21 Carbon Emissions, Climate Change, and Impacts in India's Cities

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Introduction

The Intergovernmental Panel on Climate Change concluded in 2007 that warming of the climate system is now 'unequivocal', based on observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea levels (IPCC 2007). According to the National Oceanic and Atmospheric Administration's (NOAA's) *State of the Climate Report 2007* and the National Aeronautics and Space Administration's (NASA) *Surface Temperature Analysis 2007*, the eight warmest years on record since 1850 have all occurred since 1998, with the warmest year being 2005.

According to the IPCC (2007):

- The warming trend is seen in both daily maximum and minimum temperatures, with minimum temperatures increasing at a faster rate than the maximum temperatures.
- Land areas have tended to warm faster than ocean areas and the winter months have warmed faster than summer months.

One of the expected impacts of climate change on South Asia is a general increase in both the mean minimum and mean maximum temperatures by two to four degrees centigrade (Sharma et al. 2006). A 10 to 15 per cent increase in monsoon precipitation in many regions, a simultaneous precipitation decline of 5 to 25 per cent in semi-arid and drought-prone central India, and a sharp decline in winter rainfall in northern India is also projected (Ramesh and Yadava 2005). In this chapter, we focus on carbon emissions, climate change, and their economic and ecological impacts on India's cities.

Most studies to date focus on coastal areas, given their vulnerability to climate change (Hunt and Watkiss 2007). Many coastal cities are in fact threatened by swelling sea levels and ironically, it is estimated that by 2015, 21 of the world's megacities will be in coastal locations (Kreimer et al. 2003), thus intensifying the threat perception. However, there is a near absence of studies on inland cities. Further, most of the studies so far are qualitative rather than being based on empirical analysis; and this is no doubt due to the paucity of data. Finally, most studies confine themselves to a single issue arising out of climate change, most commonly sea-level rise, whereas the impact of climate change is a multi-dimensional phenomenon.

In this chapter, we first discuss how urban areas can become growth centres for an economy. Following this, we discuss the relationship between urbanization and climate change. We also provide a description of the carbon footprint of Indian cities, based on the scant evidence thus far. The reverse impact of climate change on the ecology and the economy of a city is the next level of discussion here.

Based on the above, we make a case for developing urban infrastructure to enable low carbon urban growth and summarize some of the mitigating strategies cities in India have been adopting, including initiatives that are part of the Asian Cities Climate Change Resilience Network (ACCCRN). Finally we summarize and end the chapter with concluding remarks.

Urban Areas as Engines of Growth

The year 2007 has been described as the tipping point in human history with half the world's population living in

urban areas for the first time. Urbanization in India has been closely following this global trend. According to the 2001 Census, India had a population of 1,027 million with approximately 28 per cent (or 285 million people) living in urban areas. This share of urban population is predicted to increase to about 40 per cent by 2021. According to international experience, urbanization picks up pace after the proportion of urban population reaches 25 per cent. In India, urban population at 29 per cent indicates that this is a statistic that may be expected to increase at an alarming rate in the near future.

Cities are always the hubs of economic growth and urban areas contribute close to half of India's gross domestic product today. It is estimated that by 2011, urban areas would contribute about 65 per cent of the GDP of India (Ministry of Urban Development 2006). Evidence at India's sub-national level shows that more urbanized states (such as Maharashtra, Karnataka, and Gujarat) recorded more than 100 per cent growth in their per capita net state domestic product (at current prices) during 1993–4 to 2002–3.

However, this higher productivity seen in urban areas is contingent upon the availability of quality infrastructure services. Urban economic activities are dependent on infrastructure, such as power, telecom, roads, water supply, and mass transportation, coupled with civic infrastructure, such as sanitation and solid waste management. Adequate infrastructure is not only necessary for increasing productivity, but also for raising the general quality of living. So, the overall growth of urban GDP cannot be separated from the delivery of public services or strategies to improve them.

Economic growth often implies the conversion of rural land for urban uses (residential, commercial, and industrial) as regional economies undergo a transition from an agrarian base to urban-based industry and services. Rural development cannot be a substitute for healthy urbanization. This process occurs in urban areas of developing countries undergoing structural economic changes. Presumably, in the initial phases, when urbanization rates and per capita income increase at roughly the same rates, productivity increases reflect shifting resources from rural activities with lower productivity gains. In later phases, rapid productivity gains reflect mainly improvements within industries and services (Romer 1986; Lucas 1988; and Quigley 1998).

