# *Environmental sustainability: Air quality*

31st March 2015

Sumit Sharma, Fellow, TERI

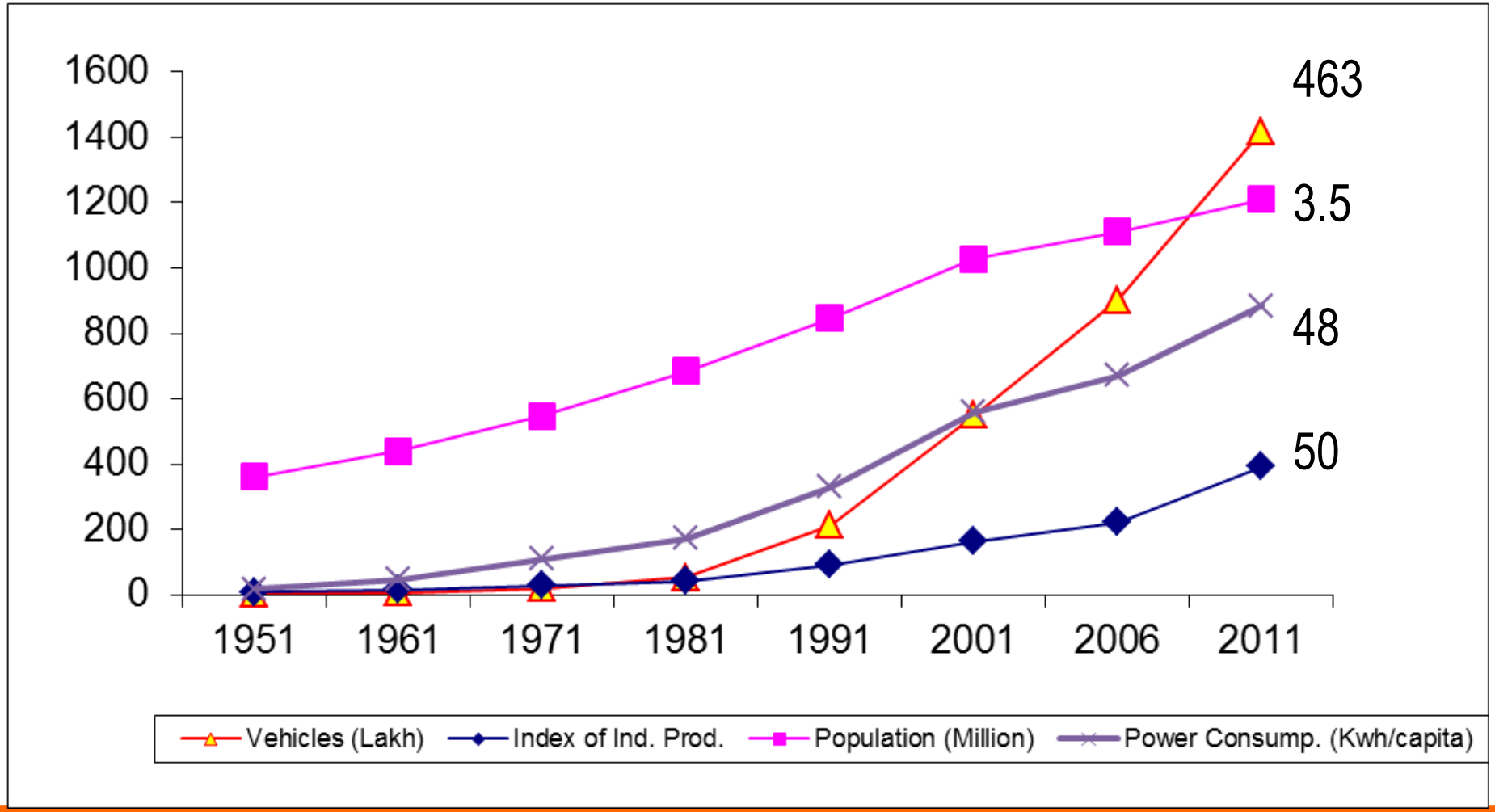
# SDGs and linkages with air pollution

| Goal | SDG | Linkage |
|---|---|---|
| Goal 1 | End poverty in all its forms everywhere | 50% PM2.5 emissions from biomass based cooking |
| Goal 2 | End hunger, achieve food security and improved nutrition and promote sustainable agriculture | 36% loss of grains due to Ozone pollution |
| Goal 3 | Ensure healthy lives and promote well-being for all at all ages | ~6 lakh people die annually due to air pollution |
| Goal 7 | Ensure access to affordable, reliable, sustainable and modern energy for all | Coal and biomass based energy |
| Goal 9 | Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation | 49% PM10 emissions from industries. No standards for NOx |
| Goal 13 | Take urgent action to combat climate change and its impacts* | Black carbon, Ozone contributors to warming |

# The growth story

- India since 1950 : Population, index of industrial production and number of vehicles have grown 3.5, 50, and 460 times, respectively
- 53 cities million plus cities. expected to grow to 85 by 2025
- 31% urbanisation , expected to grow to 38% by 2025.
- Unprecedented growth of personal vehicles in India.
- Higher consumption levels : power demands
- Faster growth in cities, leading to congestion and emissions and effects over health .

# Growth of India



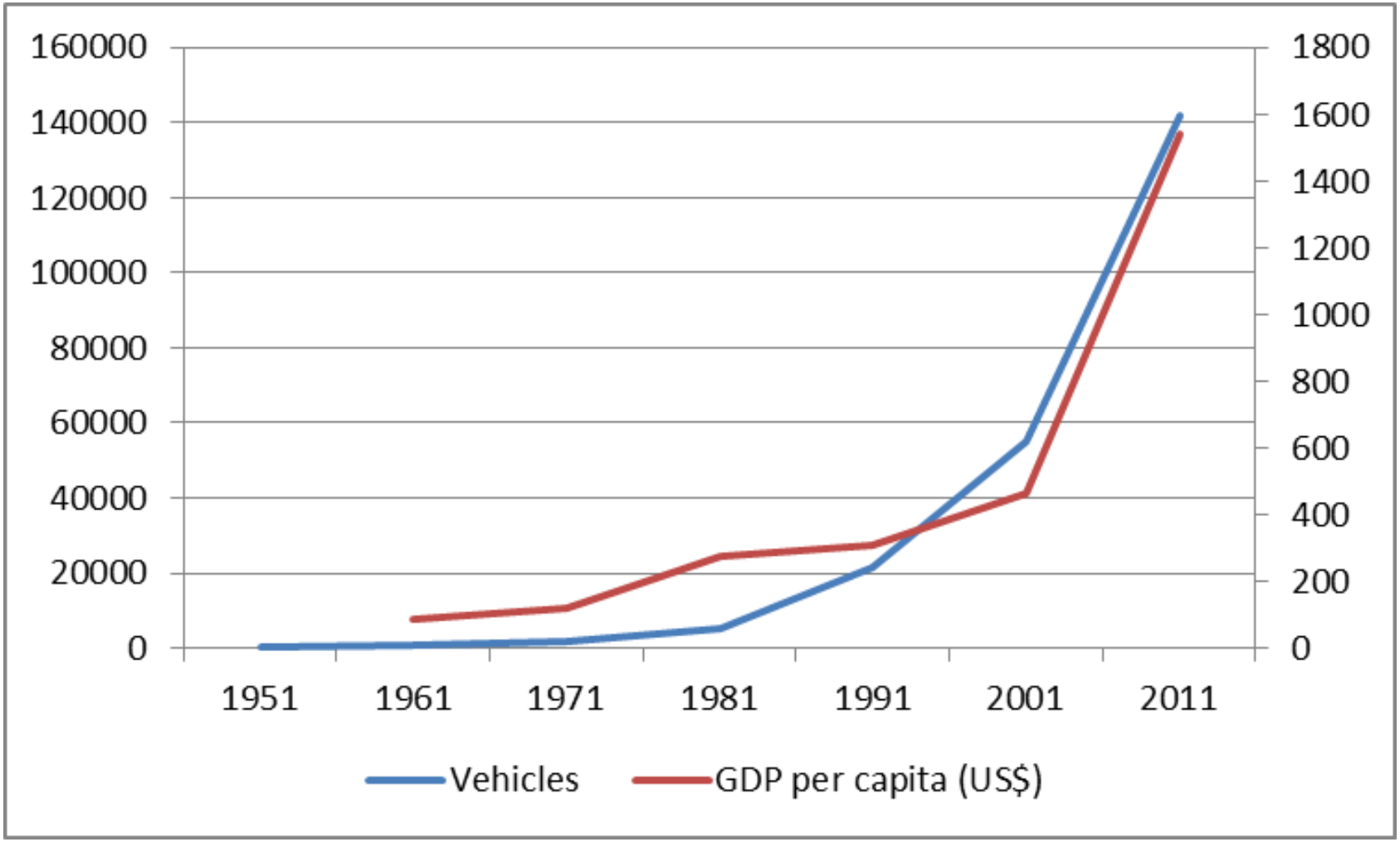
# Growing and sprawling cities


2003

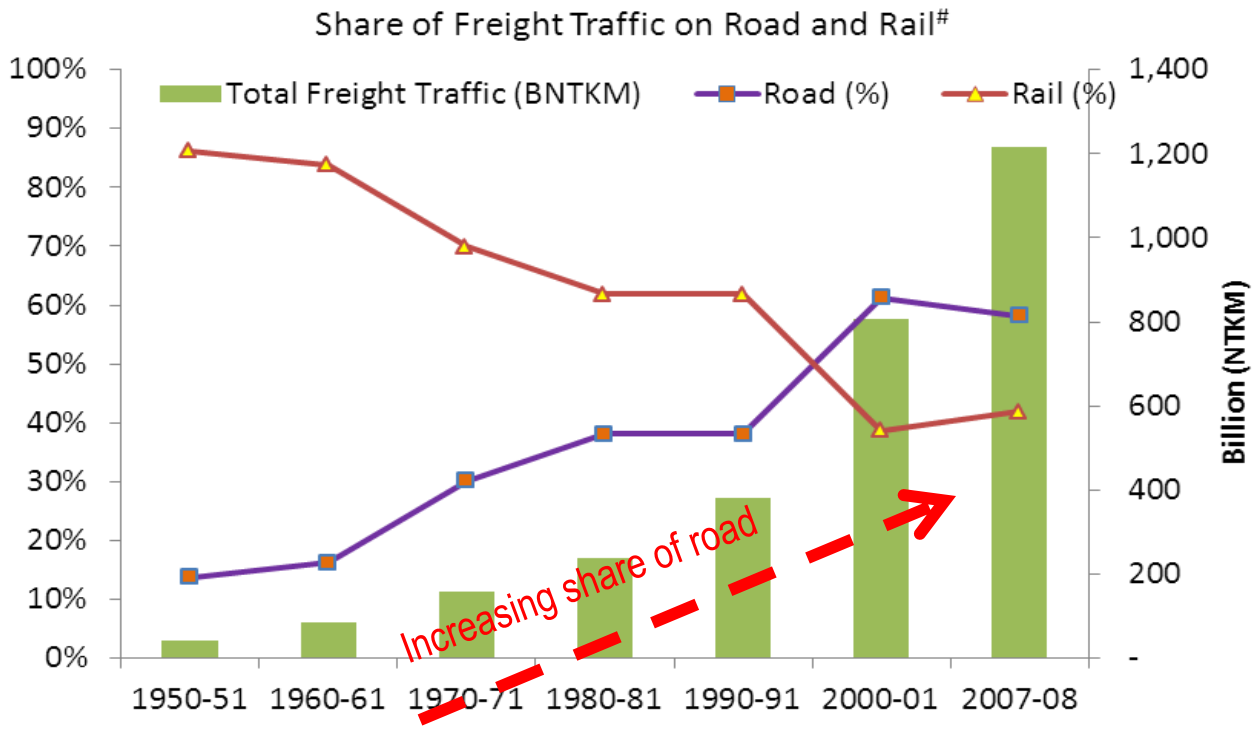
to

2010

# Changes : Growing Incomes and …



# Shifting modes: freight and passenger traffic




**% Share (NTKM)***

**Road = 50.12%**

**Rail = 36.06%**

**Coastal shipping = 6.8%**

**Pipeline = 7.48%**

**IWT = 0.24%**

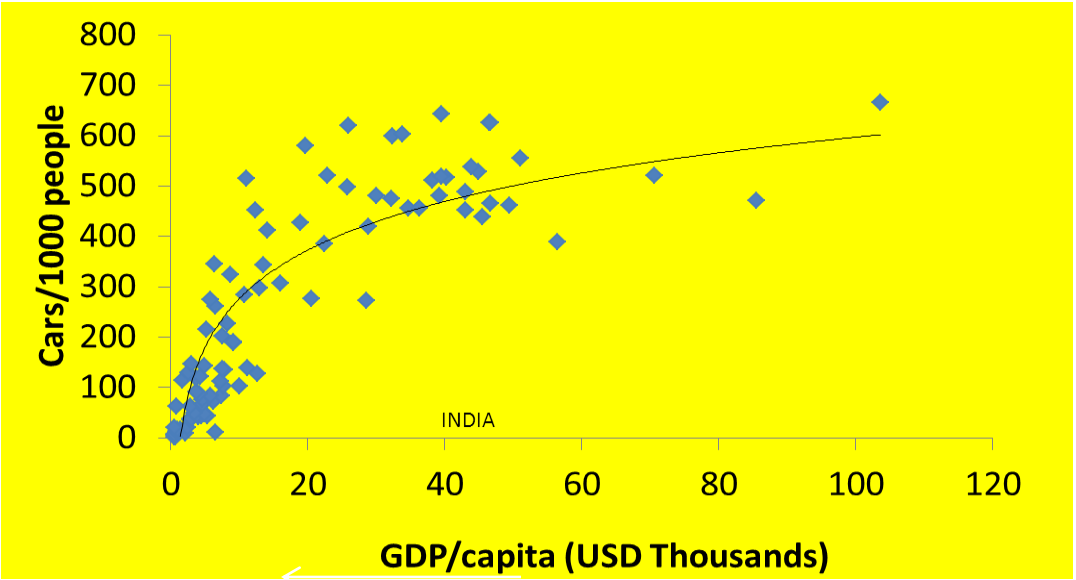
**Airways = 0.02%**

- Continuous erosion in the share of Railways in freight movement and increase in share of less fuel efficient road transport
- Road transport is the most dominant mode of transport with over 50% of the freight

***Modal share in total freight traffic as of 2007-08, source: RITES Total Transport Study; #Compiled from 11th Five Year Plan Working Group Report on Road Transport and RITES Total Transport Study**

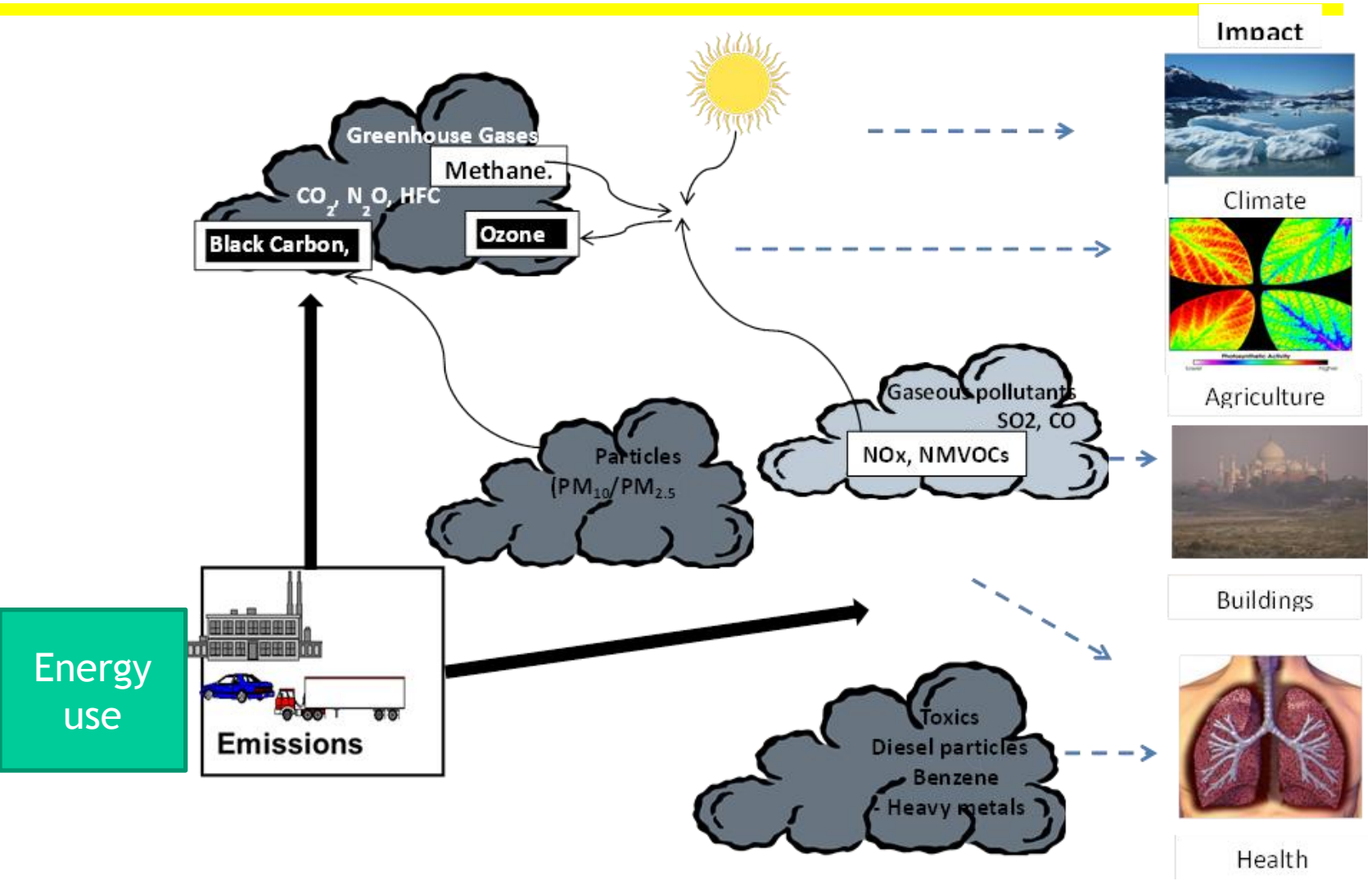
# Expect more growth

- 6% or 8% ?
- About 28000 two wheelers, and 4200 cars added to India's vehicular fleet daily (2011)
- As per Census 2011, 21% households have two wheelers whereas 4.7 % have cars/jeeps/vans
- More growth expected

