Working Paper 306

Reimagining India's Urban Future

A Framework for Securing High-Growth, Low-Carbon, Climate-Resilient Urban Development in India

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August 2015

INDIAN COUNCIL FOR RESEARCH ON INTERNATIONAL ECONOMIC RELATIONS

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Acknowledgements

The authors of this paper thank the Global Commission on the Economy and Climate for funding the project at ICRIER. We also acknowledge the funding received from the Rockefeller Foundation for the project on Climate Change and the Economic Competitiveness of Cities: Making the Business Case for Adaptation, which initiated city resilience and vulnerability work at ICRIER, and whose findings we draw on in this paper. We thank Rajat Kathuria for his support throughout the process. Feedback from Nick Godfrey, Phillip Rode, Nitin Pandit, GK Bhat, Om Mathur, and Angela Brammer on earlier versions of the paper is gratefully acknowledged. Valuable comments were received from participants at the April 14th, 2014, New Delhi workshop where the initial findings were presented. Contributions received from Eric Chu were very valuable.

Abstract

India is at the cusp of a major urban transition. In less than twenty years, India's urban population is expected to nearly double from 377 million today to over 600 million. Indian cities already contribute an estimated two-thirds of India's GDP, and this number is expected to rise to 75% by 2031. With 70% of all new jobs expected to come from urban areas, accommodating a growing urban workforce will require large investments in new urban spaces. How prepared is India to deal with this rapid, inevitable urban expansion? The evidence on the ground suggests that the costs of India's current pattern of urbanization are unsustainably high. Deep existing deficits in basic urban services such as housing, transit, water, sanitation and energy have led to a plethora of urban woes. These range from the economic, institutional and carbon costs of managing unplanned growth, congestion, poor quality of life, burgeoning slums and pollution levels that have come to threaten basic public health.

This paper reviews the current state of the literature on Indian urbanization to analyze existing urban development trajectories at the state level in order to understand the challenges Indian cities face as well as the opportunities available to them to adopt transformative urban processes that can foster inclusive economic growth that is also low-carbon. The paper explores the role of (urban) energy, multimodal transport, smart infrastructure, green buildings, water and urban finance to explore how and to what extent states are able to balance economic growth, urbanization and carbon emissions.

The paper argues that pathways of urbanization that can help India achieve its carbon commitments without compromising on growth are possible. A new growth model for Indian cities can be anchored around four core policy pillars: (1) promoting compact urban form centered on efficient public transport; (2) Reducing the energy intensity of urban industry; (3) investing in smart infrastructure, especially green buildings and resilient water networks; and (4) inducing innovation, especially in urban finance, mechanisms of urban inclusion (improving the quality of life and livelihoods of the urban poor) and institutions of governance and implementation.

JEL Classification: ***R1****- Municipality, Urban,* ***R11****- Regional Economic Activity: Growth, Development, Environmental Issues, and Changes,* ***R12****- Size and Spatial Distributions of Regional Economic Activity*

Key Words: *economic growth, urbanization, urban growth, spatial development, land use patterns, carbon emissions, urban infrastructure, mitigation options, adaptation, sustainable and inclusive growth, accessibility, urban resilience, municipal finance*

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Reimagining India's Urban Future

A Framework for Securing High-Growth, Low-Carbon, Climate-Resilient Urban Development in India

Meenu Tewari with Zeba Aziz, Mitchell Cook, Amrita Goldar, Indro Ray, Saon Ray, Sahana Roychowdhury and Vidhya Unnikrishnan*

I. INTRODUCTION: FRAMING INDIA's URBAN TURN

India is at the cusp of a major urban transition. By 2031, the number of people living in Indian cities is expected increase from 377 million today (31% of the total population) to over 600 million (~40%). India's urban centres already account for two-thirds of the country's Gross Domestic Product (GDP), over 90% of the national tax base, and the majority of non-agricultural jobs (HPEC Report 2011, McKinsey 2010, Census 2011). By 2031, India's cities are expected to contribute 75% of its GDP and generate 70% of all net new jobs created (HPEC Ahluwalia Report 2011, McKinsey Global Institute 2010). Estimates project that India will need new industrial towns, serviced land, jobs, and '700 to 800 million square miles of commercial and residential space over the next 20 years' to accommodate this growth, roughly equivalent to building a new Chicago every year (McKinsey Global Institute 2010, Balakrishnan 2014). Analysts similarly suggest that much of India's freight and transport networks and buildings that will exist by 2050 are yet to be built (McKinsey 2010, CSE 2011). The manner in which India manages this upcoming urban expansion will thus be critical in shaping its current and future growth paths.

How prepared are India's urban institutions to mange this growth and foster an urbanization process that is dynamic, inclusive, and sustainable? The evidence on the ground from India's current pattern of urban growth suggests that the challenge is sobering.

Severe infrastructural bottlenecks and deep deficits in levels of urban service delivery undercut India's urban productivity and economic performance (HPEC 2011, Government of India 12th Plan Document, World Bank 2010). There is a broad consensus that countries such as China and Brazil had much higher levels of urbanization when they were at India's current stage of economic development and that there are important positive feedback loops between urbanization, economic productivity, agglomeration economies and rates of growth (Desmet et al. 2013), that India is currently not adequately leveraging. India's urbanization is therefore lagging not only in terms of levels and quantity, but, crucially, also in terms of quality. The burden of unplanned urban growth, congestion, poor quality of services, strong negative externalities, and the failure to fully capitalize on the efficiencies of agglomeration not only

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degrade the quality of urban life today, but undermine investment and economic growth in the future.

Social inequality and spatial polarization in cities, both add to these deficits, and to urban vulnerability. Over 65 million people in India live in urban slums, up from 52 million in 2001. Nearly 45% of slum-dwelling households live with open drains, and a third have no access to any form of household sanitation (Census 2011). Of even greater concern is the fact that nearly half of slum dwellers (compared with 20% of all urban residents) burn kerosene or biomass-based cooking fuels (firewood, crop residue, coal, charcoal), that are not only harmful for air quality but seriously undermine human health (Ramachandra 2012 and NSSO 2009-10, Census of India 2011). Lacking clean water, transport and affordable housing, the urban poor already face strong odds in their struggle for a dignified life in India's cities; their vulnerability only adds to the overall vulnerability of India's urban and economic growth process.

India's urban expansion will have to be managed in the context of intensified competition over global resources—even shortages and rising prices—compounded by the risks of climate change and the global community's commitment to containing global warming within a 2-degree Celsius increase by the end of this century. Even though only 31% of India's population lives in urban areas, carbon emissions from urban sources already make up nearly half – 45% -- of India's total emissions (MoEF 2010). These urban emissions come from energy, buildings, cooking fuel, urban waste, transport and industry (MoEF 2010). Decisions concerning long-lived urban assets such as roads, water systems, transport infrastructure, housing, industry and commercial networks will have significant implications for the carbon footprint of India's urban growth and the risks of costly lock-ins, externalities and rising vulnerability. For example, current patterns of growth have led to a secular and cumulative increase of CO_2 stocks in the atmosphere that are not only exacerbating the stressors of climate change, but also narrowing planners' room to manoeuvre in the face of heightened uncertainty.

There is growing evidence that India is currently on an urban and economic growth path that is increasingly carbon and energy intensive (see our analysis of census data in Section III). Although India's overall emissions are low by international norms (1.5 mtCO2e per capita compared with China's ~9mtCO2e per capita), estimates show that India's environmental externalities already cost it 5.7% of GDP (Mani, World Bank 2012) and that urban pollution is the cause of an alarming number of premature deaths: 620,000 in 2010, up sixfold from 100,000 in 2001 (WHO Global Burden of Disease Report 2013). The Central Pollution Control Board in a recent survey found that only two of India's 148 largest cities have passable air quality and 13 of the 20 most polluted cities in the world are in India (Central Pollution Control Board 2011). World Bank estimates show that nearly half of particulate matter that harms public health could come from India's growing reliance on private vehicles for urban transport (World Bank 2012). Particulate matter from vehicular transport (most of it urban) not only worsens air quality in cities but also contributes nearly 8% to India's total carbon emissions (MoEF 2012).

Given these huge externalities, clearly, business as usual urbanization in India is unsustainable. It undermines growth and the quality of life, and is a drag on future growth. A more transformative, inclusive, and cost-effective urban strategy that is also low-carbon and climate resilient will be critical to India's continuing economic dynamism. The good news is that growing evidence from around the world suggests that leveraging the links between development and low carbon growth can generate significant co-benefits (Global Commission on the Economy and Climate 2014). The potential benefits of such a strategy include avoided lock-ins from poorly planned irreversible investments in high-carbon infrastructure, public health gains from better air quality, as well as mitigation and adaptation efforts, a more efficient building stock in the yet-to-be-built cities, economic gains from improved urban liveability, business investment and better access to jobs. Together, these outcomes can add up to gains that could far outweigh any costs incurred in adopting a more innovative, robust and resilient path to urban growth (IPCC Fifth Assessment, 2014).

The Indian government's two premier policy statements on development and the climate acknowledge these co-benefits and economic opportunities inherent in a more climate-conscious growth process. According to India's 12th Five Year Plan (2012-2017), the country's development goal is to achieve "faster, more inclusive and sustainable growth." (Government of India, 12th Plan 2011). The National Action Plan on Climate Change echoes this goal by advocating a development process that simultaneously advances India's climate objectives of mitigation, adaptation and maximization of co-benefits related to development and economic growth (NAPCC 2008). This articulation of development and climate goals in synergistic language is a good start and is supported by the pronouncements of the current government and its commitment to climate-sensitive economic development. But how can these objectives translate into a new model of resilient urban growth on the ground?

Based on a short review of plan documents, and innovative experiments underway in several cities, we argue that a high-growth, low-carbon, inclusive urban future is possible for India. However, strategic public policy choices will matter, especially in four main areas: (1) urban form and multimodal transport; (2) reductions in the energy intensity of urban industry; (3) adaptive and efficient infrastructure, particularly buildings, and water; and (4) innovation in urban finance. Equally critical will be the development of institutions, norms and incentives that can motivate – and empower – local governments and city managers to implement these strategies with support from state and central actors and civil society institutions.

The rest of the paper is organized into five sections. We first examine the current frontiers of urban growth—which are the places where the fastest urban growth is taking place—based on census data, with a view to identifying places where policy attention will most urgently be needed. In Section III we examine the choices that planners face with regard to emerging pathways of low carbon urban growth. In this section, we first discuss the link between urban growth and emissions in India, and then examine a set of state level urban, economic and carbon variables drawn from census data to understand interactions among economic growth, urbanization, and carbon in various states in India. This sets the stage for Section IV where we examine two key areas of policy where climate-aware urban planning and innovative

institutions that can make a difference to fostering a low carbon future. These areas are, urban form and efficient multimodal transport; and green infrastructure, particularly buildings. In Section V we examine how the urban model can be financed and the myriad associated challenges in that arena. Section VI concludes with reflections on a set of policy recommendations.

II. FRONTIERS OF URBAN GROWTH

Where is India's fastest urban growth taking place? The latest census data reveal that India's urban growth is taking place in and around 7935 towns and cities spread across the country. Among these, most of the growth is taking place in 468 Class I cities with a population of over 100,000 each. This is where 70% of India's urban population lives. Much of the future urban growth in India, however, will take place along four primary frontiers, sites that demand priority attention and investment to promote high-quality urban growth. We present these four broad classifications below while noting that there is tremendous variation within each category and each embodies its own carbon implications and policy challenges, requiring diverse and specific urban strategies on the ground.

1. **Secondary cities,** i.e., towns with populations between 1 and 5 million represent the first and fastest growing urban frontier in India at the moment. There are 53 million-plus cities in India, of which 45 fall into this category; the rest are first tier cities with population of 5-10 million; and three metros with populations over 10 million each. Between 2001 and 2011, secondary cities grew by 85 per cent, compared to cities in the 5-10 million category, which grew by 35 per cent, and the metros by 15 per cent. It is in these rapidly growing secondary cities where development decisions are being made everyday that the greatest potential exists for shaping a greener more innovative urban growth path.

2. The second frontier of growth is **the urban periphery,** areas adjacent to the country's large cities, beyond the purview of the city government, yet still undergoing rapid urbanization. In these in-between places agricultural land is being converted to retail, industry and large residential gated communities at a frenetic pace. In this regulatory grey zone, unserved by municipal water supply, power or public transport, we find some of the worst assaults on ground water; some of the most extensive use of polluting, diesel-generator sets and the heaviest reliance on vehicular transport. Even in some of the satellite townships that have sprung up adjacent to the large metros there is evidence of a deeply damaging urban trajectory. For example, the town of Faridabad located outside Delhi, sits besides the Yamuna River and yet relies almost entirely on piped ground water because pollution from untreated wastewater discharged by Delhi, located upstream, makes the river water prohibitively expensive to treat. Unless policy attention is focused on these areas to mitigate the costs of unplanned growth, unsustainable urbanization may get locked in. Such areas are associated with deteriorating natural resources, and are sites of large-scale construction that is hard to manage, energy inefficient and high-carbon.

3. The third frontier of urban growth is the **metros**, i.e., cities with a population of more than 10 million: Delhi, Mumbai and Kolkata. These three metros have seen a welcome slowdown in population growth rates over the past decade, growing by only 15% as a result of decongestion strategies implemented over the decade. However, given their aging building stock, they are now major frontiers for brownfield development and retrofitting of existing building stock, and urban redevelopment.

4. The fourth frontier of urban growth in India is the **census town,** a place with all the characteristics of a town but without the statutory status that endows it with municipal governance and an urban budget. This is akin to urbanization by stealth, or hidden urbanization, without the professional and financial resources needed to shape a more viable urban process. This labelling mismatch i.e., not calling a place with the size and scale of a town by that name simply because it lacks statutory status can have serious long-term implications for the cost, efficiency and effectiveness of providing services at the needed scale. Underinvestment in the necessary infrastructure undermines the quality of life and economic productivity of this incipient urbanization; it can also have negative carbon consequences if the under-served population resorts to costly self-provisioning (pollution-inducing diesel generators for power and private vehicles for transport). Between 2001 and 2011, of the 2,750 new towns that India added, 2,509 (91%) were census towns. If all the large villages that have all but one criteria of urbanization as defined by the Government of India were to be included, India's urbanization levels would be close to 50%, from the present 31% (Census of India 2011).

Part of the reason for this under-the-radar urbanization is linked to how development is currently financed in many states. In states like Bihar, for example, where the bulk of central funding is tied to the rural sector, census towns themselves refuse to accept the statutory label because it would mean cuts in funding. By contrast, states like Maharashtra and Tamil Nadu have added a large number of statutory towns over the years for a number of reasons but primarily because these states have stronger urban programs and funding lines that census towns and large villages would be interested in accessing.

The state of Kerala, which added the second largest number of census towns and the largest number of million-plus-population cities between 2001 and 2011, took a different approach. It essentially put a boundary around a set of proximate smaller towns to form larger urban agglomerations including million-plus cities. There could be several reasons for this – political as well as administrative – but one outcome of the aggregation is access urban renewal funding from the central government under the erstwhile Jawaharlal Nehru Urban Renewal Mission and the new Atal Mission for Rejuvenation and Urban Transformation (AMRUT).

The growth of census towns also suggests that India's urbanization is fuelled in large part by the growth of a locality's existing population and less so by migration. Until 2001, migration contributed only about 22% to urban growth—most cities grew as a result of boundary expansion and natural growth (2011 census' migration data are awaited and there may well

be a change in migration's contribute to current levels of urbanization). Programs like the Mahatma Gandhi Rural Employment Guarantee Scheme (MNREGS) which help create non-agricultural employment in villages and thereby slowing down outmigration may also be an important trigger for the densification of large villages. The quality of this densification and its economic and ecological outcomes will depend on the ability of these proto-urban places to access the resources and professional expertise they need to foster a more strategic and sustainable road to urbanization. This is likely to be predicated, in part, on their official recognition as towns, and their conversion from census towns to statutory status.

