Simple Interactive Model (SIM-air)

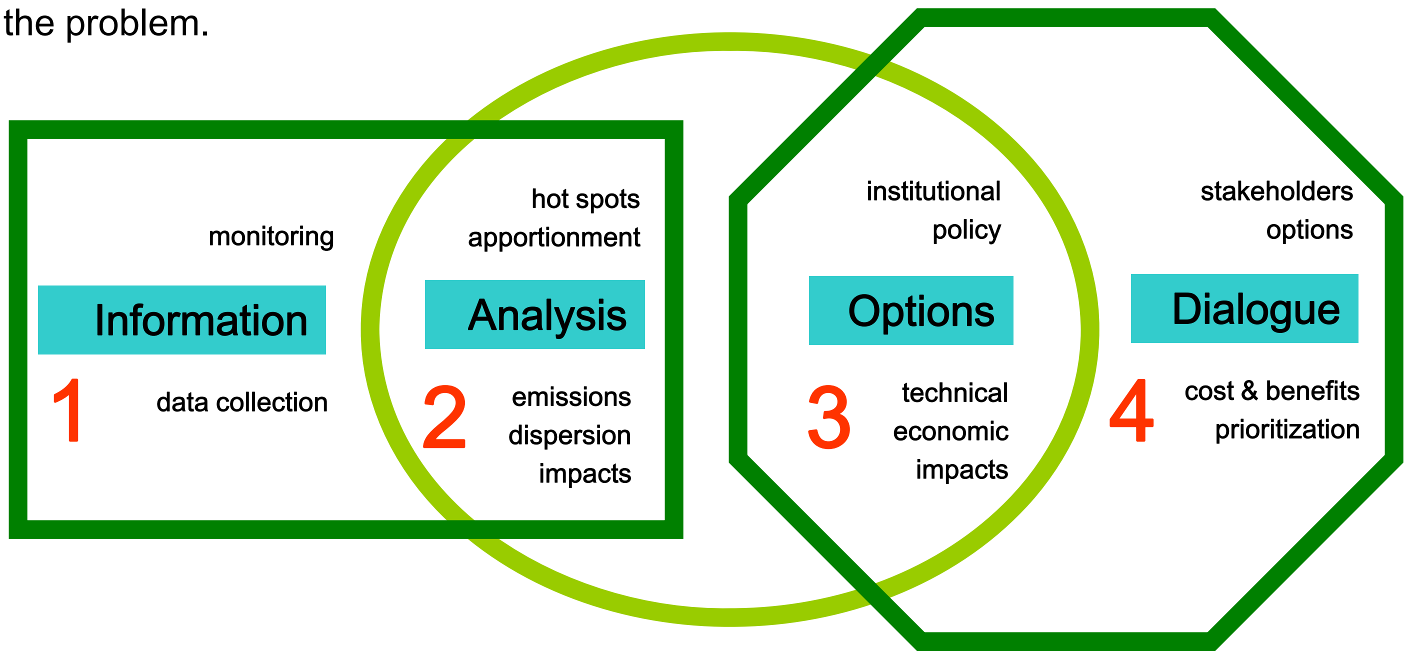
For Better Air Quality

Making informed Air Quality Management Decisions

Urban air pollution is an increasing problem not just in megacities but also in secondary cities, Key stakeholders involved in managing the vision for effective AQM lack the tools and knowledge base to implement an analytical approach to define and solve the problem.

SIM-air Analytical tool:

- simplifies analysis/implementation. SIMPLER
- analyses over 100 parameters. EXTENSIVE
- extremely affordable. The tools are FREE
- delivers credible and usable results. FAST



An Integrated Analytical Approach

SIM-air is a simple user-friendly tool in MS Excel that enables stakeholders to apply an integrated analytical approach to AQM with data that is easily accessible and provides a framework to develop a systematic knowledge base.

The main objective of SIM-air is to **use the best available information to arrive at estimates of key parameters** (e.g. emissions from various sources) and simulate the interactions between emissions, dispersion, impacts, and management options in an environmental and economic context.

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Location: New Delhi, India

Simple Interactive Model (SIM-air)

For Better Air Quality

Working Paper Titles

01. Creating GIS Road Maps for Urban Centers
02. Four Simple Equations for Vehicular Emissions Inventory
03. Informed Decision Support for AQM in Developing Cities
04. Simple & Interactive Tools for Air Pollution Analysis
05. Urban Air Pollution Analysis in Ulaanbaatar, Mongolia
06. Estimating Health Impacts of Urban Air Pollution
07. Estimating Road Dust Emissions: Methods & Parameters
08. Co-Benefits: Management Options for Local Pollution & GHG Emission Control
09. Air Pollution & Co-Benefits Analysis for Hyderabad, India
10. What is Particulate Matter: Composition & Science
11. Urban Transport in India: Not so Fast for Nano Car

SIM Cities 2008

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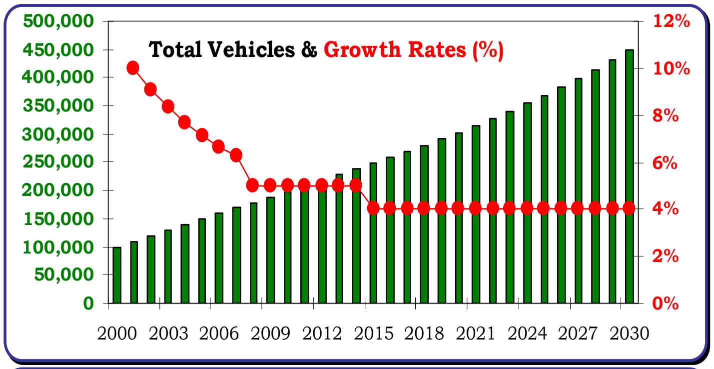
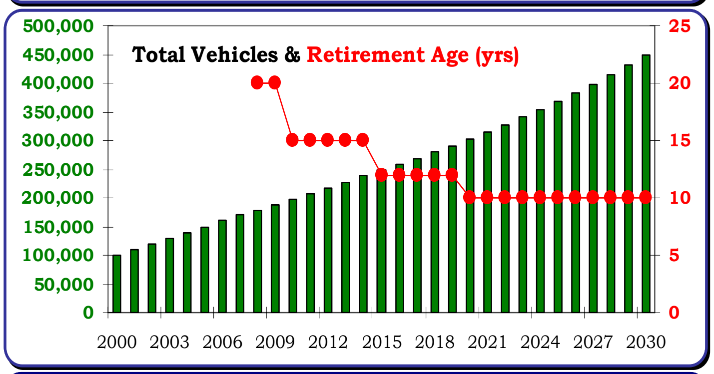
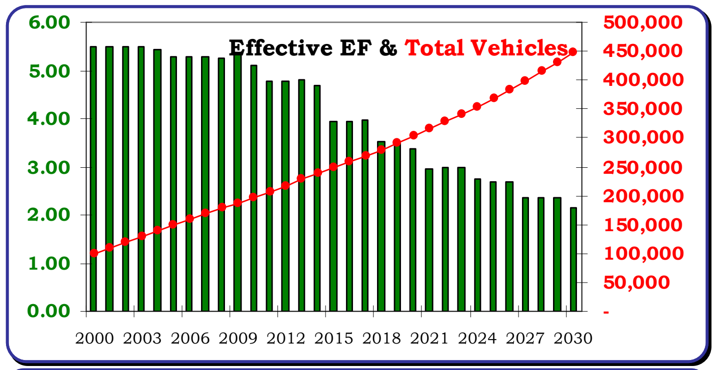
vapis
Vehicular Air Pollution Information System

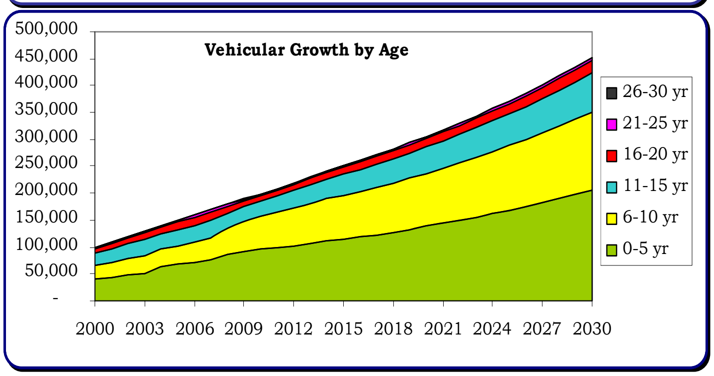
by fuel by type		VKT		by fuel by type		by fuel by type
# Vehicles	*	Usage	*	Factor	=	Emissions
1 by age		2		3 by age		4 by age
#	*	km/day	*	gm/km	=	gm/day