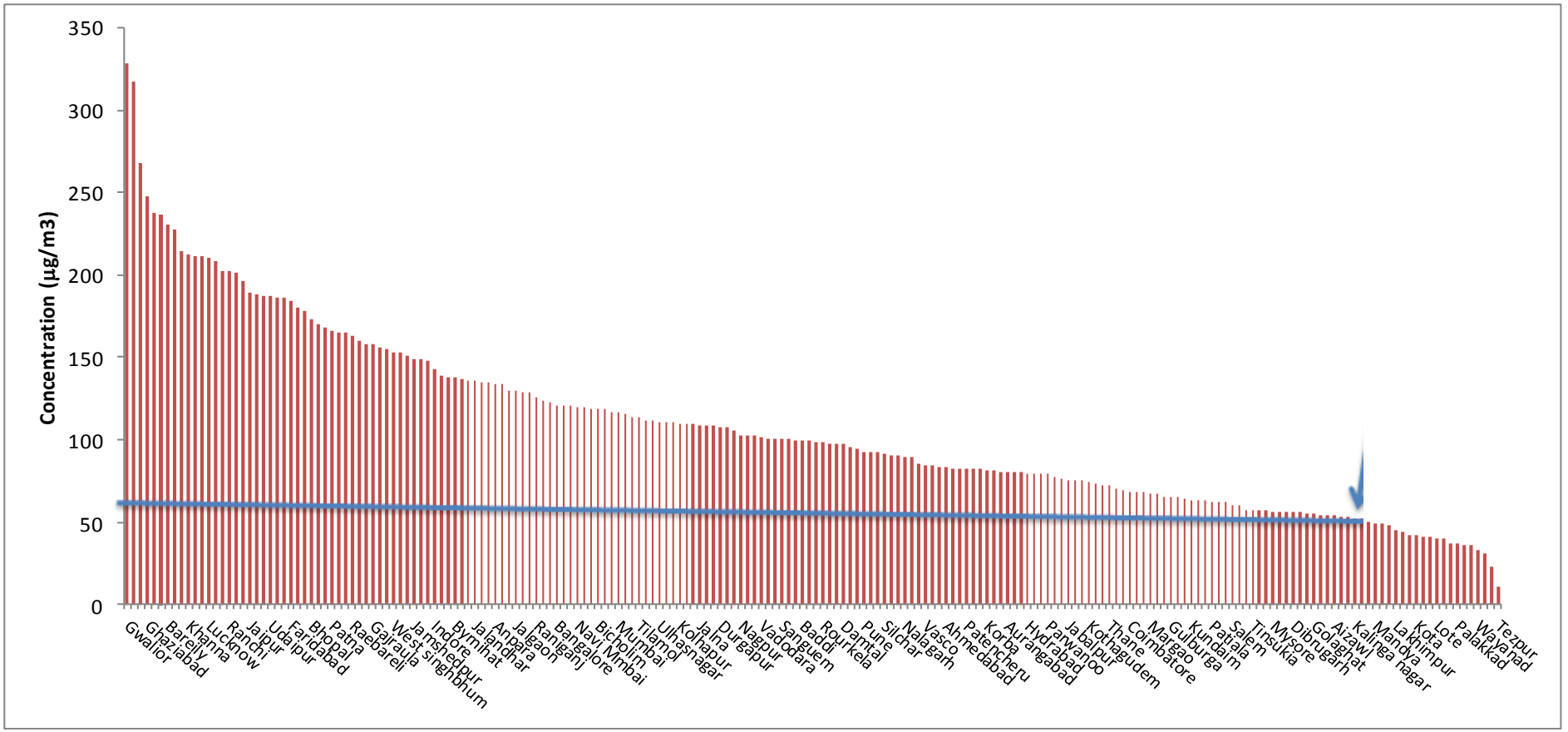



Data WDI, 2011

# Pollutant Formations and Impacts



# RSPM concentrations in Indian cities (2012)

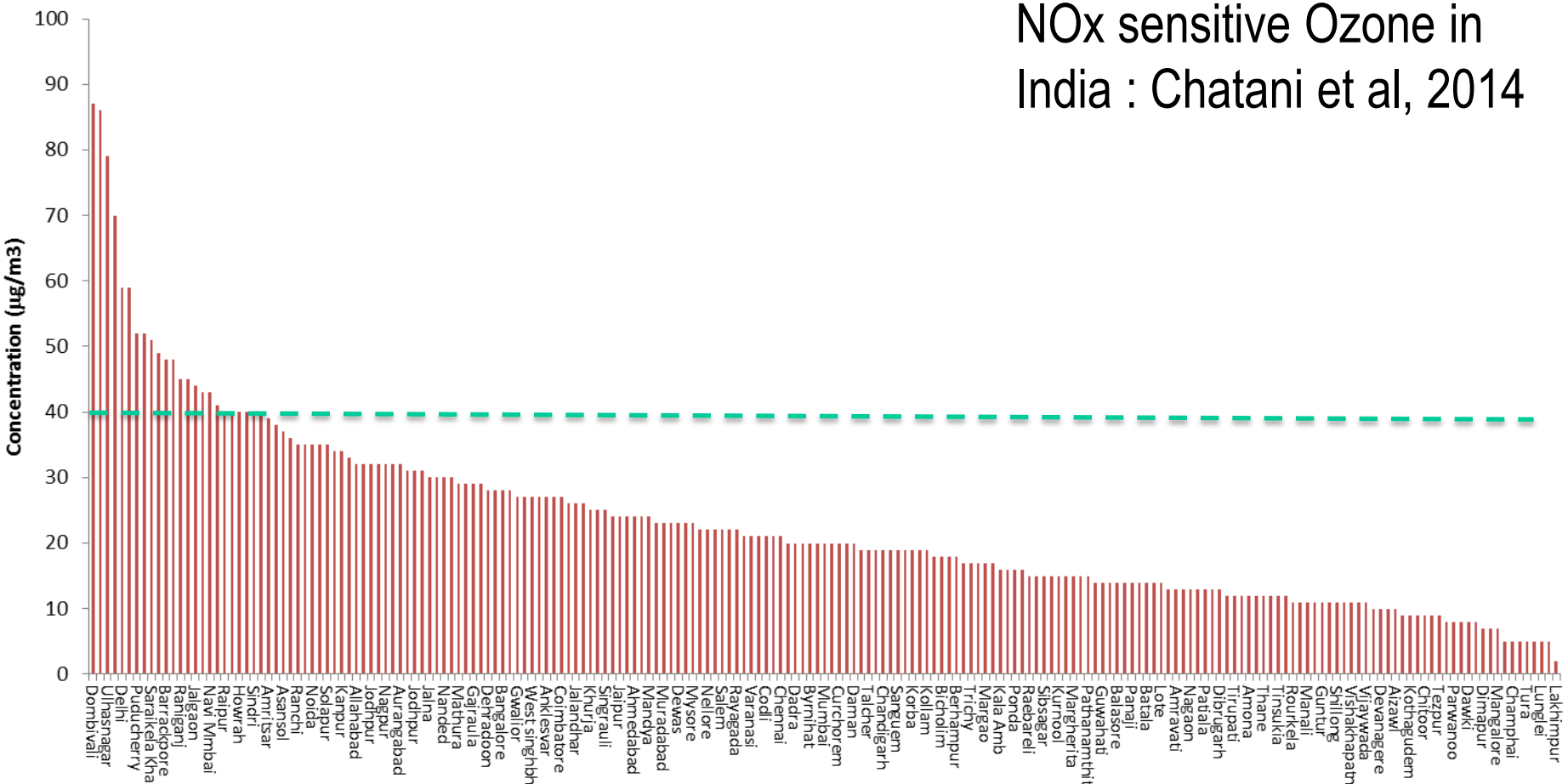



More than 80% cities violate the standards of RSPM

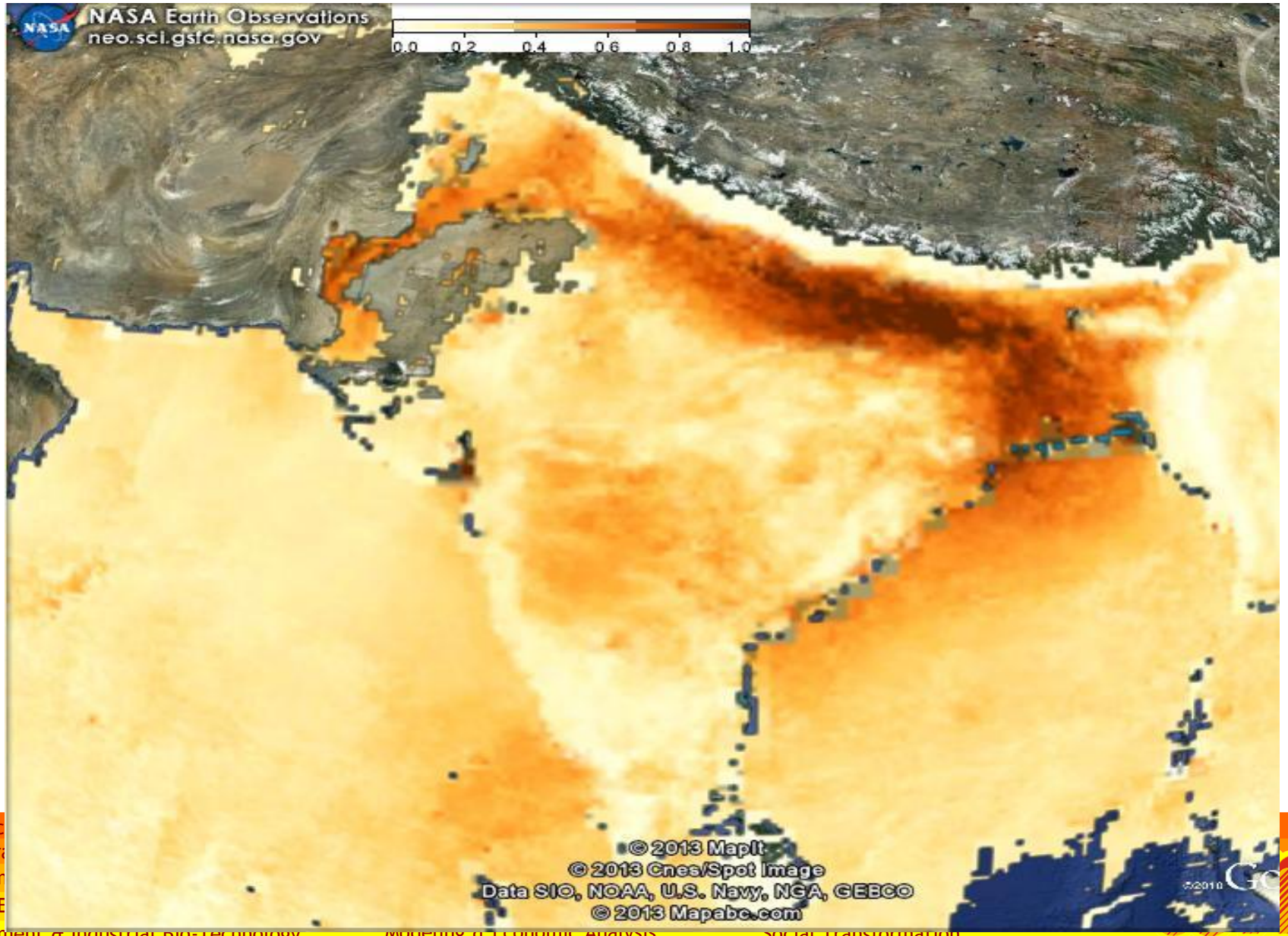
Source: CPCB, NAMP data

# NOx concentrations (2012)

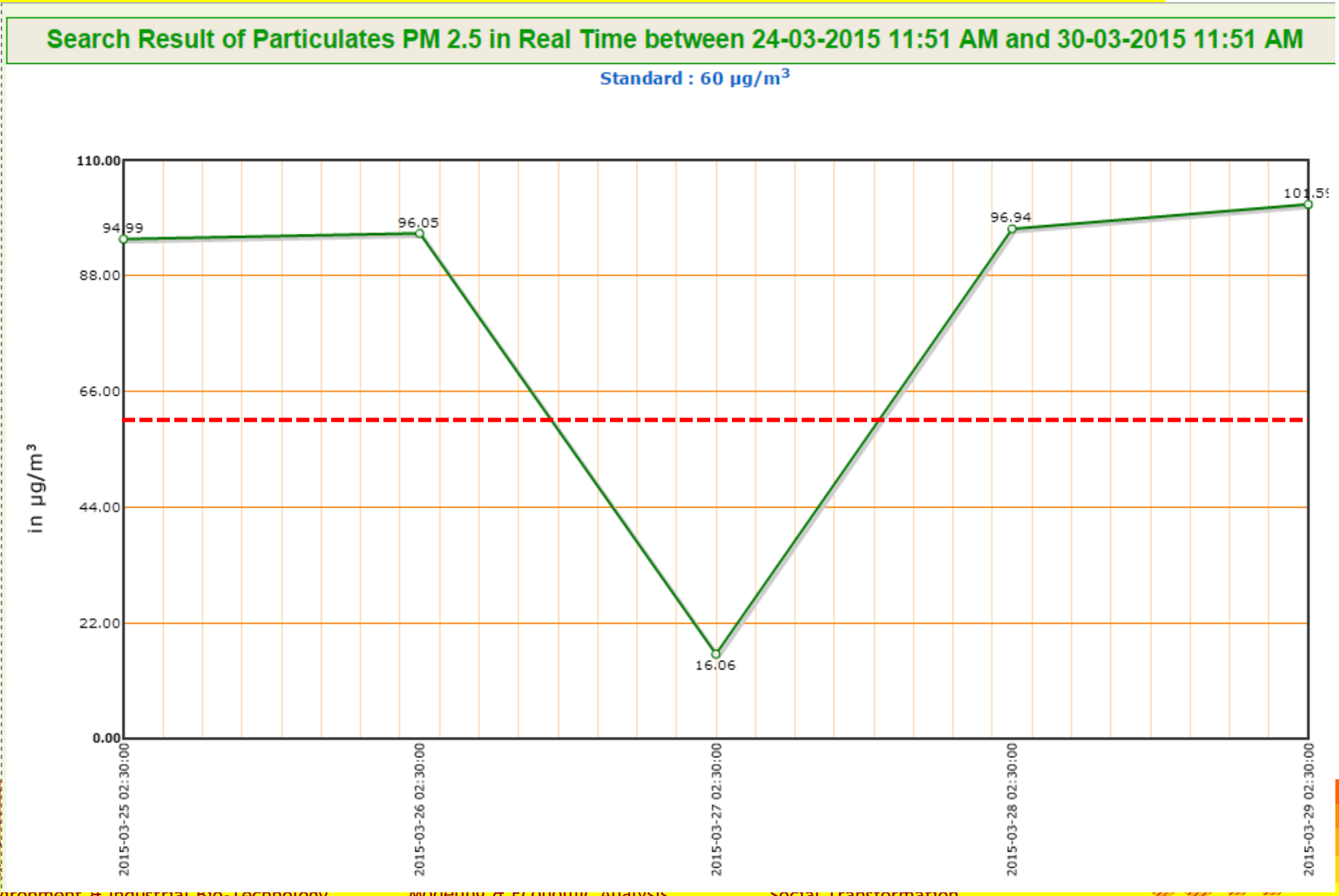
NOx sensitive Ozone in India : Chatani et al, 2014