Besides these sites of rapid urban growth and land conversation and urban growth, the 12th Five Year Plan calls for the development of 100 "smart" cities to be developed with public and private funding either in green-field sites along the economic corridors planned along the Golden Quadrilateral, or as infill development in existing cities. This is where the government's current policy attention is focused and where some "eco-cities" might be built or other low-carbon urban experiments undertaken to serve as exemplars for others to learn from.

III. CHOICES PLANNERS FACE IN ADOPTING LOW-CARBON PATHWAYS TO URBAN GROWTH

Having outlined where India's fastest urban growth is taking place we turn to two questions: (i) what is the link between urban growth and emissions in India, and (ii) What is the evidence on how Indian cities and states are currently balancing economic growth, urbanization and carbon emissions. Indian cities can either follow a high-carbon pathway to growth, or look for ways to innovate on a low-carbon pathway of robust growth. At the heart of these outcomes and pathways are choices that planners will need to make regarding urban form, urban transport, smart infrastructure (particularly buildings) and innovation in finance.

We begin with a discussion of how India's economic and urban growth story is linked to its carbon emissions story.

The Link between Urban Growth and Emissions in India

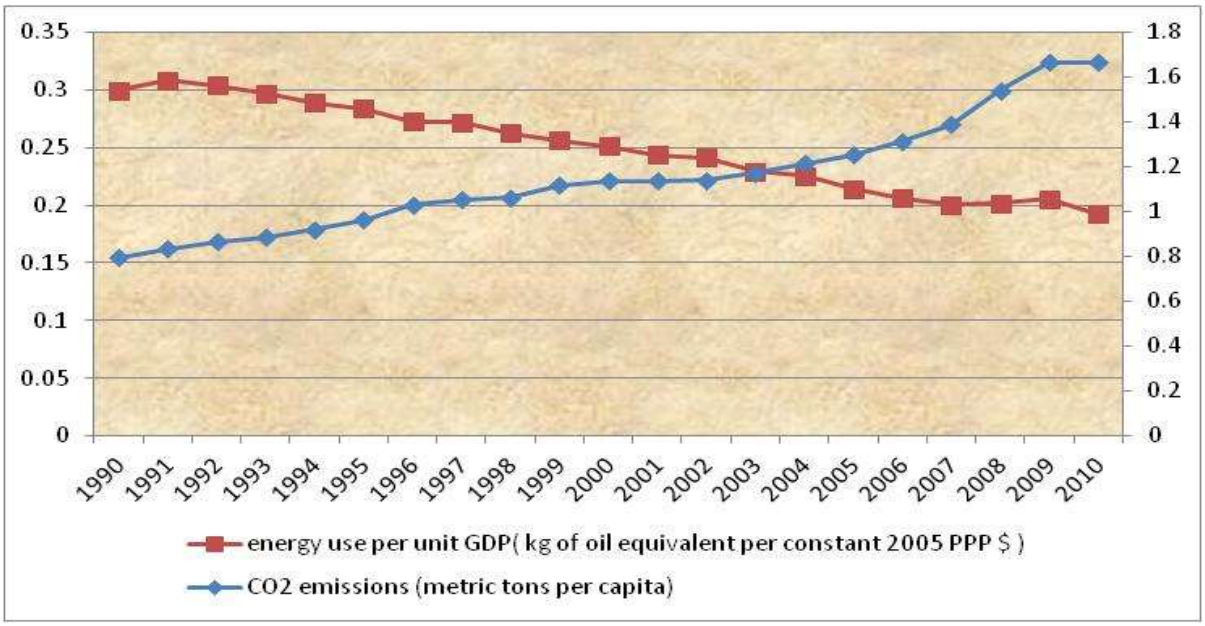
In 2007, India emitted 1,727.71 million tons of CO_2 eq. from energy, industrial processes, agriculture and waste (including emissions from land use, land use change and forestry, India's Second National Communication to the UNFCCC, MoEF 2012). This represented a 33 per cent increase over net greenhouse gas (GHG) emissions reported in 2000 (1,301.21 $mtCO_2$ eq.)[1] and a 41 per cent increase over emissions reported in 1994 (1,228.54 $mtCO_2$ eq., MoEF 2010). Current emissions stand approximately at 1.49 tons of CO_2 eq. per capita (MoEF 2012). After a slight decline between 1994 and 2000, per capita emissions rose by 22% between 2000 and 2007, while the total population grew by 11% during the same period (Pahuja et al. 2014).

[1] Or 1,523.8 $mtCO_2$ eq. excluding LULUCF emissions (NATCOM II, MoEF 2012).

Two points are noteworthy about the link between this emissions trajectory and India's growth objectives. First, as noted above, India's stated goal is to promote development while also simultaneously advancing its climate and emissions objectives (mitigation, adaptation and maximizing co-benefits). To this end, the government has made an explicit commitment of reducing the energy intensity of its GDP growth by 20-25% of 2005 levels by 2020. The 12th Five Year Plan is thus organized around the goal of ensuring faster, more inclusive, sustainable growth. Institutionally, the National Action Plan on Climate Change, (NAPCC, adopted in 2008) and the various missions and organizational networks it sets up, is the cornerstone of India's climate planning mechanism that is expected to help convert its climate commitments into reality through innovation, technical change, pricing, governance, demand management, and the building and the dissemination of knowledge, new ideas and new approaches.

Second, it is important to note that India's current commitment is to a decoupling of growth from emissions and not necessarily reductions in absolute levels. A mapping of India's energy intensity over time shows that a steady decline has occurred over time through access to better technologies, higher fuel prices, greater consumer awareness and the adoption of progressively stricter product and fuel standards (among other things). Recent estimates show that while India's GDP increased by 140% between 1994 and 2007, GHG emissions intensity (emissions per unit of GDP) declined by nearly 20% during the same period, reversing an earlier trend (Pahuja et al. 2014). The decline occurred even as the energy consumption and emissions per capita rose (See Figure 1). This shows that the decoupling process between emissions (per capita) and growth (energy ktoe/unit of GDP) has already begun.

Figure 1: Energy intensity and emissions per capita trends for India



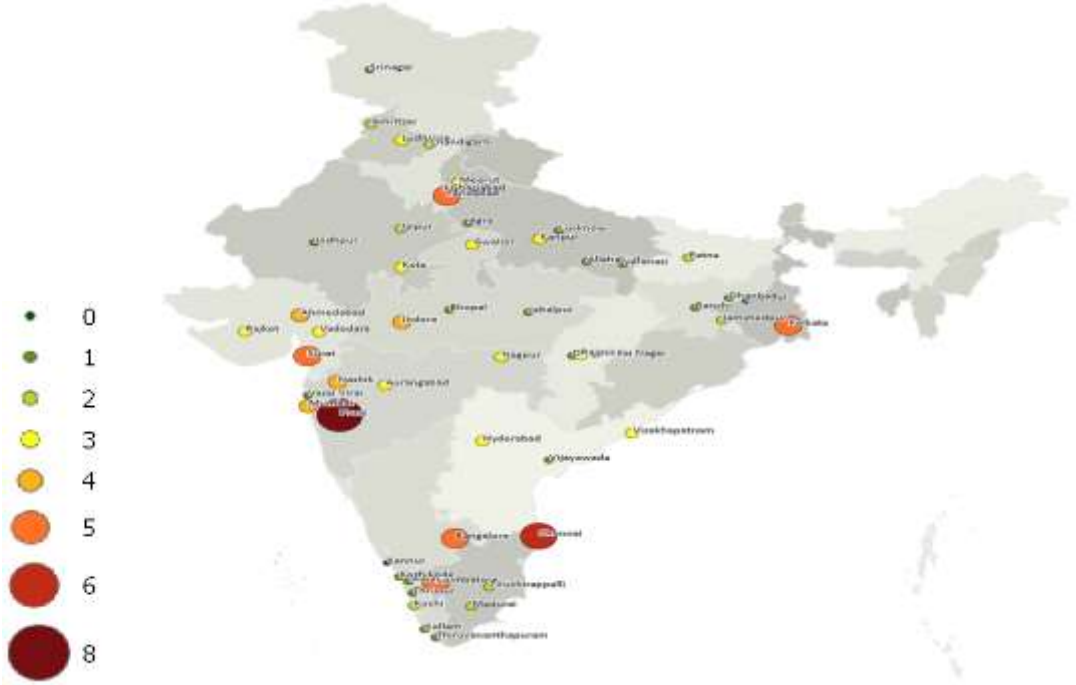
***Source**: Pahuja et al. 2014.*

Sources of Urban Emissions in India

A comparison of the government's 1994 and 2007 data on the sources of emissions shows that roughly 45% of India's total emissions have urban origins. In order of magnitude, these include industry (including cement, iron and steel, energy and other manufacturing), which generates the most emissions, a total of ~27 per cent; the transport sector, which generates nearly 8 per cent of total emissions; buildings (7.2 per cent) and waste (3 per cent). Besides these sectors, the power generation and distribution sector generates 38 per cent of total emissions, and a significant amount of power is produced and consumed in urban settings, thus pushing the total emissions that have urban origins even higher than the 45 per cent attributed to urban areas more directly. As India's urban growth escalates, and as large numbers of middle class consumers are added to the urban mix in the coming decades, the consumption of energy-consuming appliances and assets (vehicles, homes, appliances) will only grow. Consequently urban emissions will grow. To reduce India's carbon emissions, reducing emissions in the urban sector will be key.

A very important determining factor for energy consumption (and emissions) in urban areas is their geographical location as well as the location of energy intensive industries. India has high geographical variation and its cities are spread across all the 15 agro-climatic zones of India. But the intensity of energy-intensive industry mix varies. Given India's pattern of growth by accretion on and around its metros and larger cities, energy-intensive industries tend to agglomerate near the densest urban locations thus adding to local and regional emission intensities. Figure 2 shows the geographical location of various Tier 1, 2 and metro cities in India. It also maps out the number and location of the country's largest energy-intensive industries in these cities. This geography highlights the importance of customization in fostering low carbon urban trajectories across India and the relevance of city specific plans and targets.

Figure 2: **Geographic Location of 53 Million Plus Cities in India and the Location and Number of some of the Largest Energy Intensive Industries**



Source: *Mapped by the Authors using Census data and the CMIE database*

In a recent report on *Low Carbon Strategies for Inclusive Growth* by an expert group of the Planning Commission (2014) the Government of India acknowledged that the country's projected GDP growth rate of 8 per cent per annum will come at the cost of higher energy demand, resulting in higher emissions. This demand, even under a low carbon scenario, is likely to be met by emission-intensive fuels such as coal, which is likely to be the dominant source of energy for the foreseeable future. In the energy mix, the expert group proposed increasing the share of renewable energy along with grid integration. In the residential and commercial sectors, which consumes close to 30 per cent of all electricity generated, the report suggested increasing efficiency in lighting and appliances as well as pushing for energy efficient and green buildings. The suggestions on mitigation included an increase in the modal share for railways (both passenger and freight), promotion of the use of public transport, and a move towards alternate and efficient fuels. Iron and steel, and cement are some of the most energy intensive manufacturing industries. The report suggested energy efficient machinery in the industrial sector while at the policy level it recommended programs like perform, achieve, and trade (PAT) and complementary policies including energy pricing, a potential carbon tax, cap-and-trade schemes and relevant subsidies and regulations to induce adoption.

The Low Carbon Strategies for Inclusive Growth Report and its long list of suggestions for reducing energy use and emissions sends our strong signals about India's intention to achieve economic growth but not at the cost of its environment. However, the data on the patterns of energy use upon which the recommendations are based are aggregate, national level statistics. How do these patterns vary by region and location and by levels of urbanization? With the proportion of urban population increasing, and also the contribution of urban areas to India's economy, the link between services, industries, and the urban population begs attention and more detailed understanding.

Given government's focus on low carbon development strategies and the strong link between India's economic growth and urban population, it is opportune to disaggregate the national story. The objective of such exercise is to understand the drivers of existing development trajectories at the state level. It will show us to what extent states are able to balance carbon emission, urbanization, and economic growth. Such an understanding might be helpful in the analysis of lower carbon growth pattern for India its future.

It is to this exercise of disaggregating the economic, urban and carbon emissions story that we turn next.

Emerging Pathways of Lower Carbon Growth

Given the vast array of urban sources of emissions noted above, and the paucity of data on urban patterns in India, we examined the linkage between economic growth, urban growth and emissions more closely by classifying 22 major states[2] for which data were available by

[2] Per capita income for most cities is unavailable. Therefore we used states as a proxy, particularly because cities contribute the lion's share to state GDP.

their economic, urban and carbon characteristics. Our goal was to then drill down to the city level to analyse the kinds of urban form, transport patterns, land use and industrial structure that each grouping exemplified. Would the patterns we analysed allow us to identify the emergent pathways to green growth in India and the relationship between economic growth, urbanization and carbon emissions that was disaggregated down from the national to the state level?

Our main data source was the 2011 and 2001 Census, and supplementary variables from other sources. The data collected on the three parameters – economic (per capita income, per capita expenditure, industry mix), urban (levels and growth rates), and carbon (emissions) -- for each state were compared to the national average and depending upon whether a state fell below or above the national average, it was put in a matrix of 'low' or 'high' ranked groupings. In other words, if a state's per capita CO_2 emission was greater than the national average, it was placed in the high emission bracket. The same methodology was followed for the rest of the variables. Based on such categorization, six groups are formed with at least one state in each group. The interesting categories in our dataset thus included:

1. **High-growth, high-urban, high-carbon states (HHH)**: for example, all major industrialized states (Andhra Pradesh, Haryana, Goa Gujarat, Karnataka, Maharashtra, Punjab, Tamil Nadu)
2. **High-growth, high-urban, low-carbon states (HHL)**: Kerala, for example.
3. **Relatively low-growth, high-urban, low-carbon states (LHL)**: West Bengal, for example.
4. **High-growth, low-urban, low-carbon states (HLL)**: Himachal Pradesh and Uttarakhand, for example.
5. **Low-income, low-urban, high-carbon states (LLH):** the high-risk, resource-intensive states, for example, e.g., Chhattisgarh and Jharkhand.
6. **Low-growth, low-urban, low-carbon states (LLL)**: for example, the traditionally lagging states (Assam, Bihar, U.P, Orissa, J&K, Madhya Pradesh, Rajasthan). However, in this category some states such as Madhya Pradesh are taking big strides out of this category with many innovations in housing, water, energy and roads in their urban areas.

These categories reveal several patterns.

In general, we found that India's current urban economic growth produces relatively high carbon emissions. This is evident from the bimodal distribution of the states. Most states fall within two opposing categories. The high growth states generally have higher than average levels of urbanization and industrialization and are also high carbon emitters. At the other end, the lowest growth states tend to have low levels of urbanization and many are low carbon emitters. But there is substantial variation between these two extremes.

