Better Cities, Better Growth: India's Urban Opportunity

SYNTHESIS PAPER FOR POLICY MAKERS

THE **NEW** CLIMATE **ECONOMY**

The Global Commission on the Economy and Climate

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Citation

Citation: Tewari, M., Godfrey. N., et al. *Better Cities, Better Growth: India's Urban Opportunity*. New Climate Economy, World Resources Institute, and Indian Council for Research on International Economic Relations. London, Washington, DC, and New Delhi. Available at: http://newclimateeconomy.report/workingpapers

COALITION FOR URBAN TRANSITIONS

A New Climate Economy Special Initiative

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About this report

This paper has been prepared by the Indian Council for Research on International Economic Relations (ICRIER); the WRI Ross Center for Sustainable Cities; the New Climate Economy (NCE), flagship project of the Global Commission on the Economy and the Climate; and the Coalition for Urban Transitions, an NCE Special Initiative. The paper was prepared in partnership with the University of North Carolina at Chapel Hill and the Global Spatial Research Program on Spatial Development of Cities at the World Bank.

This report draws from a wider research project including four forthcoming research papers as well as expert consultations. The wider project team comprises: Meenu Tewari (UNC, ICRIER), Rajat Kathuria (ICRIER), Ani Dasgupta (WRI), Milan Brahmbhatt (NCE), Nick Godfrey (NCE, Coalition for Urban Transitions), Anil Markandya (ICRIER), Simon Alder (UNC), Mark Roberts (World Bank), Katie McWilliams (World Bank), Srikanth Shastry (WRI), Indro Ray (ICRIER), Aarsi Sagar (ICRIER), Zeba Aziz (ICRIER), Madhav Pai (WRI), Sahana Goswami (WRI), Anjali Mahendra (WRI), Apurba Chatterjee (WRI), Anirudh Tagat (WRI), Sandeep Paul (ICRIER), Todd Litman (Victoria Transport Policy Institute), Kyle Onda (UNC), Alexander Pearson (UNC), Ehtisham Ahmad (London School of Economics), Helen Mountford (NCE), Ferzina Banaji (NCE), Annie Lefebure (NCE), Joel Jaeger (NCE), Ian de Cruz (NCE), Cory Rand (NCE) and Rachel Waddell (NCE). This synthesis paper has been prepared by Meenu Tewari (UNC, ICRIER) and Nick Godfrey (NCE, Coalition for Urban Transitions). Assistance was ably provided by Milan Brahmbhatt (NCE), Anjali Mahendra (WRI), Srikanth Shastry (WRI) and Mark Roberts (World Bank).

The authors would like to express thanks to a wide range of NCE partners including Lord Nicholas Stern, Naina Lal Kidwai, Jamshyd Godrej, Shirish Patel, Smita Srinivas, and David Fuente, who all provided valuable comments and input to a previous draft. Any shortcomings or errors are those of the authors alone.

This work has benefitted from extensive stakeholder engagement with a number of experts in India, including discussion at the *CONNECTKaro2016* conference held in New Delhi in April 2016 and *Unlock Bengaluru* held in Bengaluru in July 2016. Organisations involved at both events included: Technology Informatics Design Endeavour (TIDE); Indian Institute for Human Settlements (IIHS); Consortium for DEWATS Dissemination Society; Gujarat Technological University; L.D. College of Engineering, Gujarat; CEPT University, Gujarat; Arghyam; Institute for Social and Economic Change (ISEC); BBMP Restructuring Committee (Representative); Jawaharlal Nehru University (JNU), Delhi; Ashoka Trust for Research in Ecology and the Environment (ATREE) and Godrej & Boyce.

This material has been funded by UK aid from the UK government however the views expressed do not necessarily reflect the UK government's official policies. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments that they represent. Nor do the research results and conclusions expressed necessarily reflect the views of The University of North Carolina at Chapel Hill.

About The New Climate Economy

The Global Commission on the Economy and Climate, and its flagship project The New Climate Economy, were set up to help governments, businesses and society make better-informed decisions on how to achieve economic prosperity and development while also addressing climate change. The project has released a major flagship reports as well as country reports on the United States, China, India and Ethiopia, and sector reports on cities, land use, energy and finance. Most recently, it published *The Sustainable Infrastructure Imperative: Financing for Better Growth and Development* in October 2016. It has disseminated its messages by engaging with heads of governments, finance ministers, business leaders and other key economic decision-makers in over 50 countries around the world.

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ICRIER, one of India's leading think tanks, was established in August 1981 as a not-for-profit research organisation to provide a strong economic basis for policy making. To effectively disseminate research findings, ICRIER organises workshops, seminars and conferences to bring together academicians, policymakers, representatives from industry and media to create a more informed understanding on issues of major policy interest.

About WRI Ross Centre for Sustainable Cities

WRI Ross Center for Sustainable Cities works to make urban sustainability a reality. Global research and on-the-ground experience in Brazil, China, India, Mexico, Turkey and the United States combine to spur action that improves life for millions of people. It builds on WRI's global and local experience in urban planning and mobility, and uses proven solutions and action-oriented tools to increase building and energy efficiency, manage water risk, encourage effective governance and make the fast-growing urban environment more resilient to new challenges.

About the Coalition for Urban Transitions

The Coalition for Urban Transitions is a special initiative of the New Climate Economy, hosted by the WRI Ross Center for Sustainable Cities, and jointly managed with the C40 Climate Leadership Group. The partnership is made up of over 20 major institutions who share a common purpose: delivering a better urban future for all. It does so by supporting decision makers to unlock the power of cities for enhanced national economic, social, and environmental performance, including reducing the risk of climate change.

About University of North Carolina at Chapel Hill

The University of North Carolina at Chapel Hill is a public research university located in Chapel Hill, North Carolina, United States.

About The World Bank

Established in 1944, the World Bank Group is a vital source of financial and technical assistance to developing countries around the world. The Group consists of five institutions – the International Bank for Reconstruction and Development (IBRD), the International Development Association (IDA), the International Finance Corporation (IFC), the Multilateral Investment Guarantee Agency (MIGA), and the International Centre for Settlement of Investment Disputes – and is managed by its member countries. The twin goals of the World Bank Group are to end extreme poverty within a generation and boost shared prosperity.

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Executive summary

1. Introduction

India is experiencing an urban transformation. The country's urban population reached 420 million or 33% of its total population in 2015. This is expected to almost double to 800 million by 2050, with close to 400 million more people living in towns and cities by 2050, one in every two Indians. By 2031, 75% of India's national income is expected to come from cities and the majority of new jobs will be created in urban areas.

Given the rapidity of change and the long-lived nature of urban form and infrastructure, the decisions that India's policy-makers take in the next 5–15 years will lock in its urban pathway for decades to come, perhaps even centuries. There are real choices to be made. Global evidence gathered by NCE suggests that a poorly planned, "sprawled", private-vehicle-dependent model of urban growth can have significant economic, social, and environmental costs which undermine prosperity. On the other hand, more appropriately compact, connected, and coordinated cities can be more productive, socially inclusive, resilient, cleaner, and safer, unleashing the benefits of urban agglomeration. However, in India, many cities experience the worst of all worlds: they are dense but also suffer from overcrowding, inefficient public services, poor walking and cycling conditions, inefficient public transport services, and policies that favour automobile travel. Hence, in India, sprawl means something quite different than in regions such as the United States, requiring a greater emphasis on "appropriate" or "good" density combined with adequate provision of accessible and well-connected infrastructure and services.

This report provides new analysis across 479 Indian cities – using an innovative combination of satellite data of night-time lights, census, environmental, and economic data – which demonstrates a clear link between more compact, connected urban growth and stronger economic performance in India, corroborating global findings.

That said, there is a widespread consensus that India's urbanisation is significantly underperforming in terms of the development benefits that it could deliver. While the central areas of many Indian cities are among the most densely populated in the world, current land regulations contribute to a low density of built-up floor space, combined with extreme overcrowding for many city dwellers. Real estate prices are high. Slums grow, as the poor cannot find low-cost housing. Urban sprawl proliferates as businesses and households

are forced to seek cheaper land further and further out in city peripheries. Most cities also suffer from a dearth of urban infrastructure and severe deficits in urban services, such as water supply, sewerage and sanitation, solid waste management, and urban transport. Weak public transport links encourage increasing dependence on private motorisation, contributing to severe traffic congestion and extremely high outdoor air pollution, as well as growing carbon emissions.

Case studies for four Indian cities – Bangalore, Indore, Pune, and Surat – show how the current model of urbanisation is actually worsening key deficits in basic urban services, pushing households to undertake costly forms of self-provisioning in which basic services are provided by urban residents rather than the state.

The report estimates that a continuation of this poorly planned, sprawling, unconnected pattern of urbanisation could impose significant costs on Indian development, amounting to an estimated US$330 billion to US$1.8 trillion per year by 2050, or 1.2–6.3% of GDP. However, put differently, better, smarter urban growth could be an economic opportunity for India worth up to 6% of GDP by mid-century, and maybe higher.

This report focuses on how India can foster a better urbanisation – one that promotes more rapid economic transformation, improves the quality of life of city dwellers, and curbs the potential harmful spillovers of urbanisation, such as congestion, wasteful energy use, and unwanted pollution. In particular, the report recommends reforms and progress in three key action areas that, together, can help deliver social and economic benefits for urban India:

- Reforms of land regulations to manage urban expansion and promote a more appropriately compact model of urban development, unleashing the forces of agglomeration, reducing urban poverty by bringing people closer to job prospects, and alleviating environmental impacts;
- A major expansion of sustainable urban infrastructure investment to support the development of more compact and connected cities, with a particular focus on improved urban transport;
- Reforms to urban local government and financing, to support stronger coordination and governance of urban development strategies and major infrastructure investment plans.

2. New light on India's urbanisation and economic performance

Satellite data on the intensity of night-time lights across the surface of the earth provide a new way to measure economic activity at a high level of geographical detail, identifying the actual spatial footprint of economic activity. This information is especially useful in places where sub-national level GDP data are not available or difficult to access.

This report uses an innovative combination of night-time lights data over the period 1992 to 2013 with census, environmental, and other economic information – analysed using a range of econometric techniques – to better understand the relationship between urbanisation and economic development in India.

There are four key findings that stand out.

First, the night-time lights information shows that there has been a broad improvement in real incomes across Indian districts over recent decades. But there is also substantial diversity in spatial patterns with the emergence of "leaders", "laggards", "catchups", and "slowdowns" among districts, categorised according to whether they were above or below average levels of development in 1992 and whether they had higher orlower growth rates between 1992-2013.

Second, there is clear evidence of *convergence* in incomes (proxied by the intensity of nightlights) across Indian states, districts and cities, in contrast to previous results for India by other researchers which rely on different methods and coarser data. In the post-reform period India's poorer districts have on the whole grown faster than richer ones. However, the pace of sub-national convergence has been relatively slow compared to other large economies such as China and the U.S.A and there is evidence that the pace of convergence slowed down considerably in 2001-13 compared to 1992-01. This slow convergence may well corroborate the view that India's urbanization is underperforming, suggesting that greater attention be provided to supporting the concurrent processes of economic transformation and urbanization in "laggards" and "slowdowns," including overcoming policy, institutional, and regulatory obstacles.

Third, in a first-of-a-kind analysis looking at the relationship between urban form and economic performance, we find robust evidence that more compact Indian cities have improved economic performance than more sprawled (or extensive

form) cities, especially in the 2002-2012 period. The analysis shows that, controlling for differences in initial size and level of development, Indian cities that were initially more compact (i.e. less sprawling) in 2002 experienced faster economic growth over the period 2002-2012. In this case, we measure a city's level of compactness in 2002 using, inter alia, a dispersion index based on the distribution of population within each urban area, while economic growth is proxied by the growth in intensity of a city's night-time lights. On average across the sample of 479 Indian cities, a 10% point increase in a city's dispersion index in 2002 is associated with a 0.4-0.9% point decrease in economic growth over the subsequent period. When compounded over time, this difference is significant. Using another measure of urban sprawl, the work demonstrated that growth in economic activity was higher where this took place primarily within existing urban boundaries (in the so-called "intensive margin") rather than in expanding urban boundaries (the "extensive margin"). We found that – on average – a 10% increase in the growth of existing urban areas relative to newly urbanizing areas (i.e. more compact, intensive urban expansion) is associated with a 0.4-0.5% point increase in subsequent economic activity. Other measures of compactness returned similar results. This suggests that more compact urbanisation, when it occurs, indeed supports faster economic growth.

Finally, we find that economic growth at the district and sub-district level depends significantly on the area's market access or connectivity – which, in turn, depends on two factors: the wealth and economic development of surrounding areas, and the extent of transport links to those areas. Sorting out the influence of the various individual factors driving market access is, however, complicated and will require further research. However, overall, the work demonstrates that there is strong evidence of the importance of transportation infrastructure on growth via improvements in market access.

3. The costs of getting urbanisation wrong and opportunities for smarter urban growth in India

Getting urbanisation wrong – through an unplanned, sprawled urban growth model – could be very costly for India, not only in terms of lost overall growth, as discussed in the previous section, but also in a myriad of other ways, socially and environmentally, all of which undermine shared prosperity and make Indian cities a *high-cost environment* for working and living. The global evidence suggests that sprawled urban growth often has the following effects:

- Higher costs for providing public infrastructure and services;
- Increased road and parking facility costs, by increasing road and parking requirements;
- Higher transportation costs, particularly for lower-income households;
- More per capita traffic casualties and associated damages;
- Less physical activity leading to increased health problems and lost productivity costs;
- More traffic congestion and longer commute times, as well as more accidents, local air pollution, and greenhouse gas emissions. Worldwide, of the 30 cities with the worst particulate matter (PM) outdoor air pollution, 14 are in India. The health costs of these dysfunctions are large;
- Reduced ability of poor households on urban peripheries to access basic services and economic opportunities;
- Smaller urban agglomeration effects, leading to reduced economic productivity, employment, business activity, investments, and tax revenues;
- Reductions in open space, leading to reduced agricultural productivity and environmental benefits.

The report documents the potential additional costs of a sprawled model of urban growth versus a more appropriately compact, connected urban development scenario, focusing on the added costs of urban infrastructure, in particular increased capital costs related to transport, and on the costs of traffic accidents, traffic congestion, pollution, and other health risks. The report finds that these costs could total up to US$1.8 trillion per annum by 2050, or around 6% of GDP. Moreover, these aggregates could prove to be significant underestimates, given difficulties in putting a monetary value on certain kinds of costs, for example of displaced open space.

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However, this is also a significant opportunity. Described differently, smart growth policies that create more compact and multi-modal communities could be an economic opportunity for India worth up to 6% of GDP by mid-century, with significant savings at the household level. Not all of these savings and benefits would be financial: some involve valuable non-market goods such as improved fitness, health, and environmental quality. But the total potential benefits are significant and particularly tend to help people who are physically, economically, and socially disadvantaged, and so tend to rely on affordable travel modes such as walking, cycling, and public transport.

Many current policies and institutional conditions in the country tend to encourage costly unplanned, sprawled urban development over more compact infill development and well-managed, well-connected urban extension. We note in particular the impact of current land regulations, such as overly restrictive Floor Space Indexes (FSI) or Floor Area Ratios (FAR) that promote low density in the amount of built-up floor space per unit of land area, especially in urban cores where there is high demand. Poor land registry systems and complex, costly urban planning regulations also contribute to high real-estate costs, cramped living and working conditions, and strong incentives for "leapfrog" development into remote peri-urban areas.

4. Insights from four Indian cities: The human cost of dysfunctional urban development

The real social cost of unplanned, unconnected urban development in India is laid bare when considering the impacts on urban residents who suffer from major deficiencies in basic infrastructure and service delivery. Existing estimates of capital investment requirements for urban infrastructure total US$800 million to US$1.2 trillion in the next 15 years alone. Yet, urban infrastructure investment – as a percentage of GDP – remains low.

This report draws on case studies undertaken for this project to look in more detail at the problems of urban infrastructure and service delivery in four Indian cities – Bangalore, Indore, Pune, and Surat. We look in particular at these cities' experience of public sector delivery of key infrastructure services, such as urban transport, water, sanitation, and energy. There are noteworthy variations in the extent and character of public service deficits across the four cities; however, significant deficits in the extent and quality of public service delivery occur in all these cities, as in other cities, and often force urban residents to seek out private sector sources or to supply these services themselves (so-called "self-provisioning").

These deficits mean that access to basic services is only for the richest in society and there is self-provisioning for the poorest. This serves to increase the overall social costs of service delivery, including external costs such as impacts on public health and the environment; for example, through the unsustainable collection of firewood to provide energy services or as a result of unsafe housing. These deficits are also costly for the climate, with the proliferation of diesel-powered generators and private motorised travel being particularly pertinent issues.

A common result of failures in broad-based public service delivery is the widening of urban inequities. At one end of the spectrum, the well-off are able to look after their own needs. At the other end, the city's poorest, who are left to fend for themselves to access even the most fundamental of services – but who lack economic resources – tend to end up bearing the highest burden of service deficits in terms of social, health, time, and monetary costs.

The report shows that failures in public sector infrastructure service delivery are both a symptom of and a major cause of dysfunctional urban development, with a failure of urban governance often lying at the heart of the issue, alongside other factors. Weaknesses in the institutional and fiscal framework of urban government in India hinder the capacity for effective public service delivery. In turn, the rise of self-provisioning among the well-off and the politically influential reduces the political pressure on the government to provide good-quality, broad-based public services in India's rapidly expanding urban and peri-urban areas, and also means the government is less likely to be held to account. This vicious circle in the urban political economy undermines the entire urban economy: the urban under-served grow and service level deficits persist, eroding productivity, deepening urban poverty, and undermining sustainable growth. Self-provisioning as a default is thus costly for the economy, and bad for society and the environment.

5. Conclusions and policy recommendations

While the costs of the current model of urban development are high, by the same token there is also a significant opportunity for India's policy-makers. Smart growth policies that create more compact and multi-modal communities can provide multiple savings and benefits. Some of these savings and benefits are financial, and some involve valuable non-market goods such as improved fitness, health, and environmental quality. Moreover, the total potential benefits particularly tend to help people who are physically, economically, and socially disadvantaged.

One key conclusion of this work is that unlocking the potential of urbanisation for better economic, social, and environmental outcomes should be at the very heart of the government's economic strategy.

India's policy makers should look to elevate the importance of national urban development and spatial planning as a core pillar of the government's economic plan, including creating the financial and legal infrastructure that favours sustainable urban infrastructure.

More specifically, here we outline three key areas for policy reforms that, together, can yield major improvements in urbanisation and its contribution to rapid, inclusive, and sustainable development.

5.1 Reform land use regulations to improve the efficiency and effectiveness of land use

Existing land use regulations and land market institutions play a powerful role in reducing the efficiency of land use in Indian cities and in encouraging more sprawling, extensive urban forms. Measures should be considered to:

- Launch a nation-wide debate and process of consultation on a range of options for comprehensive reform of land use regulations and land markets;
- Based on these consultations, propose comprehensive reforms of land regulations that are holding back development of appropriately compact and productive urban forms, covering such issues as Floor Space Index (FSI)/Floor Area Ratio (FAR) regulations, maximum building heights, set-back requirements, plot-coverage ratios, and parking space requirements;
- Increase efficient functioning of land markets by strengthening systems for: appraisal of land values, determining property rights, land registration, and conducting equitable public land acquisitions;
- Reform housing finance to increase the supply of new housing stock.

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It is important to recognise that reforming land regulations and markets is often controversial and challenging in the political economy of India. This will call for active public, private, and civil society leadership, public consultation, and careful consideration of local circumstances, so as to achieve successful reform.