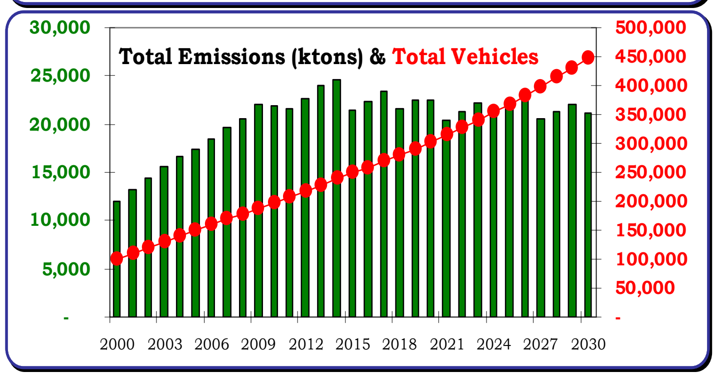


an illustration of calculations









average emission factors (gm/km)

use with discretion

	Gasoline			Diesel				CNG			
	2Ws	3Ws	Cars	Cars	LDV	HDT	Bus	3Ws	Cars	LDV	Bus
PM_{10}	0.10	0.20	0.10	1.00	1.25	2.00	1.50	0.10	0.05	0.02	0.02
$PM_{2.5}$	0.05	0.08	0.03	0.60	0.50	1.00	0.80	0.05	0.02	0.01	0.01
SO_2	0.02	0.02	0.07	0.40	0.30	1.00	1.00	0.00	0.00	0.00	0.00
NO_x	0.15	0.10	0.20	1.25	2.00	10.0	10.0	0.35	0.20	3.50	2.50
CO	2.50	8.00	5.00	2.00	2.50	3.50	3.50	3.50	1.00	3.50	3.50
CO_2	40	80	200	250	500	850	850	70	100	450	450
HC	1.50	5.00	1.00	0.40	0.20	1.00	1.00	0.15	0.02	0.10	0.10

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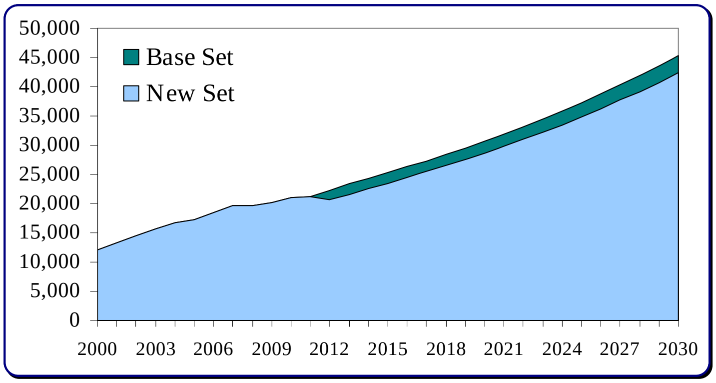
Location: New Delhi, India

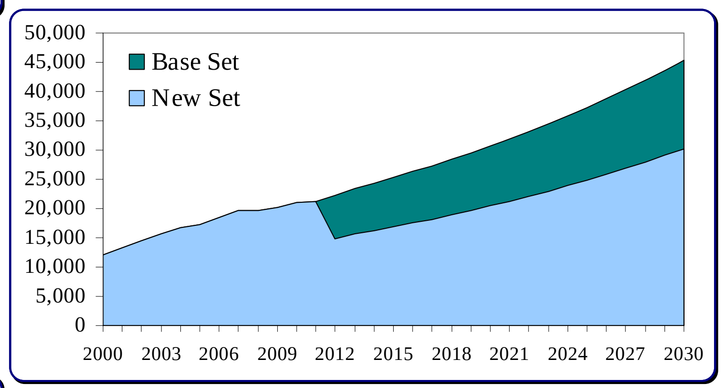
Download VAPIS 1.01 @

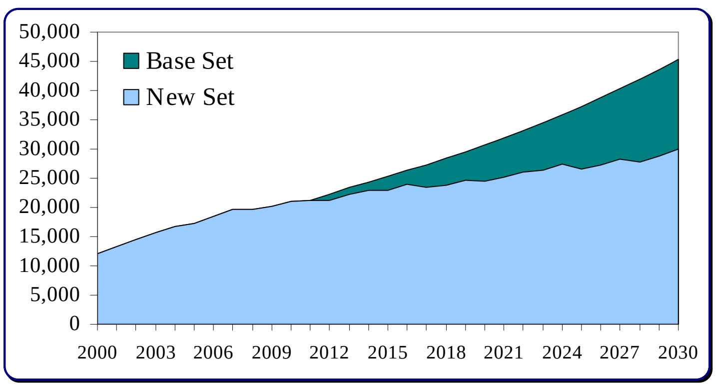
a combination of scenarios an be evaluated by exploring the parameters; below are some sample illustrations



← changing retirement age from 20 yrs to 10 yrs in 2012

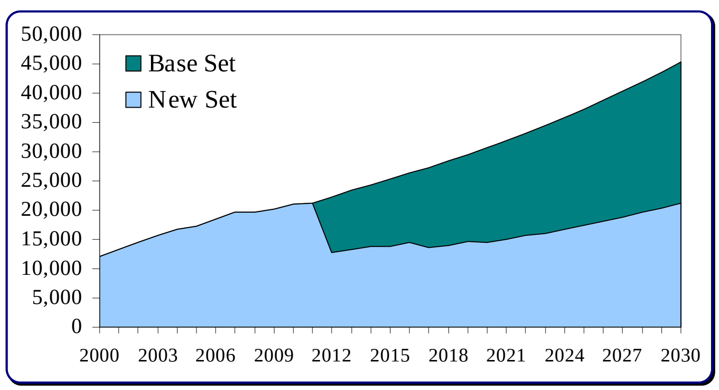
reducing the VKT by 30% from 60 km to 40 km in 2012→





← introducing newer emission standards in 2012 & 2017

.. or a combination of all the above →



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Hyderabad, India

1

This multi-agency study was designed to prepare a **co-benefit action plan** for air pollution control in Hyderabad, India, with base year 2006.

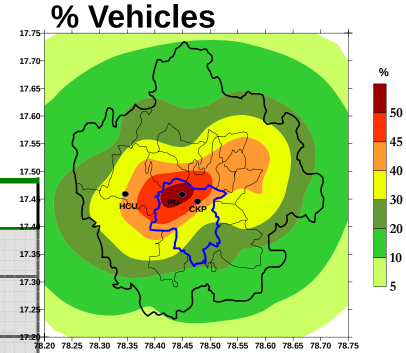
Location	% Vehicles		% Veh+RD		% Industry		% Dom+Waste	
	SA	M	SA	M	SA	M	SA	M
PG	54 ± 10	40-45	81 ± 10	66-70	13 ± 10	15-20	5 ± 10	4-6
CKP	45 ± 10	40-45	80 ± 10	60-66	15 ± 10	20-30	4 ± 10	4-6
HCU	43 ± 10	30-35	80 ± 10	50-60	16 ± 10	10-15	5 ± 10	8-10

SA = top-down = source apportionment   M = bottom-up = modeled

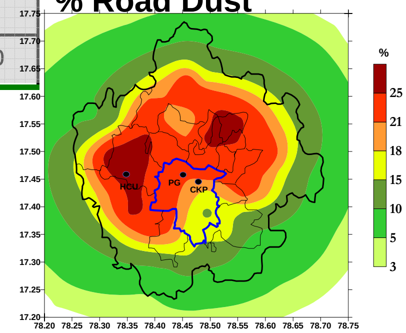
The program steps included (a) a year long source apportionment study using mini-vol sampler, chemical analysis, and receptor modeling using CMB model (summarized above) (b) bottom-up air pollution analysis by developing emissions inventory for local and global air pollutants, dispersion modeling (presented in the right panel), and co-benefits analysis of the city action plan. Tools utilized are SIM-air & ATMoS dispersion model.