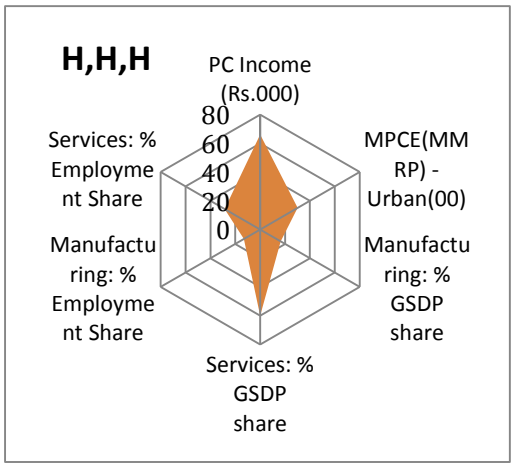
As noted earlier, India is the sixth largest emitter of greenhouse gases in the world (though on a per capita basis it is one of the lowest emitters) (Planning Commission 2014). Our analysis however, shows that there is substantial interstate variation with regard to per capita CO_2

emission across states. The more developed and natural resource intensive states are more carbon intensive in that they generate higher emissions per capita than the nation average of 1.5 tons per person.

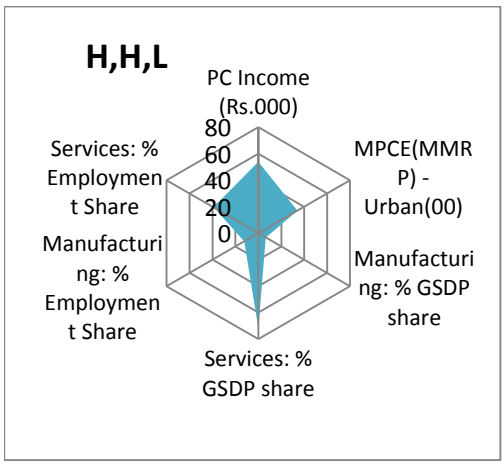
Our categorization also showed that high (economic) growth states are associated faster levels and rates of urbanization (higher than average per cent urban population). They had also added more new towns over the last 10 years than other states; they had a higher share of manufacturing and services in their employment mix; and the state GDP was higher than the national average. They also accounted for higher than average levels of per capita consumption (MPCE). But surprisingly they had lower urban Gini coefficients, and also a smaller share of the slum population (aside from a few exceptions such as Mumbai) relative to slower growing states. This growth was, however, associated with relatively high emissions, i.e., higher than average per capita CO_2, N_2O and CH_4 levels. This pattern was evident in the more industrialized Indian states: Maharashtra, Tamil Nadu, Gujarat, Andhra Pradesh, Goa, Karnataka, Punjab, Haryana and Delhi (see Figure 3)

Much of this high carbon growth came from transport mode choice—the lack of public transport systems and a high degree of reliance on polluting two-wheelers—as well as from the state's (and its cities') industry mix (gas, cement, iron and steel, and power) (see Figure 4).

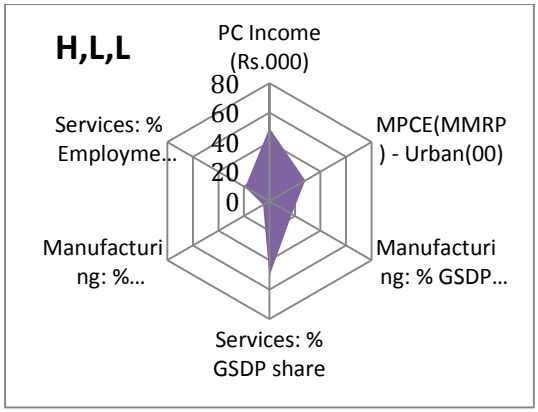
Figure 3: Income levels and associated economic parameters for different state categories



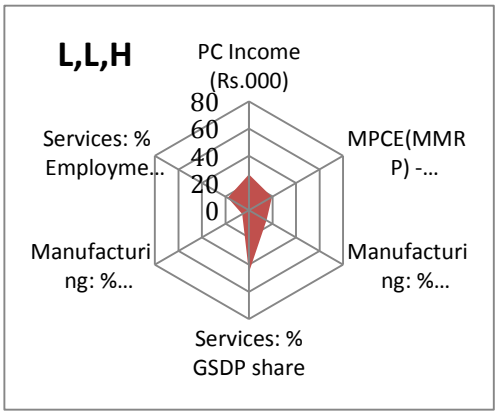
Karnataka, Andhra Pradesh, Punjab, Tamil Nadu, Gujarat, Haryana, Maharashtra, Goa, Delhi



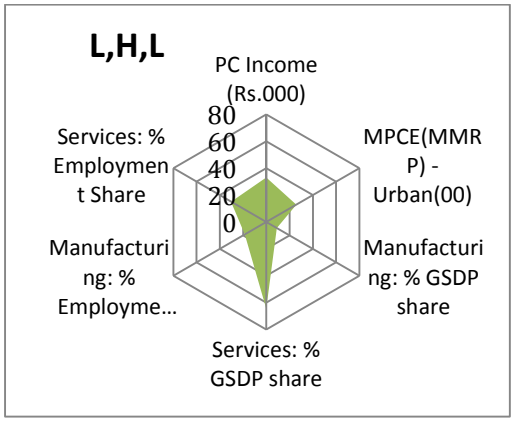
Kerala



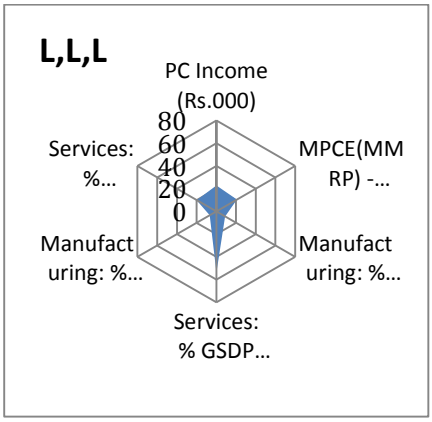
Himachal Pradesh, Uttarakhand



Jharkhand, Chhattisgarh



West Bengal

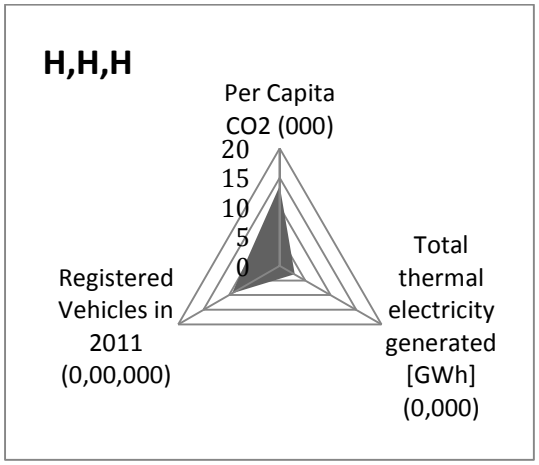


Bihar, U.P, Assam, Orissa, M.P, Rajasthan, J&K

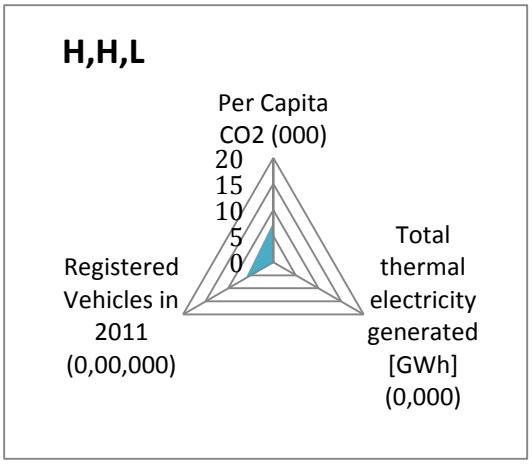
***Source**: Author's calculations based on Planning Commission's data on state level gross domestic product, expenditure levels, and Annual Survey of Industries.*

At the other end of the spectrum were low-growth, low-urban, low-carbon (LLL) states, many of which had long been classically lagging states (BIMARU) and some of which were slowly growing out of their long years of stagnation. In each of these states, carbon emissions were low but so were urbanization levels and economic growth rates. Still, this is the category where changes are taking place most rapidly in individual states and cities. Economic fortunes, led by urban growth as well as key decisions on urban power, urban transport, industrial location, built form and agglomeration dynamics, are setting some states apart and setting them up for significant transformation in the coming decade. Madhya Pradesh is the leading example of this change: in the last decade it has made significant investments in renewable energy, power-sector reforms, roads, public transit systems and affordable housing.

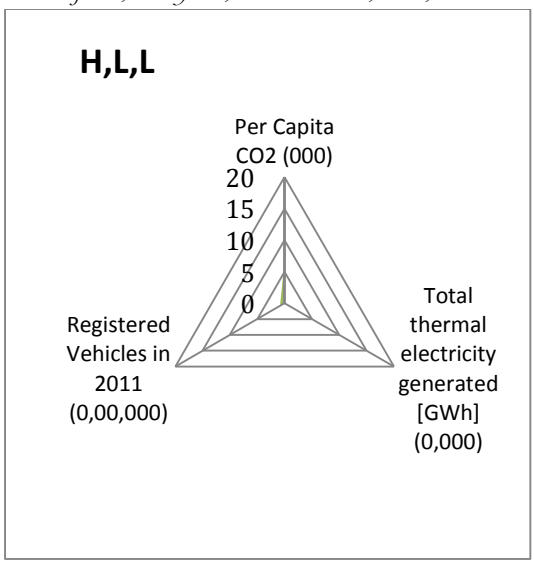
Figure 4: Carbon emissions and associated parameters for different state categories



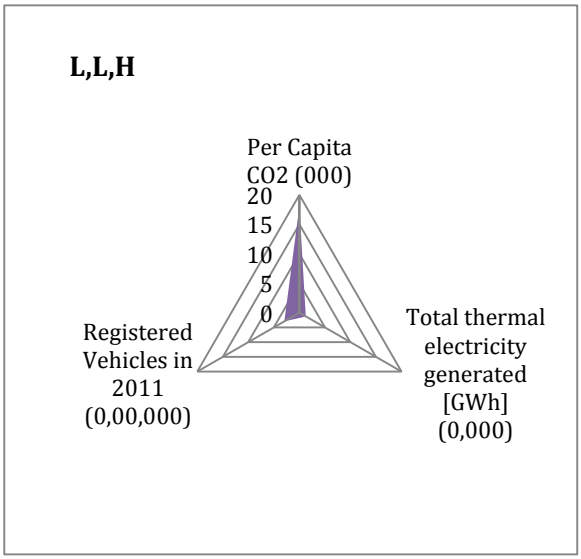
Karnataka, Andhra Pradesh, Punjab, Tamil Nadu, Gujarat, Haryana, Maharashtra, Goa, Delhi



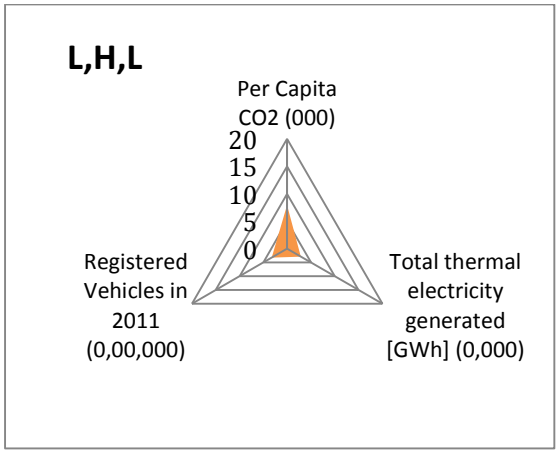
Kerala



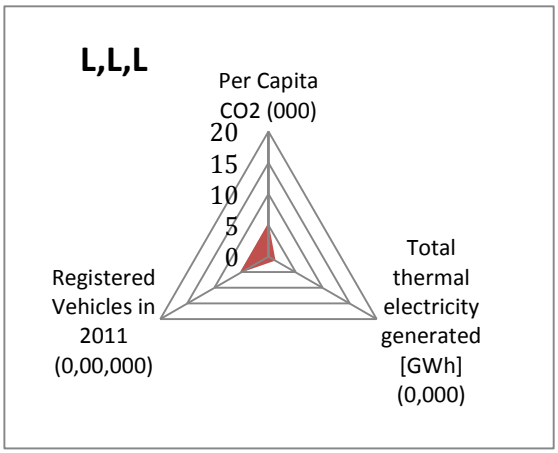
Himachal Pradesh, Uttarakhand



Jharkhand, Chhattisgarh



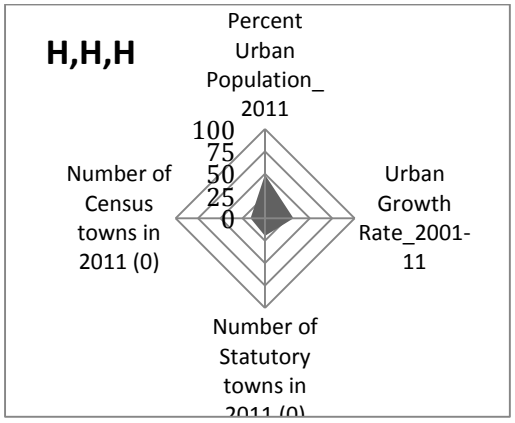
West Bengal



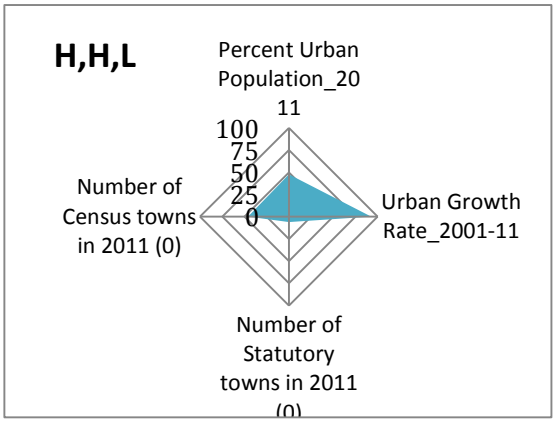
Bihar, U.P, Assam, Orissa, M.P, Rajasthan, J&K

***Sources**: Author's calculations based on data provided by Ministry of Power and Ministry of Road Transport and Highways, and Ramachandra & Shwetmala (2012).*

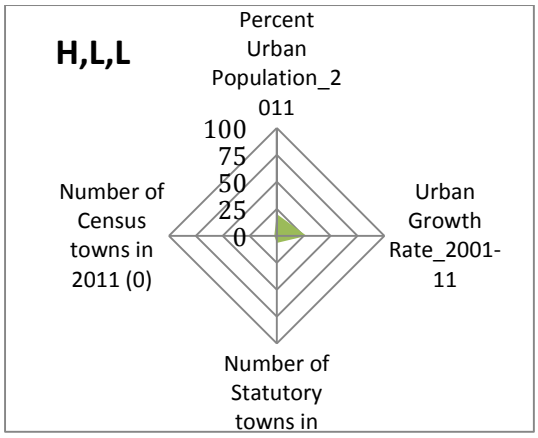
Figure 5: Urbanization levels and associated parameters for different state categories



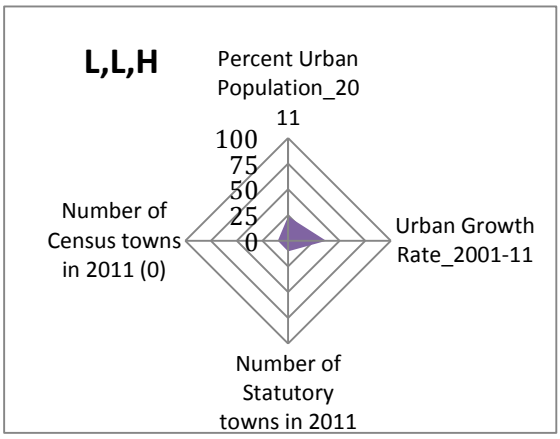
Karnataka, Andhra Pradesh, Punjab, Tamil Nadu, Gujarat, Haryana, Maharashtra, Goa, Delhi