5.2 Expand urban infrastructure to encourage appropriately compact, connected, and coordinated cities

Clearly, a vast upgrading in the scale and quality of urban infrastructure is needed if India is to tap the full potential of its cities. As the central government now brings to bear very large resources to support urban infrastructure investment through its Smart Cities and other central programmes, it has a unique opportunity to provide an overall vision and substantive leadership as to the content of the country's urbanisation. Measures should be considered to:

- Enhance the use of the Government of India's major Smart Cities and other centrally supported urban infrastructure programmes to *provide leadership and an overall vision* for the nation's urbanisation, based on a comprehensive impact evaluation of the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) and other central programmes, as well as on international experience;
- Use these major urban infrastructure initiatives to encourage appropriately compact, connected urban development that is likely to be more economically productive, less polluting and wasteful of resources, and more liveable and socially inclusive. In transport, in particular, these measures include removing subsidies that encourage urban sprawl and costly motor vehicle transport, for example through underpricing of road and parking services and through fuel subsidies. This should be complemented by more comprehensive multi-modal transport planning, which takes full account of the environmental, congestion, and other externalities associated with road development and motor vehicle transport, and which increases the focus on building efficient public transport systems such as bus rapid transit networks;

- Revisit traditional models of service provision, including encouraging cities to innovate. Many public utilities currently suffer from weak institutional structures and financial burdens, often rendering them unable to expand public service networks or improve quality of service. The four city case studies looked at as part of this report demonstrate the ability of cities to innovate and adopt new service and business models for service delivery. Drawing on rapid technological changes, new models of service delivery are emerging which aim to promote more circular or sustainable solutions in water, sanitation, and energy service delivery. Examples are already seen in Surat and Pune where treated wastewater is sold to industrial areas and bio-methanation converts municipal solid waste to energy which is used in wastewater treatment. Rapidly falling renewable energy costs create new opportunities for off-grid or mini-grid solutions in energy supply. Regulatory environments that encourage innovation and discourage high-carbon, high resource-use alternatives should be enabled.
- Ensure urban service and user fees reflect the full social costs of services provided. With growing concerns about water and other resource stress, and about growing local air pollution and greenhouse gas emissions, urban service fees and user charges should aim to reflect the full social costs of services provided.

5.3 Reform and strengthen urban local government, accountability, and financing

More compact, connected urban development will require expansion and upgrading of urban infrastructure. This is in turn points to the need for effective urban local governments which are best able to determine the infrastructure requirements of their cities, formulate and implement appropriate urban development plans, oversee efficient operation of urban public goods, and remain accountable to the urban public. Measures should be considered to:

- Ensure that the currently muddled devolution of responsibilities to cities is clarified and implemented. The central government needs to encourage and work closely with the states to ensure that this happens. With greater real responsibility for service delivery, urban governments also need to strengthen their mechanisms for public accountability and participation;
- Strengthen the administrative capacity of urban governments. Alongside greater responsibility, the administrative capacity of urban governments needs to be greatly strengthened, including capacity for urban planning and infrastructure development. Programmes for formal training in urban management need to be greatly expanded, together with development of a professional career path. Better mechanisms are needed for networking and learning among Indian cities;
- Expand the fiscal resources available to cities to accompany their growing responsibilities. Cities' own revenues need to be strengthened, in particular through reform of property taxes and stronger systems for land value appraisal and tax collection. As required by the Constitution, State Finance Commissions need to determine intergovernmental transfers to cities, and their recommendations need to be implemented fully and promptly.

In conclusion, this report indicates that the costs of getting urbanisation wrong in India could be very high economically, but also in a myriad of other ways: socially and environmentally, all of which could undermine shared prosperity. However, it also provides an indication of the size of the prize that could be achieved through better urban development policies. This is an opportunity that policy-makers across India must now seize.

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1. Introduction

India is on the cusp of an urban transition. The country's urban population reached 420 million or 33% of its total population in 2015. It is expected to almost double to 800 million by 2050,[2] when one in every two Indians is expected to reside in its towns and cities. By 2031, 75% of India's national income is expected to come from cities, an increase on the current 66%, and the majority of new jobs will be created in urban areas.[3] Policy engagement on meeting India's urban challenge is also at a turning point. The Government of India has launched an array of initiatives to tackle issues of urban growth and liveability, including "100 Smart Cities", "Swachh Bharat Abhiyan" (Clean India Mission), "500 Cities Fund", "Urban Infrastructure", "Heritage Cities", and "Make in India" programmes. This urban focus is timely and appropriate, for several reasons.

First, in terms of absolute numbers, urbanisation in India is occurring on a scale second only to China. Between 2000 and 2014, India added nearly 127 million new residents to its towns and cities; over the next 15 years its urban population is projected to grow by a further 177 million.[4] Between 2001 and 2015, the number of cities in India with a population of a million or more increased from 35 to 53. However, even these estimates may undervalue the true extent of urbanisation. India's official classification of urban areas is more stringent than in most other countries and there are long delays in the redrawing of municipal boundaries for fast-growing new areas on the edges of existing metropolitan areas. Studies by the World Bank, which use a globally comparable definition of urbanisation, estimate that India is already over 50% urbanised.[5] Such a finding would underline even more emphatically the central importance of urbanisation for India's development.[6]

Second, there is a growing understanding of the powerful potential contribution of urbanisation to economic transformation and development. These ties run in both directions. Thus, on the one hand, when a country has launched a successful process of economic transformation, the growth of the industrial and services sectors is very conducive to urbanisation. These sectors are much less dependent on land as an input than is agriculture, and they are arguably more able to benefit from the productivity enhancements that arise from agglomeration economies and the spatial clustering of firms and workers in urban areas.[7] Such effects include spillovers and diffusion of knowledge between firms, increased productivity due to a wider variety of specialised inputs and types of labour, better risk-sharing, better matching of workers to firms, and greater feasibility of infrastructure projects with economies of large scale. For example,

employment density is found to explain over half of the variation in labour productivity across US states.[8] Estimates suggest that a worker in China moving from a low-density city (in the first decile of density) to a high-density one (in the last decile) experiences a productivity increase and wage gain of over 50%.[9] Other studies suggest that an Indian household moving from a small rural area to a large urban area is able to double its per capita household expenditure due to the change in location, holding other household characteristics constant.[10]

However, third, these benefits have to be weighed against potential negative spillovers and the costs of agglomeration, city size, or urban density. While urbanisation is a necessary condition for economic transformation and development, it is difficult to argue that it is also a sufficient condition. There are numerous examples of urbanisation without much in the way of economic transformation or growth, for example in much of Africa. For one thing, urbanisation is sometimes driven by factors that have little to do with economic transformation, and, for another, there are no automatic guarantees that urban form will necessarily evolve in ways that maximise net positive agglomeration effects and productivity. Instead, market failures and bad policies – in particular failures to provide critical public goods and a lack of urban planning – often contribute to unmanaged sprawl as the dominant urban form in many countries, which curbs productivity, encourages massive growth of slums, and promotes excessive congestion and other negative spillovers, such as local air pollution, inefficient energy use, and excessive greenhouse gas (GHG) emissions.[11] A recent study estimates that, as of 2007, at least 45% of India's total emissions had urban origins.[12]

Good policies and institutions are therefore crucial in both managing and getting the most out of urbanisation. If thoughtful and innovative policies are able to anticipate and address the potential diseconomies of urbanisation, taking into account the distinctive national features of urbanisation in each country, the general evidence on the positive impacts of urban density points to the likely benefits of more compact, connected, and coordinated cities for economic development.

There is a widespread consensus that India's urbanisation is in fact underperforming in terms of the development benefits that it could deliver. It is this broad concern that motivates this paper. Given its current model of unplanned, sprawling, and disconnected urban growth, India is currently not able to leverage effectively the many positive feedback loops between urbanisation, agglomeration, productivity, and growth. This report argues that a business-as-usual urban model is likely to be extremely costly – economically, socially, and environmentally.

To be sure, India's current pattern of urbanisation needs to be characterised in terms relevant to the country's specific conditions. In many countries, "sprawl" refers to an urban form with low population density spread over a large and growing urban area, typically in the peripheral areas of cities. Indian cities, by contrast, have high population density. By one estimate, Mumbai and Kolkata are the first and second most densely populated large cities in the world, with Chennai the eighth. In the Indian context, sprawl is better understood as a low density of built-up floor space per unit of land area, combined with severe overcrowding per dwelling or unit of built-up area.[12] As we discuss more fully below, land regulations restrict the construction of tall buildings and availability of built-up space, with pervasive, harmful consequences, including severe overcrowding. Land prices are extremely high, in places such as Mumbai among the highest in the world, while the average floor spaces available to businesses and households are far more cramped than elsewhere. Mumbai homes have only about 30 square feet per person, less than a quarter of the comparable availability in urban China. Slums grow, as the poor are unable to find low-cost housing. Urban sprawl proliferates as businesses and households are forced to seek cheaper land further and further out in city peripheries. The intensity with which businesses and households can use land is constrained, reducing agglomeration economies and productivity. In this sense, one could argue many Indian cities experience the worst of all worlds: they are dense (many people per hectare) and suffer from overcrowding (many people per square metre of floor area).

These problems are aggravated by severe infrastructure bottlenecks and service delivery deficits that undercut economic performance (see Box 1). Fed by the ongoing real-estate boom, expansion in peri-urban areas is not only unplanned, but also almost entirely devoid of adequate public goods provision (water, sewerage, power) or reasonable access to transport infrastructure. This reinforces the vicious cycle of ever-deeper reliance by firms and households on groundwater, private vehicular ownership, and polluting diesel power generation, just to meet their basic needs.

Box 1

India's urban infrastructure investment challenge

A number of studies have detailed the vast upgrading in the scale and quality of India's urban infrastructure that will be needed if the country is to tap the full potential of its cities.

The government's High Powered Expert Committee (HPEC) Report on Indian *Urban Infrastructure and Services* estimated, for example, a need for total urban infrastructure capital investments of 39.2 trillion rupees (in 2009/10 prices) in the 20-year period to 2031/32 (around US$830 billion using 2009/10 exchange rates).[14] These estimates took into account not only the expected growth in India's urban population, but also the need to meet specific norms or minimum standards for urban service delivery, noting that, at present, actual service delivery in sectors such as water supply, sewerage and sanitation, solid waste management, and urban transport and roads is generally far below desired norms. In annual terms, urban infrastructure investment would need to rise from an extraordinarily low 0.7% of GDP in 2011/12 to 1.14% of GDP in 2031/32. Given the growth in the size of India's economy, this would imply a five- to six-fold rise in annual urban infrastructure investment in real terms. In addition to more capital investment, the HPEC also noted the need for a major accompanying increase in expenditures for operations and maintenance of urban infrastructure, estimated to total 19.9 trillion rupees (in 2009/10 prices) over the 20-year period (or around US$420 billion).

Another study by McKinsey Global Institute arrived at even larger estimates for India's overall urban infrastructure capital investment needs, totalling 53.1 trillion rupees (or US$1.2 trillion in 2008 prices) over the 20 years to 2030, with annual flows rising to 2% of GDP. This would encompass such elements as 2.5 billion square metres of paved road and 7,400 kilometres of metros and subways (both being 20 times the capacity built over the last decade).[15]

Poorly managed urban growth also directly impacts on health and quality of life. As we discuss in more depth in Box 5, worsening outdoor air pollution in Indian cities is estimated to cause around 1.1 million premature deaths per annum.[16] It also adds significantly to overall carbon emissions (close to half of India's net GHG emissions originate in urban areas).

It is critical, therefore, to build a better understanding of current patterns of urban growth and their full costs, including the real costs of India's urban deficits, and their economic, environmental, health and equity costs, so that creative solutions can be crafted to break the bottlenecks that prevent the country from realising its full urban, and, therefore, economic, potential. In this context, building a better understanding of the current patterns of spatial development, their drivers and their costs will be critical to help shed light on policy reforms and innovations that can help get urbanisation right.

This report argues that an alternative model of urban growth in Indian cities is possible. NCE has demonstrated at the global level that compact, connected urban growth can create cities that are economically dynamic and healthy. Recent research by NCE and the World Bank[17] has found that compact, connected, and coordinated cities are more productive, socially inclusive, resilient, cleaner, and safer. They also have a smaller carbon footprint and contribute lower GHG emissions.

Box 2 outlines key features of compact, connected, and coordinated cities at the global level. Again, the application of these concepts in the Indian context will need to be based firmly on local conditions. Especially in central city areas in India with their very high population density, greater compactness is likely to focus on the need for greater density of built-up area, allowing for less overcrowding and a better quality of life. The need for compactness also does not preclude the importance of urban extension in a fast-growing country like India. Urban extension itself, however, needs, to be undertaken in a planned way, with sufficiently high built-up density and adequate provision of accessible and well-connected infrastructure and services. Moreover, compact urban growth is not solely about density: it is also about walkable, mixed-use areas and transit-oriented urban forms that increase economic efficiency and reduce environmental and social impacts.

This report demonstrates not only the potential costs for India of getting the future urban growth model

Box 2

Compact, connected, and coordinated urban growth

1. **Compact urban growth** refers to managed expansion which encourages higher-density, contiguous development, with functionally and socially mixed neighbourhoods, and walkable, human-scale local urban environments. Denser development is complemented by public green spaces to maintain liveability. In rapidly expanding cities, compact urban development is achieved through planned accommodation of population expansion and anticipation of infrastructure needs. Compact urban growth can also be achieved through redevelopment of brownfield sites.
2. **Connected infrastructure** refers to investment in innovative urban infrastructure and technology with a focus on smarter transport systems to connect and capture the economic benefits of more compact urban forms. These transport systems would connect mixed-use, employment, housing, and commercial clusters. They include bus rapid transit (BRT), bicycle "superhighways", car- and bicycle-sharing, smarter traffic information systems, and electric vehicles with charging point networks using renewable energy sources. Transport systems can be complemented by smarter urban utilities to deliver more connected, resource-efficient public services, such as efficient energy, waste and water systems, street lighting technology, and smart grids. Smarter, more efficient buildings (both via retrofits and new builds) complete the fabric of the urban system.
3. **Coordinated governance** refers to effective and accountable institutions to support coordinated planning and implementation across the public and private sectors and civil society, particularly for land use change and transport, and coordinated planning across jurisdictions in a single urban area. The existence of organisations dedicated to coordinating policies within entire urban agglomerations, for example, has especially positive effects, ranging from lower levels of particulate matter air pollution to a reduction in urban sprawl.

Source: Floater et al. (2014).

wrong, but also the benefits and opportunities of getting it right. It focuses on how India can aim to foster a better urbanisation – one that promotes more rapid economic transformation, improves the quality of life of city dwellers and curbs the potential harmful spillovers of urbanisation, such as congestion, wasteful energy use, and unwanted pollution. It does so on the basis of four background papers that form the foundation of this synthesis report. Some of the work for these papers is new and original, including drawing on night-time lights satellite data to map and track India's spatial development and the performance of its cities over the last decade.

Section 2 of this paper analyses data from 479 Indian cities to take stock of recent trends in India's urbanisation using an innovative combination of night-time lights (satellite), census, environmental, and other economic data. Section 3 provides a broad estimate of the nation-wide costs to India of an unplanned sprawled model of urbanisation, as well as noting some of the current policies and institutional conditions that create incentives for such a pattern of urbanisation. Section 4 complements the assessment of national trends in Section 3 by showcasing the human face of unplanned, unconnected urbanisation through case studies of four Indian cities – Bangalore, Indore, Pune, and Surat – which delve more deeply into key deficits in three basic urban services: water and sanitation, transport, and energy. It quantifies the costs of key deficits in the form of self-provisioning by private individuals and examines the obstacles affecting the delivery of key urban services, including those related to urban governance. Section 5 concludes by suggesting policy recommendations for India's policy-makers.

Photo credit: Visty

2. New light on India's urbanisation and economic performance[18]

The relationship between urbanisation and economic development in India is not well understood. Yet, it is critical for policy-makers to understand the relationship between patterns of spatial development and economic performance better, in order to shape effective policies to unlock the power of urbanisation for improved economic, social, and environmental outcomes. This report uses an innovative combination of night-time lights satellite data with census, environmental, and other economic data to better understand these key relationships.

Until recently, rigorous research on India's spatial development was limited by a lack of geocoded data on economic, population, and other variables available at sufficiently disaggregated scales such as districts, sub-districts, urban clusters, and cities. This began to change when scholars pioneered the use of satellite data on night-time lights as a proxy for economic activity, and combined them with other data to carry out detailed spatial research at the national and urban levels in data-scarce contexts.[19] The findings reported here use satellite data on night-time lights in combination with other data to study the patterns of India's spatial development over the 1992–2013 period, and identify some of the key drivers of these patterns. Specifically, a measure of "mean light" (or light per area) is used as a proxy for GDP per capita at all the spatial scales analysed in the paper, including districts, sub-districts, and urban areas. (Box 3 describes the use of light data to analyse economic activity in a spatial framework.)

Box 3

Using satellite and night-time light data to study urban and spatial development

Satellites from the US Air Force-managed Defense Meteorological Satellite Program (DMSP) have recorded lights at night since the 1960s. The resulting data, made available from 1992 onwards, divides the entire world into pixels that are roughly 1 square kilometre in area, and records a "digital number" reflecting brightness or night-time lights for that pixel.

Recent work has documented that night-time lights or night-time light data provide a good measure of economic activity. One study argues that night-time lights data are a good proxy for income across and within countries, because consumption of goods during the night requires light.[20] As per capita income rises, so do light emissions. Another study shows that, at fine spatial units of analysis such as villages, a calculation of night-time light density per area strongly correlates with development and household wealth indicators.[21]

Another stream of work uses lights data to delineate urbanised areas.[22] The idea is that urban areas within a country generally reflect a concentration of people and income such that a threshold value of night-time lights can be used as a proxy for whether a piece of land is urbanised. The extent of urban areas identified depends on the threshold used. One study from 2013 chose a value of 13 (out of 63), which results in a generous identification of urban agglomerations that, for instance, puts New Delhi, many other cities to the northwest, and Lahore in Pakistan into one continuous urban area.[23] Another more recent study used a threshold of 33, which results in more discontinuous urban agglomerations that align more closely with urbanised "grey" areas identifiable in daytime satellite imagery.[24] Similar to Ellis and Roberts (2015), our analysis uses the lights data in both these respects, setting a threshold to delineate urban areas over time, and taking the average of light within an area to measure per capita income. We use the log of average mean light over time to measure income growth.

The use of night-time lights data helps overcome several measurement problems. By allowing independent measures of real economic activity at multiple spatial scales and over time, it helps to overcome data limitations in places where sub-national-level GDP data are not available or difficult to access. The use of night-time lights data helps to overcome the problem of variation in prices associated with income-based measures of GDP, enabling better comparisons of real incomes over time and geographies. It also helps in the definition of urban areas. By allowing us to identify the actual spatial footprint of economic activity, which often spills over across jurisdictional boundaries, we can better capture real economic relationships and development patterns that are critical to unpacking urbanisation and growth patterns. Finally, night-time lights data may better reflect the extent of informal economic activity than is captured in formal GDP surveys allowing for a more complete measure of urban economic activity.

Using a combination of satellite (night-time lights), census, and survey data, this section provides empirical evidence on key patterns of urban and spatial development in India over the post-reform period, and analyses factors associated with those patterns. Drawing on the detailed findings of two background papers prepared for this study,[25] we first document patterns of spatial development at the district level. This work provides evidence of convergence in levels of development, demonstrating that in the post-reform period India's poorer districts are on the whole growing faster than richer ones, although at a relatively slow pace compared with other economies such as China and the United States. We then examine a number of factors that might be associated with these patterns, ranging from urbanisation to employment and the environment, drilling down specifically to the effect of connectivity on spatial outcomes. This work finds strong evidence of the importance of transportation infrastructure for urban economic growth via improvements in market access. Finally, we drill down further to the urban level, analysing the relationship between urban form and subsequent economic growth for a sample of 479 cities. In doing so, we find that cities with more compact urban form grew faster over time. This suggests that compact urbanisation, when it occurs, supports faster economic growth, although there is evidence that nearly half of all urbanisation in India is still relatively sprawling (or of extensive form).

2.1 Mapping patterns of urban and regional growth across India's districts, 1992–2013

We begin with an overview of how the density of economic activity – as measured by the intensity of night-time lights – has increased over time nation-wide, before turning to a closer look at convergence and regional patterns of growth across India.

