AIR POLLUTION
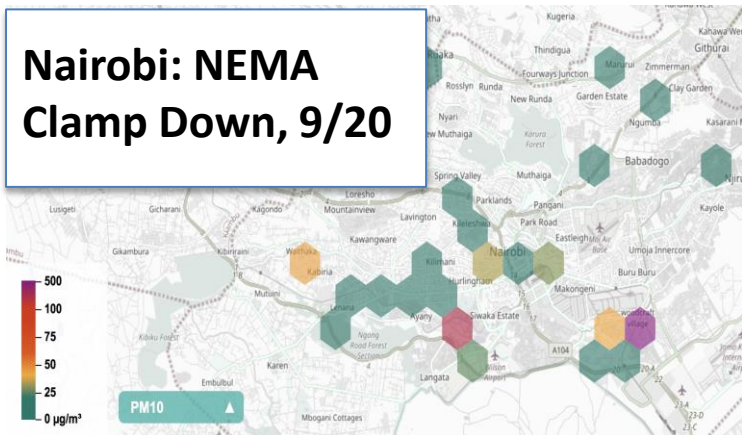# EVIDENCE/PROOF: SCIENCE AND SOCIAL DYNAMICS

Jessica Seddon, World Resources Institute

3 STORIES

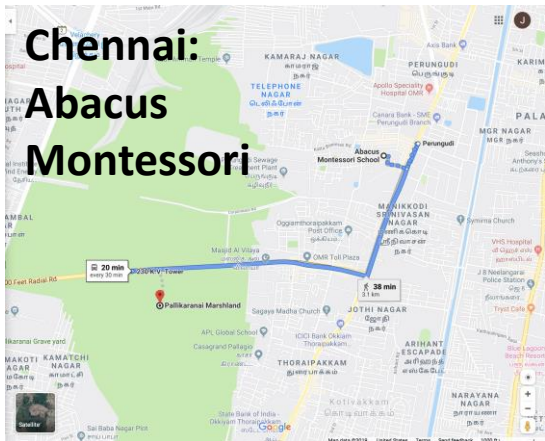India: 2015 Power Plan Emission Standards
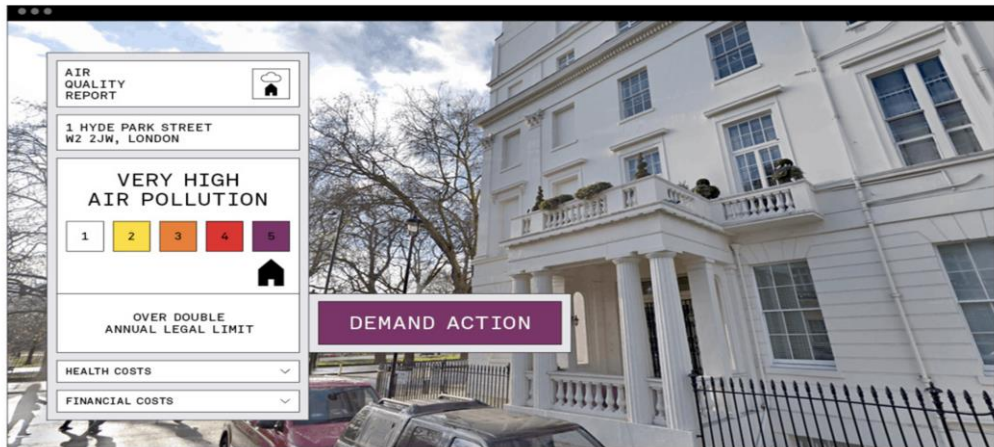

Nairobi: NEMA Clamp Down, 9/20

Chennai: Abacus Montessori

Londoners Demand Action

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AIR POLLUTION IMPACTS

ENERGY
Haze and dust from air pollution can reduce solar yields by as much as 30%.
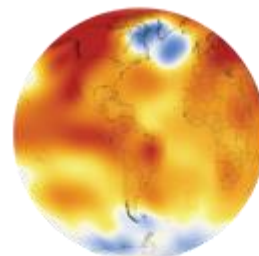
CROPS
Air pollution reduces crop yields. Estimated 6-12% global yield loss for soy, wheat, maize, rice at 2010-12 pollution levels; higher in some regions.

WATER
Air pollution shown to weaken the monsoon and disrupt rainfall patterns. China, North America, South Asia in danger of more frequent, intense drought.
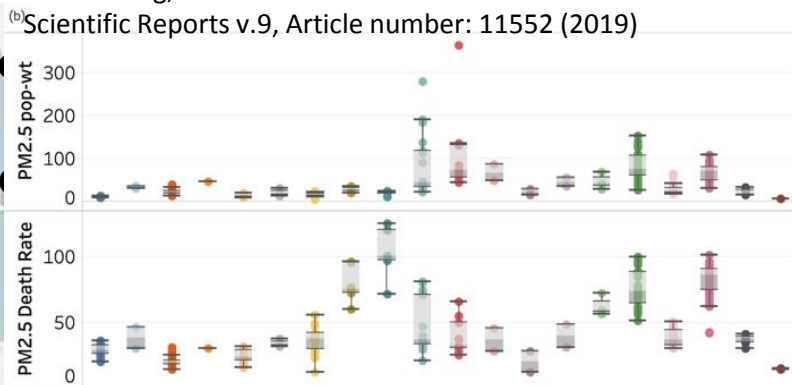
CLIMATE
Reducing air pollution could avoid an estimated 0.6°C of warming by 2050, slow Arctic warming and glacial melt, and help avoid dangerous near-term warming.

HEALTH
Indoor and outdoor air pollution linked to 6.5 million deaths in 2015 – nearly 1 out of every 8 deaths worldwide.