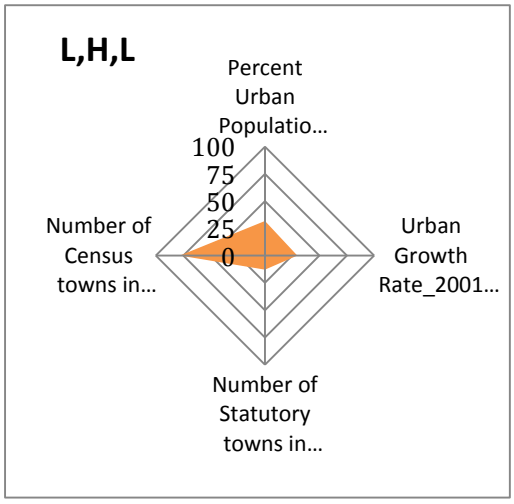
Kerala



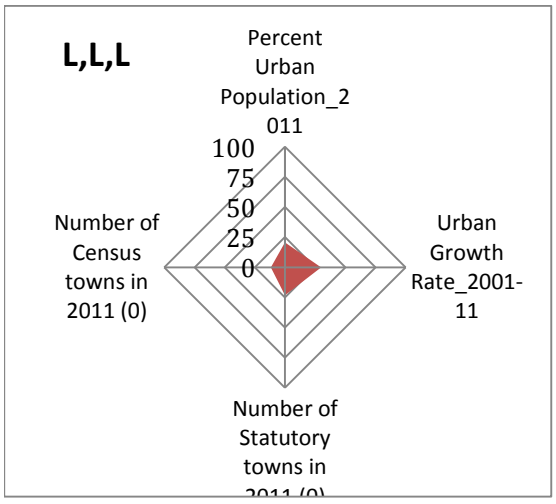
Himachal Pradesh, Uttarakhand



Jharkhand, Chhattisgarh



West Bengal



Bihar, U.P, Assam, Orissa, M.P, Rajasthan, J&K

***Source**: Authors' diagrams based on data from the Census of India, 2001 and 2011.*

A combination of the patterns across the economic, urban and emissions profile of the major states shows that even though the economically advanced states are all high carbon, bookended by the low growth, low urban, low carbon states, there are different ways of

getting to the desirable mix of a high growth and a relatively low carbon future. These pathways involve different kinds of urban processes. For example, on the one hand is Kerala, which is the only state in our sample with a high growth and low carbon mix: it has a unique urban pattern that is relatively dispersed. In the context of a service, real-estate, tourism, high value agro-processing (cashews, sea-food), port and oil and gas based economy, this urban pattern is yielding growth. But dispersed, low density urbanization may have high service delivery costs and other challenges. On the other hand high growth and low carbon outcomes in Himachal and Uttarakhand are associated with low levels of urbanization and a different industry composition (clean-tech, tourism). In other cases, investment in public transport in some states (MP, West Bengal) and creative use of live forest cover in others (Orissa) has kept some states low carbon despite their being resource intensive in contrast to other resource intensive states such as Jharkhand that remain high carbon.

A more detailed discussion of the cases and the policy and political economy insights emerging from these patterns is outside the scope of this paper, but the preliminary analysis reported here underscores the point that there is no single trajectory of green urban growth in India, nor is there a silver bullet. Significant variation exists among cities and states which calls for a more creative and customized policy attention. This diversity is, in fact, a hopeful finding in that different states and cities may be able to craft different pathways, based on local contexts, that can help then achieve low-carbon urban growth.

That said, some cross-cutting patterns do emerge that are associated with a more desirable mix of low carbon growth. These patterns include: responsive and forward-looking urban planning, mixed use public transit oriented urban patterns, energy reform, creative uses of urban finance and compactness that allows cities to provide basic services at a lower cost per capita than their underperforming counterparts.

In the next two sections we hone in on three such drivers of low carbon urban and economic growth: (i) compact urban form that is anchored around an efficient multi-modal transport system; (ii) investment in smart infrastructure with a focus on green buildings, and (iii) innovations in municipal finance. A fourth driver, efforts to reduce the energy-intensity of industry is mentioned but detailed discussion is outside the scope of this paper.

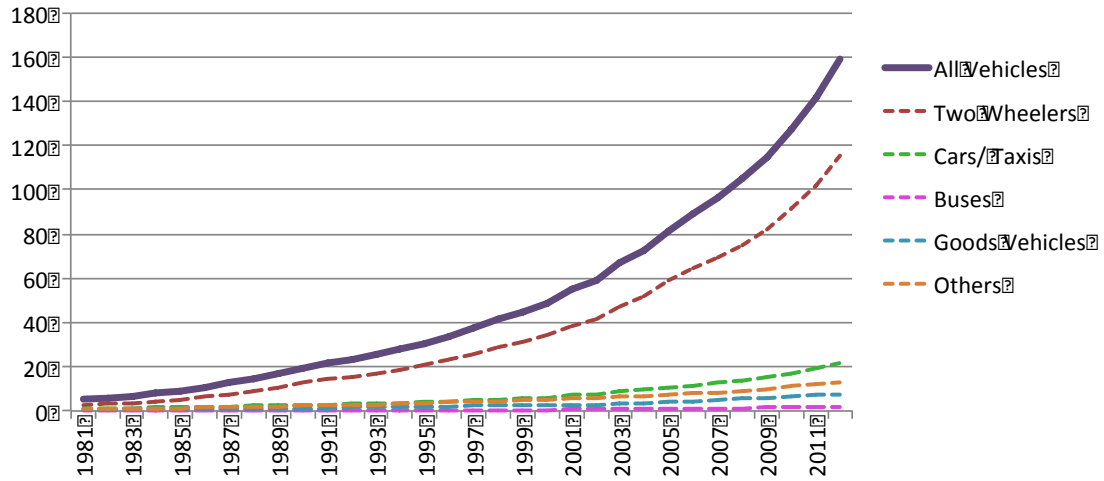
IV. A NEW LOW-CARBON URBAN GROWTH MODEL FOR INDIAN CITIES

As suggested above, a new growth model for Indian cities can be anchored around four core pillars: (1) promoting compact urban form, including efficient public transport; (2) reducing the energy intensity of urban industry; (3) investing in smart infrastructure, especially green buildings and resilient water networks; and (4) catalyzing innovation, especially in urban finance, mechanisms of urban inclusion and institutions of governance and implementation. We examine the first two drivers in this section and the third, finance, in section V.

(1) Promoting Compact Urban Form, with Efficient Public Transport

Urban transport emerges as one of the chief contributors to the high-carbon growth associated with India's urban centres. Nationwide, GHG emissions from the transportation sector increased by 61% between 1994 and 2007 with a significant contribution from urban areas (Planning Commission, 2011). Corresponding to this, are data from urban areas indicating an increase in motorization at a rate five to nine times greater than population growth during the same period (1980-2011), including a significant shift towards private modes of transportation.[3]

Figure 6: Total number of registered motor vehicles in India 1981-2012 (millions)



Source: *Mapped using Data from the Ministry of Road and Transport 2012*

Rapid rates of urbanization and expansion of cities, rising incomes and the inability of planning systems to catch up with this growth have contributed in degree to this issue. Promoting a more compact urban form centred around investment in public transport will be crucial for a new growth model for India's cities. A more compact urban form can help address the demand for travel while the provision of an efficient public transit system can help better manage the supply side of the urban transport issue.

In its 2011 report on Low Carbon Strategies for Inclusive Growth, the Planning Commission adopts a similar view and recommends a three-tier approach of "avoid," "shift" and "reduce" for low-carbon urban growth. **'Avoid'** refers to efforts that can help reduce demand for travel through the effective use of zoning and land use planning. It could potentially include measures that set industrial location criteria to minimize the movement of raw materials and finished products as well as worker commutes; use the National Urban Housing and Habitat Policy to ensure that cities remain dense, mixed in land-use and affordable to reduce (or at

[3] The largest increase was seen in two-wheelers, whose share rose from 48% in 1981 to more than 70% in 2011-12 while the share of buses fell from 3% to 1% (it was 11% in 1950s) over the same period. (Transport Research Wing, Ministry of Road Transport and Highways, government of India. 2012. "Road Transport Year Book (2011-12)."

least maintain) travel distances; and develop urban planning guidelines to encourage transit-oriented development and discourage sprawl. A TERI study (2011)[4] found that integrated land use and transport planning could reduce transport energy demand in Indian cities by 20% by 2030.

'Shift' refers to strategies that can help shift passengers to public transport. In the 2011 report, the Planning Commission projects an abatement potential of 10-15% in the transportation sector for 2020, 37-40% of which is tied to an urban shift to public transportation and non-motorized modes. Similarly, the McKinsey (2009) report on environmental and energy sustainability[5] projects an abatement potential of 24% in the transport sector for the year 2030, with expansion of public transportation in cities contributing 23%.

Prabhu and Pai (2011) present evidence for emission savings through these measures from two Indian cities: Ahmedabad and Bangalore (populations of 5-10 million). Both have made significant investments in public bus networks. Both cities indicate carbon savings of more than 2,000 tons a year. Prabhu and Pai also indicate that cities can potentially reduce their carbon emissions by up to 65% through such investments over longer periods of time.

'Improve' refers to strategies to promote carbon-efficient technologies in all modes of transport, including private modes. This includes improving vehicular efficiencies, shifting vehicles to electric and hybrid and introducing cleaner fuels. A TERI evaluation found a 17% reduction in emissions if the fuel efficiency of vehicles were to be improved by 20% by 2030. Bringing all vehicles under the purview of the Bureau of Energy Efficiency (BEE) could help regulate efficiency standards.

Taken together these strategies can play an important role in nudging cities toward a lower carbon pathway and can help prevent carbon-intensive lock-ins.

Projected co-benefits

In addition to increasing the carbon footprint, the rapid rise of motorization in Indian cities has resulted in multiple negative externalities such as congestion, increased travel times and deteriorating air quality. In a Central Pollution Control Board survey (2011), 35 of the 53 million-plus-population cities (2011) had annual PM_{10} counts in the critical range. After industry, the transportation sector is the top contributor of PM_{10} in the urban environment. These can have a deterimental impact on the public health and productivity of our cities.

Mitigation strategies such as those outlined previously can have accompanying co-benefits that address some of these issues. Increasing public transport and non-motorized modes promotes inclusive growth. Introducing better fuels and more efficient vehicles improves air quality. Reducing fuel consumption, and the concomitant reduction in imports, improves energy security for the country. Incentives that can reduce fuel consumption could translate into a reduction in the annual fuel import bill of up to Rs. 20,500 crore in the 8% GDP

[5] McKinsey & Company. 2009. "Environmental and Energy sustainability: An Approach for India."

growth scenario and Rs. 24,500 crore in the 9% GDP growth scenario in 2020); better road safety and technical leapfrogging that could give the country a competitive advantage in the global market. This can be facilitated by the government through R&D and other incentives for the automotive industry.

Projected costs

Financing will be key to the viability of mitigation measures. Several projections are available regarding costs for improvements in the transportation sector over the next several years (2030), especially in the urban context. The McKinsey (2009) report projects a total investment need of $590 billion for urban transport in the country, with two-thirds for mass transit and the remaining one-third for roads. The Ahluwalia HPEC (2011) report projects a lower investment need of about $460 billion in the next 20 years with only a 20% share for public transit. A projection by the National Transport Development Policy Committee (2012) projects the lowest investment need among the three, at $340 billion, with 44% for mass transit. These cost estimates present a starting point for important urban transport reforms.

Figure 7: Urban Transport Investment Projections for 2030

		$ billion	**Share**
McKinsey, 2009	**Urban Transport**	**590**	
	MRTS	390	66%
	Roads	200	34%
HPEC, 2011	**Urban Transport**	**460**	
	MRTS	90	20%
	Roads	350	76%
NTDPC, 2012	**Urban Transport**	**340**	
	MRTS	150	44%
	Roads	190	56%

Source: Mohan, Rakesh. 2012. "Urban Transport and the Twelfth Five Year Plan."

Mobility patterns and city size

As we observed with the economic, urban and emissions patterns across Indian states and cities, multiple pathways of growth can be observed around urban form across cities in India. A deeper understanding of these variations and their underlying causes is necessary before reforms can be initiated. Results from a MoUD survey (2008)[6] highlight the relationship between the size of a city and its mobility patterns. As a city expands in population and size, trip rates and trip lengths also increase. People travel more and over longer distances. The local economy is also at play—economic growth generates more trips (increasing trip rate) while also contributing to the city's expansion and the resulting increase in trip length. To

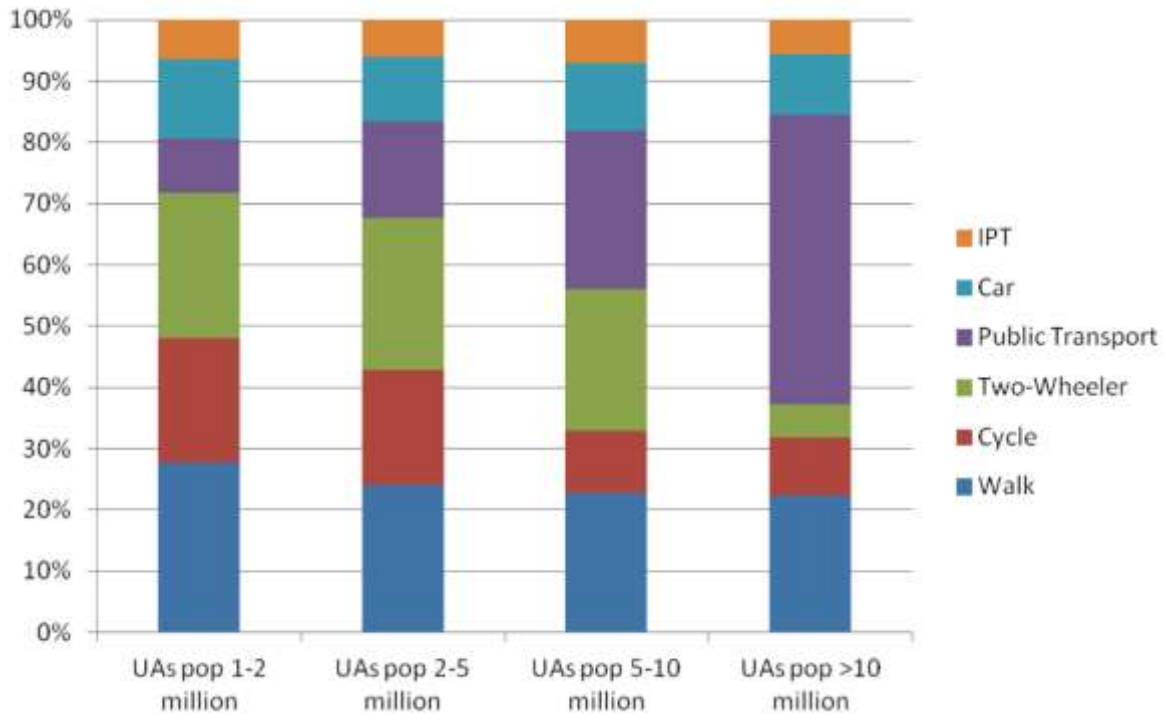
[6] Ministry of Urban Development, Government of India and Wilbur Smith Associates. 2008. "Study on Traffic & Transportation Policies & Strategies in urban areas in India."

promote compact growth, economic development plans must therefore be closely tied in with the physical plans of the city.

The choice of mode also changes with city size. Within the million-plus cities, the smaller cities (1-5 million) have a higher share of walking and biking trips as well as a higher reliance on private modes of motorized transport, especially two-wheelers. Walking and cycling suffice for shorter trips while motorized private modes support travel over longer distances in the absence of alternate public modes, generally unavailable in cities of that size. The smaller cities also have the highest rate of motorization among the million-plus cities. Investments in public transit targeted towards these cities may thus generate high carbon savings.

