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Urban Challenges in India and the Mission for a Sustainable Habitat

Abstract | This paper presents urbanization challenges in India and initiatives taken to address them. Urbanization in India is characterized by skewed urban growth between cities by large population influx creating distinct variation in core and periphery of cities in terms of urban form and services. Key challenges include growth of slums, inadequate management of solid waste, decrease in per capita water availability and unreliable water quality, inadequate sewage coverage and deteriorating ambient air. Although, these issues are not new or specific for India, what is new are the drivers and pressures behind these problems. The paper illustrates the challenges of Indian urbanization in the light of resource inefficiency, resistance to adopt upcoming technologies that do not have direct financial benefits, weak enforcement of laws, and inadequacy in regulatory framework. It also presents instances of active participation of non–formal and formal sectors in addressing sustainability challenges. There is also a recognition of the fact that city governments are faced with multiple sustainability agendas of climate adaptation. This presents a decisional challenge for planners and city administrations. Benefits incidental to a particular policy goal can help drive the implementation of the policy and sustain it in the long term, but only when the inherent risk trade–offs, if present, can be managed.

Keywords | urban growth – India – climatic change – migrations – pollution – mitigation of climate change – sustainable growth

Urbanization in India

THIS IS AN URBAN CENTURY and India is also urbanizing at an enhanced pace in recent decades (Table 1). Hence, it presents a unique opportunity to plan, develop and build a new India which is ecologically and economically sustainable. The history of urbanization in India is quite old as towns and urban places flourished in the Indus Valley around 2000 B.C. (Vesilund 1982). During ancient and medieval periods, the urban centers were associated with the

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Table 1. Growth of urban population.

Year	World urban population (billions)[1]	Urban: Rural (world)	India Urban Population (%)[2]
1950	0.74 (29.44%)	1 : 2.34	17.2
1960	1.02 (33.55%)	1 : 1.98	17.9
1970	1.35 (36.58%)	1 : 1.73	19.9
1980	1.75 (39.37%)	1 : 1.54	23.3
1990	2.28 (42.99%)	1 : 1.32	25.7
2000	2.85 (46.68%)	1 : 1.14	27.8
2010	3.56 (51.6%)	1 : 0.94	31.1[3]

Sources: [1] United Nations, Department of Economic and Social Affairs, Population Division 2012.
[2] National Institute of Urban Affairs (NIUA) 2011. Figure given are for the year 1951, 1961... respectively.
[3] Registrar General and Census Commissioner 2011.

Table 2. Urbanization trends in India.

Decade	Theme	Urban percentage
1901–1911	Famine and plague	10.84 a 10.29[1]
1911–1921	Influenza epidemic	10.29 a 11.17[1]
1921–1931	Agricultural depression	11.17 a 11.99[1]
1931–1941	War	11.99 a 13.85[1]
1941–1951	Partition of the Sub-continent	13.85 a 17.29[1]
1951-1961	Planned development	17.29 to 17.97[1]
1961-1971	Emergence of new urbanization in backward areas and concentrated urban development near big cities	17.97 to 19.90[1]
1971-1981	Decentralized urban growth	19.90 to 23.31[1]
1981-1991	Decelerated rural-urban migration and declining rate of natural increase	23.31 to 25.70[1]
1991-2001	Decentralized urban planning and development	25.70 to 27.82[2]
2001-2011	Sustainable habitat	27.82 to 31.1[3]

Sources: [1] National Institute of Urban Affairs (NIUA) 2011.
[2] Registrar General and Census Commissioner 2001.
[3] Registrar General and Census Commissioner 2011.

Table 3. Distribution of urban population by city class.

Class Size	Population range	Number of cities	Total Urban population (%)	Urban population (million)
Mega cities	>10 million	3	12.9	48.8
Million plus cities	1–10 millions	50	29.6	111.7
Class I (excluding million plus cities)	0.1–1 millions	415	27.6	104.2
Class II+III+IV+V+VI	< 0.1 millions	7467	30	112.2

Source: Registrar General and Census Commissioner 2011.

seeds of administration, trade and religion. After arrival of Europeans in India, urbanization rate was accelerated mainly because of the location and establishment of modern factories and industries. Urbanization in India during the past century was associated with a particular theme in each decade (Table 2).

India is one of the least urbanized countries of the world, yet its urban population is second largest amongst the countries of the world (CityMayors.com. n.d.). The India census recognizes six classes of cities and towns. Class I towns have a population of more than 100,000; Class II towns have a population ranging between 50,000 and 99,999. Class III towns have a range of population range from 20,000 to 49,000; Class IV towns from 10,000 to 19,999 and Class V towns from 5,000 to 9,999. Class VI towns have a population of less than 5,000. Another striking feature of the urban scene in India is currently there are 53 metropolitan cities (Registrar General and Census Commissioner 2011). These metropolitan cities account for more than 42 % of India's urban population (Table 3).

In terms of regional disparity, Western and Southern India is more urbanized than Eastern and Northern India, mainly because of topography (Figure 1). Of the total urban population more than 50% lives in just five states viz. Maharashtra, Uttar Pradesh, Tamil Nadu, West Bengal, and Andhra Pradesh. States like Bihar, Orissa and Assam have urban population less than half the national average mainly because of lack of development of secondary and tertiary economic activities (National Institute of Urban Affairs (NIUA) 2011).