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3

POLITICAL MOMENTUM FOR CLEAN IS BUILDING CITIES ARO THE WORLD

Particulate matter-attributable mortality and relationships with carbon dioxide in 250 urban areas worldwide

S. Anenberg, et al
Scientific Reports v.9, Article number: 11552 (2019)

Hazardous: Chiang Mai n leads the world in air pollution
The Nation March 19, 2019

Global air po 2,000 cities air - Unearth

Europe is reducing the average lifespan by 2 years – Quartz, March 21, 2019

PATHWAYS FOR CHANGE

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5

PATHWAYS FOR CHANGE
A Fragile Cycle

THE CLEAN AIR "SITUATION"

| Very bad and increasingly visible problem | → | Growing demands for a solution | ? | Where's the revolution? |

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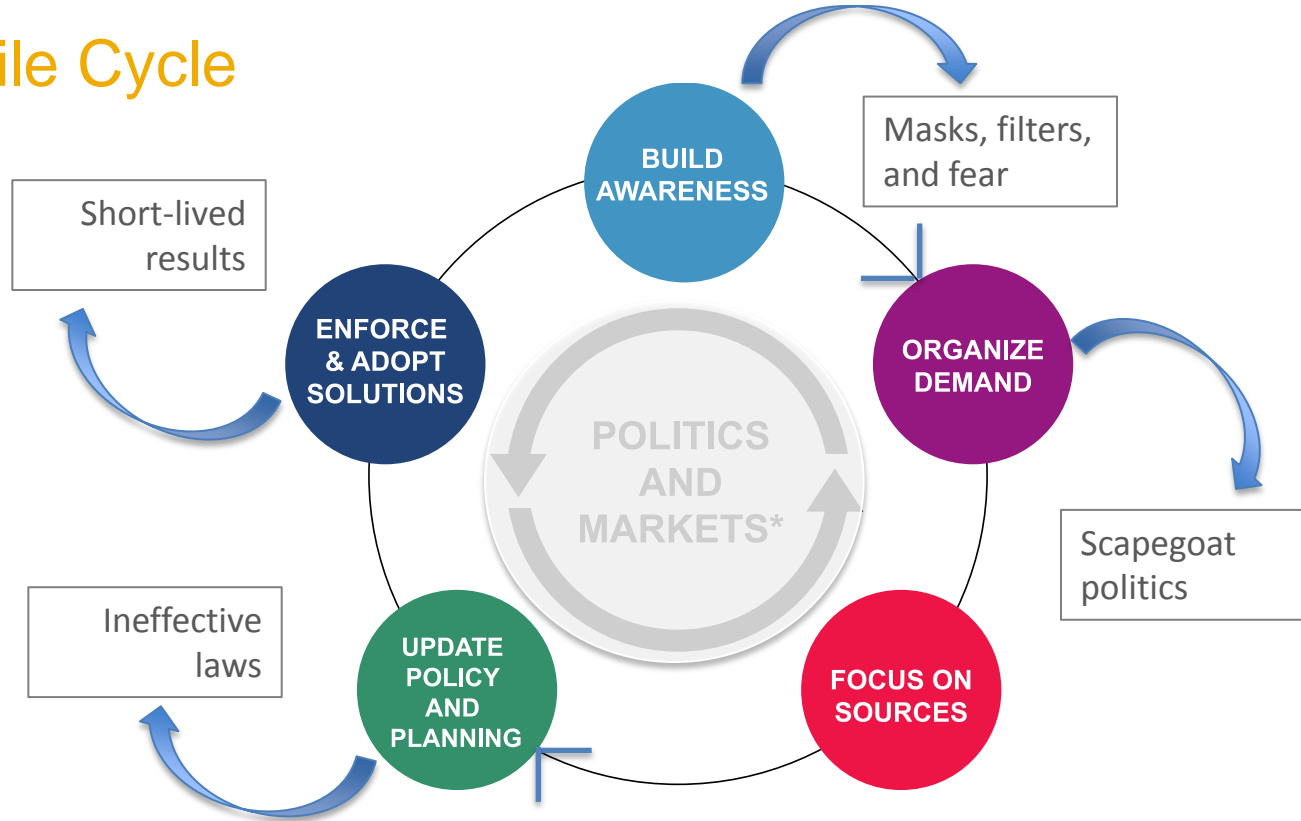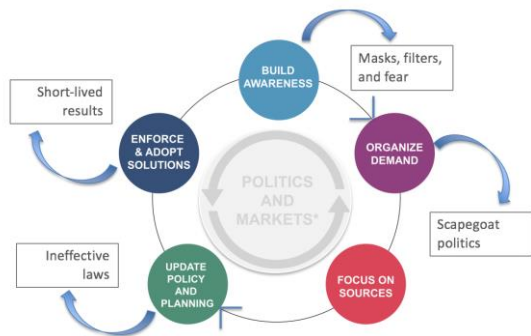
DEATH BY 1000 CUTS

"IRL"*

- A "sort of" problem - visibility comes and goes.
- Where people "sort of" know the solution – limited source attribution.
- Leaders "sort of" have the power to act – pollution comes from other places, control authority is dispersed.
- And it's "sort of" cheap to do – reducing emissions can be quite expensive for a few, even if many benefit.

