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CLIMATE CHANGE AND ITS IMPACT ON URBAN ENVIRONMENT IN INDIA

A. K. SINGH
Assistant Director, Regional Centre for Urban and Environmental Studies, Lucknow

Abstract: *Increasing urbanization, expansion of habitat into unsuitable vulnerable areas, higher population density, higher housing density, vulnerable housing and buildings construction, non engineered unsafe construction, and aging buildings and other infrastructure are some of the factors that have increased the vulnerability of hazards and disasters in urban areas. Growing urbanization is posing serious environmental concerns in India in terms of changing land use pattern, increasing carbon emissions, solid waste generation and its disposal, air and water pollution and poor sanitation amenities. Major challenge for cities in the face of rapid population growth is to maintain sustainability within the social, economic and environmental dimensions. The accelerated and uncontrolled urban growth has contributed to the ecological transformation of the cities and their immediate surroundings resulting in flash floods and water scarcity. Furthermore other factors depending on the local circumstances contribute to the urban vulnerability, hazards and risks. The present paper purports to examine the impact of climate change on urban environment.*

INTRODUCTION

Growing urbanization is posing serious environmental concerns in India in terms of changing land use pattern, increasing carbon emissions, solid waste generation and disposal, air and water pollution and poor sanitation amenities. A large segment of urban population in India resides in slums, squatters and informal settlement. These settlements are often located in low laying areas prone to direct and indirect risks due to environmental degradation including changes in the climate and lack of basic urban services (Satterthwaite *et al.*, 2007). It is to be noted that out of 35 cities in India having population over a million, 18 are in coastal states. Major challenge for cities in the face of rapid population growth is to maintain sustainability within the social, economic and environmental dimensions. Urban systems are at risk to different kind of hazards. Several factors contribute to the urban risk profile.

CLIMATE CHANGE

Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy etc. Addressing climate change requires a good scientific understanding as well as coordinated action at

national and global level. According to the latest scientific assessment, the earth's climate system has demonstrably changed in both global and regional scales. Most of the warming (of 0.1°C per decade) observed over the last 50 years, is attributable to human activities. The Intergovernmental Panel on Climate Change (IPCC) projects that the global mean temperature may increase between 1.4 and 5.8 degrees Celsius by 2100. This unprecedented increase is expected to have severe impacts on the global hydrological system, eco-systems, sea level, crop production and related products (Sathaye, J. *et al.*, 2006). The impact would be particularly severe in the tropical areas, which mainly consist of developing countries, including India. The UN Conference on Environment and Development (UNCED) in 1992 at Rio de Janeiro to Framework Convention on Climate Change (FCCC), which laid the framework for the eventual stabilization of green house gases in the atmosphere, recognizing the common but differentiated responsibilities and respective capabilities, and social and economic conditions. The Convention came into force in 1994. Subsequently, the 1997 Kyoto Protocol, which came into the force in 2005, reasserted the importance of stabilizing green house gases concentrations in the atmosphere and adhering to sustainable development principles. The Protocol laid out guidelines and rules regarding the extent to which a participating industrialized country should reduce its emissions of six green house gases – carbon dioxide, methane, nitrous oxide, chlofluoro-carbon, hydrofluoro-carbons and perfluoro-carbons. The Kyoto Protocol does not require the developing countries to reduce their green house gas emissions. However, the Kyoto reduction, by itself, is inadequate to achieve a stabilization of climate change by 2010.