The presence of public transit options increase with city size. The largest cities, the metros (>10 million) exhibit the highest share of public transport usage due to the availability of a large network coupled with disincentives for use of private transport such as long travel distances, high congestion on roads (low-urban road densities[7] - km/1000 people) and low travel speeds. Here, both the push and pull factors come into play for encouraging the use of public transit.

Figure 8: **Modal Split in Select Million-Plus Cities, 2008**



This interrelationship between city size and travel behaviour affects the carbon footprint of Indian cities and has implications for mitigation efforts. Clearly, city size is not the only determinant of travel behaviour – a variety of other factors such as location, development

[7] Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India. 2010. "Infrastructure Statistics 2010 (First Issue)."

policies, and local political economy may also come into play as we see next in examining the density question.

Urban form, multimodal transport and the density question

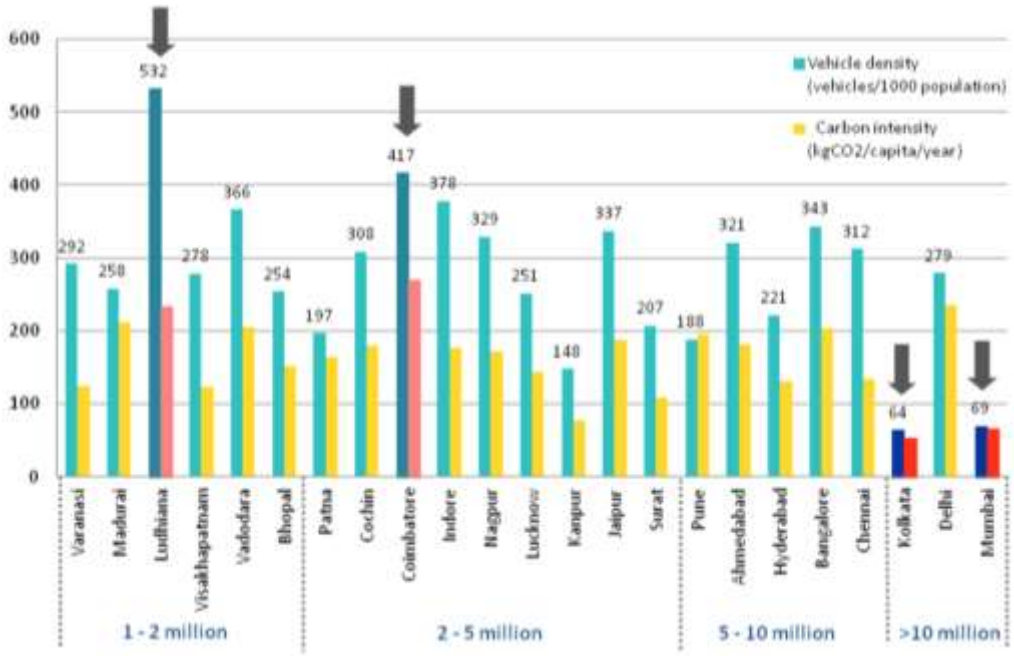
In general, the received wisdom from the global literature on the density/urban form question is that denser, mixed use compact cities are associated with low carbon growth paths. In our survey of the Indian literature we found that the relationship between transport, urban form and urban density was non-linear. Density alone is not an adequate indicator of a low carbon urban future; it is important to (i) understand the *source* of that density (e.g., is it from over-concentration that can unleash a negative spiral of the diseconomies of compactness, or is it the result of mixed and compact land use and multi-modal transit oriented options?) and (ii) to unpack the policies and political economy surrounding a city's urban form.[8]

For example, in India there is significant variation not only within states but also within similar categories of cities that is important to mine. For eample, the three metros Mumbai, Delhi and Kolkata have similar population sizes, but very different urban forms: Mumbai and Kolkata are both more compact cities; Delhi is not. Delhi's policies of decongesting growth through the formation of satellite towns in the 1970s contributed to considerable sprawl. Delhi also chose a very different transport pattern than Mumbai and Kolkata. Nearly 21% of Delhi's area is covered by roads, compared to 11% for Mumbai and only 5% for Kolkata (see Figure 9).

Both Mumbai and Kolkata have leveraged their peninsular geographies to provide extensive and effective public transit systems (congested, but effective). As a result, vehicle ownership is much lower in Kolkata (only 44 vehicles per 1000 people) and Mumbai (102 vehicles per 1000 people) than in Delhi (493 vehicles per 1000), and is indeed, lowest among all million plus cities (and, indeed, a sixth of the vehicular density of rapidly growing smaller industrial cities such as Coimbatore and Ludhiana). Kolkata and Mumbai have further enhanced this advantage by decongestion policies and growth regulations in recent years, to the extent that despite population growth, vehicle ownership (per thousand) actually fell in Kolkata in 2009 relative to 1999.

[8] The famous example is of Shanghai and New York city – Shanghai is six times denser than NYC, but has similar levels of GHG emissions. Public policies associated with urban form matter.

Figure 9: Vehicle Density and Carbon Intensity from Urban Transport across Select Million-Plus Cities, 2005



Source: Reddy, B.S., & Balachandra, P, 2012. Dynamics of Urban Mobility: A Comparative analysis of megacities of India

Legacy, geography and agency

An early history of investment in public transport helped shape travel behaviour and location decisions of homes and businesses over time in both, Mumbai and Kolkata. Both cities have had extensive public transport networks since the 19th century. Mumbai's suburban rail network, the first in Asia, opened in 1867. Kolkata's suburban rail system began in the 1850s, and its tram lines (again, Asia's oldest) were founded in 1902. Today Mumbai's suburban rail system extends over 300 km with 95 stations; along with the city's bus service it carries 88% of Mumbai's total passenger load (Rode 2007). Similarly, in Kolkata the suburban rail, the bus system and the country's first metro rail (opened in 1984) together carry 65% of the city's passenger traffic (Kolkata CMP).

Both cities' peninsular geography enhanced the effectiveness of their public transit networks. But while geography was important at the start, it, alone, was not a determining factor of transport choices over the long term. Public policies, including the decision in both cities to provide multiple modes of public transport (rail, buses, metro) and the decision in Kolkata to limit road density while actively negotiating a series of pollution control actions with industry, all helped anchor vibrant and viable urban transit systems. In both, Mumbai and Kolkata, much of the urban growth (in terms of location of residential and economic activity) until the 1970s was concentrated in a 5 km radius around the city centre, while in the case of Delhi the population was concentrated in more than a 10 km radius (Taubenböck et al.

2008).[9] The outcome of the introduction of satellite towns in the 1970s as mechanisms of decongestion led to quite different outcomes in the three cities. In Mumbai and Kolkata, this led to a "leap-frogging" of development away from the city centre, while in Delhi the effect was far more contiguous. This expanded urban boundaries and fuelled sprawl. Population and road densities reflect this divergent pattern of urbanization. Delhi has a lower population density but higher road density than the other two metros. Despite similar population levels, Delhi's urban density is about 11,000 people per sq. km, while the urban density in Kolkata and Mumbai is about 24,000 and 26,000 persons per sq. km, respectively.

Though several deficiencies exist in the current transport options for both Mumbai and Kolkata, mainly around the capacity and quality of services, the two cities illustrate how the promotion of public transportation and urban density can help regulate travel behaviour towards a low-carbon alternative.

In sum then, the transport sector is crucial to urban mitigation and adaptation. It has complex interactions with urban form and density. In compact, mixed-use cities supported by multimodal public transit systems and other land-use policies that pay attention to the siting of jobs and residential neighbourhoods, the density question is less clear cut. For example, the city of Surat in Gujarat is the classic example of a compact, relatively high FSI (floor space index), mixed-land-use city with relatively short commute times (aided by the city's siting of publicly supported worker housing around or near industry) and low levels of congestion. The city has amenities that make it livable and dynamic. Its economic vibrancy has attracted large numbers of migrants and investors. With 80% decadal growth rates and 4.5 million people today, Surat is one of the country's fastest growing cities. Yet, this compact urban form is ironically also associated with poor air quality. Two key ingredients are missing from the city's landscape: adequate green cover and an effective public transit system. The latter in part is the result of the city's compactness: with short commutes, the city never invested in a strong public transit system. Commuters rely on shared or single occupancy private vehicular transport. It is only now that the city has expanded its bus fleet and introduced a BRT system.

Compactness and density, then, need to be supported by other policies, particularly land use policies, and green cover, that can together provide a city with sustainable and inclusive *accessibility*, not just transport.

(2) Investing in Smart Infrastructure, Especially Green Buildings

Like transport, the buildings sector is crucial to addressing India's climate change question, from both perspectives, energy consumption as well as emission management perspective, not least because 70-80% of buildings that will be in place by 2050 have yet to be built. Currently the sector, including both residential as well as commercial built space, consumes

[9] Taubenböck, H., Wegmann, M., Berger, C., Breunig, M., Roth, A., & Mehl, H. 2008. "Spatiotemporal analysis of Indian mega cities." *Proceedings of the international archives of the photogrammetry, remote sensing and spatial information sciences (ISPRS), 37*, 75-82

approximately 196,041 ktoe (or 39.8% of India's total energy) (IEA, 2013). Biomass, petroleum products and electricity constitute the bulk of the sector's total energy consumption. In terms of emissions, the sector is responsible for 139.5 Mt of CO_2 eq. emissions, 12.6% of India's total (INCCA 2010, base year 2007). Data from the 2011 census show that around 77.1% of all census buildings were used for residential purposes. The rest (22.9%) were accounted for by commercial establishments such as shops, hospitals, schools, and so on. The predominance of the residential sector in the building composition implies that both building design as well as occupants' lifestyle patterns have a role to play in determining the level of emissions generated by this sector in the future.

The current policy framework for addressing energy demand in the building sector

Aggregate energy demand from a particular building depends on two variables: (1) building design (site characteristics, architectural design, etc.), and, (2) lifestyles (consumption pattern of occupants). Thus, green interventions that seek to reduce emissions from this sector need to target both of these key variables.

At a policy level, these elements are addressed in part through two missions of the National Action Plan on Climate Change, namely, the National Mission on Enhanced Energy Efficiency, and the National Mission on Sustainable Habitat. The National Mission for Enhanced Energy Efficiency is based on new initiatives to enhance energy efficiency, such as market-based mechanisms to enhance cost effectiveness of improvements in energy efficiency in large energy-intensive industries and facilities, through certification of energy savings that can be traded. The National Mission on Sustainable Habitat aims to make cities sustainable through improving energy efficiency in buildings, management of solid waste and the use of public transport. From the buildings sector context, these two missions encompass Green Rating for Buildings, Energy Conservation Building Codes (ECBC) and lighting and appliance labelling programs for improving the efficiency of energy consumption. The Twelfth Plan (2012-17) document also lists Lighting, Labelling and Super-efficient Equipment Programme as well as Faster Adoption of Green Building Codes as its focus areas for achieving sustainable development.

Analysis of data from the National Sample Survey Office allows a deeper understanding of where India's million-plus cities stand with regard to key energy consumption and housing parameters.[10] The difference in consumption patterns is starkly visible among the 53 cities. As India grows and the aspiring middle class moves to mimic consumption patterns of the urban high-income groups, energy consumption in the buildings sector will grow by leaps and bounds. Some part of this movement is clearly desirable, such as the movement away from burning biomass for cooking fuel. But a large part of the movement needs to be planned for and managed, for example, that related to petroleum product (liquid petroleum gas, kerosene), electricity consumption and the related emissions.

[10] Since unit level data from NSSO 66th Round Consumption Expenditure Survey 2009-10 and NSSO 65th Round Housing Stock Survey 2008-09 was used for the analysis, the results are predominantly for residential buildings and averages for data available at urban district level.

Table 1: MPCE Class-wise NSSO Survey Data for Residential Housing and Energy Consumption Patterns

		Lifestyle						Housing		
		Average Consumption Expenditure (Rs.)	Energy Cons (Rs.)	Electricity Consumption (KWh/capita/month)	Cooking Fuel (in %)		Lighting Fuel (in %)	Housing Plinth (sq.mtr)	Number of Rooms (no.)	
					Biomass	LPG	Electricity		Living	Other
HH Categories	**LIG**	697	83	12	38%	40%	88%	49	1.7	1.6
	MIG	1368	131	23	9%	73%	98%	75	1.8	2.0
	HIG	3754	232	50	2%	77%	96%	160	2.3	2.4
	All	**2089**	**158**	**31**	**10%**	**70%**	**95%**	**111**	**2.0**	**2.1**

Note: Households have been divided based on MPCE deciles. 0-30% MPCE class=LIG, 30-70%MPCE class=MIG and 70-100% MPCE Class= UIG
Source: *Authors' calculation*
Data Source: NSSO 66th Round Consumption Expenditure Survey 2009-10, NSSO 65th Round Housing Stock Survey 2008-09

From the above table it appears that the prioritization of mainstream policy making in the building sector is based more on technological solutions and 'do-ability' or feasibility of a particular intervention, rather than on the diffusion of new practices. For example, biomass-based cooking and related improvements in cook stove designs, even in urban areas, are largely ignored when green policy checklists are prepared despite the widespread acknowledgement of their efficacy in the academic literature. Most notably, modelling results from various research studies show that cooking demand accounts for around 60% of residential energy demand and making improvements in the carbon efficiency of cooking related tools and fuels can make a substantial difference to cutting emissions (TERI 2013, LWNL 2014, LBNL 2009).

While it is true that cooking demand for fuel in urban India is met largely by petroleum products such as LPG and kerosene, around 20% of urban households, located largely in slums, still use biomass for cooking.[11] The numbers persist despite greater access to LPG through deployment of a dense geographical network of LPG distributors in urban areas, highlighting such households' inability to pay for more expensive fuels. A reduction in the use of biomass for cooking would have the co-benefit of simultaneously reducing urban indoor air pollution. This could be accomplished through a large-scale program on improved cook stoves with an urban focus. A small-scale Programme of Activities (POA) already has been initiated with the MNRE's support that seeks to use carbon revenues to offset the capital cost of building efficient cook stoves[12] and make these accessible to rural and/or urban households for sustainable use. Households need to be encouraged to adopt cleaner cooking sources, and the government needs to support the use of LPG and BPL kerosene. More accurate targeting of existing subsidies and more effective oversight over the diversion of these fuels (and the attendant subsidies) for non-residential purposes would help ensure greener outcomes.[13]

In India, the movement toward green buildings appears to be following a two-pronged approach. The first is the MNRE-supported green building rating system, with the Indian Green Building Council (IGBC) and Green Rating for Integrated Habitat Assessment (GRIHA) being the most popular green building rating systems in India. The second is the Energy Conservation Building Code (ECBC), endorsed by the BEE. The BEE's Star Rating System for buildings evaluates existing buildings based on operational energy use and is the only energy-use-specific building label used in India. It should be noted that the terms "green" and "energy efficient" are not interchangeable when applied to buildings. The definition of "green" is broad and covers aspects of energy consumption, waste management, water use, material sourcing, site ecology, etc. The concept of "energy efficient" buildings is much narrower and covers only the electricity consumption per unit of built area.

[11] The primary cooking source distribution among urban households is as follows: LPG/PNG (65%), kerosene (7.5%) and firewood (20.1%). The rest is accounted for by coal, dungcake, crop residue, etc. (Census 2011)

12 Improved stoves are defined as stoves with efficiency greater than 25%.

[13] Subsidized kerosene is earmarked for BPL houses while subsidized LPG is meant for residential purposes only.