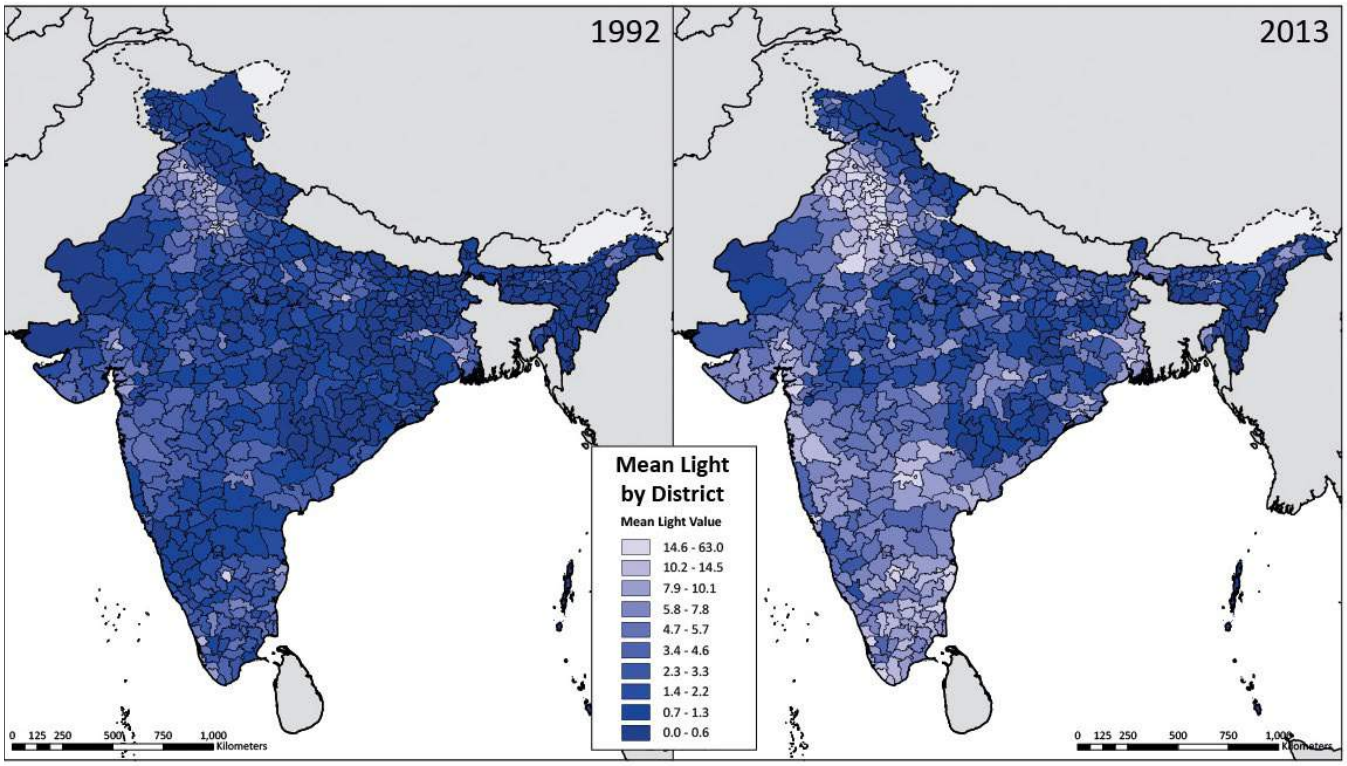
2.1.1 Night-time lights and the spatial distribution of growth across India's districts

Figure 1 presents two maps of the night-time lights data for India for 1992 and 2013, highlighting how lights data can be used to reveal changes in the density of economic activity over time. The two images of India are taken from satellites and map the intensity of light on each square kilometre across India for the years 1992 and 2013. Figure 1 maps the spatial distribution of real per capita incomes (measured by mean light) across India's 638 districts in 1992 and 2013 to help visualise the variation between different parts of the country. The brightest areas (lightest in our colour scheme) depict districts with the highest income (per capita); the darker areas progressively show districts with lower incomes.

Two patterns stand out from this map. First, there is evidence of a relatively broad-based overall improvement in incomes (as measured by mean light) across Indian districts between 1992 and 2013.[26] But second, we also observe considerable heterogeneity in the distribution of income that is spatially clustered. Several regions and pockets of districts continued to lag behind. Districts with persistently low night-time lights in 2013 were clustered in central and eastern India (parts of Madhya Pradesh, Uttar Pradesh, Odisha, and Jharkhand), the northeast, parts of Jammu & Kashmir, Uttarakhand, and western Rajasthan. There is thus evidence of spatial diversity within India's growth patterns.

Figure 1

Distribution of real income by district as measured by light, 1992 and 2013



Source: Tewari et al., 2016.

2.1.2 Leaders, laggards, slowdowns and catchups

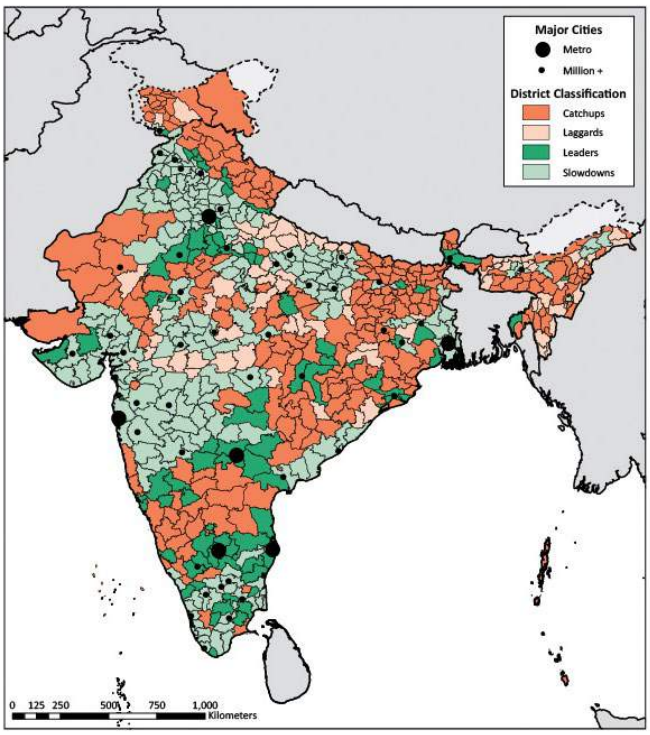
Next, we explore this spatial diversity in a different way, by asking how a district's initial level of development is related to subsequent growth as measured by night-time lights. All districts are divided on the basis of whether they were above or below the median level of development in 1992 (measured by the initial night-time lights intensity of 1.51 in 1992), and whether they had higher or lower growth rates between 1992 and 2013 (relative to the median growth rate of night-time lights of 4.97% over that period). This generates a two by two classification that allows us to classify all districts into four groups: namely, "leaders", "catchups", "slowdowns", and "laggards." Figure 2 maps how these four types of district were distributed across India. We also overlay this map with the location of India's megacities and all cities with population over 1 million.

Three broad patterns stand out from this classification.

Our first observation is that there is substantial heterogeneity across Indian districts with respect to growth, as represented by the four groups that can all be found in different parts of the country. Slowdowns (districts that started out with higher than median levels of initial development, but grew relatively slowly later on – at below median growth rates over the 1992-2013 period) and catchups (districts that started out with less night-time light or below median levels of initial development in 1992, but experienced above median growth throughout the subsequent period) are the most commonly found categories in India's pattern of spatial development in the post-war period. They represent 38% and 37% of districts respectively, or 75% of all districts when taken together. Leaders (districts that started out relatively highly developed, with higher than median development in 1992 and also sustained above median rates of growth subsequently) are less common, with 13.5% of the total, as are laggards (districts that were initially less developed, with less than median levels of development in 1992 although ahead of the catchups initially, but also grew at below median rates over time) at 11.6% of the total. Indeed, the laggards were ahead of the catchups initially (relatively higher levels of initial development, although both were below median). This signifies convergence even within the broad categories of "developed" districts (leaders and slowdowns) and the "less developed" districts (catchups and laggards) over the study period. Districts with higher levels of initial development grew at relatively slower rates than those with lower levels of initial development.

Figure 2

Leaders, laggards, slowdowns and catchups: Spatial distribution of growth across India's districts, 1992–2013



Source: Tewari et al., 2016.

Second, while there is spatial diversity across Indian districts, there is also significant clustering within states. The more "developed" states with high levels of initial development, or "old growth", (most of the southern and western states, the Delhi-Punjab-Haryana belt in the north, Gujarat and Maharashtra in the west, parts of Tamil Nadu, Andhra Pradesh, and Kerala in the south, and the old industrial belts of Uttar Pradesh and West Bengal) are well known to have slowed down over time, while a select number of districts in states and regions that were traditionally associated with lower levels of development have achieved more rapid growth over time and have caught up. These include significant parts of Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar, and Odisha in the centre and east, parts of Rajasthan, Himachal Pradesh, and Uttarakhand in the north, and parts of Karnataka, Andhra Pradesh, and Telangana in the south, as well as significant areas in the northeast. These states have the largest number of catchup districts. Strikingly, a small number of districts – many of them in Telangana, coastal Andhra Pradesh, parts of Karnataka and Tamil Nadu – have maintained consistently high levels of growth and have the largest share of leader

districts. Uttar Pradesh and Madhya Pradesh have the most number of laggard districts, where growth has been stubbornly low. Laggards in the south are rare. Interestingly, laggards can be adjacent to "old growth" states, as well as leaders or catchups. The northeast exhibits an interesting pattern of spatial development with strong concentrations of contiguous catchup districts, as well as concentrations of contiguous laggard districts. There may be an interesting policy story to unearth here that would be worth unpacking in future research. Further causal analysis is needed to understand what explains these differences, including what factors explain the performance of leaders.

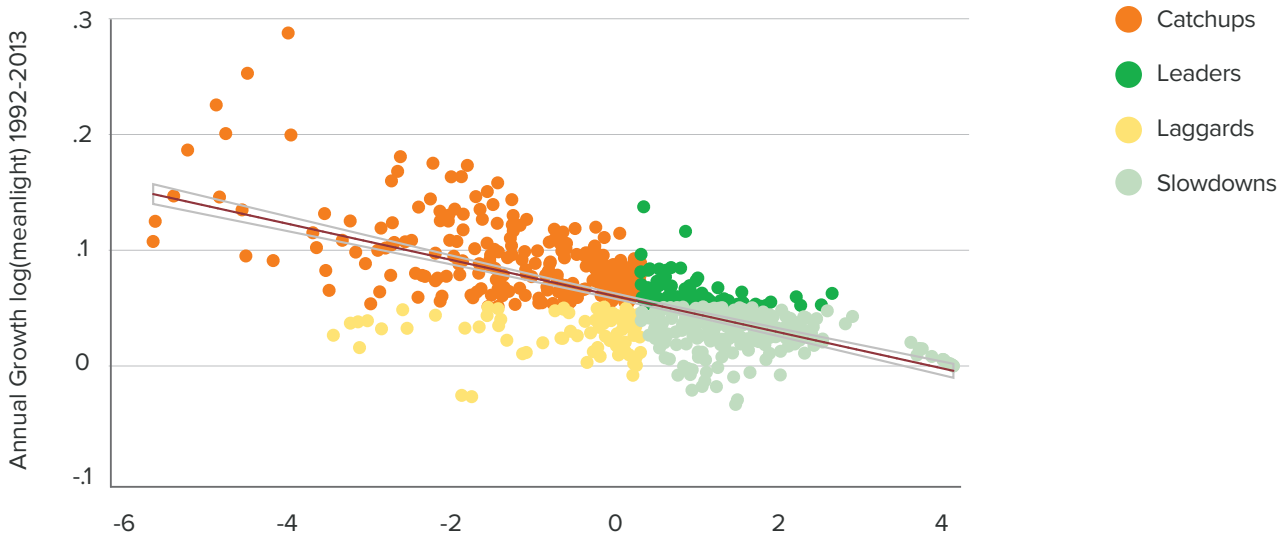
Thus, although there is a diversity of development patterns across districts overall, within states we observe a grouping of districts with similar growth patterns, although there are exceptions. In Figure 2, we find that states can be distinguished by their growth performance: those that (mainly) consist of leaders and catchups (high-growth districts) or slowdowns and laggards (low-growth districts). The diverse development pattern across districts, but with clear clustering within states, suggests that there could be an important role for state policies in shaping sub-national development trajectories. Policies, institutions, and conditions at the sub-national level are likely to play an important role in the spatial distribution of economic development across India.

It is also interesting that the metropolitan cities and most of the cities with populations over 1 million are anchored in slowdown districts that were already well developed. But some large cities appear to buck this trend and are embedded in districts that are leaders or catchups. Examples include Bangalore, Hyderabad, and, to some extent, Chennai, Raipur, and Jaipur. In future research it would be useful to unpack possible causal relationships between urban growth and its spillover effects on the hinterland to understand better how the micro-foundations of spread effects of city growth work.

Third, and most interesting, the classification reveals that, within an overall context of heterogeneity of development patterns, there is substantial evidence of spatial convergence across India's districts in the post-reform period. The faster growth of the catchup districts is perhaps the most impressive evidence of this convergence. They began with the lowest levels of initial development in 1992, lower even than the laggards in some cases, but grew to register some of the highest growth rates of all categories – 9% annualised growth rates in night-time lights over 1992–2013 relative to just 2.9% for the laggards, and 2.8% for the initially most developed districts – is impressive evidence of convergence. Also impressive is the fact that catchups and slowdowns – the categories that are more consistent with convergence – are much more prevalent than leaders and laggards across Indian districts. As the downward slope in the scatter plot below (Figure 3) shows, we observe fairly strong patterns of spatial convergence during the period 1992–2013. Districts with low levels of growth in 1992

Figure 3

Distribution of real income by district as measured by light, 1992 and 2013



Source: Tewari et al., 2016. Note: The slope coefficient of the regression of the log of night-time lights in 1992 on the growth rate in night-time lights in the period 1992–2013 is -0.014, and is significant at the 1% level.

(or districts with low levels of light density in 1992) grew on average more rapidly over the following 21 years than districts that had higher initial levels of growth (or higher levels of light density in 1992).

2.1.3 Growing together: Patterns of convergence in night-time lights

The finding of convergence, as revealed by analysis of night-time lights data, is a hopeful finding in terms of spatial equity. It is also a striking departure from many other recent studies of India's spatial development that have generally found divergence using traditional GDP data.[27] [28] To formally estimate the speed of convergence at various spatial scales – state, district, and city levels – over time, and half-life of catchup. The background paper for this report – Tewari et al. (2016) – follows the methodology outlined in Barro and Sala-i-Martin (1992). Using the intensity of light (light per area) as a measure of per capita income, this work relies on regressions to predict the annual growth rate of income as a function of the initial levels of income. This analysis is carried out for all Indian states, all 638 districts, and across a sample of 479 cities. Table 1 presents the main results.

The striking finding is of convergence, both conditional and unconditional, at each spatial scale for which results are estimated: for states, districts, and cities, and all results are significant at the 1% level.[29] (See Figure 4 for the convergence result at the state level.) The results show that in the post-reform period, income (night-time lights) across India's states, districts, and cities (479) was converging at the rate of 0.8%, 1.26% and 3.6% per year respectively. The background paper also estimates measures of sigma convergence across India's states and districts to see if absolute gaps between Indian states and districts are also falling. The finding is that, overall, there has been an absolute, if slow, decrease in income inequality between Indian states and districts over the past two decades. From a spatial equity perspective, these are indeed hopeful findings: relative geographical inequalities are gradually declining rather than increasing, as earlier findings of divergence would have implied.

Table 1

Convergence across India's states, districts, and cities, 1992–2013, and decomposed by decades, 1992–2001 and 2001–2013

		Growth Period					
		1992-2013		1992-2001		2001-2013	
Level of Analysis	N	β	Half-life (years)	β	Half-life (years)	β	Half-life (years)
States †	33	-0.81%***	86	-1.09%***	64	-0.67%***	103
Districts ‡	618	-1.26%***	55	-1.35%***	51	-0.89%***	78
Districts (with State fixed effects) ‡	618	-1.36%***	51	-2.47%***	28	-1.07%***	65
		1996-2011		1996-2002		2002-2011	
		β	Half-life (years)	β	Half-life (years)	β	Half-life (years)
Urban Areas †	479	-3.60%***	19	-1.66%	42	-5.67%***	12
Urban Areas (with State fixed effects) ‡	479	-3.66%***	19	-1.31%	53	-5.65%***	12

* p<0.1 **p<0.05 ***P<0.01 † Robust standard errors ‡ Standard errors clustered by State

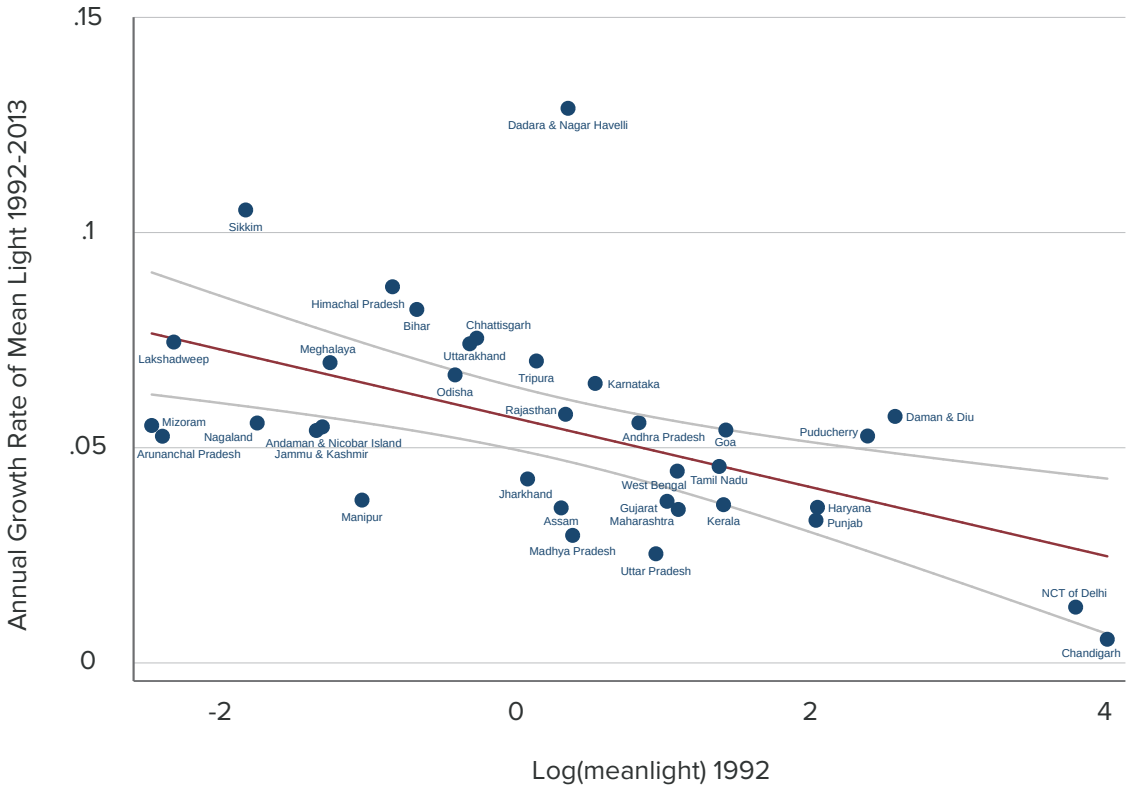
Source: Tewari et al., 2016.

However, these findings of convergence do not by themselves imply that declines in spatial disparities will be rapid, nor do they predict the future direction and magnitude of convergence or divergence. India's pace of convergence (0.8% and 1.26% per year for states and districts respectively, during the 1992–2013 period) is much slower than rates of 2% or more per year documented for economies that have grown rapidly, such as China and the United States. The estimated rate of convergence for Indian states implies, for example, that it would take 86 years to eliminate half of the inequality in per capita income between states (as measured by night-time lights). Therefore, while we see relatively faster growth in poorer regions in India, it may not be fast enough for them to catch up. Spatial disparities may continue to persist.