Interesting differences are observed in the distribution of urban population among towns of different size categories. It is revealing that 70% of the India's urban population lives in Class I or more (Registrar General and Census Commissioner 2011). Large cities are growing at the expense of smaller cities (Figure 2). Many of the smaller towns belonging to Class-V and VI of the census are "grown-up" villages. They perform predominantly agricultural functions, collecting agricultural produce from the surrounding villages and marketing it. The Mandi (grain market) forms the hub of the town. A market springs up along

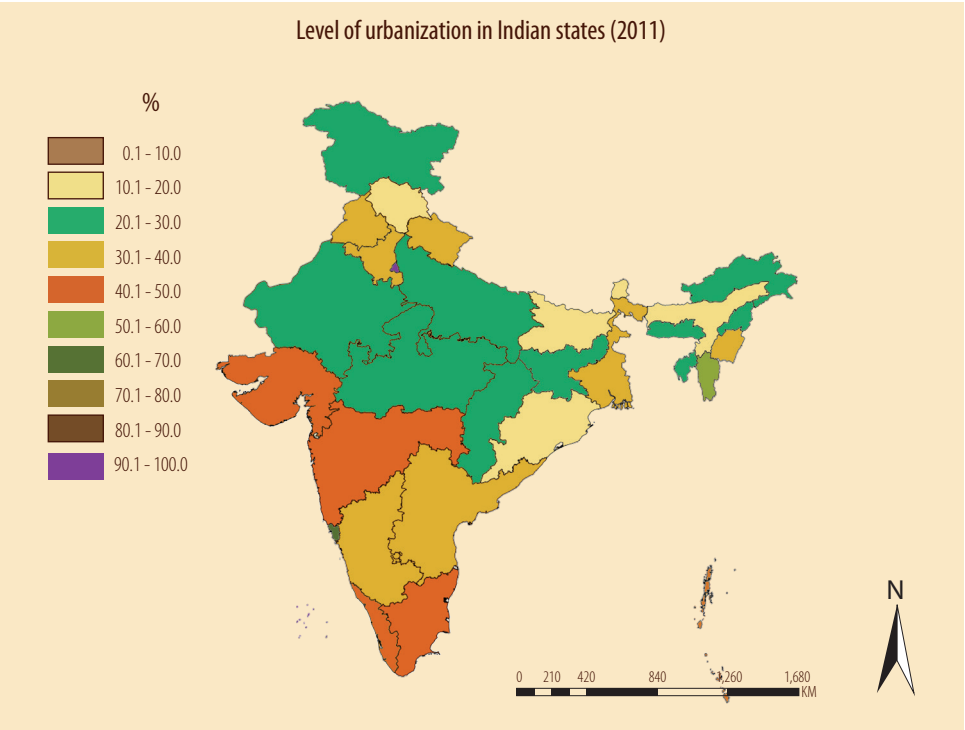

Figure 1. Urbanization in Indian states in 2011.
Source: Registrar General and Census Commissioner, 2011.

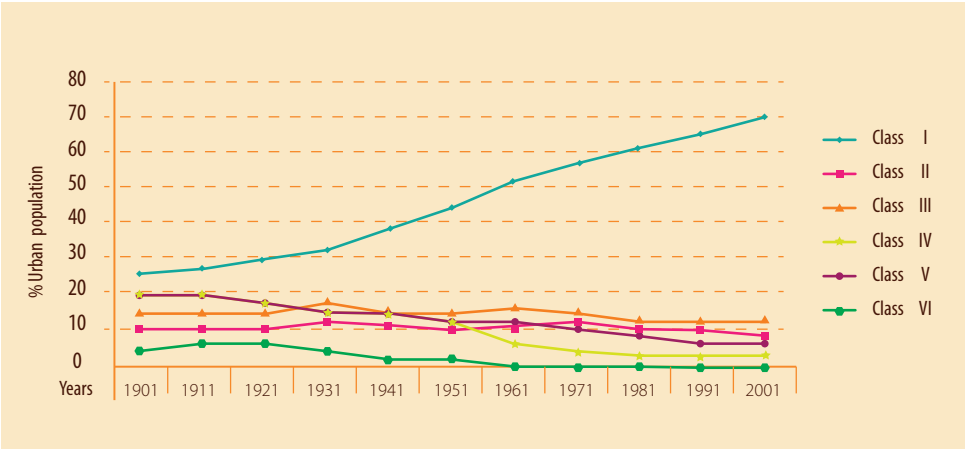

Figure 2. Trend of urbanization with city classification.
Source: Data sourced from National Institute of Urban Affairs (NIUA), 2011.

the road which provides access to the Mandi. With the passage of time some local administrative functions were also sold to urban agglomeration and it acquired the characteristic features of a tehsil town.

Problems of Indian urbanization

First, is the manner in which urban areas are growing, most of the urban growth is taking place in slums (Table 4). This is because of the large scale out-migration of rural population into cities that are generally illiterate with minimum capital. Second, is the problem of one-sided growth of metropolitan cities at the expense of smaller towns (Table 3). Smaller towns failed to attract immigrants due to poor infrastructure and employment opportunities there. In big cities, population explosion and rural migration is hampering the provision for adequate water supply, education facilities, traffic and housing. For example in Pune, only 29% coverage of metered water supply connection exists and sewerage network has collection efficiency of 73.35% (Pune Municipal Corporation 2011). Similarly, to satisfy urban education demand, schools are constructed but out of 62874 schools in urban area, only 52.16% had playground, suffers from lack of black boards (14.95%), furniture (18.23%), and 1693 primary schools do not even have school building (National Council of Educational Research and Training (NCERT) 2002). Also, social health in India has deteriorated by increase in urban malaria from 7.79% (1996) to 13.8 % (2010) (Planning Commission 2011a). Third, is the problem of core vs. periphery regions. The core region has

Table 4. Slum population in few major cities of India.