The global carbon cycle involves interaction among the atmosphere, oceans, soils and vegetation and fossil fuel deposits. The combustion of fossil fuels and other human activities are the primary reasons for increased concentrations of CO_2 and other green house gases. Between 1910 and 1999, an estimated 6.3 G+C/ year was released due to the combustion of fossil fuels, and another 1.6 G+C/year was released due to the burning of forest vegetation of the six aforementioned Green House Gases, CO_2 accounted for 63 per cent, methane 24 per cent, nitrous oxide 10 per cent and the other gases, the remaining 3 per cent of the carbon equivalent emissions in 2000. The industrialized countries have been the primary contributors to emissions of CO_2. According to the estimates, industrialized countries are responsible for about 83 per cent of the rise in cumulative fossil fuel related CO_2 emissions since 1800 (Loske, 1996). In the 1990's, they accounted for about 53 per cent of the 6.3 G+C/year which was released as CO_2 from fossil fuel combustion. Developing countries accounted for only 37 per cent of cumulative CO_2 emissions from industrial sources and land use change during the period 1900 to 1999, whereas industrialized countries accounted for 63 per cent. The contribution of India to the cumulative global CO_2 emissions from 1980 to 2003 was only 3.11 per cent. India's carbon emissions per person are twentieth of those of the US and the tenth of most Western Europe and Japan. India has reasons to be concerned about climate change. A vast population was depends (depending) on climate sensitive sectors like agriculture, forestry and fishery for livelihood in the country. The adverse impacts

of climate change, in the form of declining rainfall and rising temperatures and thus the increased severity of drought and flooding, would threaten food security and livelihood in the economy. Poor infrastructure facilities, weak instrumental mechanism, lack of financial resources and vast sectoral and regional variability adversely affect the adaptive capacity of the country to climate change. Climate change could represent additional stress on the ecological and socio-economic systems that are already forcing tremendous pressure due to rapid industrialization, urbanization and economic development (Gupta, 2005).

The potential of air pollution on vegetation is also high. Eco-systems are likely to be most at risk if they are on substrates with a low buffering capacity and receive occasional, heavy doses of pollution or contain key species that are vulnerable. The effects of air pollution of materials may include (i) loss of mechanical strength; (ii) leakage; (iii) failure of protective coatings; (vi) loss of details in carvings; (v) pipe corrosion. Air pollution may also cause damage to built environment, cultural heritage and architecture.

Dr. R.K. Pachouri, the joint Noble Peace Prize winner of 2007 for the significant contribution in the field of mitigation of climate change, has remarked that climate change has the potential to disrupt peace, stability and security across the world. The findings of the Fourth Assessment Report of IPCC (Intergovernmental Panel on Climate Change) have highlighted the impacts of climate change and other serious implications for growth, development and social well-being in some of the most vulnerable regions. There are several dimensions of climate change that bring out the equitable aspects of this problem. The emissions of green house gases which have cumulatively resulted in the problem of human induced climate change have been produced by one set of countries while the worst impacts are going to be felt by the different set of countries and communities. Thus, Dr. Pachouri is of the view that if the earth's climate system has to be stabilized, mitigation measures will have to be undertaken with urgency. However, mitigation cannot be seen as narrow challenge and would require addressing the vary structure of economic growth as the world has come to accept over many decades (Tera Green, December 2007 - January 2008). From 1900 to 2005, precipitation increased significantly in eastern parts of north and South America, northern Europe and northern and Central Asia but declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Globally, the area affected by drought has slightly increased since the 1970s. The rate of global average sea level rise has risen from 1.8 mm/yr to 3.1 mm/yr from 1961 to 1993. This has primarily been due to thermal expansion, melting glaciers, ice caps and polar ice sheets. The projected sea level rise at the end of 21st century will be an alarming 18-59 cm. The Fourth Report on IPCC underlines the impacts of anthropogenic warming that could be abrupt as well as irreversible. Partial loss of ice sheets on ice polar land could imply several meters of sea level rise, major changes in coast lines and inundation of low lying areas, great impact on river deltas and low lying Islands. Approximately 20-30 per cent of species assessed so far are likely to be at increased risk of extinction. Large scale and

persistent changes in Meridional .Overturning Circulation will have impacts on marine ecosystem productivity, fisheries and terrestrial vegetation. Report further underlines that by the year 2020, between 75 and 250 million people in Africa will be exposed to increased water stress. In fact, some areas, yields from rain fed agriculture could be reduced by 50 per cent. Conditions in Asia too would not be too different in 2050. Fresh water availability is projected to decrease while coastal areas, especially heavily populated mega delta regions will be at greater risk form sea flooding. Sea level rise is also expected to exacerbate inundation, storm surge, erosion and other coastal hazards threatening vital infrastructure in small island states (Tera Green, December 2007 – January 2008).