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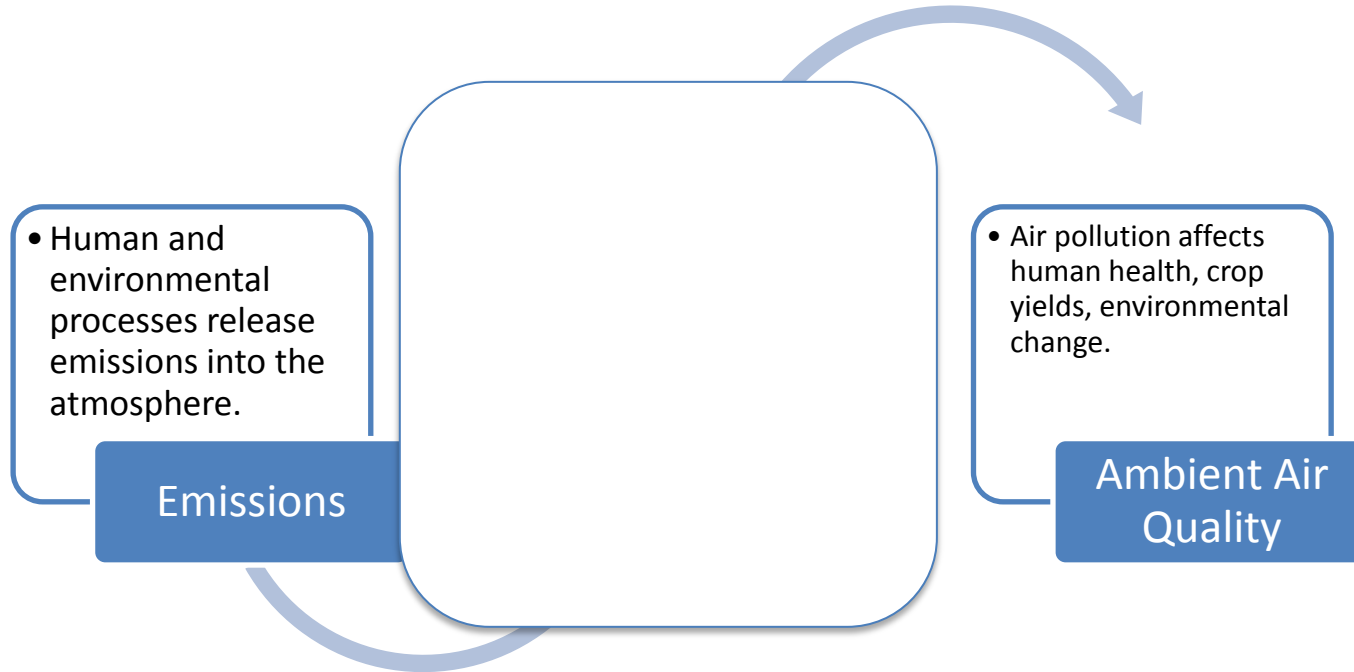
SCIENCE AS AN ACCELERANT

Monitoring & communication. Extension of monitoring and reasonable estimates to more places, more pollutants – along with better communication and outreach.

Monitoring & targeted communication. More personalized, more specific, tailored to interests of. existing or form-able groups and interests.

Monitoring & Analytics for Source Awareness. More granular (time, space), less mysterious, better communicated source attribution.

BUILD AWARENESS

ORGANIZE DEMAND

FOCUS ON SOURCES

UPDATE POLICY AND PLANNING

ENFORCE & ADOPT SOLUTIONS

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OBSTACLE 1: "MENTAL MODEL MISMATCH"

- Human and environmental processes release emissions into the atmosphere.

Emissions

- Air pollution affects human health, crop yields, environmental change.

Ambient Air Quality

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OBSTACLE 2: COMPLEX ATTRIBUTION

Even if you know how bad the air is,
finding out what caused it is scientifically complex.

R-J Huang et al. Nature 000, 1-5 (2014) doi:10.1038/nature13774
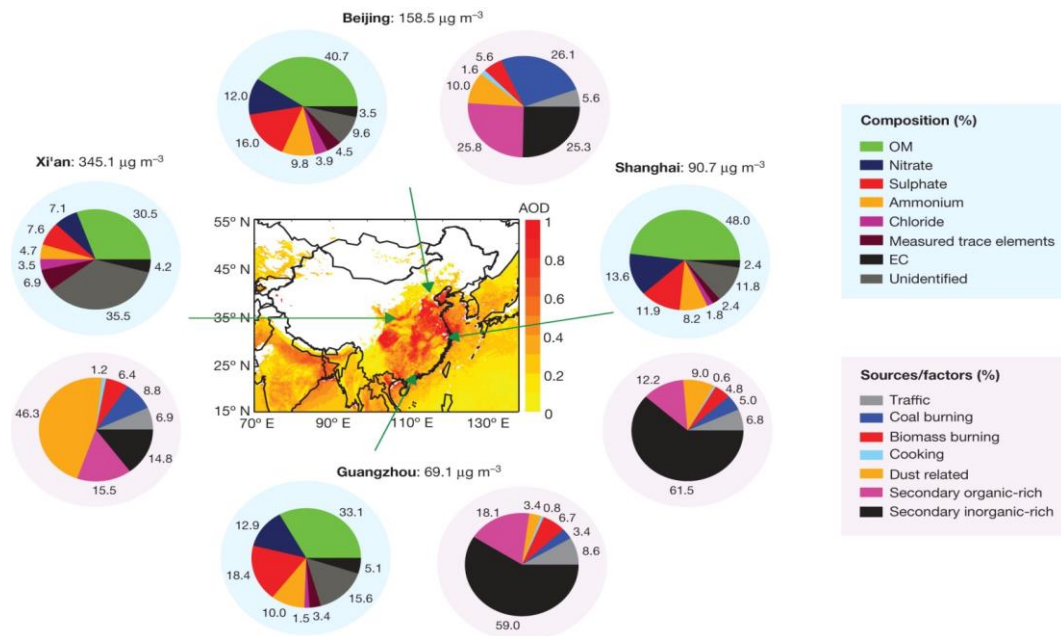
TOUGH POLITICS

- Costs of cleaning up are concentrated, benefits are widely dispersed.