Cities in India	Urban population ('ooooo)	Slum population (%)
Mumbai	119.2	48.8
Faridabad	10.5	46.5
Meerut	10.7	43.8
Nagpur	20.5	35.4
Kanpur	25.3	35.4
Kolkata	45.8	32.5
Bhopal	14.3	22.5
Pune	25.4	20.9
Delhi	98.2	18.8
Chennai	42.2	17.7
Hyderabad	34.5	17.4

Source: Ministry of Home Affairs 2001.

traffic congestion, mixing up of small-scale industries and residential settlements. Periphery regions are generally the dump yard of the core and also have some residential housing of low income group with lack of civic amenities.

This has resulted in widening gap between rich and the poor causing urban crime, street children, prostitution, drugs and associated juvenile crime. Tertiary effect of this is environmental pollution, breakdown of culture and problem of mental stresses.

The morphology of towns in India has its own peculiarities. There is hardly any difference between residential and the commercial areas. There exists social segregation due to existence of artesian and caste based colonies. The municipal administration very often makes a distinction between high-income and low-income colonies in providing civic amenities. The residential locations of low income groups often degenerate into slums. Moreover, Indian urbanization is of subsistence in nature as migrants from rural areas are attracted to the urban centers not for urban environment but for employment, i.e. push of poverty in the rural areas has been very acute. No functional or spatial integration exists in Indian urbanization. Due to this, there are breaks and imbalances in urban hierarchy. The urban base in rural areas is sub-standard and the intermediary link through the market towns is weak.

Sustainability challenges of urban growth in India

Housing and slums

Indian urbanization is characterized by growth in slum population. A rural migrant with low affordability to rent houses in core areas of cities end up in slum formation in the periphery, resulting in haphazard and unplanned urbanization. Around 30% of the urban population in India live in poor quality, overcrowded accommodation with inadequate or no provision for basic infrastructure and services (National Institute of Urban Affairs (NIUA) 2011). They are also the ones who can least afford high transportation costs, live on the periphery and hence system contributes to a self-perpetuating cycle of poverty. They also face legal barriers to get access to electricity, land tenancy, power connections with an impact on safety of the end users. It deepens the cultural, economic and social gap between rich and poor and hence poses real hindrance to attaining sustainability. These settlements face much risk and vulnerability to climate change also.

The Government of India (GoI) has initiated schemes as Rajiv Awas Yojana (Rajiv housing scheme). An amount of INR 1803 billion has been spent for construction of 32,817 housing units in 34 cities. Some other institutional initiatives taken are construction of houses for Government employees and weaker

sections, provision for rural housing, slum clearance and sweepers housing (Dwivedi 2007) and enactment of Urban Land (Ceiling and Regulation) Act 1974. To prevent one-sided (or skewed) urban growth, the GoI attempted to improve rural-urban networks and launched Integrated Development of Small and Medium Towns (IDSMT) scheme for towns below 0.1 million population which includes extending finances to civic agencies for provision of roads, pavements, bus stands, markets, shopping complex etc (Dwivedi 2007). However, all these schemes were not uniformly implemented.

Municipal waste

India generates more than 40 million tonne of municipal waste annually from urban centers (World Bank 2006) which is collected poorly (average collection efficiency is 72%, Figure 3), transported inadequately (70% cities lack required transportation capacities) and disposed unscientifically (no sanitary landfill for municipal wastes exists, Figure 4) (Kansal 2002). Considered as a low priority area, solid waste management (SWM) was never taken seriously, either by public or by concerned agencies. Prevailing SWM systems in Indian cities are publically operated through municipalities, which are already overburdened and have not been very effective as far as services are concerned. People involvement is

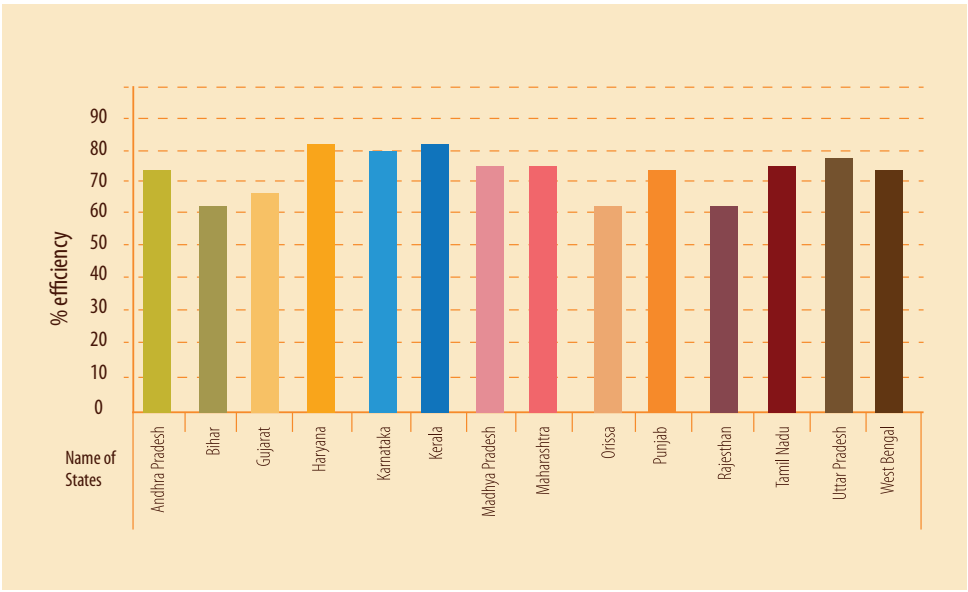

Figure 3. Solid waste collection efficiency in different states of India.
Source: Data sourced from Nema 2004; Sharholy, et al. 2008.

