

**where do we start planning for
better air quality in Indian cities?**

Dr. Sarath Guttikunda

URBANEMISSIONS.info

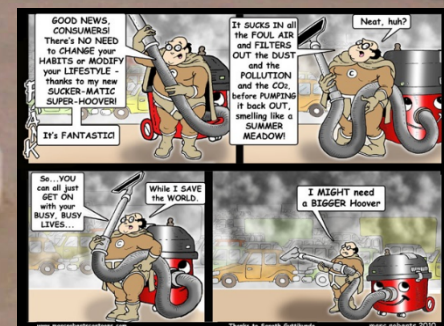
our answer....

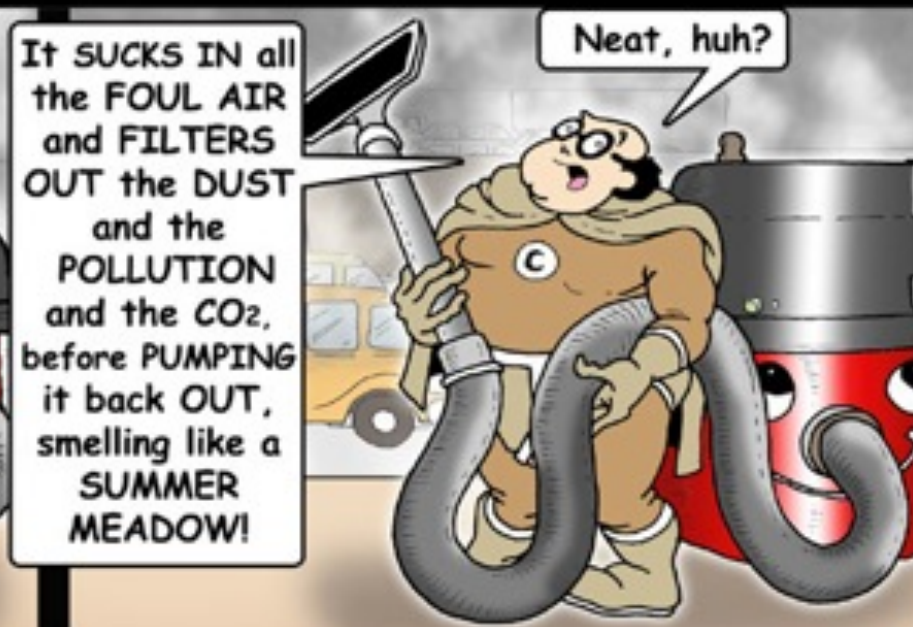
start with disseminating information on

- how much is the pollution
- where is the pollution
- when is the pollution
- what are the sources

how do we address the problem?

at least not with this...





Giant vacuum cleaner?

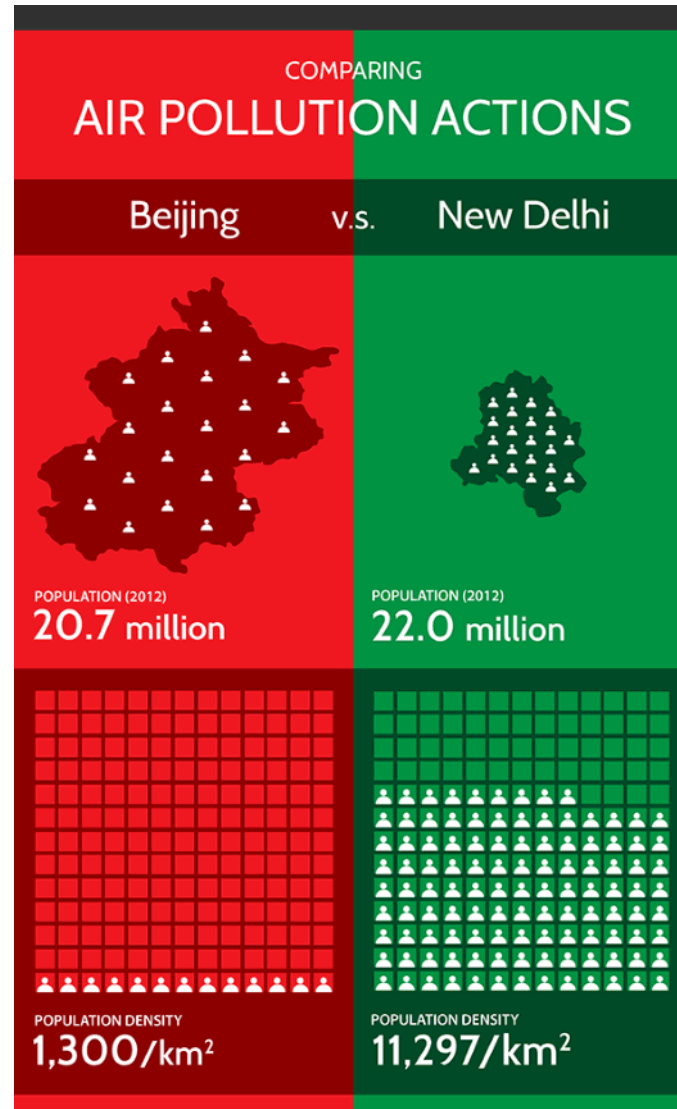


**2.5
crore**

(equivalent of at least two continuous monitoring stations)

Discontinuous Real-time Monitors

35



11

so, where do we start?

people cover their unwillingness to act under the guise of unending inquiry... we can't do anything because, we don't yet know everything...

Jon Stewart, The Daily Show (final episode, 2015)

