chapter 3

alternative urban futures: options for india

3.1 energy

Cities are major users of natural resources ranging from water and energy to land and food. They also produce a wide range of harmful pollutants – carbon dioxide, solid waste and sewage. All these issues need to be considered but, in this report, we have mainly focused on energy and to a lesser extent on water and waste. Of course, much of the same analysis can be easily applied to other areas.

Figure 10 shows how the availability of electricity is growing rapidly but is unable to keep up with demand. Although some increase in energy use is inevitable, both in total and in per capita terms, we feel that there is a broad range of future trajectories for India. Since economic development is closely linked to urbanisation, the future trajectory of energy use (and that of other resources) will be closely linked to the types of urban centres we build.

In Chapter 1, we saw how the ecological footprint of Barcelona was a fraction of Atlanta's footprint. So what should India's urban planners focus on? According to a study by The Energy and Resources Institute (TERI), transportation consumes 17% of energy in India while residential and commercial users (a proxy for buildings) consume 15%. We do not have data specifically for Indian cities but the shares of transport and buildings are presumably larger for urban areas. Thus, in this chapter we look at the implications of various strategies for transportation and building design. We also look at scenarios for water and waste.

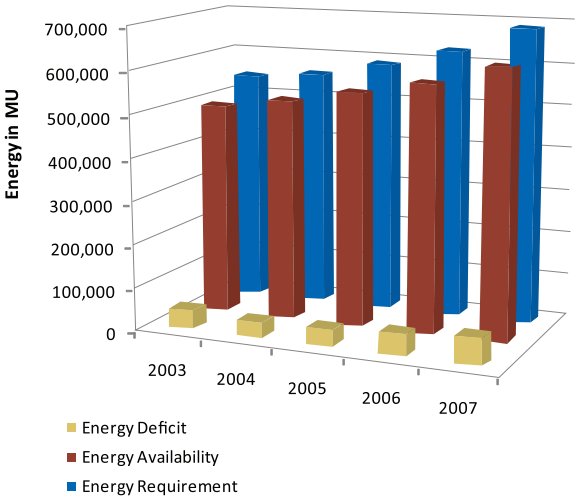


Figure 10: Power Availability across India
Source: Central Electricity Authority (CEA)[63]

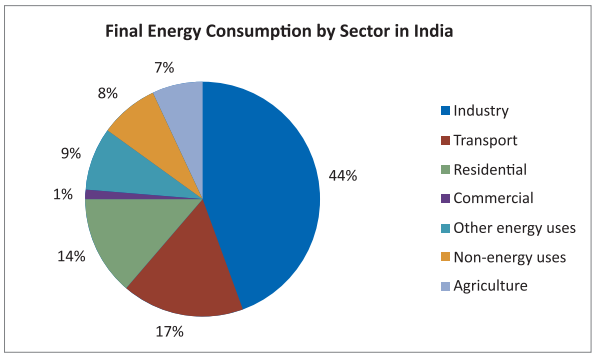


Figure 11: Final Energy Consumption by Sector in India
Source: TERI[64]

[63] Central Electricity Authority (CEA) (January 2008), 'Power Scenario at a Glance'
[64] TERI Energy Data Directory and Yearbook (2007); Final Energy Consumption, By Sector, in 2005/06

3.2 transport

The transport sector is the world's most important consumer of petroleum products, accounting for 58 per cent of total global consumption in 2004 (IEA 2007). Most of this fuel consumption comes from road transport (IEA 2007). Car ownership has been growing rapidly in Asia. Scenarios that look at vehicle/energy use and emissions for South Asia (Bose, 2007) find that the sudden growth in vehicle use has resulted in traffic congestion, fuel use and CO_2 emissions, and in deteriorating air quality. The forecasts show that if current trends continue, motor vehicles will double, fuel use and CO_2 emissions will triple, and pollution will rise exponentially by the year 2020. Nonetheless, as shown in Figure 12, affluence need not imply continuously worsening pollution. Cities like New York and London had very poor air quality in the early twentieth century but now have far better air quality than Indian cities. Urban form clearly has a large impact on the trajectory – and the embedded DNA of the city can be an important factor affecting future energy use. For instance, in Mumbai approximately 55 per cent[66] of the people walk to work, whereas in Delhi the proportion is 32 per cent. A relatively small proportion of Kolkata's population relies on walking but a large share uses public transport. Car usage is the highest in Delhi of any Indian city and even public transport has historically relied on road systems (although this may be slowly changing with the introduction of the Delhi Metro). Thus, it is important to compare the relative merits of different trajectories with a view to guiding the future path of India's urbanisation.

Traffic Jams in Gurgaon's Brand New Roads © Verma, A.

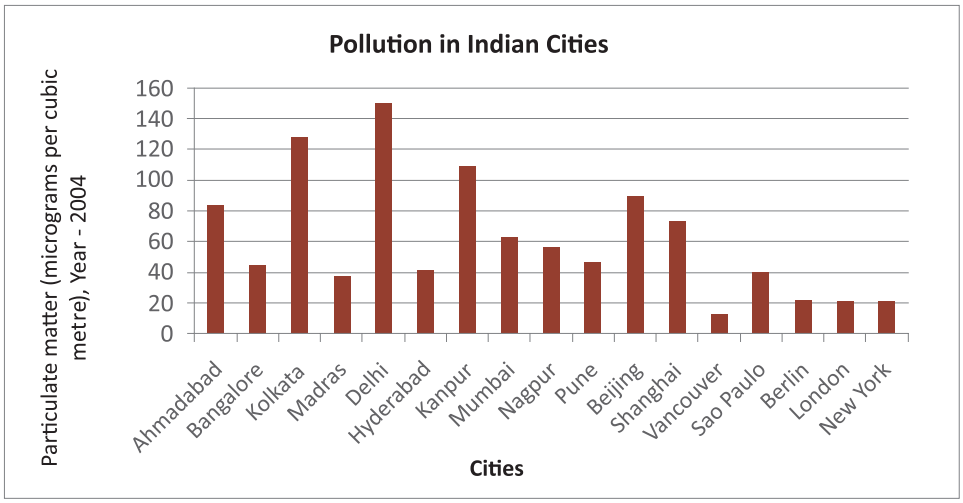


Figure 12 Pollution in Select Indian and World Cities Source: World Bank[65]

[65] 2007 World Development Indicators, Original data from World Bank study by Kiran D. Pandey, David Wheeler, Bart Ostro, Uwe Deichman, Kirk Hamilton, and Kathrine Bolt, "Ambient Particulate Matter Concentration in Residential and Pollution Hotspot A"

[66] Urban Age, Mumbai, 'Transport – Internal Mobility', 2007

3.2.1 drivers of energy demand with respect to transport

The energy demand (consumed) by the transport sector in a city is determined by the following factors:

a) mode of transport,

b) number of trips made by citizens in a day,

c) the length of the trip, and

d) speed of travel.

However, the total transport demand is determined by:

a) population,

b) urban form,

c) availability of soft and hard infrastructure, and

d) governance (existing regulatory/policy framework including taxation).

3.2.2 energy consumption in transport: paths to 2050

We now look at different scenarios or ways in which selected cities in India could develop in the future, by modelling the different modes of transport available to the city's citizens and the associated energy consumption patterns for the future. The modelling framework chosen for the study is based on established literatures. For instance a report by the McKinsey Global Institute (Energy Productivity Opportunities, May 2007) derives the demand for fuel based on the vehicle miles traveled and on the average fuel economy. Similarly, a World Bank report (Bose, 2007) uses a comprehensive analytical framework to assess energy used by the transportation network based on the activity, modal share and the energy intensity.