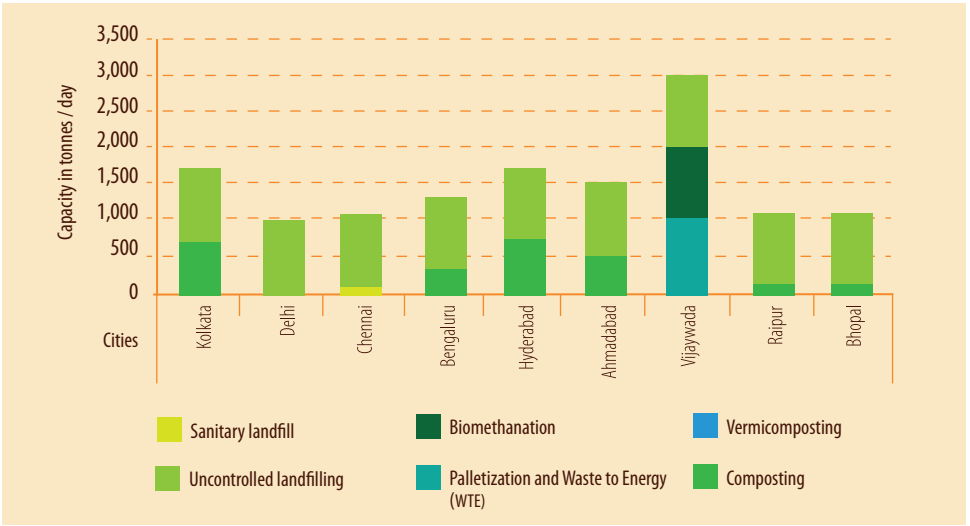

Figure 4. Municipal waste disposal practices in Indian cities.
Source: Data sourced from Kumar, et al. 2009.

normally limited to payment of some obscure and indirect taxes. Moreover, there is an absence of well-formulated guidelines and policies regarding waste management services (Kansal 2001).

Door to door primary collection system is absent except for some experiments run by non-governmental organizations (NGOs) and self-help community groups. Multiple handling of garbage during the course of collection/removal is quite common (The Energy and Resource Institute (TERI) 2010). Uncontrolled dumping of waste on the outskirts of towns and cities has created overflowing landfills, which are not only impossible to reclaim because of haphazard manner of dumping, but also have serious environmental implications in terms of ground water pollution and contribution to global warming. Burning of waste leads to air pollution in terms of increased total suspended particulate emissions in air (Kansal 2001). In the absence of waste segregation practices, recycling has remained an informal sector using outdated technology, but nevertheless thriving owing to waste material availability and market demand of cheaper recycled products (Uiterkampa, Azadib and Ho 2008; Narayana 2009). Paper and plastic recycling have been especially growing due to continuously increasing consumption levels of both the commodities (The Energy and Resource Institute (TERI) 2006).

However, there are certain good points. The per capita waste generation in India is low (0.3-0.6 kg/day) compared to many other developing countries

Box 1. Examples of institutionalised waste management.

- Initiative by Urban local body (Infrastructure Professionals and Enterprise Ltd, (IPE) 2004)
  Chennai Municipal Corporation-community waste management: 4000 million tonnes of waste generated by Chennai annually, where Chennai Municipal Corporation shares the responsibility for procurement of vehicle, collection bins, and transfer to disposal sites with private contractor, ngo-exnora. The ngo trains rag pickers for door-door collection, transport to collection bins, vermi-composting, aerobic composting, and enhancing capacity of urban managing body.
- Private sector participation, source (Infrastructure Professionals and Enterprise Ltd, (IPE) 2004)
  Navi Mumbai Municipal Corporation: It manages street cleaning and transportation of waste to dumpsite in 82 zones in a joint venture with private managing body. This helped in 40% cost reduction, 450-500 less sanitation worker requirements.
- Role of Informal sector, (Sharholy, et al. 2008)
  Rag pickers: Rag pickers collects waste in India (10–15 kg/day/head), saving usd 13,700 daily in Delhi, usd 200,000 in Pune (as an example) and also reduces waste load on dumpsites (15% reduction in waste dumping in Bangalore).

(Pakistan- 0.8 k/day, Sri-Lanka- 0.2-0.9 kg/day, Indonesia-0.8-1 kg/day) and developed countries (US- 2.1kg/day, Germany- 1.56 kg/day, Italy- 1.55 kg/day) (Shekdar 2009; Batool and Nawaz. Ch 2009; Troschinetz and Mihelcic 2009; OECDiLibrary 2009). A large number of formal and non-formal sectors have emerged in waste management (Box 1) and there are good numbers of cases of positive intervention from NGOs, resident associations, and other action groups. However, the impact of such efforts on the overall deteriorating situation is much insignificant and there is an urgent need to have strategies that would look into the overall aspect of solid waste management (Shekdar 2009).