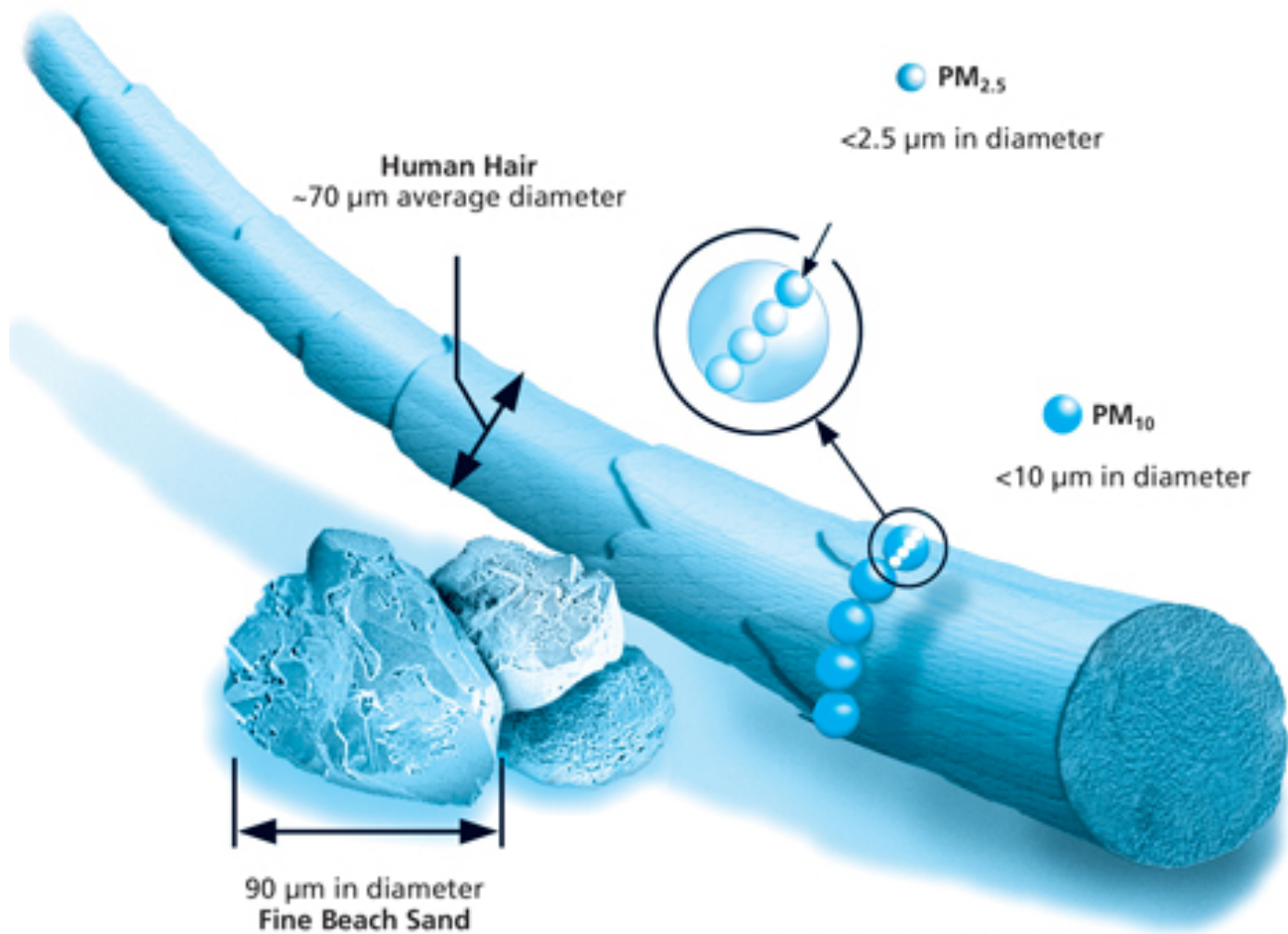


Image courtesy of EPA, Office of Research and Development

PM₁₀

PM_{2.5}

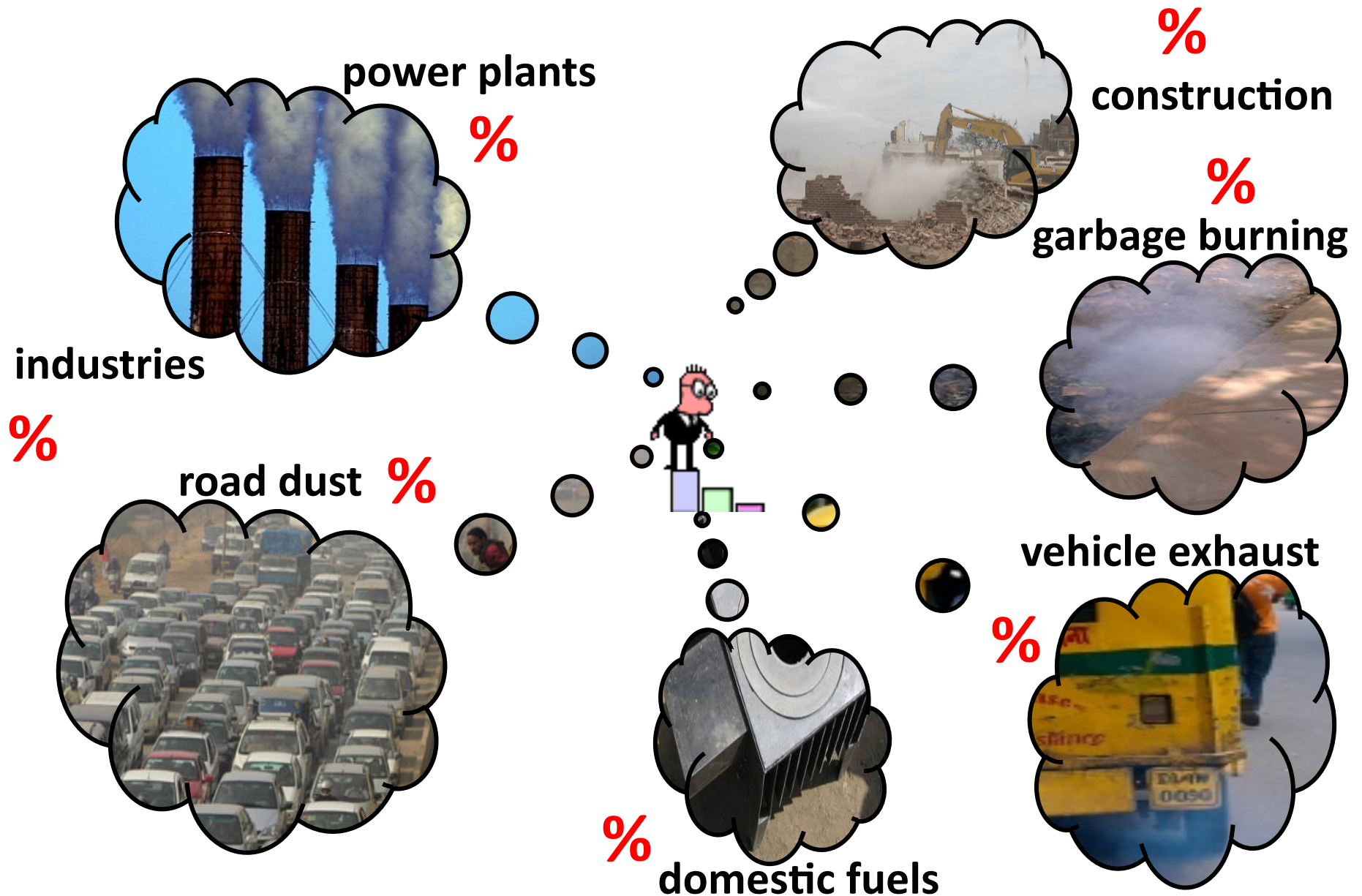
SO₂

NO₂

Ozone

CO

Source Contributions



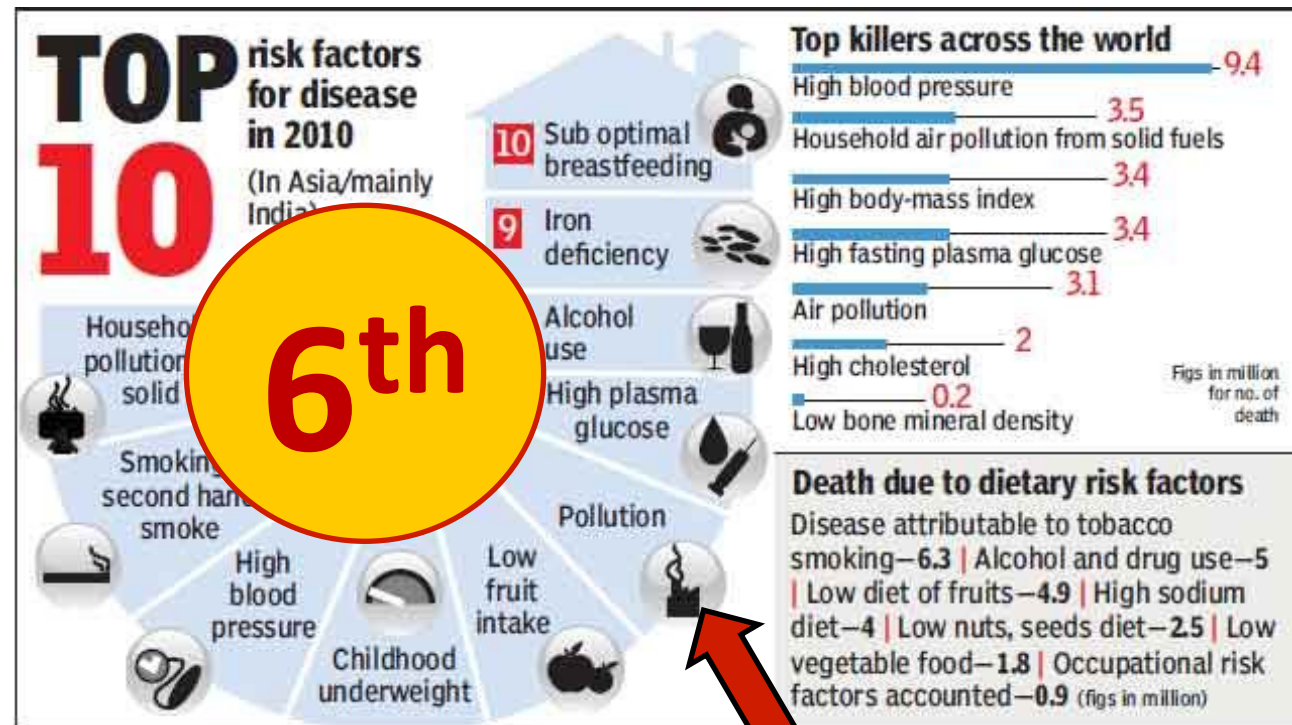
Air Pollution in Indian Cities

Capital has more toxic particles in its air than other major Indian metros

DELHI IS INDIA'S ASTHMA CAPITAL

DELHI has the highest levels of Respirable Suspended Particulate Matter (RSPM) among the four metros, exposing its residents to a greater risk of asthma than people elsewhere in the country.
RSPM was recorded at a shocking 149 micrograms, according to a report published by the Central Pollution Control Board (CPCB), with the help of data collected between January and August 2008.
This is well above Mumbai's RSPM mark of 118 micrograms, Kolkata's 104 micrograms and Chennai's 94 micrograms.
Acceptable levels of RSPM should not be more than 40 micrograms (micrograms) per cubic meter (cu m) annually. In 2008, Delhi's RSPM was 149 micrograms per cubic meter.
Turn to Page 6

**GBD 2010
(Lancet, 2012)**

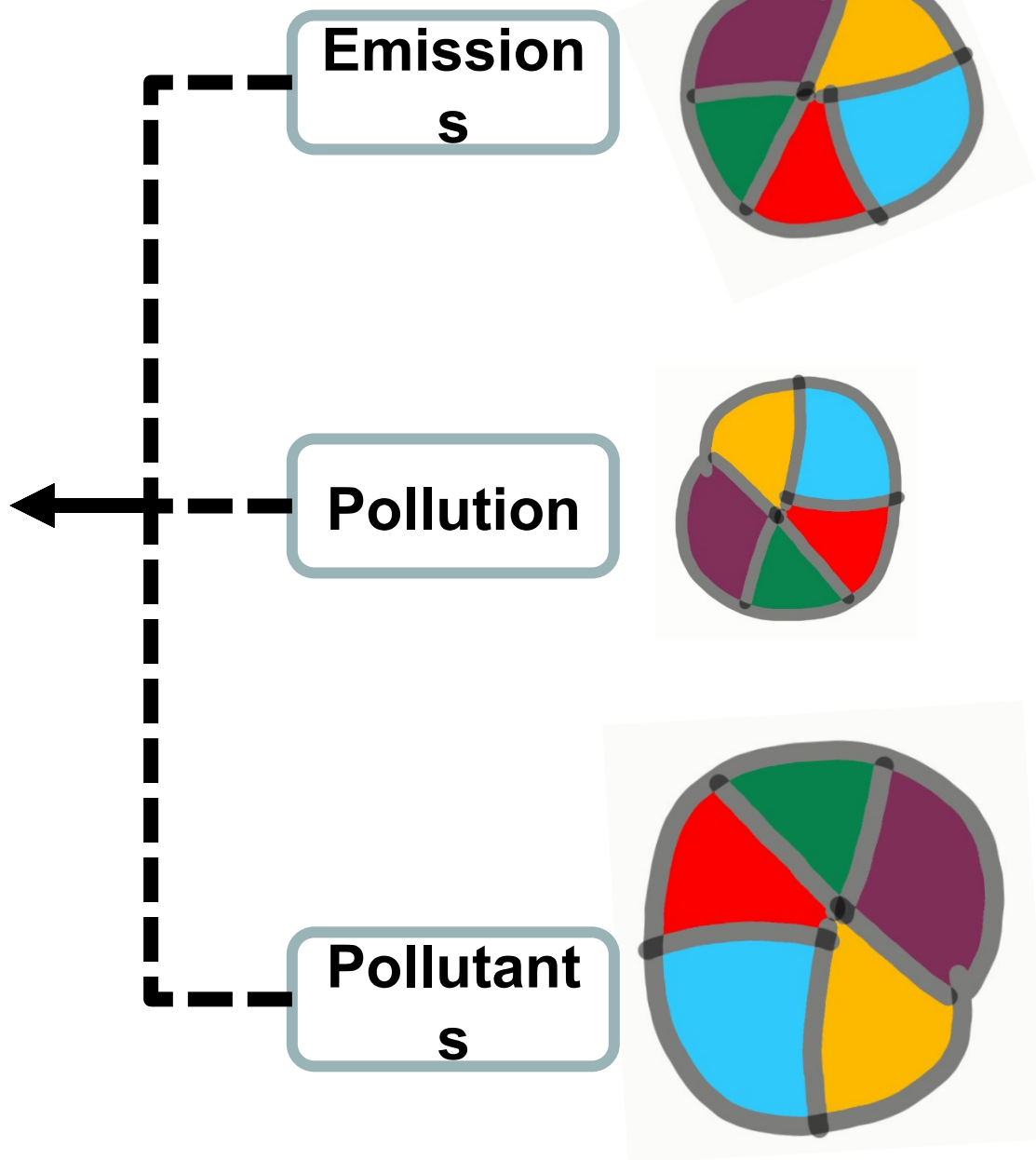


~627,000 premature deaths

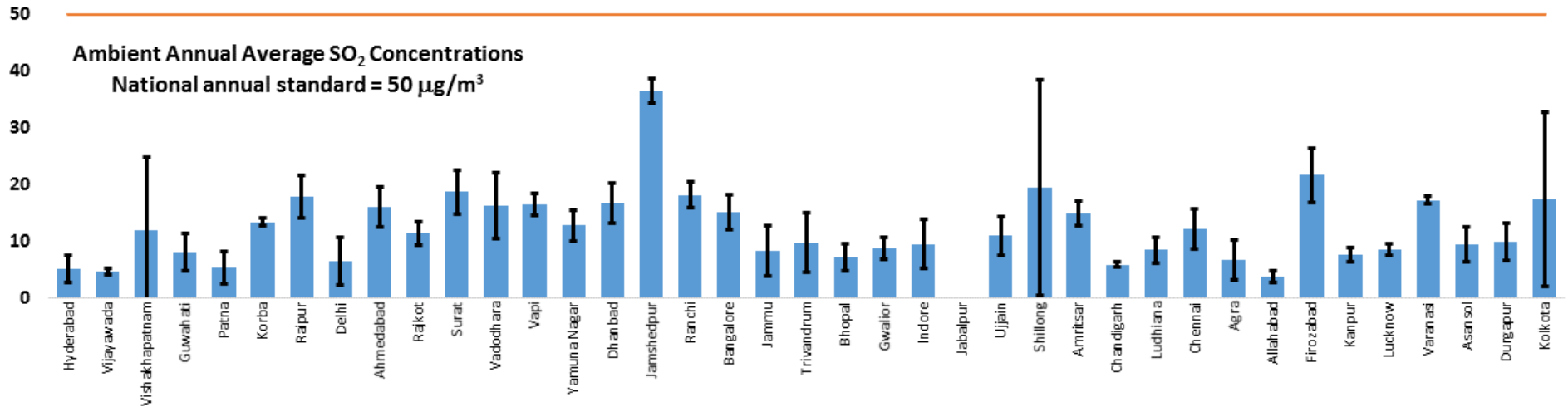
~100,000 from household pollution to outdoor



MoH Report, 2016

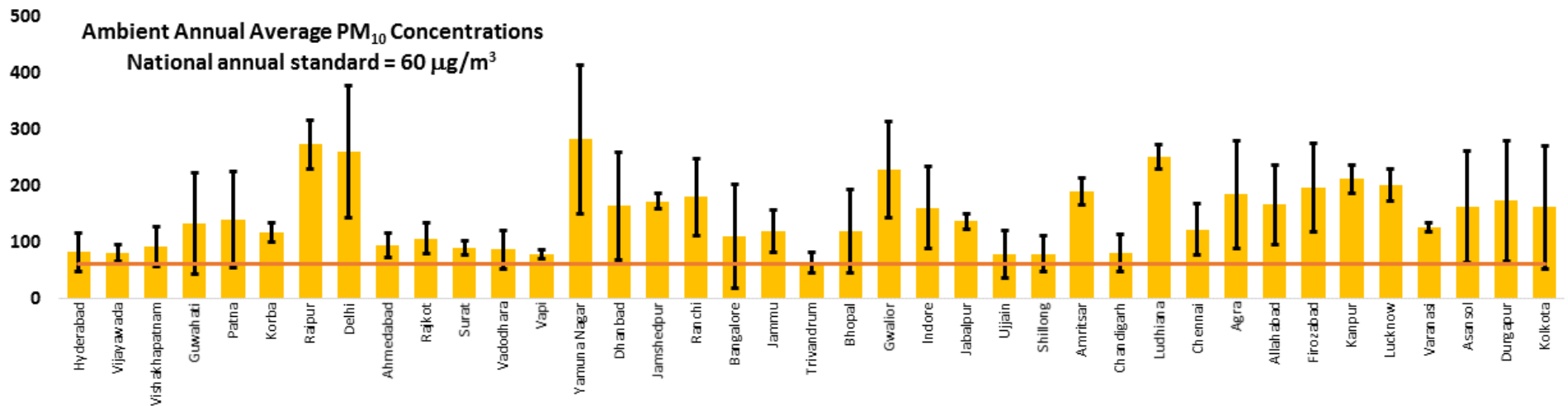


Data from the Manual Stations



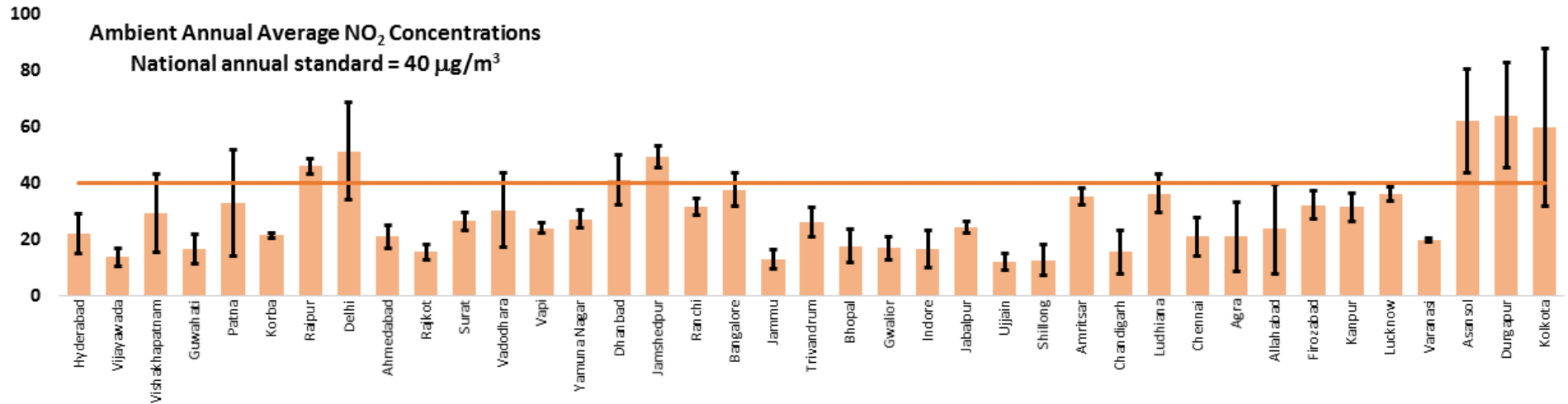
SO₂

Data from the Manual Stations



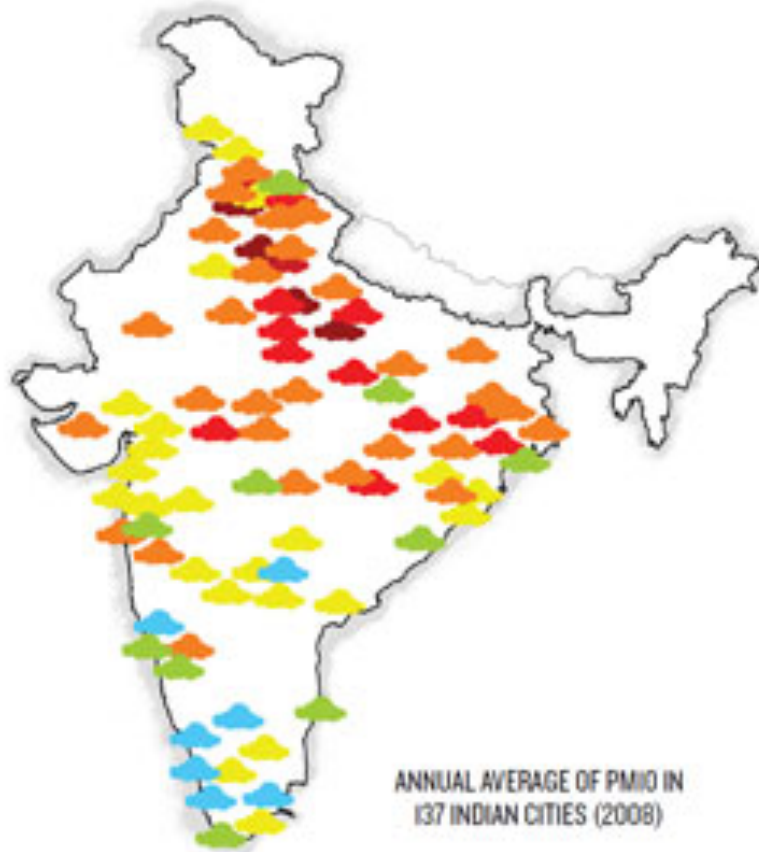
PM₁₀

Data from the Manual Stations



NO₂

Where is the data?