This report takes these studies as starting points in developing the methodology for computation of future energy demand in chosen cities in the country. The model estimates total energy consumption based on the varying transport modes in use within a city – that for mass transit and non-mass transit. The total energy consumption of a city is thus:

ENERGY CONSUMPTION IN TRANSPORT SECTOR

$$TE_x = \sum_{i=1}^{n} PDE$$

Where, TE_x equals the total energy consumption for a city 'x'

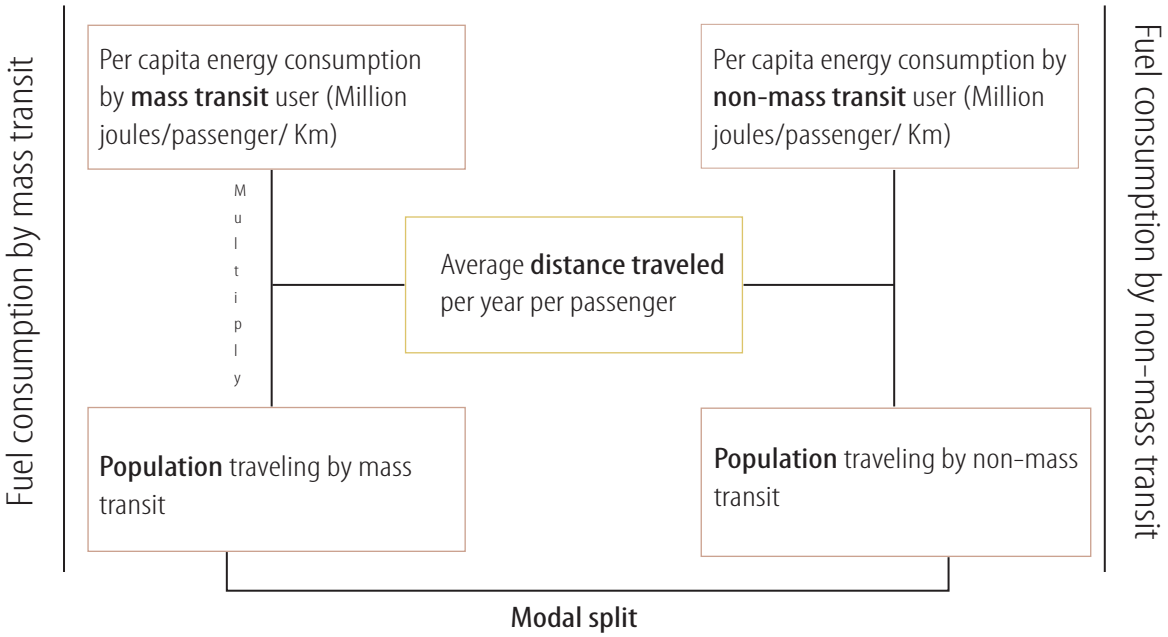
P is the total number of persons using a transport mode

D is the average annual distance travelled per capita

E is the per capita energy consumption by transport mode

and, i refers to the different transport modes

CONSUMPTION OF ENERGY FOR TRANSPORT SECTOR



The estimations are based on the following assumptions:

- The transport modes are split into: mass transit, non-mass transit and walk,
- The energy consumption associated with mass transit vehicles is 0.64 million joules/ passenger/km[67],
- The energy consumption associated with non-mass transit vehicles is 1.78 million joules/ passenger/km[68],
- Mass transit includes bus, metro and three-wheeler,
- Non-mass transit includes car, taxi and two-wheeler, and
- Non-energy consuming forms of transport include walk, cycle and rickshaw.

PARAMETERS	BUSINESS AS USUAL	DENSIFICATION	MODAL SPLIT AND DENSIFICATION
Modal split	There is a 2.5 per cent shift from mass transit to non mass transit vehicles by 2020 and an additional 2.5 per cent shift to non-mass transit vehicles by 2050.	Modal split remains the same in 2020 and 2050 as in 2001.	There is a 2.5 per cent shift from non-mass transit to mass transit by 2020 and a further 2.5 per cent in 2050, except for Kolkata where modal split shift only by 0.5%[69].
Average travel per person in a day	The city continues to sprawl, thus the average distance travelled by a person increases by 2.5km in 2020 and additional 2.5km in 2050.	The average distance travelled by a person remains constant as in 2001. The city maintains its boundaries and builds vertically.	Revised mix land use policies mean that the average distance travelled by a person decreases by 1km in 2020 and additional 1km in 2050, except for Ahmedabad where distance travelled decreases by 0.5 Km[70].

[67]Kenworthy J, Townsend C. (June 2002), An international Comparative Perspective on Motorisation in Urban China – Problems and Prospects, IATSS Research
[68]Ibid.
[69]In Kolkata only 2% people use non mass transit modes of transport like cars and two wheelers. It is therefore not possible to decrease this usage by a significant amount
[70]In Ahmedabad the travel distance is already relatively small. It would be difficult to further reduce the travel distance by a significant amount

The scenarios have been mapped for the following cities:

PARAMETERS	DELHI	KOLKATA	AHMEDABAD
Population	The population of Delhi in 2007 has been estimated as 16.7 million. The Delhi government has projected that the population of the city will increase by 3 per cent per annum[71,72].	The population of Kolkata in 2002 was 14.9 million. The Kolkata government has projected that the population of the city will increase by 1.4 per cent per annum[73,74].	The population of Ahmedabad in 2003 was 4.8 million. The Ahmedabad government has projected that the population of the city will increase by 2.6 per cent per annum[75,76].
Modal split	The modal split of Delhi in 2007 was Mass Transit (32 per cent), Non-Mass Transit (23 per cent), Walk and cycle (45 per cent)[77] .	The modal split of Kolkata in 2002 was Mass Transit (82 per cent), Non-Mass Transit (2 per cent), Walk (16 per cent)[78].	The modal split of Ahmedabad in 2003 was Mass Transit (17 per cent), Non-Mass Transit (28 per cent) and Walk and cycle (55 per cent)[79].
Average travel per person in a day	The average distance of travel per person per day is 7.7 km[80].	The average distance of travel per person per day is 7.9 km[81].	The average distance of travel per person per day is 3.5 km[82].

Scenario Mapping

Note: Base years for different cities are different due to data unavailability, therefore projections not strictly comparable.

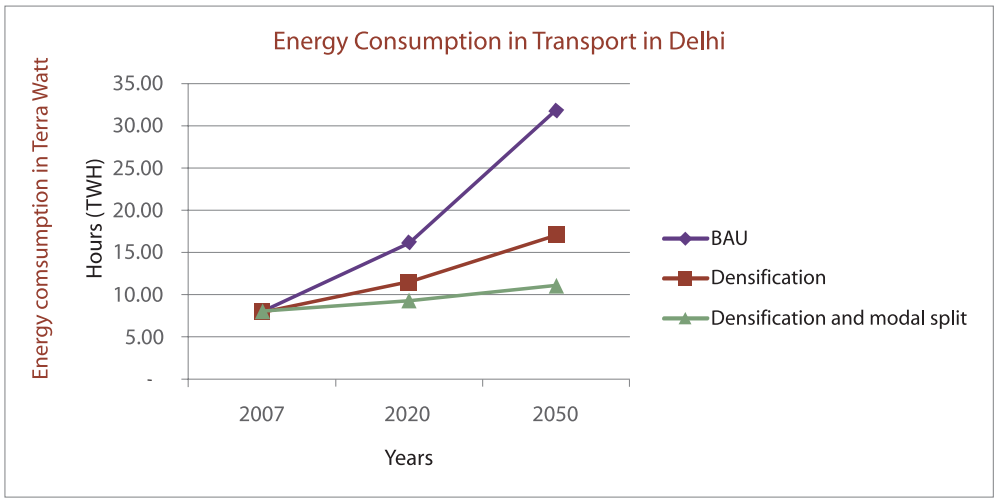


Figure 13: Energy Consumption in Transport Sector in Delhi

Source: MAPL Analysis

[71]Delhi Statistical Handbook 2006, Directorate of Economics and Statistics, Government of National Capital Territory of Delhi

[72]The population of Delhi as per 2001 census was 13,851,000. The Government of NCT of Delhi has projected the population growth at the rate of 3.2% annually until 2026. For the purpose of scenario mapping the population growth rate has been taken as 3.2% until 2015, 2% until 2030 and 1% until 2050.

[73]City Development Plan Kolkata 2006-2012, Jawaharlal Nehru National Urban Renewal Mission, Kolkata Municipal Corporation

[74]The population of Kolkata in 2001 as per Kolkata CDP was 14,720,000 and the projected growth at the rate of 1.6% annually until 2011, 1.5% until 2021 and 0.56% until 2035. For the purpose of scenario mapping the same population growth rate has been taken till 2035 and from 2035 until 2050 as 0.58%.

[75]City Development Plan Ahmedabad 2006-2012, Jawaharlal Nehru National Urban Renewal Mission, Ahmedabad Municipal Corporation and Ahmedabad Urban Development Authority

[76]The population of Ahmedabad in 2001 as per the CDP was 14,720,000 and the projected growth at the rate of 2.6% annually until 2035. For the purpose of scenario mapping the same population growth rate has been taken till 2035 and from 2035 until 2050 as 1.6%

[77]RITES Pvt Ltd(2007), RITES primary survey

[78]World Bank, India's Transport Sector: The Challenges Ahead, May 2002, Pg 59, table 9: Household Travel Characteristics in Various Cities

[79]RITES Ltd(2003), RITES Primary Survey

[80]World Bank, India's Transport Sector: The Challenges Ahead, May 2002, Pg 59, table 9: Household Travel Characteristics in Various Cities

[81]Ibid.

[82]Ibid.