Most human activities – fossil fuel combustion for power generation, transport, land use changes and industrial processes – generate emissions of green house gases. Power generation accounted for around 10 Gt CO_2e or around one quarter of the total green house gases emission. Transport is the second largest source of energy related CO_2 emissions. Over the past three decades, energy supply and transport have increased their green house gas emissions by 145 and 120 per cent respectively (Human Development Report, 2007/2008). Land use changes also play an important role. Deforestation is by far the large source of CO_2 emissions in this context. Rich countries dominate the overall emissions account. Collectively they account for about 7 out of every 10 tonnes of CO_2 that have been emitted since the start of the industrial era. Historic emissions amount to around 1100 tonnes of CO_2 per capita for Britain and America, compared with 66 tonnes per capita for China and 23 tonnes per capita for India. The United States is the largest emitter, accounting for around $1/5^{th}$ of the total. Collectively, top 5 – China, India, Japan, the Russian Federation and the United States – account for more than half; the top 10 for every 60 per cent (Human Development Report, 2007-2008).

CO_2 emissions during 2004 were reported to be 1166 Mt in India with the CO_2 intensity of 478. CO_2. The growth during 1995-2000 was recorded 2.9 per cent while it was reported significantly high upto 3.2 per cent during 2000-2005. CO_2 per capita during 2005 was recorded 1.1 tonne only in India. Carbon dioxide emissions show a steady growth (6.9 per cent) during 1990-2004. India's share in world's total CO^2 emissions was reported 4.6 per cent in 2004 however its share was recorded only 3 per cent in 1990. There has been significant increase in carbon dioxide emissions (92.6 per cent) during 1990 to 2005 in India. The per capita carbon dioxide emission has increased from 0.7 mt in 1990 to 1.1 mt in 2005. India's share in global carbon dioxide emissions was reported to be 4.33 per cent in 2005. Cumulative carbon dioxide emissions since 1850 were reported to be 28.6 billion mt in India. Non-CO2 emissions have also increased significantly from 53.1 million tons in 1990 to 89.2 million tons in 2005. Carbon emissions have been increasing in India in recent years and they are higher in urban areas. We find that average per capita carbon emissions are higher in metropolitan cities (being 1.19 tonnes per capita as compared to only 0.90 tonnes per capita in non-metropolitan cities), and the national average is 0.93 tonnes per capita (Table 1). This is because larger cities have more

polluting activity such as emissions from public and private transport. However, it should be noted that municipal corporation level emissions as a percentage of city-level emissions are much higher in nonmetropolitan areas than in metropolitan areas. Corporation-level emissions include those emanating from street lighting, water supply and sewage systems, transportation, building and other facilities.

Table 1
Carbon Emissions in India's Cities

	CO_2 Emission Per Capita (Tonnes)	*Corporation Level Emissions as % of City-level Emissions*
Jabalpur	0.30	7.80
Bhopal	0.31	8.83
Gwalior	0.37	6.09
Indore	0.41	2.28
Kanpur	0.45	3.20
Agra	0.64	10.29
Lucknow	0.64	20.77
Dehradun	0.71	7.14
Bangalore	0.82	4.14
Patna	0.83	7.10
Bhubaneshwar	0.84	1.17
Chennai	0.91	2.68
Ahmedabad	1.20	2.91
Pune	1.31	2.16
Raipur	1.32	1.85
Jaipur	1.63	4.22
Kolkata	1.83	2.15
Ranchi	1.97	0.06
Jamshedpur	2.76	NA
Average, all	0.93	5.30
Average, metros	1.19	10.39
Average, non-metros	0.90	4.72

Source: ICLEI-South Asia, Energy and Carbon Emissions Profiles of 54 South Asian Cities, 2009 and Sridhar *et al.* (2009).