All manual stations

30-40% collection

Limited CAMS

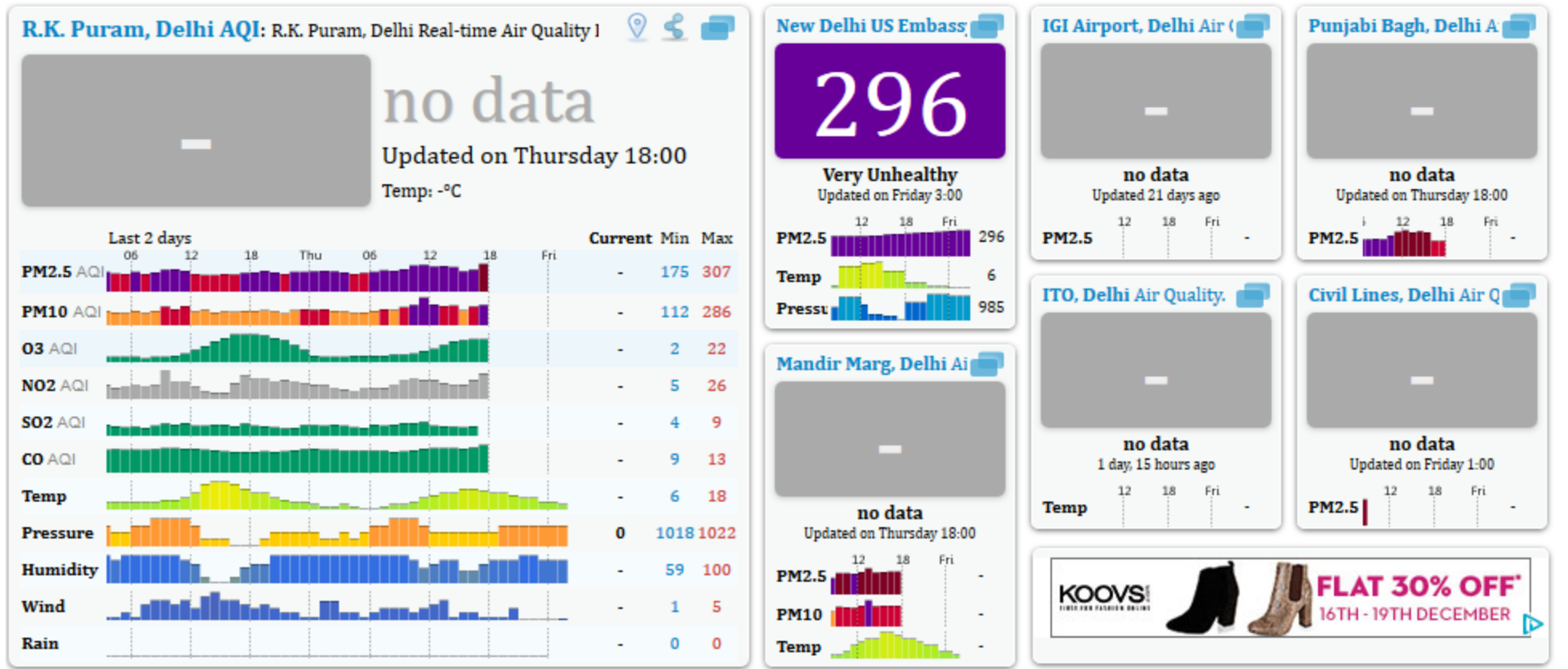
Limited PM_{2.5}

Limited access

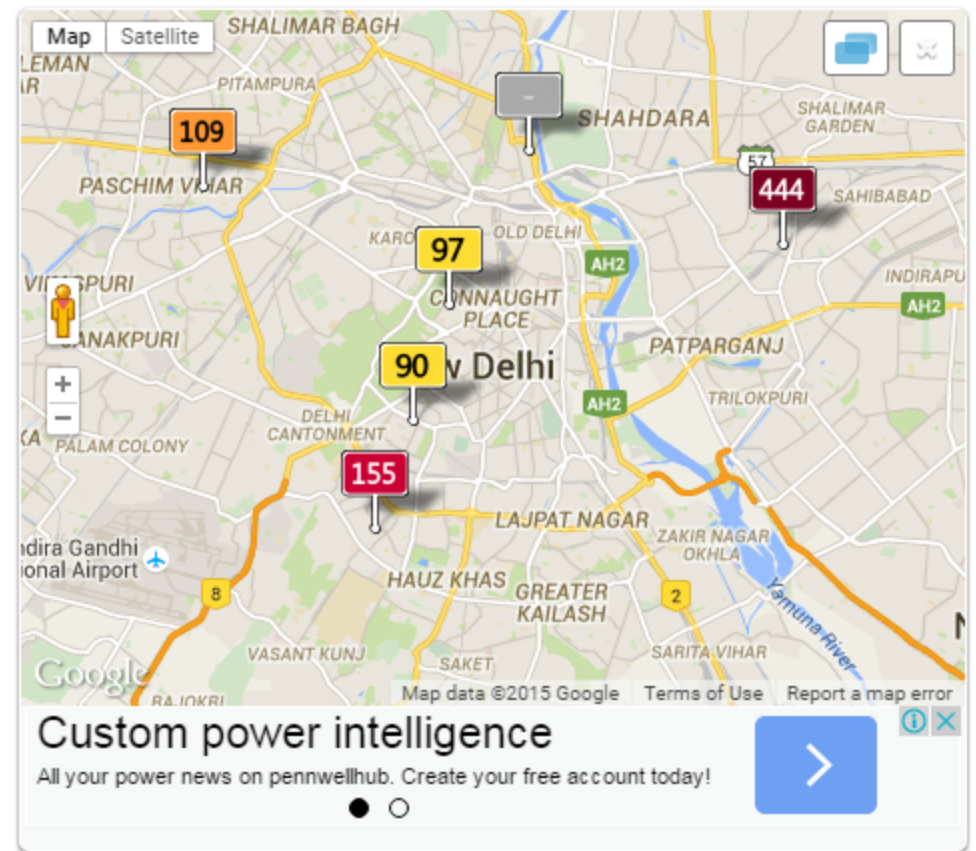
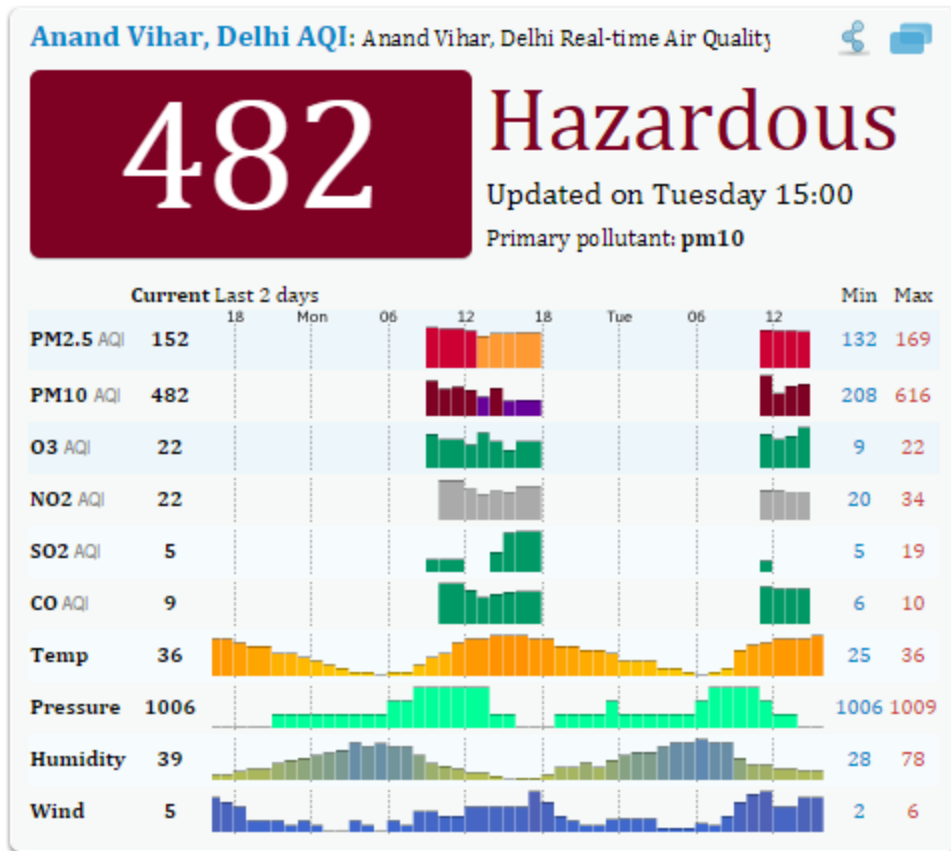
450

Stations under the national ambient monitoring program (NAMP)

Discontinuous Real-time Monitors



Discontinuous Real-time Monitors



Question

**Do we want discontinuous information for ten
pollutants**

Or

**Do we want continuous information for one critical
pollutant at ten locations**

ENVIRONMENT



POLLUTION CONTROL

What will it take to make our cities environment-smart?

PM Modi's vision of smart cities will remain unrealised till we have environmentally-smart urban centres, equipped to mitigate the severe chronic air pollution levels. But what will it entail? Sarath Guttikunda analyses.

India Together offers an excellent forum for people from diverse fields of expertise to present their views, share their experiences and raise questions about where our country and society are headed in the future.

I urge all democratic-minded

7500
crores

for up to 30 CAMS per city, in 50 cities, for 10 years of operations

500
crores

for up to 50 BAMS (PM2.5 only) per city, in 50 cities, for 10 years of operations

75
crores

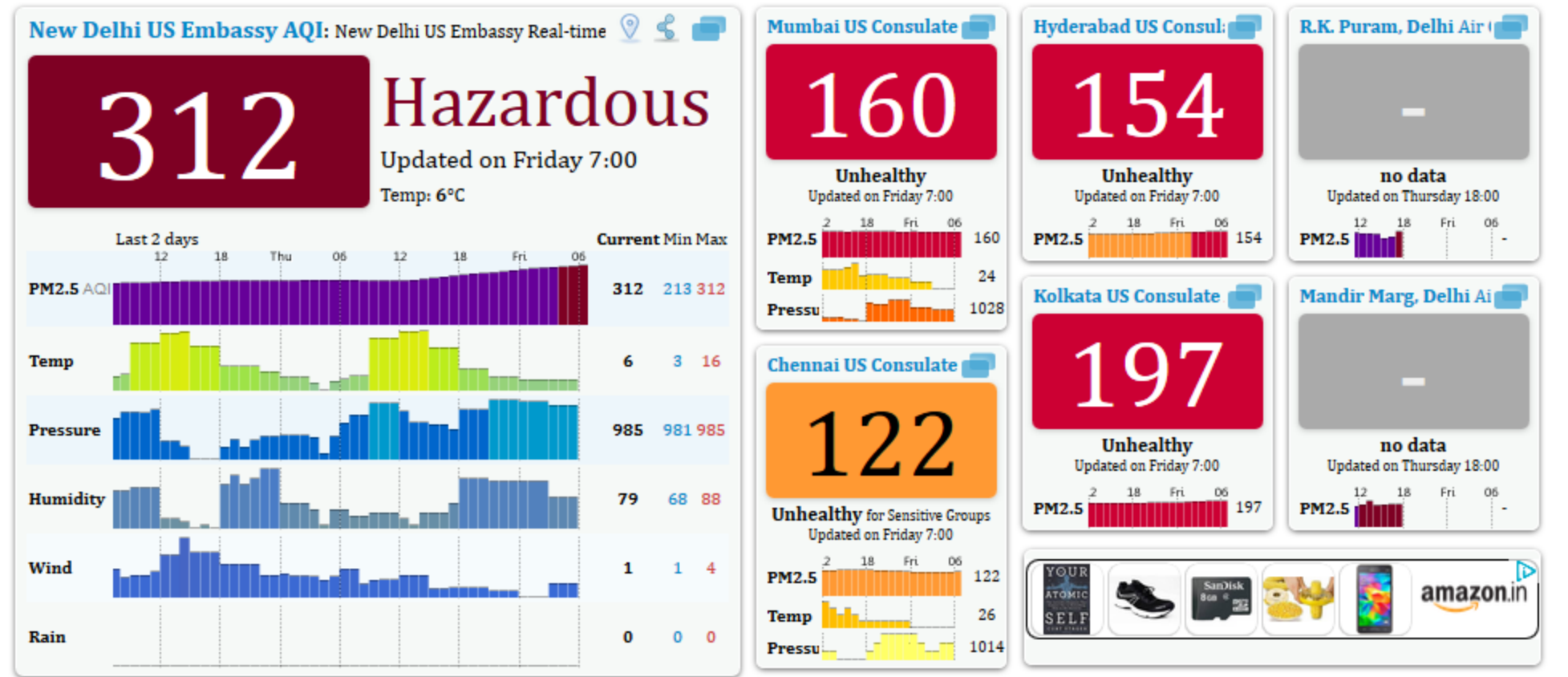
for up to 100 low cost PM2.5 monitors per city, in 50 cities, for 10 years of operations

