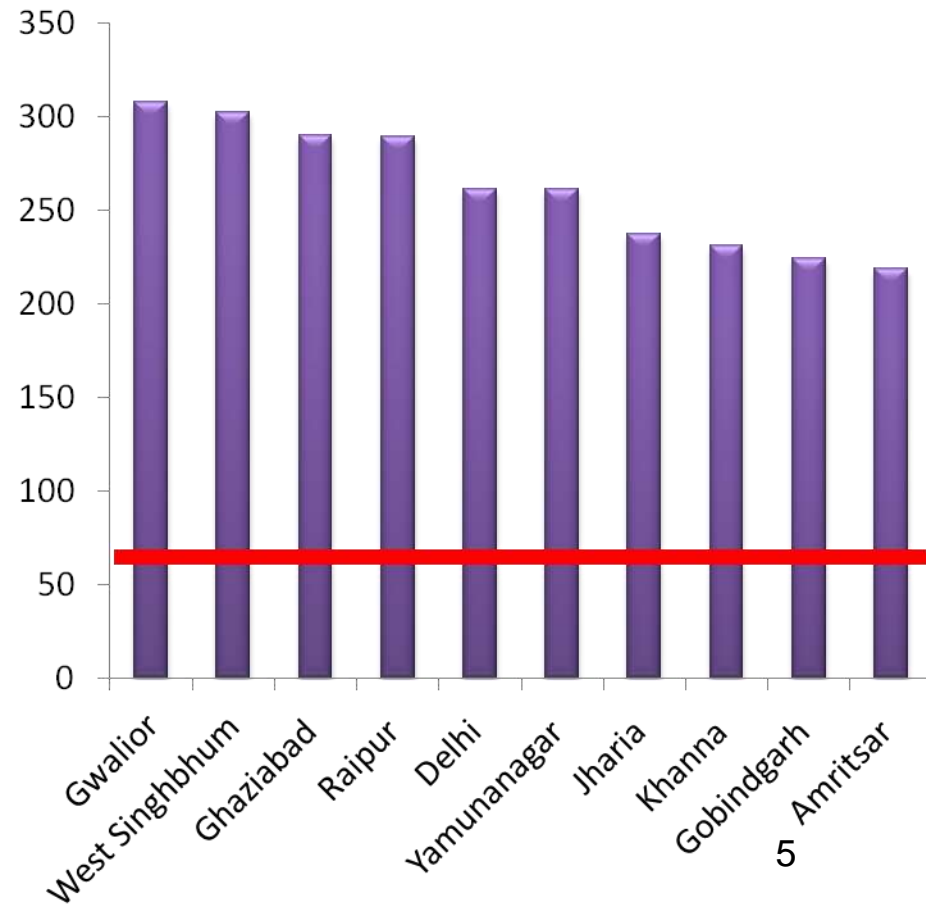
Also smaller towns are more polluted than big metros



NO2 Hotspots



PM10 Hotspots

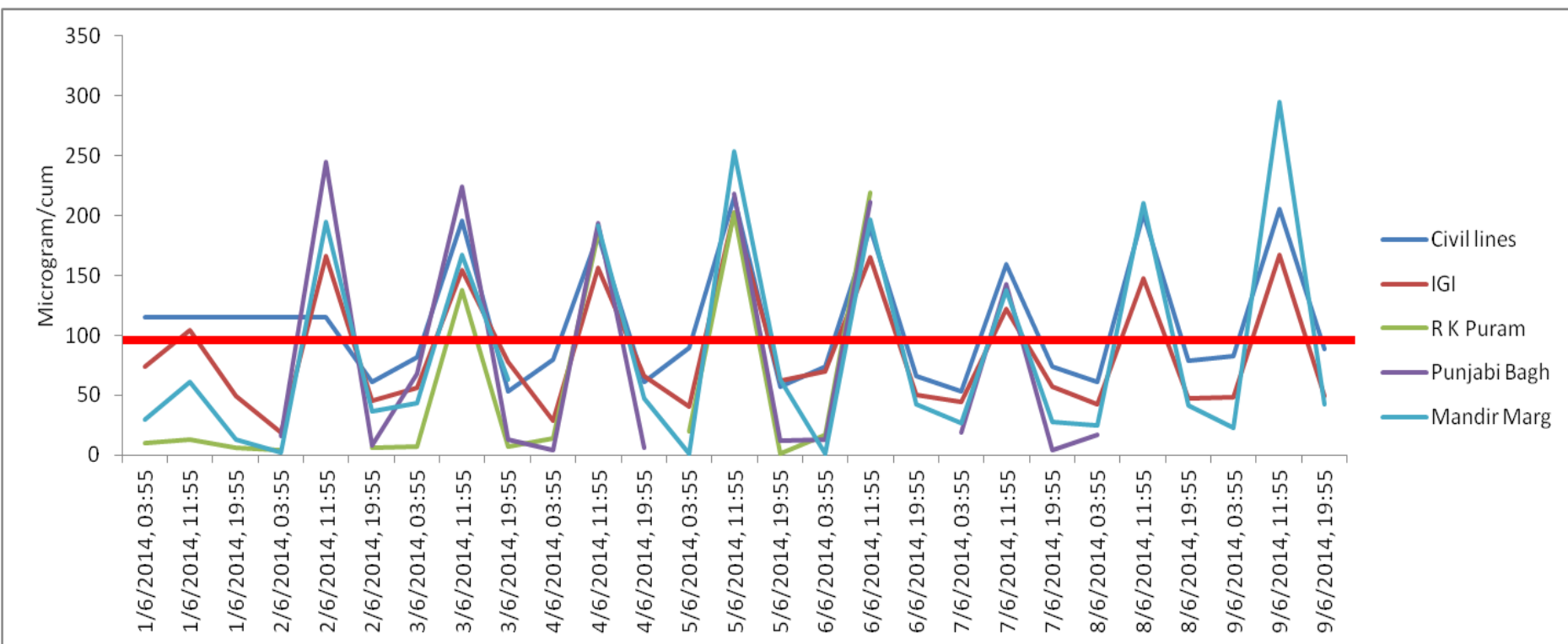




New threat in our cities.....



Ozone levels in Delhi June, 2014 (8 hr average)





Winter smog... **One third of days this winter had levels five times higher than the standards.....**



Air quality (PM2.5 concentration)	No. of days	Days (%)
Within PM2.5 standard of 60 microgramme per cubic metre	3	2
50% above the standard (60-90 microgramme per cubic metre)	7	6
100% above the standard (90-120 microgramme per cubic metre)	7	6
300% above the standard (120-240 microgramme per cubic metre)	51	41
500% above the standard (240-360 microgramme per cubic metre)	41	33
Above 360 microgramme per cubic metre	14	11



The human story....

Our health is at stake...yet
risk perception is very
poor.....Health concerns
do not drive policies....

**cough
wheeze
suffocate**

it's time you
TAKE A STAND

PUT YOUR HEALTH ON THE POLITICAL AGENDA

3.30 pm • June 5, 1999 • Silver Oak, India Habitat Centre, Lodi Road, New Delhi 110003

People for Clean Air

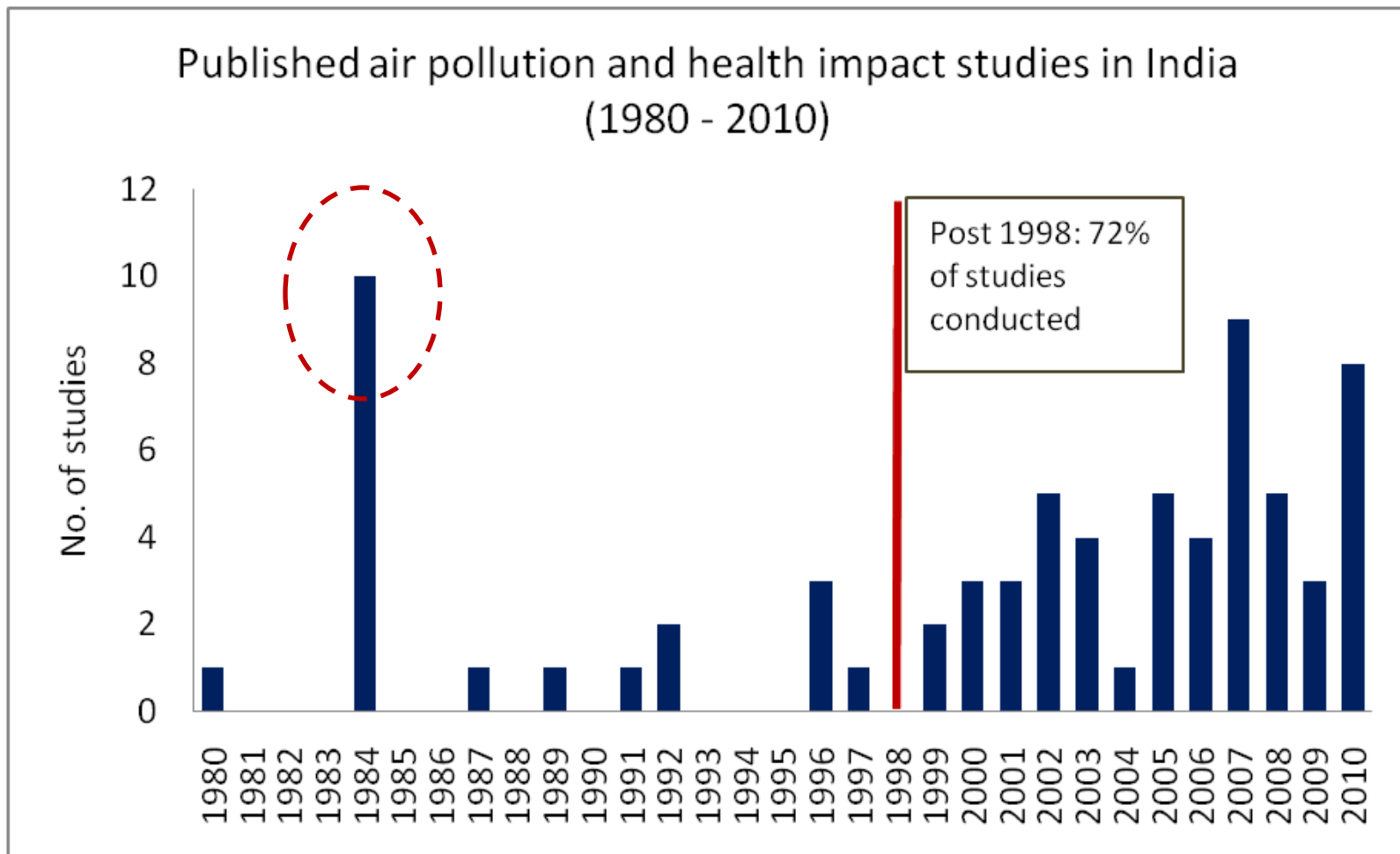


CENTRE FOR SCIENCE AND ENVIRONMENT
2995 5124, 2995 6110, 2995 6399, 2995 6394

From its early stages, CSE's Right to Clean Air campaign used a variety of communication tools — such as this poster — to put out its message to the public. It built support



Studies in India...



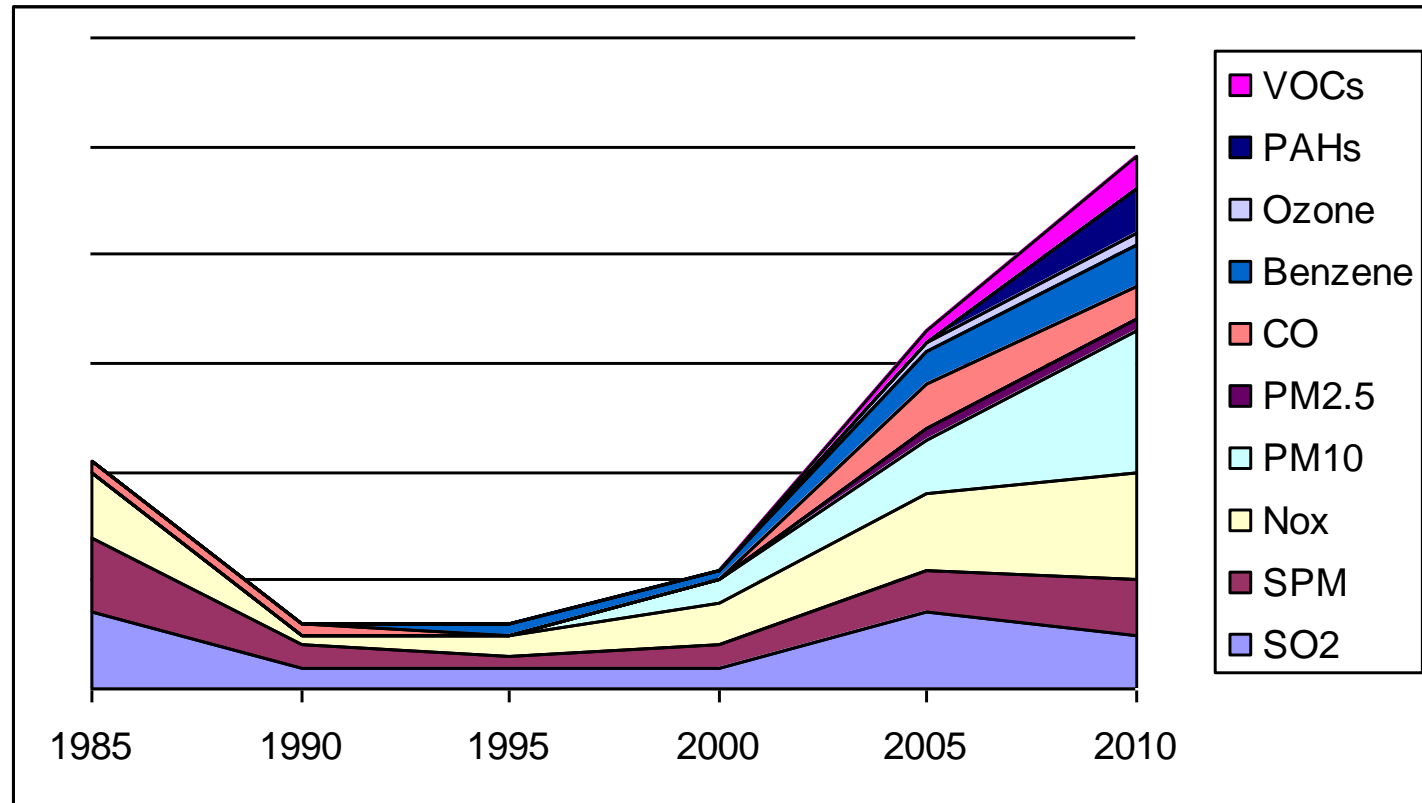


Studies have responded to the emerging concerns in air quality...