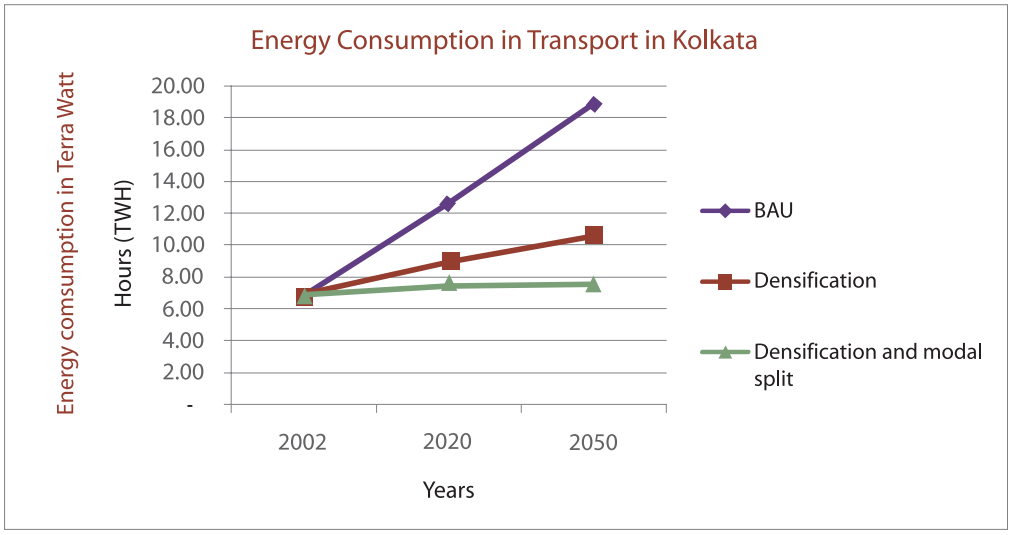


Figure 14: Energy Consumption in Transport Sector in Kolkata

Source: MAPL Analysis

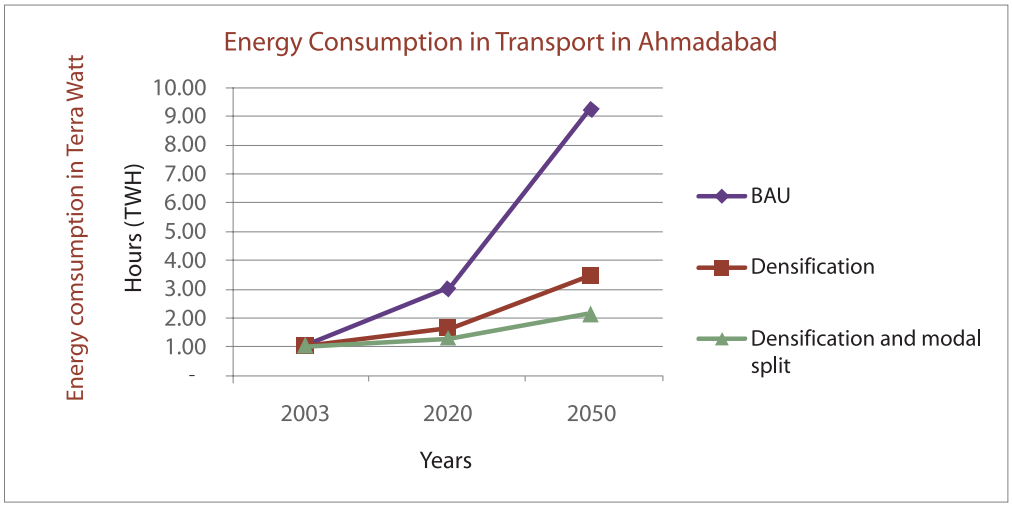


Figure 15: Energy Consumption in Transport Sector in Ahmedabad

Source: MAPL Analysis

As shown in the above scenarios, urban form and transport systems can have a large impact on the trajectory of energy use. This is especially true of sprawled megacities like Delhi. As India begins to urbanise more rapidly, it will need to act soon since the historical development of transport systems tends to hardwire cities for decades, if not centuries. Indeed the historical development of our cities' transport systems to a large extent defines their urban form.

3.2.3 importance of walkability

Much has been said about the importance of public transport systems vis-à-vis private vehicles. However, public transportation is almost always viewed in India in terms of buses, trains and so on. Walking is not seen as a means of transport. In fact, **walking is the single most important means of transport** in even large cities like Mumbai (see Figure 16). In smaller cities, distances are smaller making walking and cycling even more important as modes of transport. Furthermore, all forms of public transport require the 'last mile' to be walked. Thus, the apparent unwillingness of Kolkatans to walk is exaggerated by the data in the chart as it ignores the walk to the public transport stop. Without pedestrian connectivity, buses and rail networks cannot function efficiently. In short, walkability is critical to any urban design that aims for sustainability because of its impact on density, public transport and its own use as transportation.

So what is "walkability"? We define it as the ability of the average citizen to lead his/her life (work and leisure) by relying on walking as the main mode of transport. This involves infrastructure such

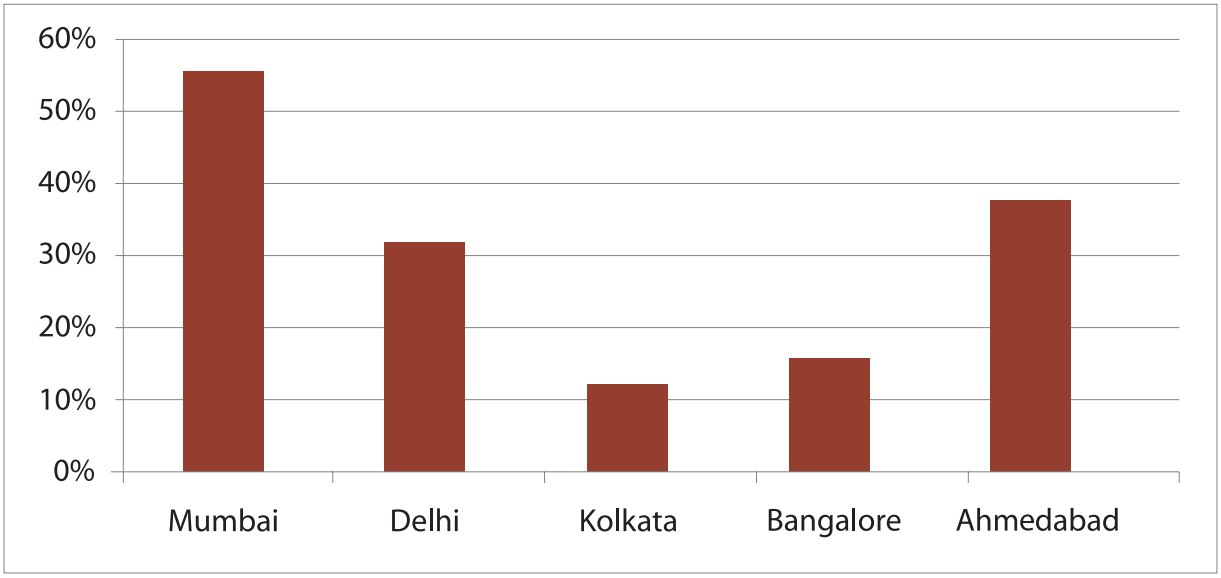


Figure 16: Percentage of People Who Rely on Walking in Indian Cities

Source: Urban Age, RITES[83]

as side-walks and foot-paths, under/over passes, shade, street-lights, safe road crossings, and more. Note, however, that this is not the same as pedestrianisation but a much broader framework of thinking. For instance, creating sidewalks in a sprawled urban form would not necessarily make the city walkable. Thus, embedded within "walkability" are several other concepts such as density, mixed use, public spaces, access to public transport, security and so on.

Note that the management of public spaces like parks and their integration into the walking experience are very important for walkability to work. Walkability is not just environmentally friendly but it is a way for making the city much more socially and economically vibrant and inclusive. Walking is accessible to all layers of society and is good for social cohesion; walking also has a positive impact on health. Similarly, we know how a vibrant street culture in cities like New York and Paris has been instrumental in giving them a "buzz"; this gives the cities a distinctive personality enhancing their attractiveness as locations, thereby also resulting in large economic benefits through improvements

[83] Urban Age, London School of Economics & Political Science (2008), 'Integrated City Making: Governance, Planning and Transport'; RITES Primary Survey (2004)

that follow in sectors ranging from real estate to tourism. In other words, walkability is very important for the success of a city. Public spaces provide the arena for all this interaction and must be tied into the logistics of walking.

In our view, therefore, walkability is the single most important paradigm that should be considered for urban planning. It is an excellent strategy to encapsulate social inclusion, health, public spaces, transportation, density and ecological sensitivity. Indeed, every effort should be made to embed it into the DNA of India's cities. Unfortunately, walkability is not given serious thought in India (see Box "Power to Pedestrians"). The focus in Indian cities seems to be on building roads and not in investing in infrastructure for non-motorised transport systems. Indeed, many Indian cities appear to be deliberately working against walkability. In many cases, side-walks have been swallowed by "road-widening" schemes. For example, in Delhi, the total funds allocated for the transport sector doubled from 2002-03 to 2006-07 – however 80 per cent of the earmarked money went towards schemes aimed at widening or extending roads in one form or another!

power to pedestrians[84]

The rich and powerful continue to enjoy special privileges and wield influence completely disproportionate to their numbers. They also appropriate a far bigger share of public expenditure than is justified. Power to the people, is a slogan now rarely heard. To many, all it means is electrification of homes! Yet, these four words have the force of history behind them. They connote a philosophy, a system of governance, which has swept across the globe, laying low many a king, feudal lord and dictator. Not all autocrats and despots have disappeared yet, but the idea of people's power has certainly shaken them.