# Satellite View (AOD)



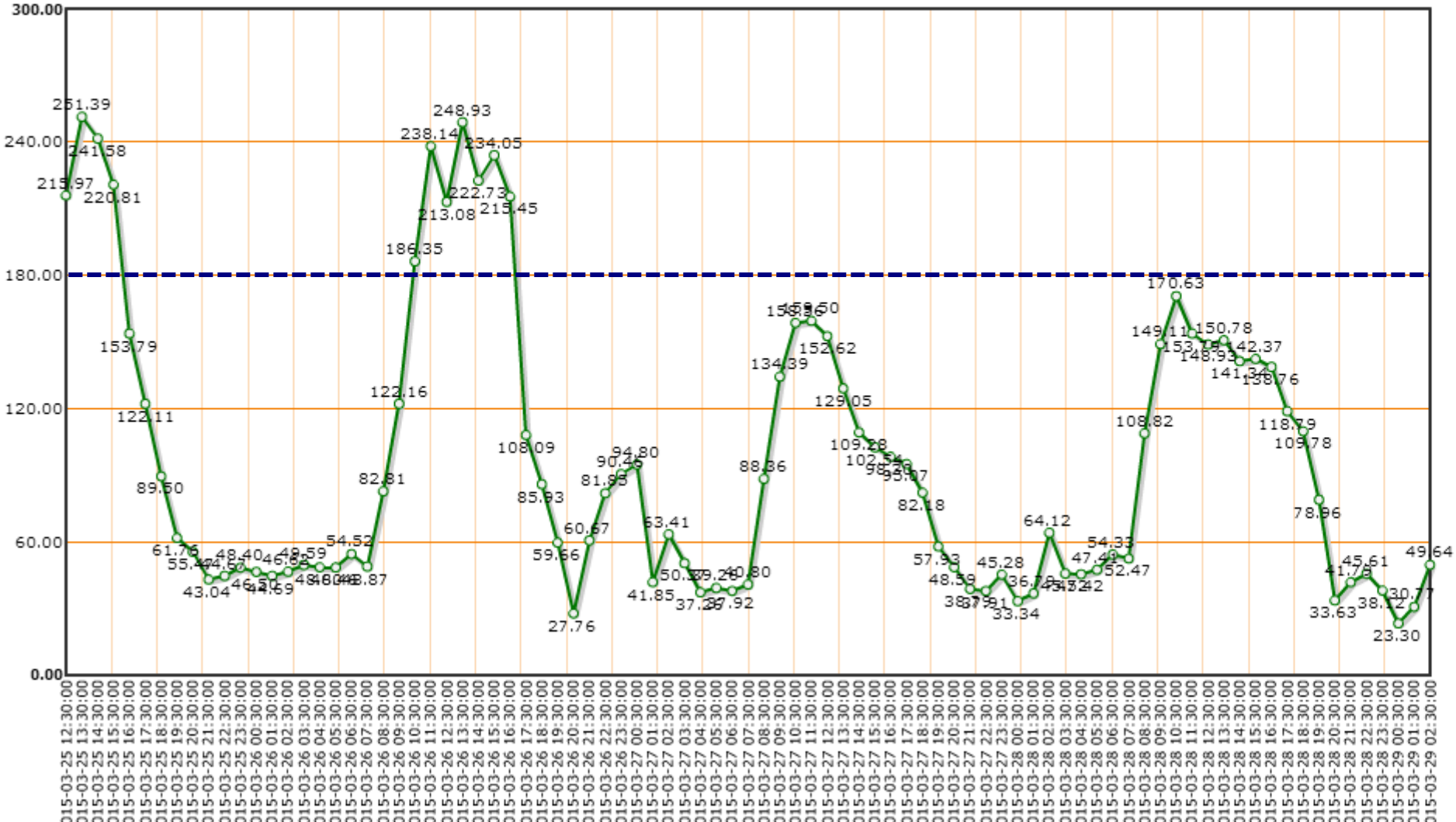
# Latest data in Delhi : PM2.5



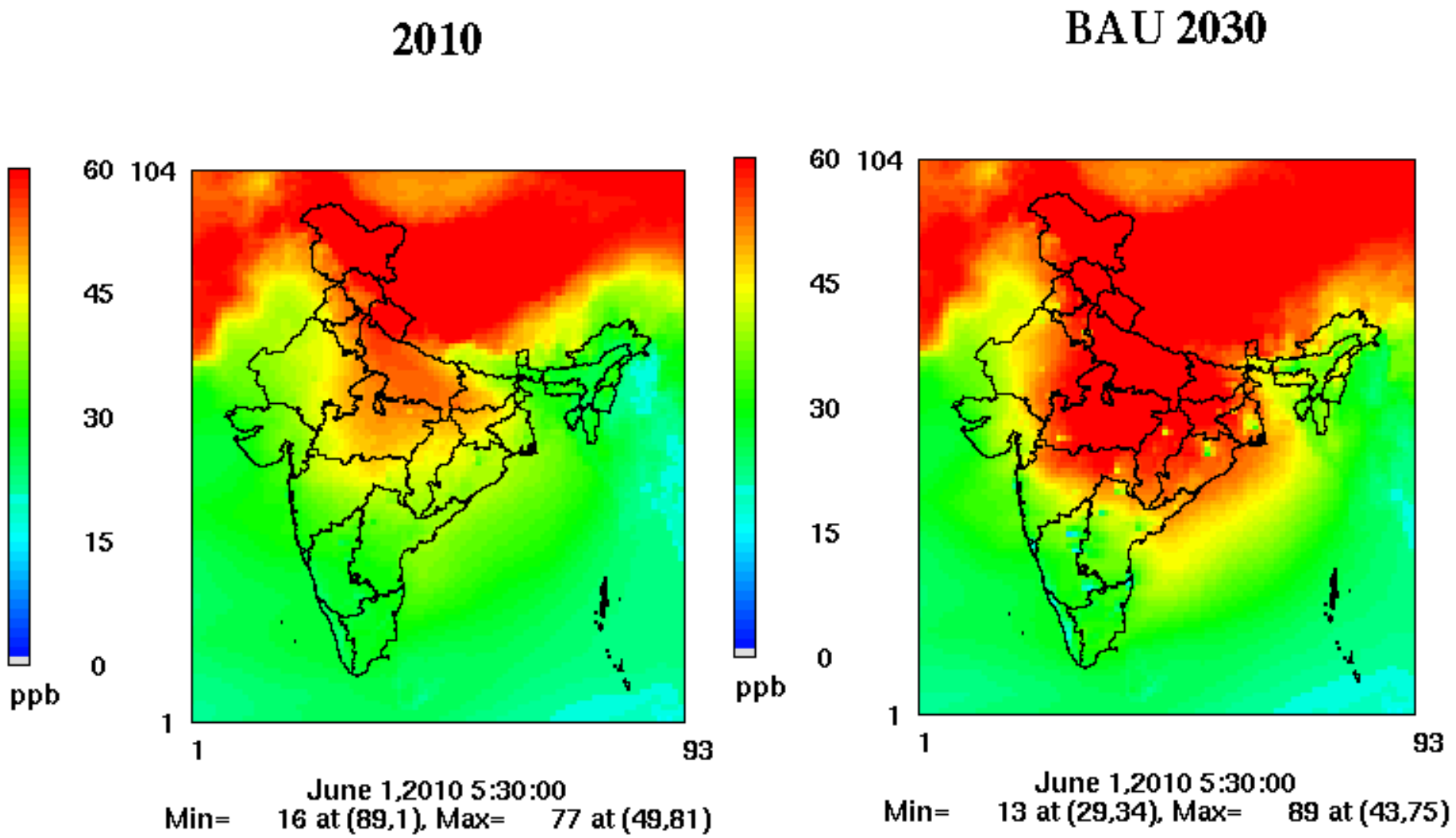
# Ozone- IGI airport (last week)