Category (2006)	PM_{10}	SO_2	NO_x	CO_2
Vehicular activity	8,410	6,304	38,772	6,260,099
Paved road dust	3,422			
Unpaved road dust	5,110			
Industry	11,054	7,110	7,836	916,486
Domestic	1,845	667	545	83,485
Open Waste Burning	810			
Total (ktons)	30,473	14,081	47,152	7,260,070

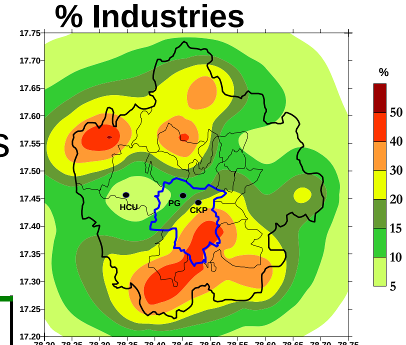
% Vehicles



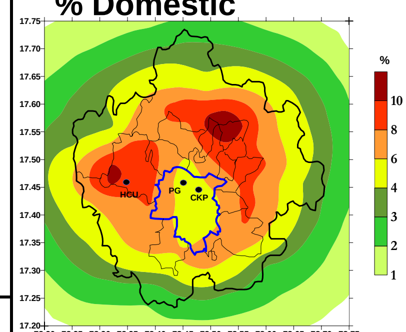
% Road Dust



% Industries



% Domestic



By improving traffic flow, public transport, emission standards, industrial efficiency, domestic LPG use, and reducing waste burning, a reduction of ~42% and ~32% in PM_{10} and CO_2 emissions respectively and ~US$472 million in health and carbon benefits is expected by year 2020.

Hanoi, Vietnam

2

In October, 2007, Swiss Vietnam Clean Air Program (SVCAP) with the relevant local and national stakeholders organized a preliminary workshop on **Air Quality Management in Hanoi**.

The objective was to shed some light on issues like: (a) What are the likely air pollution trends in Hanoi through 2020? (b) What are the likely emission levels (especially for PM) and possible local impacts? (c) What domestic interventions will make a significant difference in the air quality relative to BAU scenario?

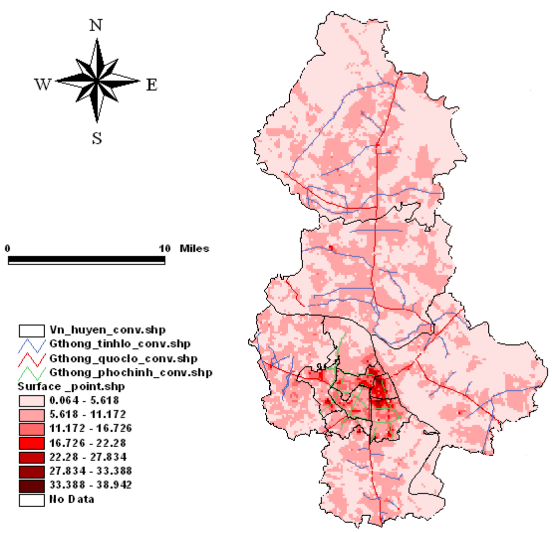


Figure: Hanoi city road density

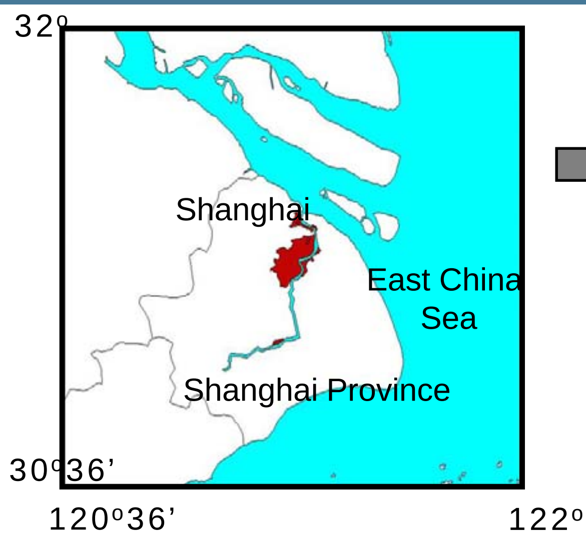
Category (2005)	PM_{10}	SO_2	NO_x
Households	1,099	358	307
Kiosks	1,261	263	220
Industries	6,665	1,407	1,919
Industrial Incinerators	338		
Vehicular Activity	4,322	1,869	24,537
Paved Road Dust	3,120		
Unpaved Road Dust	3,036		
Brick Manufacturing	1,817	466	390
Garbage Burning	1,800		
Medical Incinerators	37		
Total (ktons/yr)	**23,496**	**4,363**	**27,373**

Development planners agreed on a consensus to prepare a consolidated set of guidelines, which would enable them to develop a baseline (for year 2005, presented above) to compare the pollution management options.

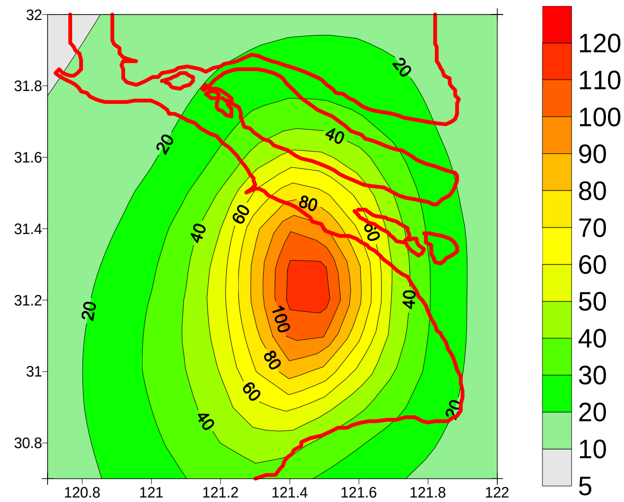
Options evaluated are promoting bus rapid transport and public transport at a large scale, stricter regulations for motorcycles, and improved energy efficiency in industrial and domestic sectors, which will enable to choose between investment projects with largest cost effectiveness to air quality in Hanoi.

Shanghai, China

3



PM_{10}
µg/m^3
1995



This study was conducted in 2001-02 with 1995 as the base year and estimates extend to 2020 for **cost-benefit analysis** under business as usual and two control scenarios for particulates, sulfur dioxide, and nitrogen oxides. Base year emissions were estimated at 166 ktons of PM_{10}, 68 ktons of $PM_{2.5}$, 285 ktons of NO_x and 458 ktons of SO_2 in 1995. Control options included application of IGCC technology for the power plants and substitution of coal with gas along with relocation for the industrial sector.

Emissions inventory development and dispersion modeling was conducted using SIM-air framework & ATMoS model; followed by benefits analysis for health and cost benefit analysis for the options. Results are summarized below and are published in *J. of Environmental Management, 2004.*

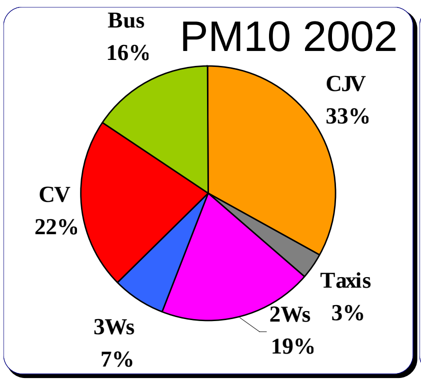
Health Benefits (US $ mil)		Power Scenario	Industrial Scenario
Mortality	Low	139	88
	Medium	347	221
	High	1,030	656
Morbidity	Low	38	24
	Medium	57	36
	High	119	76
Work Day Lossess		13	8
Total Benefits		190 – 1,162	121 – 741
	(Median Case)	**(417)**	**(266)**
	Scenario Cost (US$ mil)	**395**	**94**

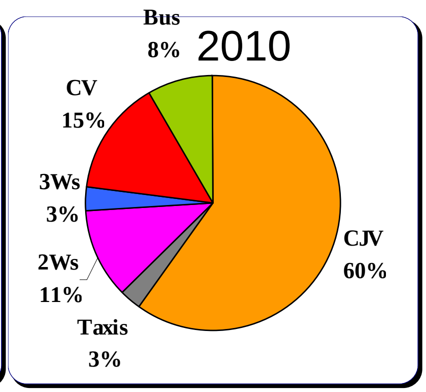
Delhi, India

For the National Capital Region, the **impact of metro rail** on the local air pollutants was investigated using one of the SIM-air family tools.. Smart-CART (Smart Carbon Analysis for Road Transport). The inputs on vehicular usage are from CRRI and the average emission factors from the VAPIS tool.

Approximately, 2.5% annual increase in VKT is assumed and assumed splits are presented in the table.