IMPACT OF CLIMATE CHANGE

Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health, energy, etc. Addressing climate change requires a good scientific understanding as well as coordinated action at national and global level. Historically, the responsibility for greenhouse gas emissions' increase lies largely with the industrialized world, though the developing countries are likely to be the source of an increasing proportion of future emissions. The projected climate change under various scenarios is likely to have implications on food production, water supply, coastal settlements, forest ecosystems, health, energy security, etc. The adaptive capacity of communities likely to be impacted by climate change is low in developing countries. The efforts made by the UNFCCC and the Kyoto Protocol provisions are clearly inadequate to address

the climate change challenge. The most effective way to address climate change is to adopt a sustainable development pathway by shifting to environmentally sustainable technologies and promotion of energy efficiency, renewable energy, forest conservation, reforestation, water conservation, etc. The issue of highest importance to developing countries is reducing the vulnerability of their natural and socio-economic systems to the projected climate change. India and other developing countries will face the challenge of promoting mitigation and adaptation strategies, bearing the cost of such an effort, and its implications for economic development.

The global carbon cycle involves interaction among the atmosphere, oceans, soils and vegetation and fossil fuel deposits. The oceans contain 39,000 giga tonnes of carbon (GtC), fossil fuel deposits about 16,000 GtC, soils and vegetation about 2500 GtC, and the atmosphere about 760 GtC2. Since 1850, land-use change is estimated to have released about 136 GtC and fossil fuel combustion, about 270 GtC. Of this, 180 GtC has ended up in the atmosphere, while 110 GtC has been absorbed by growing vegetation and the remainder by the oceans. It is the increasing concentration of atmospheric CO2 that is the cause for concern about global climate change.

The combustion of fossil fuels and other human activities are the primary reasons for increased concentrations of CO2 and other greenhouse gases. Between 1990 and 1999, an estimated 6.3 GtC/year was released due to the combustion of fossil fuels, and another 1.6 GtC/year was released due to the burning of forest vegetation. This was offset by the absorption of 2.3 GtC/year each by growing vegetation and the oceans. This left a balance of 3.3 GtC/year in the atmosphere3. Controlling the release of greenhouse gases from fossil fuel combustion, land-use change and the burning of vegetation are therefore obvious opportunities for reducing greenhouse gas emissions. Reducing greenhouse gas emissions can lessen the projected rate and magnitude of warming and sea level rise. The greater the reductions in emissions and the earlier they are introduced, the smaller and slower the projected warming and the rise in sea levels. Future climate change is thus determined by historic, current and future emissions. Of the six aforementioned GHGs, CO2 accounted for 63%, methane 24%, nitrous oxide 10%, and the other gases the remaining 3% of the carbon equivalent emissions in 2000. Thus in addition to CO2, global mitigation efforts need to focus on the two largest and rapidly increasing GHGs.

India is a large developing country with nearly 700 million rural population directly depending on climate-sensitive sectors (agriculture, forests and fisheries) and natural resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods. Further, the adaptive capacity of dry land farmers, forest dwellers, fisher folk, and nomadic shepherds is very low (Ravindra Nath & Sathaye, 2002). Climate change is likely to impact all the natural ecosystems as well as socio-economic systems as shown by the National Communications Report of India to the UNFCCC (GoI, 2004).

South Asia is most vulnerable to climate change. The region faces daunting climate related development challenges. The impacts of climate change in the form

of higher temperature, more variable precipitation and more extreme weather events are already felt in South Asia. The region is already marked by climate variability and a higher incidence of natural disasters. The region has also a long and densely populated coast line with low lying islands that are vulnerable to sea level rise. Urbanization poses an additional challenge in the region. Women, poor and indigenous people are most vulnerable to climate risk.