**Search Result of Ozone between 25-03-2015 11:46 AM and 30-03-2015 11:47 AM**

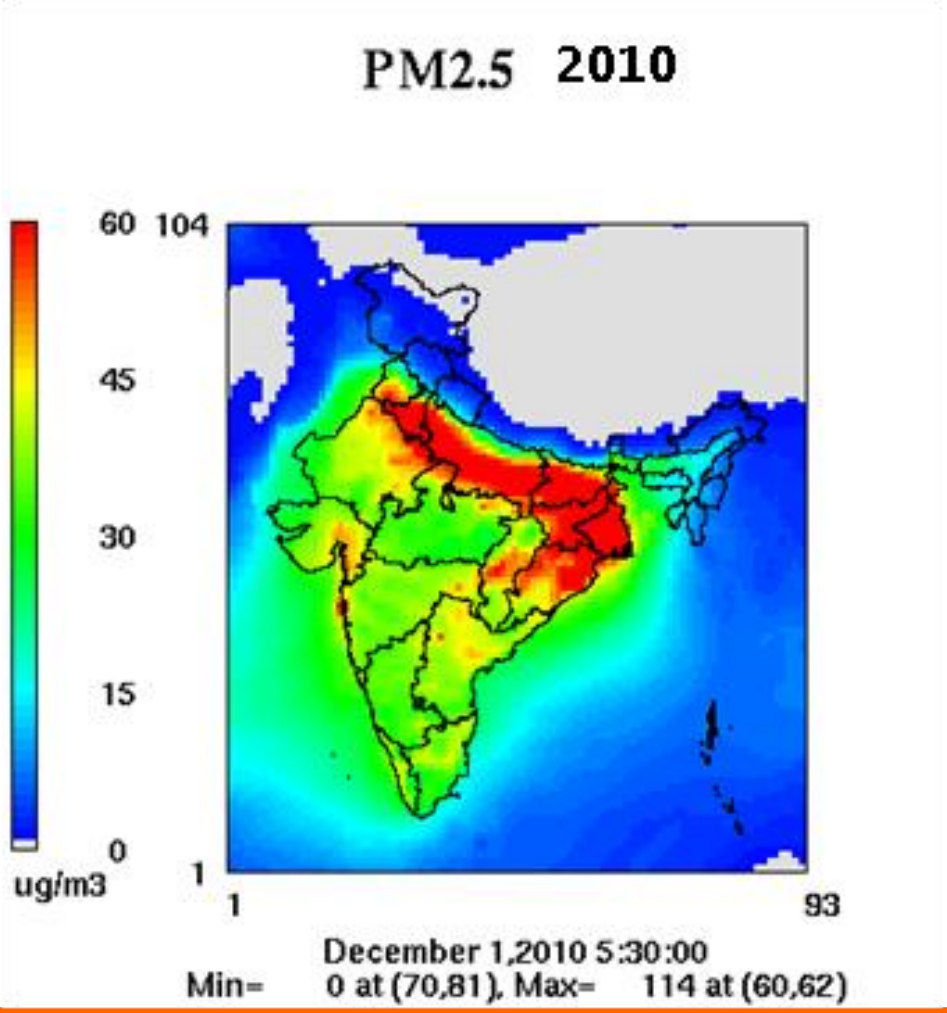
Standard : 180 µg/m$^3$

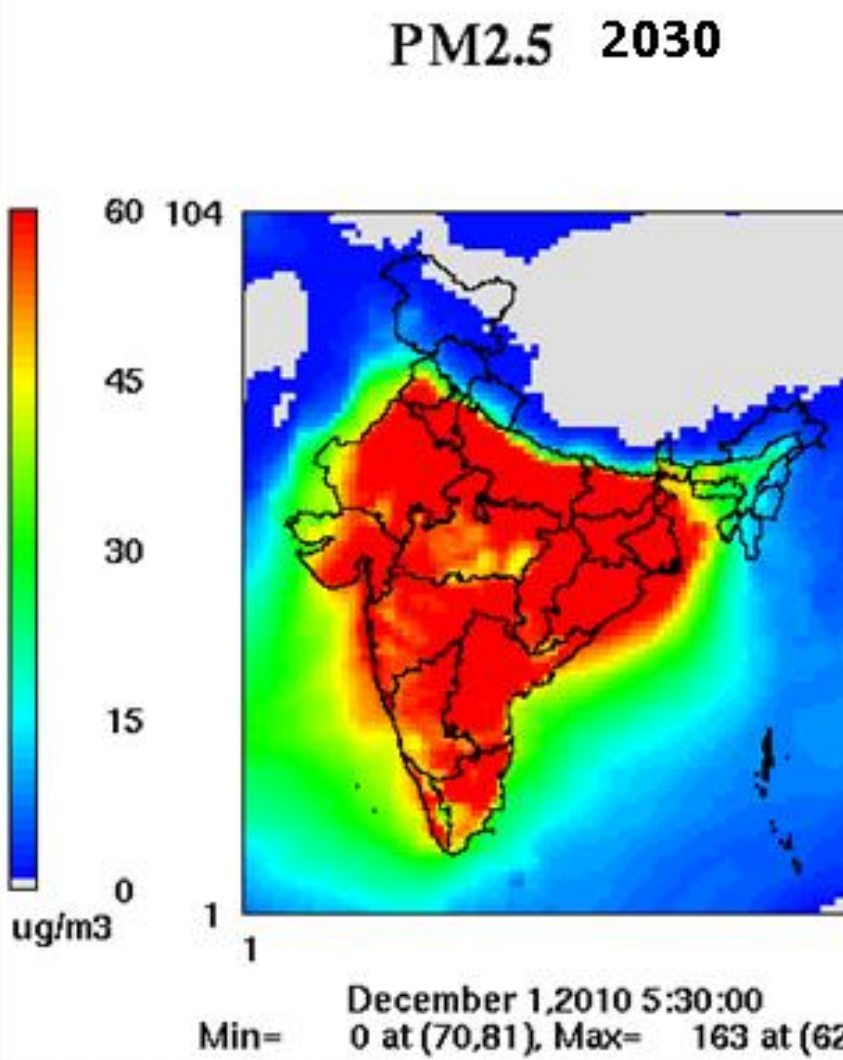


# Ozone simulations



# PM2.5 pollution projections



# Impacts

## Health

## Agriculture

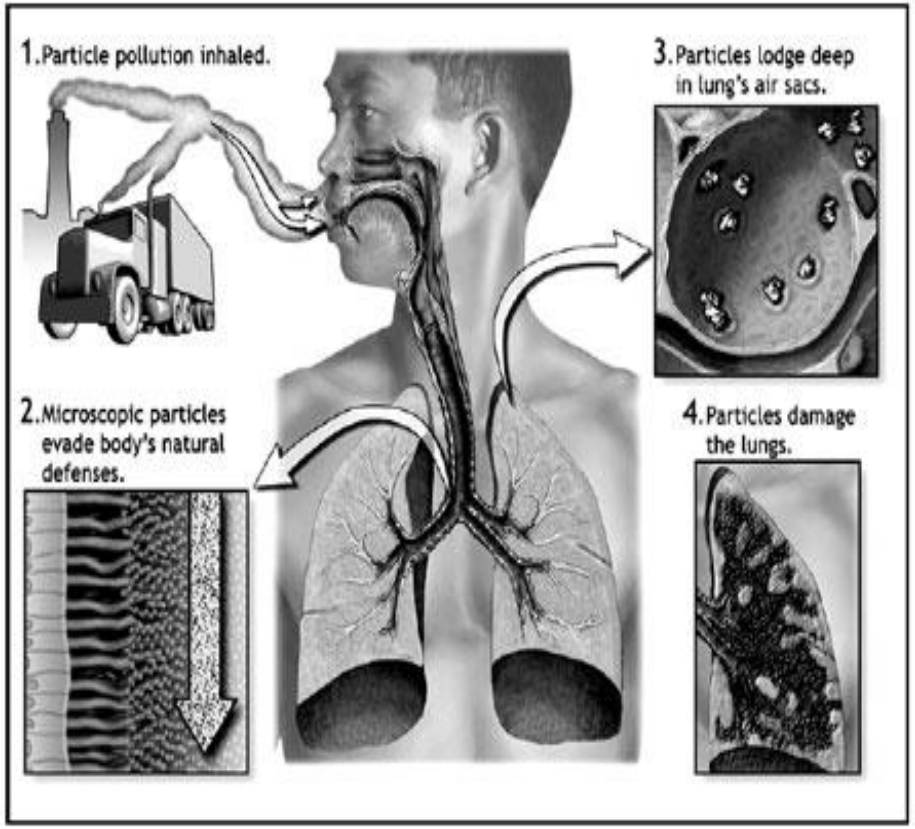
## Climate

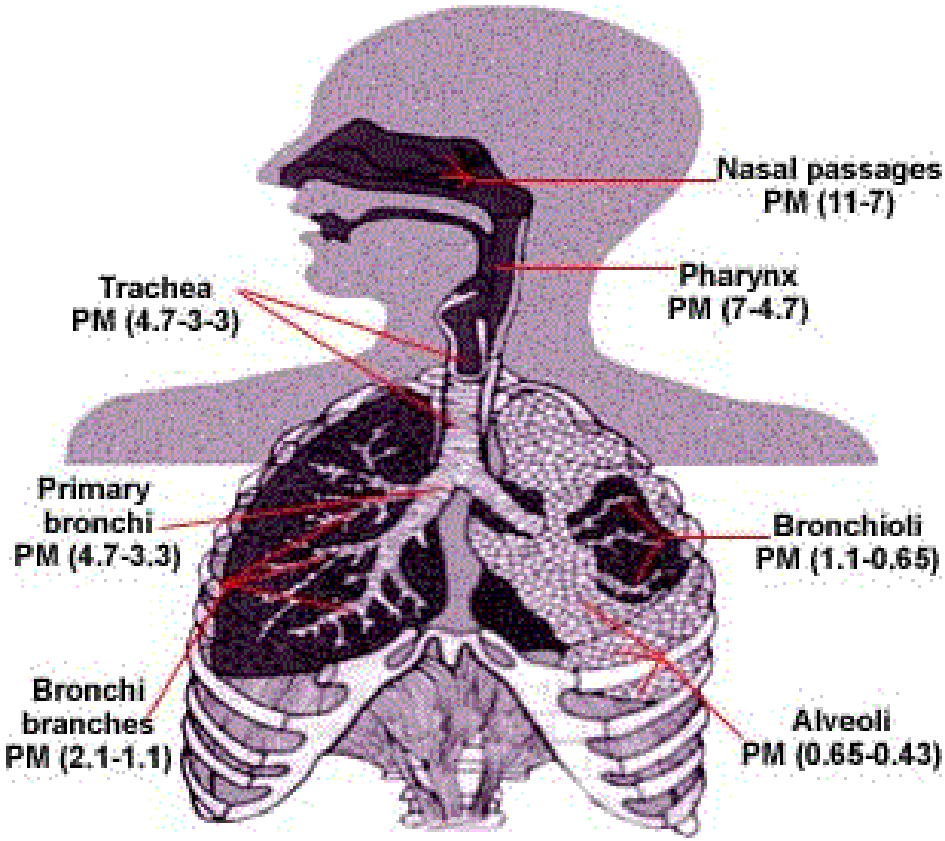
## Buildings

## Aesthetics

## Image

# Health impacts

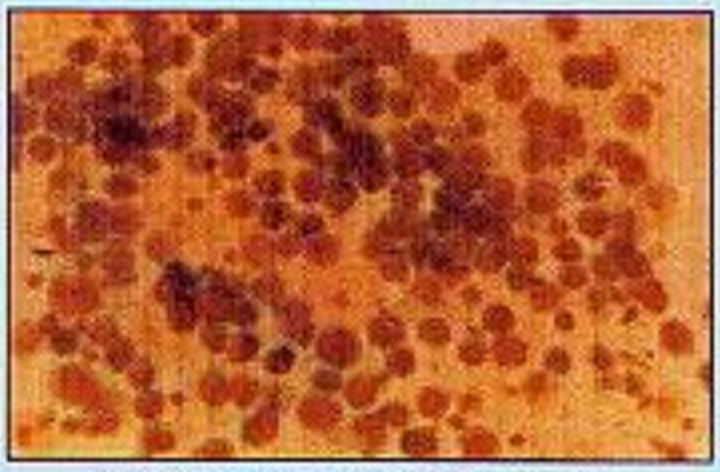


# Alveolar Macrophage (AM) count in deep sputum of residents of Kolkata (1998-2001)

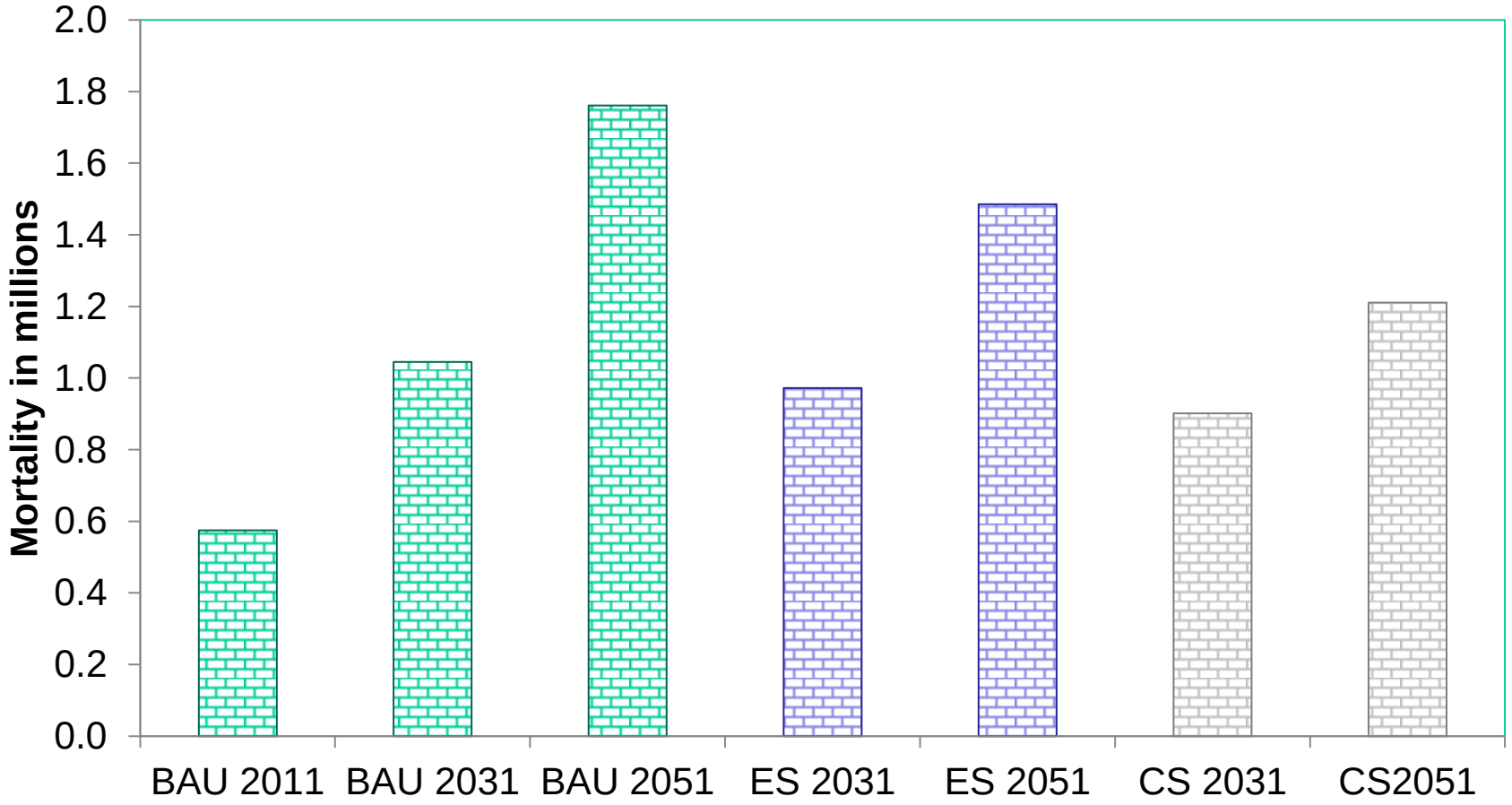
Low AM count, Sunderban

High AM count, Kolkata Petrol Pump Worker



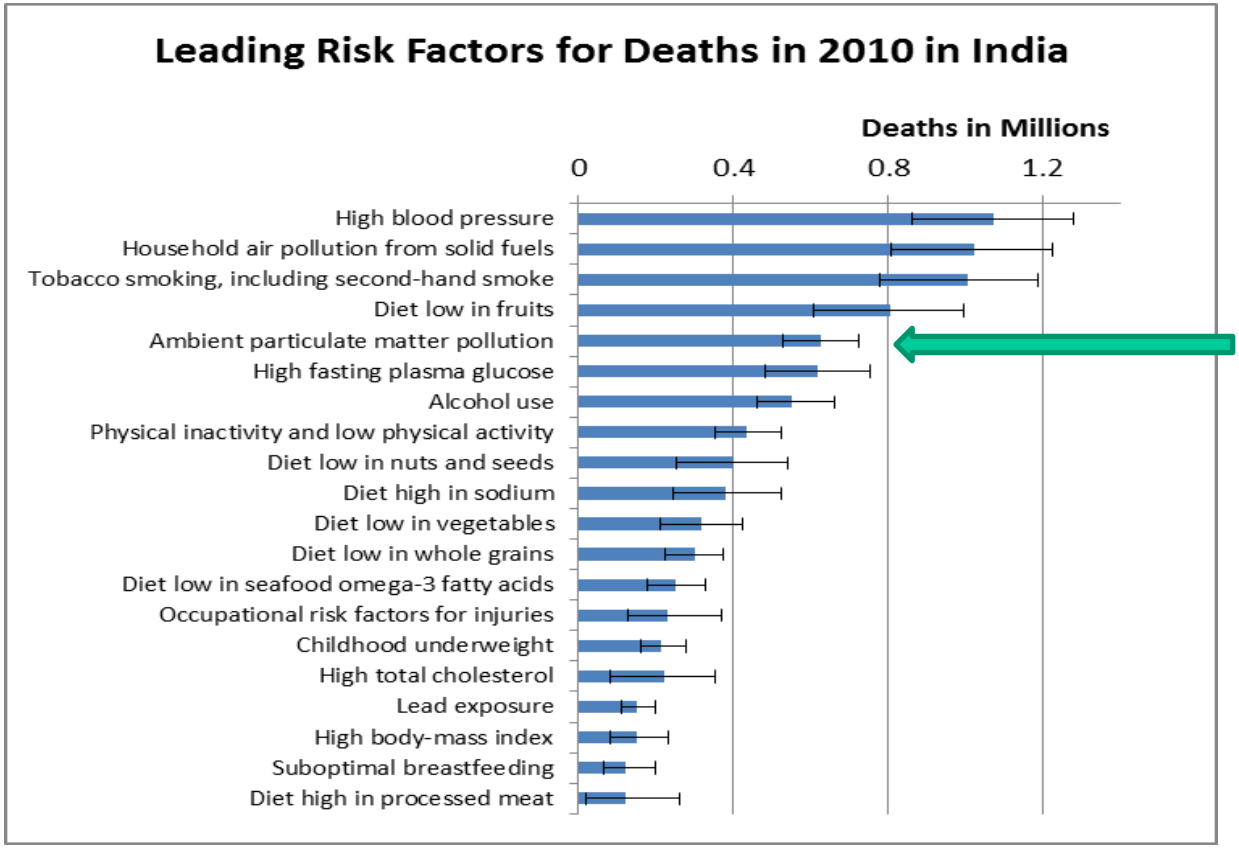
High AM count, Kolkata Taxi Driver

# Mortality due to $PM_{2.5}$ under various policy intervention's/scenarios




TERI estimates

# GBD estimates :PM2.5 is 5th Leading Mortality Risk Factor




**Ambient $PM_{2.5}$ caused an estimated 627,000 deaths ~6% of all deaths in 2010**

GBD-Lancet, 2012

# WHO classifies diesel engine exhaust as known carcinogen

World Health Organization

## Diesel engine exhaust carcinogenic

WHO/PAHO

12 June 2012 -- After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization, today classified diesel engine exhaust as carcinogenic to humans (Group 1), based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

Read the press release from IARC on diesel engine exhaust

# Effects on Ozone on crop productivity

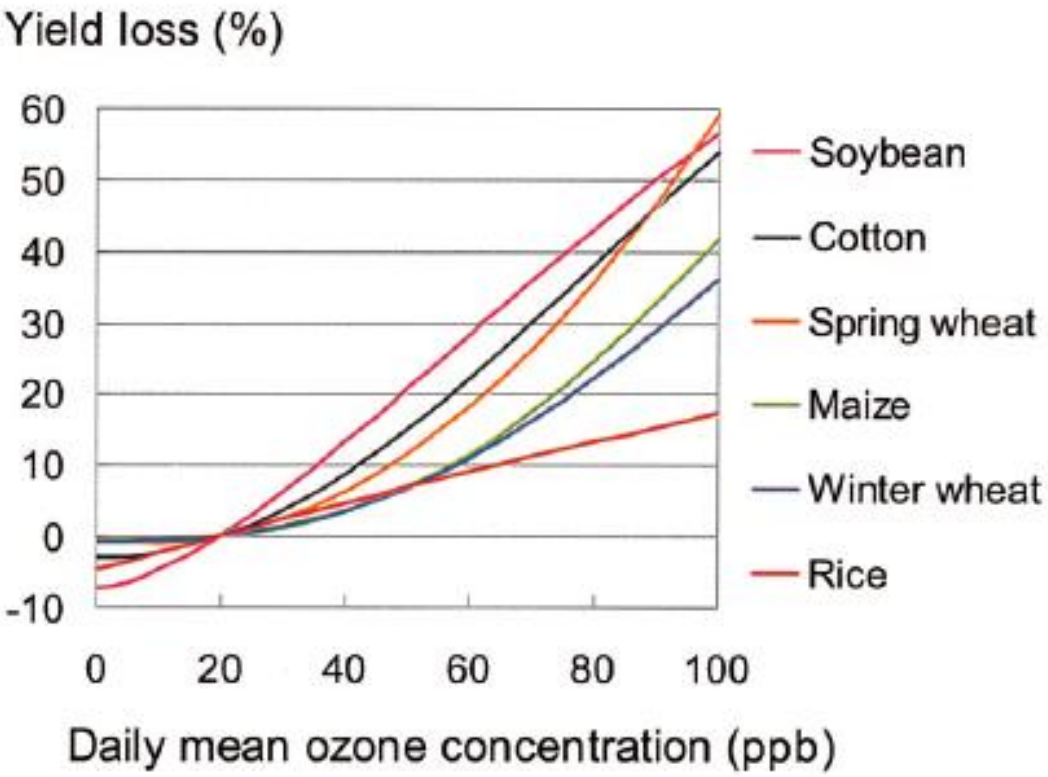



Figure 5-1. Relationships between ozone concentrations and yield losses in major agricultural crops. (Lesser et al. 1990; Skärby et al. 1993; Kobayashi et al. 1995)

# Burney and Ramanathan, 2014

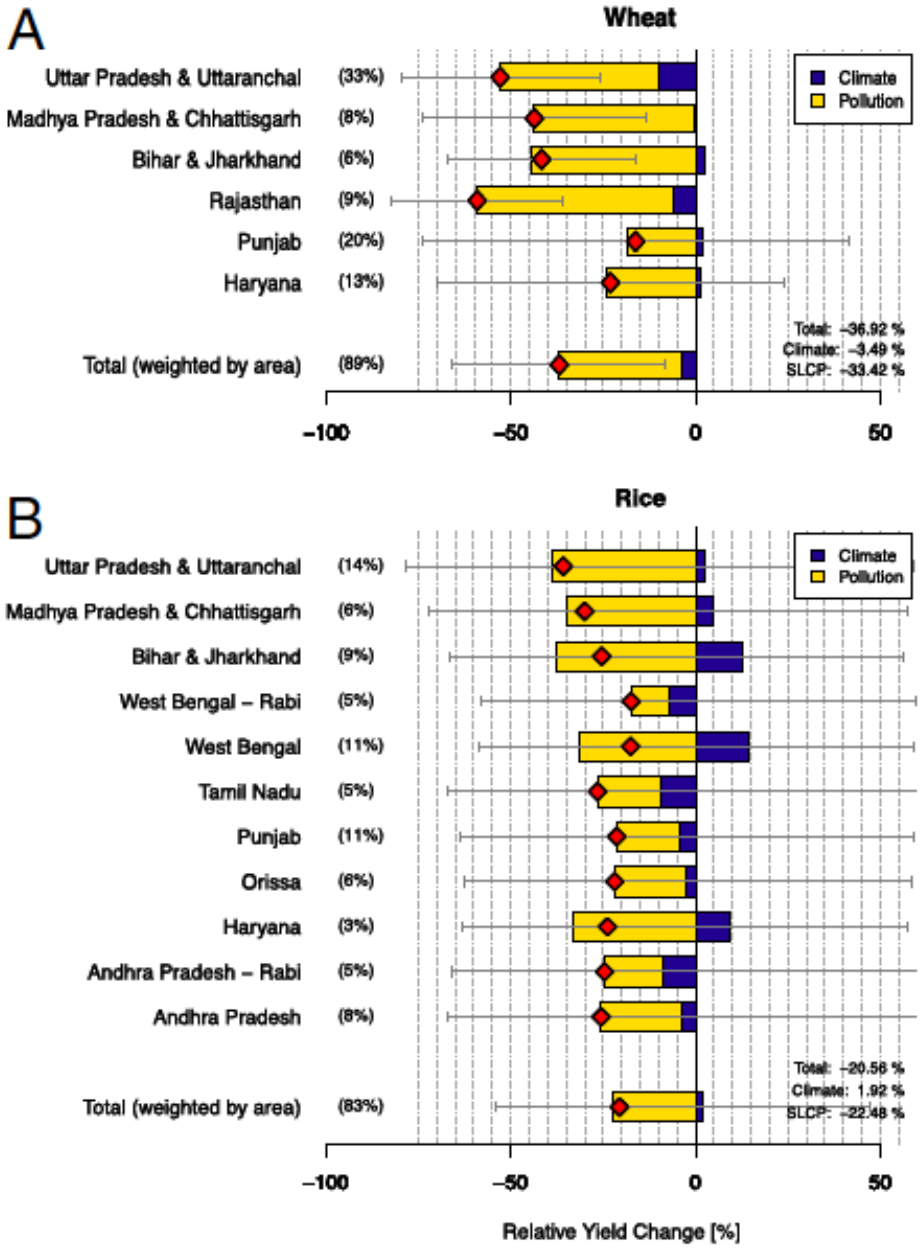



Fig. 3. RYC resulting from climate and SLCPs for (*A*) wheat and (*B*) rice. For


Earth Science and Climate Change
Decentralized Electricity Solutions
Environment Education & Youth Services
Energy Environment Technology Development
Environment & Industrial Bio-Technology
Sustainabl
Water Res
Bio-Techn
Resources
Modeling