-- **Early years:** Primary focus on SPM, SO₂, and little on NO_x – nearly 60%

-- **Subsequent years:** A wider pollutant basket:



Source: CSE

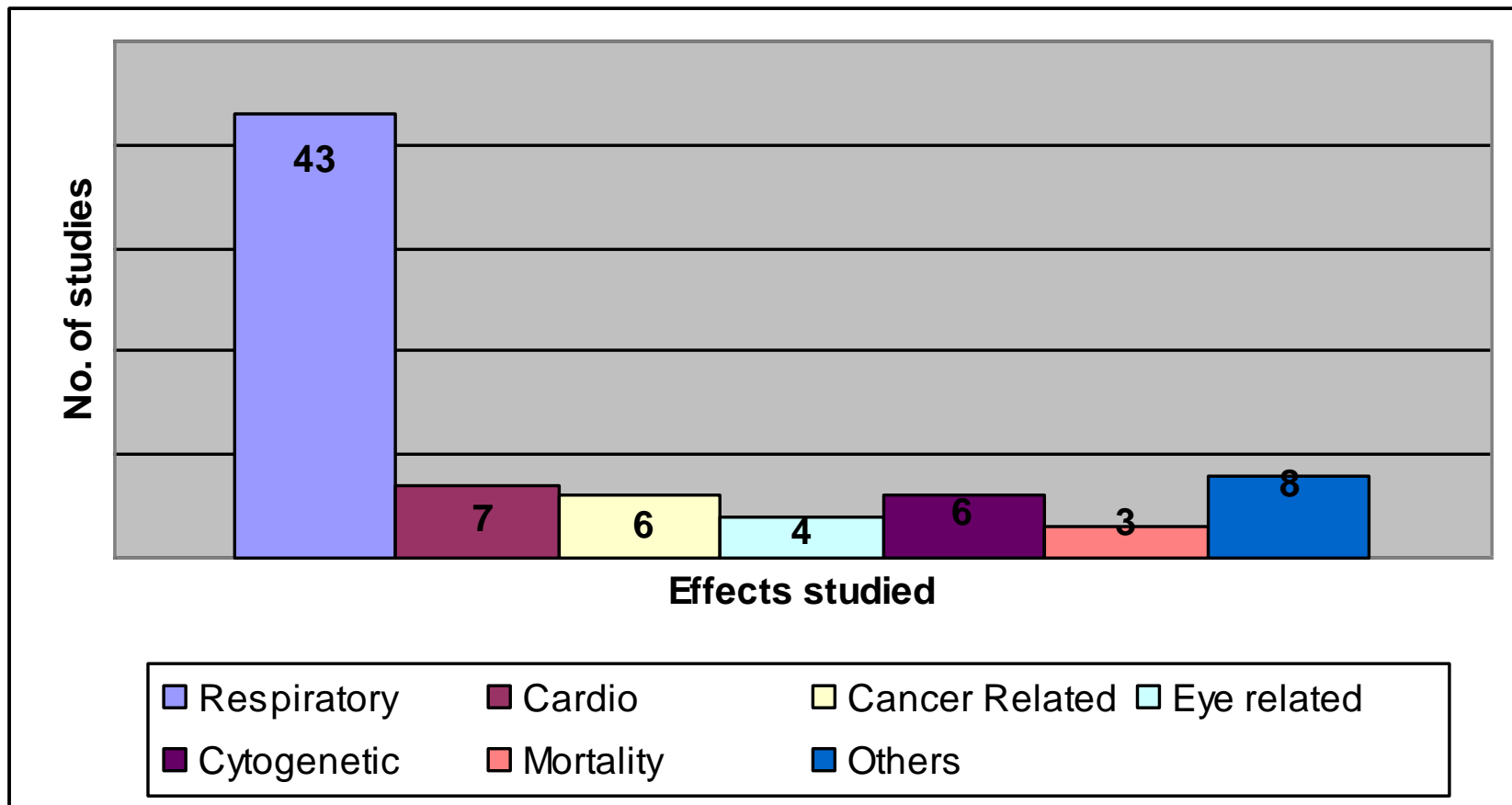


Studies looking at a more diverse health end points....



Predictably respiratory health symptoms dominate....

Broadens to other health end points – cardiovascular, eye disorders, cellular changes, cancer, premature deaths....





Global studies

Looking beyond lungs



Diabetes: First large-scale population-based study links diabetes with air pollution. Increase in insulin resistance in lab test and an increase in markers of inflammation (which may contribute to insulin resistance) after particulate exposure. Strong and consistent association between diabetes prevalence and PM_{2.5} concentrations. For every 10 µg/m³ increase in PM_{2.5} exposure, there was a 1 percent increase in diabetes prevalence. Counties with highest versus the lowest levels of PM_{2.5} pollution had a more than 20% increase in diabetes, which remained after controlling for diabetes risk factors. (Diabetes Care 2011)

Heart:

Acute Effects of Fine Particulate Air Pollution on Cardiac Arrhythmia: Conclusion: PM_{2.5} exposure within approximately 60 min was associated with increased PVC counts in healthy individuals. (He F et al 2011 The APACR Study. Environ Health Perspect)

Blood pressure

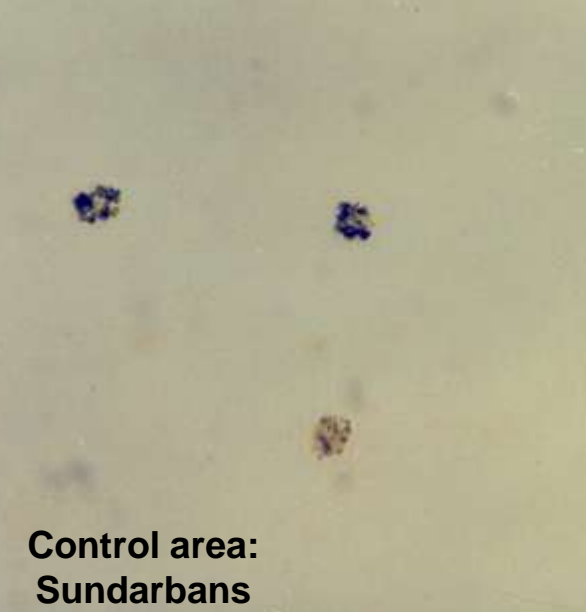
Traffic-related Air Pollution and Blood Pressure in Elderly Subjects With Coronary Artery Disease: Found positive associations of systolic and diastolic BP with air pollutants. The strongest associations were with organic carbon, multiday average exposures, ect. (Delfino, Ralph J. et al 2010, Epidemiology, May 2010)

Effect on foetus: Studies have shown damaging impact of PAH on even fetus

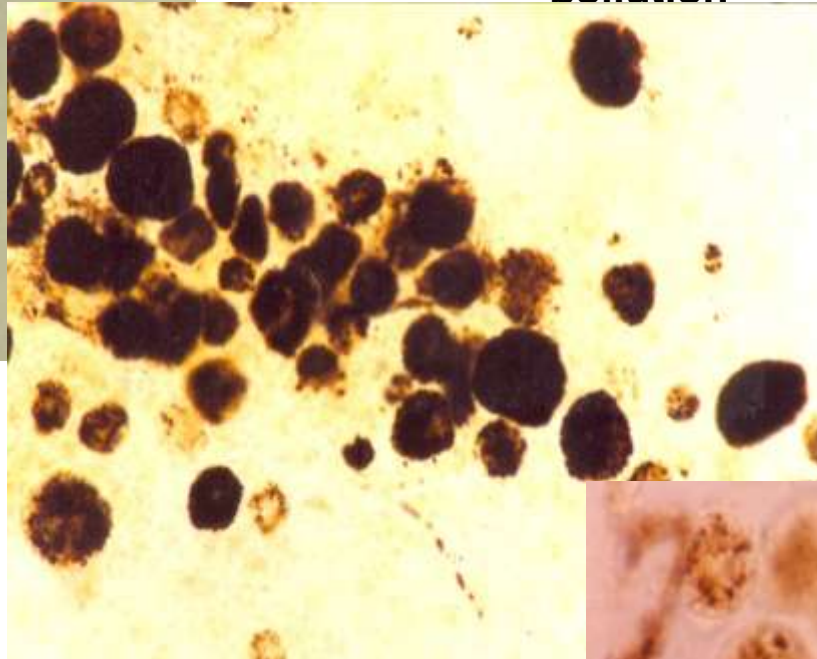
Emerging evidences of health impacts in India.....



Alveolar macrophage - biomarker of air pollution



Control area:
Sundarbans

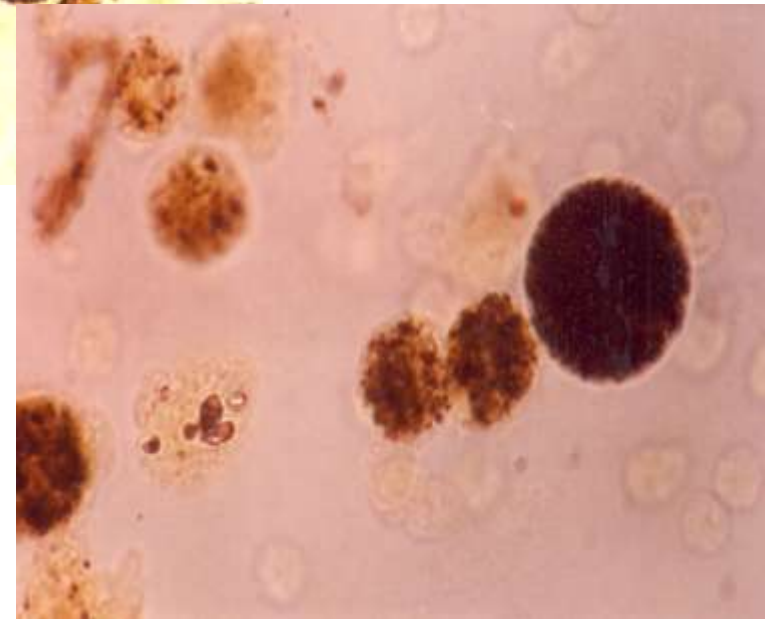


Exposed group; Kolkata
taxi driver

Increase in AM number



Larger AM – particle laden



Look at these black spots on the lung. The unfortunate owner lives in Delhi and has been breathing polluted air full of carbon particles which accumulate in the lungs (black spots). What you can't see is a cocktail of gases and tiny particles, even smaller than carbon that get into our bodies. Actually, you are getting polluted.

Delhi lung
Capital punishment

Scary? But those rats are so sexy!



Health of children compromised.....



2012 epidemiological study on children in Delhi (CPCB and Chittaranjan National Cancer Institute of Kolkata):

-- Covered **11,628 school-going children** from 36 schools.