It is also unclear whether these patterns of convergence are being sustained. A closer inspection of the results in Table 1 suggests that there are important differences in the rate of convergence over time. In general, convergence was faster in the 1992–2001 sub-period and slowed down considerably in 2001–2013. Convergence rates at the state level dropped from 1.1% to 0.67% per year, pushing up the half-life of catchup to 103 years from 64 in the first decade. These patterns are mirrored at the district level. This evidence of a weakening convergence pattern in the 2000s indicates that India's growth became somewhat more uneven during this period, suggesting that state and national policies may be disproportionately benefiting already developed states and districts after 2001, or that already better-off places might be in a position to make the most of them.[30]

Overall, the slow pace of convergence in India compared with China and the United States,[31] and the progressive slowing down of this already low rate over time, suggests that a critical examination of the causes of this slow pace, and policies and institutional practices that shape state and regional growth processes is warranted. The slow convergence in India may well corroborate the view that India's urbanisation is underperforming due to policy, institutional, and regulatory obstacles. A number of regulatory and institutional factors that could be slowing down spatial development are often cited. These include the fragmentation, or at least incomplete integration of markets across India; the relative lack of labour mobility across the country; and ineffective metropolitan governance that has led to an often "messy" and hidden form of urbanisation in India.[32]

Figure 4
State-level convergence, 1992–2013



Many census towns continue to be governed by "rural" institutions without the benefit of resources and planning associated, at least on the face of it, with municipal governance. This low-performance urbanisation adds to social disparities (e.g. large under-served slum populations in most cities), increases the costs of doing business in urban areas, and fails to realise the large potential benefits of urbanisation for productivity and human welfare. We take up many of these issues in subsequent sections.

In order to examine the factors that may be associated with the spatial patterns described above, we explore two specific factors that are often associated with growth: urban form (or level of compactness) and connectivity.

We begin by looking at urbanisation and urban form[33] and then look at connectivity, specifically the effect of transportation infrastructure on growth outcomes. The spatial form of urban development and transport connectivity are closely related: urban form and density have a profound influence on travel patterns, and, on the other hand, urban transport is an important factor in shaping urban form.[34] In the analysis reported here, however, we focus on India's districts and sub-districts to analyse how transportation infrastructure influences growth through the mechanism of improved market access.

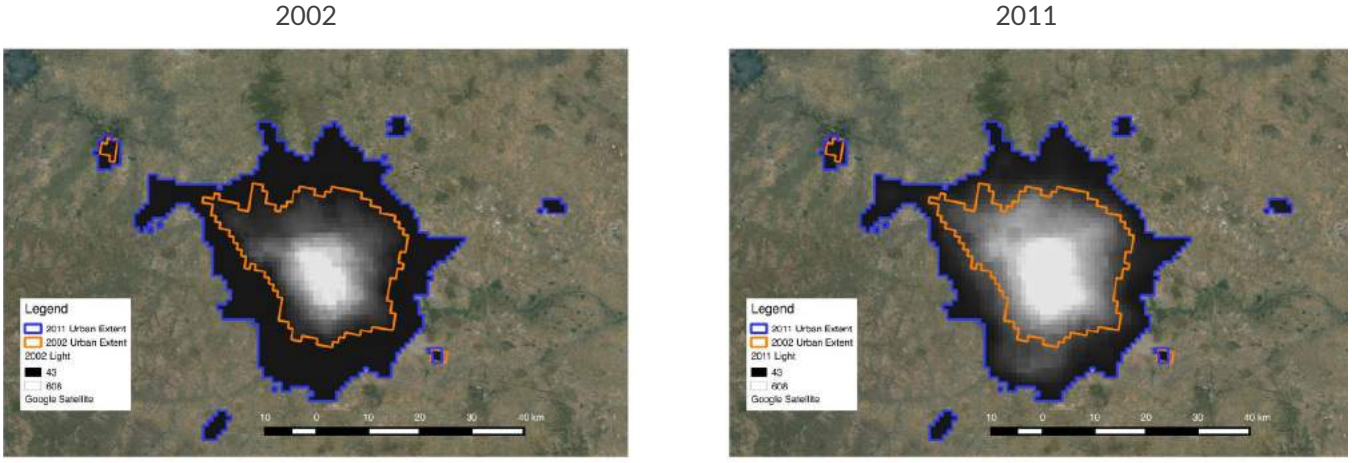
2.2 Urban form and economic performance: Do more compact cities grow faster?

In this section, we try to understand better the link between the shape of cities and their growth patterns. Cities can agglomerate in place, grow through the densification of the hinterland of existing urban areas, or can emerge as new towns and cities out of rural agglomerations such as networks of villages and small towns. Here we explore the effect of compactness on growth.

We proceed in three steps. First, we identify what actually comprises an urban area, using radiance-calibrated night-time lights data, using a threshold defined by agglomerations of pixels with light values above 33.[35] We also examine the evolution of these urban areas over time. Figure 5 illustrates how we use lights data to identify urban extent and trace its growth over time in the case of Hyderabad. This exercise gives us a sample of 479 cities.

Next we construct measures of urban form and compactness.[36] The measures that we construct draw on characteristics of urban form developed by Bertaud et al. (2003) and Harari (2016). We exploit our night-time lights data to build three-dimensional measures of each of these indices by linking income and growth data as measured by light, with spatial and population variations on the city's actual footprint.

Figure 5
Identifying urban extent and tracing its evolution over time in Hyderabad



Source: Tewari et al., 2016.

Our measures of urban form and compactness include:

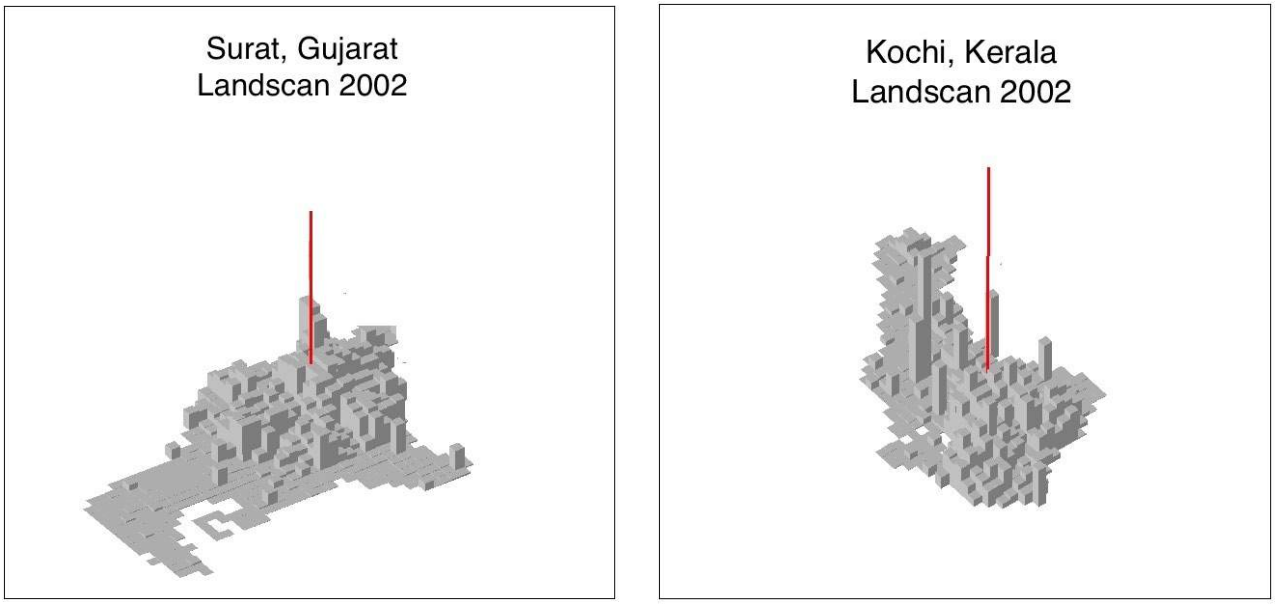
- *Density Gradient (b):* The steepness by which the population density falls moving outwards from the city centre, a measure of conformance of the city to the monocentric model. The steeper the density gradient, the more concentric/compact the urban form.
- *Dispersion(r):* The average distance of each person in the city to the city centre, normalised to a circular city of the same area and population with uniform population density, a measure of sprawl. The larger the index, the greater the sprawl.
- *Urban Centrality Index (UCI):* A measure along an axis ranging from complete monocentricity (1) to a completely uniform distribution of the population or complete polycentricity (0). This scale was developed by Pereira et al. (2013).
- *Gini index calculated over population:* A measure of the degree to which relatively few areas of a city house greater proportions of the population.

Having defined urban form measures across our 479 cities, we then relate these urban form measures to growth in light in urban areas. Using the various urban form measures noted above, we find that there is a robust and positive relationship between compactness and economic growth, significant at the 1% level, and controlling for a city's initial size. This level of significance applies to the beta, rho, and UCI measures of urban form. This implies that for a city of given initial size, greater (initial) compactness is associated with faster subsequent economic growth. To elaborate, our dispersion measure (ρ) shows for instance that across our sample of 479 cities, on average, a 10% increase in a city's dispersion (distance from city center) is associated with a 0.4-0.9% point decrease in economic growth over the subsequent period.

We illustrate these results through a comparison of Kochi in Kerala, and Surat in Gujarat. In Figure 6, we illustrate the initial distribution of population density in Surat and Kochi in 2002. The grey bars represent population density while the red line indicates the population centre of gravity.[37]

Figure 6

Population distribution for Surat, Gujarat, and Kochi, Kerala, in 2002



Source: Tewari et al., 2016.

Table 2
Urban form measures for Surat and Kochi

	Surat	Kochi
Population 2002	**2.02 million**	**1.81 million**
ρ	0.66	0.85
β	-0.28	-0.13
UCI	0.30	0.21
Gini	0.66	0.68
Mean light 2002	101	31
Annual growth rate 2002–2011	4.1%	1.7%

Source: Tewari et al., 2016.

Table 2 below shows the urban form measures of the two cities in 2002, as well as their future annual growth rate in light.

Both cities had similar populations and sizes in 2002, but very different urban forms. In subsequent years they had different growth rates. Kochi, which was more sprawled and polycentric by our urban form measures of β, ρ, and UCI, grew in mean light by about 1.6% per year over the 2002–2011 period. By contrast, Surat, which was more compact on all measures of β, ρ, and UCI, grew by about 4% per year during the same time period.

Overall, there is clear evidence that more compact, monocentric cities grow more quickly in terms of mean light, a finding in support of agglomeration benefits.

To close, we test the relationship between compactness and growth in one final way. Using district level data we estimate growth in the intensive versus extensive margin of each urban area. By the "extensive margin", we mean the increase in economic activity resulting from an increase in the size of the urban area, while the "intensive margin" is the increase in light density in the area that was already urban in the starting period. An important finding here is that high growth urban areas (in terms of levels of economic activity per capita) had a higher fraction of intensive urban expansion. These are places where growth in economic activity within the initial urban boundaries was a high proportion of overall economic activity, as opposed to places where growth in economic activity took place primarily outside existing urban boundaries. On average a 10% increase in the growth of existing urban areas relative to newly urbanizing areas in a district is correlated with a 0.4-0.5% point increase in the economic growth rate (e.g, growth increases from 1% per year to 1.5% per year).

How important was this effect at the national level? Table 3 below breaks down nation-wide growth in urban light in the period 2002–2011 into three categories: intensive growth, within the 2002 boundaries of existing cities; extensive growth between the 2002 and 2011 boundaries of existing cities; and growth in new urban agglomerations disconnected from existing cities ("new cities").[38]

Table 3
India – Growth in night-time lights, 2002–2011

Total light growth in urban areas	Light growth that was intensive	Lower-middle-income	Upper-middle-income
3,948,572	1,901,200	1,733,791	313,147
100%	48%	44%	8%

*Source: Tewari et al., 2016. *Growth in light is measured in DN, Radiance Calibrated Digital Number, a measure of light intensity as measured by the DMSP-OLS satellites.*

About 48% of total growth in urban lights across India between 2002 and 2011 was intensive by this definition, within areas that were urbanised in 2002. However, another 44% of total growth occurred in areas on the periphery of urbanised areas that became urban (but could officially continue to be classified as rural in some cases), representing economic growth in an extensive form or sprawling urbanisation process. Finally, 8% of total growth in urban lights occurred from the urbanisation of areas that were disconnected from existing urban agglomerations (i.e. the urbanisation of villages, census towns, and small towns in place). Thus almost half of urban growth occurred in a sprawled form that our earlier results suggest was associated with lower average growth rates.

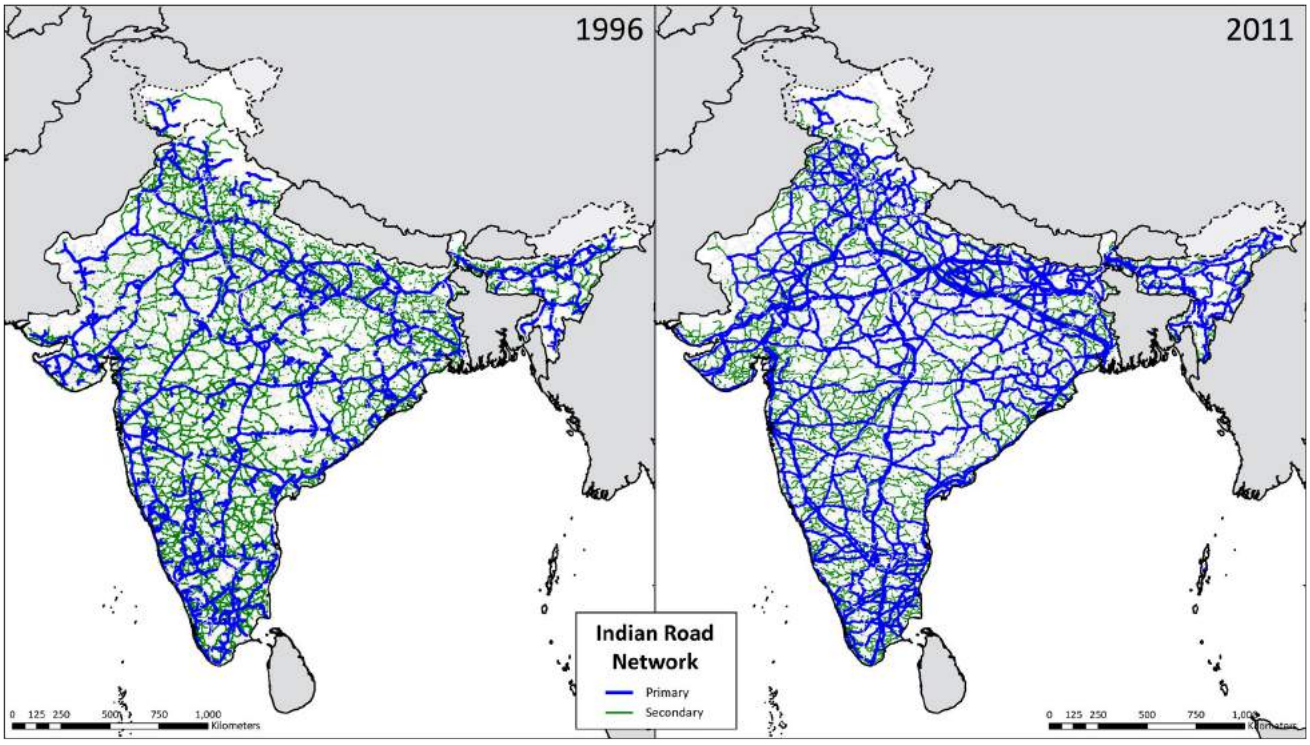
2.3 Connectivity: The effect of transportation and market access on economic performance

In addition to urban form, transportation networks which connect a place (district, region) to other places, consumers, producers, and markets, are critical to an economy's spatial development patterns and functioning of urban areas. Moreover, the availability of infrastructure and the provision of public services in general are important determinants that shape spatial development patterns. There is therefore a great interest from the public sector and development banks in research that provides a sound understanding of the development pattern and sheds light on the effectiveness of public investments.[39] In this section, we draw on background research prepared for this study that examines the effect of transportation infrastructure networks on district and sub-district level growth in India through improvements in trade costs.[40] This is done by constructing a measure of market access (following Alder 2015 among others).

Based on the existing literature, market access for a district (thought of as an "origin" for clarity) is conceived of as depending on two factors: income of all other districts in the country ("destinations"), and the bilateral travel times between the "origin" and all other "destinations". A district's market access is calculated by measuring the sum of light as a proxy for income, or GDP, of each district, and then summing over all other districts' income discounted by the transportation costs between district pairs.[41] Market access can change over time because of changes in the income of the trade partners or because of changes in the trade costs. In order to measure changes in trade costs over time, the authors of the background papers for this research digitised maps of India's primary and secondary road networks for several years, following Allen and Atkin (2016). For each available network, the shortest paths through the network were recomputed to capture changing trade costs, as shown in Figure 7 below. This provides an approximated market access measure for each district in multiple time periods.

Improvements in travel times: Over the last 20 years, India has invested significantly in its road infrastructure with large projects such as the Golden Quadrilateral and the North–South and East–West Corridors connecting major cities together. Figure 7 shows the development of the road network between 1996 and 2011 with particularly large expansion in the highway network (blue).[42] To illustrate, Table 4 shows the estimated

Figure 7
Digitised road network in India, 1996 and 2011[43]



Source: Tewari et al., 2016.

Table 4

Major metro area connectivity: Changes between 1996 and 2011

		Tier 1	Tier 2	Total
Tier 1	Travel times in 1996	39.9 hrs		
	Travel times in 2011	27.0 hrs		
	Percentage change	-32.33%		
Tier 2	Travel times in 1996	31.2 hrs	20.6 hrs	
	Travel times in 2011	21.3 hrs	15.3 hrs	
	Percentage change	-31.73%	-25.73%	
Tier 3	Travel times in 1996	31.3 hrs	27.3hrs	30.8 hrs
	Travel times in 2011	23.8 hrs	18.6 hrs	21.2 hrs
	Percentage change	-23.96%	-31.87%	-31.17%

Tier 1 cities: Mumbai, Delhi, Bangalore, Chennai, Kolkata.
Tier 2 cities: Ahmedabad, Hyderabad, Surat, Pune, Jaipur.

Source: Tewari et al., 2016.

travel times between the 10 largest cities, grouped into tiers, between 1996 and 2011. The travel times reported in the table are the average of all the travel times between each combination of two cities in the relevant tiers. We see significant improvements in the amount of time taken to reach other major metropolitan areas.

Improved market access: Reduced travel times can also translate into lower trade costs and, more broadly, greater market access. We use a reduced form regression to estimate the effect of improved market access on growth and find a robust relation between the urban growth of a district and its market access, the latter reflecting both how well the district is connected to other districts through transport links, and also the size of those markets. At the district level, we find that a 10 percentage point increase in the growth rate of market access from 2001 to 2013 is associated with a 2–5 percentage point increase in the growth rate of per capita income as measured by mean light in that district. The results are significant at the 1% level.