With regard to mitigation potential, case studies for green buildings show it is difficult to calculate a definitive improvement in energy/electricity consumption based on a particular design change. It is the interaction of these elements that improves energy consumption. For example an improved building facet and daylighting, improved ballasts and light devices all help with reducing the light energy requirement. A broad assessment shows that energy efficient buildings are around 25–30% more energy efficient than conventional buildings. Cost premiums in India are in the range of 6% to 18% depending on the level of rating. In mature markets the cost premiums range from 1% to 6% (JLLM 2008). Illustrative examples of cost premiums associated with building design changes in India are shown in Table 3. This can be attributed to lack of technical know-how, immaturity of the market and lack of resources within Indian markets. Note that since cost premiums are being looked at from the perspective of energy consumption the costs shown relate to the relative costs for the four pillars of building energy efficiency: building envelope, lighting, HVAC (heating, ventilation and air conditioning) and appliances. Table 2 shows examples of savings and costs for certain green buildings in India.

Table 2: Performance of Green Buildings in India

Name of the Project	**Location**	**Built-up Area (sq ft)**	**Rating Achieved**	**Increase in Cost (%)**	**Payback Period (years)**
CII-Sorabji Godrej GBC	Hyderabad	20,000	Platinum	18	7
ITC Green Centre	Gurgaon	170,000	Platinum	15	6
Wipro	Gurgaon	175,000	Platinum	8	5
Technopolis	Kolkata	72,000	Gold	6	3
Spectral Services Consultants Office	Noida	15,000	Platinum	8	4
HITAM	Hyderabad	78,000	Silver	2	3
Grundfos Pump	Chennai	40,000	Gold	6	3

Source: *JLLM 2008*

Table 3: Cost Premiums for Green Materials, Equipment and Techniques in India

Green Materials Equipment and Techniques	Cost Premiums	
	Unit	Value
High-quality steel with recycled metal content	INR per tonne	5,000
Fly ash content in cement	%	22
Aerated blocks for solid masonry	INR psf	37.16
Double-glazed glass	INR psf	10
Ultra-low plumbing fixtures	%	3
Storm water management system	INR million	30
Special chillers COP (coefficients-of-performance) = 6.5	%	15
Low side HVAC (Heating and Ventilation	%	10
Rooftop garden	INR psf	250
Energy modelling consultant	INR million	1.2

Source: *JLLM 2008*

The ECBC sets minimum energy standards for new commercial buildings or building complexes with connected loads that are greater than 100 kilowatts (kW) or 120 kilovolts-

ampere (kVA) (Bureau of Energy Efficiency 2011). While in principle the ECBC applies to residential complexes with the same connected load, in practice the code is applied largely to commercial buildings. An additional problem is that the ECBC has yet to be adopted by most of India's states, which means that the majority of India's new commercial buildings are not being built under the requirements of the ECBC.[14] Since the life of a building is taken to be near 60 to 80 years, this produces large-scale lock-in effects. Currently, two states (Rajasthan and Odhisha) have mandated the ECBC, and six others (Gujarat, Karnataka, Punjab, Kerala, Uttar Pradesh and Uttarakhand) have initiated the process. [GBPN 2013]

While policies such as the National Mission on Sustainable Habitat as well as National Housing and Habitat Policy 2007 emphasize the provision "affordable housing for all," not much thought has been given to efficiency improvements that can be made at the base of the pyramid. Some existing programs look to providing Economically Weaker Sections (EWS) housing (Rajiv Awas Yojana) as well as upgrading of slums (JNNURM and AMRUT). Since both of these programs involve residential building construction at a large to medium scale, implementing them within a green building paradigm could have a significant impact on energy consumption and on urban emissions. Local governments could incorporate rating provisions and design suggestions applicable under SVAGRIHA[15] for small developments or PMCs Eco-Housing Assessment Criteria (Box 1) in the program design. Incorporation of design interventions based on these rating systems could provide interesting cases of a win-win option for the buildings sector.

Mitigation options for the buildings sector

The buildings sector has been recognized globally as the sector with the highest abatement potential (29%)(IPCC 2007). A number of domestic and international studies have looked at this potential for India. Most of the abatement interventions modelled for commercial and residential building stem from the understanding of the current patterns of end use consumption. The electricity consumption patterns have been clearly shown in two figures (Figures 13and 14) contained in the Expert Group on Low Carbon Strategies for Inclusive Growth (2011) report (Planning Commission 2010).

Box 1

Determined Effort:

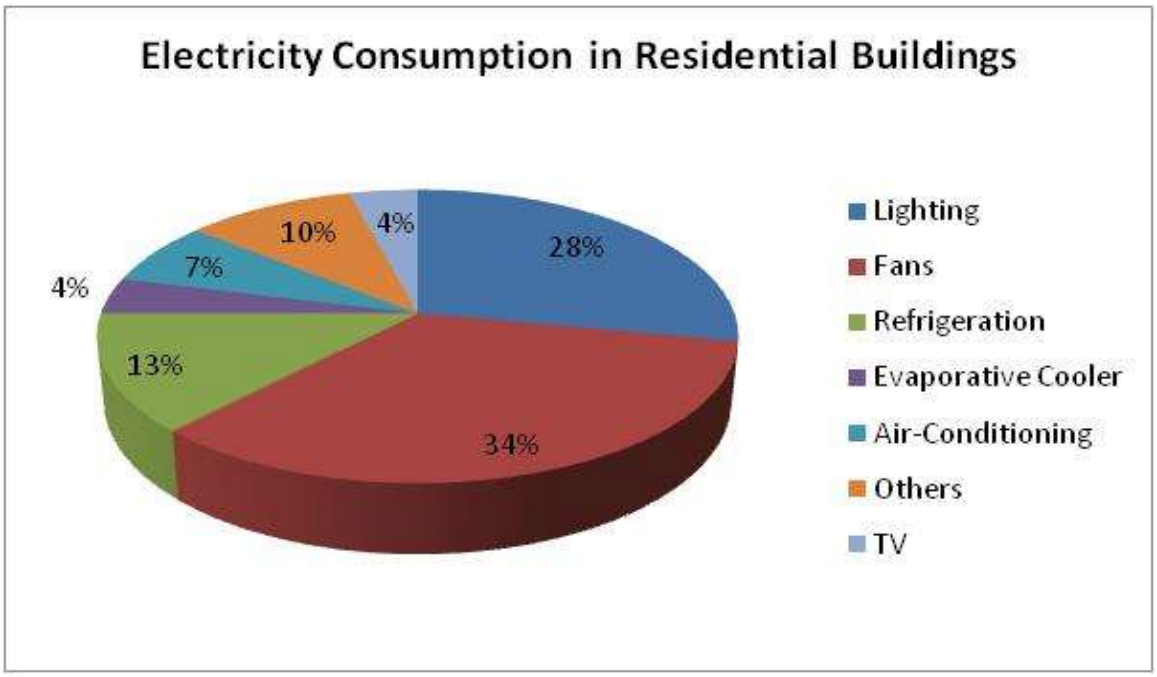
- **Mode Shift:** Compared to the expected modal shares in 2020, public transport share increases by **5.5 percent** (3 percent from MTWs and 2.5 percent from cars) and non-motorized transport share increases by **3 percent** (1.5 percent each from MTWs and cars)
- **Fuel Efficiency:** Each percentage improvement in specific fuel consumption of new cars by 2020 (with no difference in car ownership or usage) will induce a saving of about 0.7 MT CO2 in 2020

****Aggressive Effort:**

- **Mode Shift:** Compared to the expected modal shares in 2020, public transport share increases **8 percent** (4 percent each from MTWs and cars) and non-motorized transport share increases by **4 percent** (2 percent each from MTWs and cars)
- **Fuel Efficiency**: Each percentage improvement in specific fuel consumption of new cars by 2020 (with no difference in car ownership or usage) will induce a saving of about 1 MT CO2 in 2020

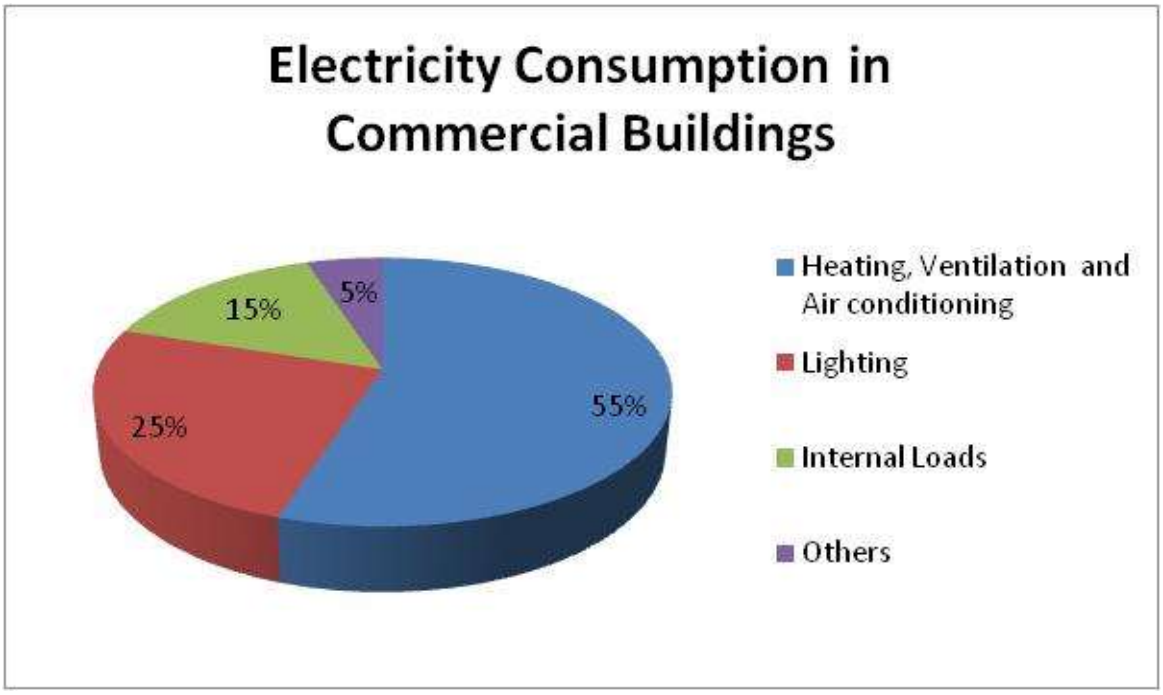
[14] The code remains voluntary until it is adopted into the by-laws of the individual states.
[15] A part of the GRIHA rating system that is applicable for small developments

Figure 10: Electricity consumption in residential buildings



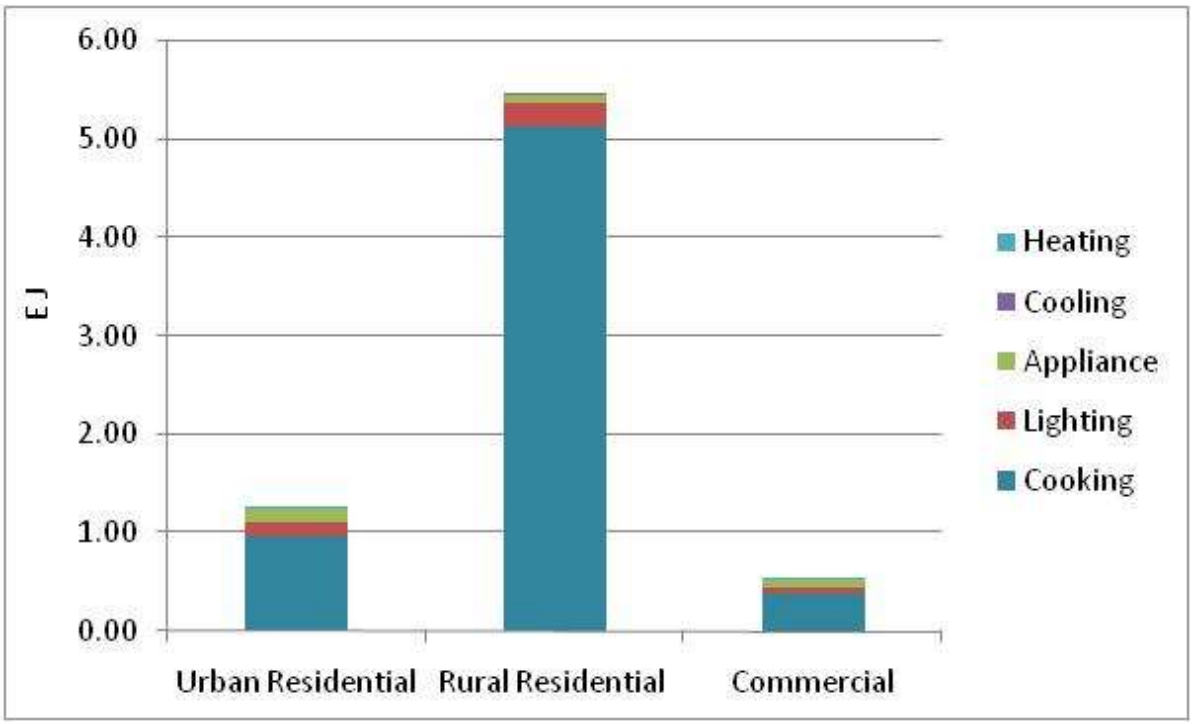
Source: *BEE*

Figure 11: Electricity consumption in commercial buildings



Source: *BEE*

Figure 12: End-use energy demand in buildings



Source: *Chaturvedi, et al. (2014)*

The energy consumption profile of households goes beyond just electricity consumption. Figure 10 shows the end-use wise total energy consumption by the buildings sector estimated by NWNL (Chaturvedi et al. 2014). The predominance of cooking energy comprising biomass and petroleum products (kerosene and LPG) is quite obvious. Thus, design interventions that improve energy efficiency as well as lifestyle changes have all been incorporated in the modelling framework of studies that seek to look at the impact of interventions in determining the emissions generating from the buildings sector. Table 4 below shows the emission reduction potential from the Indian buildings sector as estimated by various important studies.

Table 4: Abatement Potential from Interventions in the Buildings Sector

	Timeframe	Scenario	Energy Efficiency Rated Appliances, lighting	ECBC Adoption	Improved Cook Stoves	Retrofits in Existing Buildings	Notes	Abatement Potential
Planning Commission (2011)	2020	Aggressive Effort	✓ (32)	✓ (45)		✓ (45)	*Includes only Commercial Buildings*	122 Mt CO2 abated
TERI, 2013	2050	REN	✓		✓		*Movement towards 100% renewable modelled*	228 mtoe or 35% reduction from baseline
McKinsey, 2009	2030		✓ (145)	✓(145)	✓ (30)	✓ (20)		340 Mt CO2 abated
AVOID, 2012	2050	LC2	✓					~0.8 EJ or 16% reduction from baseline
BEE	2020			✓(18)			*Includes only Commercial Buildings*	18 Mt CO2

Existing barriers to adoption of energy-conserving innovations and options for circumvention

As stated earlier, energy efficient building construction is associated with a cost increase of 6-18%. While there is a three- to seven-year payback period associated with this, access to initial finance becomes a problem for such projects. On a comparative scale, it is easier for renewable projects to get financing because of their tangible output, but energy efficient projects require continuous monitoring and auditing. For this reason funding is often difficult to secure for these projects. The MNRE and many state governments offer incentives for the adoption of building-integrated renewable energy technologies. It is noteworthy that solar water-heating systems are one of the components covered by the ECBC. Many state and city governments offer property tax rebates and other incentives for properties that install and use solar heating and lighting systems. From an urban point of view, Gandhinagar (Gujarat) provides an interesting example of building "solar cities" in India. The details of this particular case are provided in Box 2.