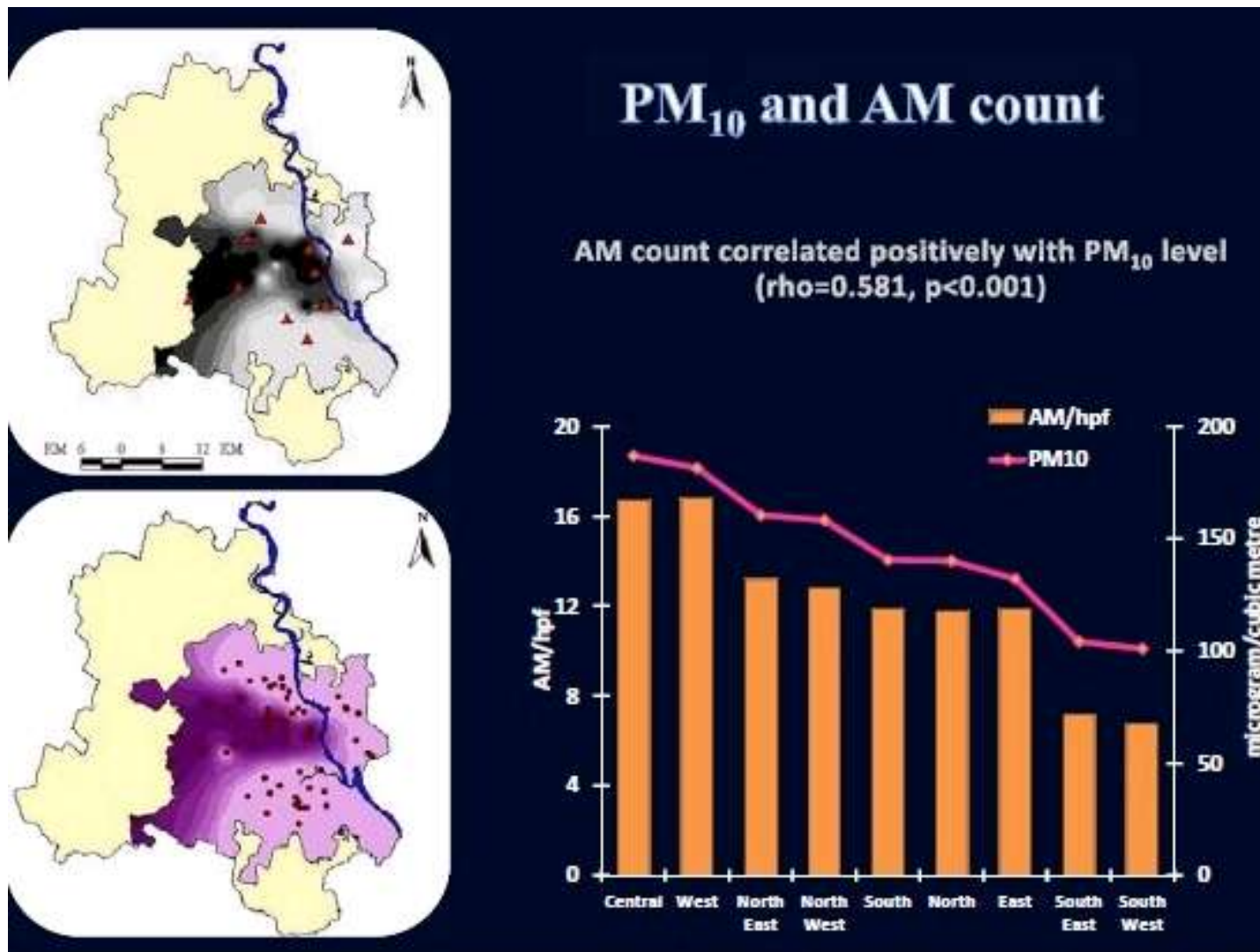
-- **Every third child has reduced lung function. Sputum of Delhi's children contains four times more iron-laden macrophages** than those from cleaner environs, **indicating pulmonary hemorrhage.**

-- **The levels of these biomarkers in children have been found to be higher in areas with high PM10 levels.**





Co-relating health evidences with air pollution in Delhi





Poor at risk....

Poor status of nutrition, high cost of treatment make the poor specially vulnerable.....

Bangalore: Increased prevalence of asthma in children of lower socio economic classes. Children from **heavy traffic region and low socioeconomic population had much higher prevalence**. (H Paramesh)

- **Hyderabad:** Drug off-take study conducted by S V S Medical College, found **highest drug sale in Punjagutta and Abids zones that have recorded highest PM1 and PM10 levels**.
- **Mumbai:** The National Cancer Control Programme has listed greater exposure to environmental carcinogens as one of the most important reasons for the prevalence of cancer. Department of Preventive Oncology of Tata Memorial Centre, Mumbai, found **incidence of cancer in the city's slums very high**. Air pollution plays a role in enhancing this risk.
- **Chennai:** Sensitivity of poor neighbourhoods.....



Air pollution and toxic risk



The endpoint of the toxic risk is cancer. The WHO has reclassified air pollution and particularly diesel emissions as a class 1 carcinogen

According to the the National Cancer Control Programme in India over 700,000 new cases and 300,000 people are set to die every year. NCCP's forecast -- by 2026, more than 1.4 million people will be falling in the grip of the disease.

-- NCCP has listed greater exposure to **environmental carcinogens** as one of the most important reasons.

-- The mitigation strategy must reduce environmental risk from all factors – and air pollution is an important factor

Numerous studies in the West assessed the causes such as genetic susceptibility, environment factors and lifestyle.

Found overwhelming influence of environmental factors.



Vehicular pollution: High exposure



Vehicular emissions contribute to significant human exposure. **Pollution concentration in our breathe is 3-4 times higher** than the ambient air concentration.

In densely-populated cities more than **50 – 60% of the population lives or works near roadside** where levels are much higher. This is **very serious in low income neighborhoods** located close to roads.

The WHO report of 2005: Epidemiological evidences for the adverse health effects of exposure to transport related air pollution is increasing.

Some of the deadliest air toxics, also carcinogens, are related to vehicular emissions. Blamed even for killing foetus.

About 60% of health studies in India have focused on exposure to traffic pollution...



What matters is what and how much we inhale.....



Stunning evidences in Delhi

New research in Delhi from University of California, Berkeley:

- Found commuters breathe far more harmful particles inside vehicles while traveling compared to the ambient concentration.
- The PM2.5 concentrations inside vehicles can be 1.5 times higher than the surrounding background air and ultra-fine levels about 8.5 times higher.
- The short-term peaks during travel can go above 1000 microgramme per cum – nearly 16 times the daily limit.

Health Effects Institute on Delhi:

This is further supported by the estimates of Health Effects Institute that about 55% -- more than half of Delhi's population live within 500 meters from arterial roads in Delhi that is the direct influence zone.

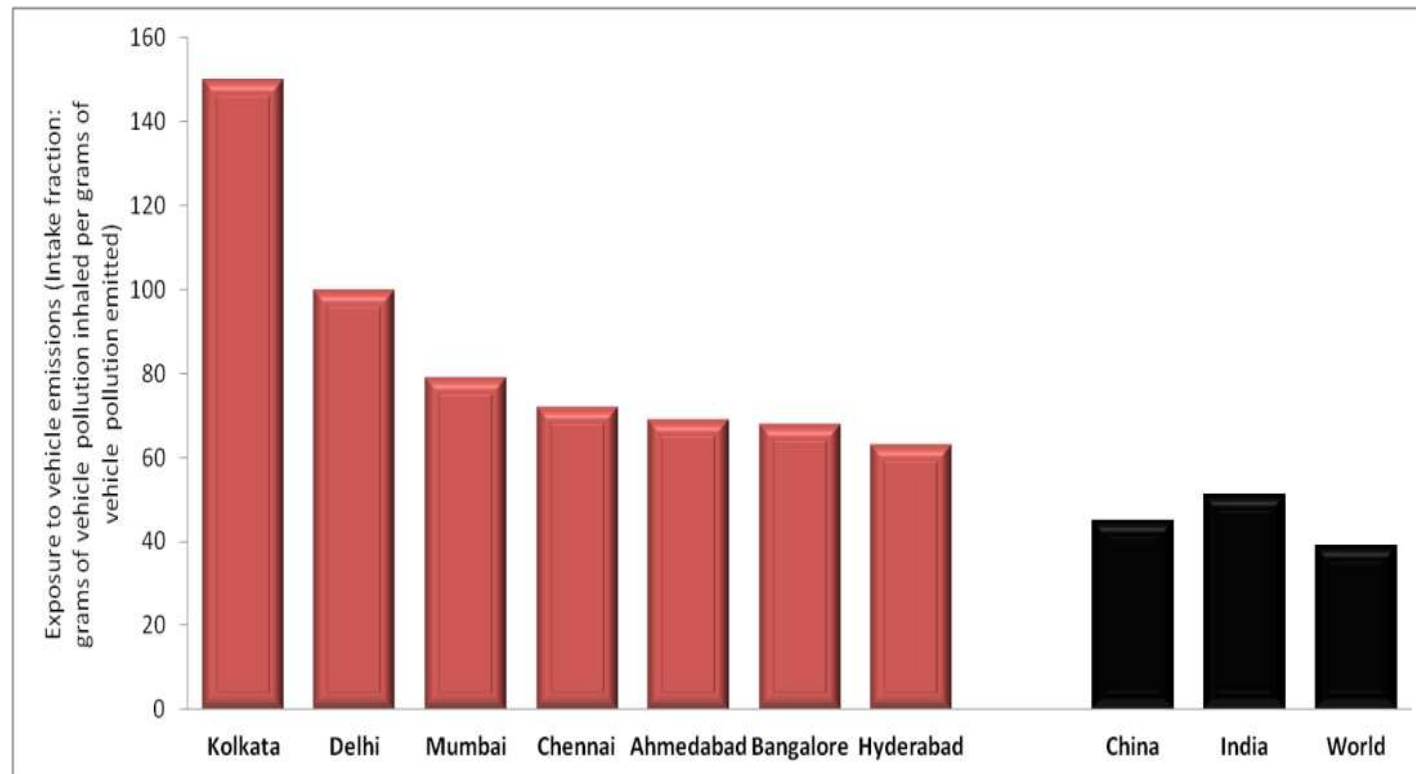
Such evidences are ominous for all road users, public transport users, walkers and cyclists.



Exposure to Vehicle Emissions



In Kolkata and Delhi, the people's exposure to vehicle exhaust is 3 to 4 times higher than the world average



Exposure (iF) is the population-weighted intake fraction, or the grams of vehicle pollution inhaled per grams of vehicle pollution emitted.

Estimates from Apte, J. S., Bombrun, E., Marshall, J. D., & Nazaroff, W. W. (2012). Global Intraurban Intake Fractions for Primary Air Pollutants from Vehicles and Other Distributed Sources. *Environmental Science and Technology*, 46(6), 3415–3423.



Delhi achieved: Policy slow down...



First generation action 1998-2008

- Enforced Euro II emissions standards in 2000, five years ahead of schedule, Euro III in 2005; unleaded petrol
- Mandated pre-mix petrol to two- and three-wheelers
- Implemented largest ever CNG programme: Largest ever public transport bus and three-wheeler fleet on natural gas
- Capped the number of three-wheelers
- Phased out 15 year old commercial vehicles
- Strengthened vehicle inspection programme (PUC)
- Efforts made to bypass transit traffic
- Relocated polluting industry; Stricter action on power plants; two power plants on natural gas; Ban on open burning

Second generation action 2008 - 2014

- Metro system expanded
- Close to 6000 new buses
- Euro IV standards in 2010; upgraded PUC tests
- Air Ambience Fund in 2009
- 40 km of cycle tracks with new footpaths in 2010
- Marginal increase in parking prices in NDMC area

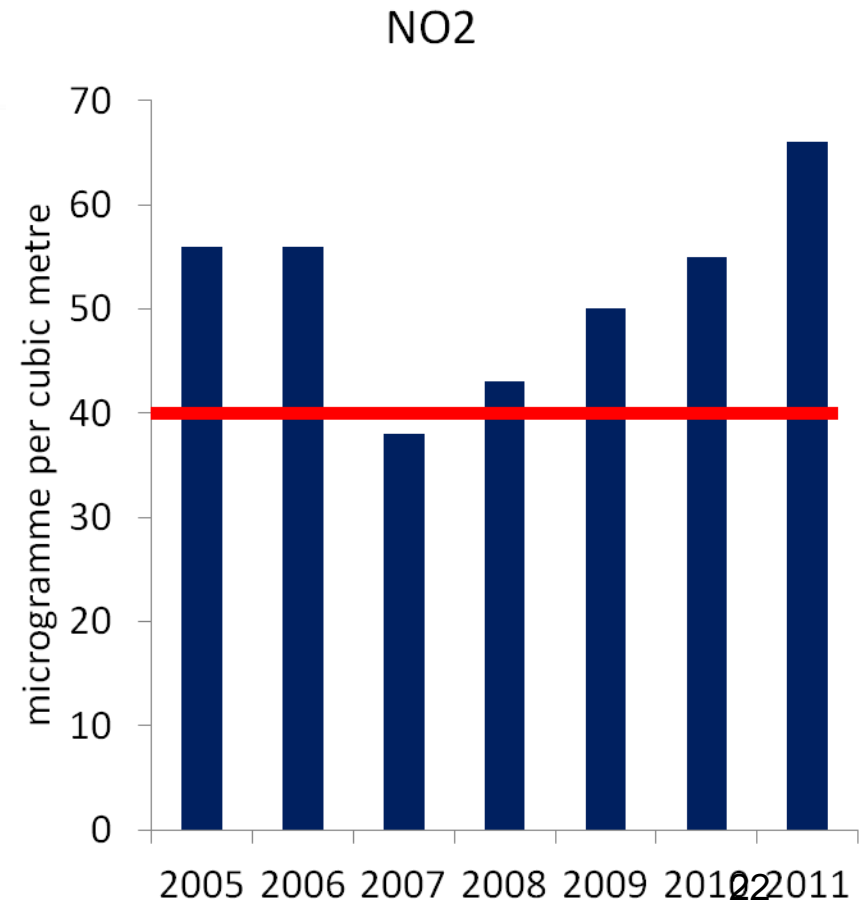
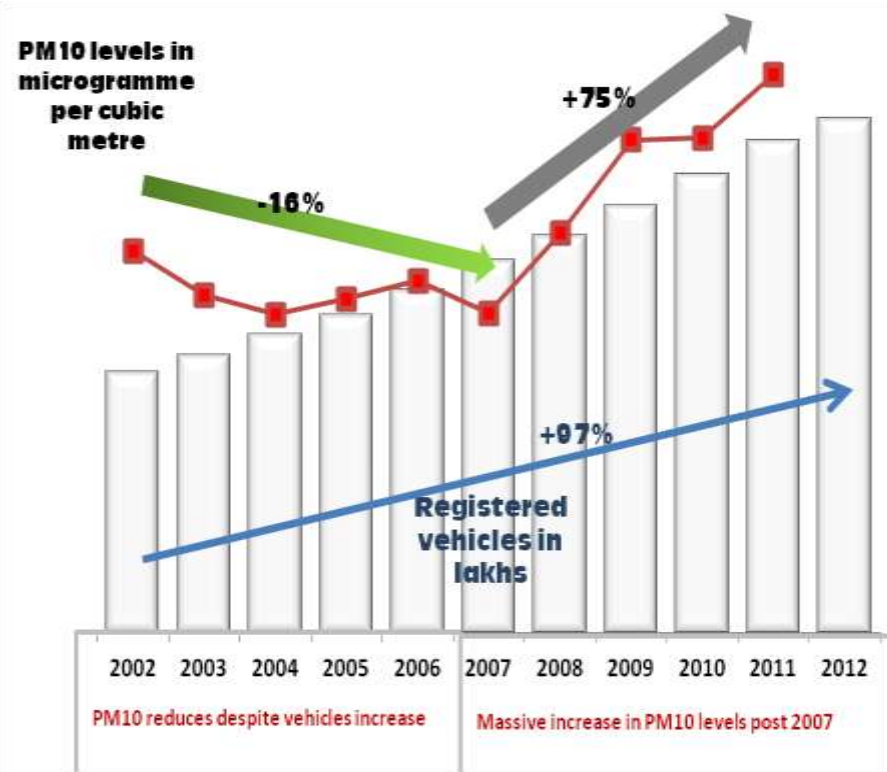