Walking is a Form of Transport for a Majority of India's City Dwellers ©Verma, A.

Democracy is a necessary means of empowering people; however, to the extent it is restricted to voting, it is far from sufficient. Electoral democracy has many limitations — even drawbacks — especially when it degenerates into majoritarianism or unregulated licence. Oppression of the few by the many is, unfortunately, not an unknown by-product of democracy. Ironically, the reverse — small organised groups of hoodlums holding the majority to ransom (as in many bandhs and strikes) — is also facilitated by "democratic freedom" and encouraged by vote-bank politics. If empowerment of every individual is the goal, it is necessary to go beyond mere elections and ensure: participatory democracy; tolerance and encouragement of diversity in life-style and thought; decentralisation of political and economic power; and equitable access to information, communication and education.

Decentralisation — through the creation of a third level of formal governance by constitutional amendments empowering

[84] Karnik, K., The Economic Times (5 March 2009), pp 14

panchayats and urban local bodies —and the Right to Information Act have, together, given a huge boost to grass-roots democracy and accountability. Potentially, these are revolutionary steps in truly transferring power to the people. Yet, the actual realisation of this is stymied by many obstacles and sometimes contradicted by other measures. The rich and powerful continue to enjoy special privileges and wield influence completely disproportionate to their numbers; they also appropriate a far bigger share of public expenditure than is justified. The plight of the pedestrian is a good metaphor for this.

Political netas and corporate leaders are hardly ever seen walking in the streets of our cities (though a few do run on them during marathons). Therefore, pedestrians — mostly the ubiquitous but indefinable "common man" — get short shrift. Over the last few years, the motor car has been getting ever greater precedence over the pedestrian and the cyclist. Footpaths have been shrinking in a flurry of road-widening projects, and even existing cycle-lanes have disappeared. An attempt in Delhi to give precedence to cycles and buses through dedicated lanes (as part of a bus rapid transit system) has met tremendous resistance from motorists. Fortunately, following its success in Delhi, a "metro" (train) system is now being put in place in major cities. However, one is not sure if this is a genuine recognition of the dire need to create mass public transportation systems, or is merely the flavour of the day.

The doubt about decision-makers' serious commitment to efficient public mobility arises from the contrast between the hundreds of crores being spent on flyovers and road-expansion in cities, and the distinct miserliness and lethargy with regard to procurement of buses and facilities for pedestrians. The priority for cars at the cost of pedestrians is evidenced by the "free left turn" at traffic signals. While this facilitates the movement of vehicular traffic, the resulting continuous flow means that a pedestrian wanting to cross the road must either be capable of out-running Usain Bolt, or be a great believer in re-incarnation! Pedestrian over-bridges and skywalks would be solutions but these, unlike the proliferation of fly-overs, are a rarity. Escalators and lifts to help the aged or differently-abled to use overbridges — where they exist — are, of course, unaffordable, unlike fly-overs! Pedestrian subways are but few; in Delhi, the aspiring world-class city, they are so filthy and unsafe that no one uses them. This, but naturally, does not bother decision-makers.

In contrast, in many cities around the world, the pedestrian is getting increasing importance — and space. In London — a second home to many of India's rich and powerful — the width of the foot-paths on Oxford Street, for example, is probably double that of the road. Despite the very heavy traffic and constant congestion, no one even thinks of widening the road at the cost of the foot-path. In many other cities, particularly in Europe, large areas are "pedestrian-only" zones. The result, despite adverse weather for many months in the year, is far more walkers. Most people there walk to and from the nearest station or bus stop. In contrast, our shrinking, uneven and often non-existent footpaths discourage walking. Those who do walk are often left with no option but to use the road — disrupting traffic and risking injury. Little wonder that Indians prefer to use a car even for short distances. On the other hand, London and Singapore, amongst other cities, levy steep congestion charges on cars entering designated parts of the city, thereby discouraging use of private transport while reducing pollution and traffic density.

In most countries, public authorities and vehicle drivers respect pedestrian rights, giving walkers the right-of-way in many situations. In India, cars run on fuel power, but also on feudal power: they assume almost divine right-of-way everywhere. Government's actions — through its investment policy, priorities and its disdain for pedestrians — reinforce this sense of superiority. Even in Mumbai, a city in which the offspring of the upper-classes too used to travel to school or college by bus or the "local" (train), the change is perceptible; driven, doubtless, by the neglect and decay of a public transport system trying hard to retain its legendary efficiency.

To make "power to the people" beyond mere cliché, what better way than by empowering pedestrians? Here is an opportunity for the central and state governments to work closely with the third tier, the urban body, and initiate a major exercise in pedestrianisation; to put this in the same class, and with similar priority and resources, as building fly-overs or modernising airport terminals. Industry and civil society must play a major role in shaping this new societal architecture and life-style, one that is environment-friendly and empowering.

Source: Op-ed in The Economic Times by Kiran Karnik; the author is a strategy and policy analyst & President, India Habitat Centre

A few researchers have recently noted that the "general political neglect of walking" and the "marginalisation of footpaths" as major obstacles in promoting walking and cycling as a major means of transportation[85]. However, these are a tiny minority and the bulk of the debate totally ignores this issue. Indeed, our survey of city development plans across India found that there is very little mention of walkability or of pedestrians. Many of the plans do not mention them at all (see Annexure 5).

During our research, we learnt that most municipal officials, academics and planners do not even consider walking as transportation. When prodded, they responded that Indians do not like to walk except under compulsion. Others argued that India's weather is not conducive to walking[86]. Yet a large proportion of Indians walk. A 2008 study of 30 cities showed 16-57 per cent of all trips involved no vehicles at all (see Figure 17)[87]. Smaller cities and hill towns, where walking commands a greater share of trips, figured at the higher end of this classification. Bigger cities have fewer people relying only on walking although more people use public transport and presumably walk the 'last mile'.

Brand New Roads in Delhi and Gurgaon Do Not Cater to Pedestrians © Verma, A

CITY CATEGORY	POPULATION	WALK	CYCLE	TWO WHEELER	PUBLIC TRANSPORT	CAR	IPT/AUTORICKSHAW
Category 1-a	< 0.5 million (plain terrain)	34	3	26	5	27	5
Category 1-b	< 0.5 million (hilly terrain)	57	1	6	8	28	0
Category 2	0.5 -1 million	32	20	24	9	12	3
Category 3	1 - 2 million	24	19	24	13	12	8
Category 4	2 - 4 million	25	18	29	10	12	6
Category 5	4 - 8 million	25	11	26	21	10	7
Category 6	> 8 million	22	8	9	44	10	7
National		28	11	16	27	13	6

Figure 17: Transport Mode Share (%), 2007 Source: Wilbur Smith Associates[88]

[85] Urban Age, London School of Economics & Political Science, 'integrated City Making: Governance, Planning and Transport'

[86] We consider the "weather" argument especially absurd. It is true that India is very hot in summer but walking in the heat is no more uncomfortable than walking in the cold of Northern Europe in winter. In any case, people are willing to walk in hot tropical cities like Singapore (which, unlike most of India, is hot and humid all year round and suffers thundershowers almost every day). We feel, therefore, that the real issue for India is the quality of walking infrastructure.

[87] Wilbur Smith Associates (sponsored by Ministry of Urban Development), 2008, "Traffic and Transportation Policies and Strategies in Urban areas in India"; data may not be directly comparable with those from other sources.

[88] Data may not be comparable with estimates by other agencies

The study commissioned by the Ministry of Urban Development, assessed footpaths and overall infrastructure, including pedestrians' ratings of the facilities. It indexed cities for Walkability (see Figure 18). The national average was 0.52; Chandigarh came on top with 0.91. By comparison, large international cities such as London score 1.5 to 1.7. Smaller cities in Europe often do better. In short, Indians walk despite the poor pedestrian infrastructure.

