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URBAN INDIA AND CLIMATE CHANGE: MITIGATION STRATEGIES TOWARDS INCLUSIVE GROWTH

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Abstract
Climate change has been emerged as a major challenge for the sustainable human settlement. The recent studies have established scientific evidences for climate change. This paper presents impacts of climate change in the urban India, which has about 30 percent of population and expected to grow over 800 million by next 50 years.
Citizens are already facing adverse impact of climate change, which is evenly spread throughout the country and mostly to vulnerable citizens. India's expenditure on adaptation measures was exceeded 2.6 percent of the GDP in 2006-07 shows the magnitude of monetary loss by climate change. Due to complexity of issues, systematic strategies are needed for adaptation and mitigation. In the light of 'National Action Plan on Climate Change' two urban sectors viz. urban transportation and municipal solid waste management are assessed and suggestions have been made for mitigation strategies.
This study is broadly based on published researches and documents. Findings reveal that yet the climate change is not taken seriously by policy makers, hence blue print for mitigation haven't placed. Findings suggest systematic mitigation measures for sustainable development which will lead to inclusive growth too. The need for collaborative planning among various stakeholders is emphasized.
Keywords: Climate change, urban India, mitigation, urban transportation, municipal waste management.

1. INTRODUCTION

Climate change has been extensively discussed in academic as well as in political domain. The affect of climate change have been observed across the globe. It has been affecting mostly to the vulnerable section of society as they have poor adaptation capability (Revi, 2008). As per Indian report, India's expenditure on adaptation measures was exceeded to 2.6 percent GDP of 2006-07. The flood, drought, disaster and urban chaos have started to occur frequently. All these needed strong adaptability capability both at individual and public agencies level. Adaptation is not the ultimate solution but a reaction measures, the solution lies in Greenhouse Gas (GHG) reduction to optimum level.

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Two sample sectors, urban transportation and municipal solid waste are selected for the analysis; these sectors are representative and selected based on the magnitude of energy consumption and the available scope. Keeping its energy consumption and relatively low adaptation options within these sectors, mitigation options are discussed in detail.

India which is known for rural population, but its urban population are growing fast and it is expected to reach over 800 million by mid of this century (Ribeiro, 2003). The problems associated with urbanization will increase due to increase in urban population as well as increase in large size cities. Cities which import energies and export waste needed optimization for sustainability. The objectives of this paper are to assess both the selected sample sectors and to suggest proper planning intervention especially in the light of mitigation. Following section explains climate change and its impacts; section 3 presents urbanization scenario in India, section 4 explains underpinnings of national action plan their principles and missions. Section 5 and 6 explore issues and strategies regarding urban transportation and municipal solid waste management respectively. And finally conclusions are presented with argument that mitigation will lead both environment friendly cities as well as inclusive growth.

2. CLIMATE CHANGE AND ITS IMPACTS

It is expected that climate change will increase both mean minimum and maximum temperature by 2-4º C (Roy, India et al., 2006; Sharma, Bhattacharya et al., 2006), which implies mean surface temperature rise by 3.5-5º C by the end of this century (Table 1). Temperature rise lead to mean increase 7-20 percent in annual precipitation. A 10-15 percent increase in many regions and simultaneous decline of 5-25 percent in drought prone areas (Ramesh and Yadava, 2005; Roy, India et al., 2006). This increase in temperature and consequently change in precipitation will effect drinking water shortage and increase in food and biomass fuel prices in urban India (as well as rural India). This will further depress demand of urban sectors good and services and also accelerate migration towards cities. The increase in temperature and consequently increase in precipitation with addition of high peak monsoon will increase river line and inland flooding.

