The Health Impacts of Coal-Fired Power Plants in India and the Co-benefits of GHG Reductions

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Motivation

- Coal-fired power plants in India are a major source of GHG emissions and local air pollution
  - In 2015, one-third of India's GHG emissions due to coal-fired electricity generation
  - Coal-fired power plants are a major source of PM2.5 in North and Central India
- Coal-fired power plants are expanding
  - 208 GW of installed capacity in 2018, 95 GW in planning stages as of 2019
- What would be the benefits in terms of CO2 and reduced mortality from PM2.5 of not building planned plants?
- What is the tax on electricity generation from coal that internalizes the health damages?

Our Approach

- Model impacts of current and planned coal-fired power plants on ambient PM2.5 and CO2
  - Construct emissions factors for each plant operating in 2018 and in the planning stages in 2019
  - Add to 2018 baseline emissions inventory for India
  - Model ambient PM2.5 at a 0.25 x 0.25 resolution; calculate plant CO2 emissions
- Use exposure-response functions from 2019 GBD to estimate mortality impacts of PM2.5
- Calculate premature mortality and CO2 emissions avoided by not building planned plants
- Monetize health damages from current plants to estimate a health tax; compare with CO2 taxes

Preview of Results

- Not building planned plants saves 500 million tons of CO2e and 19,000 lives per year
  - Over lifetime of the plants between 840,000 and 1.5 million lives saved
- 78,000 deaths associated with currently operating plants
  - Using a VSL of Rs. 10,300,000, the health tax on coal-fired electricity = Rs. 738/Mwh
  - About the same as carbon tax = $10/ton CO2
  - Equal to 20% of cost of producing electricity
- This is a lower bound to local externality costs (ignores morbidity and impacts on agriculture and ecosystems)

Overview of the Indian Electricity Sector

- Coal-fired power plants (CPPs) generated 75% of electricity in India in 2018
  - Although they constitute only 56% of installed capacity
- Coal-fired generation capacity has expanded rapidly, doubling between 2008 and 2014
- Currently about 200 GW, with 95 GW in planning stages as of November 2019
- In 2018, 5 states in North and Central India accounted for 50% of installed coal-fired capacity
- Planned expansions are concentrated on the Eastern coast of India