Water supply and sanitation

The major issue is decrease in per capita water availability, unreliable water quality and inadequate coverage (Planning commission 2008). Inadequate recharge of groundwater aquifers due to formation of impervious surface, increase distance of surface water sources and exponential increase in water demand has contributed to decrease in per capita availability. For e.g. there has been exponential growth of water demand in Delhi from 650 MGD in 2002 (13.8 million population in 2001) to 859 MGD in 2012 (16.7 million population in 2011) (Registrar General and Census Commissioner 2011; Economic Survey of Delhi 2012–13) laying pressure on water intake system. Agriculture runoffs and uncontrolled pollution from diffused sources have introduced new forms of pollutants and the conventional water treatment plants are not equipped to deal with these pollutants (Box 2). This resulted in disruption of water supply aggravating the problem of water availability. Apart from pollution, old constructed pipelines and inadequate operation and maintenance results in poor

Box 2. Disruption of water supply in Delhi due to rise in ammonia in raw water.

During the month of February in 2011, the rates of supply water of Delhi has been shut down from two of its water treatment plants (combined capacity of 210 MGD), resulted in 35% less supply of water during the month. The reason attributable for shutting down water supply is the presence of ammonia in raw water for which the treatment plant has not been designed. The ammonia present in water is due to the discharge of industrial waste water and agricultural runoff carrying canal into the River Yamuna by the upstream regions of Delhi. This incidence happened in consecutive years.

Source: Thehindu.com 2011.

quality of service delivery (Central Pollution Control Board (CPCB) 2000). In India growth of domestic water purifiers and the bottled industry has shown a phenomenal growth (Planning Commission 2011b), resulting in more energy consumption and wastage of fresh water due predominant use of membrane based filtration for the production (Central Pollution Control Board (CPCB) 2011). Slums and illegal settlements are supplied water through tankers often with unreliable quality and at a high cost. This has further widened the disparity between service delivery to urban rich and to poor. Poor end up paying 3 to 5 times more the cost of water whereas; rich are enjoying the benefits of subsidy to water pricing. However, some initiatives have been taken by private bodies to improve water supply to low income groups. All three issues add another dimension of water-energy-climate nexus in urban water supplies (Plappally and Lienhard V 2012). Despite of legislation, laws and acts (Box 3), urban water supply system still offer challenges to sustainable urbanization.

4861 out of the 5161 cities/towns in India do not have sewerage network (Figure 5).Out of total wastewater generated, less than 29% in class I city and less than 3.67% in class II city is treated (National Institute of Urban Affairs (NIUA) 2011; Central Pollution Control Board (CPCB) 2005). Slum population in these cities depends on public toilets (Registrar General and Census Commissioner 2011) which are generally devoid of water supply (National Institute of Urban Affairs (NIUA) 2011) and hence open defecation is still being practiced by significant population. Out of 423 cities surveyed, 190 cities are found to be vulnerable to water related epidemics (MHFW, 2008). GoI has formulated National Urban Sanitation Policy, 2008 (Box 4) that emphasizes on integration of institutions, enhancing sanitation infrastructure, sewage treatment facilities and mechanism of fixing responsibility and accountability.

Air pollution

One of the major concerns of urbanization in India is deteriorating ambient air quality. Urban transport, manufacturing industries, thermal power plants, and domestic fuel combustion are major sources of human induced air pollutant

Box 3. Government initiatives.

- The agenda of water supply and sanitation was added during the first five-year plan (1951- 1956).
- In 1954, the first national water supply program was launched to improvise health plan.
- The Ministry of Water Resources (MoWR) drafted National Water Policy in 1987 for planning and development of water resources throughout the country, which includes design standards for groundwater structures, water quality monitoring, and data management and valuation.
- National Water Policy was revised as National Water Policy 2002, with priority to safe drinking water to all.
- In order to improve urban water supply and sanitation services, guidance to states and cities are being provided.

Source: NIUA 2011; Ministry of Urban Development (MoUD) 2012.

emission like sulphur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM) and hydrocarbons (HC) (Central Pollution Control Board (CPCB) 1996; Central Pollution Control Board (CPCB) 2000). Out of 142 cities surveyed through national air quality monitoring program (NAMP), 9 cities exceeds national ambient air quality standards (NAAQS) for NO_x (exceeds 6%), 96 cities for PM10 (exceeds 68%), but level of SO_2 are reported to be within permissible limits for residential/industrial areas (Central Pollution Control Board (CPCB) 2011). The reason for such trend is reduction in sulphur content in vehicular fuel, use of cleaner fuel like compressed natural gas (CNG) in metropolitan cities maintaining SO_2 and nitrogen dioxide (NO_2) level in ambient air. But increase in number of vehicles, extensive use of gensets, small-scale industries and incineration units without adequate air pollution control devices, suspension of traffic dusts results in high level of PM in Indian cities. Moreover, vehicular sources contribute about 58.5%

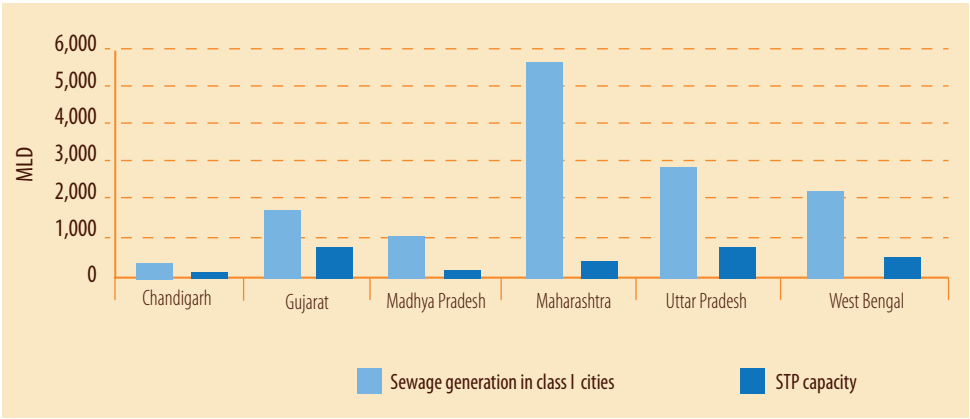

Figure 5. Sewage generation and sewage treatment plant capacity in few Indian States.
Source: Data sourced from Central Pollution Control Board CPCB, 2005.