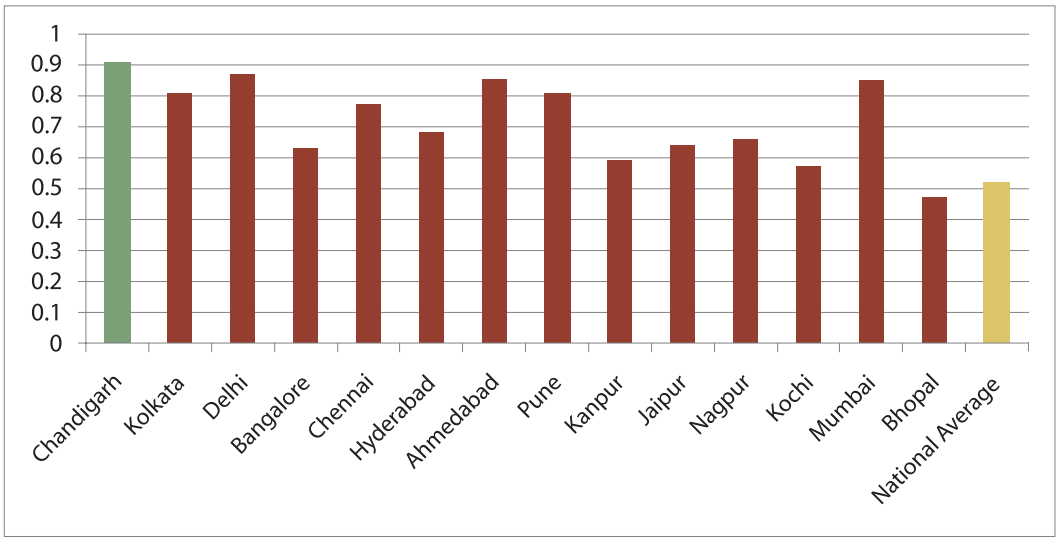


Figure 18: Walkability Index[89] Source: Wilbur Smith Associates[90]

WALKABILITY IS NOT JUST ENVIRONMENTALLY FRIENDLY BUT IT IS A WAY FOR MAKING THE CITY MUCH MORE SOCIALLY AND ECONOMICALLY VIBRANT AND INCLUSIVE. MANAGEMENT OF PUBLIC SPACES LIKE PARKS AND THEIR INTEGRATION INTO THE WALKING EXPERIENCE ARE VERY IMPORTANT FOR WALKABILITY TO WORK

[89]Walkability Index is calculated as [(W1 x Availability of footpath) + (w2 x Pedestrian Facility rating)]; Where, w1 and w2: Parametric weights (assumed 50% for both); Availability of footpath: Footpath length /Length of major roads in the city; Pedestrian Facility Rating: Score estimated based on opinion on available pedestrian facility

[90]Wilbur Smith Associates (sponsored by Ministry of Urban Development), 2008, "Traffic and Transportation Policies and Strategies in Urban areas in India"

3.3 buildings

Buildings are responsible for up to 40 percent of energy used in most countries[91]. Comparable data is not available for India but TERI's calculations suggest that it would account for around 15% (residential plus commercial). This may be mostly a reflection of fact that a large part of the population still lives off the power grid or lives in traditional homes in rural areas. Even in urban areas, a large part of the population has either limited access or cannot afford energy-consuming appliances and household gadgets. All this will change with affluence and therefore we need to think about the future of building construction/design as well as about retro-fitting existing structures.

Another important difference with countries that are already urbanised and have a large existing stock of buildings is that India is now spending more energy in construction rather than on running buildings. It is estimated that about 20 to 25 per cent of India's total national energy demand is generated by the manufacturing materials required in the building sector, while only 15 per cent goes into the running needs of the buildings. Of course, this will change over time as the mix of new and existing buildings changes. For now, there may be large gains from improving the industrial processes that produce building material.

Modelling of industrial processes is beyond the scope of this report, so we have focused on building design. Research conducted by the Ministry of Power, Government of India, points out that about 20 to 25 per cent of the total electricity utilised in government buildings in India is wasted due to unproductive design features of buildings[92]. So, should we give priority to enforcing "green" building codes?

3.3.1 energy consumption in buildings sector

The energy demand of the building sector of a city is determined by the following factors:

1. **Increase in Urbanisation**

   When people shift from rural to urban areas, the demand for housing increases.

2. **Economic Development and Rising Incomes**

   Economic development and rise in incomes results in an increase in the demand for housing.

3. **Urban Form and Regulatory Roadblocks**

   A study conducted in New York City showed that low-density suburban development is more energy and GHG intensive (by a factor of 2.0–2.5) than high-density urban core development on a per capita basis. When the functional unit is changed to a 'per unit of living space' basis the factor decreases to 0.67. In India, the legal Floor Space Index (FSI) in many cities is very low which prohibits people from building high rise buildings. Legally, in Mumbai it is as low as 1.33 as compared to 12 in New York and 17 in Shanghai (of course, Mumbai still has a very high population density but this is achieved through illegal construction, slums and extreme compromises on personal space). In addition, many Indians continue to prefer staying in single-family houses rather than high rise apartments.

[91] Energy Efficiency in Buildings, Business realities and opportunities, WBCSD (July 2008)

[92] Palit, D. (June 2004), 'Green Buildings', An Occasional Paper Prepared for World Energy Efficiency Association, The Energy and Resources Institute (TERI)

4. Construction Materials and Use of Appliances

According to a World Business Council for Sustainable Development (WBCSD) study, manufacturing, construction, transport of material, and, maintenance and renovation consume 16 per cent of total energy consumption during the full life of a building. The rest of the 84 per cent of energy is consumed by the use of various appliances on a day to day basis in the building like, heating, ventilation, cooling, computers, cooking etc. For the purposes of our scenario analysis we have ignored the energy use of inputs into building construction. This requires modeling of industrial processes that is beyond the scope of this report.

3.3.2 energy consumption by buildings: paths to 2050

This section will provide different scenarios or ways in which selected cities in India could develop in the future. The modeling framework chosen by the study is based on established literatures, for instance a report by WBCSD "Energy Efficiency in Building, Business Opportunities and Realities". This report takes these studies as starting points in developing its methodology for computation of future energy demand in chosen cities in the country.

ENERGY CONSUMPTION IN BUILDINGS SECTOR

Energy consumption in buildings = Urban population X per capita energy consumption

Where Per capita energy consumption is a factor of per metre square of floor space as well as application of green technologies in buildings

The estimations have been done for Delhi, Kolkata and Ahmedabad, and are based on the following assumptions:

- Per capita energy consumption of a person residing/working in a building in a city in India was 2014 KWH per annum (this includes energy used for space heating and cooling, water heating, cooking and lighting in buildings)[93] in 2001.
- Energy consumption increases at the rate of increase in per capita income of people[94].
- Based on discussions with leading architects in India, it has been determined that the greening of single-family homes would yield energy savings of approximately 15% with current or foreseeable green technologies.
- Densification of buildings has the potential to yield much larger energy savings. This is based on 2 factors:

1. Energy consumed per capita during the construction of densified buildings is significantly lower than that consumed during the construction of individual homes. This model does not account for energy consumption during construction (i.e. we are being conservative).
2. Energy consumed per capita from the operation of a building is reduced by approximately

[93] Nakagami, H. (2006) 'International Comparison of Residential Energy Consumption', Jyukankyo Research Institute Inc., Fig.3, Energy consumption per household by end use

[94] Goldman Sachs(2003), Global economics paper No 99; Dreaming with BRICs: The Path to 2050

30% for a multi-family dwelling (or large commercial blocks) even without applying specifically green technologies. However, integrating green technologies/design with densified buildings yields further energy savings of approximately 10%.

- The population of Delhi in 2001 was 13.8 million. The Delhi government has projected that the population of the city will increase by 3 per cent per annum[95] .
- The population of Kolkata in 2001 was 14.7 million. The Kolkata government has projected that the population of the city will increase by 1.4 per cent per annum[96].
- The population of Ahmedabad in 2001 was 4.6 million. The Ahmedabad government has projected that the population of the city will increase by 2.6 per cent per annum[97].

BUSINESS AS USUAL (BAU)	GREENING	GREENING + DENSIFICATION
The current urban form is perpetuated.	Greening of low-density units only. Green codes applied to 40% of potential in 2020 and 80% of potential in 2050.	A deliberate shift towards higher density combined with green codes. Green codes applied to 40% of potential in 2020 and 80% of potential in 2050.