- Requires multi-sector, multi-jurisdiction collaboration

INDIA

CHALLENGE I:
Pollution Comes from Everyday Activities

Mobility: Cars, buses, two-wheelers.
Transport: freight trucks
Household Energy: Heating, Lighting, and Cooking
Electricity: grid sources, backup gensets
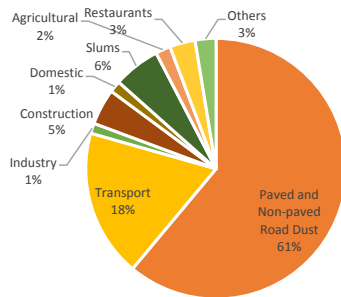**Agriculture:** crop burning, nitrogen fertilizer use
Waste Disposal: burning, decomposition (methane)
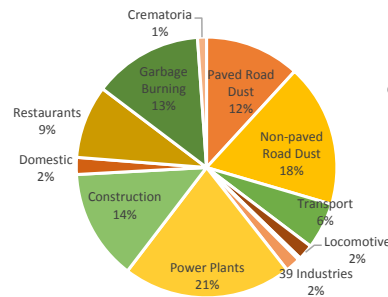**Industry:** esp heat-requiring processes
Business: Food preparation, etc.
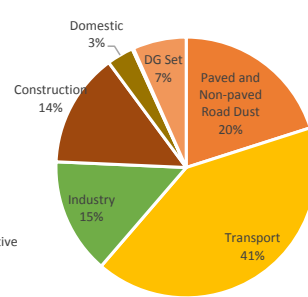
PM10 EMISSIONS LOAD FOR INDIAN CITIES
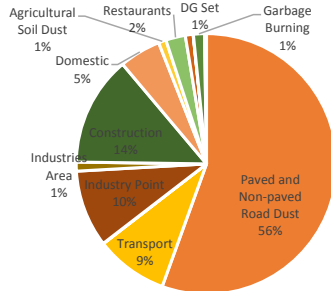

Pune PM10 % Contribution (32.3 T/day)

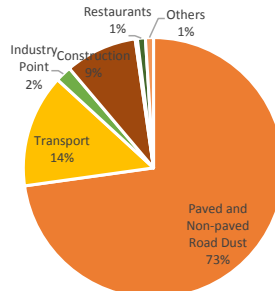Mumbai PM10 % Contribution (26.81 T/day)
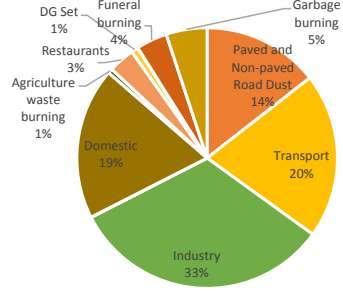
Bangalore PM10 % Contribution (54.4 T/day)

Delhi PM10 % Contribution (143 T/day) *

Chennai PM10 % Contribution (11.02 T/day)

Kanpur PM10 % Contribution (9.357 T/day)

Source: 2010 Source Apportionment Studies

WRI INDIA | SUSTAINABLE CITIES

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TWO APPROACHES

**Technology-Forcing Regulation**

- Establish outcome targets and enforce strictly and uniformly.

- Over time, market and households adapt to remain within limits.

- Regulation forces innovation, which then diffuses into practice.

"Control of Harms"

- Map the "supply chain" for the bad outcome.

- Identify the points where production/supply can be most easily disrupted.

- Act on those to avert harms.

EXAMPLE: U.S. TRANSPORTATION CONFORMITY
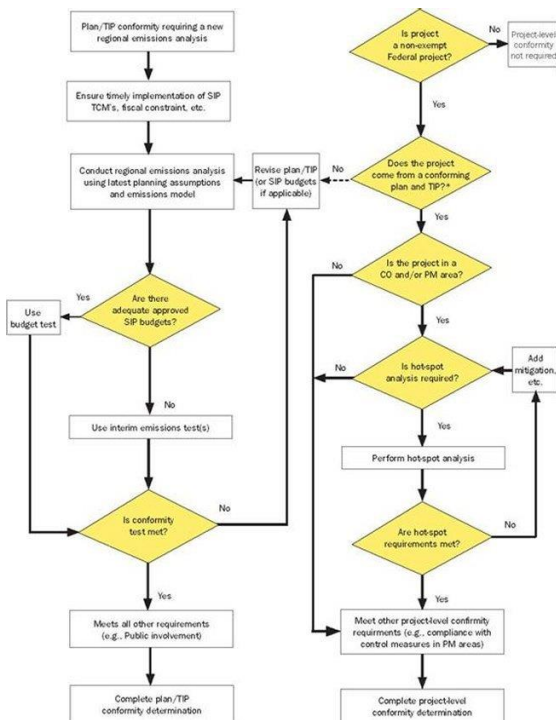
Conditions for Federal Transport Funding
- Each state has an approved State Implementation Plan (SIP) for meeting Clean Air Act standards.
- State must show that transportation plans using federal funds will not cause new air quality violations, worsen existing violations, or delay timely attainment of the national ambient air quality standards.
- Project-level demonstrations of conformity required in hotspot areas.

Benefits
- Coordination between air quality managers and transport planners.
- Innovative measures for improving air quality – states and metropolitan areas have developed integrated plans, implemented new technologies to demonstrate conformity.
- Advances in AQ monitoring and modeling – more robust predictions of AQ impacts.

CHALLENGE II: Air Does Not Respect Political Boundaries

Significant contribution from "out of boundary" sources."