Box 4. Key features of national urban sanitation policy, 2008.

- Development of city sanitation plan and national level investment in urban infrastructure for urban households including slums.
- The urban local body needs to strengthen schemes for city sanitation by fixing tariffs, reforming operation and maintenance of sewage treatment plant, implementation of new sewerage system for new housing colonies.
- Integration of central, state, and local bodies to resolve issue of tenure and space in providing sanitation facilities for poor.
- Capacity building of urban local bodies, awareness to public about sanitation and disease proliferation.
- States are mandated to set up regulatory mechanisms through an independent agency for setting standards, monitoring performance, adjusting tariffs, etc.

Source: Ministry of Urban Development (MoUD) 2008.

of the total pollutants emitted, followed by thermal power and industries (30%) and domestic sector and background concentration is (Kansal, Khare and Sharma 2011).

Vehicular emission

The vehicular stock trend in India is similar to that of the urban population including skewed concentration in few megacities. Comparing transport situation of India with developed nations, the per capita vehicular ownership in India is very low. For e.g. Germany has a high per-capita number of vehicles — 0.558 (European Comission s.f.) compared to India 0.006 (World Resources Institute 2011), but is low in the absolute number of vehicles in comparison to India, the respective numbers being 50,184,000 (European Comission 2010) and 89,618,000 (Ministry of Road Transportation and Highways (MoRTH) 2009), respectively. Similarly, the driving force of the motorization rate in Germany is comfort and lifestyle whereas, in India, it is a necessity due to the poor public transport system. The high purchasing power of Germans has resulted in significantly higher share of four–wheelers in the total vehicle stock, 83%, (European Comission 2010); whereas, in India, due to low purchasing power two-wheelers have the major share (72%, (Ministry of Road Transportation and Highways (MoRTH) 2009). Public transportation, both railways and road, in Germany functions well, but 73% people use their personal motor vehicles (Umweltbundesamt 2009). In India, about 85% of the passenger transport is carried out by road (Transport India, 2010; World Bank 2002). City bus services operate in 17 cities, while rail transport exists only in 4 out of the 35 metropolitan cities of India (S. P. Singh 2005).

Traffic congestion is one of the problems caused partly by poor public transportation system. For example, due to traffic congestion in Delhi, the average

speed has dropped to 15 km/h and is expected to decline further (Mail Today, 2010). Moreover, urban areas in India have expanded horizontally, thereby increasing passenger travel demand. The average trip length (ATL) in Indian mega-cities is about two times higher than in Germany, e.g. in Bangalore 12–13 km (Pagontra and Sharma 2006), Mumbai 12.4 km (Mumbai Metropolitan Regional Development Authority (MMRDA) 1999), and in Delhi 10 km (Bose and Sperling 2001). The vehicular travel demand (VTD) in India is approximately 4200 million passenger kilometers (Pagontra and Sharma 2006) which is about 4.6 times higher than found in developed countries. The per-capita trip rate (PCTR) in India ranges between 1.0–1.7 [Mumbai PCTR is 1.7 (Mumbai Metropolitan Regional Development Authority (MMRDA) 1999), Delhi PCTR 1 (DUEIIP 2001), and Bangalore PCTR is 1.2 (Pagontra and Sharma 2006)]. The reason behind the significantly lower PCTR in India lies in the employment structure, where SMEs employ a significant number of people and are often located in or near residential areas. Therefore, many people do not have to travel to work.

Factors attributable to high emissions from vehicles in India are: a high proportion of old vehicles on the road using out-dated technology, two-stroke engine two-wheelers, a high number of personalized vehicles, high passenger kilometer demand and poor public transport infrastructure. Studies have shown that two-stroke engines are inefficient in fuel burning (Pundir 2001), thereby resulting in higher levels of emissions (Figure 6).

The impact of vehicular pollutants is greater as these are ground-level emissions. The steps taken by the government to curb vehicular pollution in recent years are given in Table 5. In addition to these, in December 2002, following the Supreme Court (apex court in India) order, Delhi has achieved the distinction of having the largest fleet of CNG (compressed natural gas) buses in the world, numbering over 7400 buses and over 4000 mini-buses. Entire fleet of Taxis (15,000) and 3-wheelers (about 45,000) have already been converted into CNG powered engines. Following Delhi, are the cities of Beijing and Seoul in world where the number of CNG buses are around 1600 and 1000, respectively. Further, the Supreme Court directives read: 'The Union of India will give priority to the transport sector, including private vehicles all over India with regard to the allocation of CNG'. This means that in Delhi and other cities of India, CNG will be allocated on priority basis and made available for transport sector.