At a global scale, changes in information, production, and transportation technologies have had profound effects on urbanization. To the extent that these changes substitute for geographic proximity, they have vastly reduced the need for face-to-face communications (Gasper and Glaeser 1998; Sridhar and Sridhar 2003) and have greatly increased the mobility of goods, services, labour, technology, and capital throughout the world. This marked increase in the pace of globalization has spurred rapid economic growth in many developing countries.

Annez and Buckley (2009) confirm a strong link between rapid growth and a structural shift from agriculture to urban activities (manufacturing and services) in the sectoral composition of GDP growth across countries. Across the developing world, the urban sector drives growth: according to the National Research Council (2003), 86 per cent of the growth value-added in developing countries' GDP between 1980 and 1998 came from services and manufacturing. A large body of literature explains why industry and services locate in cities. Duranton (2009), Quigley (2009), and Venables (2009) discuss the role of agglomeration economies and the functioning of labour markets in cities, highlighting both productivity impacts and linkages with the growth process. Lucas (2004 and 2007) explicitly considers how urbanization affects the growth process through the enhanced flow of ideas and knowledge due to agglomeration in cities. As Quigley (2009) points out, the fundamental question in urban economics is why people voluntarily live in close proximity to one another when there are costs to competing for land. The simple answer has two parts: efficiency gains and consumption benefits.

In developing countries, poor transportation and communication infrastructure tend to magnify the advantages of cities over the countryside. The importance of the informal sector may distinguish cities in developing countries from those in developed countries. In fact, the little evidence available on agglomeration economies in the informal sector suggests that it also benefits from agglomeration and that informal operators generally have a positive impact on their formal sector counterparts through supply of inputs.

We thus have plenty of evidence to support that urban areas are growth centres for any economy in general and India's economy in particular. Further, we discuss the role of cities in climate change and the impacts of the carbon footprint[1] on the ecology and economy of cities, following which we examine the evidence regarding the carbon footprint of Indian cities in the context of their contribution to economic growth.

[1] A carbon footprint is defined as the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tonnes of carbon dioxide (CO_2).

Impact of Cities on Climate Change

Given that half of the world's population started to live in cities by 2007, it is no exaggeration to say that the battle against climate change will be won or lost in our cities. To the extent that cities promote use of cars, urban sprawl is also often associated with climate change. That is, the wider the sprawl, the greater the use of cars and carbon emissions. Energy consumed in heating and lighting of residential and commercial buildings generates nearly a quarter of GHGs globally and transport contributes 13.5 per cent, of which 10 per cent is attributed to road transport (McCarney 2009). We can safely assume that a sizeable portion of this volume of emissions is generated in cities. According to the Clinton Foundation, large cities are responsible for about 75 per cent of the GHGs released into our atmosphere.[2]

In this context, it is useful to study how Indian cities have contributed to climate change through carbon emissions. The primary impact of carbon emissions on cities is through the modes of transport used. In a simple analytical framework, Grazi and Waisman (2009) account for external (costs) benefits of land use and transport that reflect the (dis) economies arising from agglomeration. The spatial disaggregation of national into city economies is a major outcome of this research that goes beyond the scope of climate change analysis.

There is very little empirical information available on carbon emissions in Indian cities. Box 21.1 discusses a South Asian regional initiative to develop an overall regional approach and consensus for addressing urban climate change. As reported in the box, under the project, the International Council of Local Environmental Initiatives (ICLEI), South Asia, associated with 54 local governments in the South Asian region (including 41 cities from India) to collect city energy consumption and related carbon emissions inventory data of the participating cities.

Based on a cursory examination of the per capita carbon emissions across metropolitan and non-metropolitan cities (see Table 21.1), we find that the average per capita carbon emissions are higher in the metropolitan cities of India (being 1.19 tonnes per capita as compared to only 0.90 tonnes per capita in the non-metropolitan cities) as we would expect, and the national average is 0.93 tonnes per capita. This is because larger cities have more industries and other polluting activities such as emissions from public and private transport. However, the corporation level emissions as a percentage of city-level emissions are much higher in the non-metropolitan areas than in the metropolitan areas. Corporation-level emissions include those emanating from street lighting, water supply and sewage systems, transportation, building, and other facilities. While this finding is interesting, this is plausible because smaller city corporations lack the adequate technology to minimize their carbon emissions in the provision of various public services such as water supply, sewerage, street lighting, and transportation.