TERI-ARAI (Aug 2018)
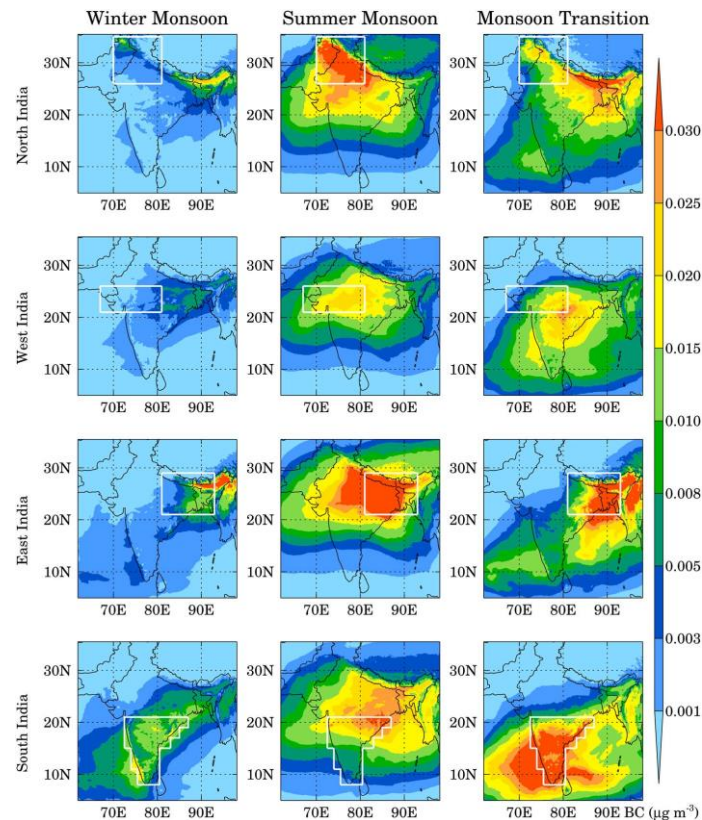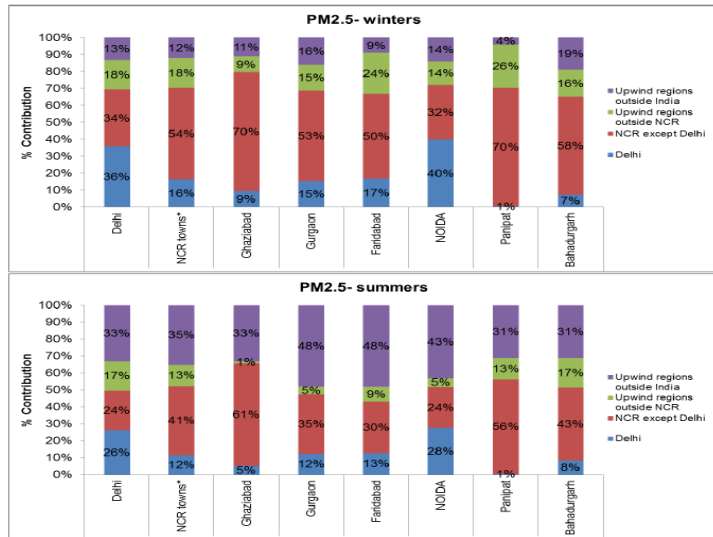
Figure 15. Spatial distribution of anthropogenic BC emitted from North, West, East, and South India during the WM, SM, and MT seasons in the free troposphere. White solid lines mark the geographical boundaries of different regions.

Kumar, R., et al (2015)
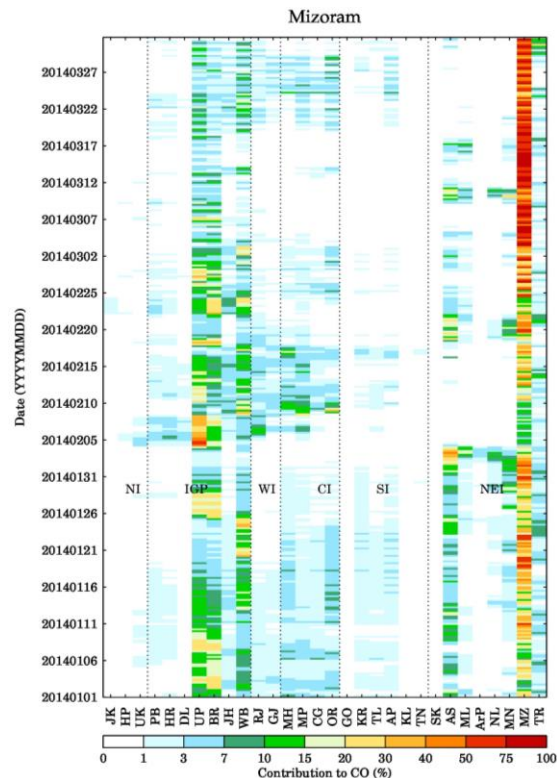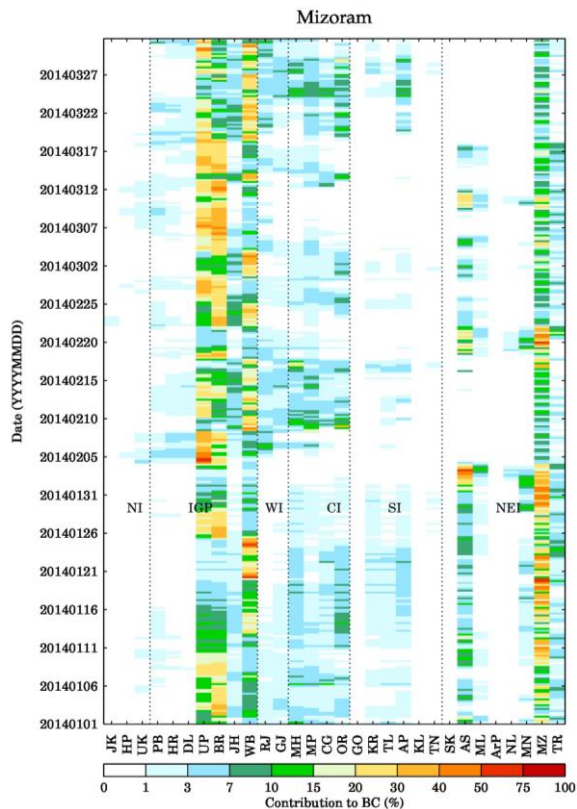
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AIR MIXES IN THE EAST

Mizoram

Mizoram

Contributions of source state to BC and CO mixing ratios (pollutant per unit of air) in named receptor state.

BC and CO serve as indicators/tracers for other particle/gas pollutants.

Kumar (2019) - forthcoming

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EVEN IN IN THE SOUTH

Kerala

Kerala

Contributions of source state to BC and CO mixing ratios (pollutant per unit of air) in named receptor state.

BC and CO serve as indicators/tracers for other particle/gas pollutants.