Location of Current and Planned Plants

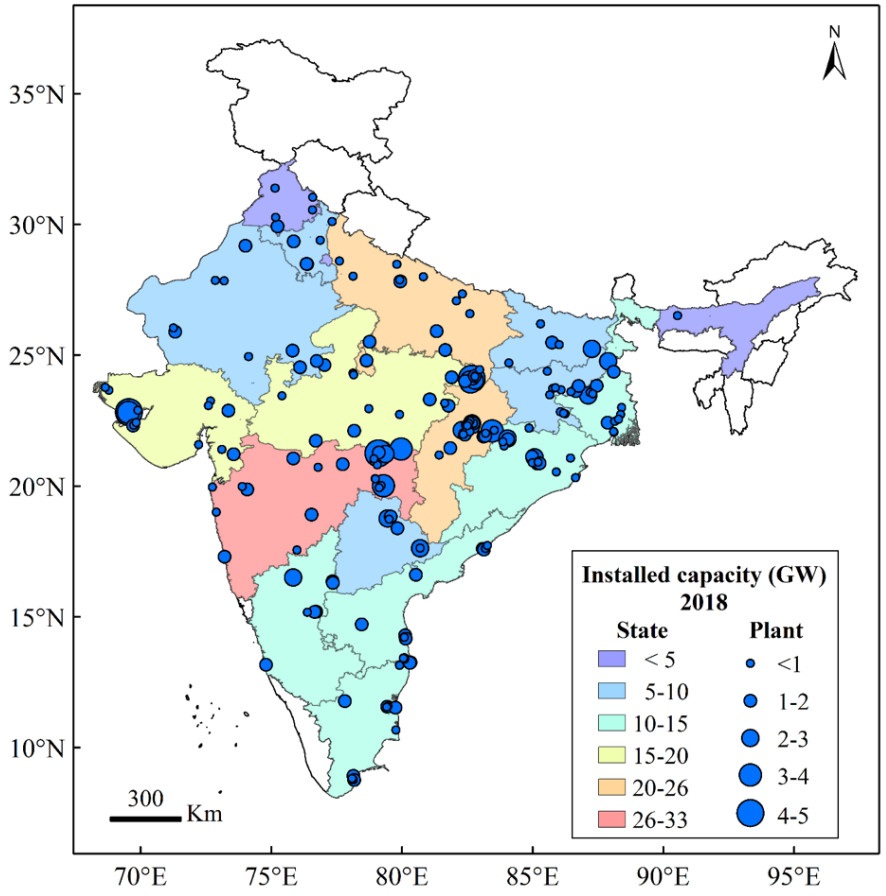


Fig. 1A. 2018 Plants

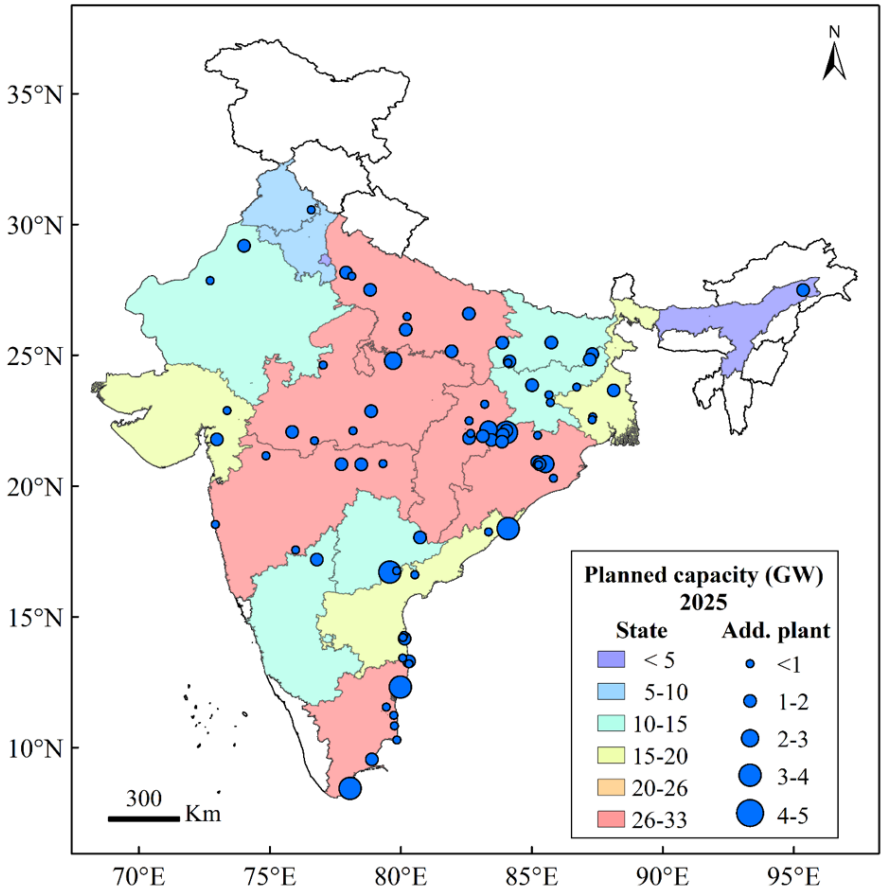


Fig. 1B. New Plants

Modeling Ambient PM2.5

- We estimate emissions of SO2, PM2.5 and NOx for each power plant in 2018, assuming a 60% plant load factor and actual pollution control equipment installed
- For planned plants we assume that pollution control equipment will mirror what is currently in use—not what is required by law—with plant load factor = 60%
  - Note: Dec. 2015 regulations, if implemented, would require scrubbers on new plants and would require retrofitting existing plants with FGDs
- Run CAMx 365 days with 2018 meteorology, at a resolution of 0.25x0.25 degrees
- Run 1: Emissions inventory for 2018 excluding TPPs (Ann. Avg. PM2.5 = 49 µg/m3)
- Run 2: Run 1 + 2018 TPPs (Ann. Avg. PM2.5 = 53.5 µg/m3)
- Run 3: Run 2 + Planned plants (Ann. Avg. PM2.5 = 55.9 µg/m3)