Alternatives

- Handheld monitors like Dust-Traks for PM or BAMS
- Low-cost monitors



PM2.5 Real-time Monitors

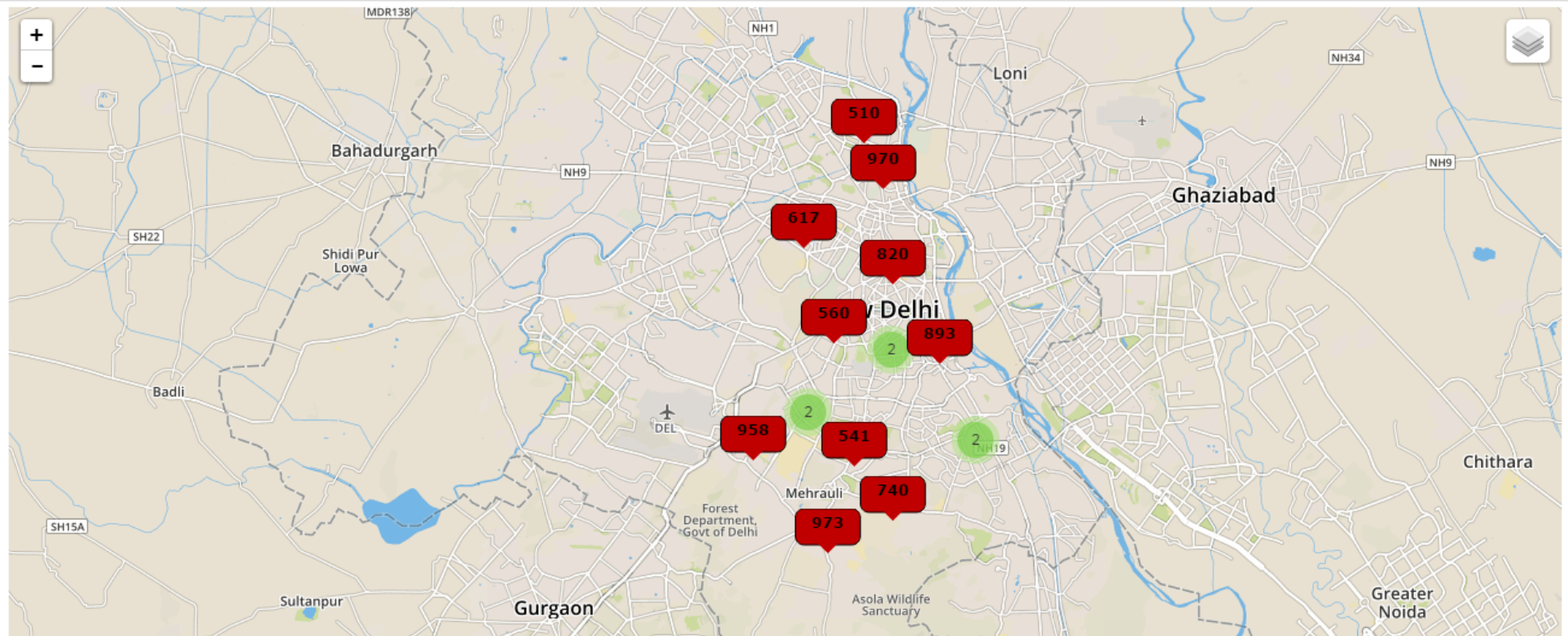


#Indiaspend



IndiaSpend #breathe

Click on a location to display its Air Quality Data



**surveys and modelling
to support urban environments**

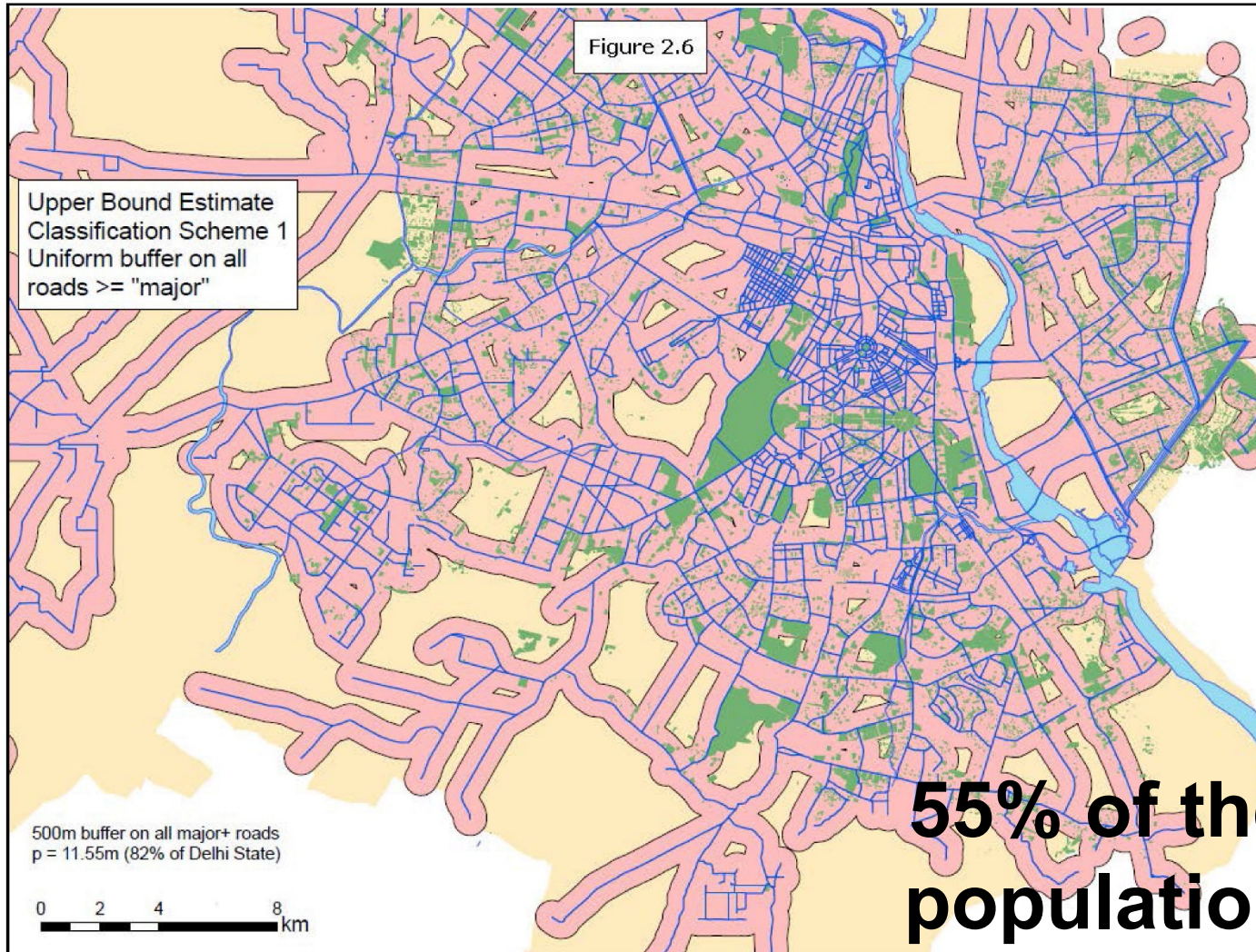
odd/even rule in Delhi....

Social awareness

Health awareness

What else?

Delhi On-road Exposures



**55% of the day time
population exposed
to air pollution (HEI)**

In-vehicle PM_{2.5} exposure

Bus Stops

Walk

Cycle

2-Wheelers

Auto Rickshaw

Car OW (Open-window)