The carbon emissions in Indian cities are also lower than what we observe internationally across a group of selected cities (see Figure 21.3). It should be mentioned that among these cities, apart from Sao Paulo and Rio de Janeiro in Brazil and Shanghai in China, which can be compared to Mumbai, other cities are not comparable directly with Indian cities in terms of their landscape or level of development.

Having said this, internationally, Palo Alto, California, USA, leads the pack with emissions amounting to nearly 12 tonnes per capita, followed by Toronto, Canada (at 9.6 tonnes per capita). Only seven of the 41 Indian cities studied by ICLEI have per capita emissions greater than Sao Paulo's 1.5 tonnes per capita.[3]

However, some caveats of the data from the ICLEI study should be noted. Their data do not include major cities such as Delhi and Mumbai, which might be contributing significantly to carbon emissions. However, the city corporations in these cities may also be contributing less through their provision of urban services such as water supply, sewerage, street lighting, and sanitation, if we were to assume that they have access to better technology than some of the smaller cities.

Impact of Climate Change on Cities

Not only do cities and urbanization impact climate change, but also, the question of whether climate change has impact on cities (the meticulous reader has to note that climate change may also have impacts not only on cities, but also on rural areas through their effects on increased or decreased rainfall which have impacts on agricultural output). Since cities have a high concentration

[2] On the other hand, cities are viewed as playing a positive role in mitigating the negative impacts of climate change. The OECD is actively working with governments to highlight the role of cities to deliver cost-effective policy responses to climate change. An analysis of emissions inventories (Dodman 2009) shows that—in most cases—per capita emissions from cities are lower than the average for the countries in which they are located. Similarly Satterthwaite (2008) suggests that the contribution of cities to global anthropogenic greenhouse gas emissions is often overstated.

[3] These are Faridabad (Haryana), Jaipur, Kolkata, Ranchi, Gurgaon, Vishakapatnam, and Jamshedpur. See Table 21.1.

of population density and economic activity, they are vulnerable to climate change. India's cities are characterized by high density of population, housing stock, and poor infrastructure, which make them all the more vulnerable to climate change. Given that the most valued infrastructure is usually located in cities, the economic and social costs of climate change will be much higher in cities. For example, cities house valuable communications infrastructure as they do physical infrastructure such as buildings, roads, bridges, and flyovers. Hence, any climate change impacts in the form of damage will be quite expensive. For instance, Kumar, Jawale, and Tandon (2008) estimate that the economic damage (this includes only building-foundation damages for the period till 2050 due to sea-level rise) to Mumbai, as a result of climate change, could amount to Rs 1,501,725 crores.[4]

Climate change impacts the physical assets used within cities for economic production, the costs of raw materials and inputs to economic production, the subsequent costs to businesses, and thus output and competitiveness. For instance, at India's sub-national level, an annual Gross State Domestic Product (GSDP) compression of about two per cent has been estimated for Gujarat, of which drought makes up 57 per cent, cyclone and storm surge

Box 21.1
The International Council of Local Environmental Initiatives

The International Council of Local Environmental Initiatives (ICLEI)–South Asia recently completed a project on the 'Energy and Carbon Emissions Profiles of 54 South Asian Cities'. The study gathered data from the engineering and administrative departments of the participating Urban Local Bodies (ULBs) to assess the energy consumption by them for services rendered to the citizens across the city.

This report by ICLEI–South Asia provides an inventory of the energy status and carbon emissions of 54 South Asian cities, including 41 cities from India, based on the city energy consumption and related carbon emissions inventory data. Analysis of the collected information was performed by ICLEI using the Harmonized Emissions Analysis Tool (HEAT, http://heat.iclei.org/), a unique and customized emissions calculation tool/software for ULBs/local governments. The final result was arrived at through a rigorous and structured feedback process by engaging engineering and administrative staff, followed by the involvement of municipal leaders, relevant institutions, and ministries.

Table 21.1 summarizes the per capita carbon emissions in the selected Indian cities, extracted from the ICLEI report. Further, in the report, for every city, energy consumption by category is given—residential, commercial, industrial, transportation, waste, and others. In addition to per capita carbon emissions, the report has the entire (absolute) consumption of electricity of 2007–08 for every city. Every city corporation's emission is given in detail by sector. For every selected city, the city level and corporation level carbon emission patterns are summarized with the help of pie charts.

Figure 21.1 summarizes the emissions by the sector in the selected Indian cities. It shows that the majority of the emissions are industrial in nature, followed by residential emissions (at 28 per cent) and then transportation (which contributes 24 per cent of all emissions).