Scenarios:

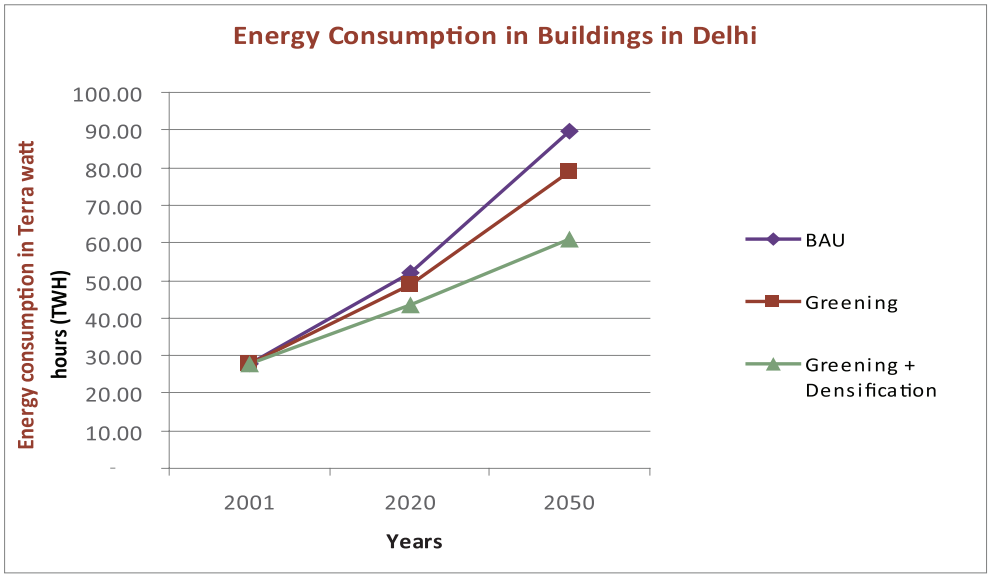


Figure 19: Energy Consumption in Buildings Sector in Delhi

Source: MAPL Analysis

[95] Delhi Statistical Handbook 2006, Directorate of Economics and Statistics, Government of National Capital Territory of Delhi

[96] Kolkata Municipal Corporation, 'Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Kolkata 2006-2012'

[97] Ahmedabad Municipal Corporation and Ahmedabad Urban Development Authority and CEPT University, Ahmedabad, 'Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Ahmadabad 2006-2012'

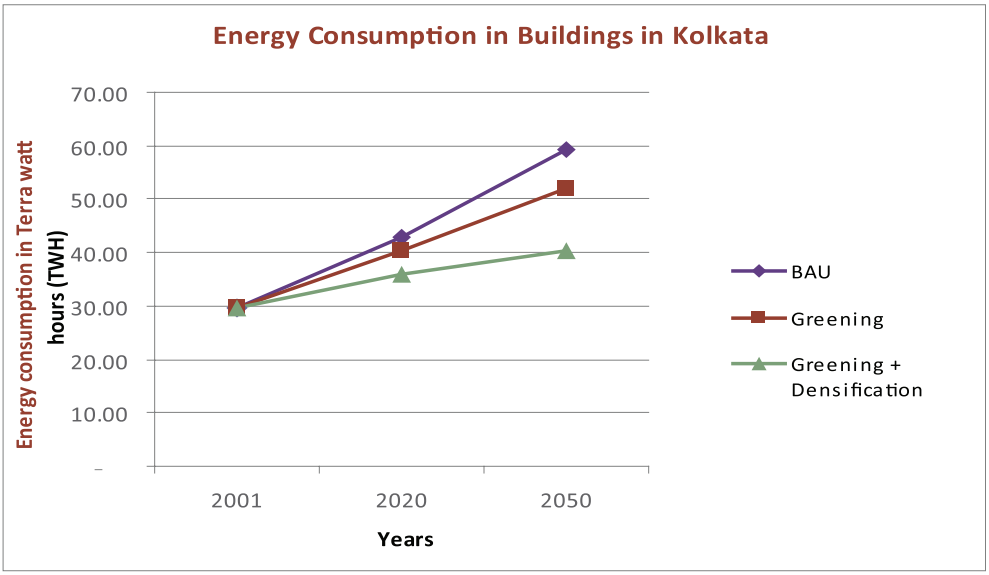


Figure 20: Energy Consumption in Buildings Sector in Kolkata

Source: MAPL Analysis

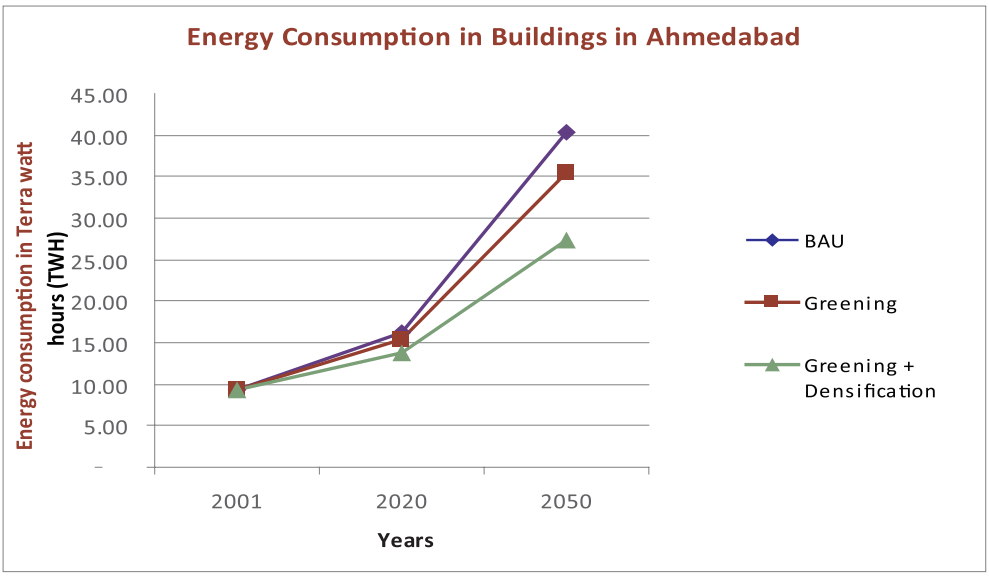


Figure 21: Energy Consumption in Buildings Sector in Ahmedabad

Source: MAPL Analysis

3.4 waste

Urban residents on the whole produce more waste than their rural counterparts. Higher per capita incomes in urban areas translate into higher consumption patterns, and thus higher per capita waste generation. Waste generation is usually expressed as Municipal Solid Waste (MSW)[98]. London and Shanghai generate 11,367[99] and 14,794 tonnes[100] of MSW per day respectively. In comparison, Delhi and Mumbai generate over 7,000 MSW[101] tonnes per day while cities like Bangalore generate 1,742 MSW[102] and Indore 500 MSW[103] tonnes per day. (See Figure 22)

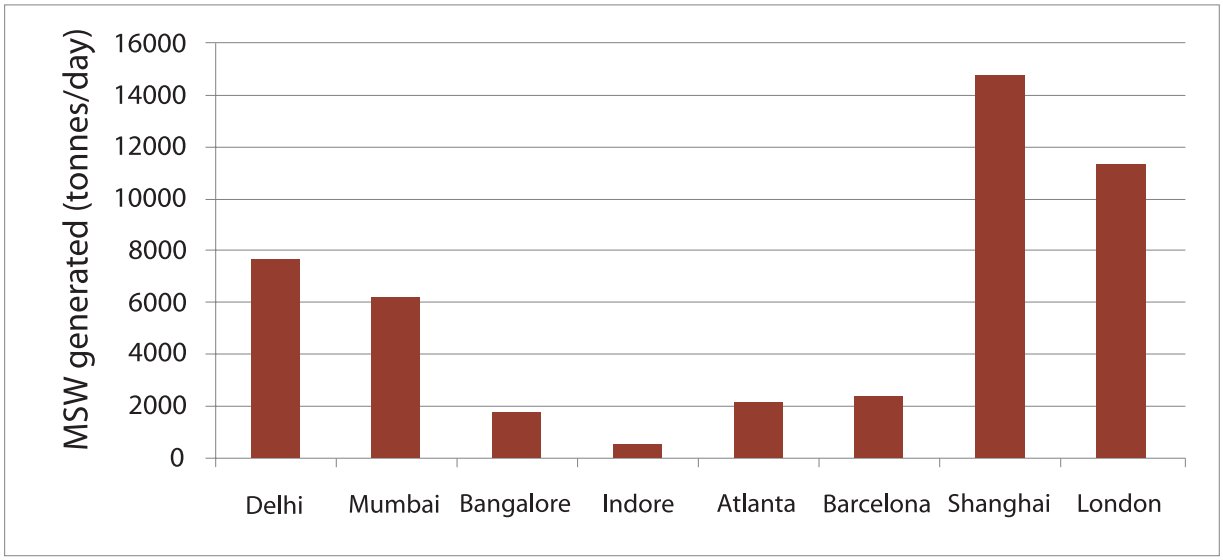


Figure 22: Total Municipal Solid Waste Generation Per Day

Source: MAPL Analysis[104]

While Indian cities might generate a lot less waste per capita than their peers, the level is rising. Moreover, Indian cities lag in waste management techniques. In Indore, for example, poor management techniques from collection to transportation to disposal meant that waste collected is dumped approximately 7 km from the city, and 70 per cent[105] of solid waste is disposed off on the streets. This results in a number of undesirable and harmful consequences not just for the environment but also the general health of the city's population. In Delhi, much of the existing dumping sites are now saturated and no new ones have been developed. And whilst treatment facilities are almost negligible, a large share of untreated waste is disposed off in the river Yamuna.