TABLE 1 - CLIMATE CHANGE PROJECTIONS FOR INDIA BASED ON AN ENSEMBLE OF FOUR GCM OUTPUTS

	Temperature change (°C)			Precipitation change (%)			Sea-level rise in cm.
Year	Annual	Winter	Monsoon	Annual	Winter	Monsoon	
2020s	1.36±0.19	1.61±0.16	1.13±0.43	2.9±3.7	2.7±17.7	2.9±3.7	4–8
2050s	2.69±0.41	3.25±0.36	2.19±0.88	6.7±8.9	2.9±26.3	6.7±8.9	15–38
2080s	3.84±0.76	4.52±0.49	3.19±1.42	11.0±12.3	5.3±34.4	11.0±12.3	46–59

Source: (Aggarwal and Lal, 2000)

3. THE URBANIZATION SCENARIO OF INDIA

The census of India defines urban areas as (a) all places with Municipal Corporation, Municipal Council/Committee, Nagar Panchayat or Cantonment Board or notified town area, and (b) all places having minimum 5,000 populations, a density not less than 400 persons per square kilometre, and at least three fourths of the adult male population employed in pursuits other than agriculture. As per census data of 2001, out of 1.02billion population 285million or 27.8 percent live in the urban area spread into 5,161 towns. The urban decadal population has increased by 2.1 percent. The urbanization pattern varies across the provinces and cities. Delhi has the highest urban population that is 93 percent, while Himachal Pradesh has the lowest urban population merely 9.8 percent. There are 27 cities with more than 1 million population, while the Urban Agglomeration (UAs)/Cities with population more than 1 million number 35 (Table 1). It is noteworthy that about 37 percent of urban population live in UAs/Cities (Table 2). During last decade 1991-2001, decadal population growth in urban and rural areas is 17.9 percent and 31.4 percent, shows relatively high growth of urban area. The urbanization patterns, which are mostly concentrated in UAs/Cities provide enormous pressure on urban amenities and causes a number of urban problems like, transportation, infrastructure, solid waste management, exclusive growth.

TABLE 2 - GROWTH OF METRO CITIES (1961-2051)

Year	Number of Metro Cities	Population of Metro Cities in millions	Population of Metro Cites as % of Urban Population	Population Growth Rate of Metro Cities
1951	5	11.66	18.9	121.7
1961	7	17.85	23.0	53.1
1971	9	27.42	25.6	53.6
1981	12	42.02	26.9	53.2
1991	23	70.68	32.5	68.3
2001	35	107.86	37.2	52.6
2051*	100	398.00	39.8	**53.1

*(Ribeiro, 2003) ** Average per decade over the five decades

TABLE 3 - NUMBER AND POPULATION (IN MILLIONS) OF URBAN AGGLOMERATIONS AND TOWNS (1951-2051)

Year	Number of UA/Towns	Urban Population	% of Total Population	Decennial Urban Growth (%)
1951	2,843	62	17.3	-
1961	2,365	79	18.0	26.4
1971	2,590	109	19.9	38.2
1981	3,378	160	23.3	46.1
1991	3,768	217	25.7	36.5
2001	3,969	285	27.8	31.4
2051*	6,500	820	47.50	**37.5

*(Ribeiro, 2003), ** Average per decade over the five decades

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4. NATIONAL ACTION PLAN, PRINCIPLES AND MISSIONS

National action plan was formulated based on country's current circumstances, especially in the shed of energy deficiency. In India 44 percent citizens have no electricity supply and about 34 percent citizens are not able to earn a dollar. Beside all this, India's fast growth rate Gross Domestic Product (GDP) about 8, and human capital are the potential for fast future development. India's rank is 4th in producing greenhouse gas, however per capita emission is much below to the global per capita emission average. Energy is critical for development and Improving Human Development Index (HDI). Per capita energy consumption and improvement in human development are well established (Figure1).