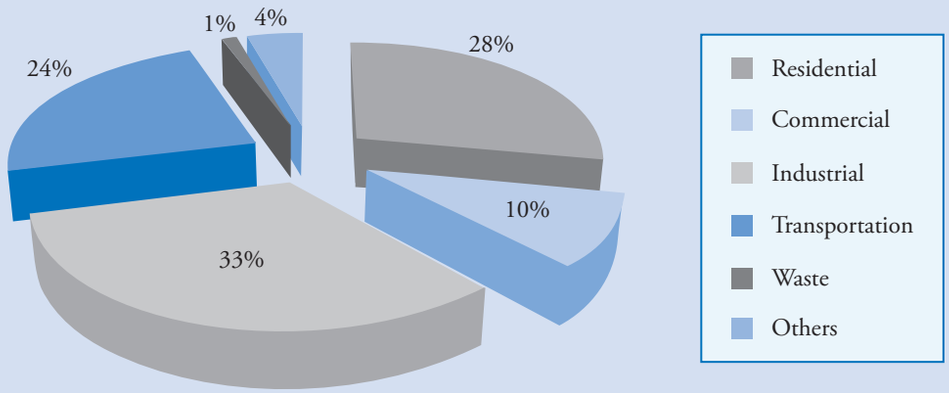

Figure 21.1 Sector-wise Emissions in the Selected Indian Cities, 2007–8

(contd.)

[4] They also estimate damages of climate change in Mumbai due to dislocation caused by flooding (Rs 407.6 crores), material damage to low-lying areas due to extreme events (Rs 6,413 crores), mortality costs due to extreme events of flooding (Rs 3,050 crores), disability-adjusted life years (DALYs) lost due to diseases like malaria, diarrhoea, and leptospirosis (Rs 3,153 crores), and tourism losses in the form of fewer tourists visiting Mumbai (Rs 1,963,500 crores).

Box 21.1 *(contd.)*

Figure 21.2 summarizes carbon emissions (in absolute terms) in the selected Indian cities. In absolute terms, the highest emissions are in Kolkata, followed by Vishakapatnam and Agra.

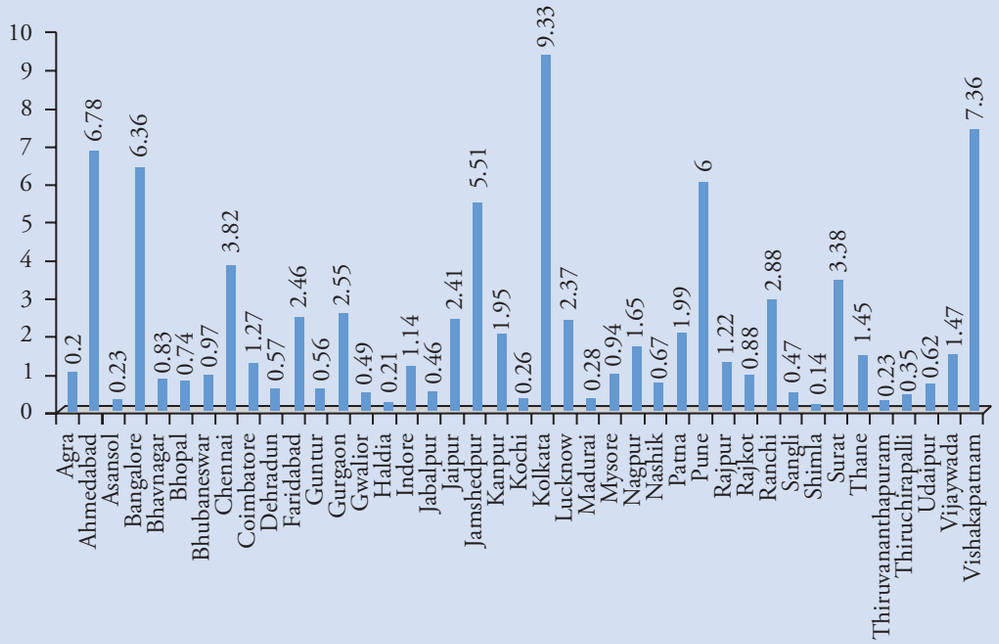

Figure 21.2 Carbon Emissions in 41 Indian Cities, 2007–8 (in Million Tonnes)

Based on this data, cities developed plans to combat climate change at the local level. These actions included efficient water usage, effective solid waste management, generating clean energy, and to thereby decrease air pollution. A survey was also carried out to gather feedback and comments of the cities on the analyses, which were then incorporated into the final report.