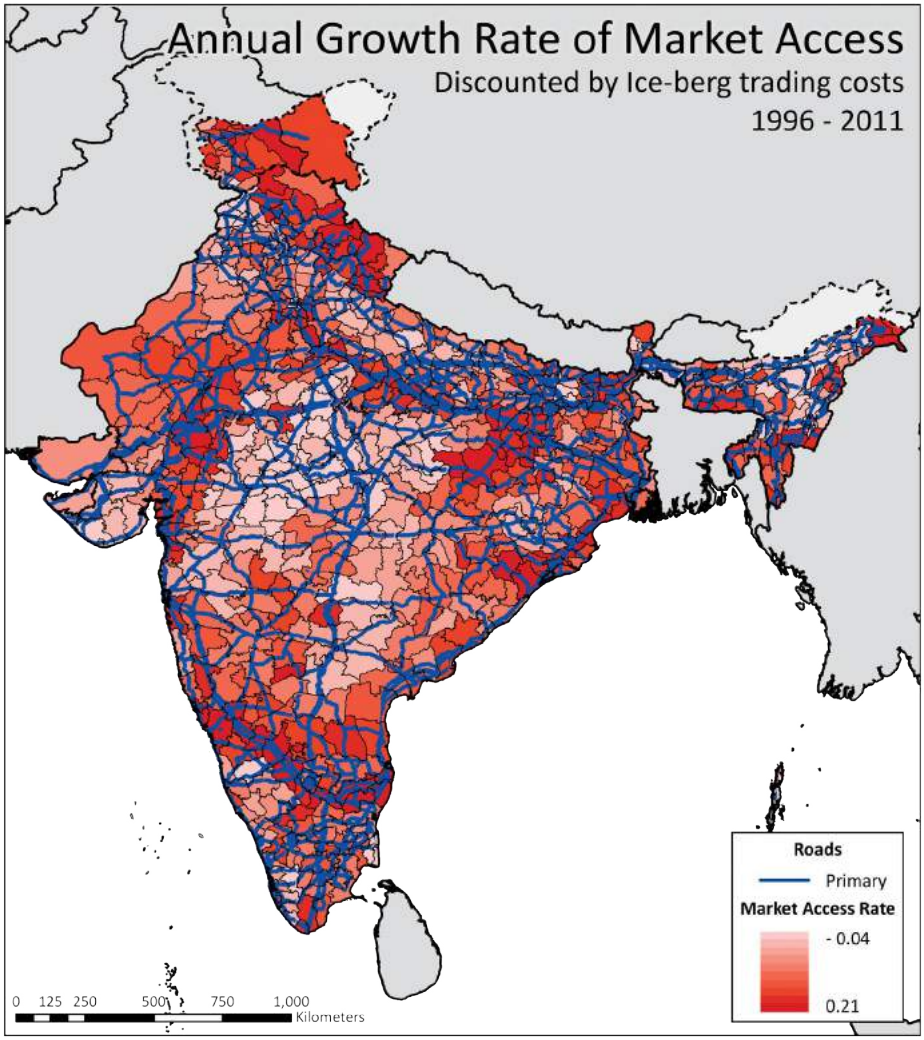
Figure 8 shows that the highway network is largely co-incident with places that saw improvements in market access. But through what channel did the growth effect occur? It is important to try and separate out how much of the effect of improvements in market access on growth comes from a reduction in trade costs due to improvements in the transportation network, andhow much is due to neighbouring districts becoming richer.

However, we get different results when we try to separate out the channels through which this effect is realised (using partial equilibrium methods). When we allow only lights to change in calculating the growth of market access, holding roads constant, we see large positive and significant coefficients on the growth of market access with respect to growth of light, suggesting that there could be strong spillover effects due to increases in income in neighbouring districts. While such economic spillovers among neighbours are possible and plausible, the estimates could also reflect an endogeneity problem in this regression because of unobserved spatial shocks and because growth in the destination also depends on growth in the origin.

When keeping light in other districts constant and only allowing roads (and hence trade costs) to vary over time, the estimates are not statistically significant and of small magnitudes, although still positive. The difference between the sources of changing market access is an important finding for two reasons.

These results suggest that there could be important spillover effects caused by growth in light. High-growth areas cause the expansion of markets, resulting

Figure 8
Annual growth rate of market access



Source: Alder et al., 2016.

in better market access for nearby districts, in other words the growth of a district is not only good for those in it but it can also be good for those in surrounding districts. It would also seem to imply that good policies in one district can have beneficial impacts on surrounding districts that might not necessarily be internalised by policy-makers (depending on the level at which the policies are formulated).

Another possible insight is that the mere presence of a road does not mean that the promised benefits are always fully realised in practice. In the Indian context, there are several plausible institutional and policy reasons why this might be so. For example, taxes, fees and tolls that have to be paid at every border crossing can slow realized travel times. In their calculations, the authors estimated a delay on average of three hours at every state border crossing, which is an average derived from overall waiting times on routes crossing several state borders. Since this is only an average, and if the costs vary substantially across different sets of borders, it may mask an important part of the trade costs along certain routes. Furthermore, as recent studies have shown connected development can enhance both growth and equity (as well as environmental) outcomes.[44] For these benefits to be realized, however, policies that help communities to benefit more fully from existing infrastructure may be as important as policies that help create new networks. In order to fully realize the benefits of improved connectivity, then, other (complementary) policies and reforms may first need to be put in place.

Another possibility is that the broad changes in the road network that we identify between 1996 and 2011 may hide important differences between parts of the network. For example, congestion on the roads, poor quality of roads, and poor maintenance can all add to delays, and these may vary substantially between different segments of the network in ways that we cannot perfectly measure based on the types of roads that we identify. Furthermore, it could be that there are substantial differences in connectivity within districts and this is not considered in this district-level analysis.

Equally, the approximated market access measure described above only partially captures the variety of important dynamics that link growth to connectivity of markets. For instance, if a highway bypassed a district, the value of the approximated market access would not change significantly. However, theory would suggest that many of the other districts may find it beneficial to divert trade from the excluded district and redirect that trade to places better connected. In this case, we should see the market access for the excluded district diminish. This decrease is not captured by the approximated market access measure used here. One solution to these limitations is to use general equilibrium models to construct market access measures. Such a study was undertaken in the technical working papers supporting this paper, focusing on India's 5,900 sub-districts.[45]

The results at the sub-district level analysis show that a measure that approximates growth in market access based on only changes in trade costs is indeed positively and significantly associated with income growth at the sub-district level. Light as a proxy for income increases by about 0.5% when we observe a 1% increase in a measure that approximates overall market access. This estimate is statistically significant at the 5% level and is based on specifications that control for initial characteristics such as income, market access, urbanisation, and pre-existing growth trends at the sub-district level.[46] Both urban and rural market access have an individual effect on income, but they are difficult to disentangle empirically when included together in the same specification. This is the case for reduced form market access measures as well as for general equilibrium measures. The effect of market access is relatively robust when allowing for heterogeneous effects in local characteristics such as environmental factors.

These results therefore seem to imply that improved urban connectivity (proxied by a measure of market access related to travel times with other destinations and the income of all other districts in the country) does have a strong impact on urban economic performance. However, the results also suggest that it is challenging to disentangle the effects related to growth in the size of the market versus that due to improved transport connectivity, with some evidence suggesting that growth in transport connectivity – proxied here by improvements in *average* travel times associated with the road network – does not automatically translate into improved economic outcomes, which means that the type and use of transport infrastructure is likely to matter. For example, initial investment in poor-quality roads, which then become poorly maintained and congested, may not automatically translate into improved economic outcomes.

Photo credit: Shomikho Raha

3. The costs of getting urbanisation wrong and opportunities for smarter urban growth in India

The previous section has highlighted emerging evidence that more compact, connected cities across India have better economic performance. This finding corroborates global evidence collated by NCE that indicates that more compact, connected urban growth tends to be associated with cities that are more economically dynamic and environmentally healthy. To the extent that such cities improve quality of life and save on wasteful expenditures, releasing funds to provide more and better quality services for all, they can also be equitable.

However, the previous section also highlights that there are many Indian cities that are not growing in a compact way, and which are underperforming on many dimensions. Numerous obstacles hinder the potential contribution of urbanisation to national productivity and welfare, and make Indian cities a high-cost environment for working and living. With a prevailing model of low density in built-up space, real-estate costs in Indian cities are sometimes among the highest in the world, while many businesses and households suffer extremely cramped availability of floor space per capita. Unplanned, sprawling development into peri-urban areas, severe infrastructure deficits and growing reliance on private motorisation for transport contribute to high traffic congestion, long commuting times, and high health costs due to severe urban air pollution and rising traffic accident rates.

There is a risk over time, as incomes continue to rise, that such urban dysfunctions will intensify and that India will fall into some of the same traps as many other countries that have based new and expanding cities on a sprawling, car dependent, resource-intensive model of urban development. This model of urban growth can be extremely inefficient, with a wide range of economic, social, and environmental costs. Nowhere is this costly model of urban growth more evident than in the United States. A study for NCE estimated that urban sprawl costs the US economy over US$1 trillion per annum, greater than 5% of GDP in 2014.[47] This includes over US$100 billion in public costs relating to increased infrastructure and service delivery, and over US$600 billion in costs relating to private vehicle use, with the remaining US$300 billion related to the costs of air pollution, congestion, and traffic accidents.

Studies in developing countries also show that sprawled, automobile-dependent development imposes significant direct and indirect costs. Analysing

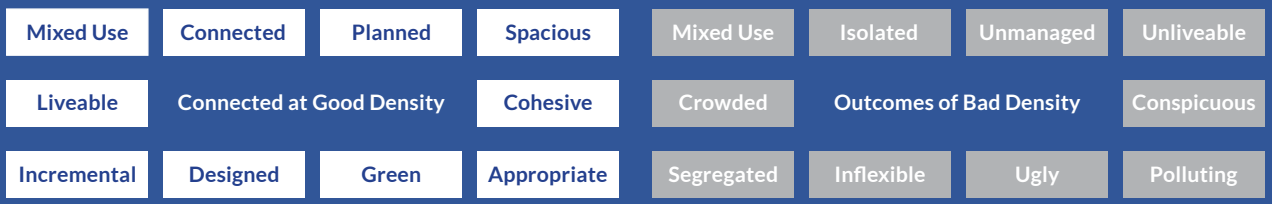
municipal budgets in 8,600 municipalities of Brazil, Chile, Ecuador, and Mexico, researchers found that low-density development can approximately triple per capita expenditures on public services.[48] Another cautionary tale comes from Mexico, where government programmes encouraged private developers to build large numbers of inexpensive single-family homes on converted farmlands. Because they are located at the urban fringe, these new communities often have inadequate public services, and jobs are difficult to access. Residents bear high transportation costs and contribute to high traffic congestion, accident risk, and pollution emissions.[49]

Given the scale of urban growth and infrastructure investment taking place in India now, what might be the additional costs to residents and society from sprawl-inducing development policies? This is difficult to say due to limited data and research in India concerning the economic, social, and environmental impacts of different transport and land use development policies. There is also considerable confusion about how to define sprawl and its opposite, which we call "smart growth" or managed urban expansion. Many people mistakenly believe that smart growth requires all residents to live in high-rise housing and forego automobile travel altogether. Currently, many Indian cities experience the worst of all worlds: they are dense (many people per hectare) and suffer from overcrowding (many people per square meter of floor area), but have inefficient public services, poor walking and cycling conditions, inefficient public transport services, and policies that favour automobile travel. As Indian cities develop, it will be important to emphasise "good" rather than "bad" density (see Box 4).

Box 4

Using satellite and night-time light data to study urban and spatial development

Recent Indian Census data suggests 510 Indian cities with a population of more than 100,000 have an average density of 308 persons per hectare – high by international standards – with over 62% of cities with densities greater than 60 persons per hectare. These figures can be disputed. However, it is important to understand that compact urban growth is not solely about high population density. Rather it is about how urban expansion is managed so as to develop dense, transit-oriented urban forms that increase economic efficiency and reduce environmental and social impacts, and thereby improve accessibility and spatial equity within cities. "Good density" encourages not only high population densities but also more spacious, less overcrowded living and working conditions, functionally and socially mixed neighbourhoods, multi-modal transport systems that have good and safe walking, cycling and public transport services, as well as access to green space. Moreover, global evidence suggests that very high densities or car-free living environments are not by themselves a pre-condition for economically successful and very liveable cities. Streets that are safe and walkable, transport that is efficiently priced, building blocks that are transport-oriented and navigable, and air that is clean and not a health risk for those who walk or use public transport, are some of the factors associated with "good" density.



Source: ULI, 2015.

It is also important to consider that while densities are already high in many Indian cities, these are falling rapidly and motor vehicle ownership rates are rising, especially in rapidly growing secondary cities where viable public transport is often lacking. India, for example, currently has only around 15 private cars and 83 two-wheelers per 1,000 residents, but this is growing at a rapid 10% annually.[50] With current policies, vehicle ownership is projected to increase about six-fold during the next three decades. Remote sensing data also suggests that cities are rapidly expanding their physical footprint. It will therefore be important that India's policy-makers open up a debate about what might constitute "good" or appropriate density for India, taking into account the very different circumstances within and between cities.

3.1 The high costs of sprawled urban development

Sprawled, unplanned, private motorisation-dependent urban development can impose quite sizeable additional costs compared with a more compact, connected urban growth model. The global evidence suggests that sprawled urban growth often has the following effects:

- Higher costs for providing public infrastructure and services;
- Increased road and parking facility costs, by increasing road and parking requirements;
- Higher transportation costs, particularly for lower-income households;
- More per capita traffic casualties and associated damages;
- Less physical activity leading to increased health problems and lost productivity costs;
- More traffic congestion and longer commute times, as well as crash and pollution damages;
- Reduced ability of poor households on urban peripheries to access basic services and economic opportunities;
- Smaller urban agglomeration effects, leading to reduced economic productivity, employment, business activity, investments, and tax revenues;
- Reductions in open space, leading to reduced agricultural productivity and environmental benefits.

Of course, compact, connected development can also increase some costs, including some public infrastructure and housing development costs. It is important that urban policy development factors in these potential impacts, in order to minimise such costs and maximise the net benefits of compact, multi-modal development.

From Section 2, we know that almost half of India's urban growth occurred in a sprawled form over the last decade and that this development was associated with lower average economic growth rates. The question is how large might be the incremental economic, environmental, and social costs that will result if this pattern is continued and extended to new areas over time, following the sprawled, private motorisation-oriented pattern of urbanisation elsewhere. And what might be the benefits of an alternative approach, transforming bad density (overcrowding) to good density (compact, multi-modal, clean neighbourhoods) in both cities which already have high population density, and in those rapidly expanding, new urban centres?

To help answer this question, recent new analysis for NCE[51] looked at the global evidence and that available for India to identify and compare the various categories of cost related to compact versus sprawled urban development. Order of magnitude estimates were generated for some cost categories to provide an India-wide estimate of cost. These order of magnitude estimates are based on urban population projections for India between 2015 and 2050 developed by UNDESA, and on a GDP growth scenario to 2050 of 6.5% real GDP growth per year until 2030, and 5% thereafter.[52]

The analysis compares how various economic, social, and environmental costs will change if India's future urban residents live in more appropriately compact, connected cities rather than urban areas that sprawl outwards in an unplanned way. It is based on conservative estimates grounded in the literature on cost differentials between sprawled and more compact development.

This analysis indicates that a sprawled model of urban growth is likely to impose the following incremental costs compared to a more compact, connected urban development scenario:

- **An increase in the cost of providing urban infrastructure and services.** The costs of providing public infrastructure and services are likely to be 10-30% higher in more sprawled, automobile-dependent neighbourhoods compared with more compact, connected locations.[53] A World Economic Forum study[54] recently recommended that Indian cities invest US$500 billion on public infrastructure over the next two decades to 2030, about US$40 annually per capita. The HPEC estimate suggests a figure of US$800 billion and McKinsey US$1.2 trillion. Assuming the lower WEF estimates and that annual investments continue to grow to mid-century, this suggests potential increases in capital costs in the region of US$125-400 billion for sprawled vs compact urban development in 2050 (0.4% - 1% in 2050). Using the McKinsey estimates, this could be as high as US$450 billion to US$1.35 trillion in 2050 (1.6-4.8% of GDP in 2050).[55] At the household level this

might equate to an additional US$215 to US$965 per capita, conservatively assuming 10%-15% of average household income is used for local public infrastructure and basic services directly impacted by urban form (water, sewerage and electricity). In aggregate terms additional costs could amount to US$200 billion to US$900 billion per annum by 2050 if applied to all urban residents (or around 0.7-3.1% of projected GDP). If only applied to new urban residents, the range is US$95 billion-US$425 billion per annum in 2050 (or 0.3%-1.5% of projected GDP in 2050).[56]

- **Increased capital costs related to transport.** Within the overall infrastructure picture, it is important to pay special attention to the costs of providing road and parking infrastructure, which is typically in the region of two to four times per capita higher in more sprawled, automobile dependent neighborhoods than in more compact, connected locations (although the unit costs may be partly offset by lower land prices in suburban areas).[57] In 2014-15 the Indian government awarded 100 billion Rupees (about US$1.5 billion) to construct 8,000 kilometres of mainly rural highways, which averages about 125 million Rupees (approximately US$2 million) per kilometer.[58] During the next 5-6 years the government proposes spending 17.5 trillion Rupees (US$250 billion) to build or improve 50,000 kilometres of highways, approximately $5 million per kilometre. A significant portion of this public capital expenditure might be avoided with better planned, more compact, connected urban growth, even accounting for costs paid directly by motorists through special fuel taxes, road tolls and parking fees. Existing studies suggest that a typical urban car imposes 65,000 Rupees to 260,000 Rupees (6.5-26 Rupees per kilometre) and a typical two-wheeler 19,000 Rupees to 65,000 Rupees (1.9-6.5 Rupees per kilometre) in combined road and parking facility costs. We conservatively assume road and parking facility costs of 11.5-15 Rupees per kilometre for cars and 2.7-4 Rupees per kilometre for two wheelers. We draw on current vehicle projections[59] and assume that by midcentury a more compact, connected model of urban expansion (associated with a doubling of urban densities) leads to a 25% reduction in vehicle kilometers travelled versus sprawled urban growth (partly due to the more intensive use of vehicles and partly due to significantly reduced vehicle ownership rates, which build over time). Using this framework, additional aggregate capital costs for transport specifically could amount to in the region of US$270 billion-US$345 billion per annum by 2050 (around 1% of GDP). This cost savings could be considerably greater if more optimistic projections of private vehicle ownership were considered. For example, Delhi already has over 7 million cars, well over 300 cars per 1000 people and some commentators expect the total number of cars nationwide to reach 400-450 million in the next 20 years alone, the majority being in cities. An upper bound set of private vehicle ownership projections – including accounting more explicitly for vehicles per capita being significantly higher in urban areas – suggests these cost savings could be upwards of US$600 billion per annum by 2050.

- **Increased personal transport costs.** Household transport costs are likely to be significantly higher in a model that encourages private vehicle ownership. For example, ownership and operating costs average 125,000 rupees per year for a car, and 20,000 rupees per year for a two-wheeler. In contrast, a typical commuter by public transport in India may pay 2,000–10,000 rupees annually for fares, and a bicycle user typically 2,000–4,000 rupees annually.

- **Increased traffic casualties (injuries and fatalities).** Per capita traffic incidents and damages are likely to increase significantly with sprawled urban growth. Although increased density tends to increase vehicle *crash* frequency, these are primarily lower-speed collisions with low casualty (human injury and death) rates. Crash casualty rates tend to be much lower (often by 40–60%) in more compact, multi-modal urban agglomerations because of less per capita vehicle travel, lower traffic speeds, and better travel options, which help to reduce higher-risk driving. India already has the largest number of total traffic deaths of any country: 137,572 were officially reported in 2013,[60] and, taking into account unreported casualties, the World Health Organization (WHO) estimates 231,000 total traffic deaths.[61] India's traffic fatality rate is likely to decline in the future, but how quickly and how much it declines will depend on transport and land use development policies.

- **Growing traffic congestion and pollution costs.** Compact development tends to increase congestion *intensity* (the degree that traffic speeds decline during peak periods), but by reducing travel distances and improving travel options so that residents drive less, it tends to reduce per *capita congestion costs*. India has four of the world's 10 most congested cities. Journey speeds in many cities average less than 20 kilometres per hour, and peak-period traffic speeds are just 5 kilometres per hour on some roadways. One study[62] estimated that, in Delhi, traffic congestion costs averaged 4.91 rupees per kilometre for cars and 9.83 rupees per kilometre for buses during peak periods, and 0.32 rupees for cars and 0.63 rupees for buses during off-peak periods. Air pollution is also a major issue (see Box 5). India contains 14 of the world's 30 most polluted cities. While density tends to increase pollution emission rates per vehicle-kilometre, it reduces emissions per capita. Likewise, while compact development can increase residents' exposure to local pollutants such as particulates, carbon monoxide, and noise, it tends to reduce total emissions and therefore pollution costs. Based on detailed analysis of how development patterns affect energy consumption, one study concluded that urban sprawl is responsible for more than a third of global CO_2 emissions, primarily related to private vehicle use.[63] Another concluded that Bangalore has a higher emission rate than most Indian cities due to its sprawled and automobile-oriented development patterns, and the 20% of residents who commute by automobile are responsible for about half of all transportation emissions.[64] Using conservative assumptions related to traffic congestion, air, and noise pollution costs,[65] order of magnitude estimates suggest that this could amount to additional costs for India of approximately US$120 billion-US$140 billion in congestion and pollution costs per annum by 2050 (around half a percentage point of GDP year on year), compared with compact, multi-modal urban development. Again, this cost savings could be considerably greater if more optimistic projections of private vehicle ownership were considered, upwards of $300 billion per annum by 2050 (around 1% of GDP).