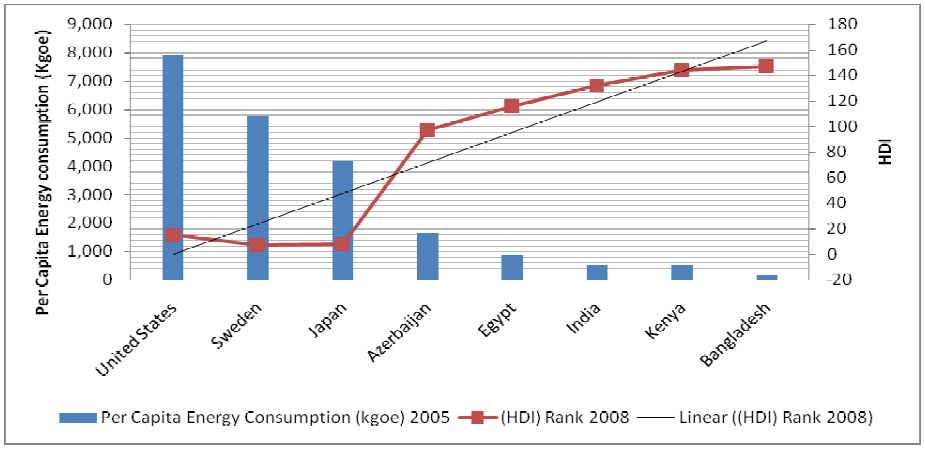

FIGURE 1 - PER CAPITA ENERGY CONSUMPTION VERSES HUMAN DEVELOPMENT INDE

At present, India does not want burden-sharing arrangement regarding GHG mitigation targets. It has a limited role in contributing to climate change [4.6% cumulative; 1.2 metric tons per capita]. India's vision on burden-sharing is equal per capita rights to global environmental resources, and convergence of per capita emissions over time. India wants to take voluntary actions for decarbonisation. NAPCC-2008 focuses on mitigation actions that are "co-benefits" of development actions, and adaptation with engagement with bilateral and multilateral partnerships with industrialized countries(India, 2008).

The NAPCC laid principles, approaches and institutional arrangement for eight national missions for managing climate change agenda. The document has explicitly advocated development without environmental degradation. The adopted principles for NAPCC are enlisted below.

- Inclusive and sustainable development strategy
- Efficient and cost-effective strategies for Demand Side management
- Accelerated deployment of appropriate technologies
- Innovative market, regulatory, and voluntary mechanisms

- Effective linkages with civil society and public-private partnerships
- International cooperation for R&D, technology transfer and global IPR regime

The salient features of eight missions are discussed here.

a) *National Solar Mission*

It is planned to increase the share of solar energy in the total energy mix and decentralized distribution of energy. It aims to create affordable, convenient solar power systems and storage.

b) *National Mission for Enhanced Energy Efficiency*

This mission wants to enhance cost effectiveness and improvements in energy efficiency in energy-intensive large industries and facilities. It also aims to shift to energy efficient appliances through innovative measures. Mechanisms for financing demand side management programmes and fiscal instruments to promote energy efficiency are adopted. For seeking energy efficiency, there is shift to energy efficient appliances, Standards and Labelling launched in 2006 by Bureau of Energy Efficiency (BEE) started for household refrigerators (frost-free), florescent tube lights, air conditioners, transformers and other equipment in future like, general purpose electric motors, ceiling fans and geysers etc.

c) *National Mission on Sustainable Habitat*

This mission will work in three broad sector of sustainable development viz., Energy conservation in habitat, urban waste management and transportation sector. This mission is developed by keeping in mind the GHG emission, more or less; these three sectors are mostly responsible for production of green house gas, hence mission developed for its mitigation. It extends application of Energy Conservation Building Code, incentives for re-tooling existing building stock and emphasizes recycling of materials and urban waste management technology development for power from waste. This mission is seeking for better urban planning and modal shift to public Transport to reduce GHG emission.

d) *National Water Mission*

National water mission focuses on conservation of water, minimizing wastage and ensuring equitable distribution of water. It also explores opportunities to recycling of waste water to meet needs of urban areas. Beside these, adoptions of new and appropriate technologies such as low temperature desalination are explored for coastal cities. Basin level management strategies in consultation with states and optimize efficiency of existing irrigation systems is dealt through this mission.