Delhi has lost its gains. After a short respite pollution curve turns upward



Particulate pollution decline and rise again
due to rapid increase in vehicle numbers

NO₂ levels rising steadily





MOBILITY CRISIS



Cities are losing battle of car-bulge: **The rapid increase in vehicles is destroying all gains of air pollution and health**



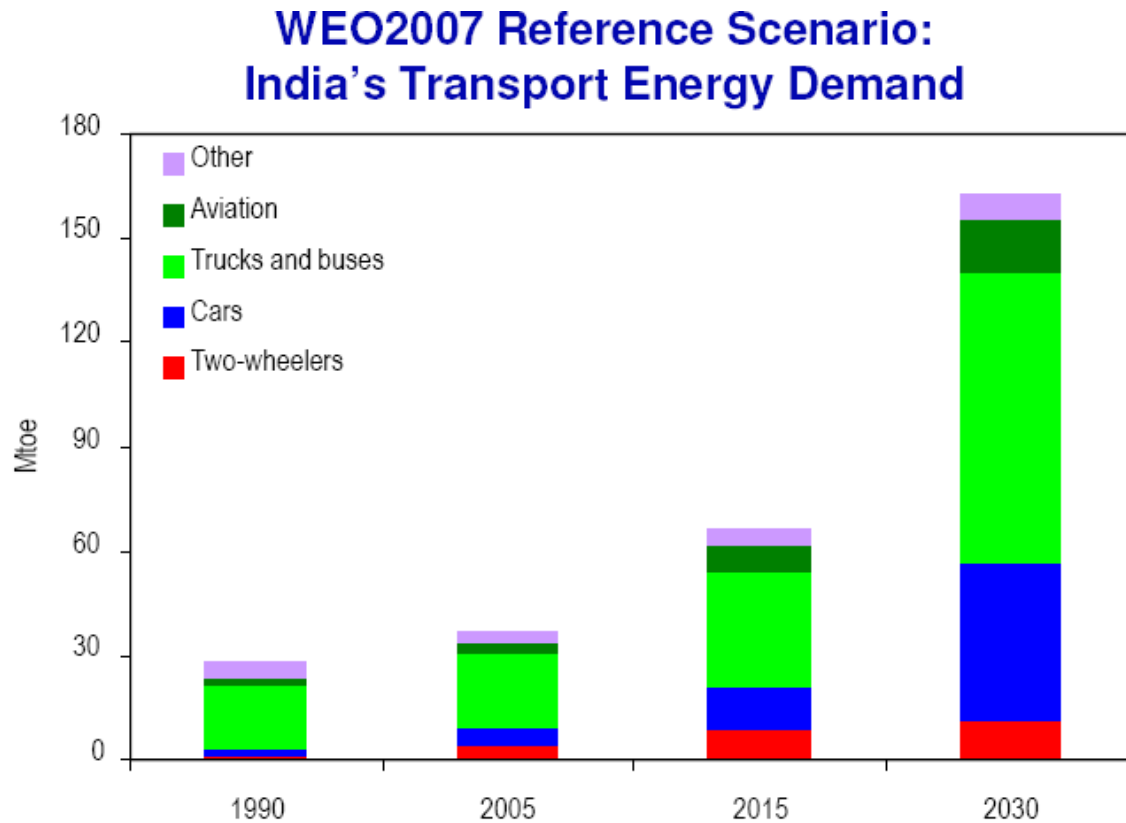


Convergence

Motorisation threatens energy and climate security



Trend in fuel consumption by different modes of transport in India



Transport demand – mostly oil – grows rapidly as car ownership increases in line with rising incomes



Challenge of co-benefits and trade-offs....

-- National Climate Action Plan takes on board the principle of co-benefits but does not outline the indicators of co-benefits and trade-offs to guide policy making.....



How do we account for health cost and benefits in decision making?



Sprinkling of evidences on health cost-benefits in India.....Such estimates rarely done to influence policy decisions.

1995: Annual health cost of polluted air

World Bank: India: Rs 5,500 crore.

Delhi alone: Rs 1,000 crore

Auto Fuel Policy 2003: Total annual health cost range between Rs 679.07 crore to Rs 9,307.81 crore. Study did not consider cost of premature deaths, only income loss and treatment cost of pollution-related sicknesses.

2004: Benefits of avoidance of more than 13,000 premature deaths in 5 cities etc

2009: Annual health cost of polluted air

SIM Air: Delhi: Rs 2450 crore

Health is valued lower in places with lower incomes. Thus the net benefits of many policies are negative in poorer areas.

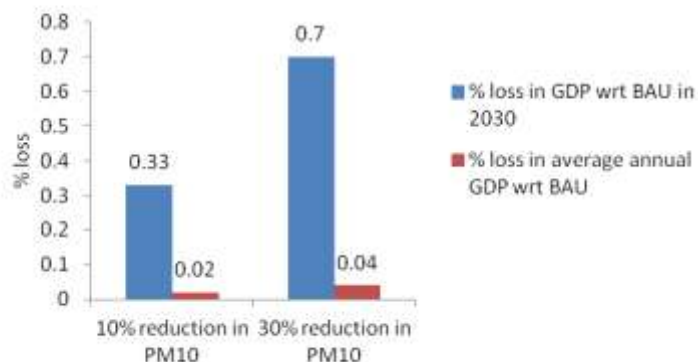
Health benefits are not estimated to drive policy decision..... Other governments integrate health cost criteria to justify the investments.



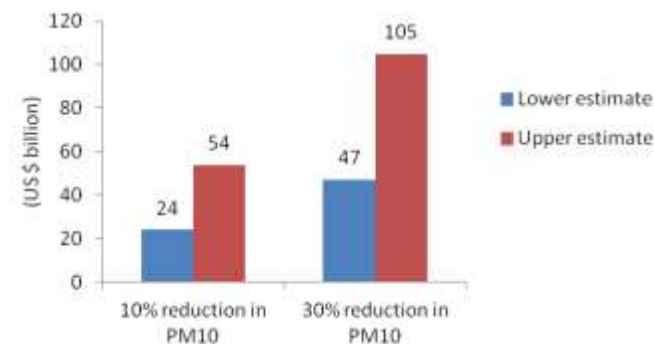
Co-benefit framework to reduce multiple risks India -- Cost of mitigation is off set by health benefits and reduced heat trapping CO2



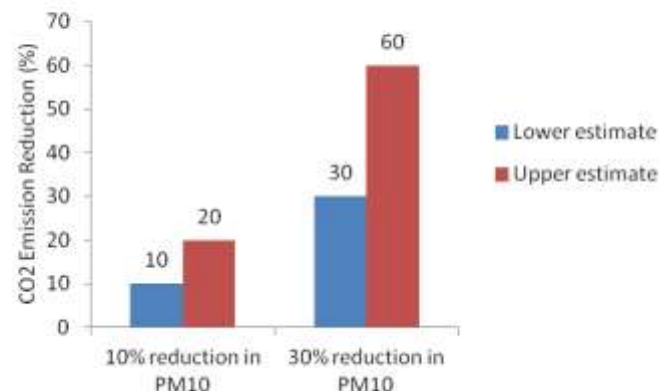
Is green growth affordable?



Savings from Reduced Health Damages



CO2 Emission Reduction (%)



•World Bank study (July, 2013):

- Outdoor air pollution is 29% of the total environmental damages
- Health cost of PM10 – 3% of GDP
- PM10 mitigation cost less than 1% of GDP
- Annual savings from health benefits can be more than USD 100 billion
- CO2 emissions can be reduced by upto 60%

Source: Based on (Diagnostic Assessment of Select Environmental Challenges in India A World Bank 2013)



•Next gen regulatory questions in India....

- How can regulatory programmes:
 - balance the costs and benefits of regulations
 - use market based instruments to shift markets and change behaviour
 - make trade-offs transparent
 - recover environmental and social costs

But often the interlinking of complex issues for co-benefits and avoidance of trade-offs are not well understood or recognised.....



(1) Policy debate on cost-benefit of auto fuel policy roadmap.....

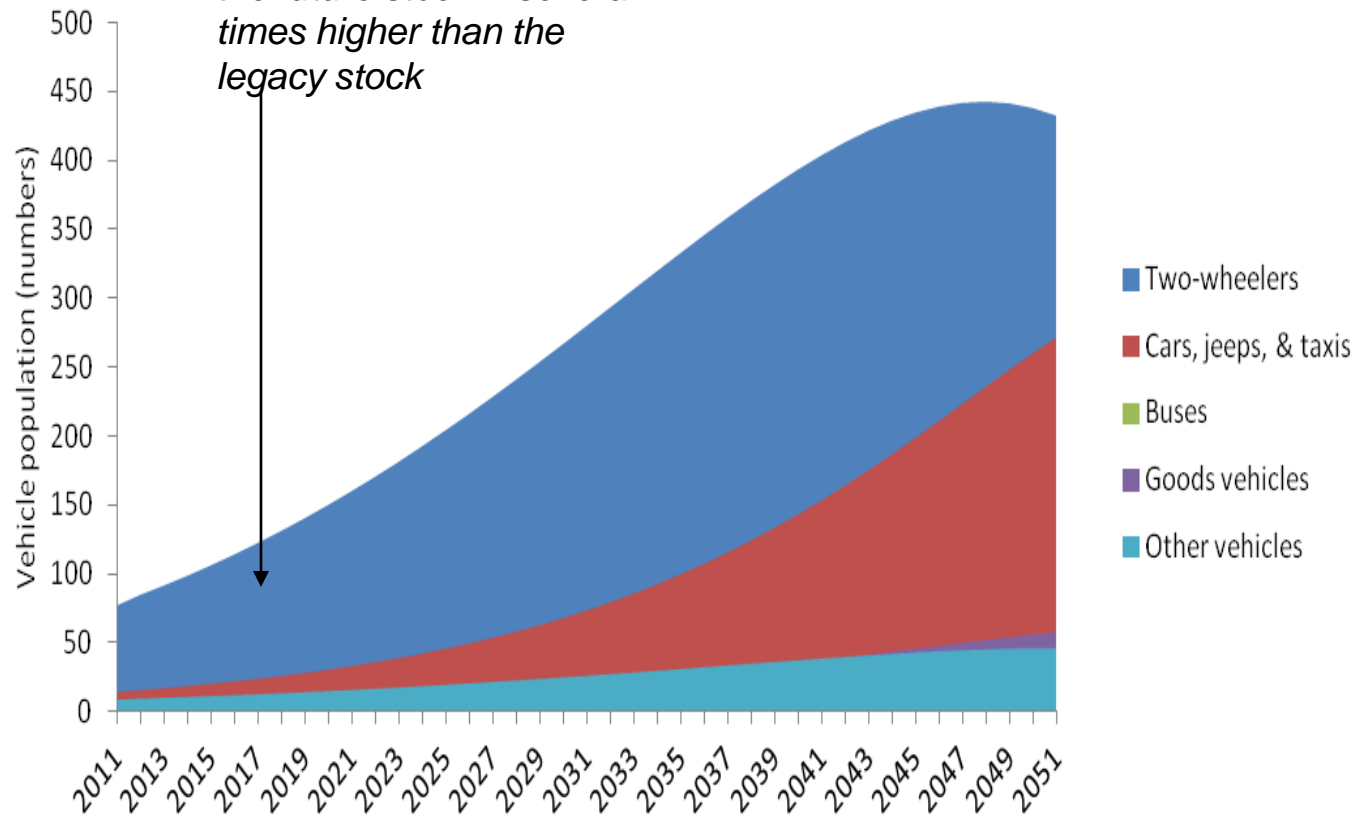
How can roadmap account for public health and climate co-benefits? Case of diesel in the context of health and energy and climate security.....