Box 2. Gandhinagar "Solar City" Project

Installation of solar panels on rooftops is one of the easiest ways to incorporate renewable electricity generation in an urban setting. An attempt has been made by the Indian government through its Solar Cities project (part of the National Solar Mission) to incorporate renewable technologies in urban buildings. The Gandhinagar (in Gujarat) project is one of the first rooftop solar projects in India to be developed in the form of a public-private partnership (PPP. The pilot project included plans for a 5MW grid-connected, distributed rooftop solar system. Since the power generated is fed directly into the grid, this would immediately translate into an equivalent level of avoided generation capacity. In terms of generation, reports show that a total of 1.2 million units of solar power were generated in the first six months of the project. The estimated capital cost for the solar rooftop project in Gandhinagar was $15 million.

As part of the PPP model, the role of the government is to provide access to roofs of buildings it owns, facilitate agreements with power procurer for electricity generated, and guarantee a subsidy if required. The role of the private developer is to identify private buildings that will participate in the project at the initial stages and then subsequently produce solar power and deliver it to the grid. Two companies—Sun Edison Energy India and Azure Sun Energy—each won 25-year concessions for a 2.5 MW solar rooftop project through a competitive bidding process. In terms of building selection, around 80% of the buildings finally selected for installation were government/public owned. Not many residential houses opted for hosting these project solar panels. Further incentives might induce more households to join these networks.

Several Indian banks have recently started offering financing incentives for both green buildings and adoption of green technologies. The Bank of Maharashtra and ING Vysya Bank offer mortgage products with a 0.5% rebate on prevalent interest rates and a 1% interest rate subsidy on certain energy-efficient equipment and appliances (solar water heaters, efficient lighting, refrigerators and air conditioners). The State Bank of India offers a 0.5% interest rate subsidy for certified IGBC projects. The State Bank of Mysore offers an interest reduction for energy-efficient, green housing, renewable energy, and waste management projects (GBPN 2013).

The problem of a lack of technical input (manpower and materials), small–scale of projects and split incentives [16] add to the list of barriers to wider adoption. The small scale of independent housing projects limits consumer access to funding and technical assistance for green construction. As has been stated earlier, innovative designing of government-supported joint housing schemes could be an answer. Regarding knowledge gaps in the field, it is widely acknowledged in the literature that for deploying the ECBC codes at a larger scale designers, builders, code officials and other stakeholders need time to build necessary capacity for implementation. The implementation of the ECBC in India has been hampered by shortage of building professionals who have been trained in energy-use issues in buildings. However, there are some capacity building initiatives that are underway (e.g., the USAID Eco – III project). There is also a new UNDP-GEF intervention that aims to address the training barriers noted above and assist the Government in implementing and operationalizing the ECBC through a comprehensive and integrated approach. The programme focuses on both, strengthening institutional capacities at various levels to implement ECBC, as well as developing technical expertise, blue collar skills, and creating general awareness.

Another barrier to adoption stems from the requirement of a process to translate the ECBC into enforceable codes for local level construction activity. In India local level building regulations, called "by-laws," are the means by which private sector buildings are regulated. Based on press reports there are efforts underway to devise ECBC compliant bye-laws in the states of Rajasthan and Orissa as well as the cities of Ahmedabad and Surat (Gujarat); Bangalore (Karnataka state); and Chennai (Tamil Nadu) [Williams and Levine, 2012]. As more states mandate the implementation of ECBC, it is expected that this process of local application of green building codes will grow.

A final deficit is the lack of a trained workforce for the construction sector. Given that the construction industry is projected to be one of the largest employers in the coming decades (McKinsey 2014), it is critical that a skilled workforce trained in green building techniques be prepared – both to lower the cost of green construction as well as to provide the workforce needed to provide scale. These efforts will in turn also create pathways for upward mobility for workers with the creation of better paying urban jobs.

(3) Water networks

Access to water is a key challenge across the board in rural and urban areas, but it is critical in urban agglomerations given the density of demand. There is tremendous unplanned growth in the urban peripheries that is occuring without sewers, water lines, or a real electricity grid for the most part. As a result, people are assaulting the ground water with pumps in the ground to draw water out, a process occurring completely outside the region's water grid.

[16] Most residential housing is built by private developers and contractors. They incur the greater costs of green building during construction, but the benefits of better design features are enjoyed by the home occupants (owner or tenant) via lower energy bills.

Experience in two cities illustrates how deeply problematic this is. Amritsar, in Punjab state, and Faridabad, a suburb of Delhi, both have populations of roughly 1.5 million. Amritsar is one of Punjab's largest cities, and yet 75% of households rely on ground water that is piped into their homes or drawn up through tube wells. A combination of unregulated tube wells, bore wells and even hand pumps (in the poorer areas) are rapidly depleting the city's ground water supply. In 2005, the ground water table was 23 meters below the surface. Today, it is 50 meters below the surface for hand pumps, and those with more resources are boring to depths of 200-300 meters due to contamination of shallower waters. Unless something changes, the city will face a serious public health crisis.

Faridabad, on the outskirts of Delhi, is sited near the Yamuna River and also has three lakes in its vicinity. The river is heavily polluted from the dumping of untreated sewage and industrial effluent upstream. The lakes have been contaminated by squatter settlements on their shores. Thus, ironically a growing industrial city with over 15,000 small, medium and large firms, located on the banks of a river and on edges of the national capital, depends entirely on ground water.

Currently, cities use 70% of JNNURM funds for the water sector, but hardly any is spent on ground water recharge, water recycling, conservation or demand management. Transporting water from distant sources is not only inefficient and costly, it is also emissions intensive. Prudent demand management and the creation of sustainable sources of water will be essential to the future of India's cities.

In the next section we examine the current state of municipal finance in India and explore the challenges of financing low carbon urban innovations.

V. FINANCING THE URBAN TRANSITION

The potential of domestic public finance has been underestimated in the debates on urban mitigation and adaptation and its role far too narrowly defined—indeed "projectized," sectorally siloed to obscure critical linkages between development goals and climate goals. Co-benefits stem from the relational nature of climate investments and the simple fact that interventions in one sector or in one location, if designed properly, have the capacity to create spillover effects felt in other sectors and other locations.

Finance is critical to enacting climate action and is too often seen as a key constraint. Planning and project design will determine whether the primary, secondary, and tertiary effects are positive or negative. The possibility of harnessing co-benefits in this way calls into question the notion that there must be tradeoffs between development expenditures and climate action. Consequently, the centrality of public finance to climate-resilient development will be dependent on the regulatory definitions fiscal policymakers adopt for objectives such as resiliency, sustainability, adaptation and mitigation, and whether the regulations that

govern public expenditure recognize the relationships among those objectives.[17] Because market actors do not have to bear the full social cost of investment, the burden will be on the public sector to identify co-benefits and arrange financing structures to exploit them.

The Critical Role of Operations and Maintenance Expenditures

O&M expenditures are the second hindrance to effective climate action and to the realization of co-benefits. In any given year, the availability of public finance and access to different revenue instruments at the subnational scale determines the distribution of resources between personnel costs, new capital investment, and operations and maintenance (O&M).

Though it is rarely acknowledged as such, in practice, nearly all investment decisions are mediated by historical trends in budget performance at national, regional and local levels. Moreover, the size of federal, state and local budgets is determined by the capacity and willingness of governments to levy and collect taxes.[18] The availability of funds or the capacity to mobilize revenue also determines the timing of capital investment and maintenance expenditures and therefore inter-temporal investment outcomes.[19]

There are, however, conditions under which public finance does operate as a binding constraint on economic development and climate action. Markets for municipal debt might be underdeveloped, leaving cities unable to finance up-front, lumpy infrastructure costs. Fiscal decentralization may be incomplete or legal statutes may not be implemented, leaving cities with a mismatch between spending responsibilities and local revenues. Subnational governments can reform taxes and user charges to increase the overall tax intake but the adjustment, especially in city governments with low technical capacity, is not instantaneous. As a result, sustained increases in revenues might lag far behind the initial reforms. Governments can loosen the binding constraint of subnational finance through the intergovernmental transfer system, or then, private sector participation.

Urban resiliency in relation to climate risk, in the long run, thus, is determined by adequate funding for operations and maintenance. What matters is sustaining the flow of co-benefits from infrastructure assets that require regular maintenance and/or upgrading/retrofitting. These critical functions at the local level are financed almost entirely from local tax revenues and user charges.

The benefits that flow from projects and programs that attempt to mitigate GHG emissions or adapt to projected impacts will not be sustainable unless adequate funding for operations and maintenance (O&M) is secured. Indeed, a shortage of O&M funds not only diminishes the

[17] This recognition is often prevented because of silo effects when officials from different ministries or government departments do not coordinate.

[18] Even if a city goes to the market to finance infrastructure development, it first must ensure that adequate tax revenue streams exist for debt repayment. With the risk of intense cyclones or extreme precipitation events, the effects on subnational fiscal systems from these climate stressors potentially threatens the ability to service debt loads.

[19] Levels of inflation and overall macroeconomic stability also affect the timing of capital and maintenance expenditures.

stream of benefits but can also worsen the circumstances for the beneficiaries of the original investment (Cohen, 1998; Gakenheimer 1989). It is not simply a matter of the infrastructure gap. Hospitals that are not maintained or drainage pipes that become degraded can exacerbate the adverse effects of climate variability on the poor and other vulnerable populations.

Finally, local government tax bases are vulnerable to many of the same climate stressors from global warming as they aim to address. Extreme weather events can cause destruction to local tax bases, for example, by reducing (or destroying) the value of housing on which cities levy the property tax. The destruction of a prominent local tax base along with the precipitous rise in demand for services might dissuade banks from lending to local governments. Revenue from sales tax could drop if household wealth is reduced or if consumers change expenditure patterns in the wake of extreme climate events. In these circumstances, there could be budgetary pressure on higher levels of government to expand fiscal transfers to cities and income support to residents through cash transfers or through tax expenditures or rebates. All of these responses raise the possibility of disrupted revenue flows and conditions for large revenue deficits in subsequent years while exacerbating already existing vicious cycles of capital investment followed by too little spending on maintenance.

Fiscal Resources for Climate Action: Potential Funding Lines

Since the passage of the 74th Constitutional Amendment Act (CAA) urban local bodies, even in the country's largest cities, have struggled to mobilize revenues from local tax and user fee bases. Table 5 provides key figures on the structure of local government finance at the macro scale. In 2007-08, total revenue collected from local sources was 23,521 crores or 0.50 percent of GDP. Revenue from the tax bases of municipalities nearly doubled between fiscal years 2002-03 and 2007-08. Yet, the asymmetry between the growing list of local spending responsibilities and the current productivity of available revenue instruments persists. For example, revenue expenditure in 2007-08, encompassing establishment and maintenance expenses was 120 percent of the total revenue collected from local sources! Local governments do receive income support for establishment costs from their share of state taxes (Assignment and Devolution) and other ad hoc or programmatic transfers from the Planning Commission (PC) and Central Finance Commission (CFC) that include outlays for personnel and maintenance expenses. It is clear is that the continued inability to mobilize local revenues will have future consequences for achieving mitigation and adaptation goals through direct investment by local governments.

Table 5: The Structure of Local Government Finance in India

	2002-03	2007-08	% of GDP (2007-08)
Revenue			
Own Tax Revenue	8,838.13 (311)	15,277.72 (492)	0.32
Own Non Tax Revenue	4,441.84 (156)	8,243.66 (265)	0.18
Total Own Revenue	13,279.97 (466)	23,521.38 (757)	0.50
Total Revenue Income (w/ transfers)	20,919.69 (733)	44,429.05 (1430)	
Expenditure			
Revenue Expenditure	15,619.46 (550)	28,431.45 (915)	0.66
Capital Expenditure	5,938.28 (208)	18,954.08 (598)	0.43
Total Expenditure	21,629.74 (758)	47,025.53 (1,513)	1.09
Revenue Expenditure/Total Own Revenue	118%	120%	

Source: *NIPFP (2011)*

The fiscal reality is that over the next 20-30 years local governments will continue to be heavily dependent on transfers for local capital formation. Optimistic estimates by the High Powered Expert Committee suggest that by 2031-32 municipal own-source revenue will still only amount to 1.47% of GDP, with a third of local government income coming from transfers (HPEC 2011) The most recent changes in the levels of dependency on transfers will be released with the 14th CFC Report, though the trend between 2002-02 and 2007-08 was that size of transfers from Union and State governments were increasing faster than local resource mobilization (NIPFP 2011). The numbers in Table 6 show this clear trend. The enormous jump in total transfers to local governments seen below in Table 6 was caused by growth in Assignment and Devolution transfers and the inception of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM).[20]

Table 6: Intergovernmental Transfers to ULBs

Transfer to ULBs	2002-03	2007-08
Assignment and Devolution	3,657.06 (128)	9,171.11 (295)
Grants in Aid	2,259.76 (79)	5,676.25 (183)
Other Grants	1,137.52 (40)	2,818.32 (91)
Transfers from Union Government	308.86 (11)	2,372.97 (76)
Finance Commission Transfers	276.53 (10)	869.02 (28)
Total Transfers to ULBs	7,639.73	20,907.67
Share of Transfers in Total Revenue (%)	36.5	47.0

Note: Figures in parentheses are per capita levels.
Source: *NIPFP 2011*

[20] The near tripling of CFC transfers to ULBs is also striking.

A small but noticeable shift in transfers occurred with the 13th Finance Commission. Within the aggregate transfer pool, many block transfers from the CFC along with Planning Commission transfers to state governments relate increasingly to adaptation and mitigation. The grants-in-aid in to states in Table 7 are all connected to investments in urban resilience. For example, the capacity building portion of the Disaster Relief Grant includes training to improve adaptive capacity and coping ability in areas that have already experienced income, livelihood, and physical destruction. Though detailed project information is not available regarding the specific use of the grant transfers, it is possible the Government of India could include provisions encouraging or mandating use of the latest technology under the direction of the Building Materials and Technology Promotion Council (BMTPC) during reconstruction.

As the CFC and PC have expanded transfers to states and local bodies, they have also increased the number of conditions for gaining access to the funding. Access to the Renewable Energy and Water Sector Grants is based on state performance within the respective sector. For example, the Renewable Energy grant is structured to incentivize renewable energy projects linked to the existing grid. Twenty-five percent of the final allocation is based on achievement in expanding energy capacity relative to historical levels within the state while 75% is based on achievement in installed capacity relative to changes in national aggregate installed capacity (Thirteenth Finance Commission Report, 2009). The former ensures that all states have the potential to access the funds, while the latter creates a "race to the top" incentive. The Roads and Bridges Grant is devoted to annual normal repair requirements. Yet, given the increasing use of conditionalities, it does not seem unreasonable that a portion of the grant could be given to states designing programs that seek to adapt road infrastructure to climate change.