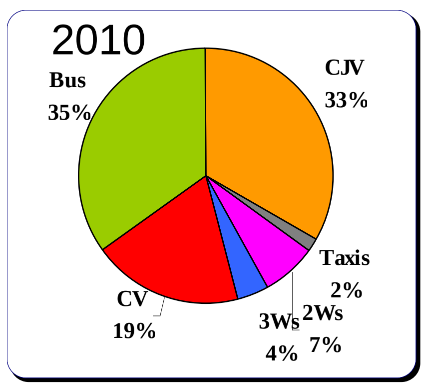
Category --- VKT	2002 - % of 79.2mil km	2010 - % of 96.5mil km	2010 - % with metro	2020 - % with metro etc
Cars/Jeeps/Vans	38	43	38	33
Taxis	1	1	1	1
2 Wheelers	42	37	32	32
3 Wheelers	12	10	9	9
Commercial Vehs	3	3	3	3
Bus Service	4	6	6	5
Total	**100**	**100**	**89**	**83**

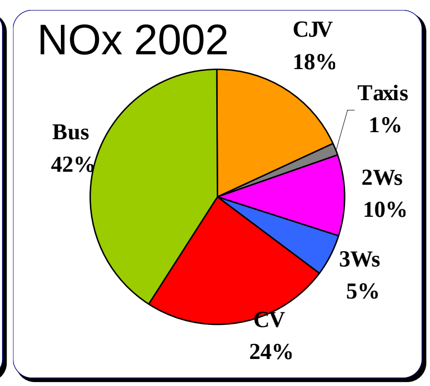




2000's experienced a large increase in the personal cars/jeeps/vans and more specifically diesel vehicles, which nullified the CNG bus conversion effects.

NO_x emissions, a precursor to the ozone formation also increased (presented here), along with SO_2, CO, and CO_2 emissions. Table below summarizes totals in tons/yr.





Year/Scenario	PM10	SO2	NOx	CO2
2002 BAU	6,336	2,632	18,329	4,346,237
2010 BAU	11,693	4,713	28,157	6,065,999
2020 BAU	18,459	7,313	40,117	7,958,948
2010 with Metro	10,636 (9% red)	4,318 (8% red)	26,660 (5% red)	5,569,162 (8% red)
2020 with Metro	14,580 (21% red)	5,604 (23% red)	31,344 (22% red)	6,398,281 (20% red)

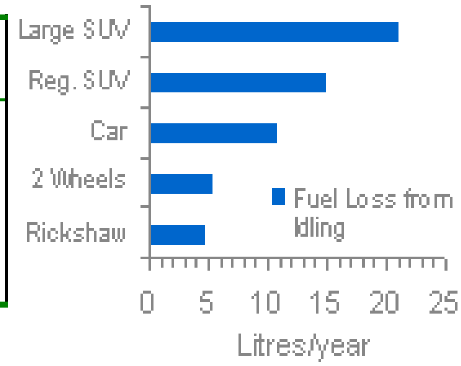
Pune, India

5

Using vehicle numbers from the Pune Municipal Corporation Environment Status Report, emission factors for various pollutants from SIM-air and some assumptions about vehicular usage, the **impact of idling** were estimated for Pune. Analysis results are staggering and highlighted in the local newspaper (below) for further public awareness.

On a daily basis, assuming a vehicle idles for just 2 minutes every day -- the total fuel wasted by idling cars, two wheelers and rickshaws amounts to an incredible 19 thousand litres per day! Emissions of greenhouse gases amount to 45 tonnes/day.

Vehicle Type	Total Fuel Loss from Idling lt/yr	Total CO_2 tons/yr	Total PM_{10} tons/yr	Total SO_x tons/yr
Cars	1,625,500	3,899	9.75	4.8
2 Wheelers	4,959,000	11,901	4.86	4.9
3 Wheelers	333,200	800	3.05	1.9
Total (ktons)	6,917,700	16,600	17.66	11.52



From, Times of India, Pune July 25th 2008

City Wastes Rs 34 Crore Every Year Due To Idling, Finds Study

Switch off at signals, save fuel

Aditi Utpat | TNN

Suvrat Kher

The study finds that idling vehicles waste upto 19,000 litres of fuel and emit 45 tonnes of greenhouse gases every day in Pune

Pune: Every Punekar wastes at least Rs 100 worth of fuel per year by not switching off his/her vehicle at traffic junctions, as per a study conducted by Punekar, Suvrat Kher. Applying this equation to entire Pune, Kher says the entire city wastes about Rs 34 crore due to idling of vehicles. A geologist by profession, Kher was inspired to study the relationship between pollution and idling of vehicles by the maddening traffic jams he faced everyday in the city.

"I cross the Law College road junction everyday. The situation there is appalling. I studied the Pune Municipal Corporation's (PMC) annual environment status report, and realised that it did not provide any relevant data. That was when I embarked on this study," said Kher.

Assuming that each vehicle idles for about two minutes per day (which, he confesses, is a very conservative estimate), vehicles in the city waste up to 19,000 litres of fuel every day and emit 45 tonnes of greenhouse gases, said Kher.

Elucidating on the methods used for calculation, Kher described how he used the annual environment status report of the PMC to obtain the statistics. He further obtained a carbon calculator for vehicles created by the Canadian Office of Energy Efficiency and multiplication factors from World Bank Energy report. "I thought the calculations will be very complex. But after obtaining the tools, I realised that it was a matter of mere multiplication," said Kher.

He added that for the purpose of calculation, he had estimated that most engines of vehicles were produced in the years between [illegible] and 2003. "The efficiency of vehicles changes with usage, and also depending on the level of maintenance. Since the vehicles in the city are neither brand new nor very old, I chose this period." Kher stressed that while the emphasis is on carbon dioxide emissions, other pollutants like sulphur dioxide are as harmful, if not more. While the effects of carbon emissions will be visible in the medium to long term, effects of particulate pollutants are immediately visible in terms of health hazards.

"We must accept that no one is going to stop using their vehicles very soon. But simple acts like switching off your vehicle while waiting for the signal to turn green can help you and the environment in a big way. There are western countries that use hybrid cars — cars that switch to electric engines while idling. But it is still a long way off for India," said Kher.

Kher has uploaded his findings on his website. "A lot of people have downloaded the graphs I have created for their personal usage. While I did the study to satisfy my curiosity, I am happy if it is being used as a resource by someone. Reporters from Pakistan and US have written to me, as also students from all over the world," said Kher.

The study while elementary in nature and made using very conservative estimates, proves the benefits of switching to fuel-efficient ways of driving for the city. According to the study if all Punekars reduced their idling time by one minute everyday it will have benefits equivalent to removing [illegible] cars off the roads of Pune.

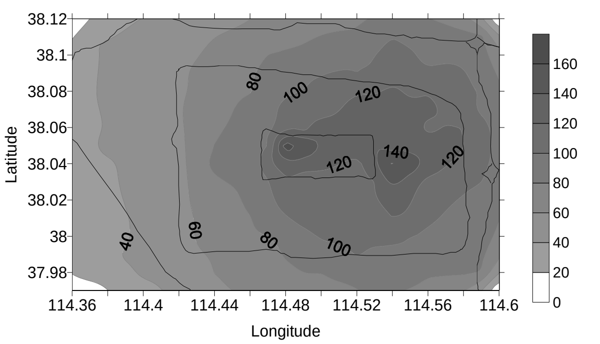
Shijiazhuang, China

6

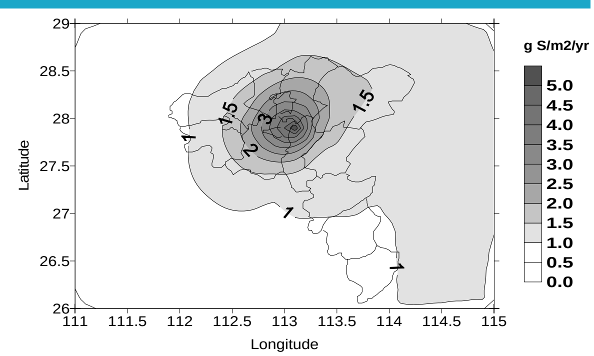
This study conducted in 2000-01, analyzes China's national **<u>sulfur pollution control program</u>** by looking at local implementation plans and actions for reducing sulfur emissions in two municipalities.

The city of Shijiazhuang in Hebei Province was chosen for a case study on ambient SO_2 pollution control, representing a northern Chinese city, while the tri-city region of Changsha, Zhuzhou, and Xiangtan in Hunan Province was chosen to represent a southern area experiencing serious levels of acid rain. The study included sulfur emissions inventory development, dispersion modeling, and cost benefit analysis of options.