# Other Impacts

Materials and heritage


Visibility


Plants and vegetation

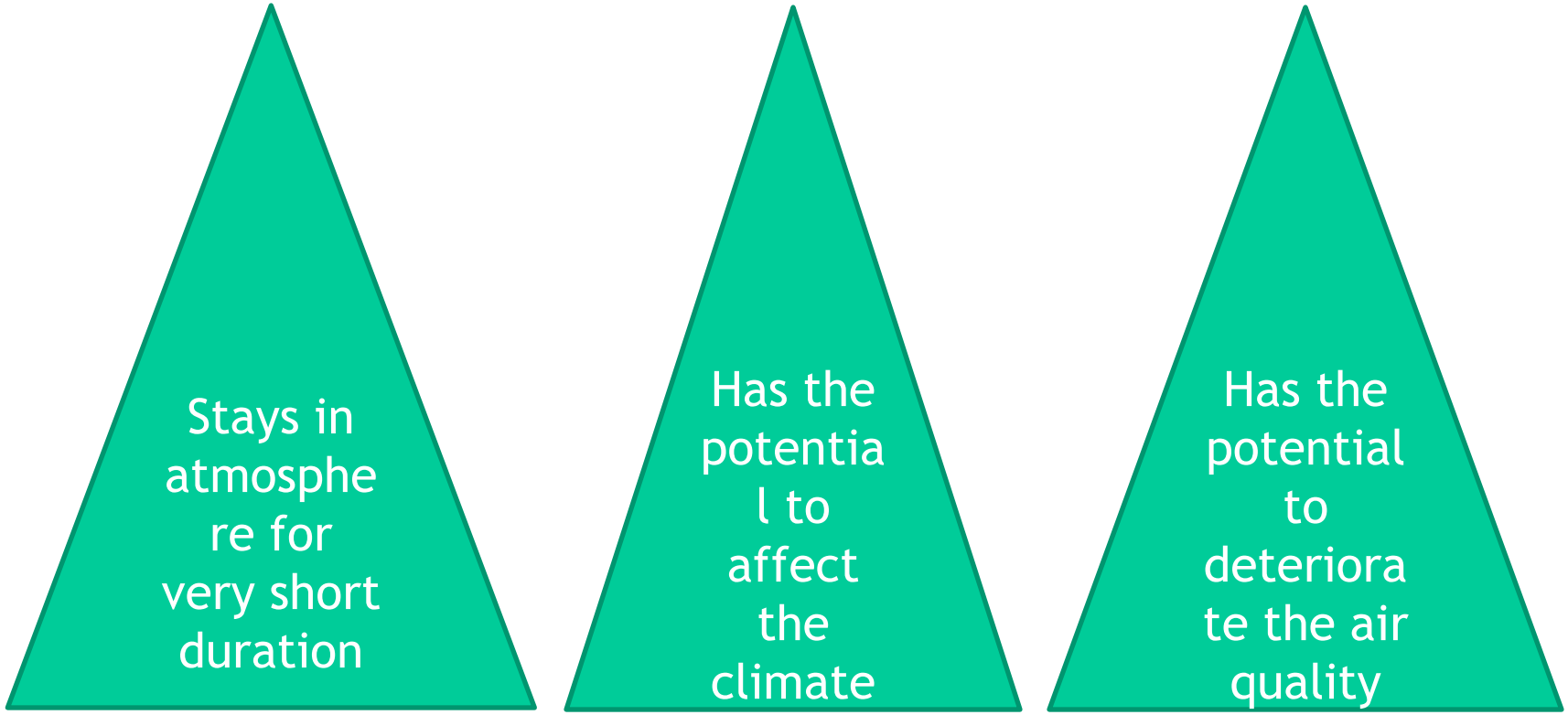
# Impact on climate

# Climate Warmers

- GHG Emissions
- SLCP

# What are SLCP ?

- Short-Lived Climate Pollutant



# Air Pollution and Climate Change

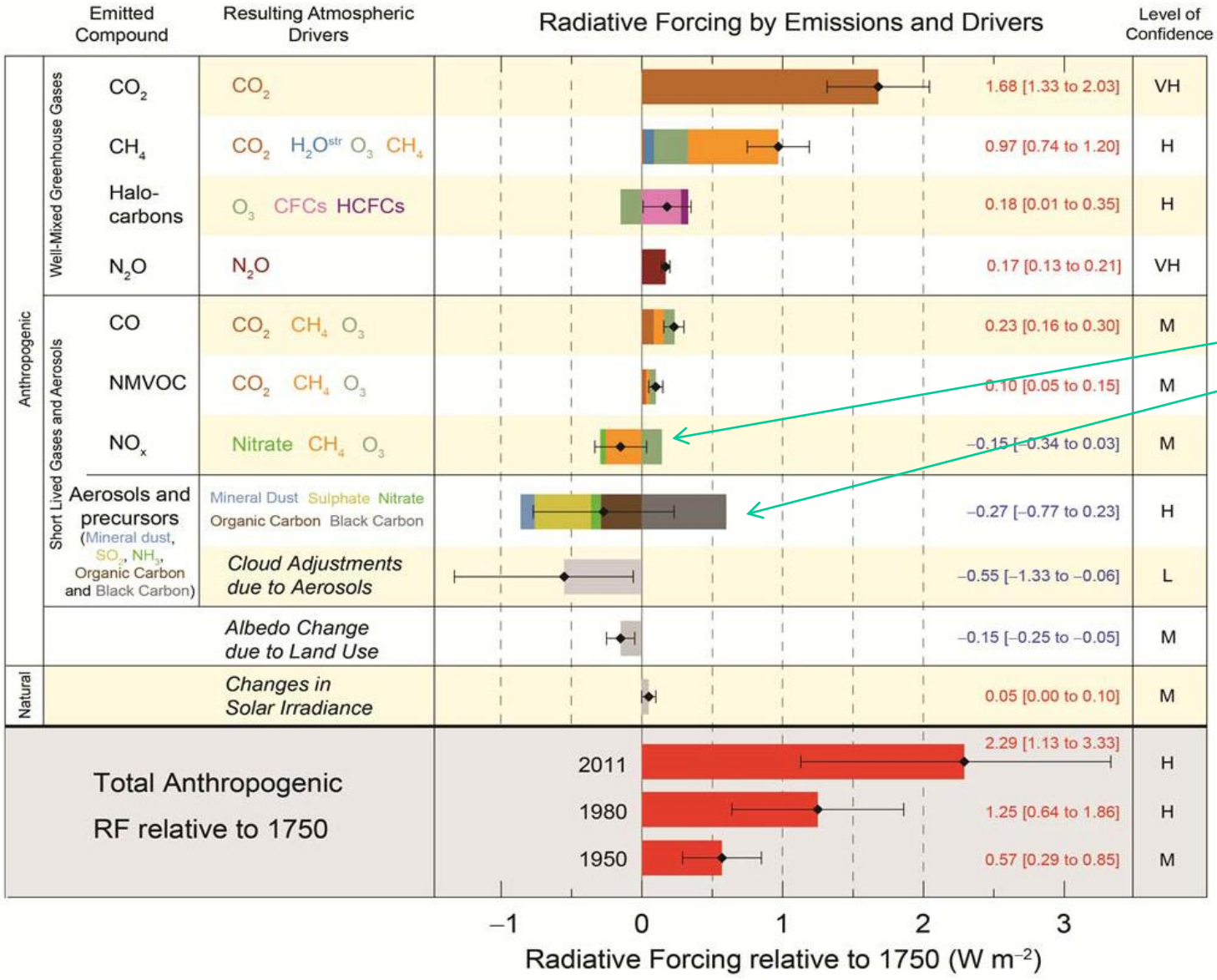
- Particles emitted from diesel vehicles contain black carbon
- Gases (NOx, VOCs) emitted from different sources form Ozone
- Black carbon is now known to have second highest radiative forcing after CO2
- Other than health and agricultural effects it is contributing to warming of the planet
- Absence of ULSD does not allow for installation of tail-pipe PM control devices
- Reducing emissions may result into co-benefits

**Black carbon**

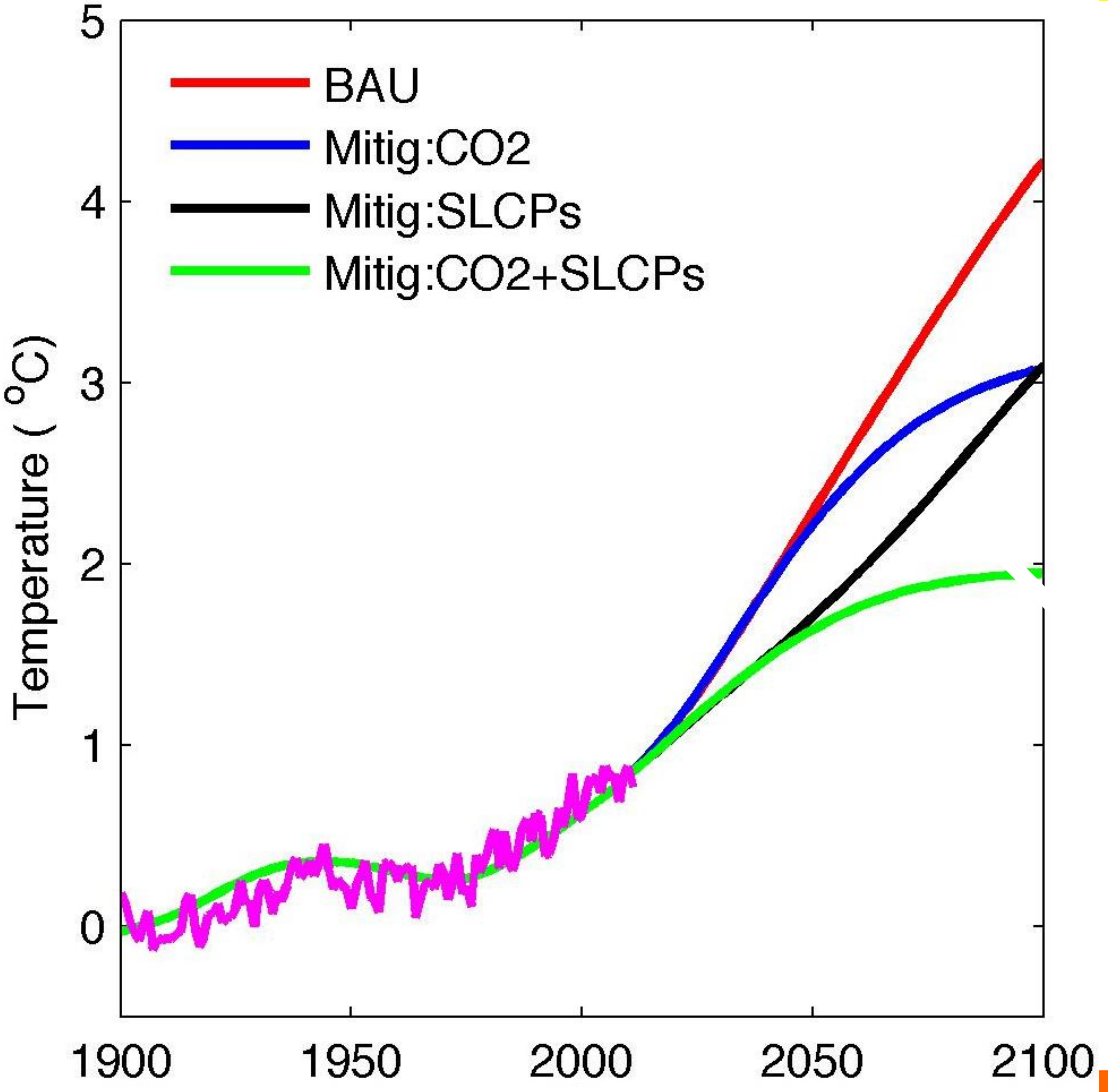
**Ozone**

**Methane**

# Radiative Forcing of Climate (1750 to present): Important Contributions from Air Pollutants



# Future climate scenarios




*Source*: Ramanathan and Xu. 2010 and HU *et al*, 2013

# Impacting image

The Indian EXPRESS NATION WORLD BUSINESS CITIES SPORTS ENTERTAINMENT LIFESTYLE TECHNOLOGY OPINION PHOTOS V



## Delhi most polluted city in the world : WHO

Share 114 Tweet 26 Google + 1 Comments (0)

Nanoparticle Detector
Miniature and robust, easy to use, made in Switzerland www.naneos.ch

Ads by Google

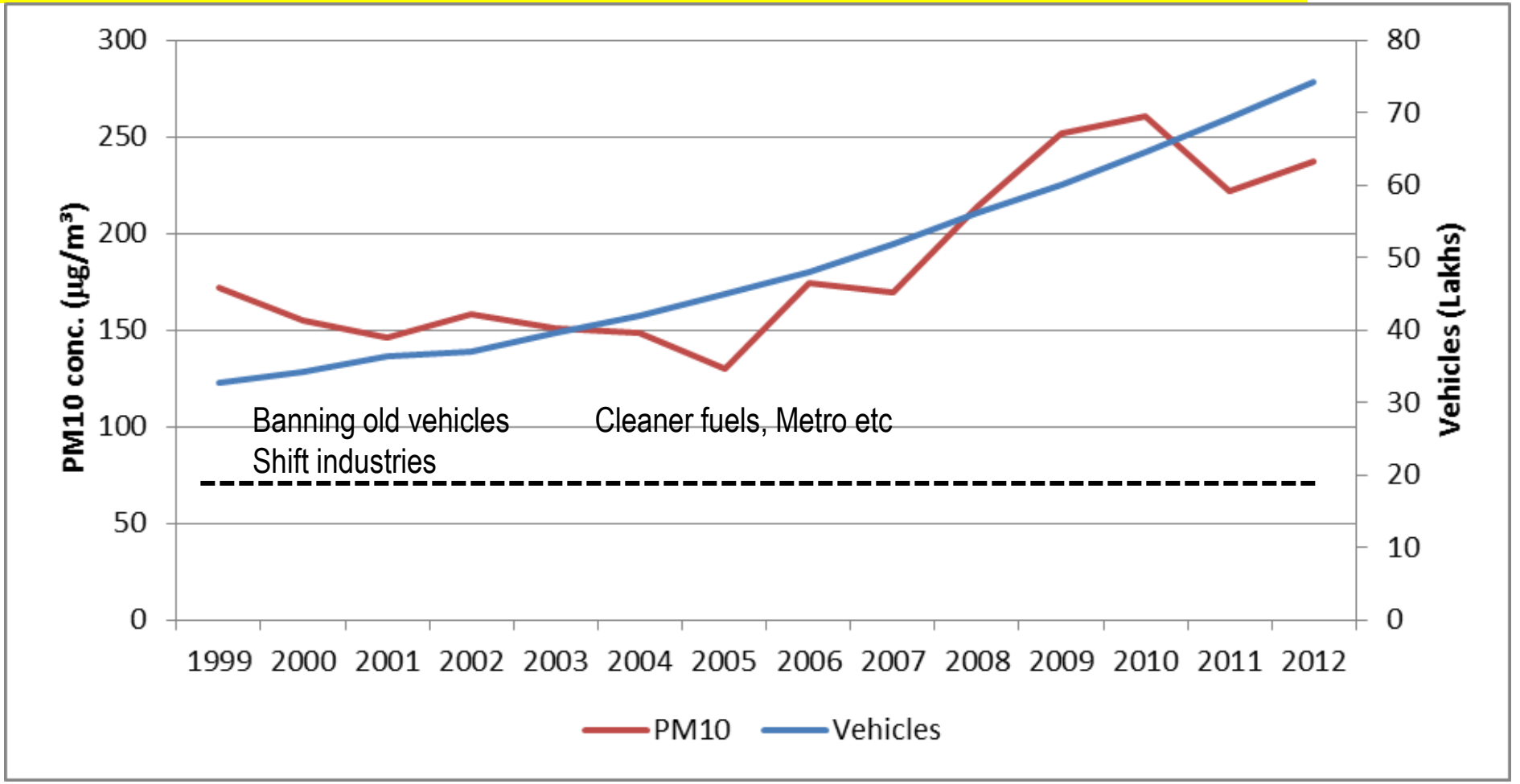
By: Press Trust of India | New Delhi | Published on:May 7, 2014 9:00 pm

Delhi is the most polluted city in the world, says a study released by World Health Organisation (WHO) on Wednesday.