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e) *National Mission for Sustaining the Himalayan Ecosystem*

This mission will sustain and safeguard the Himalayan glacier and mountain eco-system. It would be help in understanding whether and the extent to which the Himalayan glaciers are in recession. It also seeks for observational and monitoring network for the Himalayan environment: to assess fresh water resources and health of ecosystem. This mission will also explore protection and enhancement of forest lands in the Himalayan region.

f) *National Mission for a Green India*

The advantage of forestation for carbon sink and balancing ecosystem is well known in climate change regime. Through this mission afforestation of 6 million hectares are proposed. The national target for area under tree cover is 33 percent while at present it is 23 percent only. It will cover degraded forest land. This mission will look forward to involve communities in forest protection and afforestation.

g) *National Mission for Sustainable Agriculture*

This mission is of adaptive in nature, seeking for sustainable agriculture by developing new varieties of crops capable of withstanding extreme weather, thermal resistant crops, and alternative cropping patterns. It also emphasizes for orientation of agricultural research systems to monitor and evaluate climate change and recommend changes. Further, it seeks for convergence and integration of traditional knowledge and practice systems, information technologies and biotechnology. It also focuses on improving productivity of rain fed agriculture.

h) *National Mission on Strategic Knowledge for Climate Change*

Last mission in the series is on building strategic knowledge for climate change. It focuses on funding of high quality research into climate change. This mission will study impact on health, demography, mitigation patterns and livelihoods due to climate change. It will establish network of dedicated climate change related units in academic and scientific institutions. A Climate change research fund will be setup. Private sector initiatives through venture capital funds will be launched. And finally research to support policy and implementation through identified centres will be done.

These all eight missions compass almost all sectors which either contributes to GHG or the area which will be impacted with climate change. The third mission implicitly deals with the urban area. The scope of this paper is limited to two sub-missions of it. These two sub-missions 'urban transport' and 'solid waste management' needed integrated strategies which will be discussed in next two sections.

5. URBAN TRANSPORTATION

In Indian cities transportation is one of the most pressing issues. For last few decades, transportation infrastructures have not paced with the increase in urban population, even in some cases public transportation has been decreased, for instance, in Delhi; percentage increase in Buses are less than the private vehicles increase. In India, till now except Mumbai, Kolkata and Delhi MRTS do not exist anywhere. National Urban Transport Policy, which sought for involvement of private sectors, innovative finance mechanism to enhance efficiency and reduction in travel demand by integration of land use and transportation planning came into existence in 2006 (India, 2006).

To elaborate the present and future scenario of urban transportation, trips by mean of travel and their projection by cities' size are discussed here. This will provide a broad framework for analysis of urban transportation.

Modal share is an important indicator for understanding characteristics of mobility in any city. Typically in Indian cities Informal Public Transportation (IPT) mainly auto rickshaws, cars, public transportation (buses, subways and some time regional trains), two wheelers, cycles and walking are used. Figure 2 shows percentage distribution of urban trips in cities by their sizes. Across the all size of cities about 20 percent of trips are covered by walk. Use of cycle for cities between 0.5 - 4 million sizes is about 18 percent, its percentage decreases in bigger as well as smaller cities/towns. Two wheels are extensively used about 25 percent in all size of urban settlements except in cities with more than 8 million plus settlements and hilly towns. At present large percentage of trip by public transport is limited to 8 million plus cities. As percentage of trips by public transport decreases in 0.5 – 8 million cities, use of car has been increased.