Box 5

High costs of air pollution in India and growing urban carbon emissions

Air pollution is among the largest risk factors for premature death in India. Outdoor (ambient) particulate matter (PM) pollution is estimated to have caused some 1.1 million premature deaths in 2015, with household air pollution from solid fuels related to around 1 million. Total premature deaths related to air pollution outnumber those associated with dietary risks (1.9 million) or tobacco smoke (0.9 million). Outdoor PM pollution is also among the fastest-growing risks, with the estimated number of premature deaths associated with this risk having increased by 48% since 1990.[66] There are also other serious costs in addition to premature mortality, such as chronic ill health, reduced effective time for work and leisure, and increased health system costs.

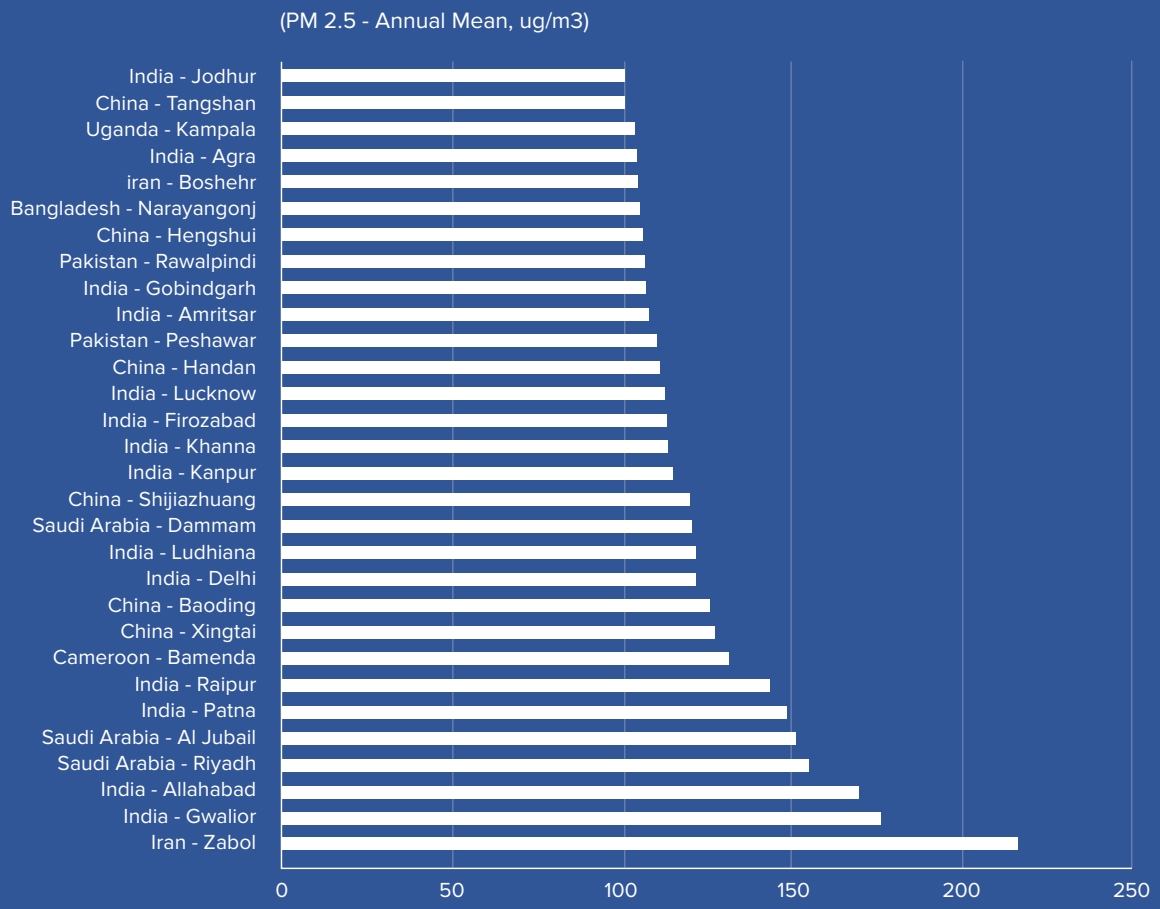
The major health risks from ambient and household air pollution are related to the release of PM and various harmful gases from the burning of fossil fuels and traditional biomass. PM pollution in particular increases the prevalence of lung cancer, chronic obstructive pulmonary disease (COPD), ischemic heart disease (from reduced blood supply), and stroke.[67]

Ambient (outdoor) air pollution in Indian cities is now among the worst in the world. Figure 9 draws on WHO's Global Urban Ambient Air Pollution database (update 2016), which provides information on concentrations of particularly harmful $PM_{2.5}$ (fine particulate matter less than 2.5 microns in diameter) in 3,000 cities in 103 countries. Of the 30 cities in the world with the worst ambient $PM_{2.5}$ pollution, 14 are in India.[68]

Delhi's measured $PM_{2.5}$ level of around 120 micrograms per cubic metre is 12 times WHO's suggested guideline for $PM_{2.5}$. Recent studies suggest that even these estimates may be too low in some respects, with on-road exposure when travelling in an auto-rickshaw in Delhi being about 50% higher than the levels captured at fixed measuring sites.[69] The major sources of primary $PM_{2.5}$ emissions in Indian cities are estimated to be from fossil fuel consumption due to road transport (20–40%), industry (15–30%), power generation (15–20%), brick kilns (10–15%), and diesel-powered backup generators (5–15%). Other sources include wood and waste burning, construction, and road dust.[70]

High costs of air pollution in India and growing urban carbon emissions (continued)

Figure 9



Source: WHO, 2016.

The economic cost of ambient PM pollution is already high. Estimates prepared for the 2014 New Climate Economy report using a cross-country "Value of Statistical Life" methodology place a value on lives prematurely lost in India due to ambient $PM_{2.5}$ pollution as equivalent to 6.5% of GDP in 2010, with a 95% confidence interval of 5.5–7.5% of GDP. Among the top 15 CO_2 emitters in the world, India had the third highest value of lives lost from outdoor air pollution relative to GDP, coming after China and the Russian Federation.[71]

In addition to particulates, India also emitted 2 billion tonnes of CO_2 from energy use in 2013, making it the sixth largest CO_2 emitter in the world. Emissions in 2013 were double those in 2000, rising at a rapid annual average pace of 5.3% a year over that period.[72] A recent study estimates that, as of 2007, at least 45% of India's total emissions had urban origins, including emissions from industry, transport, buildings, and waste.[73] Besides these sectors, the power generation and distribution sector generates 38% 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% attributed to urban areas more directly. India's current urban economic growth pattern produces relatively high carbon emissions, as indicated by the state-wide pattern of emissions, with high carbon-emitting states also having higher than average urbanisation and faster economic growth.

Urban areas will continue to become an ever more important source of India's GHG emissions, as urban growth escalates, as urban industry and transport activities expand, and as large numbers of middle-class consumers are added to the urban mix in the coming decades, boosting use of energy-consuming appliances and assets. Cities will therefore be key in India's efforts to mitigate its GHG emissions. Especially important will be development of appropriately compact urban forms anchored around efficient multi-modal transport systems, and investment in smart infrastructure with a focus on green buildings.

- **Increased health risks.** Sprawl and private vehicle dependency tend to increase a variety of health problems caused by physical inactivity, traffic accidents, and vehicle pollution, including obesity, cardiovascular and respiratory diseases, and diabetes. These problems are already severe in India, and are likely to increase if cities sprawl. Attributing a monetary cost to reduced walking and cycling is challenging. Few studies have been conducted for India. However, WHO has monetised the value of active transport health benefits, using the same values of human life used when estimating crash damage costs and traffic safety programme benefits. These studies suggest that an additional kilometre walked or bicycled provides health benefits worth US$0.30–3.00, which converts to approximately 10–100 rupees per kilometre, depending on assumptions. This implies very significant aggregate economic costs of a sprawled model of urban growth versus compact, connected development in India given the scale of urban change. For example, assuming a highly conservative value of US$0.30 (10 rupees) per additional kilometre walked or bicycled, aggregate savings in India associated with halving average urban densities (i.e. between smart growth and sprawled growth) between now and 2050 could be in the region of US$120 billion per annum.
- **Reductions in open space, potentially leading to reduced agricultural productivity and environmental benefits.** Dispersed urban development displaces land. In addition to land that is directly displaced, urban expansion often disturbs nearby open space, called an urban shadow effect: for example, when urban development disturbs nearby farming and wildlife activity. As a result, each hectare of open space displaced by urban development may represent several hectares of open space that is disturbed and therefore less productive. If, for example, Indian cities on average expanded and converged over the next 35 years towards an average density proxied by typical North American cities (just 20 residents per hectare), this could lead to the use of 40.7 million hectares of land by 2050. This would represent 12% of India's total land or quadruple current levels. This use of land would be halved with an average density of double this amount, and so on. At average urban expansion, with an average density of around 80 people per hectare, Indian cities will only require approximately 10.2 million hectares, little more than the amount of land that is currently urbanised. Monetising the cost of this displacement is challenging given limited research on the value placed on open space in India (including its aesthetic, food production, wildlife habitat, and flood control benefits). However, any – even conservative estimation – would value the preserved open spaces at many billions of dollars' worth of economic, social, and environmental benefits.
- **Growing external fuel costs.** About 40% of India's total import value consists of petroleum and motor vehicles, making it a major contributor to the country's trade deficit and India's economy vulnerable to petroleum price fluctuations.[74]

In aggregate terms, these order of magnitude estimates suggest that the undiscounted and non-inflation adjusted annual costs of a more sprawled versus compact, connected model could amount to US$330 billion – US$1.8 trillion per annum by 2050 (or 1.2–6.3% of GDP), taking into account increased costs of public service delivery, congestion, air pollution, and reduced physical activity. This is a lower-bound estimate because it excludes the increased road and parking capital requirements based on the assumption that these will be partially offset by additional public transport costs, plus other costs that we are currently unable to monetise, such as the value of displaced open space and barrier effects.[75] At the household level, this analysis indicates that sprawl can impose cumulative costs equivalent to more than 20% of average household incomes.

In addition, more sprawled urban development also tends to reduce equity. Of particular concern is the tendency of slum redevelopment programmes and other affordable housing programmes to relocate low-income households from central to urban peripheral areas where access to services and jobs requires more time and money. This is particularly harmful to people with disabilities, women, and children. Even for those who can afford private vehicles, the costs are high. Assuming a basic car costs 60,000 rupees in fixed annual expenses plus 4.00 rupees per kilometre in operating expenses, and a basic motorcycle 6,000 rupees in fixed annual expenses plus 2.00 rupees per kilometre in operating expenses, households in sprawled, automobile-dependent areas face a bill of 50,000–120,000 rupees annually for transport, compared with 10,000–20,000 rupees in a compact, multi-modal neighbourhood.

Moreover, although few lower-income travellers can afford to travel by private vehicles, the majority of transport funding and road space is devoted to accommodating motor vehicle traffic, and cars are further subsidised through the provision of free or underpriced parking. Some of these equity considerations impact planned corridor developments across India. For example, the Delhi–Mumbai Industrial Corridor that involves highway expansion and land development to attract specific industries risks creating dispersed, automobile-dependent industrial centres, which will force many employees to purchase motor vehicles and live in sprawled neighbourhoods.

3.2 Current policies and institutional conditions in India

In addition to the evidence above which suggests that the costs of getting urbanisation wrong could be quite high for India, many current policies and institutional conditions in the country tend to encourage costly sprawled forms of urban development and automobile travel over more compact development and resource-efficient modes.

Several of India's current development policies and planning practices, for example, encourage unplanned sprawl into distant peri-urban areas over infill development. These include poor land registry systems and complex and costly urban planning regulations, which can make it difficult to purchase smaller, more central urban parcels for redevelopment. The World Bank's Doing Business 2016 report ranked India among the most expensive countries in terms of "Dealing with Construction Permits": 183rd out of 189 countries, coming ahead of only Afghanistan, Albania, Eritrea, Libya, Syria, and Zimbabwe.[76]

A characteristic feature of urban development in India is low density in the amount of building floor area per area of city space. Land regulations based on the use of Floor Space Indexes (FSI) or Floor Area Ratios (FAR) greatly restrict the construction of tall buildings in many Indian cities. Indian FSIs are generally very low compared with those in many of the most economically dynamic and prosperous cities in the world, such as Shanghai, Hong Kong, New York, and Tokyo. Other regulations, such as maximum building heights, set-back requirements, plot-coverage ratios, and minimum parking requirements, also sharply limit the efficiency with which households and businesses are able to make use of available land. Rent control laws and the lack of a well-developed housing finance system also constrain the supply of new housing stock. Efficient functioning of land markets is hampered by weak systems for appraising land values, determining property rights, and conducting public land acquisitions.

Such regulations and the resulting low availability of built-up space generate pervasive and generally harmful consequences. Real-estate prices in places such as Mumbai are among the highest in the world, higher than in much richer cities like Singapore and Shanghai. The average floor spaces available to businesses and households are far more cramped than elsewhere. Mumbai homes have only about 30 square feet per person, compared with 140 square feet per person in urban China. Slums grow as the poor are unable to find low-cost housing. Businesses and households are forced to seek cheaper land further and further out in city peripheries and beyond.[77]

One report by commercial real-estate specialist Jones Lang LaSalle explains: "With high prices of land within the city, the low-income housing projects are being developed at 'leapfrogged locations', which offer land parcels at suitable price points for such developments. Leapfrogging is a real estate phenomenon, in which high prices of intermediate land parcels lead to development of far-flung areas before immediate periphery is developed." In the case of Mumbai and the National Capital Region around Delhi, leapfrogging means that affordable housing projects are located as much as 65–75kilometres away from the city centre.[78]

Some current policies intended to preserve farmlands may also be misguided and increase unplanned sprawl. In most jurisdictions, landowners, for example, must apply for a Non-Agricultural Use Clearance (NAC) to convert farmlands to alternative uses, a process that is highly regulated and costly. As a result, urbanisation often occurs where it is legally easiest, rather than where it is most rational for providing public infrastructure and services, or for accessibility, and therefore transportation cost efficiency.

There is also a significant underinvestment in public transport infrastructure in most Indian cities. This has encouraged rapid growth in private motor vehicle ownership, which has aggravated the social costs of urban sprawl; for example, congestion, longer travel times, local air pollution, and GHG emissions. The number of vehicles rose at 5–9 times the rate of growth

Photo credit: Ferzina Banaji

in the urban population between 1980 and 2011, with the fastest growth in two-wheelers.

India's bus rapid transit network has been slow to develop.[79] Similarly, major urban transport programmes, such as Delhi's metro development, have suffered from challenges in planning and coordination. Various Transportation Demand Management (TDM) strategies have been proposed,[80] but to date, many Indian cities have taken limited steps to implement them.[81]

In conclusion, this analysis has shown that, in aggregate terms, the adoption of policies that encourage sprawled, automobile-dependent development could increase economic, social, and environmental costs for India with a value of at least US$1 trillion per annum by 2050, representing at least 3% of GDP in 2050, and probably much higher.

Similarly, at the household level, sprawl can impose cumulative costs equivalent to at least 20% of average household incomes. However, policy reforms can avoid or significantly reduce these costs, providing significant net economic and wider benefits. Described differently, policies that create more compact and multi-modal communities can provide savings and benefits equivalent to a 20% increase in incomes. Not all of these savings and benefits are financial: some involve valuable non-market goods such as improved fitness, health, and environmental quality. The total potential benefits are significant and particularly tend to help people who are physically, economically, and socially disadvantaged, and so rely on affordable travel modes such as walking, cycling, and public transport.

Photo credit: Shomikho Raha

4. Insights from four Indian cities: The human cost of dysfunctional urban development

The preceding section discussed the substantial additional costs of unplanned, sprawled modes of urban development, including the additional costs of making up India's large urban infrastructure deficits. This in turn is likely to exacerbate the need for residents to meet these costs themselves.

This section draws on case studies undertaken for this project to look further at the deficits in infrastructure service delivery in four Indian cities – Bangalore, Indore, Pune, and Surat – focusing in particular on urban transport, water, sanitation, and energy.[82]

As in other cities, significant deficits in the extent and quality of public service delivery often force urban residents in these cities to seek out private sector sources or to supply these services themselves (so-called "self-provisioning"). At the same time, there are noteworthy variations in the extent and character of public service deficits across the four cities. A common result of failures in broad-based public service delivery is the widening of urban inequities, as the well-off are better able to look after their own needs. It also serves to increase the overall social costs of service delivery, including external costs such as impacts on public health and the environment. At the other end of the spectrum, the city's poorest, who are also left to fend for themselves to access even the most fundamental of services – but who lack economic resources – tend to end up bearing the highest burden of service deficits in terms of social, health, time, and money costs.

Failures in public sector infrastructure service delivery are both the result of and the cause of failures in governance, alongside other factors. Weaknesses in the institutional and fiscal framework of urban government and urban finance in India hinder the capacity for effective public service delivery. In turn, the rise of self-provisioning among the well-off and the politically influential reduces the political pressure on the government to provide good-quality, broad-based public services in India's rapidly expanding urban and peri-urban areas, and also means the government is less likely to be held to account. This vicious circle in the urban political economy erodes urban performance and undermines goals of equity: infrastructure service deficits persist and costs rise, eroding productivity, deepening urban poverty, and undermining sustainable growth.

The city case studies for this report, whose findings are documented in detail in a background paper and which are summarised here, attempt to quantify the full costs of service provision in cities, whether by the public sector, private sector or self-provisioned – and provide some estimates for the economic, social and environmental costs of various modes of service delivery.

4.1 "Business as usual": Public service delivery deficits and outcomes in four Indian cities

The rapid urbanisation of many Indian cities is often characterised by high intensity development in the urban periphery, a slowdown or negative population growth in central city areas, incomplete service networks (transport links, water supply lines, sanitation), and a near total lack of formal public services in peripheral areas. The cities of Bangalore, Indore, Pune, and Surat have been urbanising at a rapid pace for the past few decades. Surat has had a consistently high growth rate since the 1980s while Bangalore has experienced a resurgence in urban growth since 2001 due to the growth of the IT industry. Population and economic growth in these cities have, however, not always been supported with improvement in the coverage and quality of services, such as for transport, water and sanitation, and energy. Table 5 below presents the extent of publicly provided services and corresponding household access across various sectors in the four cities.

As Table 5 indicates, in all four cities public provision of services does not reach all households. Public transport accounts for a mere 1%, 9%, and 13% of all daily trips in Surat, Indore, and Pune respectively (although Bangalore has a higher share of public transport at 28% of daily trips). Only 60% of households in Indore have access to piped water. Sanitation access ranges from only 62% of households in Indore to 86% in Surat. Regarding access to energy, LPG has a significant share in all these cities and is the primary cooking fuel used, ranging from 71% in Surat to 86% in Pune. Despite the high penetration of LPG access, kerosene continues to be a major cooking fuel in Surat and Bangalore with 20% and 16% of households, respectively, dependent on this cooking fuel. Finally, while electricity access is high across all these cities, with at least 98% of households using publicly provided electricity as their primary energy for lighting, the reliability of this supply varies across cities, and this has direct consequences for whether households decide to use the service or not.

For municipal agencies and public utilities tasked with providing basic services to all citizens, high household access, or coverage, is only one of the indicators of good service. For households, efficiency and the quality of service access also determine whether they choose to shift to private or self-provisioned solutions. For example, in Bangalore despite the high percentage of households with access to electricity (98%), approximately 15.6% of total annual electricity demand is met by electricity generated by diesel-powered

Table 5
Services provided by public agencies indicating limited service coverage across sectors

		Bangalore	Indore	Pune	Surat
Transport	% share of trips by public bus	28	9	13	1
Water	*% of households with water connections supplied by public utility*	*81*	*60*	*98*	*88*
Sanitation	*% of households connected to public sewer system provided by public utility*	*79*	*62*	*71*	*86*
Energy	*% of households with electricity for lighting provided by public utility*	*98*	*98*	*98*	*99*
	% of households with access to cooking fuels such as LPG and kerosene	*78 / 16*	*84 / 5*	*86 / 8*	*71 / 20*

Source: Census 2011 and survey data.

electricity generation sets. This dependence arises due to inadequate supply of electricity and poor quality of service in the form of power outages.