Shijiazhuang SO_2 $\mu g/m^3$ for 2000



Changsha S Dep g/m^2 for 2000



Emission Reductions in tons SO_2/year	*Shijiazhuang City*	*CZX Tri-City Area*
Total Planned Sulfur Emission Reduction by 2005	36,000	77,600
Switching to low-sulfur coal or processed coal	19,000	8,400
Switching to natural gas or LPG	13,000	31,600
Other measures (Emissions from Smelter)	4,000	37,600

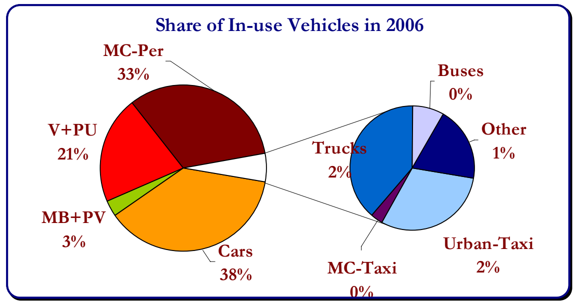
The current costs of sulfur abatement actions are high and the associated health and agricultural yield benefits would largely justify the actions proposed by local governments. The cost effective measures include promotion of low sulfur coal, fuel switching, adoption of latest control technologies like sorbent injection or CFBC, and strengthening sulfur pollution regulation and enforcement. Details of the study and the final report is available @ http://go.worldbank.org/R22KKMM0N0

Bangkok, Thailand

7

DIESEL program is aimed at developing emission factors for a mix of in-use vehicles and a **comprehensive transport strategy** in Bangkok, Thailand.

With primary focus on transport sector, a modified SIM-air called IDEAS was developed and utilized for data collection and options analysis (presented below) for cost effectiveness.



IDEAS = Informed Decision-support for Evaluating Alternative Strategies

Intervention	Assumptions	PM Reductions		Cost	Tons/million USD
		Tons	% BAU	USD (million)	
CNG Conversion of Buses	2000 Buses are converted	362	1.5%	200	1.8
Diesel Particle Fiters	For all the diesel vehicles; 90% reduction in direct PM emissions; including low sulfur diesel	18,406	61.0%	852	21.6
Congestion Pricing	5% reduction in person VKT and 5% increase in VKT of Bus	604	2.42%	200	3.0
Inspection & Maintaince	10% reduction in deterioration rates of emission factors	2,916	11.7%	100	29.2
Mass Rapid Transport	200 km of rail MRT; 5% shift from auto to 3.5% MRT, 1% to Bus, 0.5% to Walk	535	2.2%	7,000	0.1
Bus Rapid Transport	100 km of rail and 100 km of bus rapid transport; 5% shift to MRT/BRT; half from autos,/taxis/buses	312	1.3%	2,000	0.2
Walking	1% Shift in VKT of Cars and Buses	95	0.4%	50	1.9
Preventive Maintaince	25% reduction in bus PM emissions	177	3.6%	2	89
Traffic Management	1mph increase in average traffic and bus speed - average is currently 15mph in peak hour (approx).	521	2.1%	80	6.5
Fuel Pricing	A 4% reduction in the fuel usage translated to VKT for 10% increase in fuel price	533	2.1%	50	10.7
Fuel Economy	15% increase in fuel economy for the cars & pickups	2096	8.4%	50	41.9

Detailed results from the emissions tests, policy analysis, and presentations are available from Pollution Control Department, Thailand. Final report is available on CAI-Asia website @ www.cleanairnet.org

Ulaanbaatar, Mongolia 8

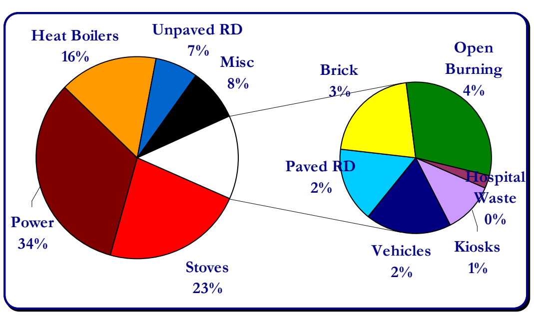
In 2007, following stakeholder meetings, an **Air Quality Management** Bureau was set up to undertake exercises on data collection, analysis of sources and estimate their potential to reduce air pollution.



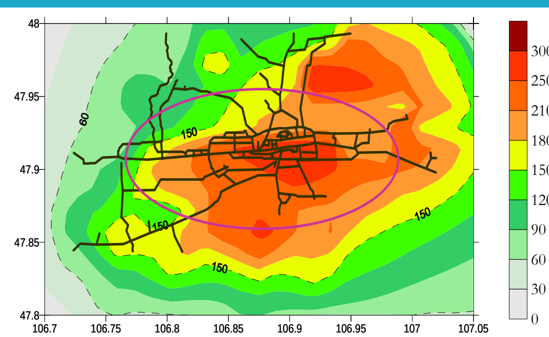

An application of SIM-air was developed for a 30 x 20 grid at a resolution of ~1 km, to underpin discussions on air quality in Ulaanbaatar and possible short- and long- term strategies for reducing air pollution. Major sources include domestic stoves for heating and cooking, heat only boilers in small scale industries, power plants, fugitive dust from roads and construction sites, and open waste burning.

The emissions gridding and modeling process included geographical maps from the city council – Ger areas and road maps, and industrial location information (for power plants and 350+ HoBs) from local experts.

PM_{10} emissions in 2006 = 98 ktons



2006 average modeled PM_{10} $\mu g/m^3$



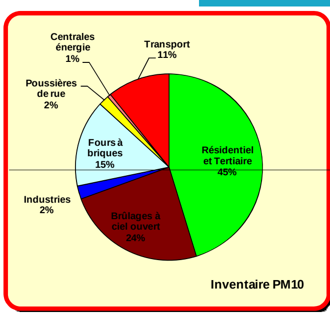
Analysis and results were extended to 2020, are based on discussions (with ministries, academic, and non-governmental agencies) and workshops in Ulaanbaatar with the city environmental authorities.

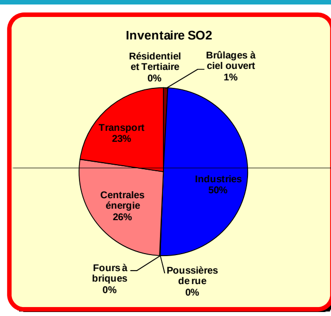
Main interventions included clean coal for domestic and small scale industries, ESP's for power plants, and control of fly ash and road dust.

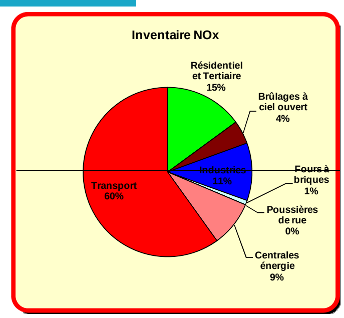
Tana, Madagascar

Under the CAI-SSA, the **<u>Air Quality Management</u>** study utilized the SIM-air tools to (a) Inform and raise users' awareness of risks linked to air pollution (main features of air pollution, its effects on health and economy) (b) Facilitate a consensus among stakeholders based on a realistic, immediate, and long-term action plan to reduce air pollution in Antananarivo (action plan includes technical & financial evaluation of possible investments, in the transport and industrial sector).

Emissions Inventory for 2005







Sector	Management Options Evaluated for City
Transport	• Traffic management to increase in average speed •□Reduce sulphur content in petrol & diesel •□Renovation of taxi stands and city taxis •□Switch to ethanol in tourist vehicles and petrol taxis
Residential & Tertiary	•□Encourage LPG used instead of wood & charcoal •□Improve efficiency of ovens (improved ovens)
Industry & Similar Activities	•□Reduce sulphur content in heavy fuel oil •□Improve efficiency in brick ovens •□Supervision of open burning of waste deposits

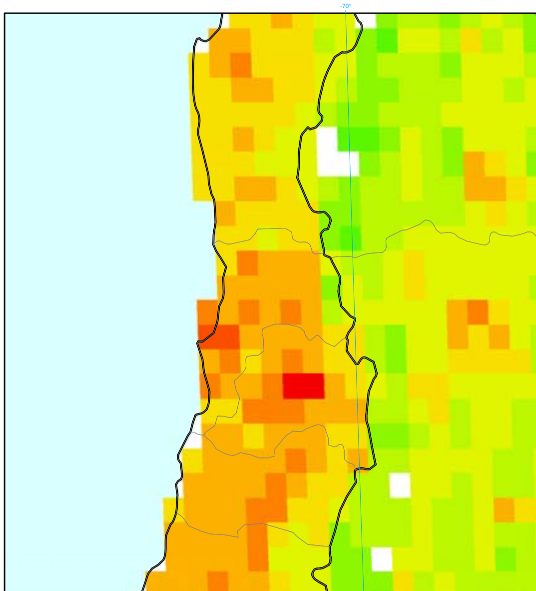
This study included developing emissions inventory, dispersion modeling, impact assessment, analysis of management options, and training of the local counterparts of AQM components.