Technology roadmap: Leverage India's opportunity.....



Need stringent and preventive action and decision here to influence the future stock -- several times higher than the legacy stock



Bharat Stage IV and III norms are 9-14 years behind Europe

India needs stringent emissions standards

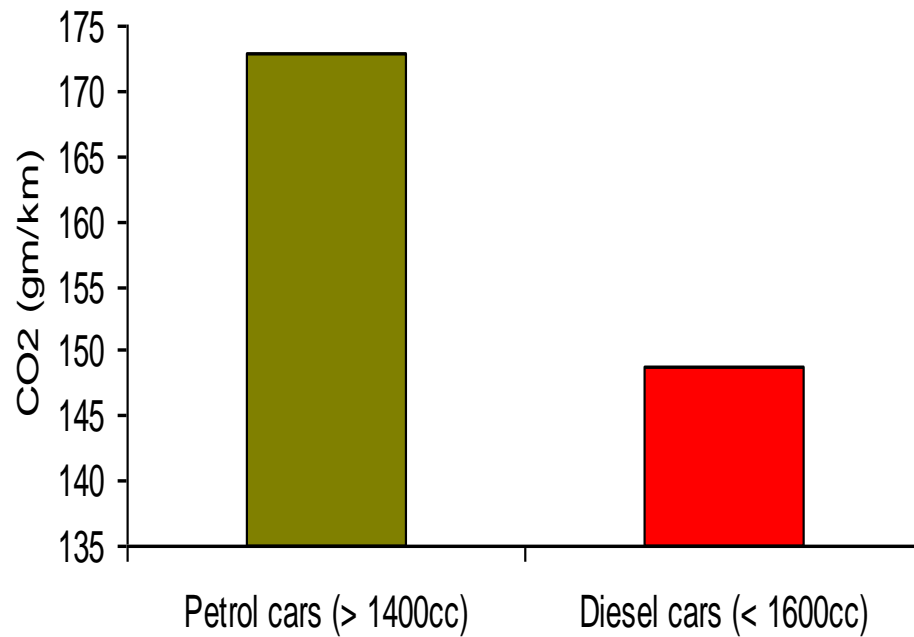
Meet Euro VI standards in 2020
– Only at this level petrol and diesel emissions equalise



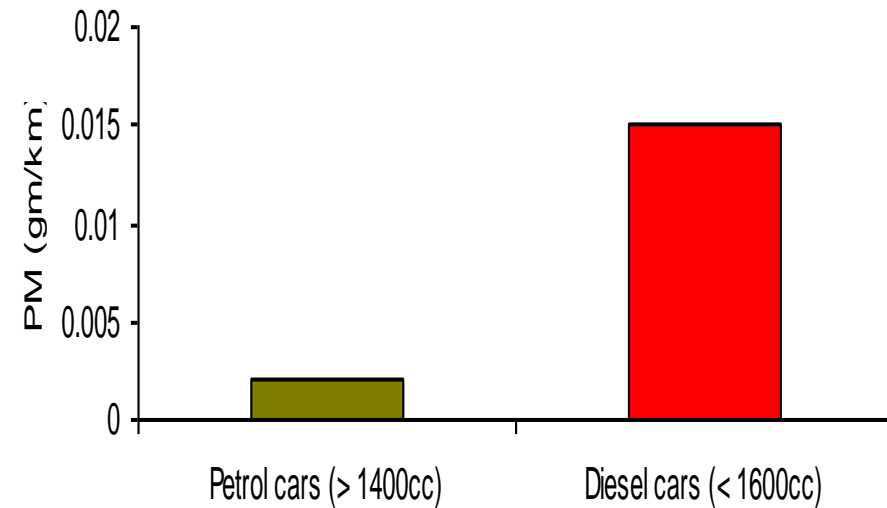
Diesel: the trade-off....



CO₂



PM



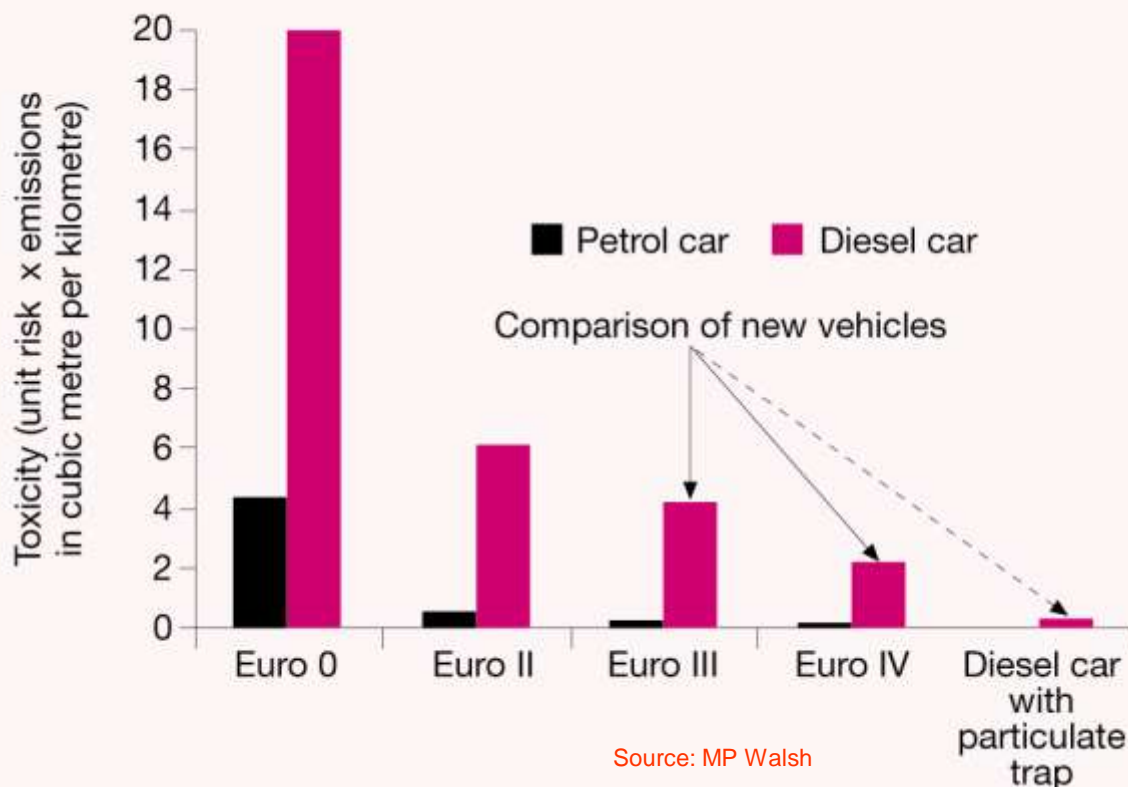


The shocker: Cancer risk of diesel



June 2012

The WHO/
International Agency
on Cancer Research
reclassify diesel
emissions as **class 1
carcinogen**, -- same
class as tobacco for
its strong link with
lung cancer.





Potent...



Other governments consider toxic Air contaminant Unit Risk Factors to prioritise action

Toxic Air Contaminant	Unit Risk/Million People	Detection limit (ppb)
Acetaldehyde	2.7	0.10
Benzene	29	0.05
1,3-Butadiene	170	0.04
Carbon Tetrachloride	42	0.02
Chromium, Hexavalent	150,000	0.06 (in nanogram)
<i>Para</i> -Dichlorobenzene	11	0.30
Formaldehyde	6	0.10
Methylene Chloride	1	0.10
Perchloroethylene	5.9	0.01
Diesel particulate matter	300	N/A

Note: Unit Risk represents the number of excess cancer cases per million people per microgramme per cubic meter TAC concentration over a 70 year lifetime exposure

A diesel particulate matter unit risk value of 300 is used as a reasonable estimate in the "Risk Reduction Plan to reduce Particulate Matter Emissions from Diesel Fuelled Engines and vehicles (ARB, October 2000)

Source: California Air Resource Board

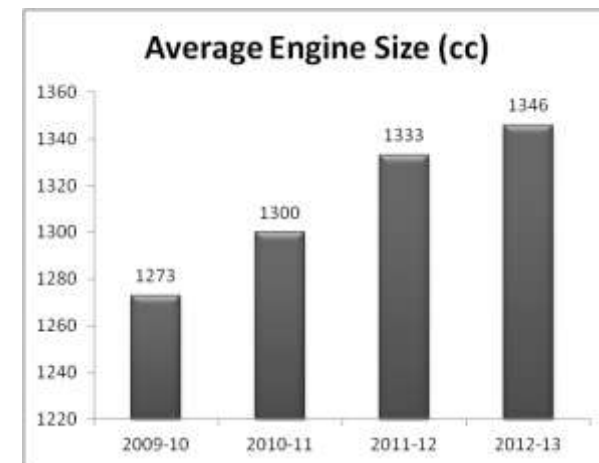
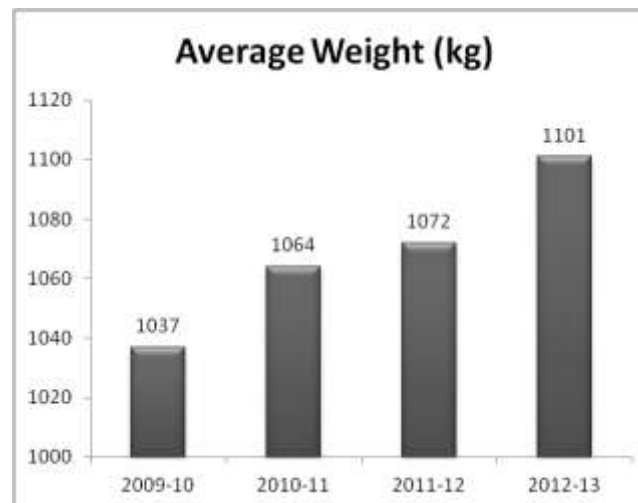
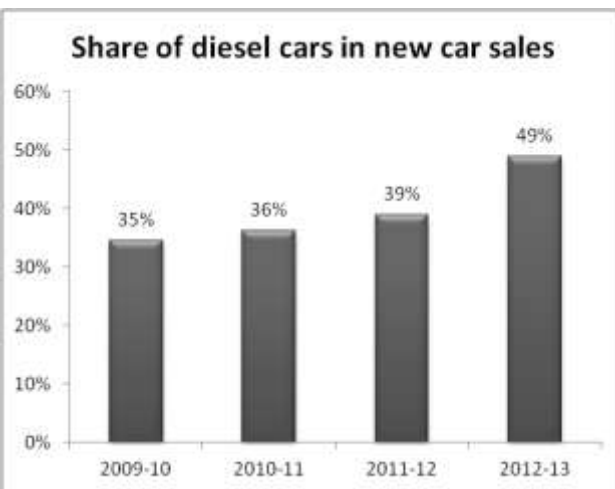


Energy challenge

Diesel vehicles locking up enormous energy and carbon. Increasing average weight of car fleet



- Average weight and engine size during 2009-10 and 2012-13 has increased by 6%.
- On an average every year, the weight and size of new vehicles is increasing at a rate of 2%. While 87% of petrol cars have engine size below 1.2 litres, 40% of diesel is 1.5 litre and the rest are more. This threatens fleet-wide fuel economy

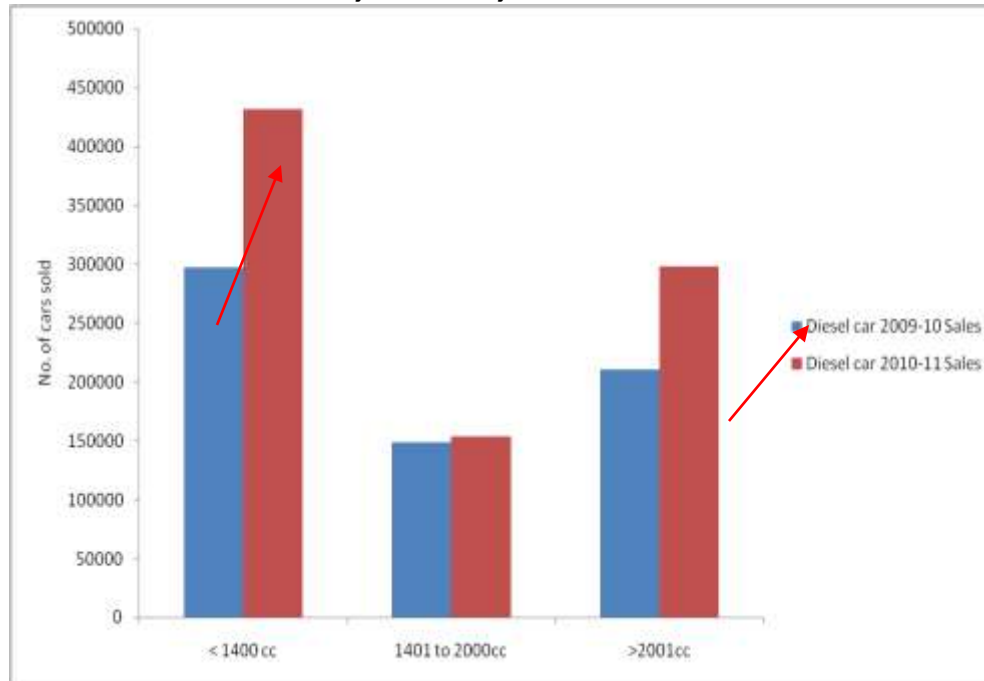




Why diesel makes us climate insecure?