Impact of Plants on Ambient PM2.5

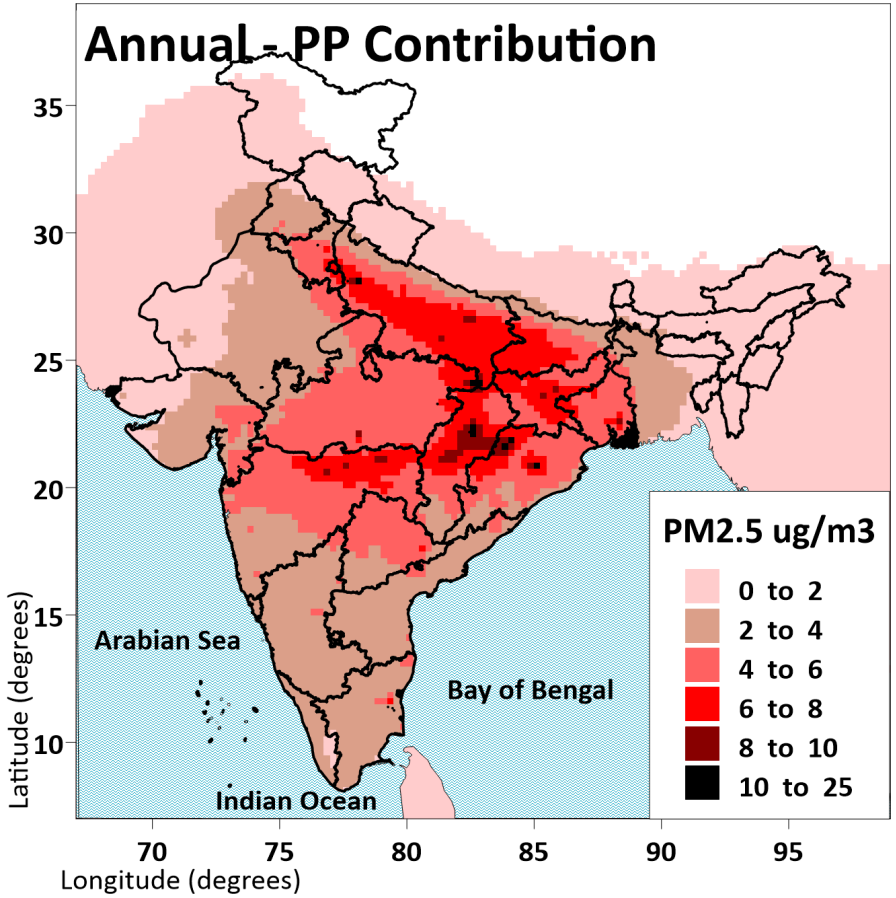


Figure 2A. Impact of 2018 Plants

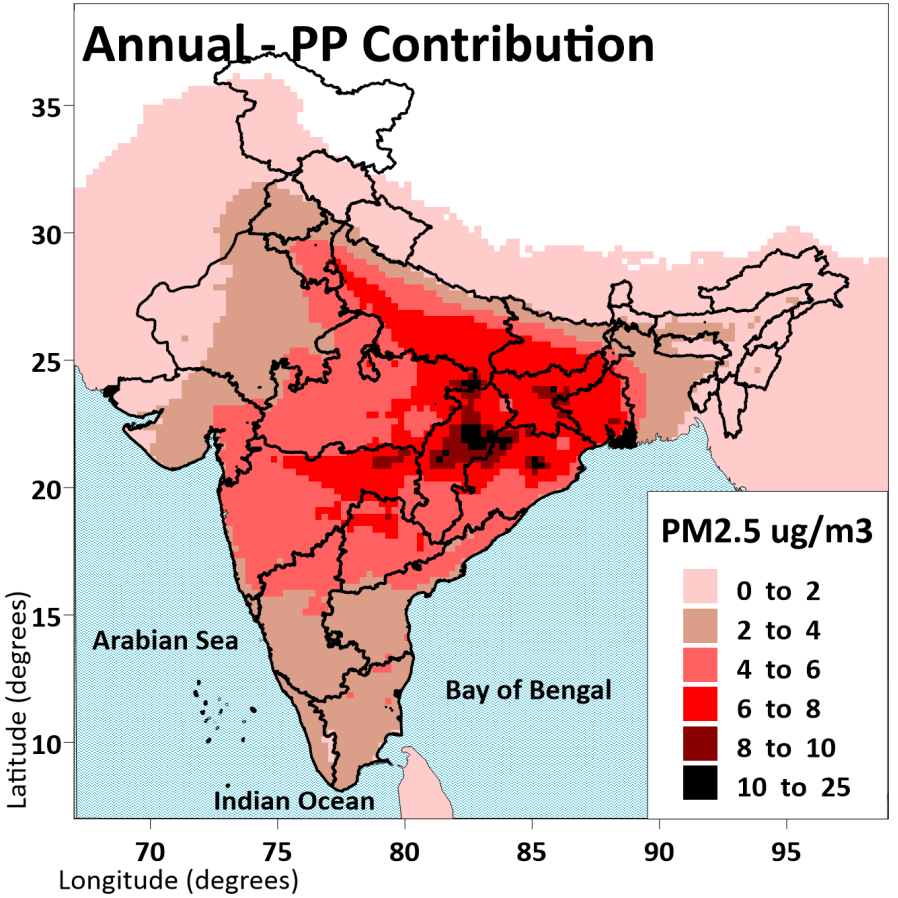


Figure 2B. Impact of 2018 Plants and New Plants

Calculation of Health Impacts

- Calculation of health impacts based on total exposure to PM2.5 = Ambient PM2.5 Exposure (AAP) + Household Exposure to Solid Fuels (HAP)
- We use the MR-BRTs from the 2019 GBD for IHD, Stroke, COPD, LRI, Type II Diabetes and Lung cancer—applied to each grid cell
- Deaths attributable to AAP = Total PM2.5 Deaths * [AAP/(AAP + HAP)]
- Deaths attributable to CPPs = AAP Deaths * Fraction of AAP due to CPPs
  - Treats CPPs as the average source of emissions
- **Deaths attributable to 2018 CPPs = 78,000 (9.2% of AAP deaths)**
- **Deaths attributable to 2018 CPPs plus planned plants = 112,000 (13% of AAP deaths)**