The following action plans were suggested and discussed with cities (through sample surveys) to reduce carbon emissions in their cities in the following broad areas:

- Street lighting EE programme which has high potential of energy savings (20–5 per cent).
- Building and facilities energy efficiency programme.
- Pumping system-efficient projects for water supply and drainage pumping stations.
- Residential/commercial and industrial sectors.
- Transportation system.
- Public awareness.
- Others—Integration of renewable energy (RE) and EE measures in public places.

Source: Energy and Carbon Emissions Profiles of 54 South Asian Cities, ICLEI—South Asia.

12 per cent, and inland flooding five per cent over a 100–year time horizon (Revi 2008). A recent report using data collected over 193 years shows that since the 1960s, there has been a dip in India's annual rainfall. For instance, in the plains of Kerala, peak rainfall declined from at least 3,700 mm received in the 1920s and 1930s to around 2,800 mm in the 1960s, a fall of 24 per cent. The Kerala State Planning Board's Compendium of Environment Statistics finds that as of 2003, the state's annual rainfall fell nearly 17 per cent short of the normal rainfall from 1990 to 2003. In the plains of Punjab, there is a similar fall, from 1,100 mm in the early years of the twentieth century to around 687 mm, now registering a decrease of 37.5 percent.[5] Part of this could probably be attributed to global warming.

Cities in developing countries face more risks of economic and social catastrophes due to their relative lack of resources to adapt and mitigate. Mukhopadhyay and

[5] http://www.livemint.com/2008/08/17233753/India8217s-fluctuating-rain.html

Table 21.1 Carbon Emissions in India's Cities

City	*CO_2 emission Per Capita (tonnes)*	*Corporation level emissions as % of City-level Emissions*
Asansol	0.25	3.63
Thiruvananthapuram	0.25	22.50
Jabalpur	0.30	7.80
Bhopal	0.31	8.83
Madurai	0.31	8.64
Tiruchirapalli	0.33	6.11
Nashik	0.34	8.94
Gwalior	0.37	6.09
Kochi	0.40	7.53
Indore	0.41	2.28
Kanpur	0.45	3.20
Sangli	0.52	3.40
Agra	0.64	10.29
Lucknow	0.64	20.77
Shimla	0.66	12.50
Nagpur	0.67	7.80
Rajkot	0.67	2.80
Dehradun	0.71	7.14
Guntur	0.71	1.72
Mysore	0.72	6.80
Udaipur	0.76	6.33
Bengaluru	0.82	4.14
Patna	0.83	7.10
Bhubaneshwar	0.84	1.17
Vijayawada	0.90	1.20
Chennai	0.91	2.68
Surat	0.91	3.48
Haldia	0.95	NA
Bhavnagar	1.11	2.39
Thane	1.15	2.88
Ahmedabad	1.20	2.91
Pune	1.31	2.16
Raipur	1.32	1.85
Coimbatore	1.37	0.67
Faridabad	1.58	2.06
Jaipur	1.63	4.22
Kolkata	1.83	2.15
Ranchi	1.97	0.06
Gurgaon	2.13	0.27
Vishakapatnam	2.25	0.32
Jamshedpur	2.76	NA
Average, all	0.93	5.30
Average, Metros	1.19	10.39
Average, Non-metros	0.90	4.72

Source: ICLEI-South Asia, Energy and Carbon Emissions Profiles of 54 South Asian Cities, 2009.

Revi (2009) highlight the multiple ways in which climate change can impact Indian urban residents through loss of livelihood opportunities (including housing and assets) and income, loss in terms of health or ability to work, of community and informal social nets due to forced migration, reduced resilience to future shocks, reduced affordability and access to public services, and greater vulnerability to unsustainable debt exposure, that could be necessitated in times of crisis. There is nothing uniquely urban about these phenomena and these channels can work equally in rural areas. Both authors also mention second-order impacts of climate change on Indian cities as occurring via migration, since climate change can accelerate the pace of rural–urban migration, driven by increases in extreme events, greater monsoon variability, drought, flooding, and resource conflict, as well as loss of both livelihood opportunities and informal social nets.

