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Title: The Greenness of Pakistani Cities 2004-2014: Urban Growth and Household Carbon Emissions

This study provides the first empirical estimates of carbon emissions and emission changes from 2005 to 2014 for all Pakistani cities using nationwide household survey data. This deepens our understanding of the linkage between development and climate change, especially the carbon footprint of urban development in developing countries, which often lack effective urban environmental policies or abatement technologies.

Pakistan is the sixth-most populated country in the world and has the highest population growth rate and urbanization level of all South Asian countries. The United Nations estimates that half of Pakistan's population will live in urban areas by 2030-approximately 60 million Pakistanis will move from rural areas to cities over the next decade. Although the environmental impacts and carbon footprint of urban growth has been explored for the United States, Australia, China, and India, those studies rely on a single year's data and thus only provide a snapshot of the "greenness" of cities. By relying on four rounds of nationwide household surveys spanning over a decade, we uncover dynamic linkages between climate footprint and rapid urbanization, migration and income growth, and technological improvements in abatement technologies. Following Glaeser and Kahn (2010), we estimate and predict bi-annual carbon emissions for household-level energy consumption and waste generation in each district of Pakistan. We then rank all districts based on the representative households' carbon emissions by energy types, and examine the drivers of changes in the greenness of urban growth for different districts. We find that emissions for rural districts decline with less use of firewood, yet emissions for mega-cities rebounded recently. Our results reveal that omitting household waste leads to an underestimate of the urban carbon footprint by about 10%. We also show that 20% of districts experienced changes in their respective greenness ranking over the past decade.

We provide the first analysis on how changes in urban growth patterns result in different trajectories of greenhouse gas emissions using Pakistani data. This showcases the need for more research in development and climate change in developing countries, especially those facing unprecedented population growth in cities, greater climate risks, and lacking adequate mitigation strategies.