Bus OW

Bus AC

Car AC

Metro Platform

Metro



PM2.5 Monitor

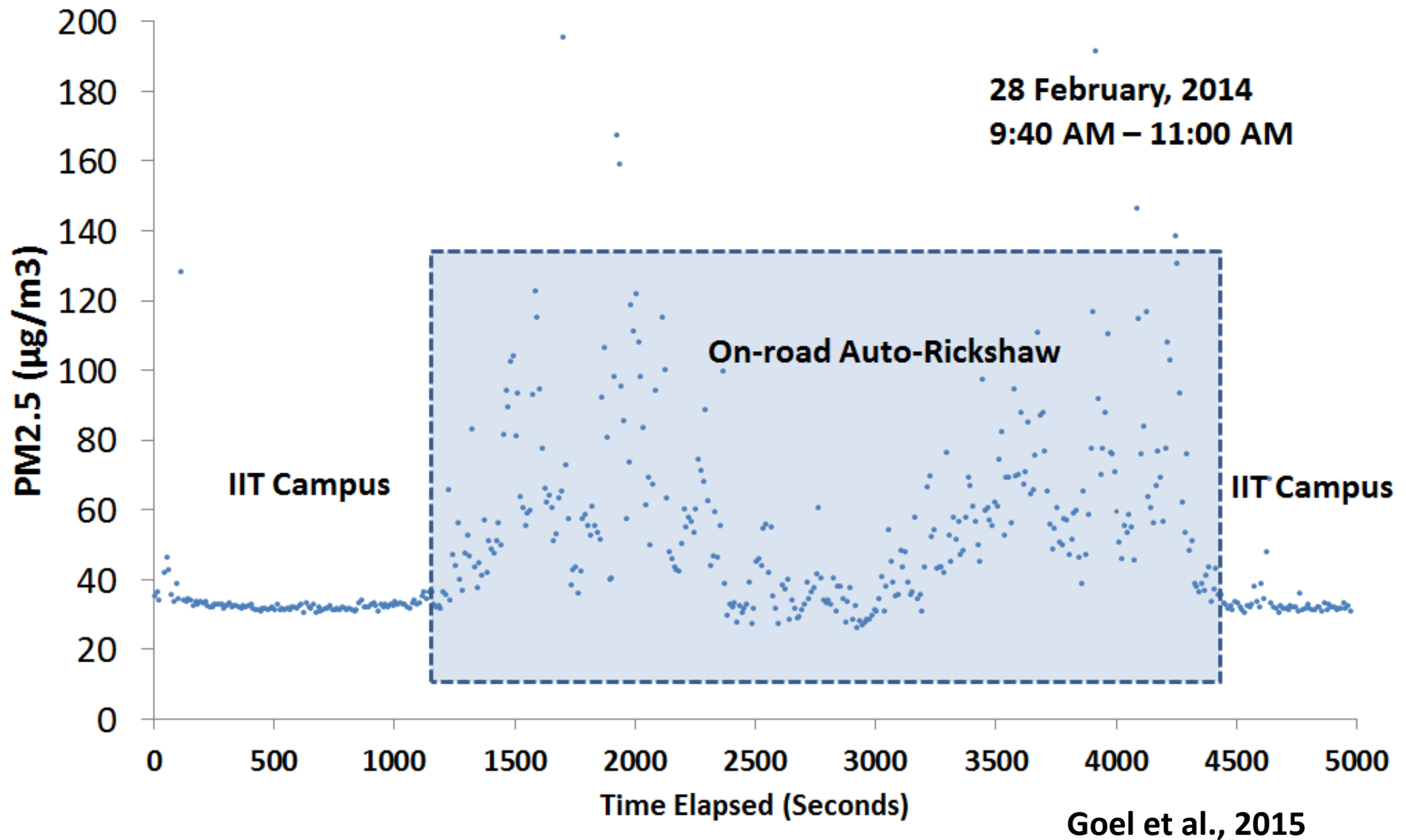


GPS

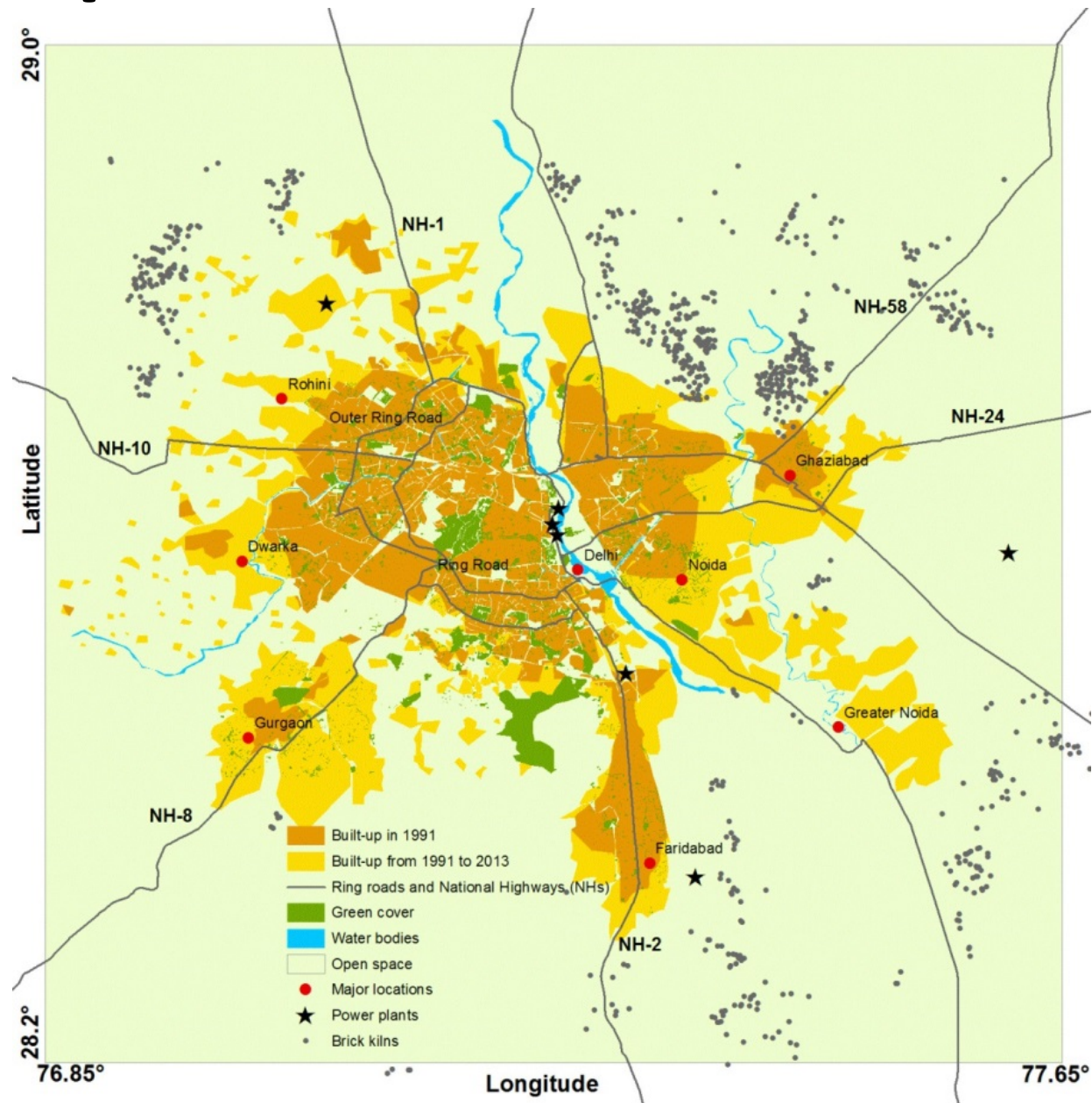


Relative
Humidity

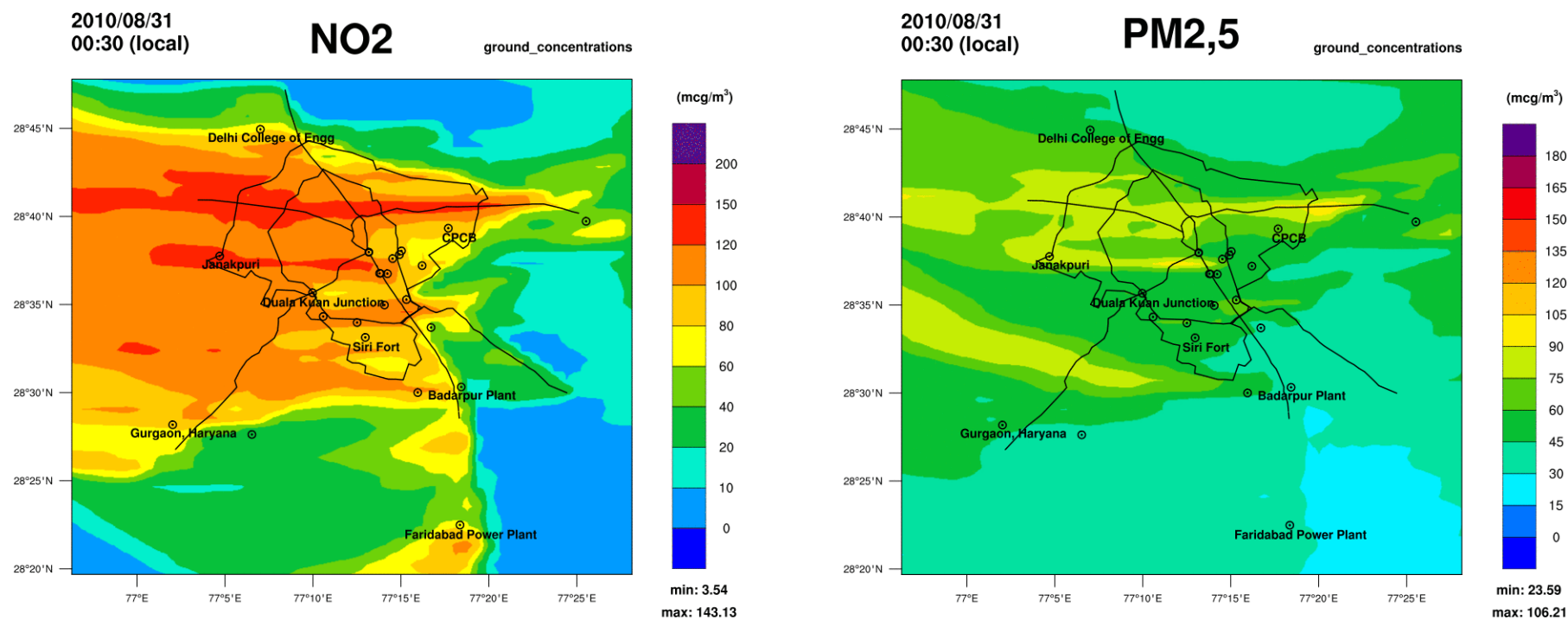
Sample Data Collection Run



Urban Sprawl between 1990 and 2013



Air Pollution Modeling in Delhi



Results from 3D Eulerian Chemical Transport Modeling
@ 1km grid resolution over a 80 x 80 km² domain

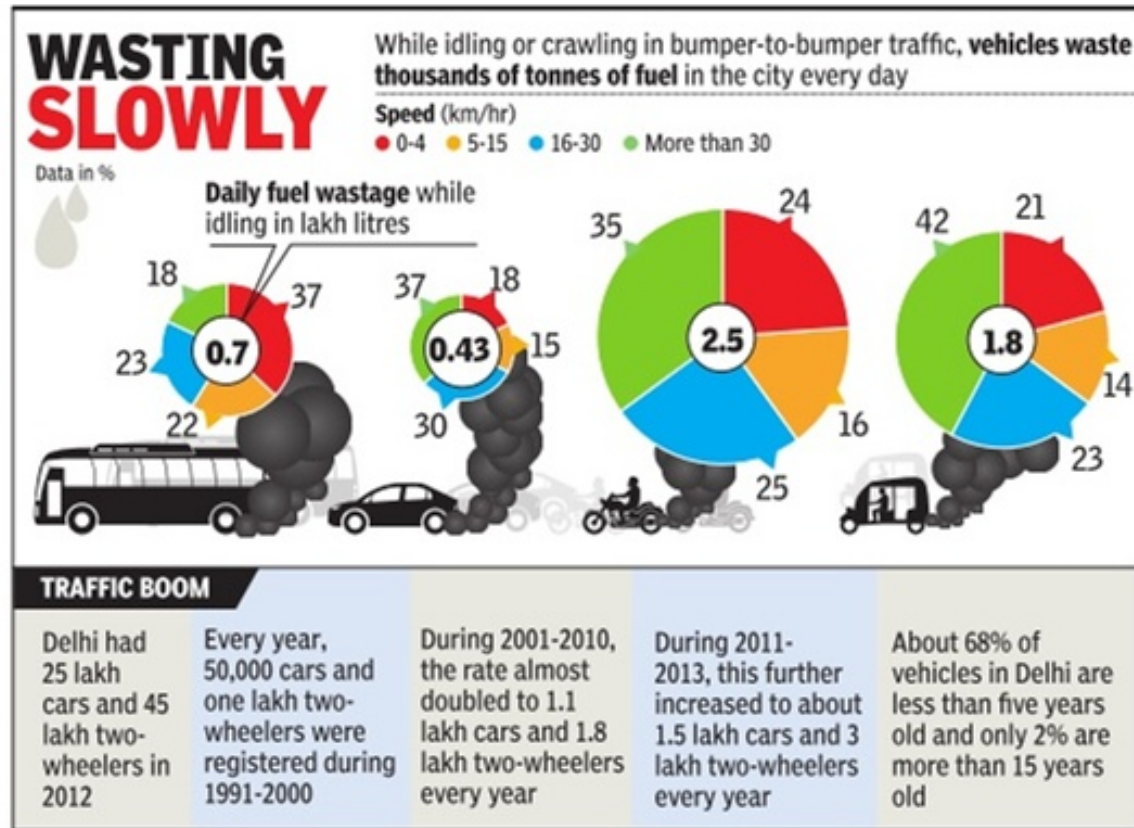
<http://delhiairquality.info>

On-road Idling Pollution

Ludhiana Delhi Vizag

20%

Driving time is spent
idling for passenger
cars



In Delhi, 20 min of idling for cars = Rs. 1 crores in fuel losses (~\$150,000) per day

Goel & Guttikunda, 2014

bengaluru transport information system

TRIPS ↓

TAXI / SHARED-CAR

BUSES ↓

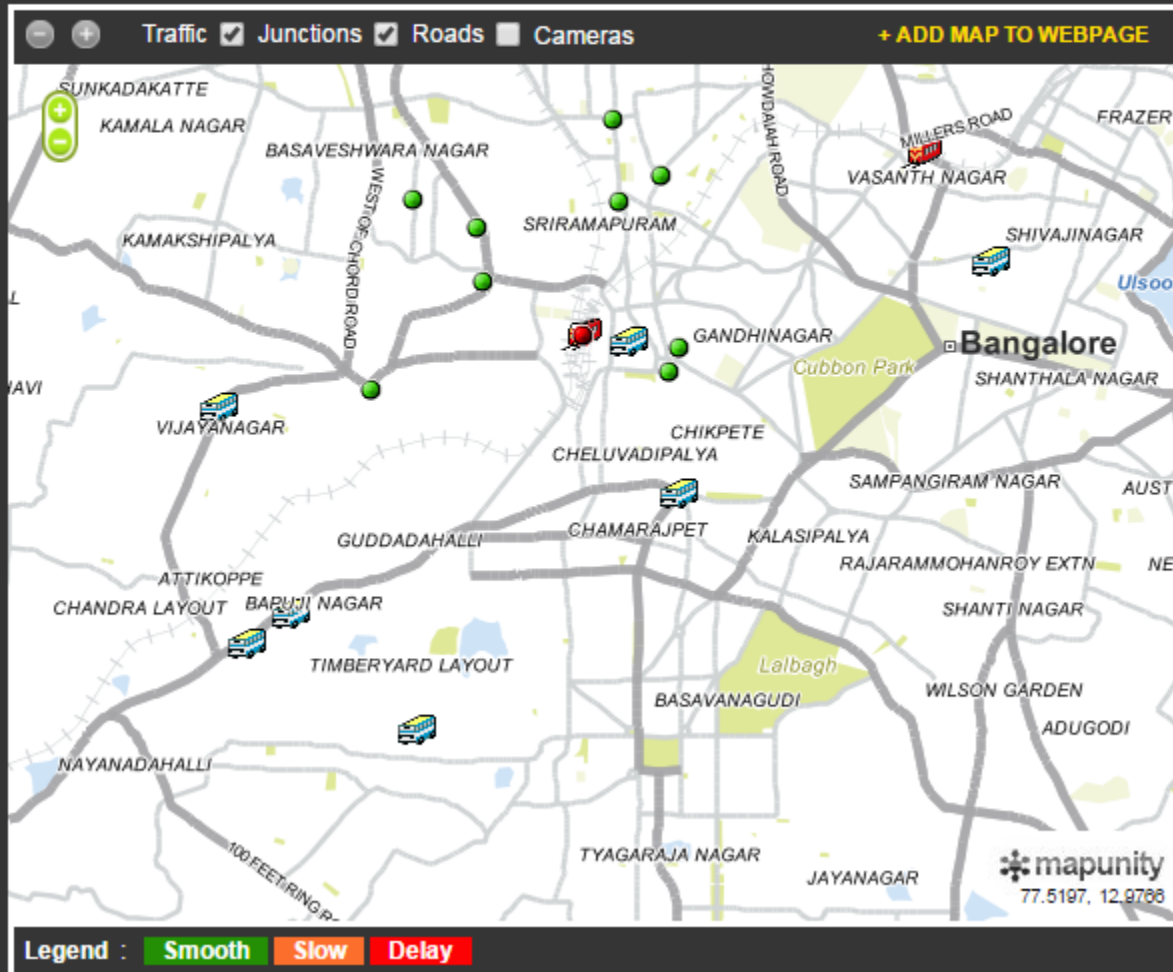
DRIVING ↓

OFFICES ↓

MOBILE ↓

SAFETY

MAPID



TRAFFIC

TRAFFIC DELAYS

LIVE CAMERAS

View all cameras

LIVE CAMERA

HISTORY

DENSITY



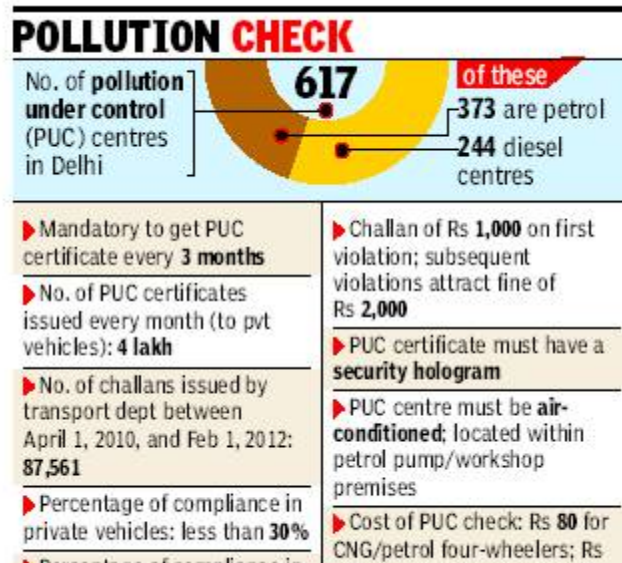
(Active: 0 / 160) [CHANGE LOCATION](#)