Sales of diesel Cars, MUVs, MPVs

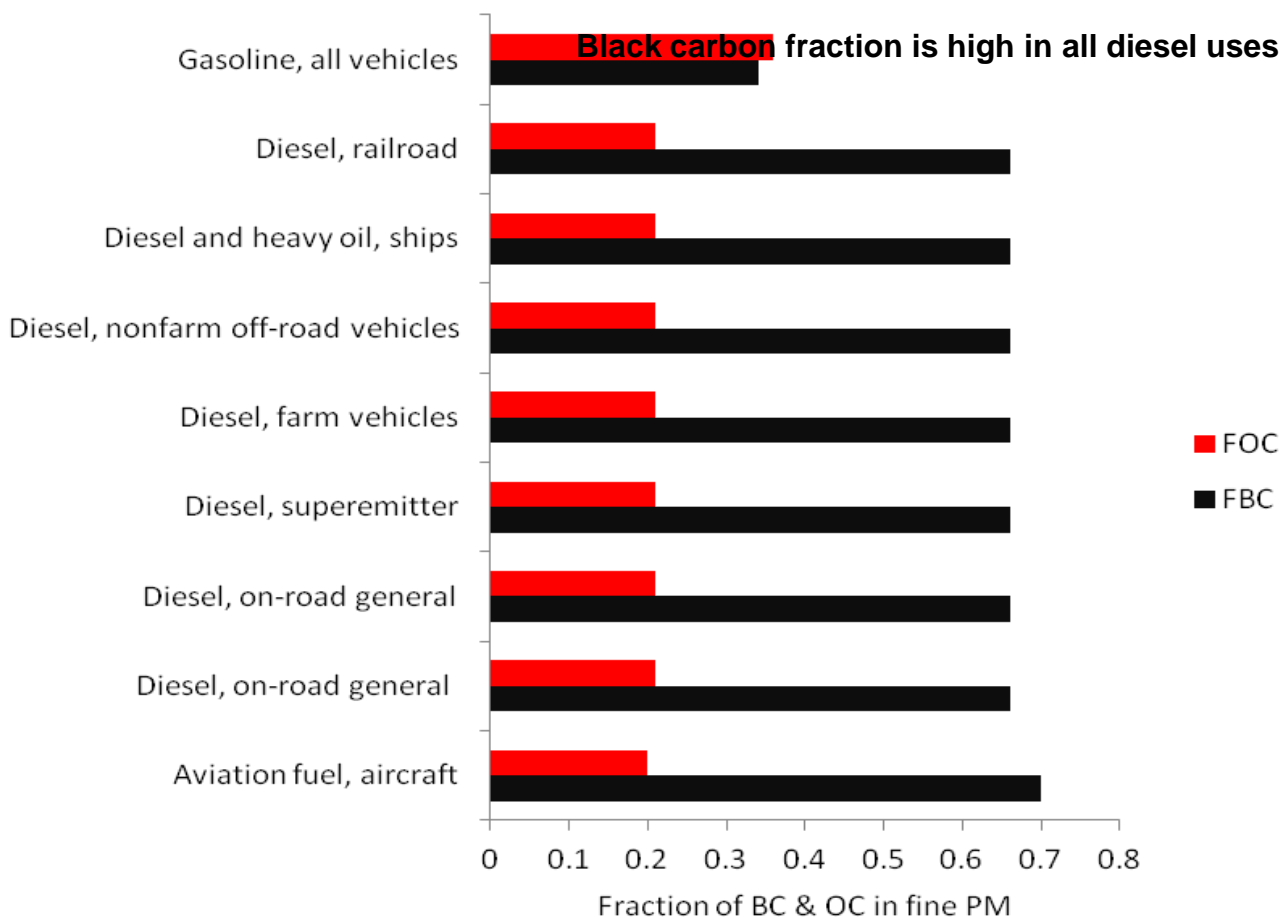


Rebound Effect: Diesel fuel has higher carbon content than petrol. If more diesel is burnt encouraged by cheaper prices and more driving, more heat-trapping CO₂ will escape.

CO₂ emissions from the upstream diesel refining process will increase: European Commission estimates difference in lifetime pollution costs of Euro IV diesel car and petrol car: -- Pollution cost of a Euro IV diesel car is 1195 Euros vis a vis 846 Euros for a petrol car. Negates marginal greenhouse gas reduction benefit



Challenge of black carbon emissions and warming impact.....

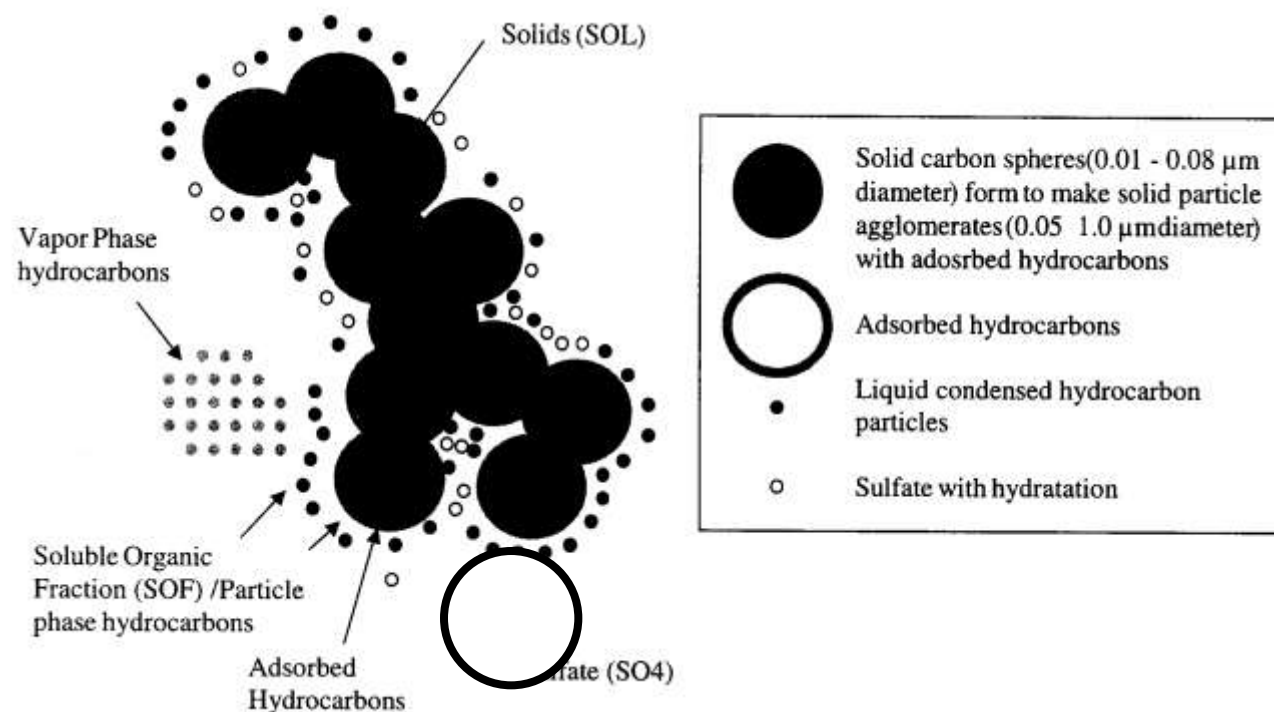


Black carbon emissions from diesel vehicles are several times more heat trapping than CO₂.

Even under Euro IV particle standards, diesel vehicles may still warm the climate for well over the next 100 years (Jacobson's assessment)



Black Carbon is the Core of Diesel PM



‘Bounding the role of black carbon’ Report 2013:

- Globally diesel BC is expected to be 20 per cent of the total BC emissions
- Total emissions from gasoline are less than 10% of diesel BC emissions, although gasoline vehicles are more numerous.



Much cleaner diesel vehicles are possible.....Do we have a fiscal strategy?



No retrofit system
Uncontrolled Diesel Exhaust
(Level 1)

Old technology
Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash



Retrofitted with
Diesel Oxidation Catalyst (DOC)
(Level 1)

Old technology
Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash



Retrofitted with
Partial Filter
(Level 2)

Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash



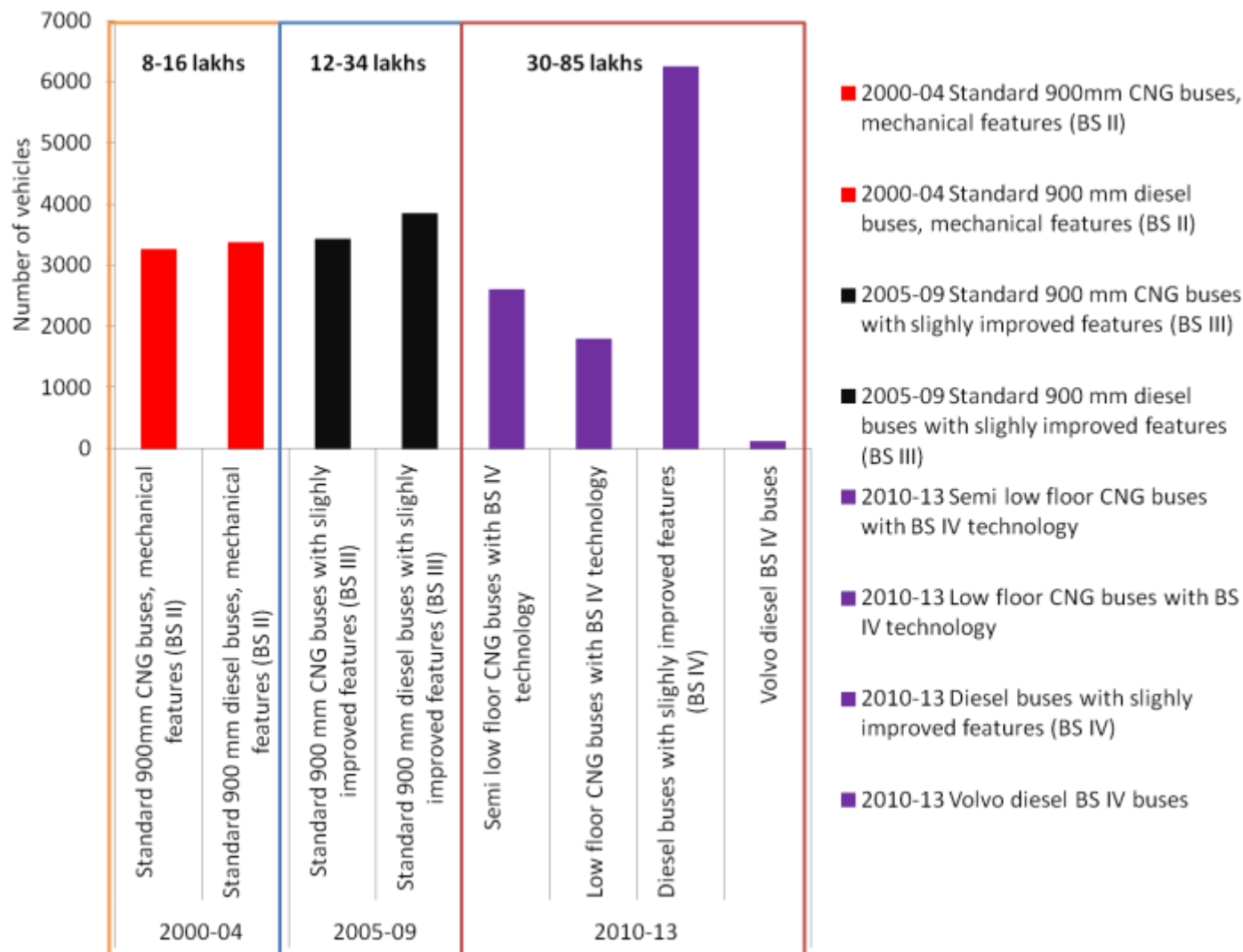
Retrofitted with
Diesel Particulate Filter (DPF)
(Level 3)

New Technology
Used on all new trucks since 2007
>85% black carbon removal
>85% ultrafine removal
>85% lube oil ash removal

DPFs are typically installed on new diesel passenger vehicles with Euro V standards and on heavy duty vehicles with Euro VI standards.....



Challenge of costs.....



