

India Emissions: Evaluating Contribution of Household Energy Consumption to Ambient Air Pollution & Health Impacts

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PM_{2.5} POLLUTION in INDIA 1998 vs. 2014



Gridded PM_{2.5} data is constructed by combining data from satellite retrievals and a 3D global chemical transport model, and subsequently calibrated with available ground-based observations

(Source: Dalhousie University - http://fizz.phys.dal.ca/~atmos/martin/?page_id=140)

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trends and apportionments









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Global Burden of Disease Estimates for India





Bengaluru, Karnataka



Meteorology at fine resolution from WRF (driven by NCEP fields) Dispersion modeling via CAMx chemical transport model



Patna, Bihar



Meteorology at fine resolution from WRF (driven by NCEP fields) Dispersion modeling via CAMx chemical transport model



Clean Fuel Gap





Kirk Smith



often underestimated – various reasons first being lack of enough understanding

Global inventories (GAINS → HTAP) Urban inventories

National scale inventory gridded, with a district level base

Four sub-categories Cooking Water heating Space heating Lighting



Overview of the methodology and the databases assembled for this analysis











URBAN emissions .info Each grid is tagged with overlapping district and state code Intersecting grids are tagged multiple times, based on the overlapping district area



Each grid is tagged urban or rural, based on the identified built-up area (database downloaded from U.of.Wisconsin SAGE program)





Grid level population data is obtained from CEISEN GRUMP and Landscan 2013 and adjusted to the Census 2011 levels at the state level (district to grid area overlaps was used for intersections)



For each district, CENSUS 2011 provides share of HH's using different fuels – segregated into urban/rural areas and inside/outside cooking



an example of the census file <u>http://www.censusindia.gov.in/DigitalLibrary/Tables.aspx</u>

cooking category – HH10

fuel classifications

Firewood, crop residue, cow dung, coal or charcoal, kerosene, LPG, biogas, electricity, and others

cooking classifications cooking inside the house, cooking outside the house, and no cooking

> regional classifications rural vs. urban areas within the district



Per capita "useful" energy per year





Source: NSSO

URBAN emissions

.info

estimated based on the cooking patterns at the state level, reported by the national sample survey (NSSO) data



Emissions by pollutant @ grid level = population @ grid level (with district intersections) * per capita "useful" energy per year * share of fuels in the district (with inside/outside cooking and rural/urban tags) * heat efficiency of stoves by fuel type (averaged) * rural/urban tag @ grid level * emission factor by pollutant



an example of the census file http://www.censusindia.gov.in/DigitalLibrary/Tables.aspx

lighting category – HH7

fuel classifications kerosene, electricity, solar, others

regional classifications rural vs. urban areas within the district



an example of the census file <u>http://www.censusindia.gov.in/DigitalLibrary/Tables.aspx</u>

heating category – HH10

fuel classifications

Firewood, crop residue, cow dung, coal or charcoal, kerosene, LPG, biogas, electricity, and others

regional classifications rural vs. urban areas within the district





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an example of the census file http://www.censusindia.gov.in/DigitalLibrary/Tables.aspx

population clause - C-14

regional classifications rural vs. urban areas within the district

age classifications 1yr and 5yr groups within the district



national residential cooking energy share

2011-12



kerosene and LPG sales matched (MoPNG statistics report) details available @ grid, district, state, and national (shown above) level



Ujjwala's big footprint

Uttar Pradesh leads the states, with maximum LPG connections given under the Ujjwala scheme. Although Ujjwala has covered all states, prominent LPG distribution has taken place in 15 states



Target of 50 million new connections by 2019

national residential cooking energy share

2011-12

2016-17



kerosene and LPG sales matched (MoPNG statistics report) details available @ grid, district, state, and national (shown above) level



national residential cooking emissions



national residential share to ambient PM2.5





District wise reports @ www.indiaairquality.info

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



20

GLOBAL ALLIANCE FOR

CLEAN COOKSTOVES

\$3

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.



29.6%

32.7%



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

WRF-CAMx models)

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 agedependen trelative risk functions detailed in the Global Burden of Disease study (2013) and dispersion modeling results from this study. The final calculation swere 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
 10 - 13

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

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







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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
1	5 5

Emissions and Dispension Modeling Schematic

Raw Data

Gridded

Emissions

Ambient

PM2.5

Population by urban/rural

age group classes (Census) Fuel us e patterns (Census) Energy us e (Nation al Surve

Emission factors by fuel

(biomass, cow dung, coal, kerose ne, gas, and o thers) for each class (CK, LG, SH,

Meteorology from WRF using

29.6%

16.2%

NCEP Reanalysis data CAM x dispension modellin

tive maps GIS Urban built-up map

GIS adm

and WHI

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

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Emissions - Household Cooking & Heating

The global burden of disease assessments, listed outdoor air pollution among the top 10 health risks in India. The study estimated 695,000 premature deaths and loss of 18.2 million healthy life years due to outdoor PM2.5 and ozone pollution for year 2010-11. Among the health risk factors studied, outdoor air pollution was ranked 5th in mortality and 7th in overall health burden in India. Household (indoor) air pollution from burning of solid fuels was responsible for an additional one million premature deaths. The issue of household energy consumption (HEC) and its contribution to indoor and outdoor air pollution is critical to India, because of the high magnitude of population exposed to such pollution every day.

With that in mind, the HEC was studied in detail, to estimate its contribution to the ambient air pollution via source modeling approach – emissions and dispersion modeling. The HEC emissions are broken down into four categories (a) cooking (b) lighting (c) space heating and (d) water heating. The emission factors for the fuel categories are obtained from studies collated by the Indian Institute of Technology Bombay, Mumbai. No new lab tests for the emission factors or surveys to ascertain the HEC patterns were conducted. A summary report for each of the 640 districts can be viewed below (and download the same as a pdf document by clicking it). The summary sheet includes information from census-India on share of cooking fuels in use, total





Understanding Household Energy

- More understanding on fuel consumption patterns
- More resources for space heating
- More resources of ambient monitoring urban and rural
- More support for ground truthing emissions and exposure





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