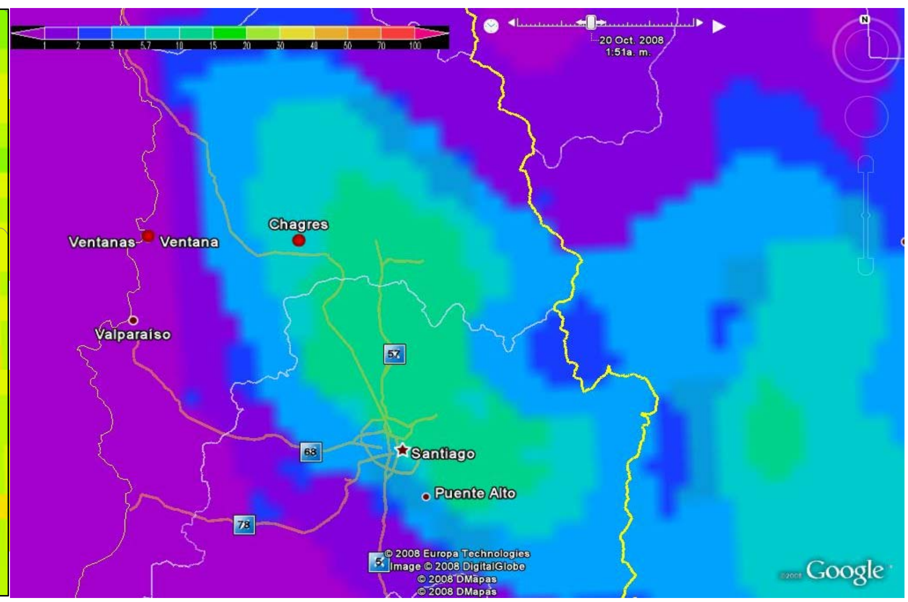
Santiago, Chile

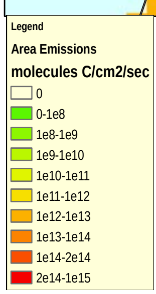
Universidad Andrés Bello, Santiago, Chile, established a new set of **air quality models** to account for both local area emissions and the contribution of regional emissions to the city of Santiago.

A gridded emissions inventories for Santiago was established using the SIM-air framework for local emissions and national data for Chile and Argentina from EDGAR for regional emissions. The STEM (Eulerian Chemical Transport) model was utilized to simulate the local and regional air quality for particulates and ozone.

The methodology used the best available inventory and the framework was useful to rapidly assess changes in emission patterns, due to policy related emissions restrictions and land use.







The preliminary results from regional air quality modeling are currently in use for the VOCALS campaign in Chile @ http://www.eol.ucar.edu/projects/vocals/

The campaign is targeted to improve regional model simulation by better understanding the local and regional sources and lead to improvement for regional chemical and weather forecasting.

Lagos, Nigeria

The Lagos **vehicular emissions study** was initiated in mid-2007, under the management of the Lagos Metropolitan Area Transport Authority. Table below presents a summary of daily average concentrations from seven stations for the period of May'07 to Apr'08.

Main focus of this study is to update and expand vehicular emissions inventories, baseline current air quality at critical receptor sites, and recommend various strategies and measures for improvement of air quality through measures applied to the transportation sector.

Pollutant	Range	Average
TSP (μg/m^3)	89 – 860	368
PM_{10} (μg/m^3)	37 – 741	252
$PM_{2.5}$ (μg/m^3)	72 – 822	162
CO (ppm)	1 – 2.4	1.9
SO_2 (ppbv)	59 – 124	79
NO_2 (ppbv)	27 - 465	109

SIM-air was selected for estimating current air quality impacts and gaming on various growth rate assumptions, emission rates, vehicle usage statistics by vehicle class, and various emission limits. Figure presents an overview of the current transport plan.

The **impact of industrial sector** is also under study. Lagos has ~70 percent of Nigeria's industries, with as many as 1,053 different manufacturing outfits. The local experts now have the tools and training to formulate and investigate various strategies for transport and industrial sector to improve air quality in Lagos, Nigeria

Kathmandu, Nepal

12

National, China

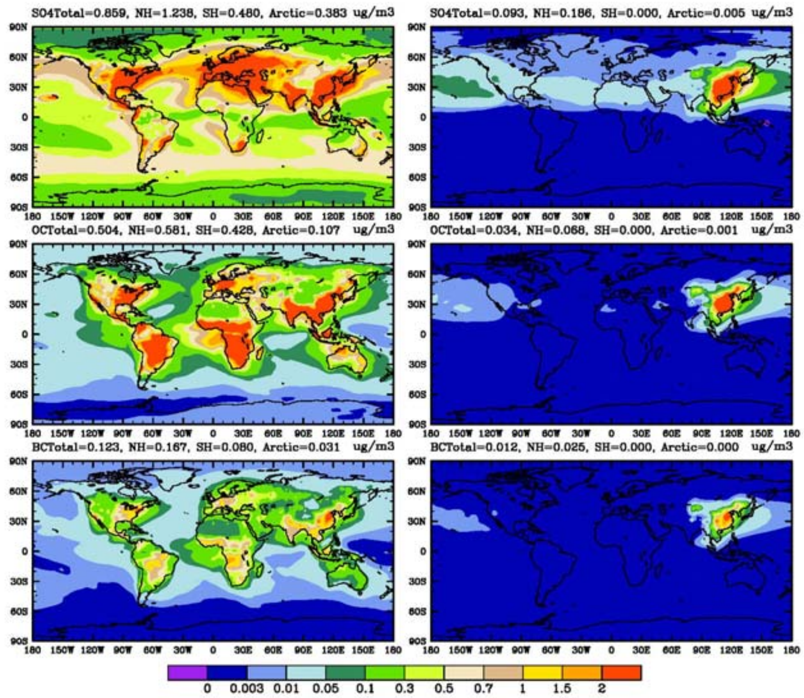
13

Global Air Quality & Premature Mortality due to Aerosols from China

This study aims at better understanding the interactions between **air quality, premature mortality, and global radiative forcing** due to anthropogenic emissions, especially contribution of China's growth.

Data & Models: Emissions from IPCC SRES A2 & IIASA, MOZART global coupled chemistry-aerosol model; followed by mortality estimates using population grid.

Global Average | China Contribution



Annual premature mortality associated with Chinese aerosols (SO_4, BC, & OC)

	2000 BASE	2030 BAU	2030 CLE	2030 MFR
North America	247	465	302	98
South America	7	17	10	3
Europe	172	250	162	48
F. Soviet Union	163	248	148	61
Africa	193	506	330	110
India	648	1,544	895	345
China	385,324	602,945	395,131	200,365
S. East Asia	7,939	15,833	10,053	3,952
Australia	0	0	0	0
Korea & Japan	8,868	10,876	7,939	3,116
Total	403,562	632,673	414,970	208,097

Reductions in aerosols would provide benefits to local & regional health and global climate. However, it will be necessary to reduce greenhouse gas emissions to compensate for the loss in negative radiative forcing of aerosols (not presented here) and maximize co-benefits.

 details by Ms. Saikawa, esaikawa@princeton.edu

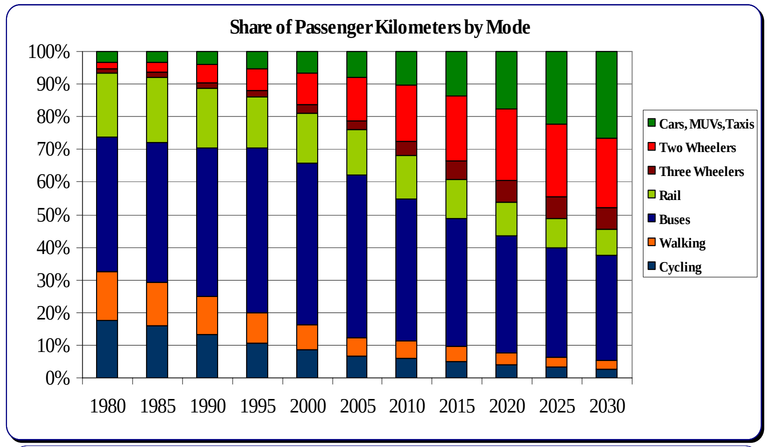
National, India

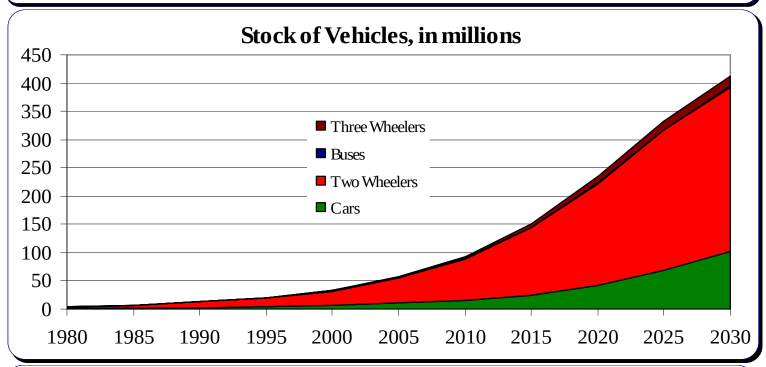
This study was conducted to project the levels of **<u>mobility, energy demand, and emissions</u>** in India up to year 2030, for land based passenger transport.

