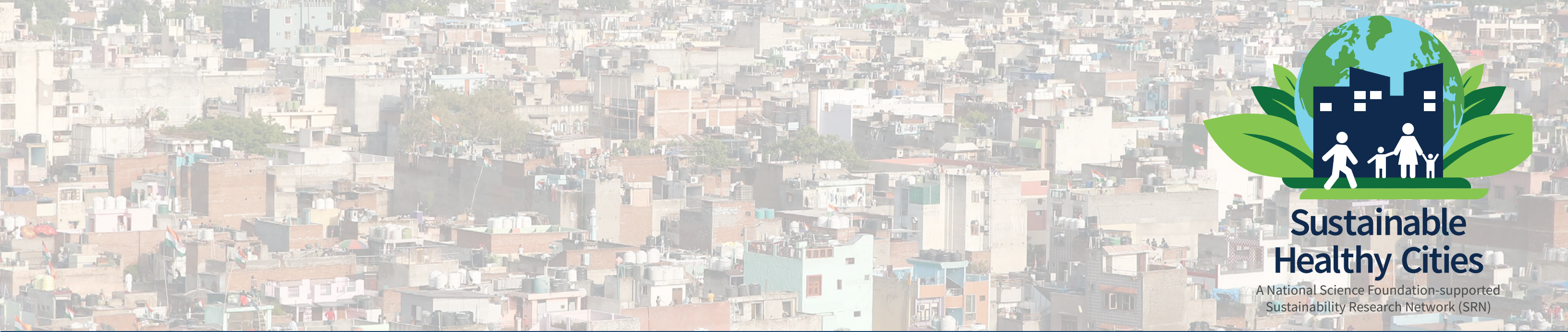

Designing equitable infrastructure interventions for carbon and air pollution mitigation in Indian cities

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This brief is adapted from a peer-reviewed journal article: Nagpure, A.S., Tong, K., & Ramaswami, A. (2022). Socially-differentiated urban metabolism methodology informs equity in coupled carbon-air pollution mitigation strategies: insights from three Indian cities. ***Environmental Research Letters***, 17(9). DOI: 10.1088/1748-9326/ac881e.

Study Intent and Research Question

Both greenhouse gas (GHG) and PM2.5 (small, inhalable particles) air pollution emissions create challenges for cities. Both can arise from multiple infrastructure sectors in cities, including fossil fuel use in mobility, power generation, cement production, etc. This paper asks three key research questions:

1) Who is responsible for these emissions, comparing **households across different income strata** with industries and business emissions? Do emissions come equally or unequally from different social groups?

2) Are there **infrastructure interventions that can simultaneously reduce GHG and PM2.5** emissions?

3) How can these **co-beneficial interventions** be designed to address **social equity**?

To answer these questions, researchers developed a new socially differentiated urban metabolism methodology that evaluates how much fuel, construction materials, electricity, is used, and associated pollution, generated by different sectors within cities: households stratified by income compared with businesses and industry.

A key innovation of this study is its focus on inequality within cities, combining inequality in income, infrastructure access and consumption, as well as air pollution and GHG emissions.

Key Findings

▶ ***GHG emissions:*** Households in the top 20% income group produced by far the largest amount of GHG emissions in all three cities, emitting three to six times as much as households in the lowest 20%.

▶ ***PM2.5 emissions:*** Households in the top 20% income group also contributed as much or more in-boundary PM2.5 emissions than either all commercial or all industrial emitters, in all three cities. For instance, Delhi's top-20% homes contributed 21% of in-boundary PM2.5 emissions, similar to industries in the city, which also contributed 21%.

▶ ***Sources of GHG emissions:*** Looking more closely at GHGs, households of different income levels were associated with different sources for the emissions. The top 20% income households produced the most emissions resulting from motorized transportation, electricity, and using construction materials (which have high embodied GHGs), while the homes in the lowest 20% income quintile produced the most emissions stemming from biomass and kerosene use (though overall, these households' emissions were much lower).

▶ ***Co-beneficial interventions:*** Across all three cities, only three infrastructure interventions simultaneously yielded >2% GHG and > 2.5% of PM2.5 emissions reductions: modest 10% efficiency improvements among top-20% households, industry, and commercial sectors; phasing out all biomass and kerosene use within cities; and replacing gas and diesel vehicles with renewable electric vehicles. Given the unequal patterns of emissions, each of these co-beneficial policies can be designed for equity, discussed next.

Policy and Practice Implications

Policymakers should implement the differentiated urban metabolism approach based on data for each city to identify the co-beneficial strategies for PM2.5 and GHG mitigation, and use the inequality data to design equitable, low-carbon clean air infrastructure interventions.

For example, equitable policies can address the high emissions produced by highest income households through increasing electricity block rates and behavior nudging, while subsidizing low-income households to switch to clean cooking fuels. Specific examples in the three cities in India include:

- ***Prioritizing free/subsidized clean cooking fuels*** to the lowest income homes.
- ***Increasing*** electricity block rates and behavioral nudging for wealthiest homes
- ***Prioritizing electrification of mass transit*** and promoting electric two-wheelers ahead of providing subsidies for electric cars (avoiding the free-rider phenomenon that can otherwise occur, which benefits wealthiest homes)

Background Information

Researchers developed a methodology called ***differentiated urban metabolic accounting*** to evaluate household ownership of different assets; the use of fuel, electricity, and construction materials; and associated emissions; by households from different income strata, compared to businesses and industries.

The study computed direct in-boundary PM2.5 emissions relevant to local air pollution (within the geographic boundary of the city, also known as in-boundary). For GHGs, which have global impact, the study computed transboundary emissions, including Scope 1 (direct territorial emissions) and supply chain emissions associated with producing electricity, cement, and fuels used by homes, businesses, and industries within the city (Scope 2 + Scope 3).

Researchers fused multiple databases from the government, including the National Sample Survey, the Census, City Statistical Abstracts, and the Annual Survey of Industries.

The three cities represented municipalities of different population size, household income, and levels of basic infrastructure services (such as provision of clean water and cooking fuels), giving this case study broad relevance and applicability to other cities in the future.

Further Reading and References

United Nations Environment (2018). Sustainable urban infrastructure transitions in the ASEAN region: A resource perspective Summary for Policy Makers. Ed. A. Ramaswami, S. Tabory, A. McFarlane & R. Pelton. https://wedocs.unep.org/handle/20.500.11822/31583.

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About the Sustainable Healthy Cities Network

The Sustainable Healthy Cities Network is a U.S. National Science Foundation-supported sustainability research network focused on the scientific advancement of integrated urban infrastructure solutions for environmentally sustainable, healthy, and livable cities. We are a network of scientists, industry leaders, and policy partners committed to building better cities through innovations in infrastructure design, technology, and policy. SHCN connects nine research universities, major metropolitan cities in the U.S. and India, and infrastructure firms and policy groups to bridge research and education with concrete action in cities.