Table 7: Grant-in-Aid to States 2010-2015

Grant-in-Aid to States	**Amount (Rs. Crore)**
Local Bodies	87,519
Disaster Relief (w/ capacity building)	26,373 (500)
Renewable Energy	5000
Water Sector Management	5000
Maintenance of Roads and Bridges	19,930
State-Specific	27,945
Total	**171,767**

*Figure in parentheses is share of grant devoted to capacity building.
Source: *13th Finance Commission Report.*

Many state-specific grants from the CFC also fall into the category of climate finance. Table 8 lists some of the state-specific grants from the 13th Finance Commission that are channelled to the urban scale and promote mitigation and adaptation and likely generate additional co-benefits. Tamil Nadu requested Rs. 500 crore for slum improvement and

rainwater harvesting; Karnataka requested Rs. 750 crore for drinking water, solid waste management and traffic management infrastructure. Clearly, the Government of India is channelling considerable resources to climate-related investments in cities though it may not always recognize it as such. The 13th Finance Commission stated in its report that the environment is a critical sector that requires more policy attention and fiscal resources. Indeed, one of the motivations for expanding the CFC grants to ULBs was to facilitate larger capital outlays devoted to sustainable urban development.[21]

Table 8: 13th Finance Commission State-specific Grants (2010-2015)

State	**Purpose**	**Amount (Cr.)**
Bihar	Flood prevention	333
Gujarat	Ground water recharge	200
Himachal Pradesh	Sewerage, drainage, solid waste disposal	50
Karnataka	Drinking water, solid waste management infrastructure, traffic management infrastructure	750
Kerala	Sea walls, inland waterways	250
Meghalaya	Water supply, construction of bridges	130
Punjab	Infrastructure maintenance, water harvesting	250
Tamil Nadu	Slum improvement, restoration of water bodies	500
Uttarakhand	Sewerage for Dehradun	150
	Total	**2,613**

Source: *Central Finance Commission*

In addition to expanding CFC grants, the Government of India has elevated urban infrastructure development and governance reform through the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). JNNURM began in 2006 and is the largest intergovernmental finance program since Independence. The Government of India set the goal of mobilizing US $20 billion in capital financing by encouraging private investment and making available to 65 participating cities matching capital grants for municipal transport, road, water, and sanitation infrastructure and for the construction of subsidized housing for the urban poor. The total approved costs for UIG component of JNNURM was Rs. 74,877.92 crore but only Rs. 21,399.00 crore of federal funding had been released by the end of 2013, falling short of the original ambitious goal (Ministry of Urban Development 2013). Table 9 shows that the sector distribution of projects approved and completed is heavily skewed toward water supply, sewerage, and roads and flyovers. Climate-related objectives were included in many of the City Development Plans submitted by participating Municipal Corporations, but there were no design or project selection conditionalities imposed by the Central Sanctioning and Monitoring Committee (CSMC).

[21] The CFC, however, gave the additional grant funds untied in hope that ULBs would spend it on improving the environment.

Table 9: JNNURM Approved Costs and Central Assistance Released by Sector 2006-2013 (Rs. Crore)

Sector	No. of Projects Approved	Approved Costs	Total ACA (Central Share)	Total ACA Released	No. of Projects Completed
Drainage/Storm Water Drains	79	8,963.05	3,711.73	2,729.50	28
Roads/Flyovers	110	9,053.86	3,805.26	2,319.69	60
Water Supply	203	25,637.89	12,364.61	7,987.80	68
Urban Renewal	10	464.45	192.49	97.65	4
Sewerage	138	19,503.62	9,280.55	5,006.48	34
Other Urban Transport (Metro)	17	790.64	371.58	269.76	12
Mass Rapid Transport System	26	6,680.67	3,235.05	2,000.13	7
Solid Waste Management	50	2,520.36	1,360.46	752.84	12
Parking Lot PPPs	5	860.42	337.28	103.36	0
Heritage Areas	8	286.21	192.75	75.07	2
Preservation of Water Bodies	4	116.70	68.61	56.67	0
Total	650	74,877.92	34,920.39	21,399.00	227

Source: *Ministry of Urban Development.*

The large gap between projects approved and completed reflects the low level of project execution capacity in ULBs in India. For example, according to the Comptroller and Auditor General (CAG), New Delhi only completed four of 28 projects. Even in the states with the highest levels of urban governance capacity, project completion rates were low. Gujarat completed 46% of projects and Karnataka completed only 35% of projects (CAG 2012). Table 9 lists the sector-wise composition of completed projects in four of the most urbanized states. Of the projects completed in Gujarat, roads/flyovers comprised the largest share, followed by sewerage, and water supply. Projects in Karnataka were oriented towards transit, with over half in the roads/flyover category but also over 33% in "Other Transport." Maharashtra, followed a different pattern. The state completed 13 water supply projects followed by 7 drainage projects. In Tamil Nadu, water supply dominated the project portfolio, taking 13 of 20 projects with the next closest sector, solid waste management, only having three. With state-level funding being necessary for project sanctioning, the overall composition of projects reflects both state-level priorities and local realities.

The selection of projects also reflects a lack of intention to make investments that would lead to positive ancillary effects. Though Gujarat drew down JNNURM funds to help finance its Bus Rapid Transit System (BRTS), it also utilized grants to construct many new flyovers. JNNURM, in general, privileged heavy capital investment, particularly in water supply,

flyovers, and sewerage, while urban renewal projects, investments that would directly reduce congestion, improve public health, and increase resiliency were mostly an afterthought. The Ministry of Urban Development only approved eleven out of 532 urban renewal projects under UIG. Not a single state completed an urban renewal project. Moreover the construction of low-income housing was abysmal in the Basic Services to the Urban Poor (BSUP) component. Only eight of 499 housing projects were completed between the launch of the scheme in 2006 to March 31, 2011 (CAG 2012).

If we expand the list of investment inputs to include those that generate co-benefits, whether they be economic, environment, health, education, or gender-oriented, the pool of available resources at the federal level extends far beyond the quantum of funds released under JNNURM. The National Urban Health Mission (NUHM) could be considered climate finance because it targets urban residents below the poverty line thus improving their health and capacity to adapt to climate stressors. Likewise, the recently initiated Rajiv Awas Yojana (RAY) housing scheme for the urban poor presents a high profile, national platform to integrate housing with climate mitigation and adaptation actions. Because the majority of funds (50%) come from the Union Government, MHUPA could use its leverage to enhance building standards for the poor by requiring the use of advanced insulation materials to keep the temperature of the housing units more constant. Moreover, they could require that construction material used be resilient to the potential localized, contextual risks from climate change (e.g. extreme precipitation/flooding). From a regulatory standpoint, funding from these Central Sponsored Schemes (CSS) historically has been considered "orthogonal" to climate-related projects. This is not surprising, given that it is only in the past decade that the necessary advances have been made in climate research that encourage multi-sector integration of investments to generate co-benefits (Wilkinson et al., 2009; Huq et al., 2007).

Though the potential to generate co-benefits from the projects financed by these schemes is high, the funds do not have a direct connection to climate/environmental finance as currently defined by the Central Finance Commission and Planning Commission. For example, within the recently inaugurated fund--Assistance to States for Infrastructure Development for Exports (ASIDE) – environmental sustainability objectives can and should be integrated into this primarily economic development program, though climate change is not a priority in the program's design.[22] Yet, some of the funding will go towards capital investment in port infrastructure that could be vulnerable to sea rise and significantly stronger cyclones. Rajiv Awas Yojana (RAY), the universal housing scheme managed by MHUPA, also can integrate economic and human development with climate-related objectives by setting rigorous siting standards that privilege locating poor beneficiaries near their places of work. As a measure of the scale of available funds, the budgeted outlays for RAY exceed the quantum of funds disbursed through JNNURM over its six-year period.

[22] This is especially true because one sanctioned use of funds from the ASIDE scheme is for the creation of Special Economic Zones (SEZs), which have had deleterious effects on local environments in other countries.

Table 10: Climate-Resilient Related Programs (12th Five-Year Plan) (Rs. Crore)

Centrally Sponsored Scheme	Amount
National Urban Health Mission	22,507
National Urban Livelihood Mission (formerly SJSRY)	1,003
Rajiv Awas Yojana	29,710
Assistance to States for Infrastructure Development for Exports	800

Source: Planning Commission

Table 10 shows outlays from the Planning Commission by major budget heads for the two most recent fiscal years. Though these are only budget numbers and not actual utilization, it is clear the scale of available resources is large. The challenge is to frame the programs financed by these funds as climate-related so that a standard of co-benefit production can be incorporated into their structuring. Though this section has only briefly reviewed the flow of some funds from the Government of India to states and cities, it should be apparent that the common discourse on the scarcity of resources for climate action overestimates the level of scarcity. In fact, because that discourse does not take into account transfers in other sectors that have a strong relation to increasing adaptive capacity while mitigating GHGs, policymakers have *underestimated* the level of resources available. There are significant fiscal resources that with proper regulation could be used by cities to generate large co-benefits for the economy, the environment, and for the livelihoods of the poor.

VI. CONCLUSIONS AND POLICY RECOMMENDATIONS

From this brief review of the existing policy literature on Indian urbanization and emission growth, it is clear that pathways for low-carbon urban growth are emerging in India, but public policy choices will figure heavily in the overall success of their implementation. At core, the key areas in which these decisions will matter most are: (i) urban form and multimodal transport; (ii) reducing the energy/coal-intensity of industry; (iii) smart infrastructure, especially buildings and sustainable water networks; and (iii) innovation, particularly in urban finance and institutions of governance. We elaborate on a few of these core areas of focus.

(1) Urban Form and Multimodal Transport Networks

Transport and urban form are central to achieving a low-carbon urban future. The study of Kolkata/Mumbai vs. Delhi illustrates how the promotion of public transport and urban density can lead to a lower-carbon urban model. But it also shows that the relationship is complex: compact urban form has to be combined with public transport to be effective. One cannot have one without the other. City size also matters. In Mumbai and Kolkata, polycentric urban extensions did not increase the overall effective size of the city as they did in Delhi. Careful consideration of how to manage the rise in vehicle ownership and its interface with the national car industry will be necessary. The mini-case study of Surat

demonstrated how the city has improved its economic prosperity by attracting talent and capital and also now recognizes the importance of investing in public transport.

The geographical focus for achieving low-carbon growth should be the numerous and fast growing medium-size towns along with the sites of suburban sprawl. These areas lack financial resources and institutional capabilities to plan and implement a low-carbon growth trajectory (or avoid high carbon development). Regions where these urban centres are located have shown economic prosperity but have mainly achieved it through high energy and natural resource intensive industrial sectors. To change to a greener growth model, cities in these regions need to diversify their economic base so that economic prosperity doesn't come at the cost of heavy dependence on high carbon emitting industries.

At the city level, it is important to get the urban form, landuse, density and transport nexus right in order to mitigate the effects of climate change. This can be achieved through mixed land-use policies, providing sufficient and affordable public transport options, and incorporating improved and efficient technologies linked to vehicular standards as well as fuel efficiencies and the subsidies that hide the real cost of private travel.

(2) Smart Infrastructure

Emerging urban centres and suburbs are creating high demand for residential and commercial buildings, and green buildings can be one of significant answers to fostering a resilient and low carbon urban future. Investing in green buildings will be crucial to implementing low-carbon growth models in cities in order to avoid the long-term negative lock-in effects associated with conventional buildings. While green buildings have higher initial costs, we saw that they have relatively short payback periods and generate wide economic benefits. Support for the promotion of green buildings in Indian cities is gathering momentum. Energy use can be significantly reduced – or at least better managed – with the use of green construction materials, practices and climate-sensitive design. To achieve better results these measures can be complemented with inducements that encourage changes in lifestyle choices (e.g., moving away from the use of biomass in low income households) and the adoption of energy-efficient appliances.

Significant barriers exist to the wider adoption of green building practices due to a range of market failures, institutional gaps and capacity deficiencies (e.g., split incentives, lack of know-how). More importantly, current initiatives lack scale which raises the cost of adoption. Access to finance is also a considerable barrier, as is the fragmentation of administrative roles and responsibilities. In spite of these barriers, the government can take several measures to enhance benefits from the buildings sector:

1. Mandatory incorporation of green design aspects in building bylaws or incentives for their incorporation through rebates in property tax, building premiums, etc.
2. Programs to improve biomass cook stoves at the urban level.

3. Eliminating barriers to improvements in energy efficiency due to small-scale operations by targeting larger collective-housing schemes such as Economically Weaker Sections and slum-upgrading housing schemes. Collective action could pave the way for soliciting additional/incremental international finance (CDM, GEF) as well.
4. Finding ways to make the lived environments of the poor in cities better, safer and less carbon intensive (e.g., through the diffusion of fuel-efficient cookstoves and fuels that help eliminate the use of biomass for cooking will go a long way toward improving public health and lowering the city's carbon footprint.
5. Inclusion in every dimension of urban service delivery reform is key – the poor are not a burden for a city to banish to the urban periphery in a quest for slum-free cities. The persistence of urban poverty is a sign of the lack of the evolution of a city's policy paradigms and its institutions of governance.
6. Building capacity and awareness campaigns for green/energy-efficient buildings on a larger scale, similar to the Star Rated Appliance Programme of the BEE.
7. An explicit effort to provide viable green cover to every city not only to allow it to breathe but to also act as a mechanism for carbon storage.

It will be important to pursue greener building stock (and not just energy-efficient buildings), fuel diversification and energy-efficient product standards simultaneously with principles of conservation (water, energy, fuel waste). Attention must be paid—and quickly—to water networks and resources. In the fast growing cities and regions, ground water is being exploited at an unsustainable rate on account of polluted surface water sources, high water demand and low coverage of water supply networks, among other reasons. To address this issue, cities needs to look beyond their boundaries to revive surface water bodies and other natural endowments such as wetlands, etc., to diversify their water sources and proceed on a more sustainable and resilient growth trajectory.

(3) Innovation

The push for a faster, more inclusive and greener urban transition in India can benefit greatly from institutional innovations that break bottlenecks while lowering costs and leveraging the co-benefits of simultaneously pursuing the objectives of development, low-carbon growth and climate safety. Cities need greater levels of fiscal autonomy if they are to drive a new growth model. The current situation is sobering. Projects depend too heavily on fiscal transfers and the limits of public financing at the city level, which may be made worse by climate change. Underdeveloped municipal debt markets are forced to fund up-front capital intensive investments. But positive developments include devolution reforms; JNNURM (although some barriers existed, e.g., project by project approach; and emerging sources of financing of low-carbon, climate-resilient infrastructure, including property tax reform, which is in itself linked to reducing sprawl. It will be important to continue to press for efforts to reform municipal finance and to aggregate some of the existing but hidden sources of climate financing.

The structuring of creative incentives can make it politically easier for decision makers to push for the new urban agenda. Currently urban sector reforms are being undertaken and supported by several different agencies: the Ministry of Urban Development with its SMART cities program, Swatch Bharat Abhiyan, the 500 cities mission for rejuvenation and urban transformation (AMRUT) and the Make in India campaign that seeks to create jobs in and around urban areas. Other agencies supporting low carbon urban interventions are the Ministry of Environment and Forests, the MNRE, and the agencies involved in implementing and financing programs under the National Climate Action Plan and private efforts such as GRIHA to support green buildings. While there are crucial synergies to be tapped across these programs, the organizations and agencies often operate in isolation. Similarly agencies that support reform in the water sector, energy and power sector, buildings and housing, water and sanitation often work in silos; indeed, they even work at cross purposes as they guard their turf. Finally jurisdictional tensions are between municipalities, other urban local bodies and nagar panchayats add to administrative gridlock that can undermine the adoption of network based innovations that cut across urban-peri-urban and rural boundaries.

Breaking these sectoral silos and getting past administrative boundaries, as well as encouraging experimentation and evaluation to refine and customize approaches that work will be critical to supporting new pathways to dynamic and carbon efficient growth and urbanization in India. This might call for a rescaling of political boundaries as some scholars are pointing out[23] and paying attention to the urban periphery and the urban-rural interface in India's urban transition

Finally, policy makers will need to turn to innovative sources of urban finance, while making sure that O&M funding and performance standards are made an institutional priority in addition to the funding of capital costs. At the same time, pricing reforms, where possible, may allow consumers to see the real costs of their choices and economic actions. Given the scale of India's anticipated urban growth, there are immense challenges but also a tremendous opportunity to get India's urban process right to enable a more robust, resilient and inclusive prosperity.

[23] Sai Balakrishnan and Katharina Pistor 2014 mimeo.

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