In the context of cities, several climate-induced challenges also remain neglected. In urban areas, inequities will become more apparent as certain populations are less able to relocate away from highly vulnerable locations, especially due to sea-level rise and enhanced flooding in cities by the coasts, leading to changes in the spatial distribution and density of both formal and informal settlements. Degradation of building and infrastructure materials is also projected to occur. As warmer temperatures extend into higher latitudes, diseases that have long been considered eradicated may re-emerge; and new diseases may also be experienced. The health ramifications could be serious. The gap between water supply and demand is also projected to increase as drought-affected areas expand and the episodes of floods intensify.

Overall, climate change and increased climate variability will alter the environmental baseline of urban locales, such as the temperature regimes and precipitation patterns. Shifts in climate and increased frequency of extreme events have direct impacts on water availability and quality, flooding and drought periodicity, and water demand amongst a host of conditions. These dynamic changes will affect system processes within multiple sectors in cities interactively, increasing the uncertainty under which urban managers and decisionmakers must operate (Mehrotra et al. 2009).

Economic costs of climate change in cities need to 'bracket' for uncertainty and assess both intra- and inter-sectoral and systemic risks to address direct and indirect economic impacts. Risk frameworks tend to fall broadly into three categories or groups. The first group stems from the work of climate scientists associated with the IPCC and focuses primarily on climate hazards—variances in mean and extreme climate parameters, collectively referred to as

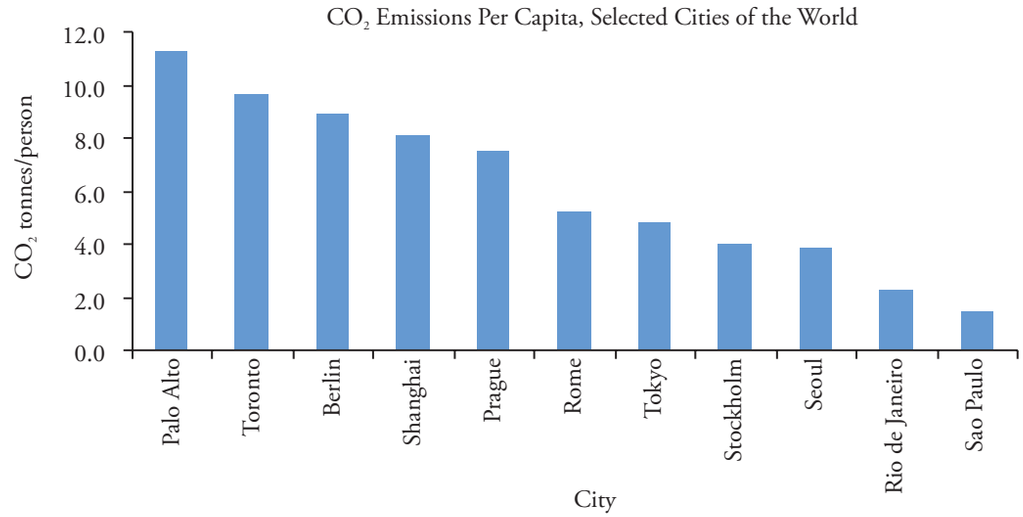

Figure 21.3 Carbon Emissions in Cities Around the World

Source: McCarney (2009).

climate hazards. The second group emerges from the work of planners and policymakers, such as those associated with UN Habitat's *The Cities in Climate Change Initiative* (CCCI) or the World Bank. The World Bank's East Asia Unit's recent analysis summarized in the *Climate Resilient Cities: A Primer on Reducing Vulnerabilities to Disasters*, focuses on vulnerabilities—essentially city characteristics that determine the susceptibility a city has to climate change. The third group of risk frameworks focuses on economic analysis of climate impacts, such as the OECD reports.

Much of the risk associated with climate change in cities is concentrated among low-income households, as described by Aromar Revi for India and Patricia Romero-Lankao for Latin America.[6] The cities most at risk are those which:

- lack the ability to avoid the direct or indirect impacts because of their location—on the coast, by rivers, or where cyclones or hurricanes are common. For example, as Mehrotra et al. (2009) point out, each year New York City is susceptible to mid-latitude cyclones, which peak from November to April. These storms contribute greatly to coastal erosion of vital wetlands that help defend areas of the city from coastal flooding. Tropical cyclones (hurricanes) also have the potential to reach New York City usually during the months of August to September. There is some indication that intense hurricanes will occur more frequently in the future, but this, as they point out, is an area of active scientific research.
- are likely to be most affected by the impacts because of their physical form—poor-quality buildings and lack of water supply and storm drainage infrastructure. Nothing can explain this better than the floods that occurred in Mumbai on 26 July 2005, aggravated by the poor and inadequate drainage system of Mumbai, which was not capable of carrying even half the amount of water per hour on the day the disaster took place in the city. Further, the mangroves that existed along the banks of the Mithi River and Mahim Creek have been destroyed over time to make way for the construction of new buildings.
- are least able to cope with the impacts due to a lack of local government capacity and funding to rebuild or repair damage, restore services, and support households to rebuild homes and livelihoods. The example here is of Mumbai again, which experienced floods in 2005. One of the factors that had an adverse impact on the floods was the rapid growth and development of the northern suburbs of the city which lacked proper control and planning on the part of the city's municipal authorities.