However, the missing ingredient in current air pollution strategies is the travel demand management. It is desirable to complement the 'supply-side interventions' with 'demand management measures', if the ultimate objective is to secure improved levels of air quality. They range from simple traffic engineering interventions (coordinated signals, reversible lanes, one-way street pairs, and other traffic control devices) to traffic restraints (area licensing schemes,

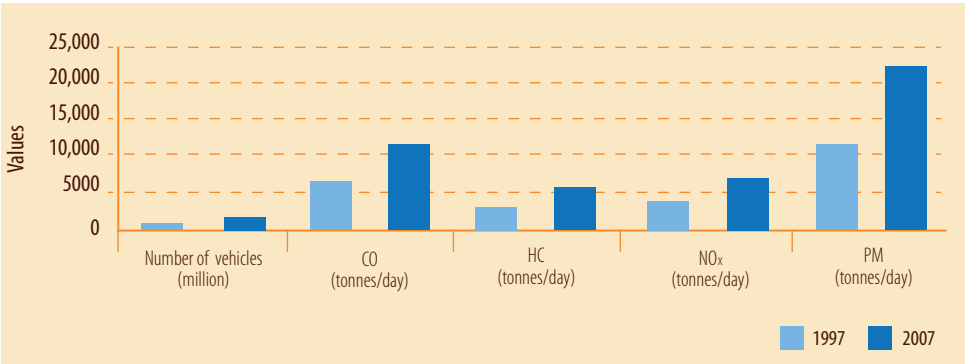

Figure 6. Increase in number of vehicles and associated emission in India from 1997 to 2007.
Source: Data sourced from MoRTH, 2004; SIAM, 2008.

parking controls, exclusive pedestrian zones, vehicle bans, special bus and high occupancy vehicle lanes and so on), advance traffic control techniques, and provision of facilities and services to encourage modal shifts (such as sidewalks, bicycle lanes, light and rapid rail transit, and commuter rail). All these measures would require a policy framework encompassing regulatory, pricing, and taxation mechanisms, and are to be reinforced with effective enforcement so as to encourage the use of clean vehicles and fuels and to modify travel behavior and transport demand.

Industries

Industrial sector (manufacturing, power, mining and quarrying, construction) contributes roughly 20–40% to urban air pollution in India (Kansal, Khare and Sharma 2011). In India, due to small and medium enterprises (SME) that consists mainly of small family enterprises, there are significantly more manufacturing industries in urban areas, e.g. in Delhi around 126,000 (DoES 2000). Very often these industrial units operate illegally with primitive technology and process standards. Thermal power plants (TPPs) are the second biggest contributors to urban air pollution in India. In Delhi, there are four TPPs within the city limits, and another three near the city contributing significantly to the urban air pollution levels (Kansal, Khare and Sharma 2011). The main fuels used in the industrial sector are fossil fuels (Table 6). Due to the higher number of pollution sources, poor technology, and fuel quality the resulting pollution levels in India is higher (OECD 2006; Chaphekar and Madav 1999).

Some assorted measures that have been taken so far include: closure and/or shifting of polluting industries, strict enforcement of pollution control measures in the remaining industries, compulsory use of beneficiated/blended coal with ash content less than 34% in all coal based thermal power plants from June

Table 5. Policy measures for vehicular and industrial pollution control in India.

Air quality control measure	India	Remarks
Emission norms for vehicles	Started with Central Motor Vehicles Rules in 1989, introduced Euro equivalent norms in 2001, currently having Euro IV norms.	India broadly followed European path for emission norms with a time lag of 4–5 years.
Emission norms for industry	Started with the Environment (Protection) Act in 1986, Minimum National Standards are in place for several categories.	In India, both the number and diversity of industry is large causing weak enforc‹wement of regulatory measures as compared to Germany, where, due to smaller number of large scale industries, regulatory measures are easier to implement.
Fuel quality standards & alternative fuels for vehicles	Fuel quality standards introduced in 1996, lead phased-out in 1998. CNG-powered public transportation (Delhi), ethanol blended (5%) petrol.	Regulatory and economic instruments are introduced to meet Euro (equivalent) norms for reducing emissions.
Fuel quality standards & alternative fuels for industries	Started with the Environment (Protection) Act in 1986, differentiated norms indicated in legislation, low ash content required. Partial substitution of fossil fuels with bio-fuels, 'cleaner' fossil fuels.	India needs strong public support and involvement for successful implementation of renewable in industrial sectors.
Technology improvements for vehicles	Catalytic converters introduced in 1995, Built-in-on-board diagnostic system and electric cars pilot level.	India has followed the path of technological innovations of Germany with a significant time lag due to the expensiveness of technology upgrades.
Technology improvements for industries	Promotion of best available technologies, not mandatory: e.g. Filters, smoke gas cleaning systems, Low NO_x burners.	In India high number of (often illegal) small and medium size enterprises (SME) are not able to implement less polluting processes and pollution control equipment due to high cost involved.
Planning activities for transportation sector	Restriction on goods vehicles, time clocks on traffic lights, road construction incl. bus lanes etc.	India focuses on infrastructure development before it can move on to setting stricter traffic restriction.
Planning activities for industrial sector	The Policy Statement on Abatement of Pollution 1992 integrates environmental concerns into decision making, incl. licensing; creation of Zoning Atlas; heavily polluting industries are shifted to undeveloped areas inside the country.	In India, there are continuous problems with the land-use pattern and with following the licensing procedure. Many industries are located in residential areas and the other way round.
Emissions' Information provision	Emissions' info is published, and displayed in bigger cities.	In India, industrialists are not required to report their emissions, resulting in caps in the emissions' data and weak control over the emissions.
Educative, informative measures	Promoting public transportation and alternative energy sources (e.g. renewables' promotion since 1980's).	Sensitizing and empowering the public regarding environmental issues has not been effective in India.