Kumar (2019) - forthcoming

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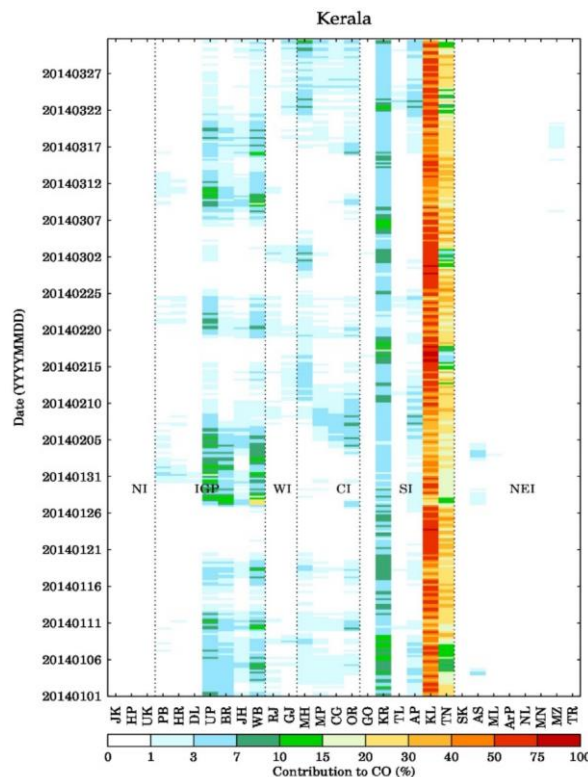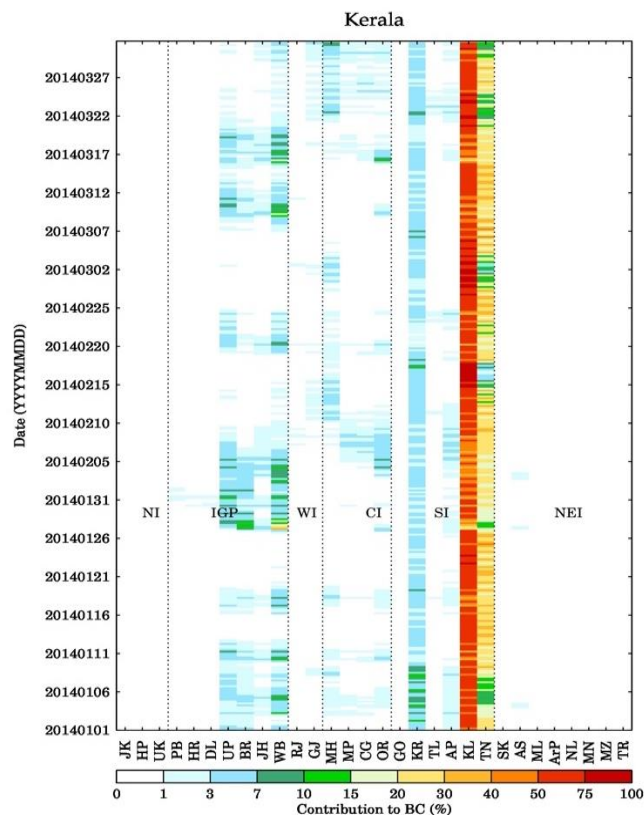
1. AIRSHED GOVERNANCE

Metropolitan

- Combined authority: core city + surrounding areas.
- Models:
  - Mexico PICCA, CAM, CAM-e
  - Los Angeles SCAQMD

Interstate

- Joint air quality management based on common model linking emission sources to impact.
- Model:
  - Long Range Transboundary Air Pollution Convention

EXAMPLE 1: SCAQMD

South Coast Air Quality Management District

- Formed in 1976 to regulate stationary sources in the L.A. basin
  - 4 counties, 28,000 km^2, 17+ people.
  - U.S.'s largest port complex (Long Beach, Los Angeles)
- Activities:
  - Permitting & pollution control for businesses from refineries to drycleaners.
  - Hotspot identification & remediation (e.g. port emissions management)
  - Air quality monitoring & modeling – experimental as well as operational. Leader in innovation.
  - Alerts & public communication
- Governance:
  - Governing board of 12 members, 9 are county supervisors and city council members, 3 appointed by CA state officials.
  - Coordinates with CA Air Quality Board (State) and EPA (Federal), which have primary responsibility for vehicle emissions standards & control.
- Funding ($163M in 2018)
  - 3/4 from evaluation fees, annual operating fees, emission fees, Hearing Board fees, penalties/ settlements and investments
  - 1/4 from federal grants, California Air Resources (CARB) subvention funds, and California Clean Air Act Motor Vehicle fees

EXAMPLE 2: LRTAP

Convention on Long-Range Transboundary Air Pollution

- Motivated by effects of acid rain.
  - Opened for signature in 1979, ratified in 1983 with 32 members, later extended by 8 protocols around specific pollutants.
  - Currently 51 parties, with accession terms designed to motivate more to join.
- Activities
  - Develop and update a common scientific understanding across countries – joint monitoring, modeling, dissemination of sources and impacts.
  - Develop, negotiate, and provide a platform for ratifying protocols – science-based plans for least-cost control of pollutants.
    - Initial protocols were technology-based, by the 1990s had shifted to focus on the least-cost means of achieving outcomes.
  - Pioneer multi-pollutant, multi-effects protocols (Gothenburg Protocol Abate Acidification, Eutrophication and Ground-level Ozone in 1999)
  - Implementation Committee (est 1997) reviews national compliance with protocols & identifies systemic issues.
- Implemented by the European Monitoring and Evaluation Programme (EMEP), directed by the United Nations Economic Commission for Europe (UNECE).

CHALLENGE III: Weak "MIS"
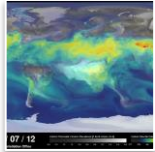
Global Models

Regional Models & Interpolation

Observations: Ground & Vertical Profiles

Emission Inventories
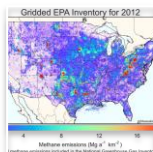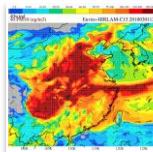
Modeling: Statistical & chemical transport models link sources to observed pollution level & observed pollution to sources. Global models help with local vs long-range transport, regional models often have higher resolution & can be more customized.