Bus technology and quality have improved Indian market has absorbed significant cost pressures. Example of bus market in Delhi and Bangalore.. **Approx 150% increase in prices.....**

Compact car prices have also increased 16 – 29% between 2000 and 2010



Emerging global strategies to meet the cost of transition



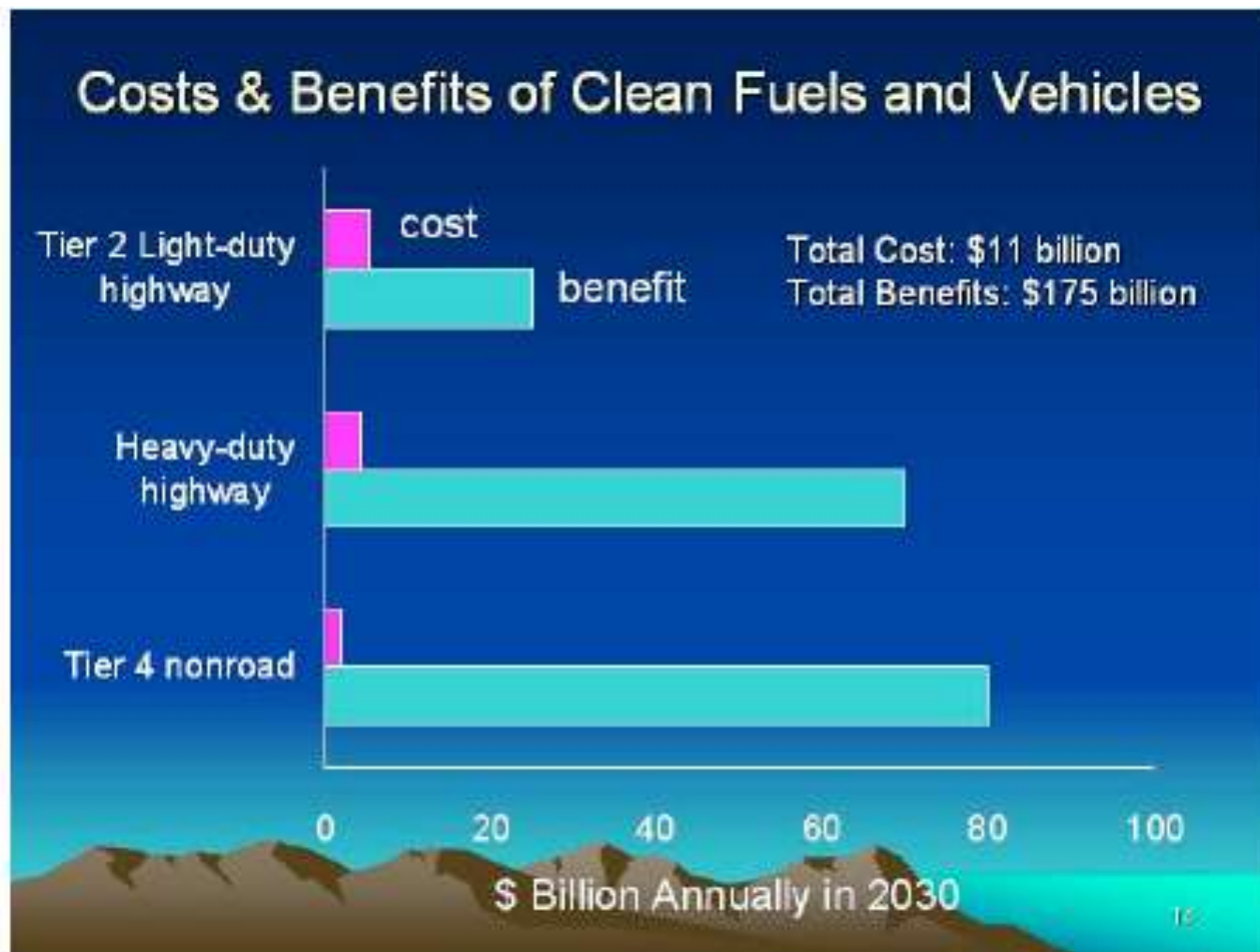
Fiscal strategy

- Setting differentiated tax rates
- Tax reduction/credits to refiners that provide lower sulfur fuels
- Directly subsidizing the supply of lower sulfur fuels
- Incentives targeting consumers, such as tax reductions implemented at the pump, -- combined with an increased tax at the pump for higher sulfur diesel.
- **Fiscal incentives must be combined with regulatory mandates on clean fuel quality (10 ppm sulphur fuels) for public health and environmental benefits**



Example from other regions

Cost benefit analysis convince other governments to take hard action.....



USEPA calculates cost benefit of clean air regulations to justify aggressive action

In the US – Total cost of Tier 2 emissions standards for light duty, heavy duty and non-road vehicles rules together expected to cost USD 11 billion.

But the total benefits estimated to be USD 175

Source: Michael Walsh, 2005.



Cost-benefit of leapfrog strategy....



The International Council on Clean Transportation study 2013:

Economic benefits with costs associated with ultra-low sulphur fuel production and cleaner vehicles.

Economies of scale stabilize costs in the long-term benefits far outweigh costs.

Benefits continue to rise, as vehicle population increases and lower ambient PM2.5 concentrations reduce premature mortality.

Cumulatively from 2010-2030, fuel costs add up to Rs. 94,000 crore and vehicle costs add up to Rs. 850,000 crore. But the cumulative benefits are of Rs. 3,365,000 crore. The net benefit is Rs. 2,400,000 crore by 2030.



(2) Mobility management.....Case of public transport..



Mobility crisis is aggravating air pollution



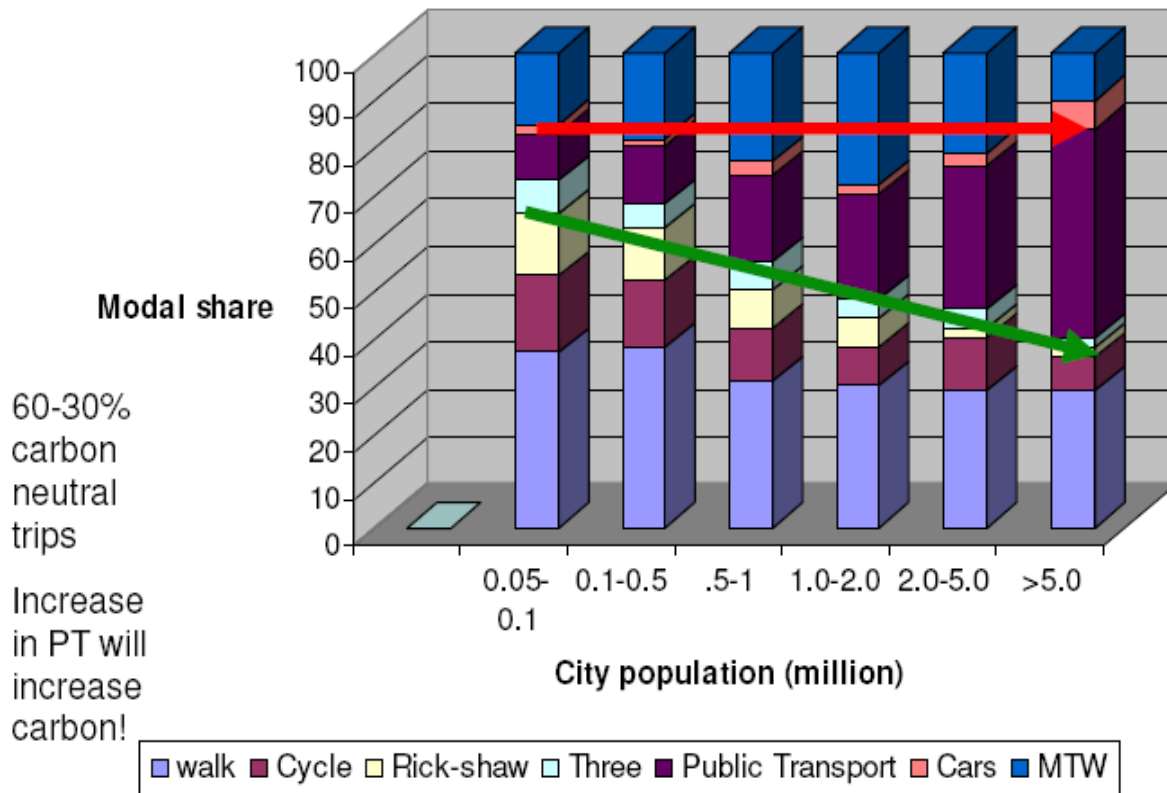
- **Air pollution to worsen with increased dependence on personal vehicles and erosion of pollution neutral modes....**
- Between 2011- 2030:
 - Daily travel trips will double;
 - Share of public transport trips to fall from 26% to 16%;
 - Share of personal vehicle trips to increase from 34% to 51%;
 - Peak traffic to crawl at 8km/hour compared to 16 km/hour.



How can we protect our baseline?

Urban Mobility

PT and NMV based, MTW majority personal vehicles



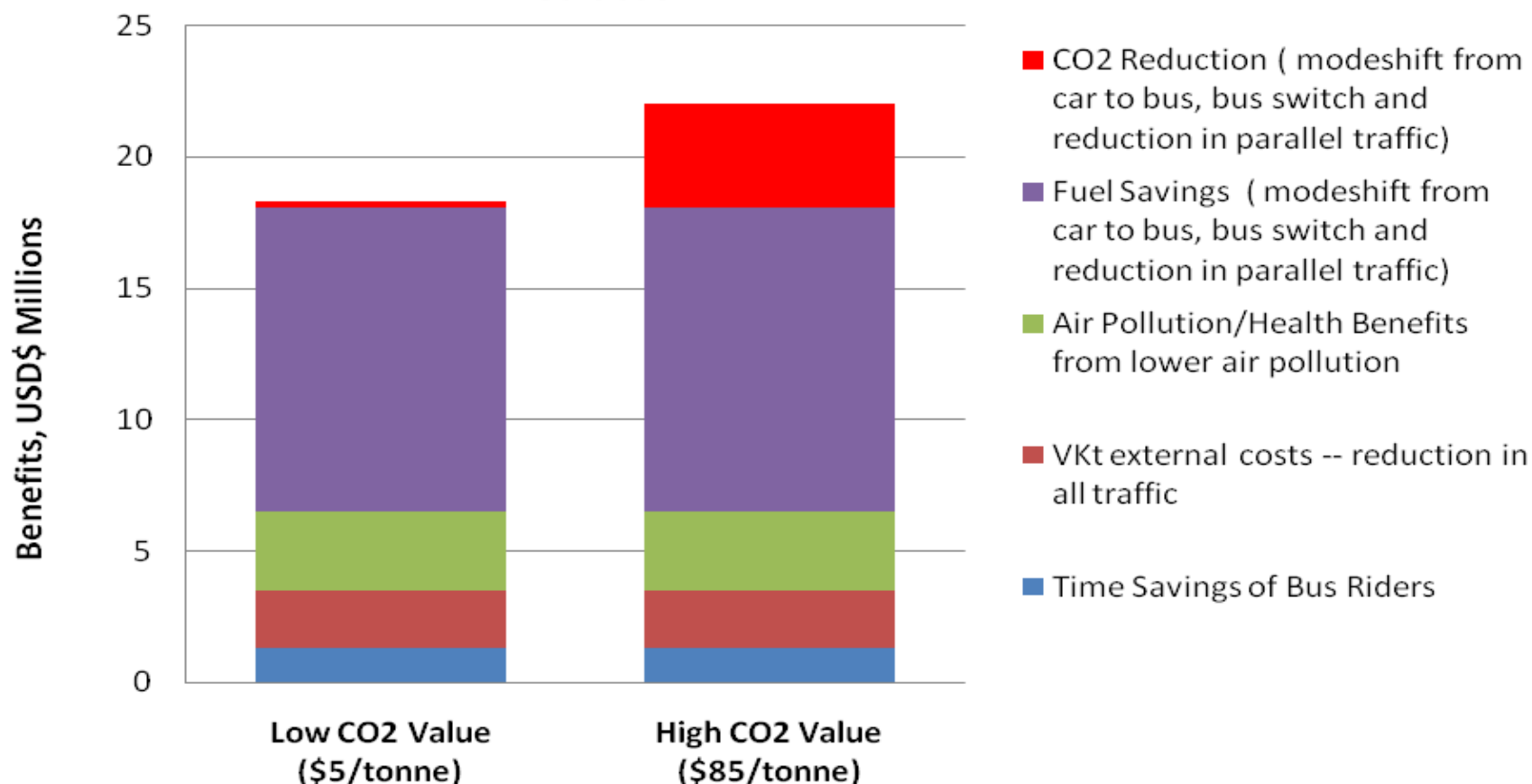


Co-benefits public transport intervention

Other countries have begun to assess co-benefits of their transportation projects



Fuel savings and CO2 savings of a BRT corridor in Mexico City





BRT transition: Co benefits in India?



Delhi BRT: • Peak Load: in 2009:
6,500
passenger/hr/direction

Now: 12,000
passenger/hr/direction

- Frequency: 120 buses/hr
- Commercial Speed In corridor:
18-19 km/hr (peak hour)
 - Off corridor: 7-11 km/hr (peak hour)
- Infrastructure Investment: Rs.
14 crores/km (3 million/km)

Major impact on bicycle traffic
Co benefits?

Pimpri Chinchwad BRT: World
Bank evaluation brings out
co-benefits



How do we account for lock-in of pollution and carbon in transport infrastructure?

-- Need indicators to assess co-benefits and trade-offs for all infrastructure projects to guide policy....