An important step in the waste management process is recycling, and in Indian cities much of the recycling is carried out by an informal economy primarily comprising rag-pickers. In Delhi,

[98]Solid waste is defined as any solid material intentionally discarded for disposal, however much of this waste, such as recyclables is valuable to someone else and can be extracted from the waste stream.

[99]Capitalwastefacts.com, 'Londonwide Fact File'

[100]World Bank, Urban Development Working Papers, Waste Management in China: Issues and Recommendations (May 2005)

[101]New Delhi Municipal Corporation, 'Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Delhi, 2006-2012'; Kansal, S., 'Urbanisation And Municipal Solid Waste Management: A Case Study Of Mumbai'

[102]Bangalore Municipal Corporation, 'Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Bangalore; 2006-12', pp 78

[103]Indore Municipal Corporation, 'Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Indore, 2006-2012', pp 43

[104]New Delhi Municipal Corporation, 'Jawaharlal Nehru National Urban Renewal Mission, Delhi: City Development Plan Delhi, 2006-2012'; Mumbai: Kansal, S., 'Urbanisation And Municipal Solid Waste Management: A Case Study Of Mumbai', IGIDR, Mumbai; Bangalore: Bangalore Municipal Corporation, 'Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Bangalore, 2006-2012'; Indore: Indore Municipal Corporation, ' Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Indore, 2006-2012'; Atlanta: World Bank, Site Resources, Atlanta (United States); Barcelona: Official website of the city of Barcelona , Department of Statistics (2007); Shanghai: World Bank, Urban Development Working Papers, Waste Management in China: Issues and Recommendations (May 2005); London: Capital Waste Facts; Headline Waste Data (2007/2008)

[105]Indore Municipal Corporation , 'Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Indore; 2006-2012', pp 43

approximately 100,000-150,000 rag-pickers currently collect 12-15 percent of the 7,700 tonnes of waste generated daily[106]. In Mumbai 100,000 rag-pickers collect and sell re-usable waste worth Rs.900 million every year[107]. Although the work carried out by the rag-pickers is an important and efficient part of waste management in India, the sector is wholly unorganised and is often based on social exploitation that is not acceptable. Based on the experience of developed countries, the

The Yamuna River Near Delhi © Jha, V.

World Bank forecasts trends for India and China compared to that of the US. Total municipal waste generation in India is expected to grow from 70 million tonnes in 2000 to 250 million tons by 2030, surpassing that of today's United States[108]. Keeping in mind the relationship between economic growth, urbanisation and the generation of waste, developing country cities will have to contend with managing much higher levels of absolute and per capita waste tonnage in the coming years.

3.4.1 transforming waste to energy

Not only can proper waste management save energy, it can also produce additional energy. The following methods can be adopted to achieve this additional energy production:

1. Energy Saving:

   Recycling is now globally accepted as the most efficient way of managing waste. Producing paper, glass, plastics and extracting metals from ores is much more energy intensive than recycling and reusing[109]. According to a study by Waste & Resources Action Programme

[106] United Nations Habitat Settlement Programme; A Report on 'Urban Environment Waste'

[107] Kansal, S., 'Urbanisation And Municipal Solid Waste Management: A Case Study Of Mumbai'

[108] World Bank (May 2005), Urban Development Working Papers, 'Waste Management in China: Issues and Recommendations'

[109] Sinha, S. (2008), Associate Director; ToxicLinks

(WRAP), up to 95% energy reductions can be achieved from recycling waste materials[110].

Material	% Reduction of energy
Aluminium	95
Paper	40
Glass	30
Steel	60
Plastic	70

Recycling also reduces emissions of pollutants that can cause smog, acid rain and the contamination of waterways. In India most of the recyclable waste is collected and recycled by the informal industry. Since there is no information available on how much waste is actually recycled in the city by both the formal and informal sector it is difficult to estimate the energy saving in Delhi as a result of recycling.

2. Energy Production:

The two main options available for energy production from waste are recovery of biogas, and energy by firing of MSW as fuel. The potential electric power generation from Delhi's MSW in 1998 was estimated at 80.13 MW and 30.78 MW respectively at 70 per cent collection efficiency of MSW[111].

3.5 water

Good water supply and sanitation facilities are essential for the basic functioning of a city. Access to safe drinking water and adequate sanitation can have knock-on effects on improvements in health, increases in incomes and consumption, social and gender inclusion and educational improvements[112]. However, Indian cities, like many others in developing countries, struggle to provide their citizens with this basic amenity.

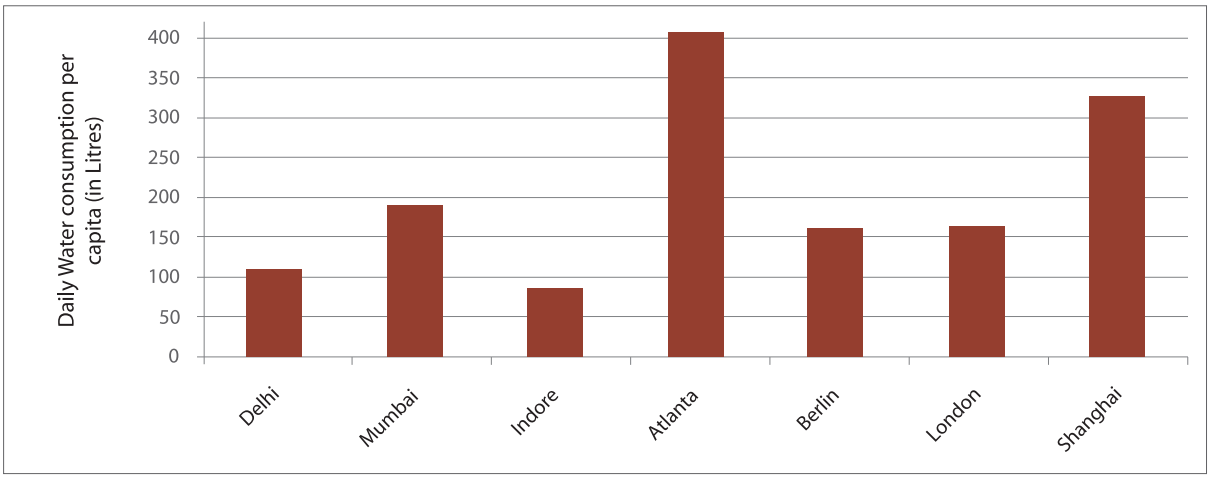


Figure 23: Per Capita Consumption of Water per Day

Source: MAPL Analysis[113]

[110] The Economist (June 2007); 'The Truth about Recycling'; Original Study by Waste & Resources Action Programme

[111] Ramakrishna, V. and Babu, B.V.; Birla Institute of Technology & Science; Energy Recovery From Urban Solid Wastes

[112] World Bank (2006), 'A Guide to Water and Sanitation Sector Impact Evaluations', Washington DC

[113] Delhi, Mumbai, Indore: Asian Development Bank (2007), Benchmarking and Data Book of Water Utilities in India ; Atlanta: USGS, Science for a Changing World, Rain A Water Resource; Berlin, London, Shanghai: Urban Age, London School of Economics & Political Science, 'Integrated City Making: Transport, Planning & Governance'

As seen in Figure 25, the current per capita consumption of water in cities like Mumbai (191L)[114] and Shanghai (362L)[115] are already far above that in developed country cities such as London (164L)[116] and Berlin (162L)[117]. Again, urban form seems to matter with Atlanta using a lot more water than Berlin and London.

The relatively high consumption rates for India are especially worrying since the supply is erratic and not everyone has regular supply. Note that the problem is not always that of availability. Delhi, for example, has enough water to fulfill the needs of its entire population, but a poor distribution mechanism and an absurdly high rate of leakage means that a significant proportion of its citizens are denied access to water[118].

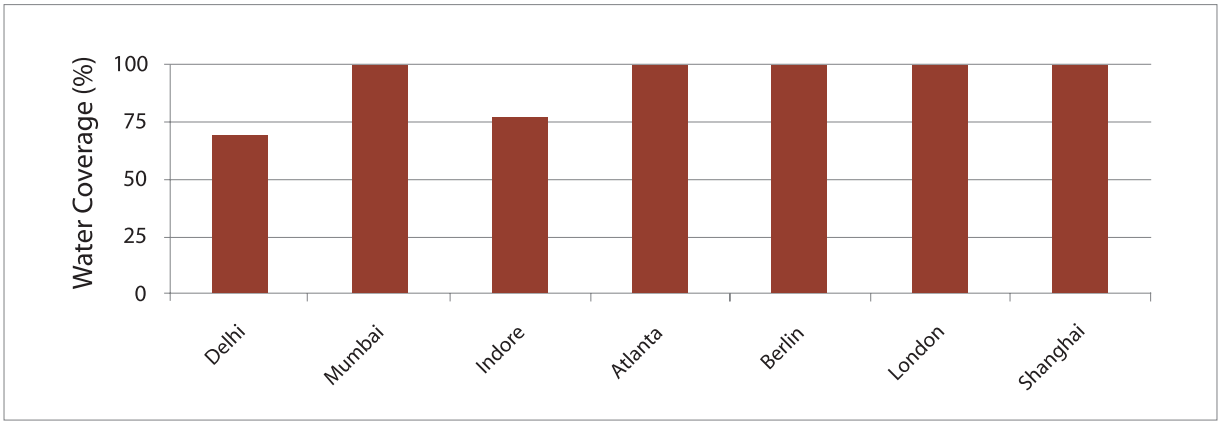


Figure 24: Water Coverage for Select Cities

Source: MAPL Analysis [119]

Non-revenue water refers to the amount of water that is lost on the way from production to consumption – owing to leakages, thefts or metering inadequacies. Delhi[120] and Indore[121] lose about 50 per cent of their water production, whereas Mumbai and Shanghai perform somewhat better with losses at 25 per cent[122] and 17 per cent[123] respectively. However, Berlin has losses at a mere 3 per cent[124] of its total water production while Singapore not only loses only 2.5% but is able to reuse a lot of the sewage water (called "Newater"). The point is that water scarcity in many Indian cities is not due to the lack of water but the lack of governance and management.