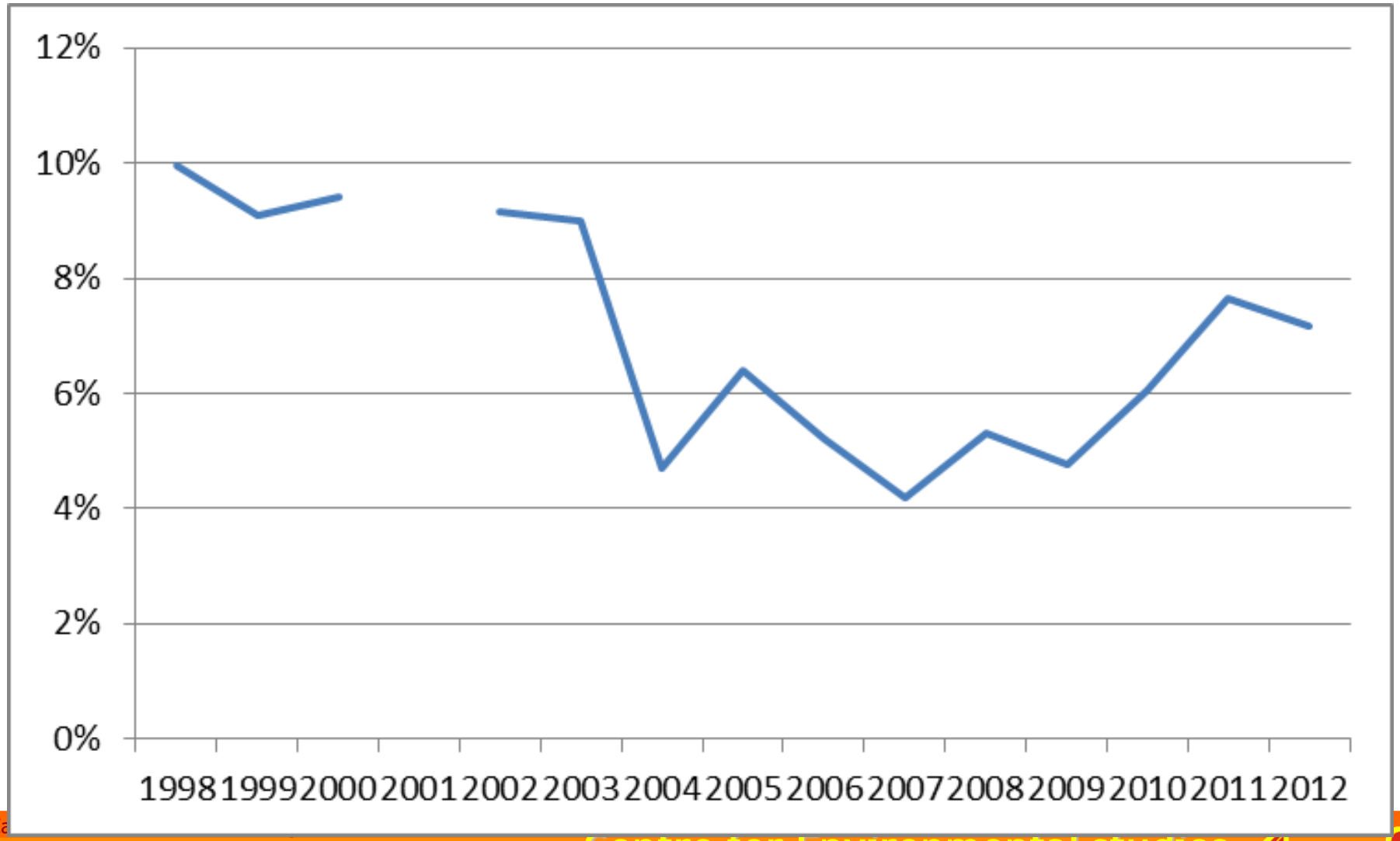
ARE ALL RE
FOR IMP
PATIENT
QUALITY

# Delhi- Case study

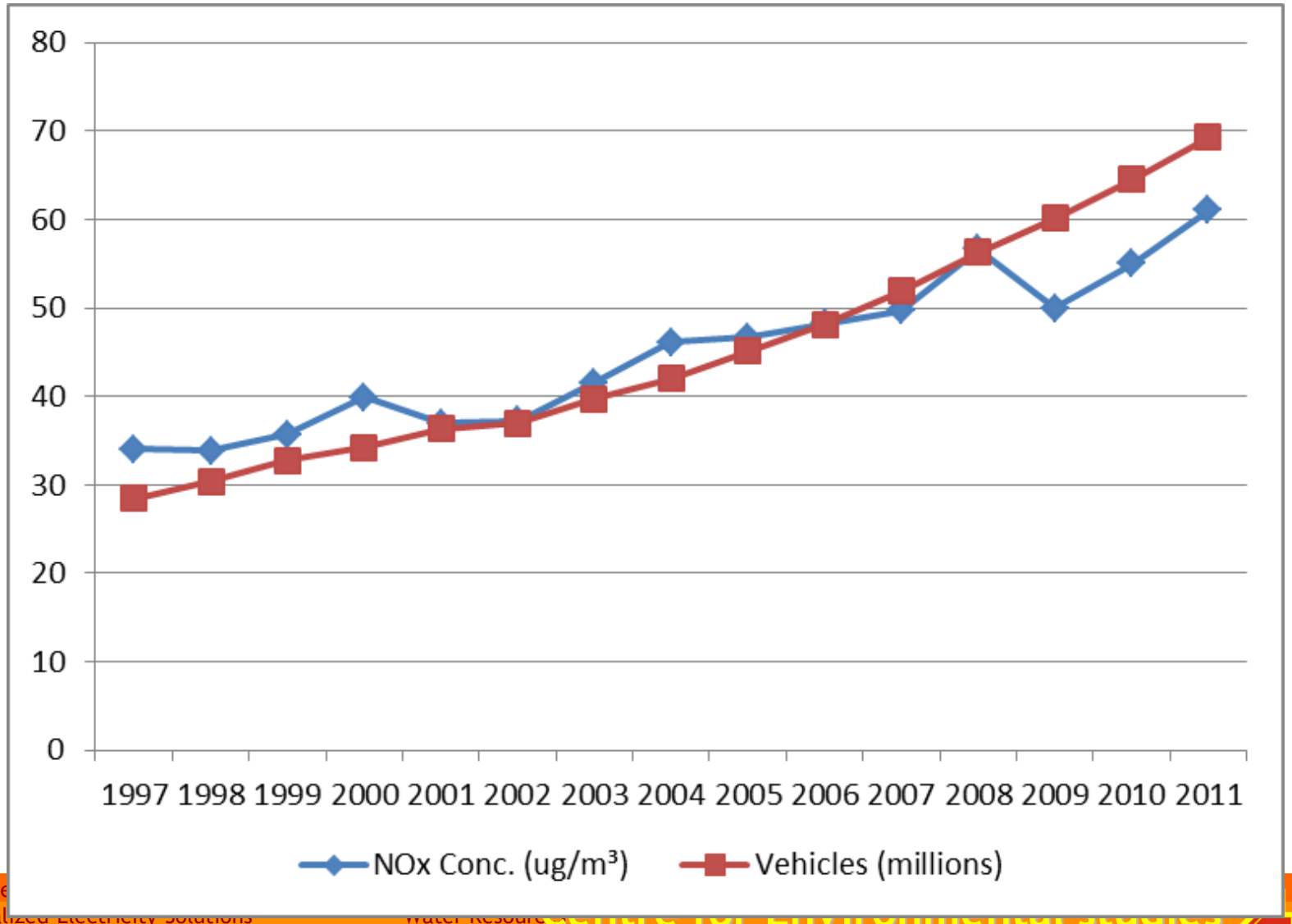
# Urban Air Quality (Delhi)- PM10



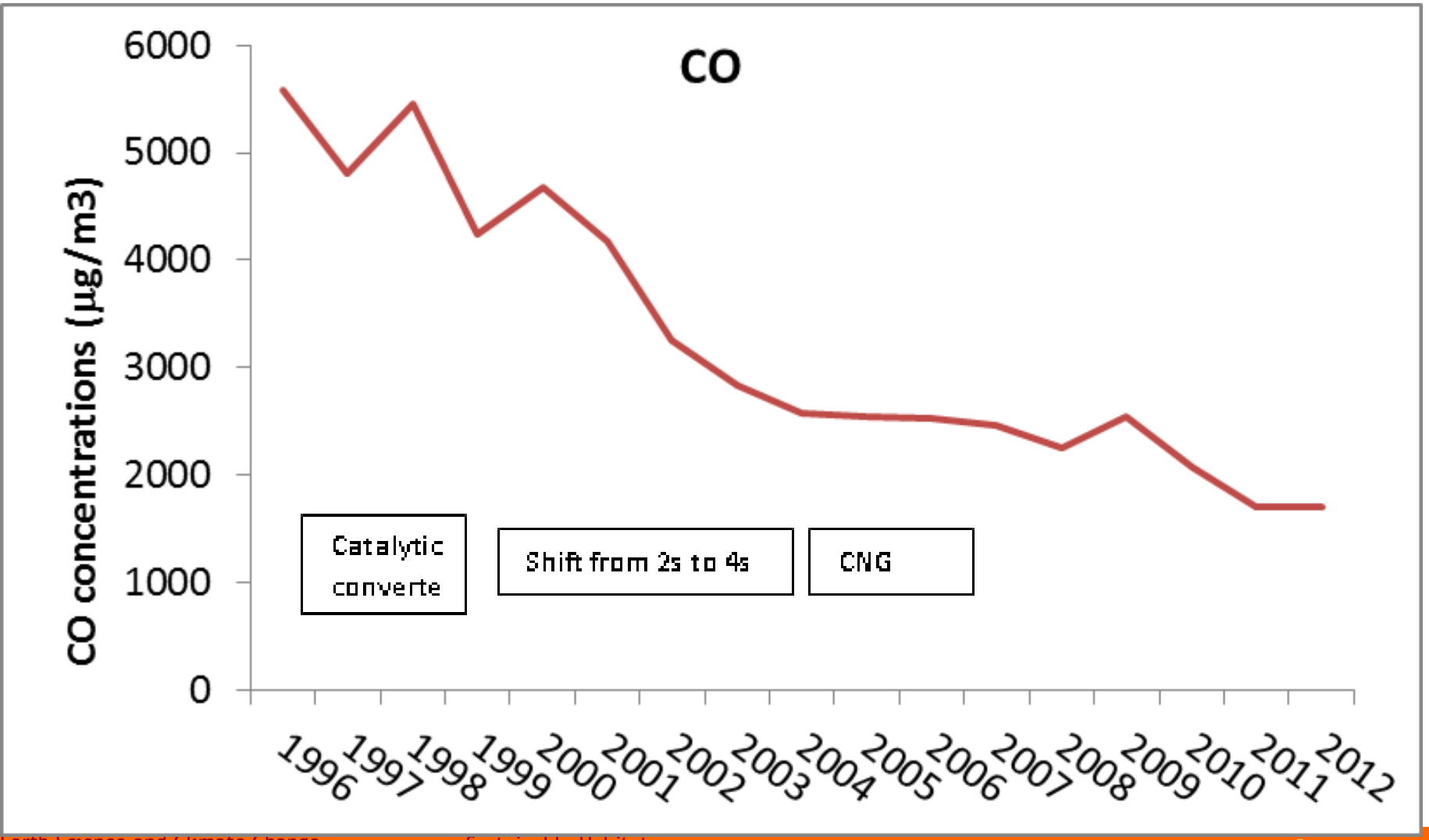
# % deaths due to respiratory illness



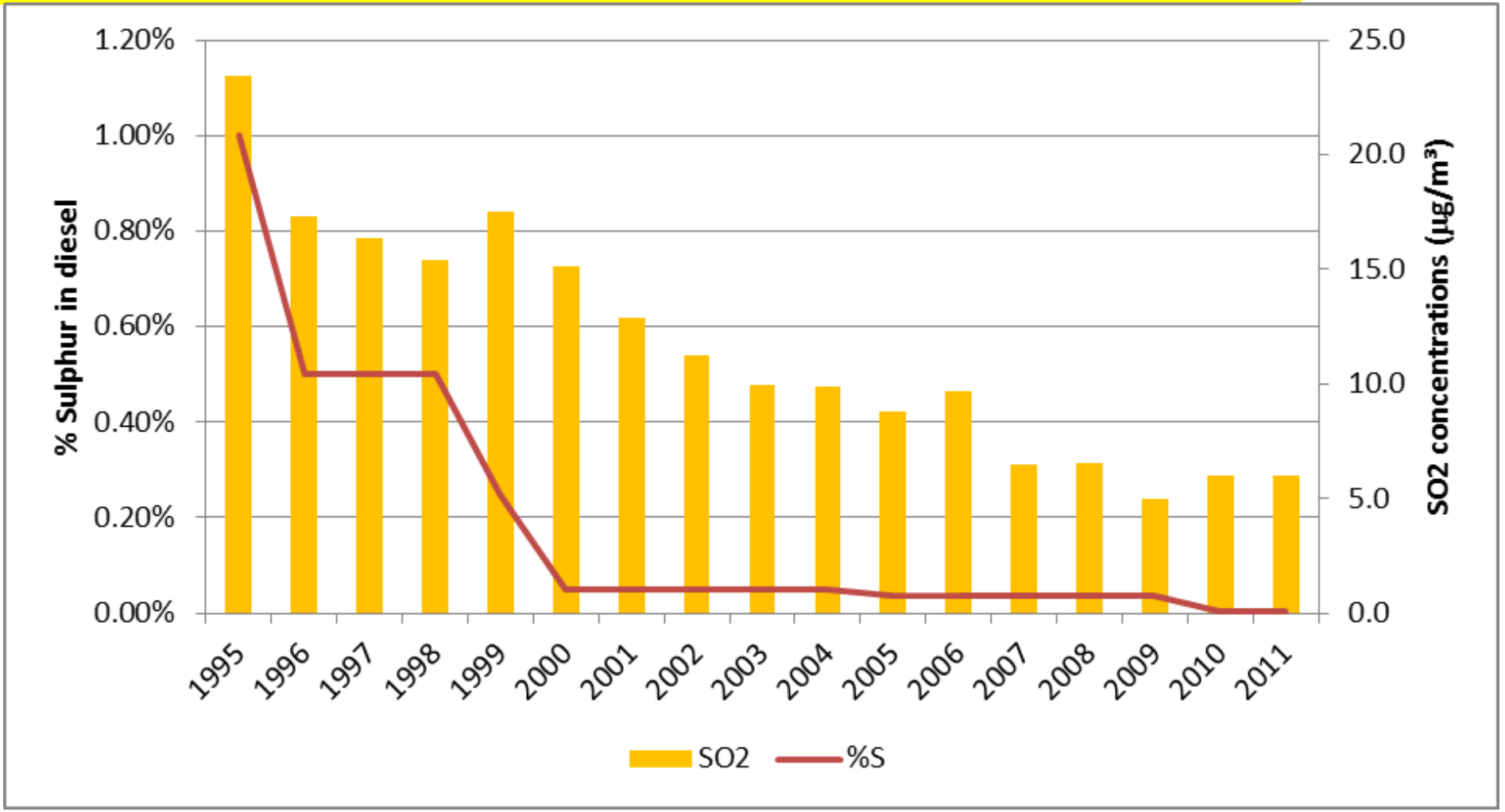
# Urban Air Quality (Delhi)-NOx & Vehicles



# Urban Air Quality (Delhi)- CO

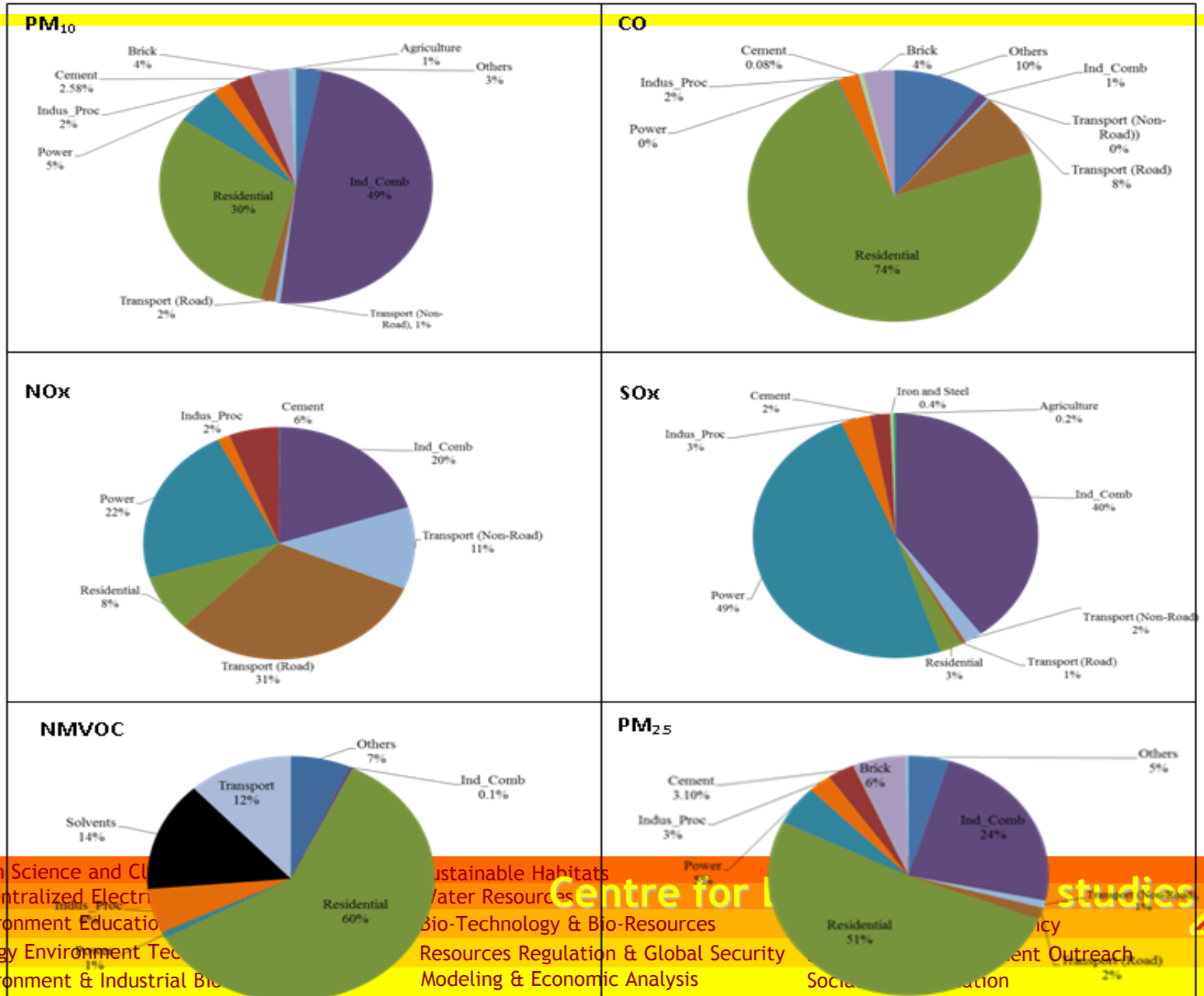


# Urban Air Quality (Delhi)- SO2



# Causal factors

# Source Contributions- National Scale



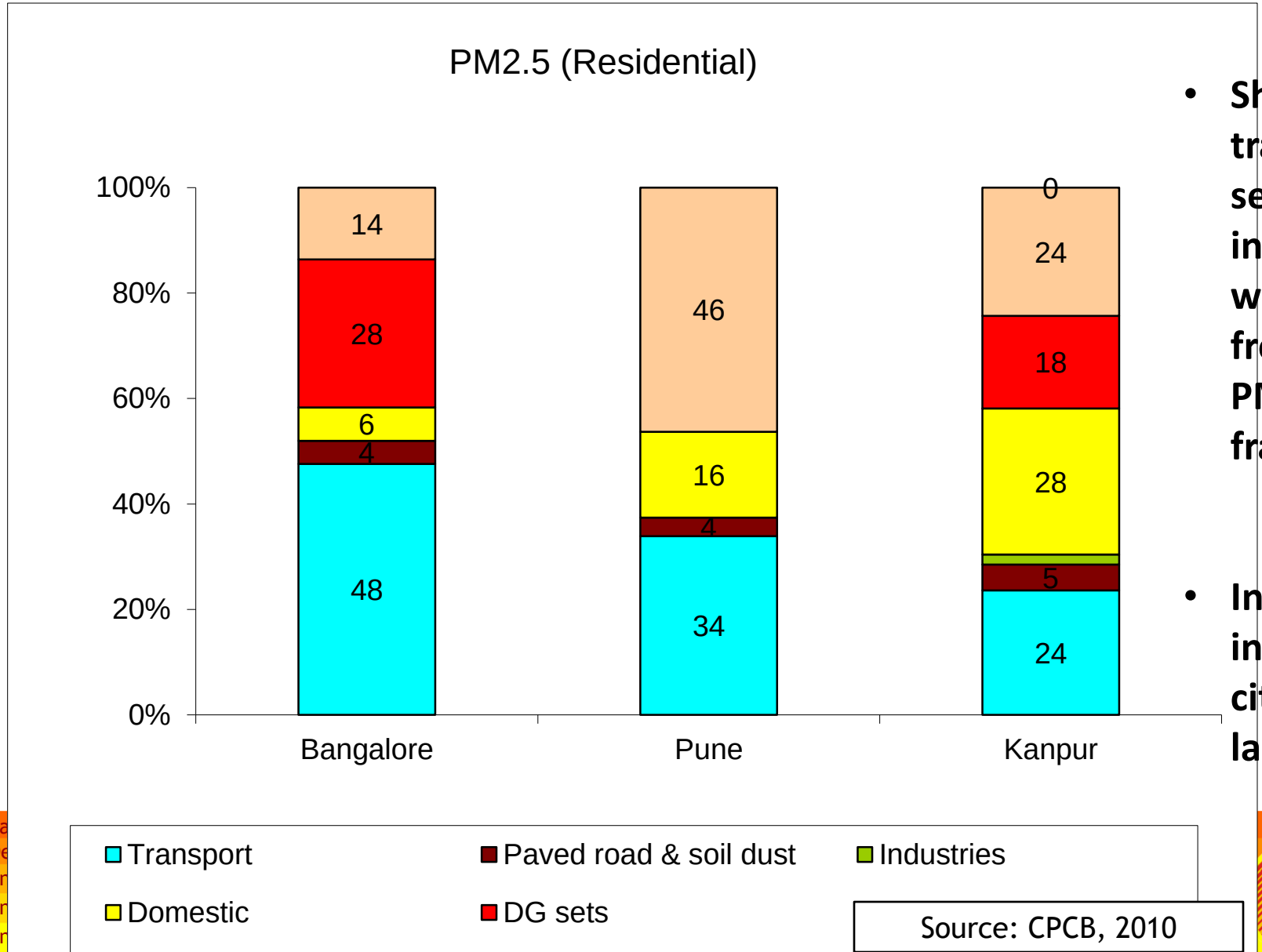

NOx standards

APC at Industries

Cleaner fuels and cooks-stoves

Earth Science and Cl… ustainable Habitats
Decentralized Electri… /ater Resources
Environment Educatio… Bio-Technology & Bio-Resources
Energy Environment Tec… Resources Regulation & Global Security
Environment & Industrial Bio… Modeling & Economic Analysis
Centre for … studies
…cy
…ent Outreach
Soci… …ation
teri