Deaths Attributable to Power Plants

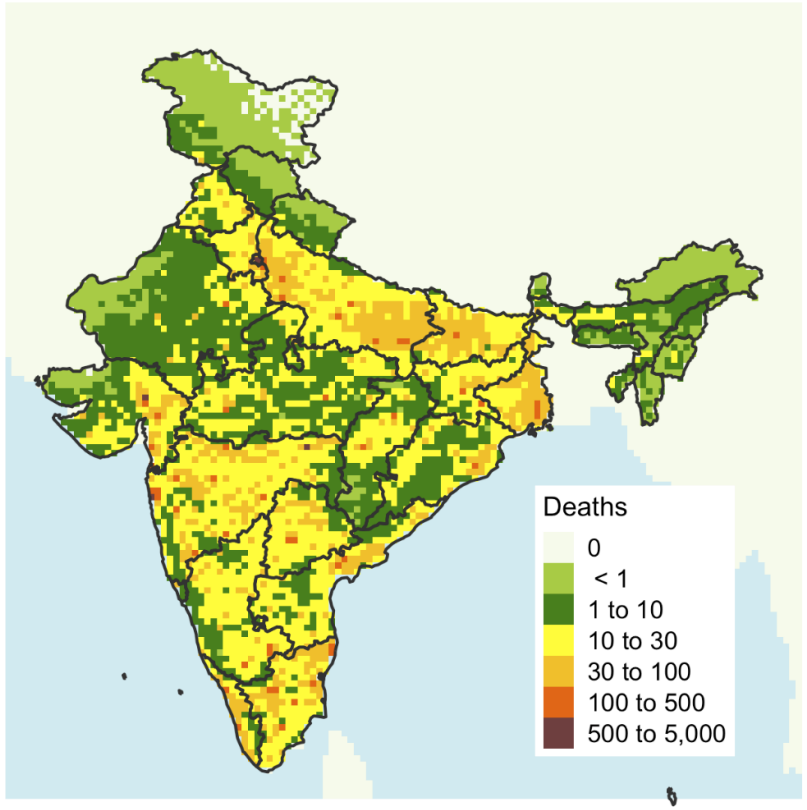


Figure 3A. Deaths Attributed to 2018 Power Plants

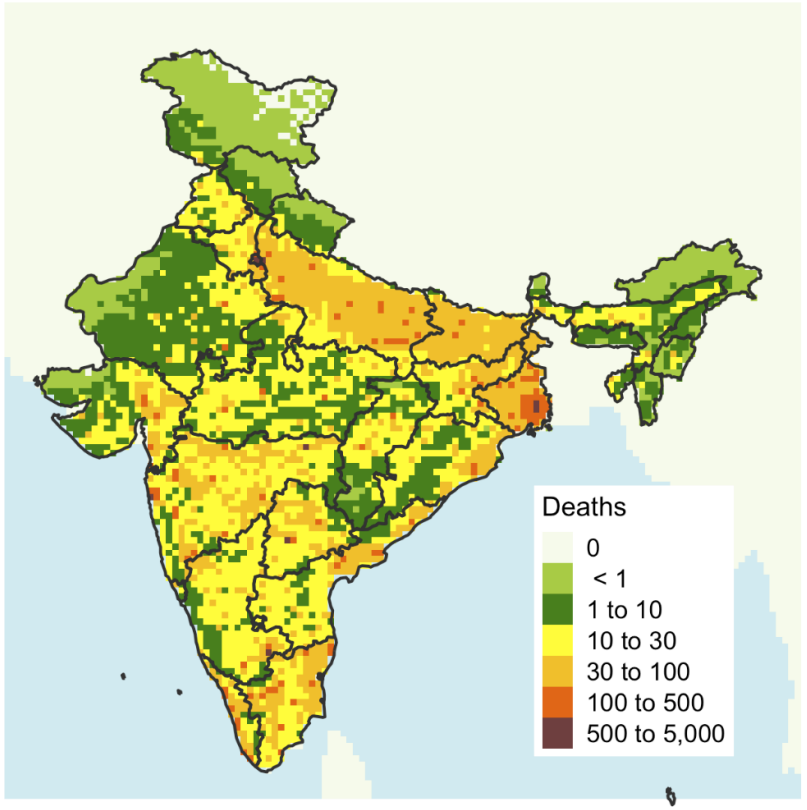


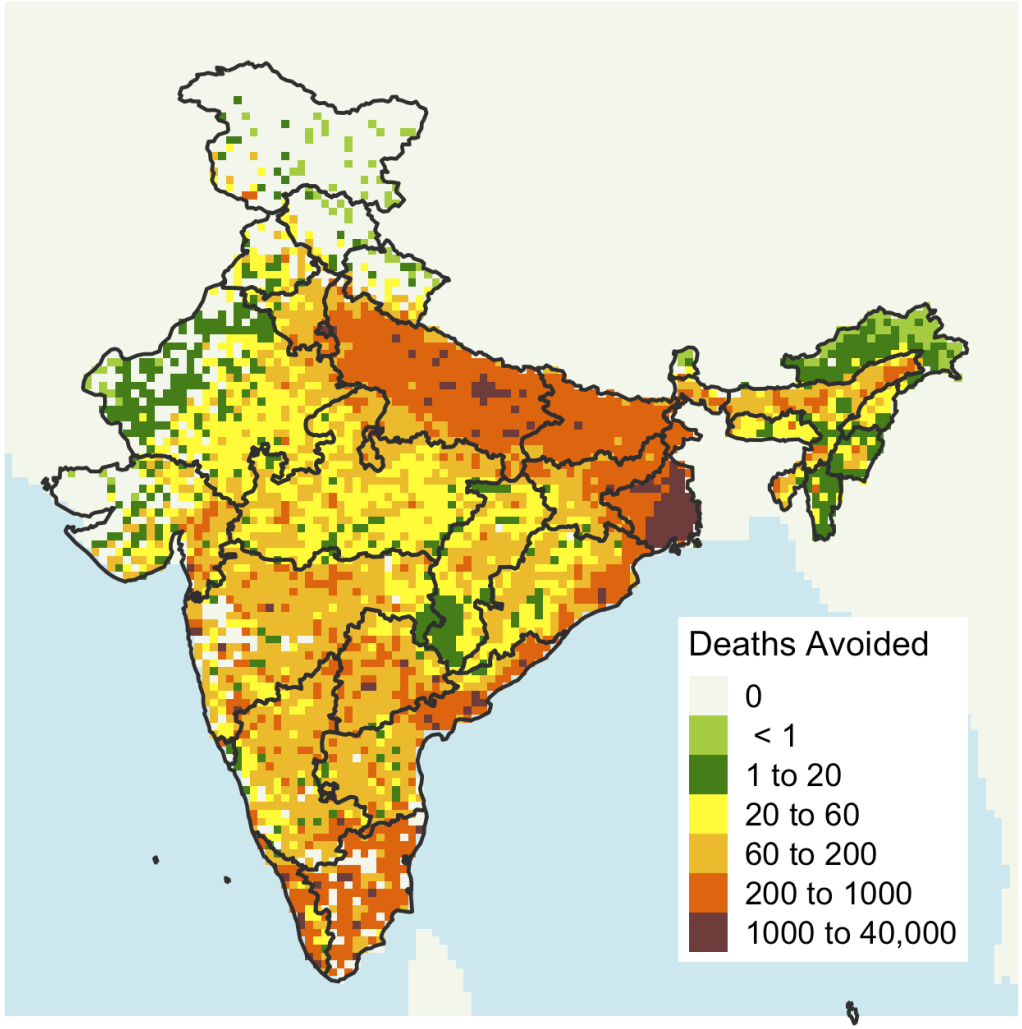
Figure 3B. Deaths Attributed to 2018 Plants and New Plants

Deaths Avoidable by Not Building Planned Plants

- Treat not building planned plants as a marginal decision—reducing concentrations of PM2.5 from the Run 3 baseline
- Due to concavity of exposure-response functions, deaths avoidable are much smaller than deaths attributable to planned plants:
- 34,000 deaths are attributable to planned plants
- 19,000 deaths are avoidable by not building planned plants
- Over 40-year plant lifetimes, deaths avoided will grow for two reasons:
  - Population growth
  - Reductions in HAP exposure (moves impacts of TPP toward the steeper part of the ER function)

Deaths Avoided by Not Building Planned Plants

- Deaths reflect population density and impact of planned CPPs on PM2.5
- 49% of deaths avoided are in Uttar Pradesh, Bihar and West Bengal
- Bihar and West Bengal have only 10 GW of planned capacity but are downwind from states with large increases in capacity
- States with 50% of planned CPPs account for 20% of deaths



Deaths Avoidable by Not Building New Plants, Assuming 40-Year Plant Life

Monetizing Deaths due to Current Plants

- To provide an incentive to switch to renewables, tax electricity from coal equal to value of local externalities—value of deaths attributable to CPPs a lower bound
- What VSL to use? Somanathan and Chakravarty recommend a VSL of Rs. 10,300,000 for 2018 (82 times per capita income in 2018)
- This leads to a tax per kWh of Rs. 0.74 (about one-fifth of the cost of a kWh)
- If use a VSL = 100 times per capita income, tax = Rs. 0.90 per kWh
- How does this compare with a carbon tax? A carbon tax of $10 per ton of CO2 = Rs. 0.72 per kWh

Conclusions and Caveats

- We find significant health impacts of current power plants on premature mortality associated with PM2.5 – 78,000 deaths annually.
- Although damages vary spatially, basing a health tax on average damages per kWh would be easier to implement, = Rs. 0.74-0.90/kWh depending on the VSL
- Not building planned plants would save 500 million tons of CO2e and, initially, about 19,000 lives per year
  - This could amount to 840,000 – 1.5 million lives over a 40-year plant life
- The co-benefits of switching from coal to renewables depend on pollution controls on coal-fired CPPs
  - About 70% of impacts on ambient PM2.5 could be eliminated by using FGDs and SCR