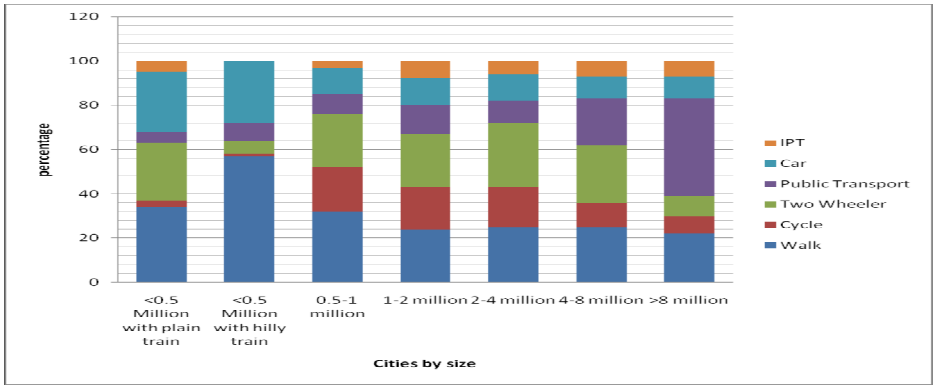

FIGURE 2 - PERCENTAGE DISTRIBUTION OF URBAN TRIPS BY MEANS OF TRAVEL FOR SELECTED INDIAN CITIES, 2002
Source: Ministry of Urban Development (India, 2008)

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Increase in personnel and informal public transportation mode share is expected in the coming future (Figure 3). And at the same time percentage of public transport will decrease (figure 4). Personal vehicles occupy more area with less occupancy capacity hence more emissions, consequently adverse air pollution. For example in case of Delhi vehicular emission contribution is about 67 percent of total emission in Delhi about 2/3rd of emissions (Ministry of Environment and Forest, 1997; Gurjar, Van Aardenne et al., 2004).

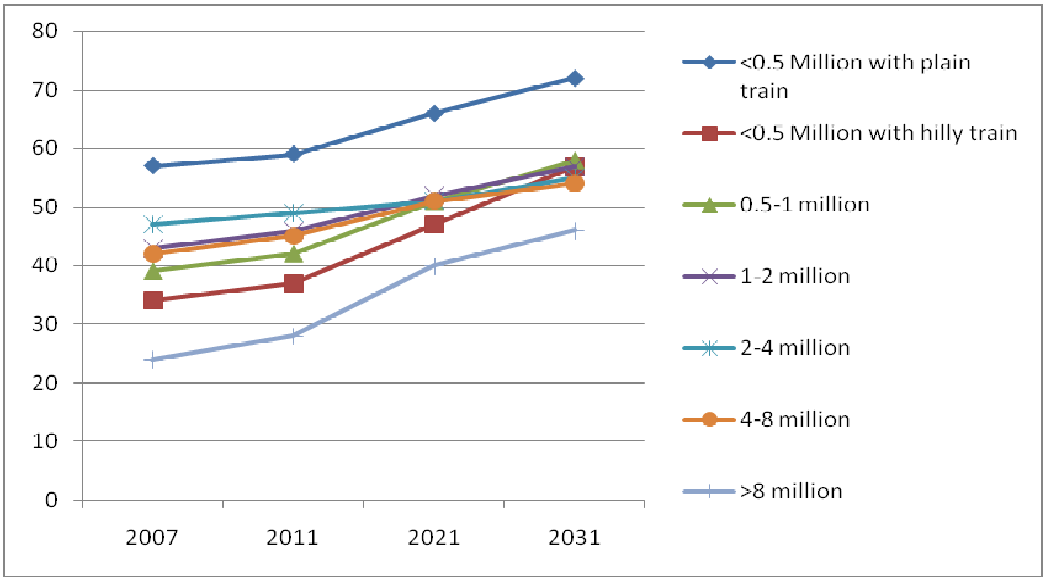

FIGURE 3 - ESTIMATED PERSONNEL VEHICLE AND IPT (AUTO RICKSHAW) MODE SHARE IN FUTURE (%)
Source: Ministry of Urban Development (India, 2008)