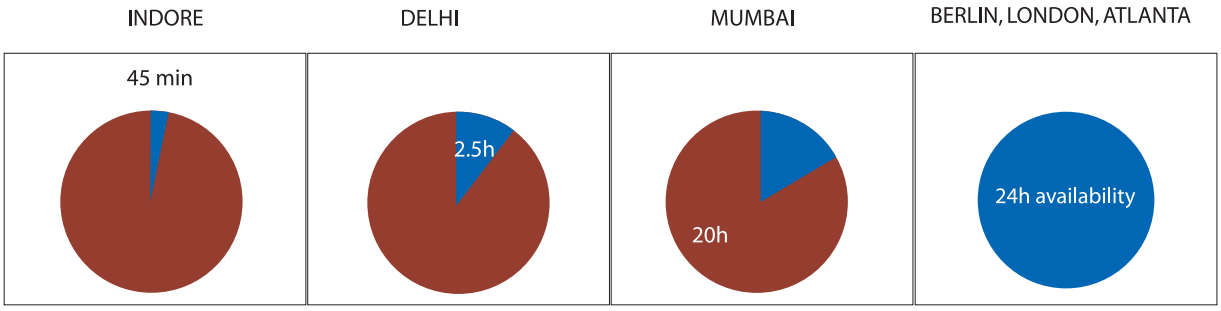


Figure 25: Average Water Availability per Day

Source: MAPL Analysis [125]

[114]Asian Development Bank (2007), '2007 Benchmarking and Data Book of Water Utilities in India', pg 79

[115]Asian Development Bank (2004), 'Water in Asian Cities, Utilities Performance and Civil Society Views'

[116]Urban Age, London (2006), 'General – Water Consumption'

[117]Urban Age, Berlin (2006), 'General – Water Consumption'

[118]WaterAid, Delhi

[119]Delhi, Shanghai: Asian Development Bank (2004), 'Water in Asian Cities, Utilities Performance and Civil Society Views';Mumbai, Indore: Asian Development Bank (2007) Benchmarking and Data Book of Water Utilities in India ; Atlanta, Berlin, London: assumed to be 100 per cent

[120]Asian Development Bank (2004); 'Water in Asian Cities, Utilities Performance and Civil Society Views'

[121]Indore Municipal Corporation, 'Jawaharlal Nehru National Urban Renewal Mission, City Development Plan Indore, 2006-2012', pp 16

[122]Municipal Corporation of Greater Mumbai, 'Water Sector Initiatives'

[123]Asian Development Bank (2004) 'Water in Asian Cities, Utilities Performance and Civil Society Views'

[124]Wittenberg, D., Berlinwasser International (2004), 'Non-Revenue Water Reduction Programme', pp 23

[125]Indore, Delhi and Mumbai: Asian Development Bank (2007), Benchmarking and Data Book of Water Utilities in India; Berlin, London, Atlanta: Urban Age, London School of Economics & Political Science 'Integrated City Making: Governance, Planning and Transport'

3.5.1 water scenario in delhi in 2050

The estimation of a scenario for Delhi in 2050 has been done using the following assumptions:

- Population of Delhi was 13.8 million in 2001,[126]
- Per capita demand of water in 2001 was 110L per day[127] or 0.00004015 Cubic Metres annually,
- Total production of water in Delhi was 1,044 Million Cubic Metres (MCM) in 2001[128],
- 45 per cent water is lost due to leakage and no metering[129],
- Total supply of water = Total water production – Leakage; this amounts to 573.65 MCM, and
- Total water shortage = Total supply – Total demand; in 2003, the supply was 17 MCM in excess of the demand.

Reducing Leakage to 10 per cent	**422.415**
Waste Water Treatment	**200**
Water Harvesting	**150**

Figure 26: Potential for Increasing Supply (Million Cubic Metres)[130]

ASSUMPTION	BUSINESS AS USUAL (BAU)	OPTIMISED	REVOLUTIONARY
Supply of water	Total supply of water remains the same	50 per cent of water leakage opportunity is captured by 2050. 50 per cent of water harvesting opportunity is captured 50 per cent of waste water treatment opportunity is captured	All of water leakage opportunity is captured All of water harvesting opportunity is captured. All of water waste treatment opportunity is captured

[126]Directorate of Economics and Statistics, Government of National Capital Territory of Delhi, Delhi Statistical Hand Book 2006

[127]Asian Development Bank (2007), Benchmarking and Data Book of Water Utilities in India

[128]Asian Development Bank (2004), Water in Asian Cities, Utilities Performance and Civil Society

[129]Ibid.

[130]Soni, V., (November 2003), 'Water and Carrying Capacity of a City: Delhi', Economic and Political Weekly

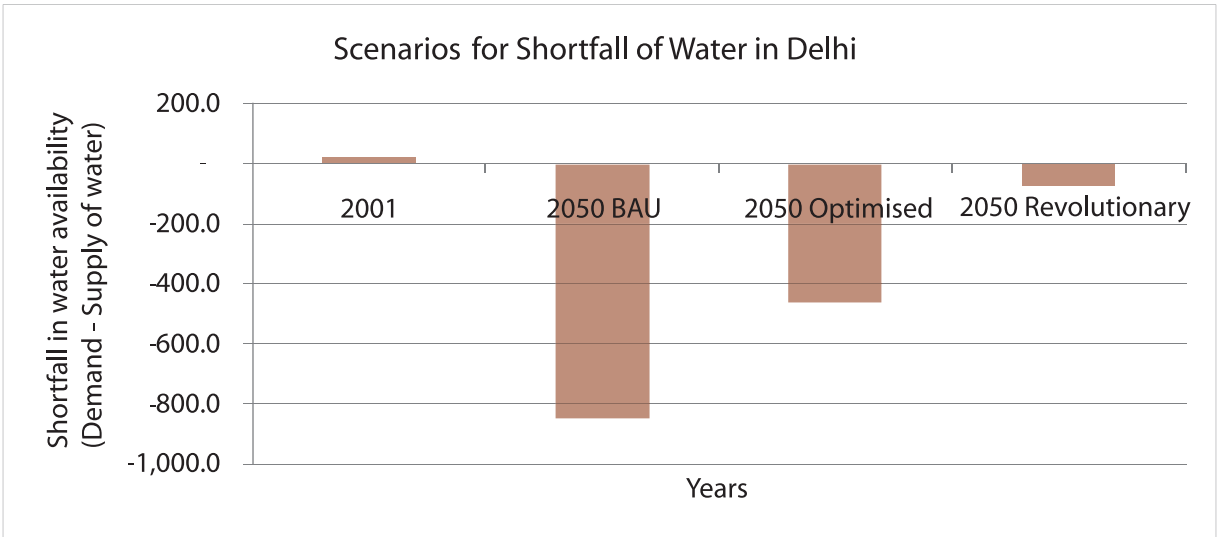


Figure 27: Scenarios for Shortfall of Water in Delhi

Source: MAPL Analysis

Our analysis suggests the fundamental cause of Delhi's water problems lies in governance and management and not in the availability of water. This is true of most of the country's water starved towns. As we will discuss in the next chapter and in the appendix, the problem of governance is a complex one and requires a great deal of attention. If it is not resolved, cities like Delhi will have to rely on increasingly expensive solutions or seriously think about shrinking population. Readers should remember that a previous incarnation of Delhi, the city of Tughlakabad, was abandoned because of water shortages in the fourteenth century. In addition, note that even issues such as water supply and waste management are closely linked to urban form. One of the biggest problems with water distribution and sewage management is the complex systems of piping that need to be maintained. A dense urban form can dramatically reduce the size of the required network. In other words, urban form is not just energy efficiency but also feeds into other aspects of environmental sustainability.