MAIN MENU

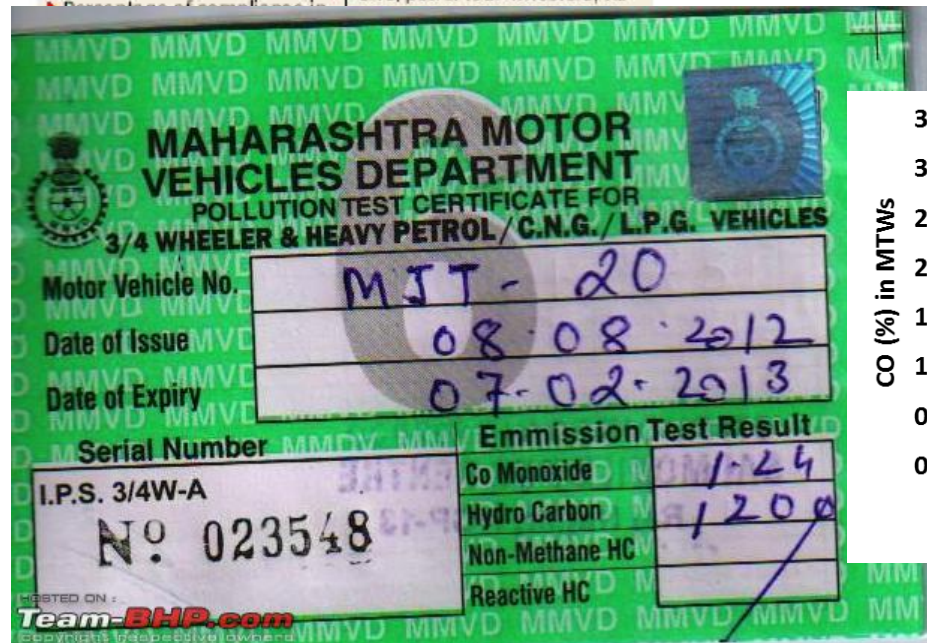
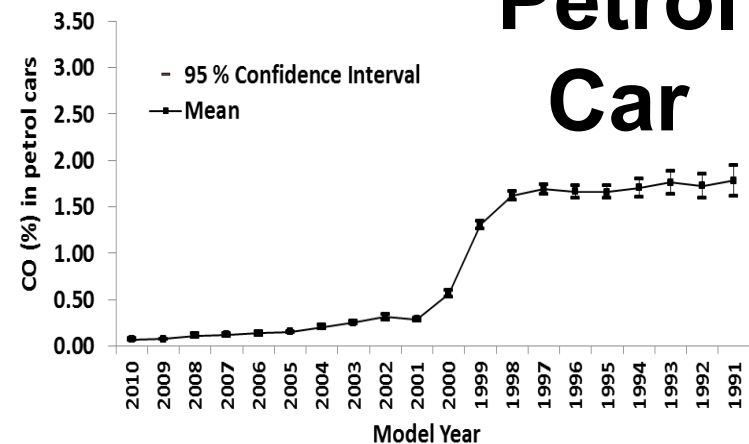
contact@mapunity.in

mapunity

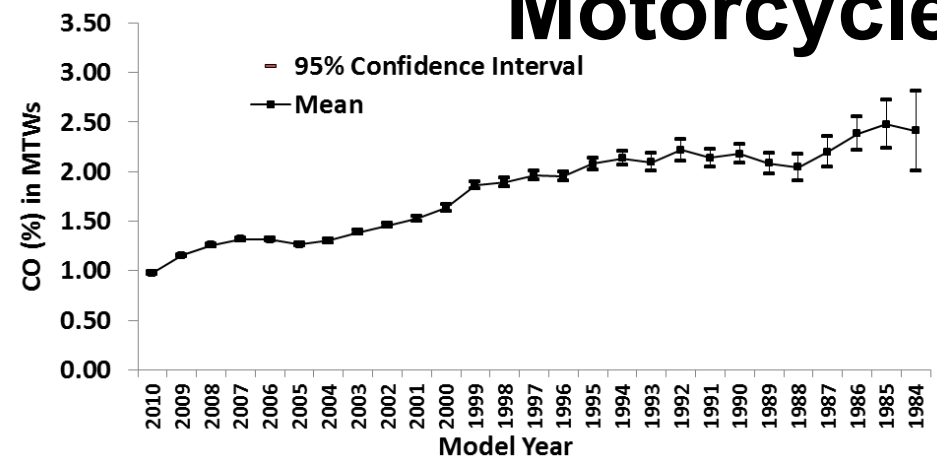
“Pollution Under Check” (PUC) Data Analysis




Petrol Car



Motorcycle



Fuel Station Surveys



Vehicular Fuel Efficiency Survey in Delhi
by
INDIAN INSTITUTE OF TECHNOLOGY
DELHI

Type of Vehicle: ☐ Car ☐ SUV ☐ Auto ☐ MC ☐ Other

Type of Fuel: ☐ Petrol ☐ Diesel ☐ CNG ☐ LPG

Make/Model/ Year _____

Mileage - Km/litre

Odometer Reading

Type of Vehicle: ☐ Car ☐ SUV ☐ Auto ☐ MC ☐ Other

Type of Fuel: ☐ Petrol ☐ Diesel ☐ CNG ☐ LPG

Make/Model/ Year _____

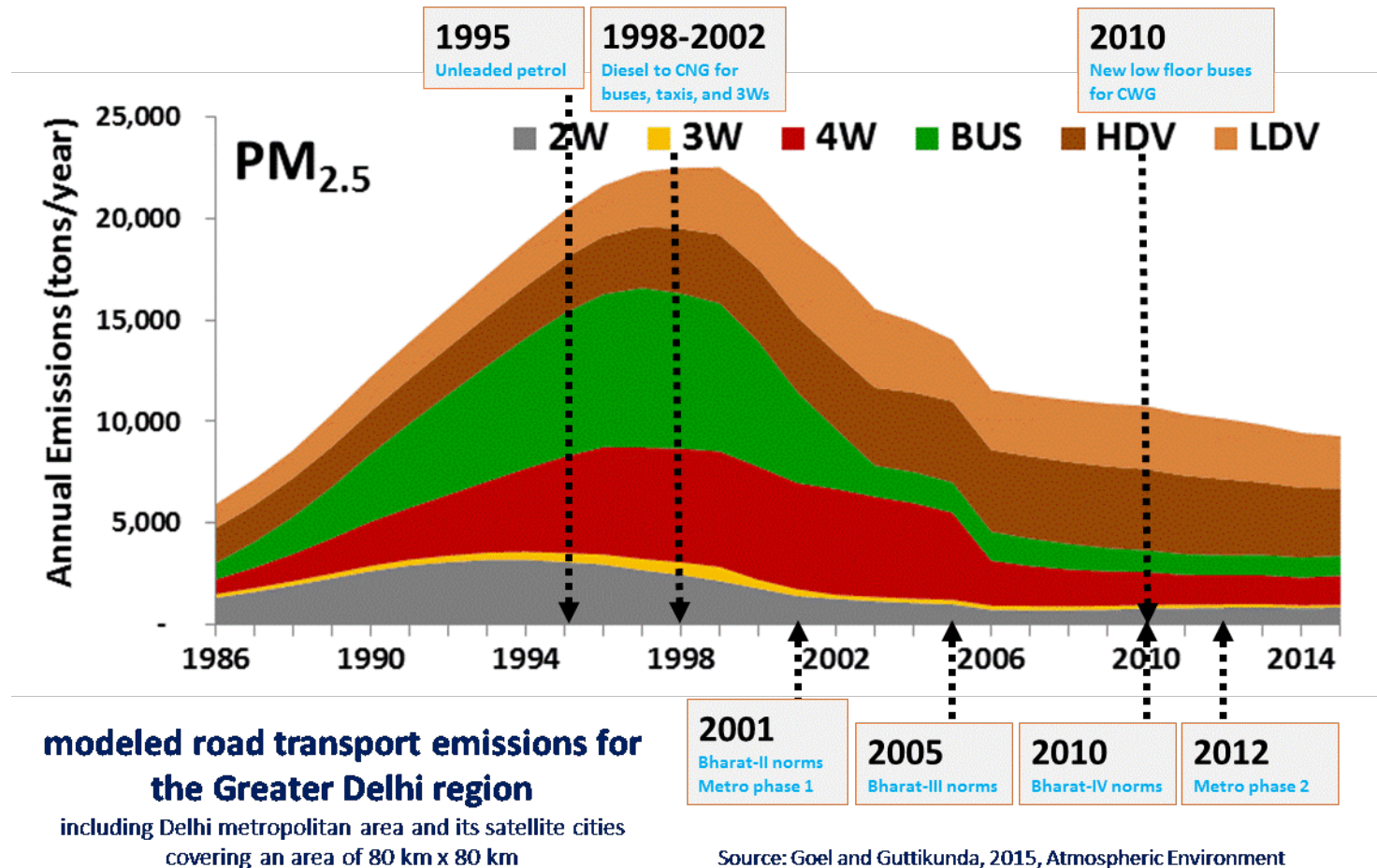
Mileage - Km/litre

Odometer Reading

**2-3 minutes
per response**

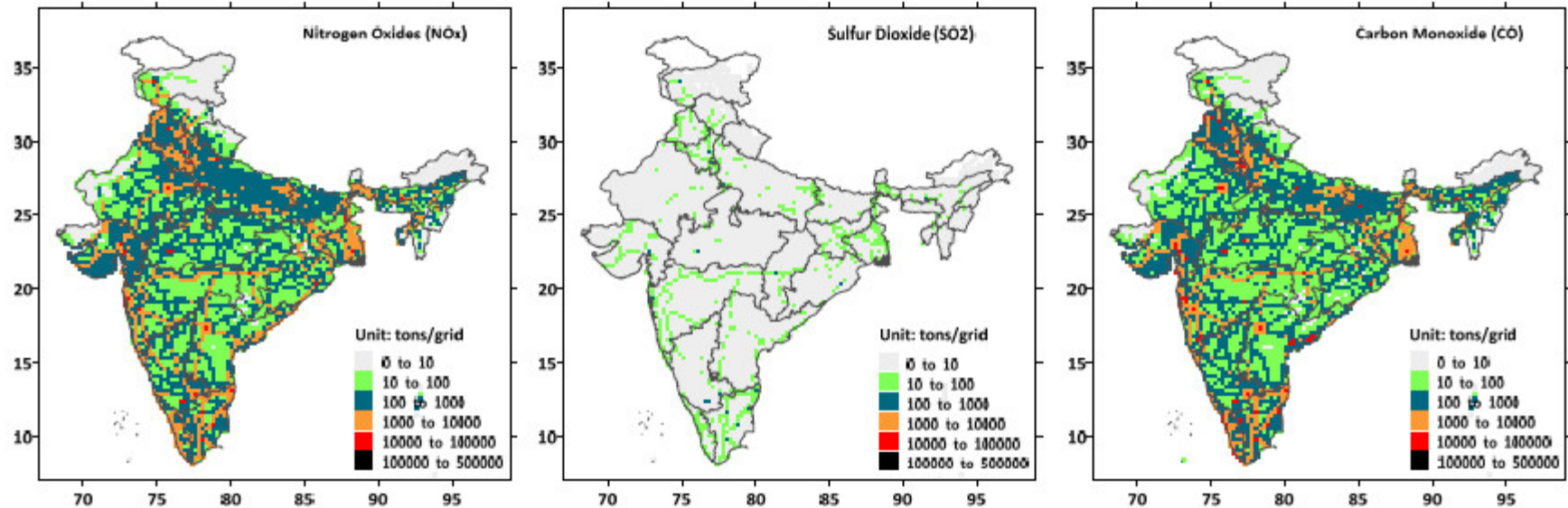
**age mix
vehicle usage by age
fuel efficiency**