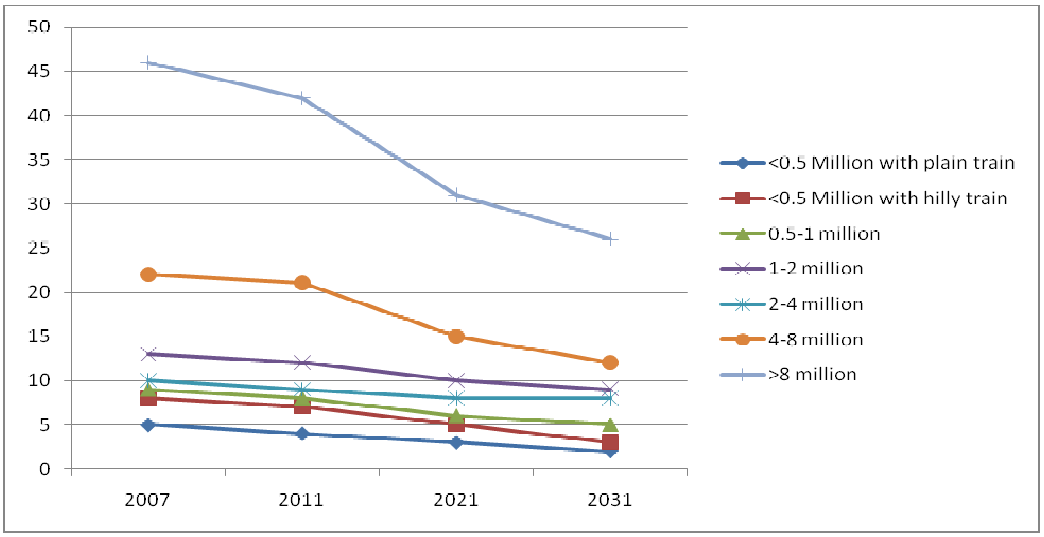

FIGURE 4: ESTIMATED PUBLIC TRANSPORTATION MODE SHARE IN FUTURE (%)
Source: Ministry of Urban Development, (India, 2008)

Indian cities constitute of more than 25 percent of urban poor and slums, and percentage of poor and slum increase with the size of the city (India. Ministry of Housing and Urban Poverty Alleviation. and United Nations Development Programme, 2009). According to the National Sample Survey, 81 million poor live in urban areas. Their mobility is mostly based on walking and cycle.

It is tragedy of climate change that richer section of society and higher per capita income cities contribute more GHG in contrast the adverse impact of climate change will be on the opposite, the poor and slum dwellers and cities with lower per capita income because of their poor adaptive capability.

The policy intervention in urban transportation planning provides niche for both mitigation as well as inclusive growth, mitigation in term of reduction in GHG and inclusiveness in term of providing equitable share of the modes which are mostly used by urban poor. These can be done by promoting non-motorized vehicles and strengthening public transportation.

So now question is what policies should be adopted. The public transport system is not adequate in bigger cities and moreover, the space for non-motorized vehicle is in margin. There is urgent need of increase modal shift in public transportation in large cities as well as in medium size cities. Urban settlements in general and bigger cities/UAs in particular are needed proper planning for non-motorized transportation.

In term of spatial planning there is needed to check urban sprawl which is common due to the unregulated urban growth. Suitable policies for urban periphery will lead to check urban sprawl and hence decrease in trips by length and consequently decrease in emission. Other kind of intervention like stringent norms, rules and regulations on vehicular ownership, suitable congestion charge and high parking price, and cheap, efficient and comfortable public transportation system will lead to sustainable urban transportation as well as inclusive growth.

Urban India has history of weak planning implementation or in other words, planning is not implementable. Hence there is need of judicious planning based on acceptable and adaptable standards rather than higher standard of norms rules and regulations.

6. URBAN WASTE MANAGEMENT

6.1. Waste generation and their characteristics

This section explains salient features of urban waste in Indian cities. The urban waste produces Methane by their anaerobic decomposition which contributes to the climate change (Doorn and Barlaz, 1995). Methane is the second largest GHG emission from India, and about 400 to 600 Gg (about 25-35

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percent of total Methane emission) are produced from municipal solid waste (Kumar, Gaikwad et al., 2004; Thakur, 2009). In Indian cities the issues in waste management are of many folds from waste generation to disposal, moreover, disposal systems mechanism is most dire. Various causes are cited for poor waste management like, unregulated urban growth, accelerated increase in urban population, poor know how for disposal etc.

According to Ministry of Urban Development, urban India produces about 42 million tone of municipals solid waste annually, implies 0.115 million ton per day (India, 2008). Urban India per capita waste generation varies from 0.2 kg to 0.6 kg across the cities from 0.1 to 5.0 million populations (Figure 5) and it is increasing by 1.3 percent per annum, moreover, with the growing urban population it is expected to increase by 5 percent (also see (Van Beukering, Sehker et al., 1999)).