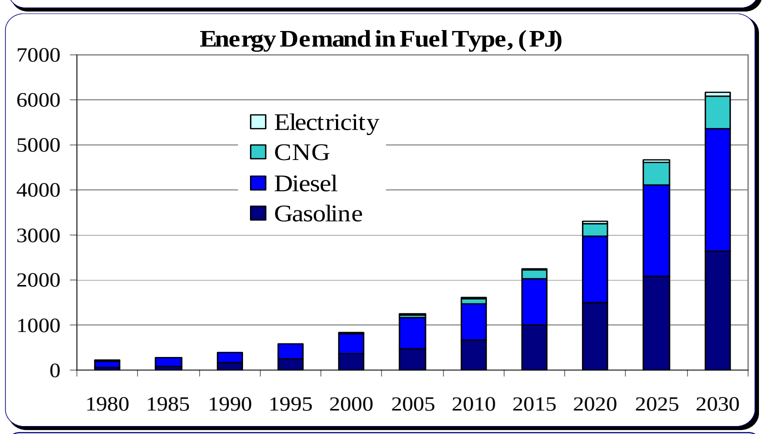
The analysis was conducted for four scenarios - business as usual (first three figures) and three policy scenarios – energy efficiency, stringent regulations for two and three wheelers, and sustainable urban transport.

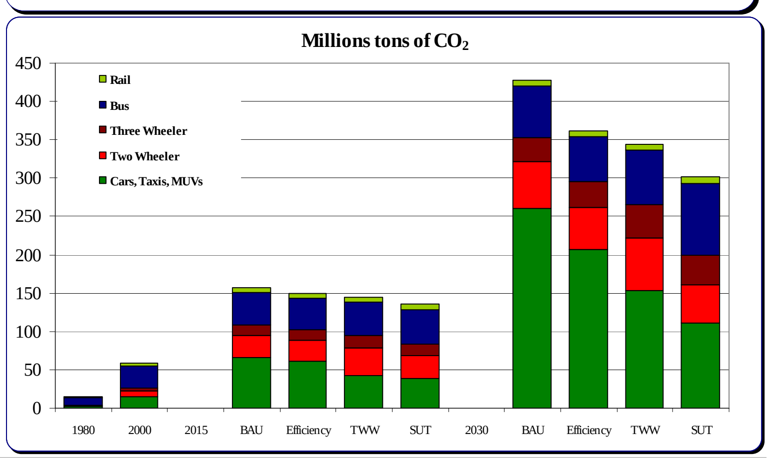
The projections are made by aggregating the contributions of the individual modes over time. The growth rates are determined based on sales growth rates, GDP, and population growth rates, government plans for the future (ex.. in railways) and synthesis of existing literature.

Last Figure presents a comparison of CO_2 emissions under BAU and the scenarios. The study is further extended to include CO, NOx, SO_2, HC, and PM.



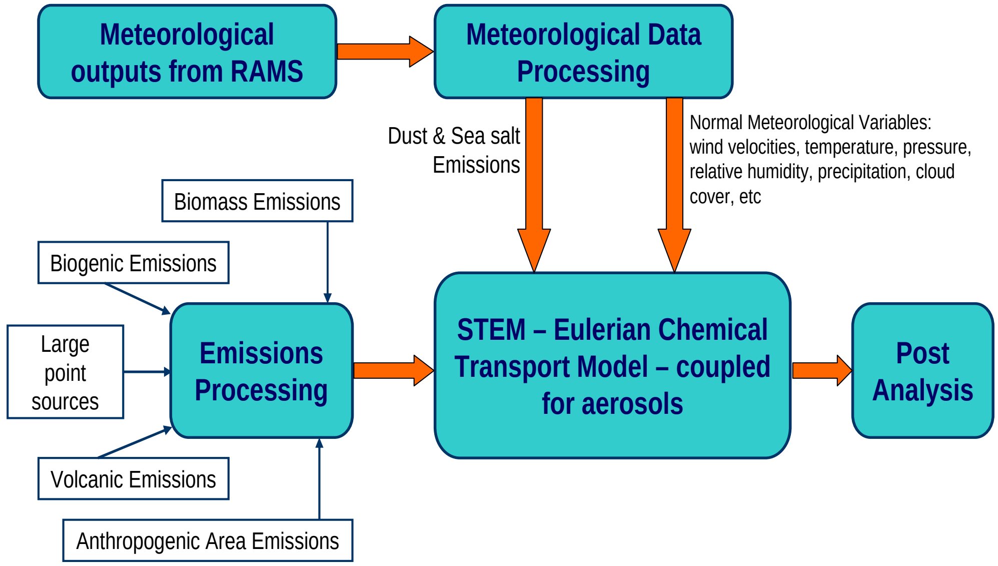






Regional, Asia

<u>Analysis of PM pollution</u> in Asia was conducted using met (RAMS) coupled 3D Eulerian Chemical Transport model (STEM), to better understand source contributions at regional level and to identify hotspots.