Delhi On-road Emissions

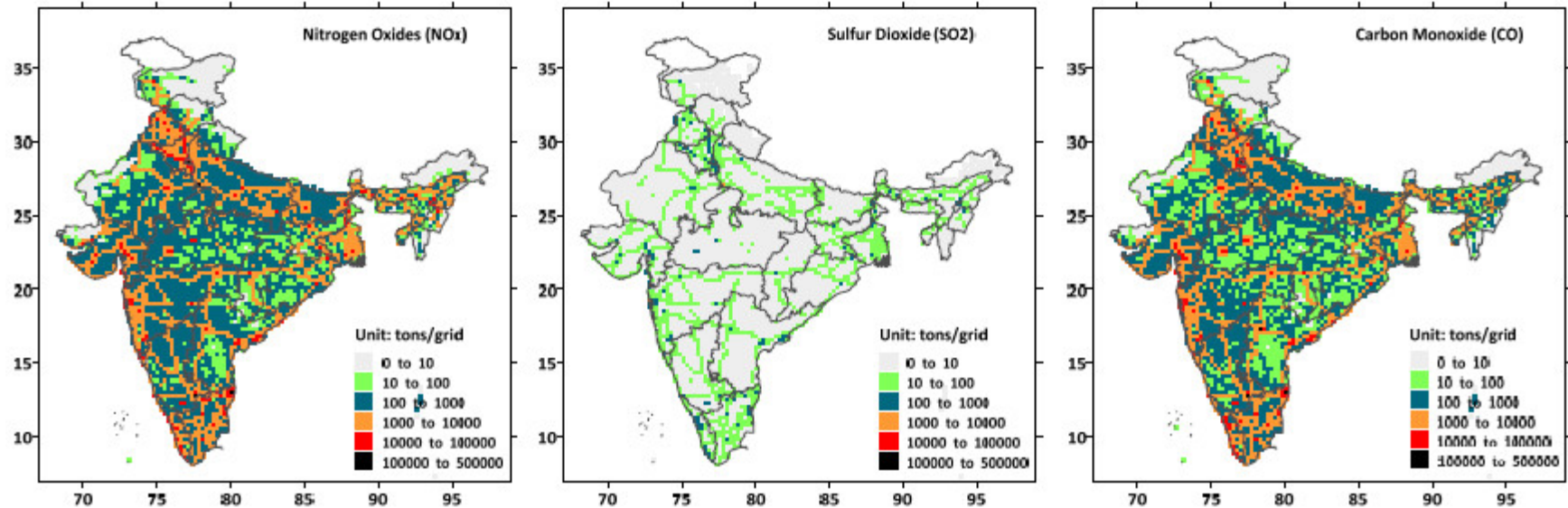


National Transport Emissions 2030

2012



2030



Planning Commissions NDTPC report; Guttikunda and Mohan, 2013

More @<http://www.urbanemissions.info>

information to policy support

Coal-fired thermal power plants

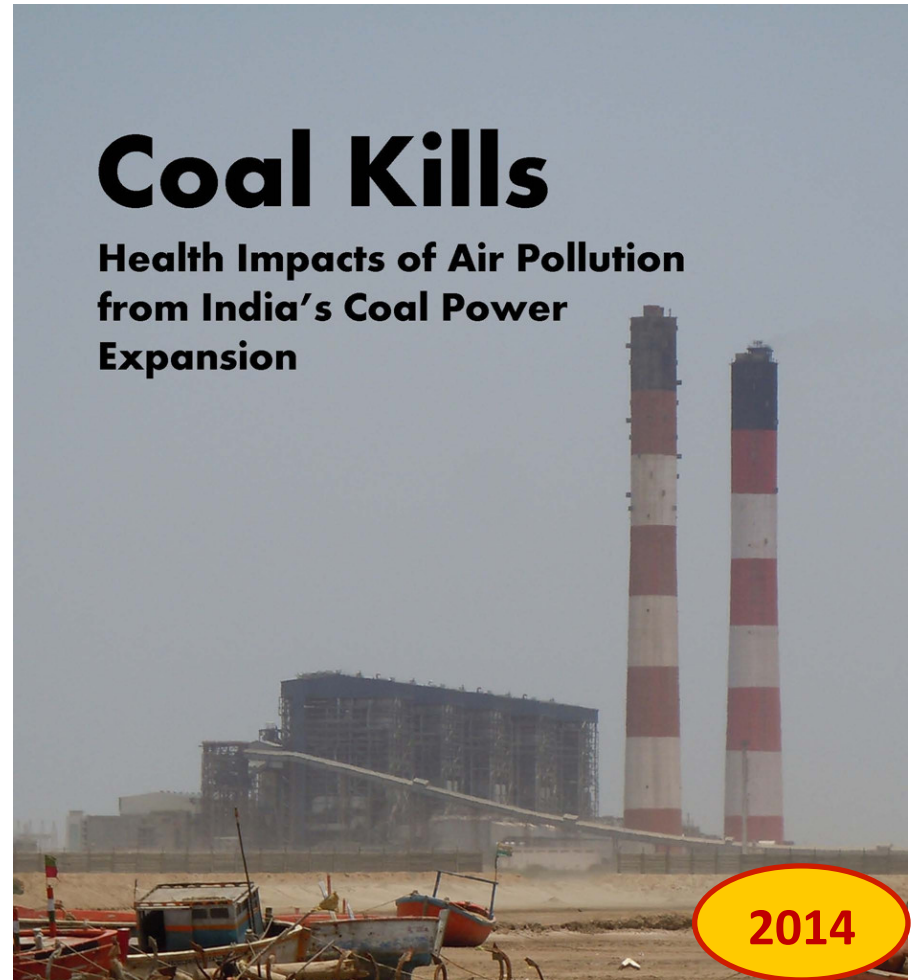
COAL KILLS

An Assessment of Death and Disease
caused by India's Dirtiest Energy Source



Coal Kills

Health Impacts of Air Pollution
from India's Coal Power
Expansion



Conservation
ACTION TRUST

Coal-fired thermal power plants

Country	PM	SO ₂	NO ₂	Mercury
India ^a	350mg/Nm ³ for <210MW 150mg/Nm ³ for >210MW	None	None	None
China ^b	30mg/Nm ³ (proposed all) 20mg/Nm ³ for key regions 50mg/Nm ³ for key regions	100mg/Nm ³ for new 200mg/Nm ³ for old	100mg/Nm ³	None
Australia ^c	100mg/Nm ³ for 1997-2005 50mg/Nm ³ after 2005 standards	None	800mg/Nm ³ for 1997-2005 500mg/Nm ³ after 2005	In discussion based on USA
European Union ^c	Pre-2003 100mg/Nm ³ for <500MW 50mg/Nm ³ for >500MW Post 2003 50mg/Nm ³ for <100MW 30mg/Nm ³ for >100MW	Pre-2003 Scaled for <500MW 400mg/Nm ³ for >500MW Post 2003 850mg/Nm ³ for <100MW 200mg/Nm ³ for >100MW	Pre-2003 600mg/Nm ³ for <500MW 500mg/Nm ³ for >500MW Post 2003 400mg/Nm ³ for <100MW 200mg/Nm ³ for >100MW	In discussion
USA ^{c,d}	37 mg/Nm ³ for old 6 mg/Nm ³ for new	245 mg/Nm ³ for old 50 mg/Nm ³ for new	61 mg/Nm ³ for old 42 mg/Nm ³ for new	

Coal-fired thermal power plants

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Australia ^c	Pre-1997-2005 2005	None	800mg/Nm ³ for <500MW 500mg/Nm ³ for >500MW	In discussion based on
European Union ^c	Pre-2003 100mg/Nm ³ for <500MW 50mg/Nm ³ for >500MW Post 2003 50mg/Nm ³ for <100MW 30mg/Nm ³ for >100MW	Pre-2003 Scaled for <500MW 400mg/Nm ³ for >500MW Post 2003 850mg/Nm ³ for <100MW 200mg/Nm ³ for >100MW	Pre-2003 600mg/Nm ³ for <500MW 500mg/Nm ³ for >500MW Post 2003 400mg/Nm ³ for <100MW 200mg/Nm ³ for >100MW	In discussion
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Draft standards proposed in April, 2015
Amended in December, 2015

open and untapped information

Household Energy Consumption, Emissions, Pollution, and Health Impacts in India

STATE **Andhra Pradesh**

(state and district as of census-India, 2011)

DISTRICT **Hyderabad**

%Households Primary Cooking Fuel

gas+elec

67.6%

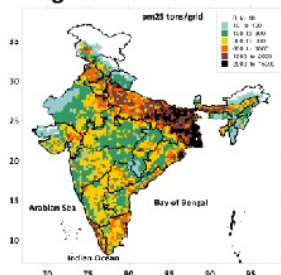
others

32.4%

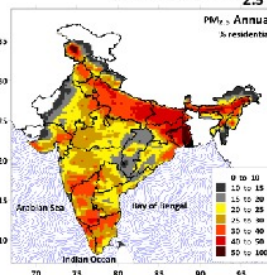
Estimated district annual HEC emissions

Particulates (2.5 μ m)	700 tons
Sulfur dioxide	110 tons
Nitrogen oxides	35 tons
Carbon monoxide	8,600 tons
Hydrocarbons	2,340 tons
Black carbon (BC)	160 tons
Organic carbon	300 tons
Carbon dioxide (CO ₂)	0.30 mil tons

Estimated PM_{2.5} emissions @ 0.25 degree resolution

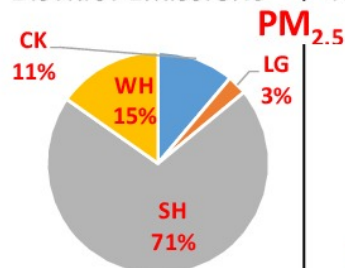


Modeled share of HEC emissions to ambient PM_{2.5}

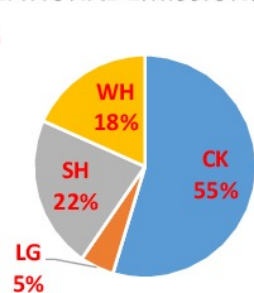


Household energy consumption (HEC) emissions were calculated in four classes - cooking (CK), lighting (LG), space heating (SH), and water heating (WH). Bottom-up emissions for the four classes are available @ 0.25 degree spatial resolution, and further aggregated to district and state level. A sub-classification is available by fuel - biomass, coal, kerosene, liquified petroleum gas (LPG), and others.

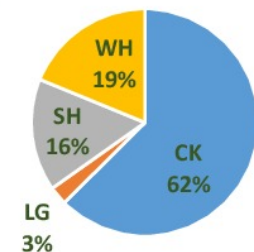
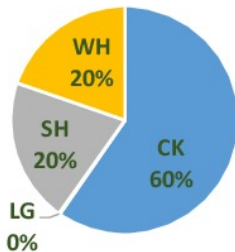
DISTRICT EMISSIONS



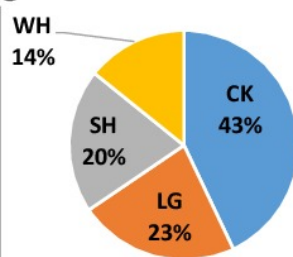
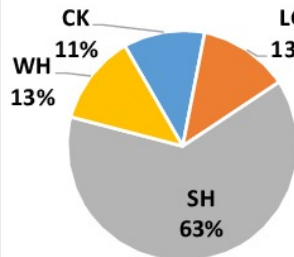
NATIONAL EMISSIONS



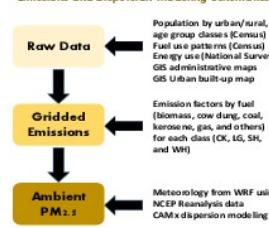
CO₂



BC



Emissions and Dispersion Modeling Schematics



% contribution of HEC emissions to modeled ambient PM_{2.5} concentrations

(concentrations were conducted using the WRF-CAMx models)

National	29.6%
District	29.0%

The health impacts of outdoor air pollution as ischemic heart diseases (which can lead to heart attacks), cerebrovascular disease (which can lead to strokes), chronic obstructive pulmonary diseases, lower respiratory infections, and cancers (in trachea, lungs, and bronchitis) were estimated using the age-dependent relative risk functions detailed in the Global Burden of Disease study (2013) and dispersion modeling results from this study. The final calculations were conducted at the district level using the population distribution by age presented in

Estimated premature mortality of outdoor air pollution per year - apportioned to HEC emissions

National	59,000 - 72,000
District	168 - 198

Emission and dispersion modeling results, pollution animations, and summary sheets by district and state are hosted @ <http://www.urbanemissions.info>
Send your comments and questions to sim-air@urbanemissions.info

Household Energy Consumption, Emissions, Pollution, and Health Impacts in India

STATE	NCT of Delhi
	(state and district as of census-India, 2011)
DISTRICT	New_Delhi

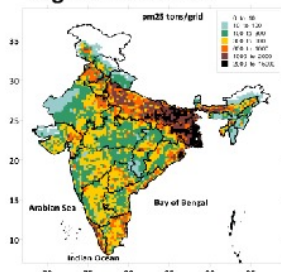
%Households Primary Cooking Fuel

gas+elec	others
78.8%	21.2%

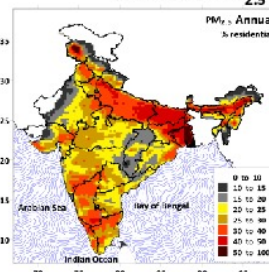
Estimated district annual HEC emissions

Particulates (2.5µm)	500 tons
Sulfur dioxide	80 tons
Nitrogen oxides	20 tons
Carbon monoxide	6,400 tons
Hydrocarbons	1,560 tons
Black carbon (BC)	100 tons
Organic carbon	220 tons
Carbon dioxide (CO ₂)	0.19 mil tons

Estimated PM_{2.5} emissions @ 0.25 degree resolution

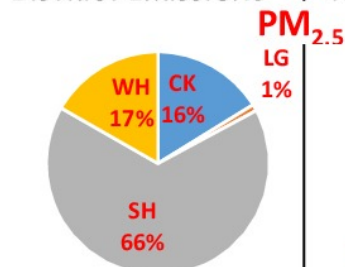


Modeled share of HEC emissions to ambient PM_{2.5}

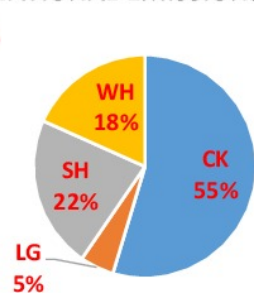


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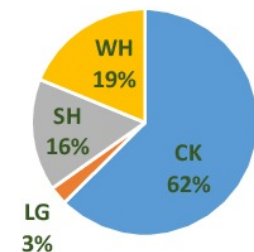
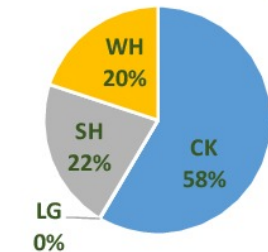
DISTRICT EMISSIONS



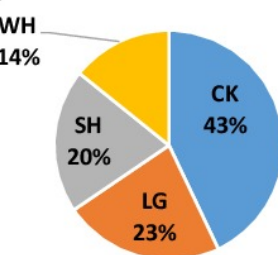
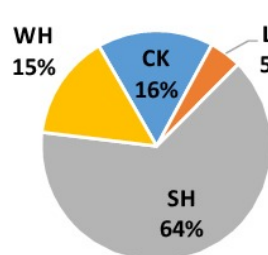
NATIONAL EMISSIONS



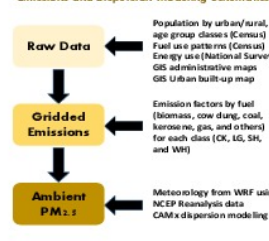
CO₂



BC



Emissions and Dispersion Modeling Schematics



% contribution of HEC emissions to modeled ambient PM_{2.5} concentrations

(concentrations were conducted using the WRF-CAMx models)

National	29.6%
District	32.7%

The health impacts of outdoor air pollution as ischemic heart diseases (which can lead to heart attacks), cerebrovascular disease (which can lead to strokes), chronic obstructive pulmonary diseases, lower respiratory infections, and cancers (in trachea, lungs, and bronchitis) were estimated using the age-dependent relative risk functions detailed in the Global Burden of Disease study (2013) and dispersion modeling results from this study. The final calculations were conducted at the district level using the population distribution by age presented in

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STATE **Uttar Pradesh**

(state and district as of census-India, 2011)

DISTRICT **Lucknow**

%Households Primary Cooking Fuel

gas+elec

57.6%

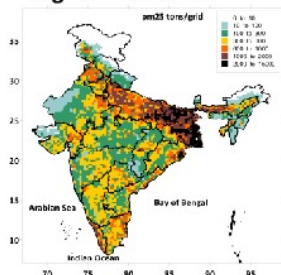
others

42.4%

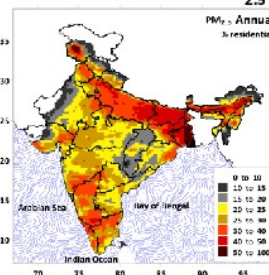
Estimated district annual HEC emissions

Particulates (2.5µm)	5,560 tons
Sulfur dioxide	620 tons
Nitrogen oxides	155 tons
Carbon monoxide	76,200 tons
Hydrocarbons	12,020 tons
Black carbon (BC)	1,220 tons
Organic carbon	2,200 tons
Carbon dioxide (CO ₂)	0.56 mil tons