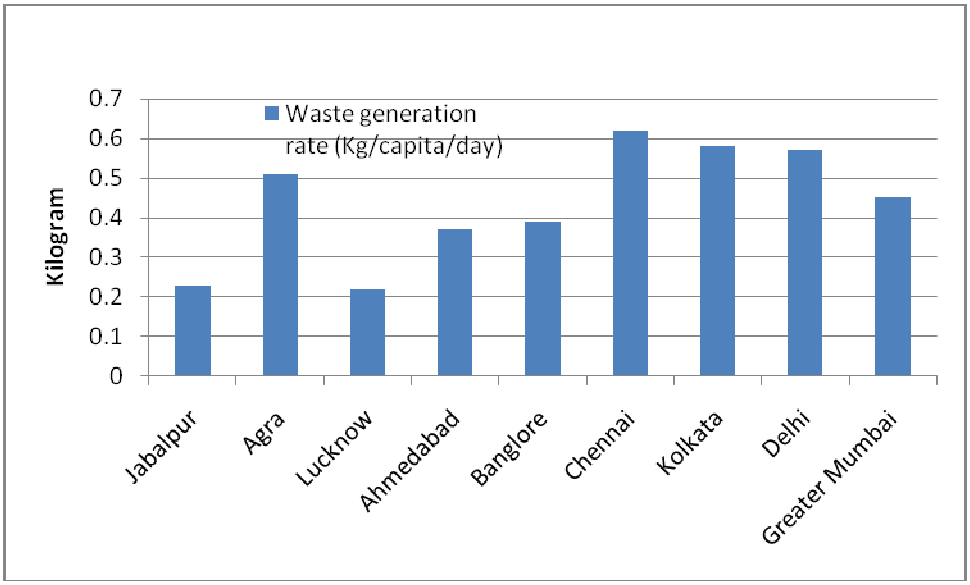

FIGURE 5 - WASTE GENERATION RATE (KG/CAPITA/DAY) IN SELECTED INDIAN CITIES 2004-05

Source: CPCB 2009

The waste collection efficiency is between 50 to 90 percent. Other study reveals 30-40 percent of urban waste remains uncollected (Joardar, 2000). And normally, Urban Local Bodies spend Rs 500 to 1500 per ton on Solid waste management. About 60-70 percent spends on collection, 20-30 percent on transportation and less than 5 percent on treatment and disposal (India, 2008).

Table 4 shows the quantity of waste generated in mega cities and class-I towns. The six mega cities produce 21, 000 tons per day which is about 18 percent of total garbage generation. Million plus cities and Class-I towns (population 100, 000 plus) generate about 37 and 72 percent respectively. In sum 72.5 percent of total waste is generated by urban India in 423 class – I cities that amounted about 84000 tons per day.

TABLE 4 - WASTE GENERATED IN MEGA CITIES AND CLASS - I TOWNS

	Quantity (TPD)	Total garbage (%)
Waste generated in 6 mega cities	21,000	18.35
Waste generated in metro cities (population ≥1 millions)	19,643	17.08
Waste generated in other class-I towns (population ≥ 100,000)	42,635.28	37.07
Total	83,378.28	72.50

Source: SWM Report, Ministry of Urban Development (India, 2008)

In the scenario of 'business as usual', the projected municipal solid waste generation will be about 250 million tonnes per year by 2047 and corresponding methane emissions will be 40 million tonnes which is about 10 million tons presently (Singhal and Pandey, 2001).

Municipal solid waste is composed of biodegradable and non-biodegradable. Figure 6 shows percentage of compostable and recyclable waste generation in selected Indian cities. Typical Indian cities produce 40-60 percent of compostable waste and rest recyclable in nature. The heating calorific values, which normally varies from 1200-2500 Kcal/Kg across the cities as shown in selected Indian cities in figure 6. Indian urban waste doesn't provide fuel value for profitable energy potentials (Zhu and World Bank, 2007). Notably two cities Delhi and Lucknow effort to produce energy from waste were failed in this account.