Similarly, despite a high number of households with access to public supply water, limited and unreliable hours of water supply lead to a dependence on groundwater extraction using borewells in almost all our sample cities. Thus, in Bangalore, despite relatively high household access to public water connections, public water supply accounts for only a 48% share in the total water consumed in the city. In Surat, by contrast, 98% of the water consumed in the city is from public supply, even though only 88% of households have access.

4.2 Public service deficits drive higher-cost infrastructure options

The deficits in public service delivery described above often encourage households and businesses to seek alternative private suppliers or self-provisioning systems to provide the required services, despite the significant additional social costs that such options may generate. This may occur through greater private motorisation for mobility, more use of diesel-powered electricity generation sets, dependence on tankers and borewells for water supply, or greater use of firewood for cooking. Poor households are likely to be disproportionately impacted by the lack of public supply, as they may be unable to afford safe or high-quality alternatives. The four city case studies reveal a number of positive trends, but also significant challenges related to public service delivery of basic services.

Transport

In the case of the transport sector, the lack of adequate public transport options – such as public bus or rail systems – leads to a dependence on other transport modes, particularly motorised vehicles such as two-wheelers, private cars, auto-rickshaws, and taxis, as well as walking. This exacerbates other incentives towards more sprawled, automotive-dependent urbanisation. While transport mode shares vary across cities, there are also some similarities in trends for transport costs, with private cars in general tending to have the highest overall costs (as outlined in Section 3). Walking tends to be one of the higher-cost options in some cities, but only because of the costs associated with travel time. Apart from travel time, walking incurs the lowest costs across modes, while also accruing health and wellness benefits. A more compact urban development model with activity centres in closer proximity could generate large transport cost savings by encouraging more walking. Public transport or buses tend to have the lowest per passenger-kilometre costs within motorised modes. While vehicle-kilometre costs for public transport are high, the fact that they are distributed over a larger number of people, based on average occupancy of buses, helps to bring down the average costs per passenger. Efforts to promote use of public transport, carpooling, and shared rickshaws should thus be encouraged. The case studies also suggest that reductions in congestion and corresponding air pollution would provide significant additional co-benefits from such efforts.

Energy

Two components of the energy sector were studied in each of the four cities as part of this report – energy for lighting (electricity) and energy for cooking (LPG, kerosene, and firewood). As Table 5 above indicates, there are generally high household access rates for electricity for lighting in the four cities. This may be because electricity planning (procurement and supply) happens at a regional rather than city scale. Pune reports the highest full cost of public supply electricity at 9 rupees per kWh, while Bangalore reports the lowest at 4.5 rupees per kWh. Surat is the only city that reports health costs associated with electricity supply due to the presence of a thermal generation plant in close proximity to the city.

Some of the four cities are also acting to promote energy efficiency and renewable energy. The Surat Municipal Corporation, for example, runs its own renewable energy plants for wind, solar, and biogas, and promotes energy efficiency through a variety of programmes. Its energy efficiency measures helped the city to reduce its annual energy consumption by approximately 48 million kWh in the year 2014 (0.7% of the total consumption). Pune Municipal Corporation (PMC) has also been increasing its portfolio of renewable energy in recent years. PMC runs about 20 biogas plants of 5 tonnes each and a 300-tonne waste to energy plant producing compressed biogas plants. It introduced an environmentally friendly housing policy in 2007. It has made solar water heating compulsory for certain buildings in the municipal area and has adopted a green rating system to evaluate building designs to promote energy efficiency.

However, despite positive trends, survey data and the existing literature indicate that many of the cities studied face disruptions in public power supply. Bangalore, for example, experiences significant disruptions in public power supply, which has led to a dependence on diesel-powered generator sets and open access electricity to fill the demand gap.

In energy from cooking fuels, LPG has a high use in urban centres in India, but dependence on kerosene (predominantly higher use in rural areas) and firewood also continues in some of the cities studied. Indore and Pune report lower use of kerosene at 5% and 8% respectively. This is higher in the case of Bangalore and Surat at 16% and 20% respectively. One reason for higher dependence in the latter two cities could be due to the expansion of municipal limits in the past decade, wherein erstwhile rural areas were included in the new urban jurisdiction. Households in these newly added areas might be continuing to use inefficient cooking fuels and stoves, and this could account for the higher use of kerosene.

Unfortunately, the use of kerosene has significant health impacts in terms of indoor air pollution. This cost is disproportionately borne by women and children, owing to their proximity and exposure time to the pollution from cooking fuels such as kerosene and firewood, as they usually bear the primary burden for household chores such as cooking. In Bangalore and Indore, the health cost from kerosene use is estimated at 56% and 82% of the full cost of energy from kerosene.

Water and sanitation

Of the case study cities, Bangalore and Indore in particular suffer from inadequate and inefficient supply of treated tap water, compared with Pune and Surat. The gap in public water supply in Bangalore and Indore is largely supplemented by water from private and self-provisioning systems, such as vended water and borewell water (see Figure 9).

The direct cost of extracting water from borewells is the most important cost in the full cost of water delivery for urban residents, ranging from 68% in Pune to 96% in Surat (Bangalore and Indore report the share of direct cost to full cost as 94% and 89% respectively). Despite this high cost, which is often borne directly by the household, a large volume of the four cities' water needs is met from this source (almost 41% and 55% of total water consumed in Bangalore and Indore).

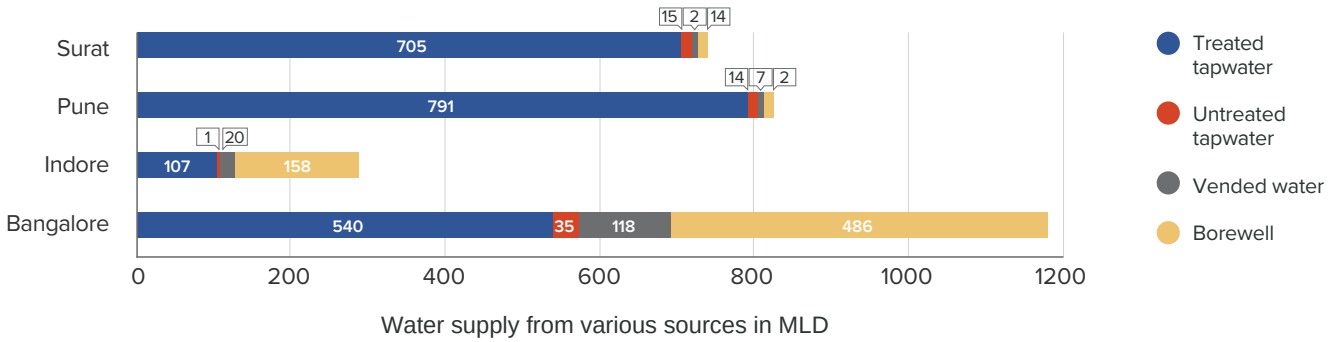
Other than treated tap water from public supplies, water from all other sources is at risk from contamination from chemical and biological pathogens, due to urban activities. This is especially so in Bangalore and Indore where lower network coverage and household access to treated supply forces households to depend on water from untreated sources, with significant health risks.

Household access to piped sanitation ranges from 62% to 86% across the four study cities (see Table 5 above). The gap in sanitation service provision is often met by alternate systems such as septic tanks and pit latrines. Unfortunately, not all households have access to such systems and a small proportion of households continue to practise open defecation in the case study cities (Bangalore 1.6%, Indore 5%, Pune 2%, and Surat 1.5%). The lack of sanitation access has associated costs in terms of productive time lost and also has repercussions on the safety and dignity of users.

Another aspect of sanitation services is that both public and self-provided sanitation services are susceptible to leakage and can contaminate groundwater sources. Furthermore, not all wastewater generated in urban areas is treated (or treated fully) before being released into natural water bodies leading to further risk of contamination and environmental degradation.

Figure 9

Water supply from various sources in the four study cities (in million litres per day)



Source: Tewari et al., 2016.

4.3 Institutional weaknesses and unplanned sprawled development undermine public service delivery

The reasons for the weak public service delivery and infrastructure deficits that lead to high levels of self-provisioning in many Indian cities are complex. They include both institutional weaknesses in urban governance in India, as well as the unplanned "sprawled" model of urban growth that characterises urban expansion in many cities.

As Box 6 explains, the constitutional position of urban governance in India faces a number of challenges, and the municipal authorities' capacity, fiscal resources, and accountability to citizens, can often be limited, far below the level needed to accomplish their tasks.

Box 6
Urban governance and finance in India

Urban governance in India is in a state of partial or incomplete decentralisation. The Constitution (Seventy-fourth Amendment) Act (1992) for the first time gave municipal bodies a constitutional status as a third tier of government, although they remain a responsibility of the states. The Act defined 18 functions for devolution to local-government level. In practice, however, the allocation of responsibilities between various levels of government remains muddled. Local governments' administrative capacity and accountability to residents is limited, while their fiscal resources remain often far below levels needed to accomplish their tasks.

First, the devolution of responsibilities to local government is too often an unfunded mandate, with local governments left short of the revenues with which to tackle the large and growing infrastructure deficits of urban areas. The Zakaria Committee of 1963 established expenditure norms for adequate service delivery but by 2001 it was estimated that larger Indian cities were spending not even a quarter of the Zakaria Committee norms in inflation-adjusted terms. The total revenues of Indian local governments amounted to only 0.94% of GDP in 2007/08, which is low by international standards. By contrast, municipal revenues in Brazil are over 7% of GDP.

On the one hand, local governments have found it difficult to mobilise their own taxes and user fees, while on the other hand, intergovernmental transfers to local governments from the state and central governments have also been inadequate to their needs. Historically, the use of octroi or taxes on domestic trade had formed a significant part of local government revenues. However, with octroi now being subsumed under the new Goods and Services Tax (GST), which will be shared between the central government and the states, local governments face a significant shortfall in their revenues, which will need to be made up from other own revenues or transfers from the states.

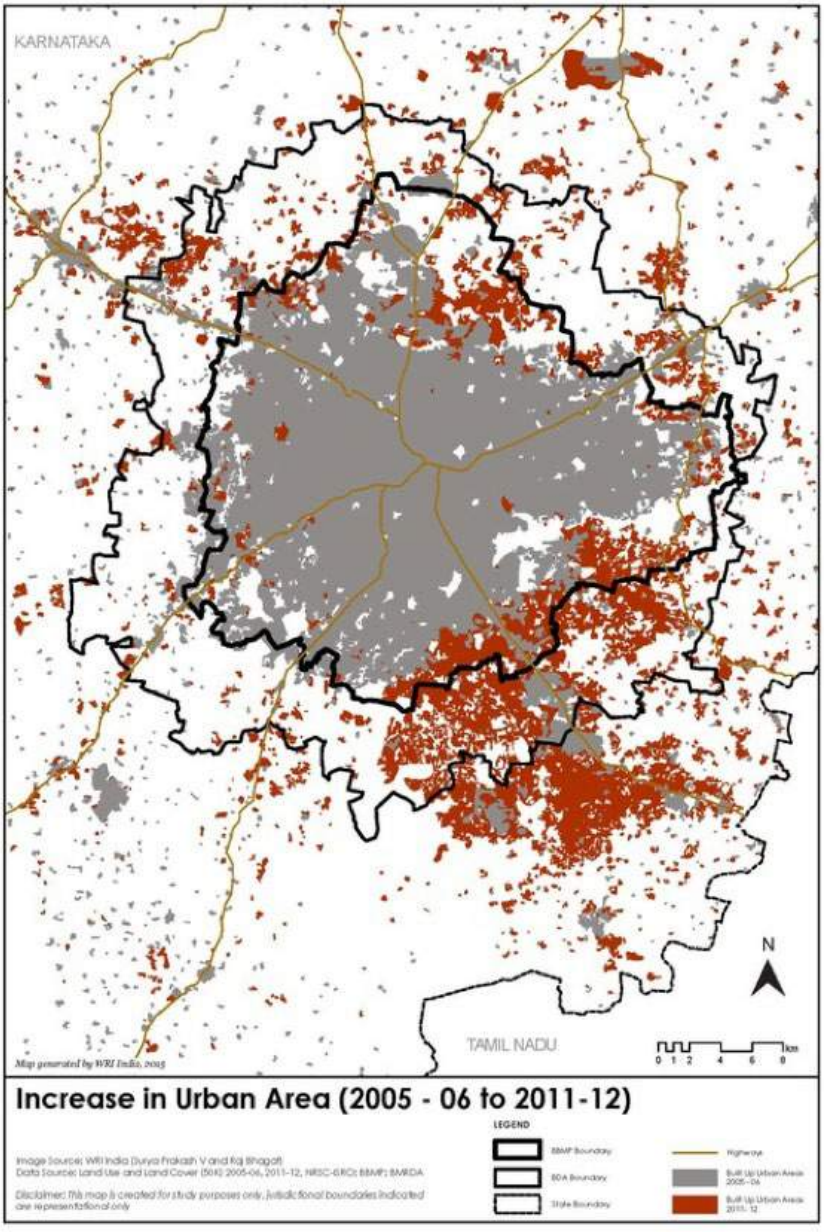
The own revenues of India's local governments were only 0.5% of GDP in 2007/08 (compared with 2–3% in Brazil), while intergovernmental transfers were only 0.4% of GDP. Property taxes are the primary own revenue source available to local governments but have suffered from poor collections and lack of buoyancy, due to a lack of systems to appraise current land values, outmoded tax assessment methods based on rental value rather than area, and widespread tax evasion, among other factors. The potential for reforms to bring major returns was shown in Bangalore, which shifted to a presumptive basis for taxing properties, based on location and size as a way to try to approximate true values. The change resulted in a near 80% surge in revenues between 2007/08 and 2008/09. Property tax reforms that focus on taxing land values rather than building space can be particularly effective in promoting compact development.

As regards intergovernmental transfers, the Constitution requires states to establish State Finance Commissions to determine the allocation of state revenues to local governments but often these Finance Commissions have not been established or their recommendations have simply not been implemented. Intergovernmental transfers to local governments have remained opaque, ad hoc, and inadequate. Cities with a more secure revenue base – either from own revenues or transfers – are likely to secure better credit ratings and greater access to private capital for urban infrastructure investment. This can create a virtuous circle, as stronger urban growth generates more revenues. Second, apart from the financing of local government expenditure, the allocation of responsibilities between various levels of government itself often remains unclear and confused, hampering effectiveness in urban service delivery. Being at the discretion of the states, there is considerable variation in the extent to which functions have actually been devolved to local government. Low administrative capacity in local governments provides states with a convenient reason to limit devolution. Third, there is little effort to foster accountability of local government officials to area residents. Elected local officials often have little control over key decisions such as staffing, which remains in the hands of the state governments. Institutions to elicit participation by local residents remain underdeveloped.

In addition to challenges related more directly to urban governance, both the rapid pace of urbanisation and the unplanned, sprawled mode of urbanisation in India have also contributed to incomplete household access to publicly provided services, inadequate supply and low quality of supply. Service delivery capacity has just not kept up with the rapid growth in infrastructure and service delivery demands due to urbanisation. In some cases, including in Pune and Surat, municipal boundary expansion to incorporate urbanising peri-urban and rural areas on the fringes has also driven rapid growth in service demand.[85] The expansion of municipal boundaries is often essential to begin providing key public services in fast-growing fringe areas but it also directly increases the demands and stresses on municipal corporations and public utilities with limited institutional capacity and financial resources. The municipal boundary expansion in Bangalore increased the service area from 226 to 800 square kilometres (Figure 10) and in Surat from 112 to 326 square kilometres.[86]

Figure 10

Spatial expansion of urban areas in Bangalore, 2005/06 to 2011/12



Source: Tewari et al., 2016.

Across Indian cities, development is most rapid at city peripheries, where open land is readily available; hence the demand for services is most pressing in these peripheral areas. In the absence of administrative authorities, such as municipal corporations or other public utilities, households, businesses, and industries in these areas bear the financial and external burdens of private or self-provisioning. Therefore, though municipal boundary expansion adds a significant burden to public utilities, it also provides households in newly incorporated areas the option to choose between public, private, or self-provisioning systems. Public utilities are generally under significant debt and are unable to expand coverage and meet existing or new demand. For example, Bangalore's water supply utility (BWSSB) is in debt to the electricity utility of the region over unpaid dues of 6.1 billion rupees.[87] This leaves limited resources to undertake infrastructure upgrades or efficiency improvements on a regular basis. Another key planning problem that persists in India is that municipal corporations often do not have the mandate for providing services including water supply and sanitation, public transportation, electricity etc. (as in the case of Bangalore).

Urban extension is a necessary element in a fast-urbanising country like India. However, as the New Urban Agenda adopted by the 2016 Habitat III conference observes, spatial development strategies "need to guide urban extension prioritizing urban renewal by planning for the provision of accessible and well-connected infrastructure and services, sustainable population densities, and compact design and integration of new neighbourhoods in the urban fabric, preventing urban sprawl and marginalization".[88] That is to say, urban extension in India itself needs to be done in a planned, compact way, with a high density of built-up space, which will help municipalities provide the required infrastructure and services in a more cost-effective way than would be possible in an unplanned, sprawling development with a low density of built-up space.

Having noted these broad factors that affect capacity for urban public service delivery, it is also true to say that there is much that cities themselves can do to improve their institutional capacity in this regard. Surat and Pune in particular have implemented many reforms that can provide good practices for urban governance elsewhere.

Surat Municipal Corporation (SMC), Surat Urban Development Authority (SUDA), and Hazira Development Authority (HADA) are the three main authorities with jurisdiction in Surat City. The SMC proactively restructured governance following the trauma of the endemic plague outbreak of 1994. The crisis was a key trigger in rethinking urban planning and urban governance in Surat. The rapid short-term and long-term reforms thereafter led to Surat becoming the second cleanest city in the country. These administrative and institutional reforms included:

- Decentralisation of municipal power, followed by appointment of commissioners for each of the six zones;
- Strict monitoring and daily review of municipal activities;
- Maintaining transparency in system of accounts;
- Increased community participation in the form of grievance redressal platforms;
- Financial reforms and greater accountability towards general public.

SMC has a comprehensive and interactive online portal that helps citizens to engage with the municipal agency. Municipal functions, such as property tax payments, property assessments, water bill payments, and future development and master plans (such as the Surat Solar City Mission), are hosted here. These reforms and an active elected body of the municipal government have enabled the city to cope with the challenges posed by urbanisation and to maintain high efficiency in service delivery, despite the municipal boundary expansion, which increased the area from 112 to 326 square kilometres. In addition, this has helped to avoid power load-sheading and the need for diesel-powered generator sets.

In Pune, the municipal corporation has two parts, an administrative wing headed by the Commissioner and an elected wing comprising a Mayor and Ward Committees. The elected body is responsible for advising the administration about various developmental activities undertaken by PMC. The Standing Committee, which is the most powerful body as per the Bombay Provincial Municipal Corporations Act (BPMC), has discretionary powers regarding financial matters and is responsible for preparing the civic budget. Some 76 Prabhag Samitis (under elected Ward Committees) identify and prioritise developmental schemes to be undertaken. Zonal officers in the administrative wing are responsible for carrying out the developmental activities and tax collection.

Photo credit: Shomikho Raha

Pune city has received funds under the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) to carry out various improvements to municipal services and amenities. The reforms undertaken by PMC since 2005 have been:

- Revisions in property taxes and increased efficiency in tax collection system by using GIS and MIS applications as part of enabling e-governance;
- Adoption of modern accrual-based double-entry system of accounting;
- Levy of reasonable user charges in order to recover O&M costs (over a period of 7 years – water sector projects);
- Provision of basic services to the urban poor including security of housing tenure at affordable prices.

Improvements in tax collection and recovery of water supply cost has increased revenue collection and helps support other developmental activities undertaken by the municipality. The realignment of the organisational structure allowed PMC to realise gains from the implementation of mandatory reforms.