Monitoring: Measurements of concentrations and chemical composition of pollution at ground & diff heights, including via satellite products, improves model accuracy, spatial resolution, source attribution – if data are managed, labelled well.

Emission Inventories: Based on activities data (essentially economic data) & emissions factors. Observed concentrations can be used in some cases. Combos ideal. Higher spatial, temporal granularity of emission inventories improves attribution, estimation.

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INFORMATION & ANALYTICS - CONTEXT

Pollution Control Board Data is not adequate to assess pollution or its sources.

- 731 stations vs 4000 (estimated) required under CPCB guidelines.
- Most stations only monitor PM10, SOx, NOx.
- Less than 50% also monitor PM2.5
- Only 15 (2%) monitor full set of criteria pollutants including ozone.
- Mostly urban siting, limited reference monitors.
- Delays in collation and reporting from manual monitors.
- Data quality concerns related to siting, operation of monitors, calibration.

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INFORMATION & ANALYTICS - CONTEXT
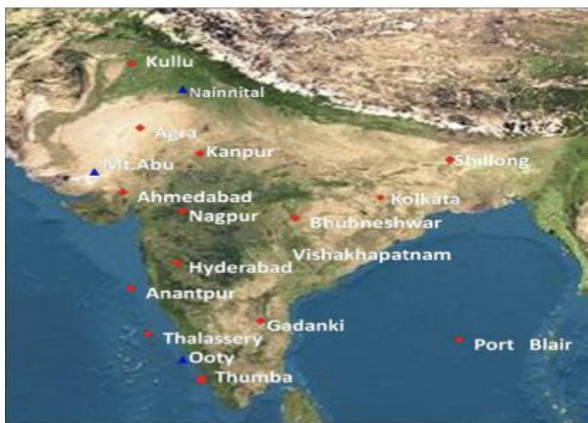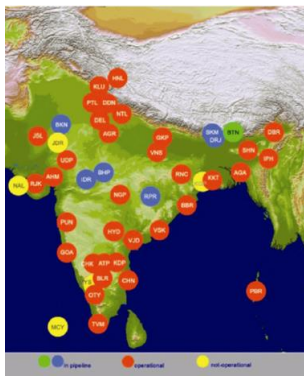
But there's more to work with.

- SAFAR – high resolution data and forecasts for Mumbai, Pune, Delhi, Ahmedabad. (MoES)

- ARFINET – aerosol measurements across India & surrounding ocean (ISRO)

- AT-CTM – ozone & trace gases (ISRO)

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INFORMATION & ANALYTICS - CONTEXT

Pollutants	Location	Nature of site	Reference
O3, CO, NOx, SO2, PM2.5, PM10, CO2, CH4, NH3, N2O, 75 VOCs, BC	IISER Mohali, Punjab	Suburban	Sinha et al., 2014
O3, CO, NOx, PM2.5, PM10, BC	Aries Nainital	High altitude	Sarangi et al., 2014; Dumka & Kaskoutis, 2014
CO, CO2, CH4, SF6, N2O, BC	Hanle Pondicherry Port Blair	High altitude coastal coastal	Lin et al., 2015; Nair et al., 2013
O3, SO2, NOx, CO, PM2.5, PM10, BC	Kullu	Semi-urban	Sharma et al., 2013
O3, CO, CH4	Pantnagar	Rural	Ojha et al., 2012
O3, NH3, NOx, SO2, CO, CH4	Delhi	Urban	Sharma et al., 2010
O3, NOx, CO, SO2, PM2.5, PM10	Agra	Suburban	Singla et al., 2011
O3, CO, NOx, SO2, aerosol chemical composition	IIT Kanpur	Urban	Gaur et al., 2014; Chakraborty et al., 2015
O3, NOx, CO, PM2.5, PM10, BC	Dibrugarh University	Urban	Bhuyan et al., 2014; Patak et al., 2013
O3	Kolkata	Urban	Ghosh et al., 2013
O3	Bubaneshwar	Urban	Mahapatra et al., 2014
O3, CH4, CO, CO2, VOCs	PRL Ahmedabad	Urban	Naja & Lal, 1996; Lal et al., 2014; Chandra et al., 2019
O3, CO, NOx, PM2.5, PM10	Udaipur	Semi-urban	Yadav et al., 2014
O3, NOx, CO, PM2.5, PM10, BC, C2-C5 VOC's	Hyderabad	Urban	Venkanna et al., 2015; Badarinath et al., 2007
O3, NOx, CO, PM2.5, PM10, BC	Anantapur	Rural	Reddy et al., 2012
O3, NOx, CO, PM2.5, PM10, BC	Gadanki	Rural	Renuka et al., 2014
O3, NOx, PM10, PM2.5, CH4	Kannur	Rural/coastal	Nishanth et al., 2014

Emissions Inventories

Emissions

$$E = A \times EF$$

Emissions Factor

Activity

- No official, open, high resolution, EI with national coverage.

- Inconsistent use of available activity data.

- No systematic review of EF availability & local relevance.

INFORMATION & ANALYTICS - CONTEXT

Emissions

$$E = A \times EF$$

Emissions
Factor

Activity

But there's more to work with

- At least two new initiatives underway: TERI, National Carbonaceous Aerosol (MoEFCC, IIT-B lead)
- Much potential for innovation in data sourcing for activities: private sector, marketing, digital economy data, remote sensing.
- Scope for improvement in EF by looking beyond EPA/regulatory EF.