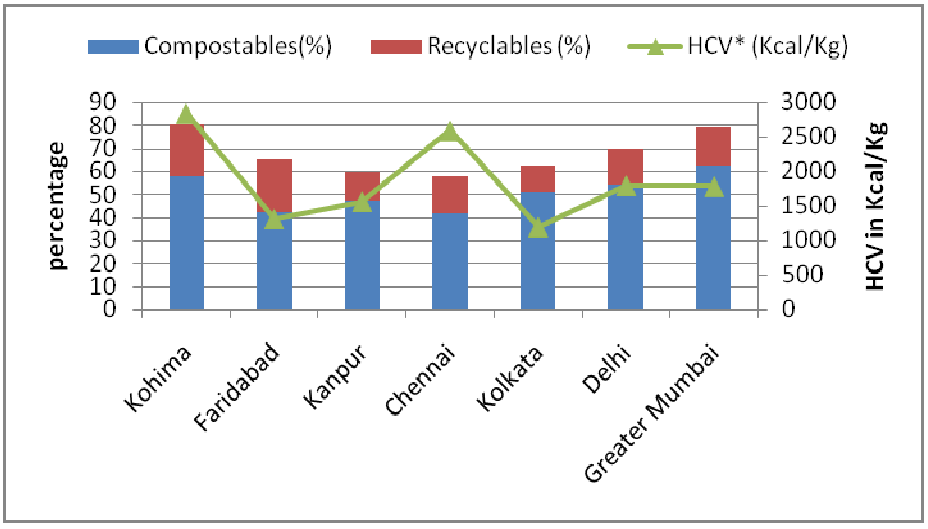

FIGURE 6 - WASTE CHARACTERISTICS WITH HEATING CALORIFIC VALUE (KCAL/KG) IN SELECTED INDIAN CITIES 2004-05
Source: CPCB 2009

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6.2. Poor Segregation, Collection And Disposal

The quantity of solid waste generation is far below than advanced countries cities, however poor segregation at the point of waste generation have been major threat to waste management. Hardly any city has proper segregation mechanism against western cities even Asian cities like Tokyo and Seoul have segregation mechanism on place. Informal sectors especially urban poor mostly children have actively involved in recycling, locally called as rag picker in bigger cities (KUMAR ; Agarwal, Singhmar et al., 2005). These all poor disposal mechanism, reduced collection efficiency have become threat to citizens and environment.

Beside all odds urban India has prospects for managing their solid waste in sustainable way. Integrated solid waste management mechanisms with decentralized approach are needed. Beside it integration with informal sectors and active public participation will be equally important. It would also provide livelihood for urban poor. Effective and efficient institutional arrangements, technological input especially in disposal sector would be of great advantage. Composting and Recycling may be opted as suitable rather than mechanism of incineration (Zhu and World Bank, 2007) or energy generation.

7. CONCLUSION: MITIGATION TOWARDS INCLUSIVE GROWTH

Two urban infrastructure domains have been discussed in context of mitigation, urban transportation and municipal solid waste management after briefly discussion on climate change and its impact on urban India. It has been argued that proper mitigation would provide two fold benefits, reduction in GHG emissions in one fold and inclusive growth with better environmental conditions in urban India.

In Indian cities there is significant scope in mitigation in both the sectors. Urban transportation sector could take mitigation in the form of augmenting public transport system in large size cities and expanding in medium and small size cities and towns. Proper planning for non-motorized vehicles and pedestrian movements will lead to significant reduction in GHG. The later will provide a niche for urban poor in mobility.

Effective and efficient municipal solid waste management will provide environmentally sustainable cities. The mean to achieve waste management is active involvement of informal sectors and public participation. The involvement of informal sectors will provide livelihood to the urban poor.

So in nutshell these both sectors which are not effective and efficient at the moment will offer mitigation and inclusive growth as well as good environments in Indian cities provided that proper action can be taken without any further delay.

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