The urban populations most at risk are those who are:

- least able to avoid the direct or indirect impacts, because, for example, they live in poor-quality homes

[6] http://www.id21.org/insights/insights71/art04.html

and in areas with inadequate drainage systems, and are unable to move or change jobs if climate change threatens their livelihoods.
- most vulnerable to the impacts, such as infants and elderly people who are less able to cope with heat waves or unable to flee quickly when a disaster is imminent.
- least able to cope with illness, injury, or premature death; or loss of income, livelihood, or property.

Mitigating Strategies in Urban India

Many cities have the potential, and indeed are becoming, key actors in global mitigation efforts, as will be discussed in Chapter 23 in this Report. McCarney summarizes five sectors which can help mitigate the negative effects of climate change—energy supply, transport, buildings, industry, and waste. The Vienna City Council adopted the city's Climate Protection Programme as a framework for its Eco-Business plan[7] and as a result, the city reduced its solid waste output by 109,300 tonnes; toxic solid wastes by 1,325 tonnes, and carbon dioxide emissions by 42,765 tonnes.

This climate protection programme, described in detail in Box 21.2, saved a total of 138.7 million Kwh of energy and 1, 325,000 cubic metres of drinking water. The Eco-Business plan is also now being implemented in Chennai, India, and Athens, Greece.

In India, the ACCCRN aims to catalyze attention, funding, and action on building climate change resilience for the poor and vulnerable by creating robust models and methodologies for assessing and addressing risks through active engagement and analysis of cities. Gorakhpur, Surat, and Indore have taken up pilot projects for adaptation and mitigation of the impact of climate change in their cities. Indore, Madhya Pradesh, which has been affected by climate change in the form of rising temperatures and increasing incidence of non-monsoon drought, has identified potential pilot activities such as underground water storage and a volunteer-based water supply availability tracking system.

At the sub-national level, various pollution control boards and several city corporations have taken the lead in reducing carbon emissions. For example, various carbon emission-reducing processes such as the use of methane gas emanated from 180 million litres per day (MLD) sewerage plant, the Gyaspur landfill site and the process of burning waste-beads to produce electricity are gaining carbon credits in the Ahmedabad Municipal Corporation (AMC). Technologies involved in cutting electricity consumption in street lights, use of LED (light emitting diodes) lighting source, the BRTS mass transit system, green technologies and e-governance are part of this process. There are several private firms helping the AMC trade in carbon credits such as United Phosphorus, Creative Technologies, and Excel Technologies. These bodies would trade carbon credits generated out of using 1,900 tonnes of waste for green processes. AMC has agreements with the three companies with a 60 to 40 per cent profit-sharing arrangement for carbon credit trade. Gujarat Urban Development Corporation (GUDC) is the main agency for the carbon credit trade in the state of Gujarat.[8]

The ICLEI project (see Box 21.1) aims to illustrate local criteria pollutants and CO_2 emissions from India's growing transport sector using available data, and to provide policies and measures that will prevent future undesirable consequences of motorization. ICLEI has also initiated a programme on carbon emission reduction through city-level local action plans by integrating RE and EE measures into city activities funded under the Climate Change and Energy (CCE) programme of the British High Commission by UK's Foreign and Commonwealth Office's Global Opportunity Fund (GOF). The project is aimed at promoting greater use of renewable energy and more efficient use of energy to help address climate change and ensure energy security and a low carbon future for Indian cities.

So it appears that while urbanization and climate change are inextricably related, some attempts are being made by Indian cities to cope with this phenomenon. However, in order to do this, municipal finances are a constraint. In this volume, the chapter by Annez and Zuelgaray examines the impact of high-cost carbon on municipalities' finance, and concludes that raising energy prices will create an adverse fiscal shock for local governments, the magnitude of which will depend on the structure of spending.