**This locks in enormous carbon,
pollution and ill health.....**



Engineering changes once made cannot be reversed easily... It permanently decides our travel choices and locks up pollution.....Traffic and pollution impact of infrastructure is never carried out.....





Make connection between road design and pollution

Car centric design does not allow safe, quick and shortest crossing.. Discourages zero emissions modes....



Sai Chowk, Patparganj



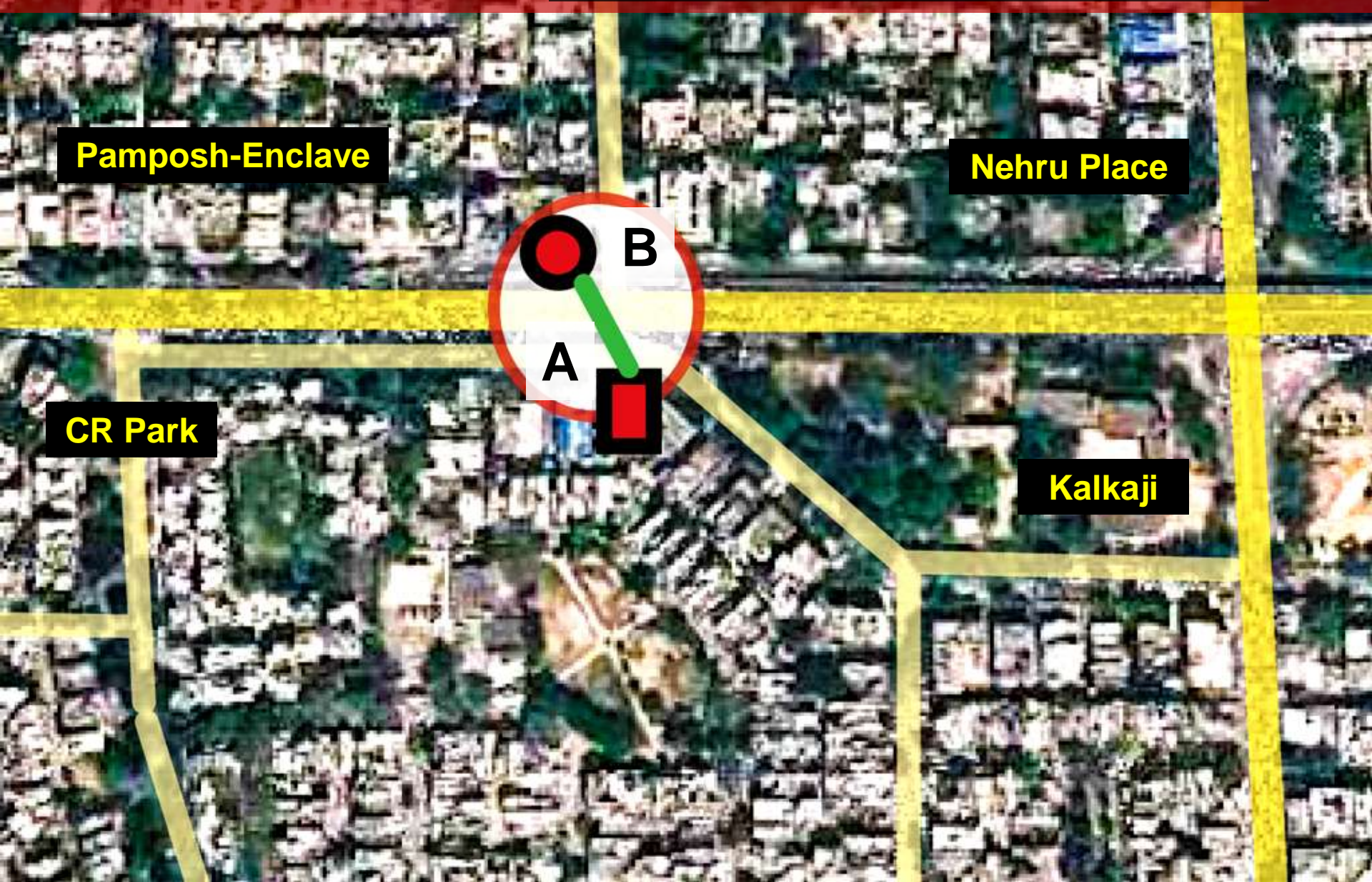
Scindia House, CP

Seamless and signal free traffic is interrupting shortest direct route for pedestrians. This is inciting jay walking

Case Study – Outer Ring Road (Nehru Place Flyover)

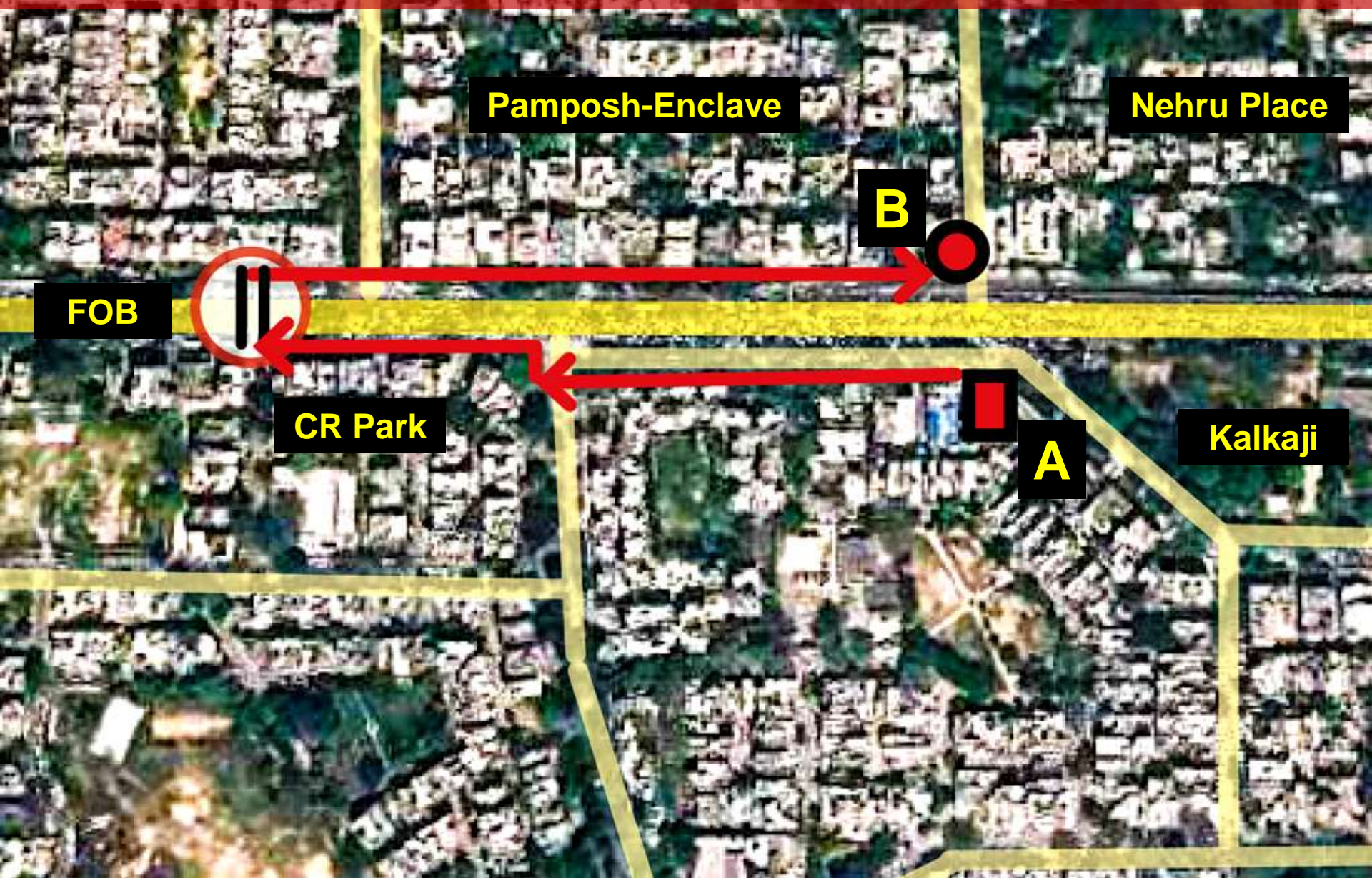
Travelling from A to B

Originally 30M across the road



Case Study – Outer Ring Road (Nehru Place Flyover)

Travelling from A to B – Pedestrian Route 1 1000M via FOB





How can we promote this paradigm?



WHO – Need active transportation to cut pollution and secure public health...



Credit: SG Architects



Dealing with hidden subsidies....



Parking and automobile dependancy...



Reform parking –

Organise and limit parking spaces and increase parking charges

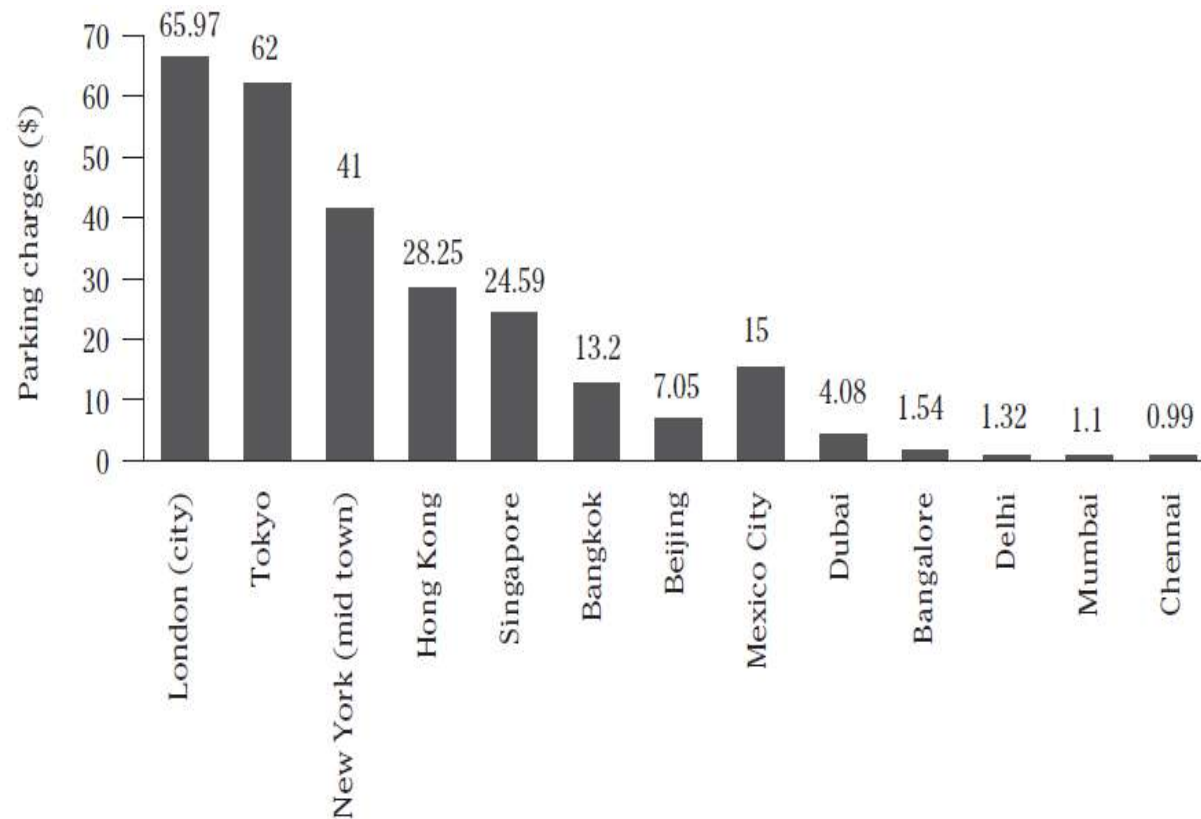
Global studies show :

Shifting from free to cost recovery parking rates can reduce automobile commuting by 10-30 per cent especially if linked with other transportation choices

Parking charges influence commuting choices:

People will opt for alternatives

Indian cities have the lowest parking rates in the world



Source: Colliers International (2011) - CBD daily parking charges (in US \$)



Parking and clean air



It is still not clear to many how parking management and restraints can reduce air pollution and give public health benefits

Boston froze their parking requirements at a level that is only 10 per cent higher than the 1973 level to meet the Federal clean air standards.

New York: very high parking fees and limited parking supply have lowered car ownership far below the average rates in other US cities.

Amsterdam -parking fees expanded to meet EU directives regarding NO₂ and PM₁₀ emissions. Car plate numbers are registered with emissions information. Trucks are allowed to unload for a maximum of 15 minutes in spots where they are not allowed to park

Zurich considers total NO₂ emissions when determining the amount of parking to be allowed.

Aizawl, Sikkim have made proof of parking mandatory for purchase of cars; High Court of Jodhpur has given similar direction



On-street parking pricing has major impact on vehicualr use.....



No meters



Meters



Prices quadrupled

Grosvenor square, London



Way forward



Let us manage the health and environment risk transition well....

- India needs innovative fiscal strategies to fast track change
- **Need new generation regulations to:**
 - balance the costs and benefits of regulations
 - use market based instruments to shift markets and change behaviour
 - make trade-offs transparent
 - recover environmental and social costs

We cannot afford to wait.....



Thank You