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3 PRIORITIES

1. Airshed governance
   - Metropolitan NCAP, Indo-Gangetic Plains Authority

2. PPP for AQ MIS:
   - MoES + MoEFCC + NCAP NKN + more

3. Outcome-based AQ Mission
   - AQ as objective for integrating across sector/geography

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AIRSHED GOVERNANCE – IGP-AQMD

	LRTAP	IGP - AQMD
Executive Body *Biannual workplan, budget*	Representatives of signatory countries	State representatives/Chief Secretaries
Funding Source	Country contributions	National allocation
Technical Support	Working groups, European Monitoring and Evaluation Program (EMEP), Task Force on Emissions Inventories, Projections	CPCB, Regional centers of excellence, MoES, MoEFCC
Social Returns	Working Group on Effects	Ministries of Agriculture, Health, Labor, MoEFCC
Implementation	Implementation Committee	NITI Aayog/CPCB
Enforcement	No formal sanctions, commitments and achievements reported to public.	Judiciary? Incentive grants?

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Thank You

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WRI STRATEGY

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START WITH CITIES

City Clean
Air
Accelerator

- Where the most of the health impact hits.
- Where the problem is most visible.
- Where the demand is growing.
- And where, ultimately, the recipe for change gets specific and actionable.

ELIMINATE THE "SORT OF'S"

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(CITY) CLEAN AIR CAPABILITIES

Knowing the Air

- What's in the air?
- Where did it come from?

Making the Case for Clean Air

- Health and other impact assessment of policy and investment choices
- Communications and outreach

Integrated Strategy

- Feasible, integrate, politically viable plans for reducing multiple types of emissions
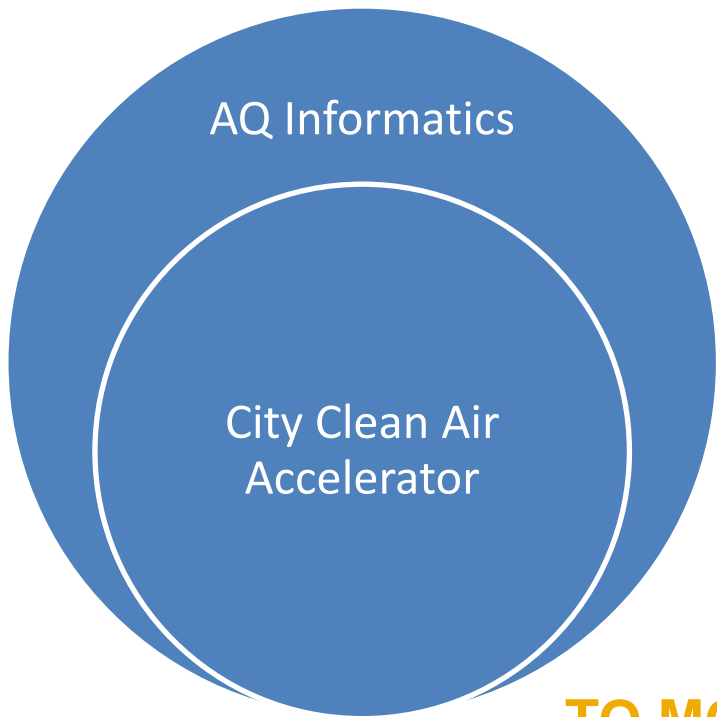
Integrated Implementation

- Coordinating and tracking effectiveness across sectors and geography

Governance, Policy, Diplomacy

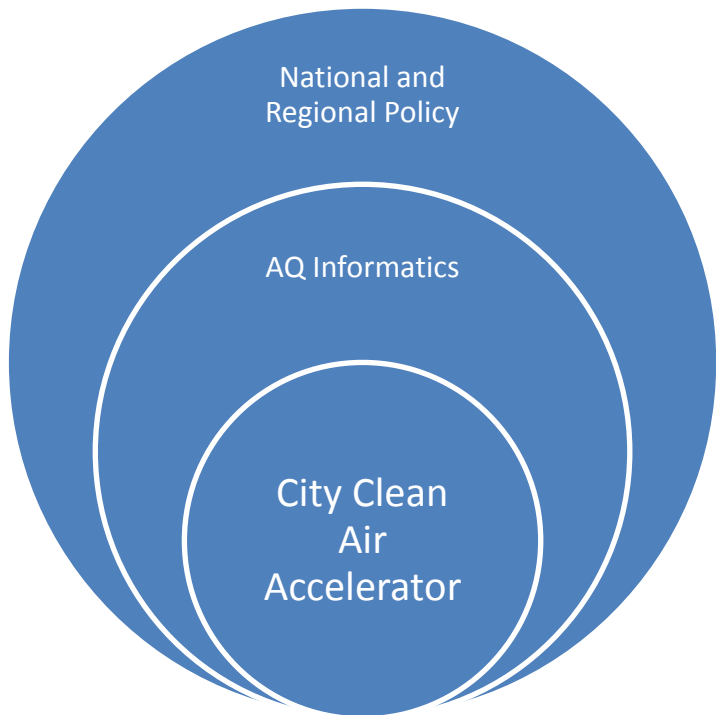- Working with other levels of government, neighbors, stakeholders.

GET THEM (AND OTHERS) THE TOOLS THEY NEED

AQ Informatics

City Clean Air Accelerator

- Data and science help make the problem personal, and the real solutions visible.
- In order to produce this evidence at scale, we need to accelerate & connect science innovation to social dynamics: policy, advocacy, markets.
- How? (we think)
  - AQ Data Cooperative
  - Clean Air Collaboratory
  - "Do What Only You Can Do"

TO MOTIVATE AND ENABLE EFFECTIVE ACTION

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AND PAVE THE WAY FOR SCALE

National and Regional Policy

AQ Informatics

City Clean Air Accelerator

Cities need help from national governments to clean up airsheds, and national governments sometimes need help from their neighbors.

- National investment policies for energy, urbanization, agriculture, and other sectors matter.
- International agreements can help increase national ambition.
- Treaties can help effective joint management of international airsheds.

BY CREATING AN ENABLING NATIONAL AND INTERNATIONAL POLICY ENVIRONMENT

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