2001 (Ministry of Environment and Forests (MoEF) 2001), increase in green cover etc. However, the impacts of such measures are not perceptible (Table 5).

Air pollution from domestic sectors

Domestic sector too has its share, although small, in contribution to overall pollution load. According to health impact studies done by World Bank in 2004,

Table 6. Fuel usage and energy consumption in industrial sector.

Indicator	India
Fuel usage in industrial sector:	
— Coal	55.0%[1]
— Oil	29.9%[1]
— Natural gas	8.5%[1]
— Renewable	5.6%[1]
— Nuclear energy	1%[1]
Energy consumption	
— Total	594.9 Mtoe[2]
— Per capita	529 kgoe[2]
— Urban	167.5 Mtoe[2]

Source: [1] Bhattacharya and Chinmoy 2009; [2] World Bank 2010; Mtoe: Million tonnes of oil equivalent.

indoor air pollution has emerged as one of the prime environmental health concerns in India. The report points out that biomass fuels combine with open chulhas (stoves) and inadequate ventilation create problems with the lives of two major vulnerable groups: children and women. The situation is further aggravated due to the use of inefficient and highly polluting fuels in the poorer households that have low nutritional security and low capacity to pay for health care. For e.g. based on the emission factors for Indian cooking chulhas (stoves), the contribution of domestic sector to air pollution includes 3338 tonnes/yr of suspended particulate matter (SPM); 6319 tonnes/yr carbon monoxide (CO); and 859 tonnes/yr NO_x (Tata Energy Research Institute (TERI) 1997).

Policies for sustainable urbanization in India

The GoI has launched Nation Mission for Sustainable Habitat (NMSH) to address urbanization challenges (Ministry of Urban Development, (MoUD) 2010; Planning commission 2011; Planning commission 2013b; (Planning Commission 2013c; National Institute of Urban Affairs (NIUA) 2011). Key features are given below:

- Formulation of national migration and population growth policies in order to foster a more balanced geographic pattern of urban growth and economic development. Such policies would also help to designate areas where guided stimulation will be necessary.
- Policies for de-concentration and control of peripheral growth, green belt and ribbon development.
- Policies for growth of centering and major infrastructure provision like transport, communications and power.

- Policies for the reconstruction of the rural landscape, including the development of marketing towns and service centers.
- Metropolitan policies to limit the growth of metropolitan cities, provision of mass transportation facilities and policies for redevelopment of central city areas, urban renewal and slum clearance programs.
- Housing policy to provide mass housing and building rent control measures.
- Policies for checking environmental pollution in cities, particularly water and air pollution.
- Urban land policy including measures like "socializing", urbanizable land, restriction on building plot sizes and simplification of land acquisition procedures.
- Policies for Urban administration, including determination of powers and functions of local bodies and measures to improve their finance, administration and co-ordination of civic services.

As cities are dynamic, complex and connected system, therefore intervention in one aspect of urbanization will influence the other. Benefits incidental to a particular policy goal can help drive the implementation of the policy and sustain it in long term, but only when the inherent risk trade-offs, if present, can be managed. For e.g climate change will worsen the pressure on city infrastructure (Indian Network for Climate Change Assessment, Greenhouse Gas Emissions (INCCA) 2010; Ministry of Urban Development, (MoUD) 2010). Review of mitigation and adaptation strategies of cities reveals that, climate change is in many cases either absent or insufficiently linked to the discourse on overall sustainable urban development (United Nations Human Settlements Programme (UNHSP) 2010). Climate change adaptation strategies in many cases creates the impression it is some separate undertaking, that takes place detached from other on-going discourses, or it is even outside the institutional entities usually dealing with issues related to sustainable urban development (Birkmann, et al. 2010). Additionally, it has been found that the disaster risk reduction community and adaptation community, work separately and synergies between them have not been well-established, even though both these communities have a common goal of reducing the impacts of extreme events and increasing urban resilience (Solecki, Leichenko and O'Brien 2011). Both these functions are generally housed in different Departments or Ministries with fragmented roles and responsibilities (Ministry of Urban Development, (MoUD) 2010; National Institute of Urban Affairs (NIUA) 2011). Also, better land use planning and improved building code, proposed as key adaptation measures, do not often sufficiently match the reality because of existence of informal social mechanisms of land management in

India. The probability of finding win-win solutions, for sustainable urbanization, is low, and trade-offs between conflicting goals are more common (McEvoy, Lindley and Handley 2006). For example, energy efficiency related mitigation measures are considered as the low hanging fruits of a city's responses to climate change (Dodman 2009). However, implementing these measures in existing infrastructure might generate waste consisting of fully working devices. Hence, climate change mitigation and adaptation measures are at times associated with conflicts and trade-offs of competing goals of sustainable development strategies and hence is a decisional challenge for planners and the city administration. Further, mitigation strategies for individual cities may deprive other areas for mitigating their emissions if the reductions are achieved by outsourcing emission-intensive sectors. To avoid problem shifts between regions, it is essential to complement the analysis of individual cities with analyses at larger scales. Assessment of how cities and countries have progressed with respect to execution of existing sustainability agendas and mitigation and adaptation plans in a depressed economic scenario would help identify the determinants of successful urban sustainable development strategies.

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