The reforms in Surat and Pune indicate a shift in municipal governance from a top-down approach to a more zonal (localised) approach. Furthermore, administrative reform has combined with a shift to e-governance and improved accounting to increase transparency and accountability. Strict and regular monitoring of services and quality of supply has enabled these agencies to continue functioning despite growing demand from urbanisation. Improved accounting has also led these municipal agencies to look at new and innovative ways of revenue generation. This has led to municipal solid waste and wastewater being considered as a valuable resource in these two cities, creating closed- loop, sustainable systems.

Photo credit: Shomikho Raha

5. Conclusions and policy recommendations

Urbanisation provides a major opportunity for India to accelerate inclusive and sustainable growth and improvement in welfare of its citizens. However, as preceding sections have documented, the way in which it is occurring in India is likely to hamper the country's ability to tap the full potential of urbanisation. As Section 2 indicated, there is clear evidence that a more sprawling urban growth pattern is associated with lower economic growth. It can also be associated with a wider range of other economic, social, and environmental costs, such as greater congestion and travel times, pollution, accidents, and other sources of health damage. In particular, a sprawling development model inflates the cost of providing adequate urban infrastructure services, exacerbating existing public sector infrastructure and service delivery costs. Section 3 suggested that – as an initial estimate –an extensive, sprawled urban development model in India could generate additional costs in the range of US$330 billion to US$1.8 trillion per year by 2050, or 1.2-6.3% of GDP, as compared with a better managed urban development model, and possibly even higher. Section 4 looked at the extent of public sector infrastructure and service delivery deficits in four Indian cities, and considered how weak urban governance and unplanned, sprawling urban growth contribute to and exacerbate these deficits, leading to the growth of socially costly self-provisioning for services.

The dysfunctional patterns of urbanisation in India noted in the previous sections arise from a number of long-standing, deeply ingrown and mutually interlocking policy distortions and institutional weaknesses. Highly restrictive land regulations create incentives for urban sprawl. Yet proposals to build more appropriately compact cities are often countered by the risk that greater densities in urban cores could overwhelm the rickety and inadequate existing infrastructure of these areas. Efforts to strengthen urban infrastructure and planning are in turn stymied by financing challenges and the weaknesses of urban governance and institutions. This vicious circle creates a challenge for reformers, who will need to proceed simultaneously on many interlinked fronts, as well as difficult political economy problems, such as close ties between the real estate development industry, which has evolved to seek rents from the present regulatory structure, and the political system at different levels.

However, there is also a significant opportunity for India's policy-makers. Described differently, smart growth policies that create more compact and multi-modal communities can provide multiple savings and benefits. Some of these savings and benefits are financial, and some involve valuable non-market goods such as improved fitness, health, and environmental quality. Moreover, the total potential benefits particularly tend to help people who are physically, economically, and socially disadvantaged.

We therefore outline three key areas for policy reforms that, together, can yield major improvements in urbanisation and its contribution to rapid, inclusive, and sustainable development.

5.1 Reform land use regulations to improve the efficiency and effectiveness of land use

As noted, existing land use regulations and land market institutions play a powerful role in reducing the efficiency of land use in Indian cities and in encouraging more sprawling, extensive urban forms. Measures should be considered to:

- Launch a nation-wide debate and process of consultation on a range of options for comprehensive reform of land use regulations and land markets;
- Based on these consultations, propose comprehensive reforms of land regulations that are holding back development of appropriately compact and productive urban forms, covering such issues as Floor Space Index (FSI)/Floor Area Ratio (FAR) regulations, maximum building heights, set-back requirements, plot-coverage ratios, and parking space requirements;
- Increase efficient functioning of land markets by strengthening systems for: appraisal of land values, determining property rights, land registration, and conducting public land acquisitions;
- Reform housing finance to increase the supply of new housing stock.

It is important to recognise that reforming land regulations and markets is often controversial and challenging in the political economy of India. This will call for active public, private, and civil society leadership, public consultation, and careful consideration of local circumstances, so as to achieve successful reform. Increasing FARs will require, for example, concurrent investment in supporting municipal services and good urban design, to avoid the creation of urban canyons, which can trap pollutants. Increasing building heights will require more efficient services and higher pressure services (e.g. water) overtime, pointing to an overhaul of municipal networks.

Given the challenging nature of the issue, the Indian government should initiate a nation-wide debate and process of consultation on a range of options for comprehensive reform of land use regulations and land markets.

5.2 Expand urban infrastructure to encourage more compact, connected, and coordinated cities

Clearly, a vast upgrading in the scale and quality of urban infrastructure is needed if India is to tap the full potential of its cities. As previously noted, the government's High Powered Expert Committee (HPEC) *Report on Indian Urban Infrastructure and Services* estimated that urban infrastructure spending of about 39 trillion rupees (in 2009/10 prices, or about US$830 billion) was needed over the 20-year period to 2031/32, to meet a defined set of service delivery standards for water supply, sewerage, solid waste, urban roads, and urban mass transit.[89] A study by McKinsey Global Institute estimated that there was an overall urban investment need of US$1.2 trillion(in 2008 prices) over the period to 2030. This would encompass such elements as 2.5 billion square metres of paved road and 7,400 kilometres of metros and subways (both being 20 times the capacity built over the last decade).[90]

The government's Smart Cities and 500 Cities programmes build on the earlier Jawaharlal Nehru National Urban Renewal Mission (JnNURM), launched in 2005. These programmes represent a major effort to move forward urban infrastructure development, by greatly increasing central government financing for urban development, in coordination with the states and municipal bodies which have primary constitutional responsibility for cities. While there has not yet been a comprehensive impact evaluation of the JnNURM or its successor schemes, initial reviews of results have highlighted challenges in project selection and implementation capacity at the level of urban local governments.

As the central government now brings to bear very large resources to support urban infrastructure investment through its Smart Cities and other central programmes, it has a unique opportunity to provide an overall vision and substantive leadership as to the content of the country's urbanisation. Measures should be considered to:

- Enhance the use of the Government of India's major Smart Cities and other centrally supported urban infrastructure programmes to *provide leadership and an overall vision* for the nation's urbanisation, based on a comprehensive impact evaluation of the JnNURM and other central programmes, as well as on international experience. As work for this report and other international NCE studies suggests, *more compact, well-connected and coordinated cities* are also likely to be more economically productive, less polluting and wasteful of resources, more liveable, and more socially inclusive;
- Use major urban infrastructure initiatives to encourage more compact, efficient urban forms, in part by removing biases against compact forms. In transport, in particular, these include subsidies that encourage urban sprawl and costly motor vehicle transport, for example through underpricing of road and parking services and through fuel subsidies. More comprehensive multi-modal transport planning is needed which takes full account of the environmental, congestion, and other externalities associated with road development and motor vehicle transport, and which increases the focus on building efficient public transport systems such as bus rapid transit networks;
- Revisit traditional models of service provision, including encouraging cities to innovate. Many public utilities currently suffer from weak institutional structures and financial burdens, often rendering them unable to expand public service networks or improve quality of service. The four city case studies looked at as part of this report demonstrate the ability of cities to innovate and adopt new service and business models for service delivery. Drawing on rapid technological changes, new models of service delivery are emerging which aim to promote more "circular" or sustainable solutions in water, sanitation, and energy service delivery. Examples are already seen in Surat and Pune where treated wastewater is sold to industrial areas and bio-methanation converts municipal solid waste to energy which is used in wastewater treatment. Rapidly falling renewable energy costs create new opportunities for off-grid or mini-grid solutions in energy supply. Regulatory environments that encourage innovation and discourage high-carbon, high resource-use alternatives should be enabled.
- Ensure urban service and user fees reflect the full social costs of services provided. With growing concerns about water and other resource stress, and about growing local air pollution and greenhouse gas emissions, urban service fees and user charges should aim to reflect the full social costs of services provided.

5.3 Reform and strengthen urban local government, accountability, and financing

The need for reform of land regulations to promote greater compactness and well-managed urban extension has increasingly become a part of the India policy debate. It is nevertheless often argued that such reforms on their own will fail to achieve improved productivity and greener development because the increased urban population density would overwhelm the already rickety urban infrastructure of Indian cities. A massive expansion of urban infrastructure investment is also needed. But this, in turn, points to the need for effective urban local governments, which are best able to determine the infrastructure requirements of their cities, to formulate and implement appropriate urban development plans, oversee efficient operation of urban public goods, and remain accountable to the urban public. Yet, as discussed above, the allocation of responsibilities across various levels of government remains muddled, local governments' administrative capacity and accountability to residents is limited at best, while their fiscal resources remain far below the levels needed to accomplish their tasks. Measures should be considered to:

- Ensure that the currently muddled devolution of responsibilities to cities is clarified and actually implemented. While urban governments are primarily a state responsibility under the Indian Constitution, central government needs

to encourage and work closely with the states to ensure that this happens. With greater real responsibilities and authority for service delivery, urban governments also need to strengthen their mechanisms for public accountability and participation;

- Strengthen the administrative capacity of urban governments. Alongside greater responsibility, the administrative capacity of urban governments needs to be greatly strengthened, including capacity for urban planning and infrastructure development. Programmes for formal training and qualifications in urban management need to be greatly expanded, together with development of a professional career path in urban management. Mechanisms need to be expanded for Indian cities to network and learn from each other's experience in urban management and development. The progress in urban governance noted above for cities like Pune and Surat provides valuable lessons for others;
- Expand the fiscal resources available to cities. With growing responsibilities, the fiscal resources available to Indian cities need to be greatly increased. Cities' own revenues need to be strengthened, in particular through reform of property taxes and stronger systems for land value appraisal and tax collection. As required by the Constitution, State Finance Commissions need to determine intergovernmental transfers to cities and their recommendations need to be implemented fully and promptly.

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ENDNOTES

1 The four forthcoming background papers are: (1) Tewari, M., Alder, S., and Roberts, M., 2016 (forthcoming). *India's Urban and Spatial Development in the Post-Reform Period: An Empirical Analysis*. New Climate Economy background paper; (2) Alder, S., Roberts, R., and Tewari, M., 2016 (forthcoming). *The Effect of Transport Infrastructure on India's Urban and Rural Development*. New Climate Economy background paper; (3) ICRIER and WRI, 2016 (forthcoming). *Towards Smarter Service Provision for Smart Cities: Accounting for the social costs of urban service provision*. New Climate Economy background paper with Indian Council for Research on International Economic Relations and World Resources Institute; and (4) Litman, T. (forthcoming). *Evaluating Economic Impacts of India's Urbanisation Policy Pathways*. New Climate Economy background paper with Victoria Transport Policy Institute (VTPI).

2 UN-Habitat, 2016; United Nations, 2014.

3 HPEC, 2011; World Bank, 2013.

4 World Bank, 2013.

5 See, in particular, Ellis and Roberts, 2015, Chapter 2.

6 World Bank, 2013.

7 Michaels et al., 2012.

8 Ciccone and Hall, 1996.

9 Combes et al., 2015.

10 Li and Rama, 2015. See also Duranton, 2005; Duranton, 2014; Duranton, 2015; Ciccone, 2008; Duranton and Puga, 2004; Spence et al., 2009; Brulhart and Sbergami, 2009.

11 Fay and Opal, 2000; Jedwab and Vollrath, 2015; Polèse, 2014; The Global Commission on the Economy and Climate, 2014; Gouldson et al., 2015.

12 Tewari et al., 2015.

13 It is useful to note the connection between various density concepts. In particular, population density (population per unit of land area) is equal to built-up density (built-up floor area per unit of land area) multiplied by occupation density (population per unit of built-up area).

14 HPEC, 2011.

15 McKinsey Global Institute, 2010.

16 Global Burden of Disease Study 2015 Results. See: IHME, 2016..

17 Ellis and Roberts, 2015.

18 The supporting evidence for the discussion in this section is available in two background papers prepared for NCE in collaboration with the University of North Carolina and the World Bank: Tewari, M., Alder, S., and Roberts, M., 2016. *India's Urban and Spatial Development in the Post-Reform Period: An Empirical Analysis*; Alder, S., Roberts, R., and Tewari, M., 2016. *The Effect of Transport Infrastructure on India's Urban and Rural Development*.

19 Elvidge et al., 1997; Henderson et al., 2012; Harari, 2016; Roberts et al., 2012; Alder et al., 2016; Ellis and Roberts, 2015; Pandey et al., 2013.

20 Henderson et al., 2012.

21 Michalopoulos and Papaioannou, 2013.

22 Pandey et al., 2013;, Zhang and Seto, 2011; Ellis and Roberts, 2015.

23 Pandey et al., 2013.

24 Harari, 2016.

25 Tewari et al., 2016; Alder et al., 2016.

26 A caveat with this version of the night-time lights data is that satellites are replaced over the years and have different calibrations, which affects the overall growth we observe. In our background paper, we discuss how this issue is addressed using inter-annual calibration and we find that there is overall growth with that approach as well. The comparison of growth across districts is not affected by the calibration. See: Tewari et al., 2016.

27 We have to interpret this result with caution, however -- in the absence of a welfare model that allows us to measure trade-offs, we cannot be sure if the reduction in spatial inequality through convergence was achieved at the cost of lower aggregate growth. Still the finding is important from an equity perspective and can be the basis for further research.

28 Cashin and Sahay, 1996; Ghate, 2008; Shankar and Shah, 2003; Bandyopadhyay, 2012; Das et al, 2015. The last study does find evidence of conditonal convergence when controlling for initial characteristics such as urbanisation, although it is smaller than the one reported in Tewari et al. (2016) that we draw on here. A notable exception is Khanna and Gaurav (2014), which uses light data at the sub-district level.

29 There is a finding of convergence both when growth is regressed on initial income alone ("unconditional convergence"), as well as when it is regressed on initial income and additional sets of controls ("conditional convergence"). See the background paper, Tewari et al. (2016), for details.

30 These are speculative claims and do not follow directly from the results in Tewari et al. (2016) and therefore cannot be attributed to them.

31 See Desmet et al., 2015.

32 Ellis and Roberts, 2015.

33 The background papers supporting this report examine the role of a number of other factors, such as economic and structural factors, and the environment (see Tewari et al., 2016), but here we focus on only two factors: transportation and urban form.

34 See Zhao et al., 2015, for further detail.

35 Following Harari, 2016.

36 Landscan data models population density in 1km grids based on combining census data with daytime satellite imagery that allocates census population at the finest administrative level of detail available to grid cells based on assumptions about population density based on building type and distance from roads. See: Dobson et al., 2000, 2003.

37 It is important to note that these are descriptive results that are all statistically significant at the 1% level. They are not causal results.

38 Note that this excludes all light growth in rural areas that did not become urban.

39 Alder et al., 2016. For example, the World Bank's 2009 *World Development Report* states that "spatially connective infrastructure" is crucial for market integration and plays a key role in shaping economic geography (World Bank, 2009).

40 See Tewari et al., 2016, and Alder et al., 2016, for details.

41 The bilateral travel times capture the trade costs and are calculated as the shortest path through the road network and depend on length, speed, and state border crossings. Market access for each origin is calculated as the weighted sum over all destinations' incomes, where the weights are given by the bilateral trade costs, i.e. market access discounts the destinations' incomes by the bilateral trade costs. See the background papers from which the supporting evidence is drawn: Tewari et al., 2016, and Alder et al., 2016.

42 With digitally scanned historical road maps and code that the authors of the technical background papers obtained from Allen and Atkin (2016), they were able to conduct a fast-marching algorithm to compute the shortest path to all districts within mainland India. See Tewari et al., 2016, and Alder et al., 2016.

43 It is important to note that in our calculations of market access we only used those portions of the highway network that was actually built between 1996 and 2011, including portions of the Golden Quadrilateral and the North–South and East–West Corridors that were actually in the maps we digitised. We show the GQ, NS and EW Corridors here only for representation.

44 NCE, 2015; World Bank, 2009; Ellis and Roberts, 2015.

45 See Alder et al., 2016.

46 See Alder et al., 2016, for details.

47 Litman, T., 2014.

48 De Duren and Compeán, 2015.

49 OECD, 2015.

50 Ministry of Statistics, 2014; MRTH, 2014; Shirgaokar, 2012.

51 Litman et al., forthcoming.

52 The GDP scenario used here implies that India's real per capita GDP increases by 5.4% a year in 2016-30, which would roughly match the exceptionally rapid 5.6% historical pace in 2000-15. Thereafter real per capita growth runs at a lower but still rapid 4.4% per year in 2031-50. In this scenario India's real per capita GDP in 2050 would be 5 times higher than in 2015.

53 For a survey of the literature, see Todd Litman (2014), *Analysis of Public Policies That Unintentionally Encourage and Subsidize Urban Sprawl*, Victoria Transport Policy Institute (www.vtpi.org), commissioned by LSE Cities (www.lsecities.net), for the Global Commission on the Economy and Climate, the New Climate Economy; at http://bit.ly/1EvGtIN.

54 WEF, 2015

55 NCE calculations

56 This assumes that urban household incomes per capita grow at a rate of 8% per annum to 2030, 6.5% thereafter to 2050, providing for a growing percentage of urban GDP within overall GDP that typically occurs in fast growing economies over time.

57 For a survey of the literature, see Litman, 2014. Per capita roadway supply increased markedly between compact cities and low density cities. Where residents have to commute dozens of kilometers from outlying suburbs across urban areas to distant worksites, this requires particularly costly, grade-separated, high-speed urban freeways. Although road and parking unit construction costs tend to be higher in denser areas due to higher land costs, there are also efficiencies of density, particularly for parking; in sprawled areas each destination requires its own on-site parking spaces, but in urban areas parking spaces can be shared, so a parking space can serve office workers during the day, shoppers during the evening and weekends, and residents at night. As a result, suburban areas tend to have 4-8 parking spaces per vehicle, compared with about 2 in compact urban neighborhoods.

58 ET Bureau, 2015

59 The work draws on projections from the Ministry of Road Transport and Highways (Government of India, 2012) and the IEA to 2040, extrapolating at a slower rate of growth to 2050.

60 MRTH, 2014.

61 Bhalla et al., 2011; WHO, 2014a.

62 See: Sen et al., 2010.

63 Mehaffy, 2015.

64 Wang et al., 2015.

65 Here we assume ₹6.0-₹8.0 per vehicle-kilometer for cars and and ₹4.0-₹5.0 per vehicle-kilometer for two-wheelers for traffic congestion, air and noise pollution costs, based on conservative values grounded in Indian and international studies and assuming 0.3 Passenger Car Equivalents (PCEs) where needed.

66 Global Burden of Disease Study 2015 Results. See IHME (2016).

67 Particulate matter (PM), a mix of tiny solid and liquid particles suspended in the air, affects more people than any other air pollutant. The most health-damaging particles have a diameter of under 2.5 microns and are referred to as PM2.5. See: WHO, 2014b.

68 WHO, 2016.

69 Apte et al., 2011.

70 Apte, 2014.

71 NCE, 2014. Estimates of the value of lives lost due to air pollution are scaled by GDP to provide a point of reference and a basis for comparison across countries. They should not be interpreted to mean that GDP in a given year would increase by the estimated amount if air pollution were eliminated. For one thing Value of Statistical Life (VSL) is inherently a multi-year concept.

72 World Bank, World Development Indicators on-line for relevant years.

73 Tewari et al., 2015.

74 Ramakrishnan, 2010.

75 The *barrier effect* (also called *severance*) refers to delays, discomfort, and reduced mobility that vehicle traffic imposes on active modes (pedestrians and cyclists), equivalent to congestion costs imposed on other motor vehicles.

76 World Bank, 2016a.

77 Glaeser, 2011.

78 Jones Lang LaSalle, 2015.

79 Ives, 2014.

80 Chakrabartty and Gupta, 2015.

81 Mahendra and Mulukutla, 2015.

82 The discussion in this section draws on the background paper, ICRIER and WRI, 2016 (forthcoming).

83 Sources for this box include: Rao and Bird, 2010; Mohanty et al., 2007; Tewari et. al., 2015; ACCCRN India, 2013; New Climate Economy, 2015; Ahmad, 2016.

84 Rao and Bird, 2010.

85 Municipal boundaries expanded in Surat in 2006 and in Bangalore in 2007.

86 Savani and Bhatt, 2016.

87 KERC 2015

88 Habitat III, 2016.

89 HPEC, 2011.

90 McKinsey Global Institute, 2010.

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978-0-9906845-9-6