Conclusions

This chapter has initiated discussing issues as to how urban areas can become growth centres for an economy. Following this, the relationship between urbanization and

[7] Examples of some activities included under a typical eco-business plan might be to rebuild and renovate buildings with green materials to reduce energy usage, reduce the energy consumption of appliances as well as heating, lighting, and cooling systems with the use of Light Emitting Diodes (LEDs) and replacement of incandescent lights with compact fluorescent lamps (CFLs).

[8] http://timesofindia.indiatimes.com/city/ahmedabad/City-has-lowest-carbon-emission-Study/articleshow/5121470.cms, retrieved 10 February 2010.

Box 21.2
KLiP—Vienna's Climate Protection Programme

Vienna's climate protection programme known as Klip Vienna (KlipI), was enacted in 1999 by the city council and is valid until 2010. KliP's goal of preventing an increase in annual emissions of CO_2 equivalents by 2.6 million tonnes by 2010 was achieved in 2006. So far, the city has successfully avoided an annual emission of 3.1 million tonnes of CO_2 equivalent. Now, Vienna's climate goal is a 21 per cent reduction in per capita greenhouse gas emissions by the year 2020 from the base year of 1990. This is achieved through the measures of KliP II.

The update of the 1999 KliP I consists of 37 sets of measures with a total of 385 individual measures in the following five fields of action:

- Energy production.
- Use of energy.
- Mobility and city structure.
- Procurement, waste management, agriculture and forestry, and nature conservation.
- Public relations.

Actions in the context of energy production are primarily supply-related projects that reduce CO_2 emissions produced by power generation and district heating and cooling that Vienna can influence directly. With respect to the use of energy, the focus is to encourage end-consumers to use energy in the most efficient way, particularly with regard to measures taken for energy efficiency in buildings. This comprises all aspects of energy use that are necessary for constructing and maintaining buildings. In addition, there are also measures for public lighting, equipment using combustion engines, and electric devices. Actions with respect to mobility and town structure, relate to the objective of reducing, both directly and indirectly, greenhouse gas emissions generated by transport. Measures include promotion of bicycling, walking, public transport, and car pooling. In addition, this demand-orientated strategy has been supplemented with restrictions on using modes of transportation that cause environmental and climactic damage. The Viennese population has the opportunity to better combine various types of transportation to best fit their mobility needs. Finally, public relations guidelines for the entire climate protection programme have been developed. The measures in this field aim to inform the Viennese population and other relevant stakeholders. They endeavour to induce climate-friendly behaviour by raising awareness.

The implementation of the planned measures will allow Vienna to prevent an additional annual emission of 1.4 million tonnes of greenhouse gases in the period from 2009–20.

Climate Protection in Vienna: Precise Measures with Precise Targets

Increasing the share of district heating to 50 per cent: This goal will be reached by the continuous development of 'Wien Energie District Heating' via the expansion of the heating network, increasing energy efficiency, and the use of renewable energy.

Further promotion of thermal rehabilitation of residential buildings: There is great potential in the field of thermal rehabilitation of residential buildings, especially concerning the subsidy programme Thewosan. The subsidy guidelines will be adapted and the statutory provisions (for example, building code) will also be changed, further tightening prescriptive limits for new buildings and for the thermal rehabilitation of buildings.

Expansion of public transportation, reduction of passenger car traffic and promotion of public transport, bicycles, and walking. In future, particular attention will be paid to the use of bicycles. Efforts will also be made to make walking more attractive. This will provide a vital contribution in reducing greenhouse gas emissions. In addition, one may also expect that greenhouse gas emissions produced by Viennese passenger car traffic will significantly decrease due to advances in automotive technology and accompanying measures.

More than doubling of the amount of final energy produced by renewables compared to 1990: All the different options available to the City of Vienna and its municipal enterprises shall be utilized to make use of the various kinds of renewables within the urban area as well as within.

Creation of a plan for the secure supply of energy: Energy efficiency and renewable energy sources will be focus areas by adopting clearly defined measures for reducing energy demand by improving final energy efficiency and increasing the use of renewable energy.

The current organizational and operational structure in the field of climate protection in Vienna will be retained to reach the targets in the best manner possible.

Source: http://www.wien.gv.at/english/environment/klip/

climate change has also been discussed here. In this, we first highlighted how cities contribute to climate change and provided a description of the carbon footprint of Indian cities. Also in discussion were issues such as the reverse impact of climate change on the ecology and the economy of a city. Based on the above, we make a case for developing urban infrastructure to enable low carbon urban growth and summarize some of the mitigating strategies cities in India have been adopting to adapt to climate change.

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