# Source contributions- urban scales




- **Share of transport sector increases if we move from PM10 to PM2.5 (finer fractions)**
- **In non-industrial cities, it is the largest source**

- Key issues and challenges
  - Auto fuel policy issues
  - Unattended evaporative emissions
  - Congestion and driving conditions

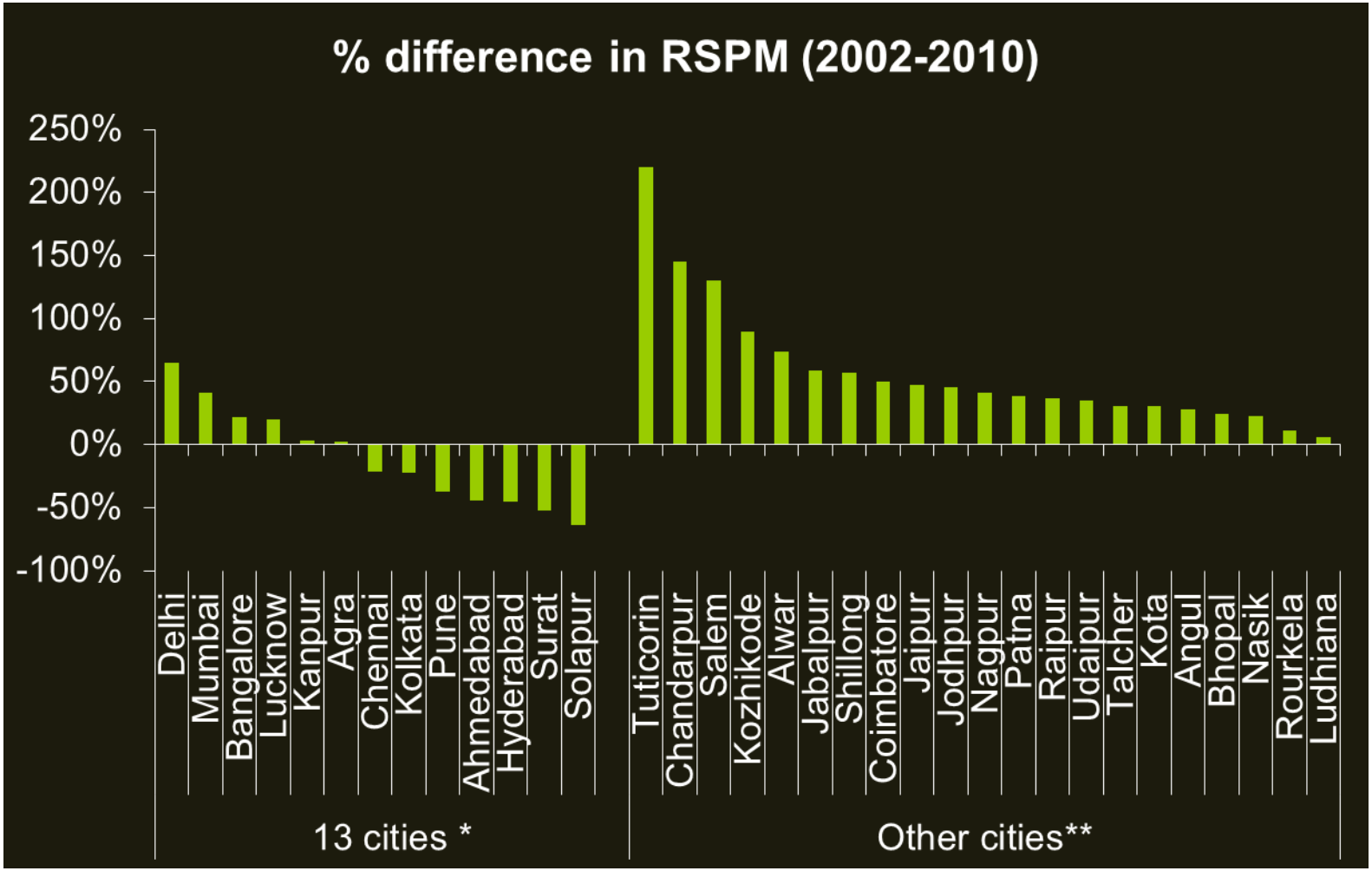
# Government's Auto Fuel Policy

| Category | Bharat Stage II | Bharat Stage III | Bharat Stage IV |
|---|---|---|---|
| 2 & 3 wheelers | Entire country April 2005 | Entire country April 2010 | To be decided |
| All other new vehicles | Entire country April 2005 11 cities- April 2003 | Entire country April 2010 13 cities- April 2005 | 20 cities by April 2010 No date for rest of the country |

# Regional Differentiation

- One set of standards for air quality
- Different vehicle emission and fuel quality standards for 13 cities and rest of the country
- Many other cities in the country are much more polluted than the ones where better quality fuel is presently provided.
- Better quality vehicles moving out of 20 cities, may fill the inferior quality fuel and may end up choking their engines
- No road map after 2010

# Impact of AFP on air quality (RSPM)



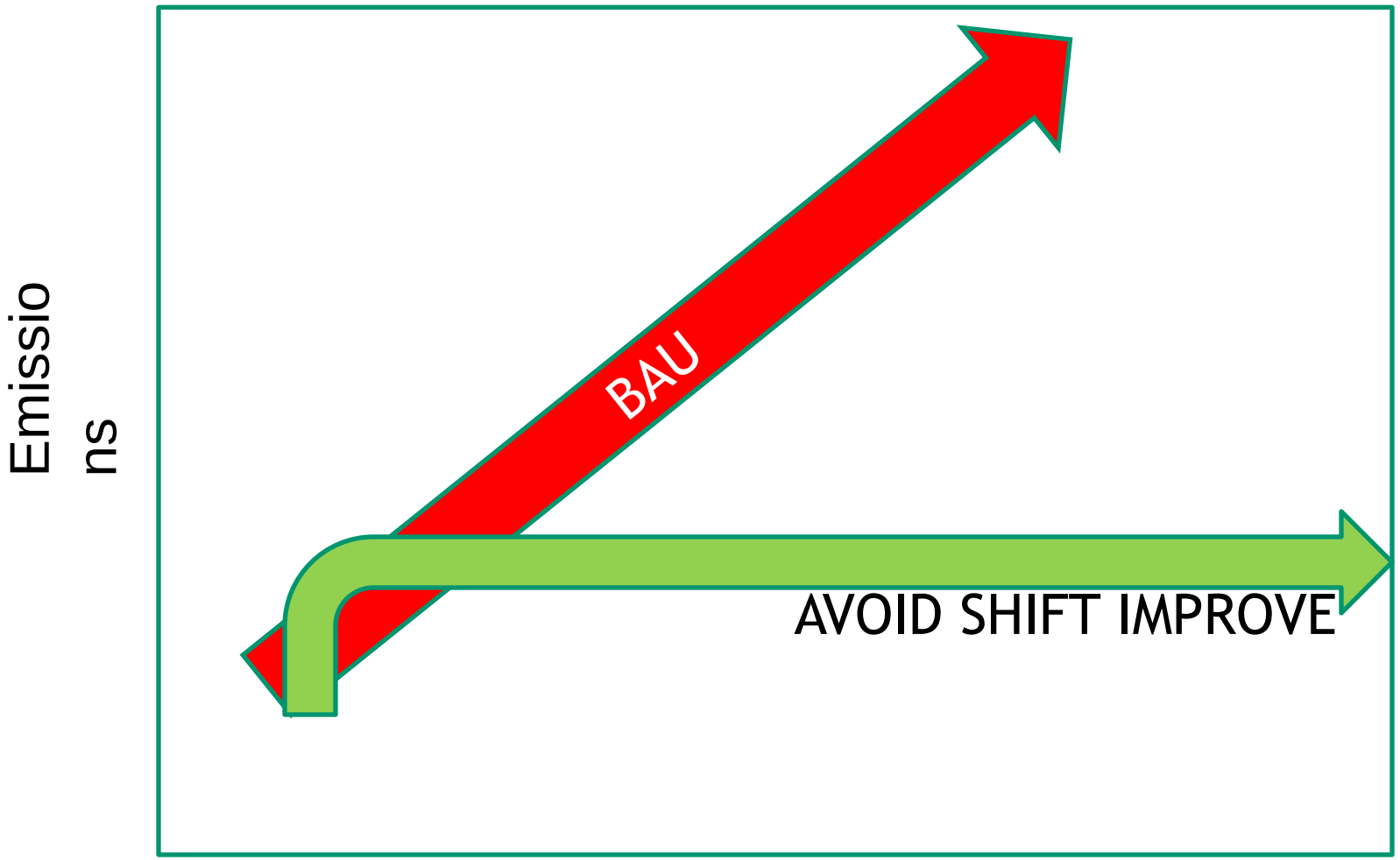

*13 cities : Selected in AFP, 2002 for advanced implementation of BS norms

** Other cities which show higher increase in RSPM in the last 8 years.



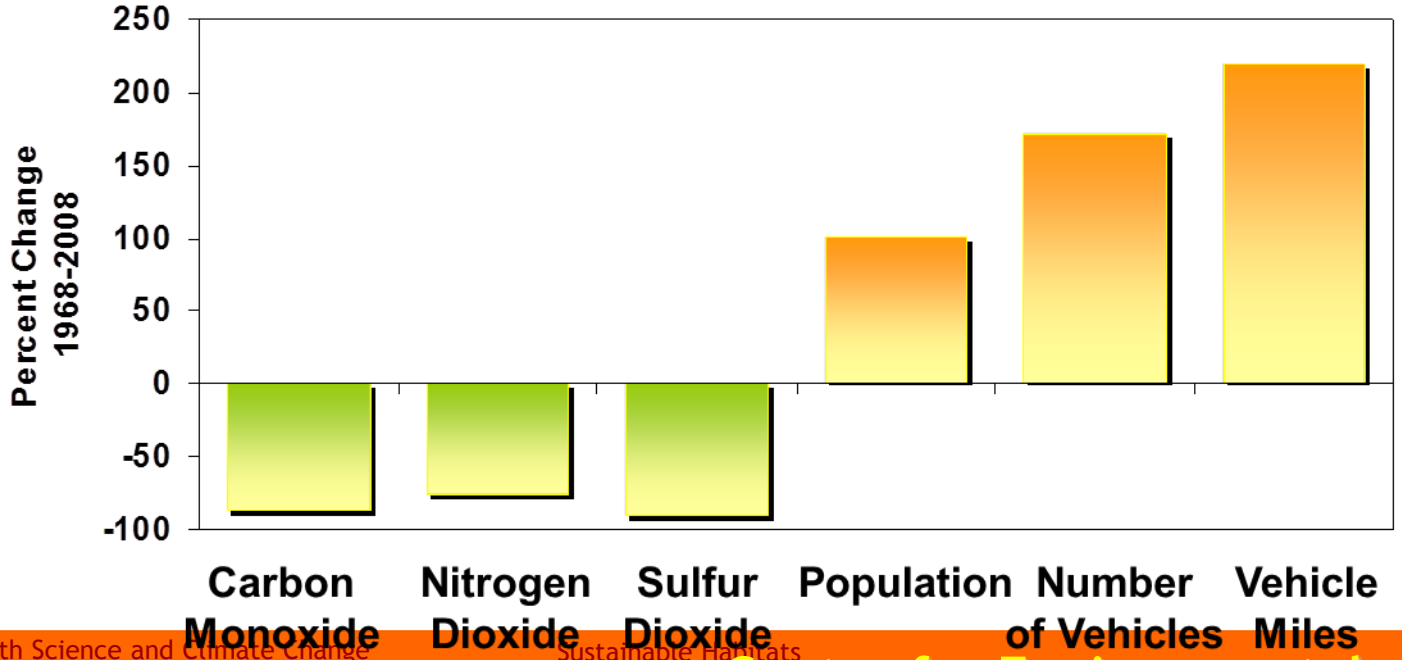
Data source : CPCB, NAMP

# Opportunities

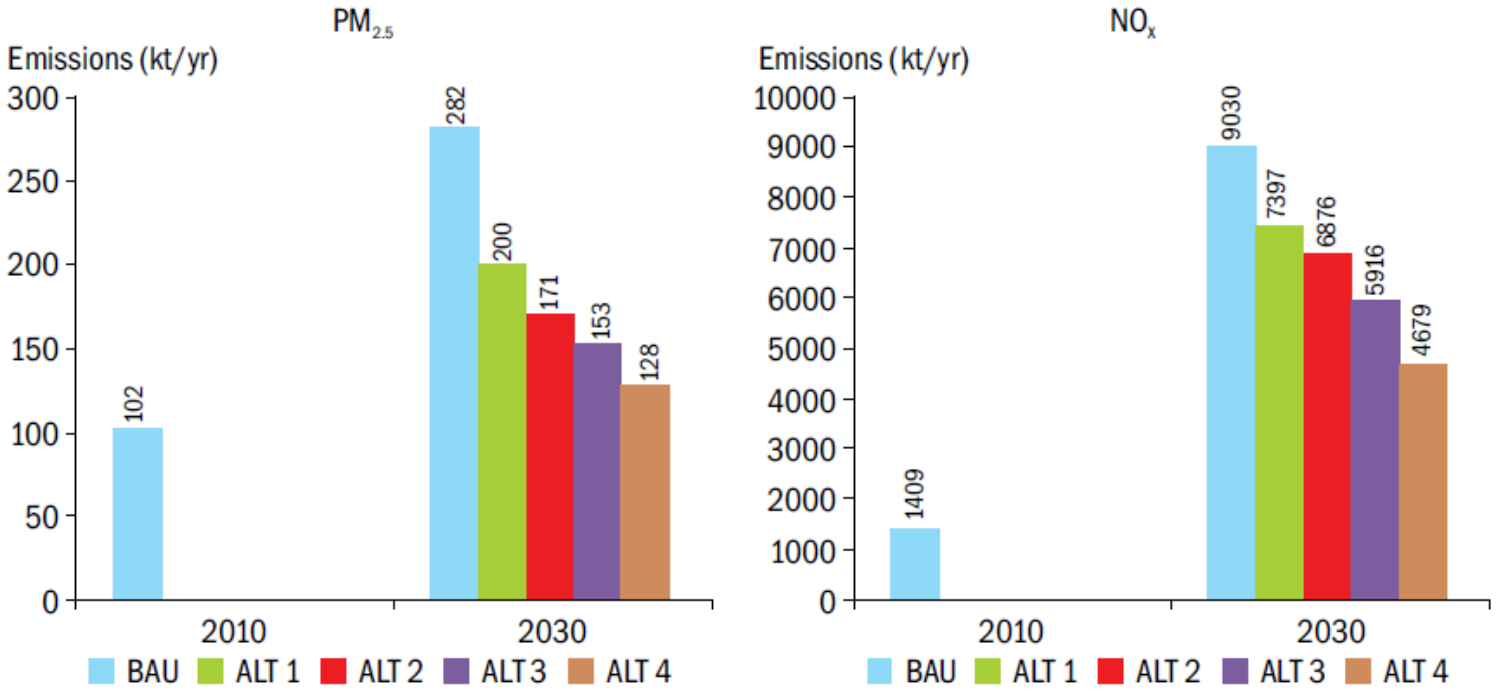


# Improving fuels and vehicles : a tested model

- Quality of fuel and technology of vehicles play an important role in defining emissions
- California introduced clean fuels and vehicles and reduced emissions of
  - ozone precursor gases (CO, NOx and SO2) by 75% to 90%
  - black carbon (major part of diesel PM) emissions by 90%