Estimated PM_{2.5} emissions @ 0.25 degree resolution

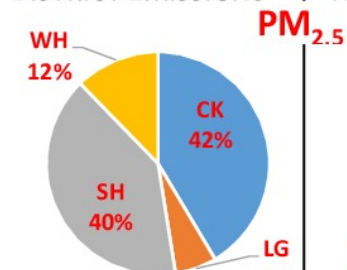


Modeled share of HEC emissions to ambient PM_{2.5}

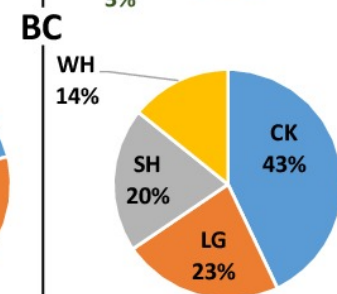
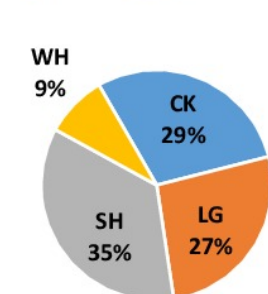
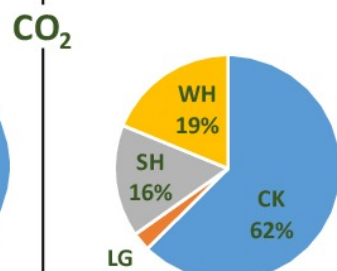
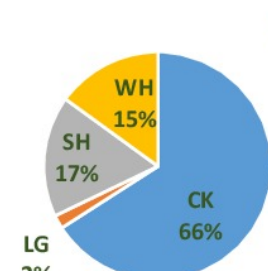
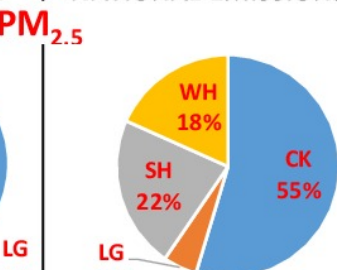


Household energy consumption (HEC) emissions were calculated in four classes - cooking (CK), lighting (LG), space heating (SH), and water heating (WH). Bottom-up emissions for the four classes are available @ 0.25 degree spatial resolution, and further aggregated to district and state level. A sub-classification is available by fuel - biomass, coal, kerosene, liquified petroleum gas (LPG), and others.

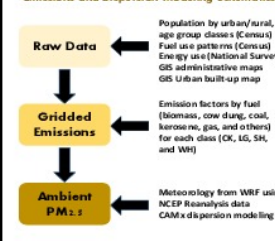
DISTRICT EMISSIONS



NATIONAL EMISSIONS



Emissions and Dispersion Modeling Schematics



% contribution of HEC emissions to modeled ambient PM_{2.5} concentrations

(concentrations were conducted using the WRF-CAMx models)

National	29.6%
District	36.8%

The health impacts of outdoor air pollution as ischemic heart diseases (which can lead to heart attacks), cerebrovascular disease (which can lead to strokes), chronic obstructive pulmonary diseases, lower respiratory infections, and cancers (in trachea, lungs, and bronchitis) were estimated using the age-dependent relative risk functions detailed in the Global Burden of Disease study (2013) and dispersion modeling results from this study. The final calculations were conducted at the district level using the population distribution by age presented in

Estimated premature mortality of outdoor air pollution per year - apportioned to HEC emissions

National	59,000 - 72,000
District	274 - 343

Emission and dispersion modeling results, pollution animations, and summary sheets by district and state are hosted @ <http://www.urbanemissions.info>
Send your comments and questions to sim-air@urbanemissions.info

Household Energy Consumption, Emissions, Pollution, and Health Impacts in India

STATE	Chhattisgarh
(state and district as of census-India, 2011)	
DISTRICT	Korba

%Households Primary Cooking Fuel

gas+elec

16.6%

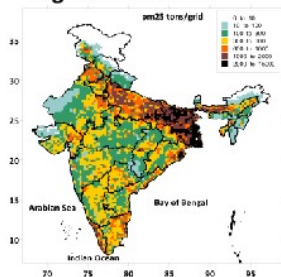
others

83.4%

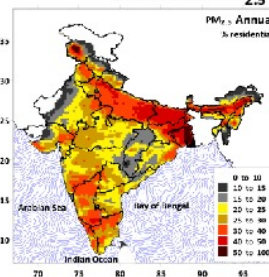
Estimated district annual HEC emissions

Particulates (2.5µm)	4,700 tons
Sulfur dioxide	910 tons
Nitrogen oxides	60 tons
Carbon monoxide	84,900 tons
Hydrocarbons	7,460 tons
Black carbon (BC)	1,170 tons
Organic carbon	1,940 tons
Carbon dioxide (CO ₂)	0.34 mil tons

Estimated PM_{2.5} emissions @ 0.25 degree resolution

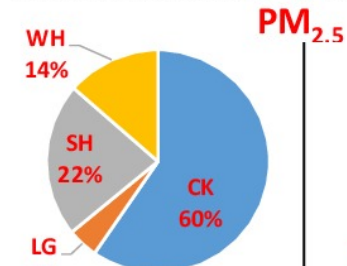


Modeled share of HEC emissions to ambient PM_{2.5}

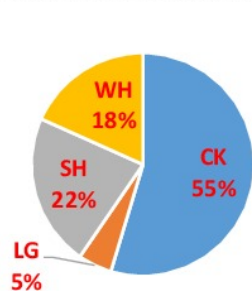


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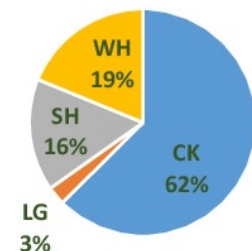
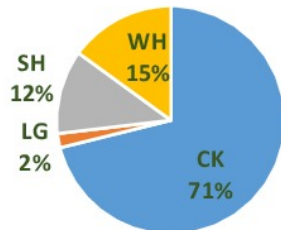
DISTRICT EMISSIONS



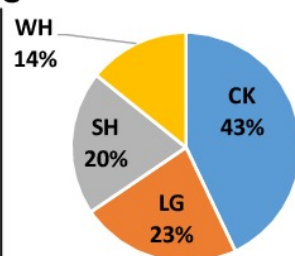
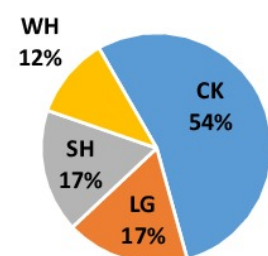
NATIONAL EMISSIONS



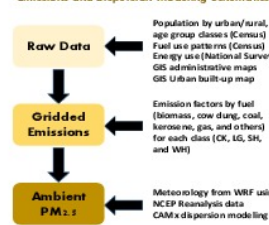
CO₂



BC



Emissions and Dispersion Modeling Schematics



% contribution of HEC emissions to modeled ambient PM_{2.5} concentrations

(concentrations were conducted using the WRF-CAMx models)

National	29.6%
District	16.2%

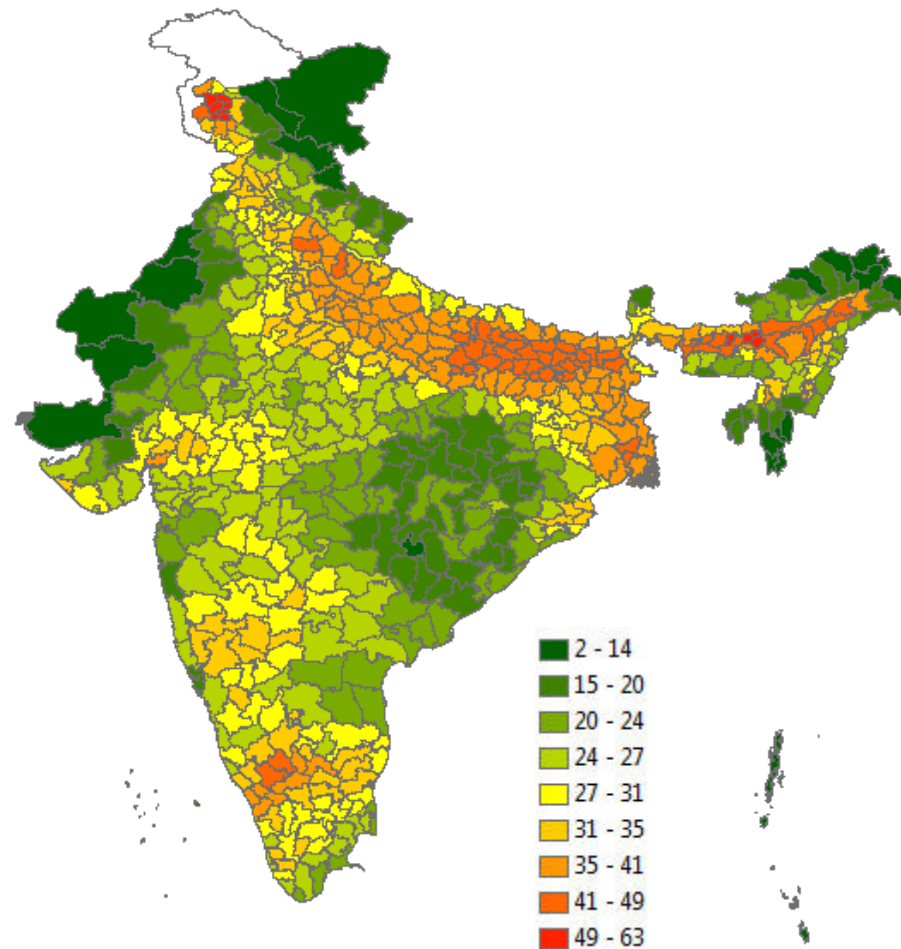
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Estimated premature mortality of outdoor air pollution per year - apportioned to HEC emissions

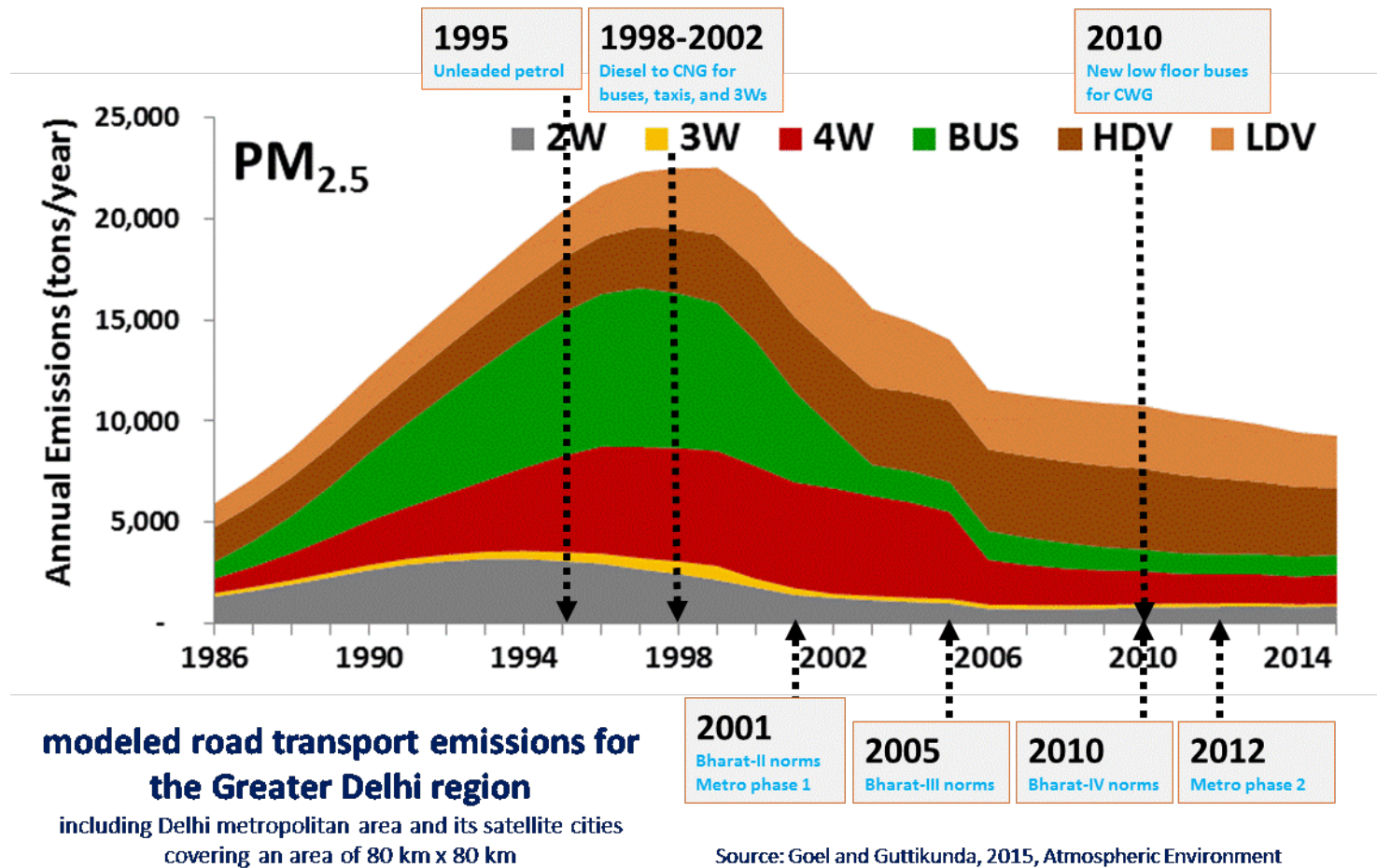
National	59,000 - 72,000
District	28 - 31

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Share of HH fuel consumption to outdoor PM2.5 pollution



improving economic measures



Pollution tax for diesel vehicles
Or
DPF's for diesel vehicles

People cover their
unwillingness to act under the
guise of unending inquiry - we
can't do anything because, we
don't yet know everything

Jon Stewart, The Daily Show (final episode, 2015)



Thank
you

More @

URBANEMISSIONS.info