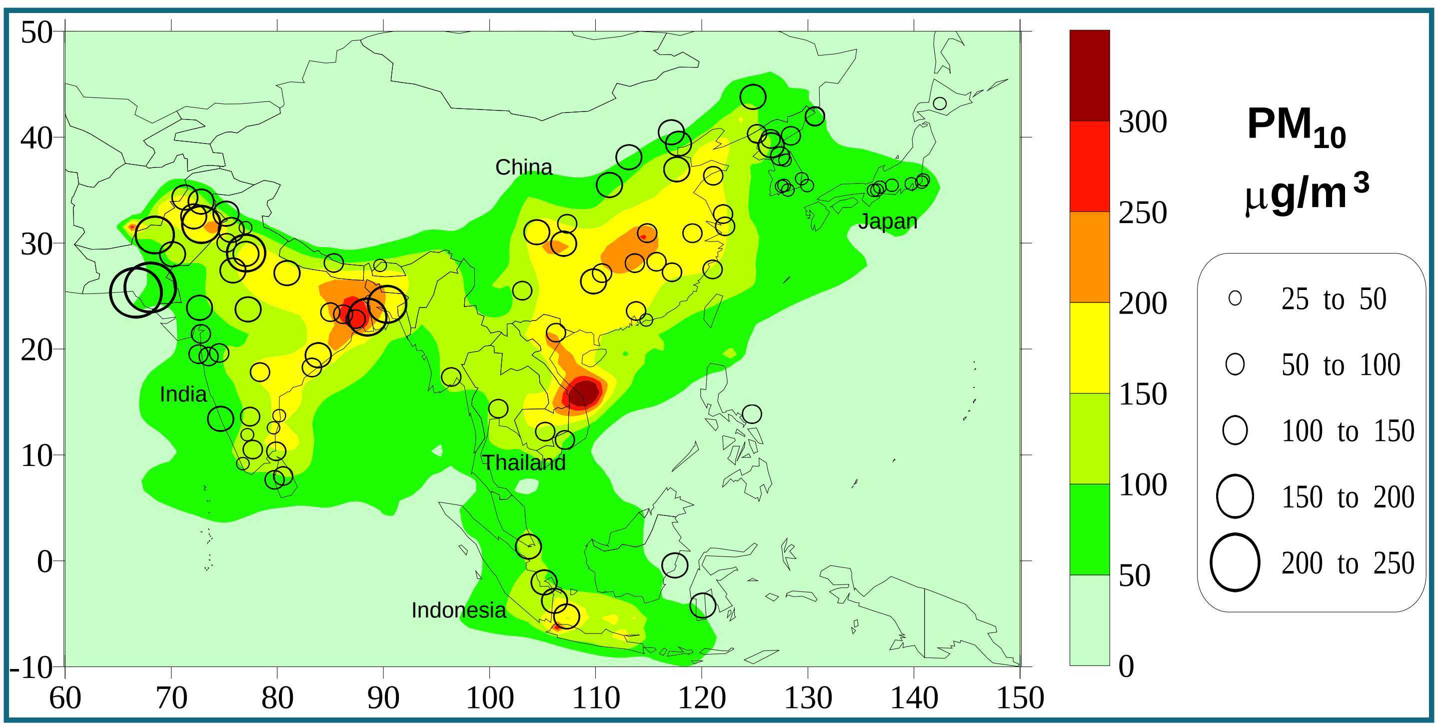
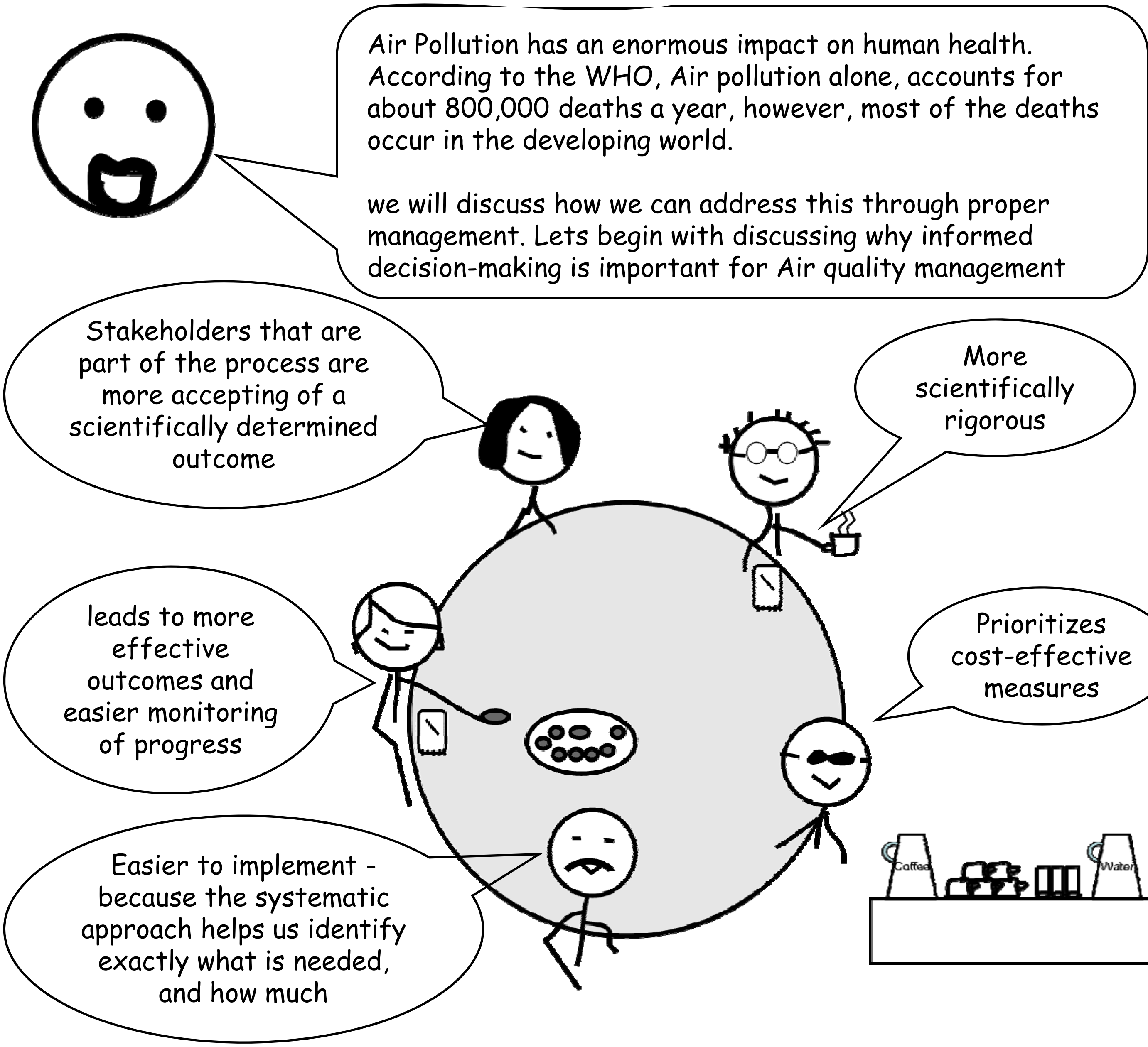


Figure above presents modeled annual average PM_{10} concentrations in Asia including emissions from anthropogenic sources (transport, industries, domestic), biomass burning (domestic and forest fires, based on AVHRR counts) and natural sources (dust and sea salt) for year 2000. Circles indicate measurements published by WHO/GEMS program for 2000. Study extends to 2020 and 2030 and other pollutants like Ozone.

A Primer to AQM



The "**Primer to Air Quality Management**" talks you through the steps of AQM. This fast-paced, fact-filled look at the underside of monitoring, emissions, dispersion, and impacts, might teach you something or make you laugh. And it just may simplify the way you look at your air quality information.

Learn more at www.urbanemissions.info

Simple Interactive Model (SIM-air)

Working Paper Series

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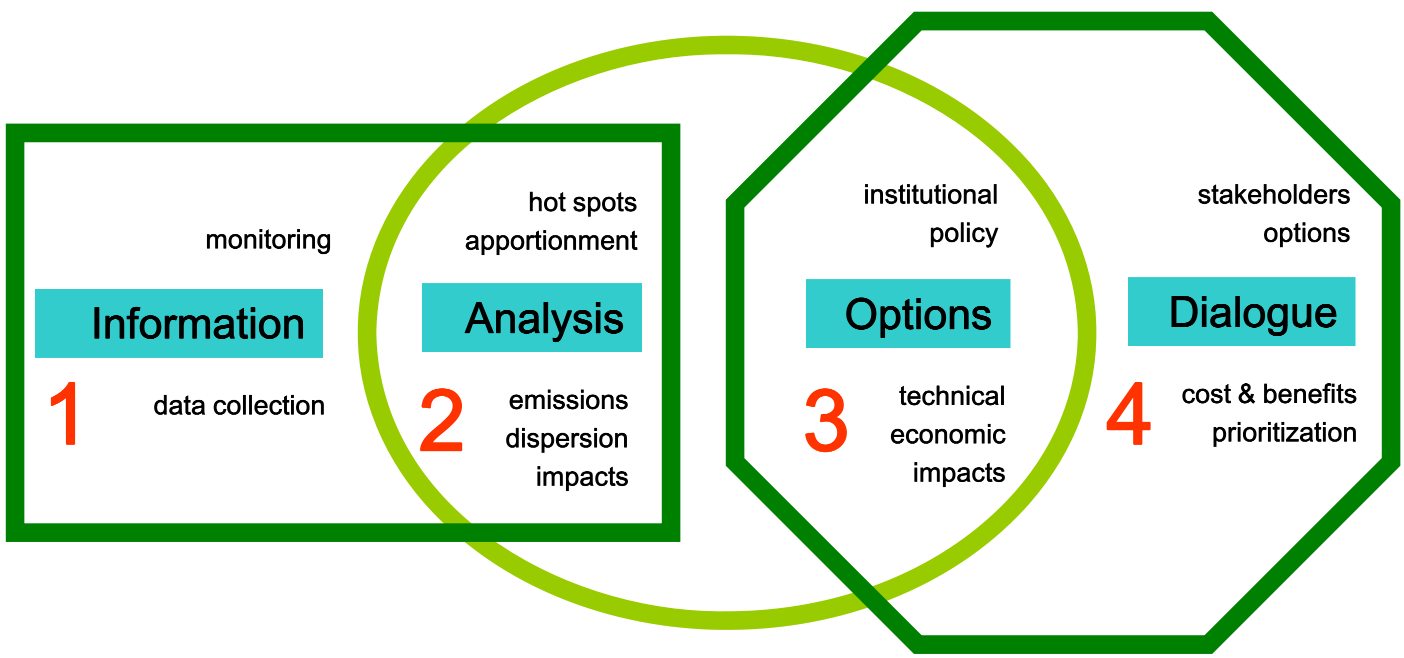
SIM-air: An Integrated Analytical Approach to Air Pollution



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