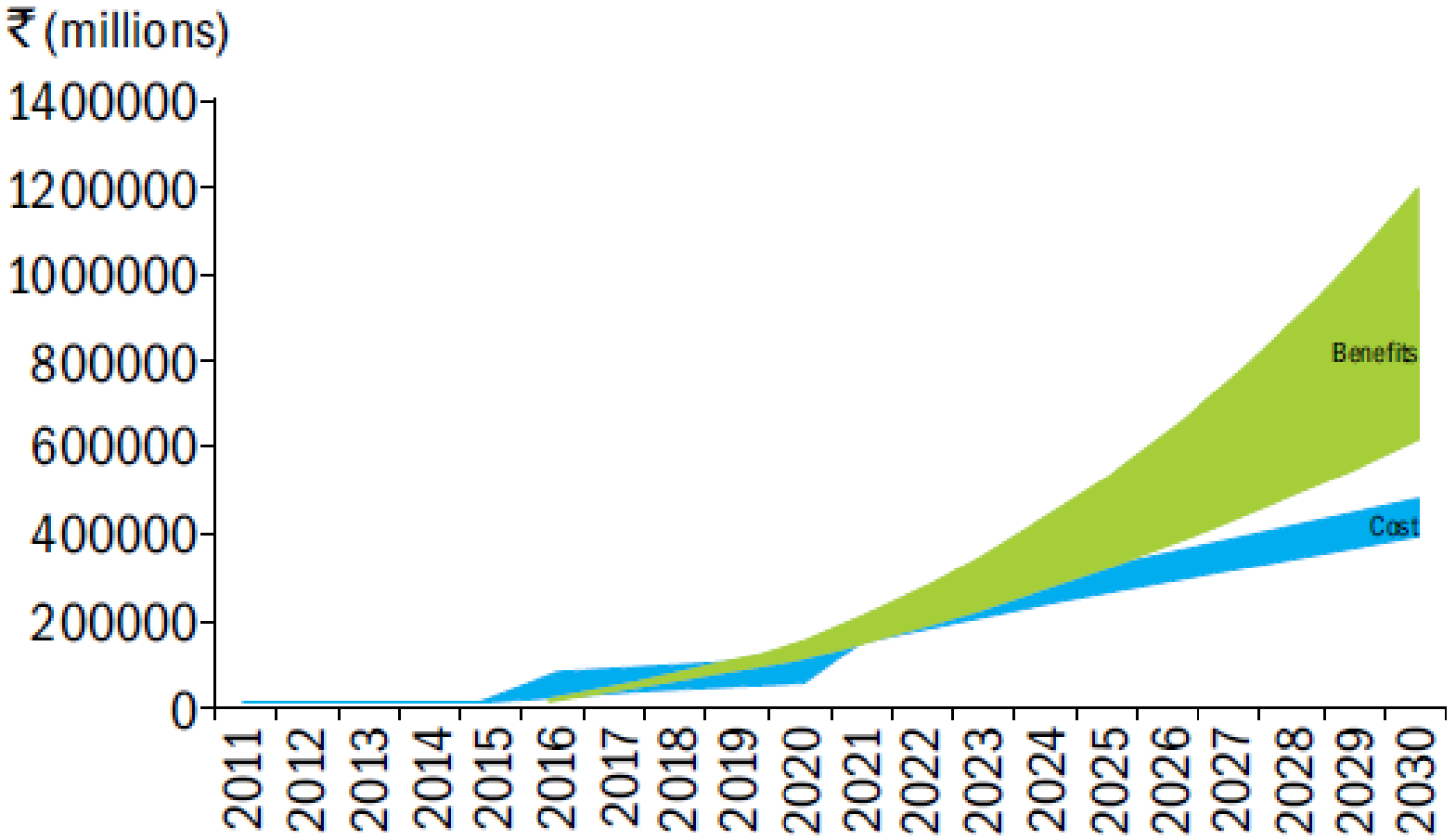


# Effect of Future Vehicular Emission Norms




| Scenario | Description |
|---|---|
| BAU | Based on current plans and policies of the government (BS-III all across the country and BS-IV in 13 cities) |
| ALT-1 | BS-IV all across the country by 2020 |
| ALT-2 | BS-IV all across the country by 2015 |
| ALT-3 | BS-IV all across the country by 2015 and BS-V in 2020 |
| ALT-4 | BS-IV all across the country by 2015 and BS-VI in 2020 |

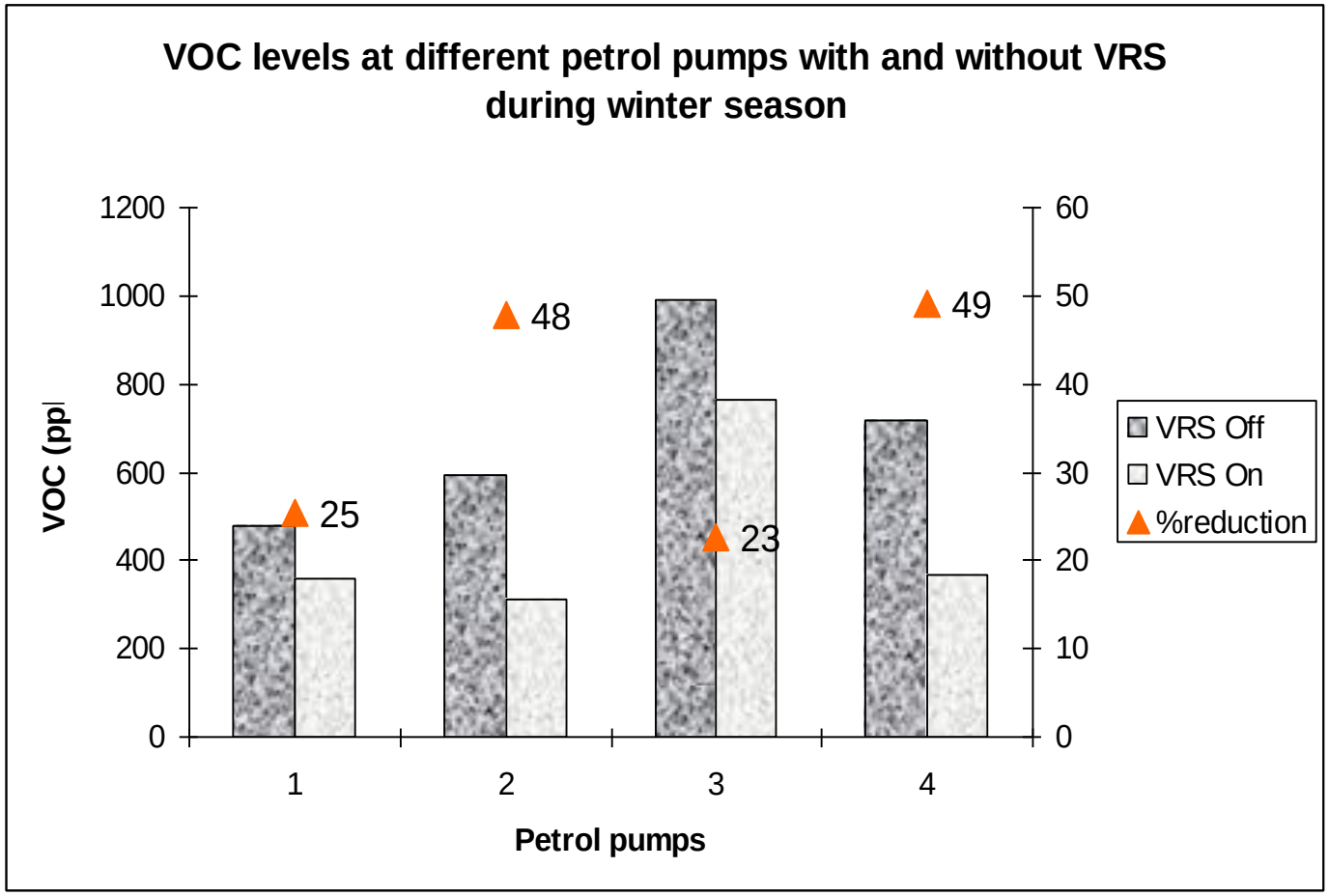
# Benefits Start Outweighing Costs



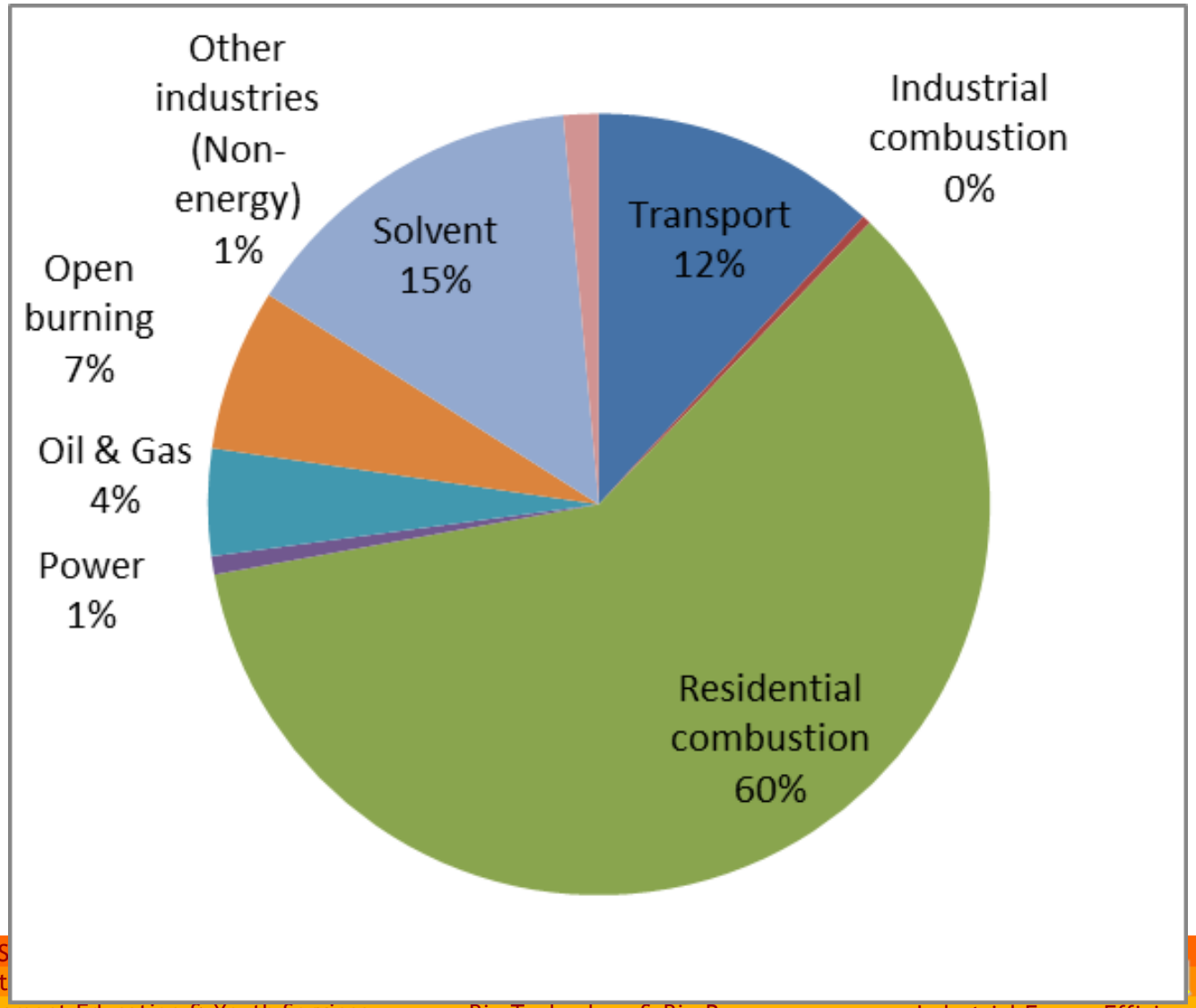
# Evaporative sources

# Fugitive Emissions at Petrol Pumps


# Effect of Vapour Recovery System on VOC at fuelling stations in Urban Delhi during winter

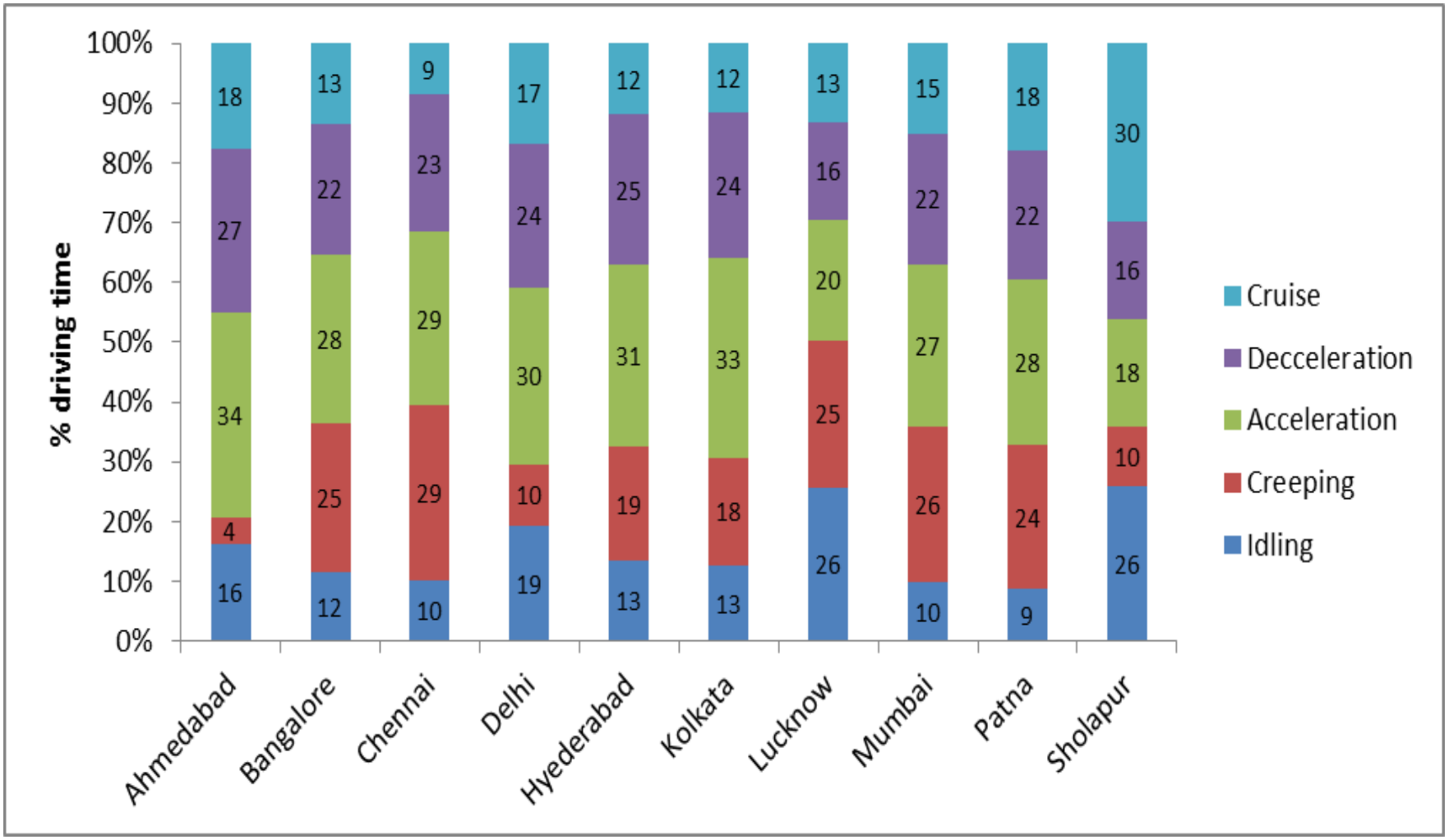


# NMVOC emission inventory India

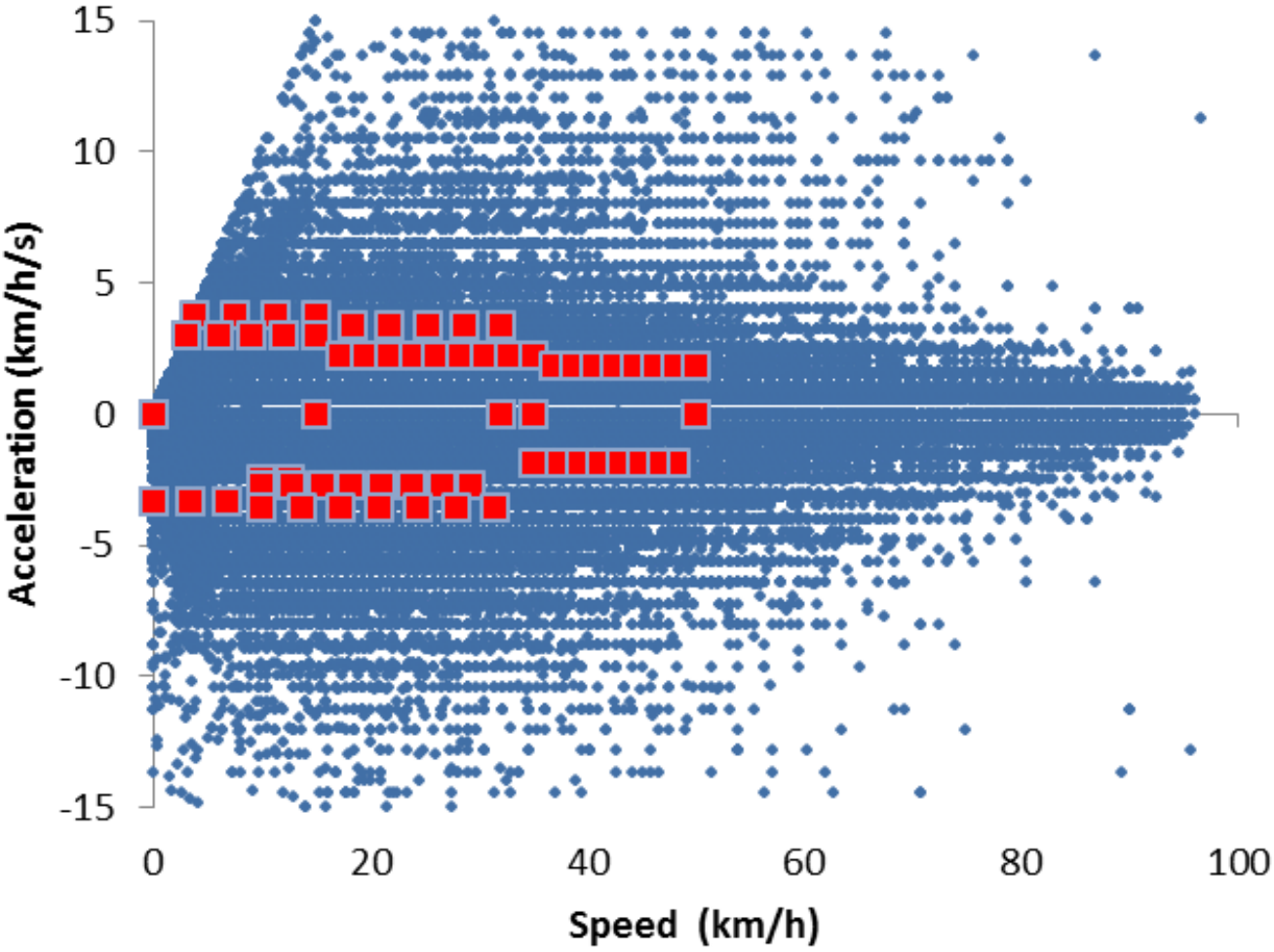



Sharma et al, 2015

# Driving Modes



# Real World Driving v/s driving test cycles




Saves fuel, money, time, emissions, and exposure

# Key recommendations

Transport

- Auto fuel policy
- On-road vehicle emission management

Power and industries

- Standards for NOx
- Installation and control of APC devices

Domestic

- LPG penetration
- Improved cook-stoves

# Thanks