Among the 32 states and Union Territories in the country, 22 are multi-disaster prone. About 40 million hectares of land in the country has been identified as flood prone and on an average 18.6 million hectare of land is flooded annually. About 57 per cent of area of the country is vulnerable to seismic activity. About 18 per cent of country's total area is drought prone, approximately 50 million people are annually affected by droughts and about 68 per cent of total sown area of the country is drought prone. India has a long coastline of 8040 km. which is exposed to tropical cyclones arising in the Bay of Bengal, the Arabian Sea and Indian Sea. The Indian Ocean is one of the six major cyclonic prone regions of the globe (Jain, 2004). The Coromandal coastline is more cyclones prone, with 80 per cent of the total cyclones generated in this region. Risk to the existing housing stock in various states and union-territories had been estimated by Expert Group Set up by the Ministry of Urban Affairs and Employment, Government of India. About 3.9 million houses are susceptible to earthquakes of very high intensity, about 20 million houses are susceptible to damage due to winds and about 9.3 million houses are susceptible to damage due to floods. Besides the risk of earth quakes, cyclones and floods are liable to very high damage and destruction of vulnerable houses under heavy rains. (Jain, 2004). Some 49 per cent of the total housing stock is liable to very high damage from natural hazards, while about 1 per cent of the total housing stock gets destroyed every year. It is to be noted that in earth quake, 80 per cent of the casualties are due to collapsing buildings. Brick and stone buildings without proper support are liable to collapse. Non-engineered buildings continue to be built in the areas prone to natural disasters. Unemployment, poverty backwardness, migration from rural areas and increasing price of land and construction, million of people are occupying disaster prone areas. Thus about 6 per cent increase in disaster affected population has been reported. The changing topography due to environmental degradation has also increased the vulnerability in the country. In 1988, 11.2 per cent of total land area was flood prone, but in 1998 floods inundated 37 per cent geographical area. Three major disasters that India have experienced in the recent past are the super cyclone in Orissa (1999), earthquake in Gujarat (2001) and Tsunami (2004) in Tamil Nadu, Pondicherry, Andaman Nicobar Islands and parts of other southern states. Frequent disasters lead to erosion of development gains and restricted options threatened by hazards.

The continent of Asia is particularly vulnerable to disasters strikes. Between the years 1991 to 2000 Asia has accounted for 83 per cent of the population affected by disasters globally. Within Asia, 24 per cent of deaths due to disasters occurred in India, on account of its size population and vulnerability. Floods and high winds

account for 60 per cent of all disasters in India. Many parts of the Indian sub-continent are susceptible to different types of disasters owing to the unique topography and climatic characteristics. About 54 per cent of the sub continent's landmass is vulnerable to earthquakes while about 4 crore hectares is vulnerable to periodic floods. The country has suffered four major earthquakes in the span of last 50 years along-with a series of moderate intensity earthquakes that have occurred at regular intervals. Since 1988, six earth quakes have struck different parts of the country. Tsunami in India killed 10749 persons while $1068 million loss or damage to properties was reported.

Short term and long-term changes in climatic variables such as temperature and precipitation may pose hazards to urban systems. Changes in the climatic variables are likely to impact future patterns of spatial growth and development in cities and act as a stressor in addition to existing pressures. The populations most vulnerable to climate change are those living in slums and informal settlements that often lack access to basic services and infrastructure (IDS, 2007). Apart from the risk to coastal populations from sea level rise, cyclones, storm surges and other associated impacts, a high proportion of urban settlements in the low and middle-income countries are on sites that are at risk from flooding or landslides. The key primary and secondary order impacts on cities due to short-term and long-term changes in climatic variables have been summarized in Table 2

An urban environment is complex primarily because of rapidly changing variables such as socio- economic and demographic indicators, land-use patterns, resource demand and utilization patterns, lifestyle changes etc. In the light of climate change, a new layer of uncertainty is added in terms of changes in precipitation, temperature and occurrence of extreme events. Furthermore, there are scale mismatches; in terms of the timescales over which policymakers and urban planners operate, and scales over which projected impacts of environmental decisions, degradation, climate variability and change will manifest. Also policies and developmental initiatives in cities should enable urban systems to adjust to changes as and when they happen and accordingly respond in a way that maintains their original structure and function. Key policies, programmes and initiatives of the Government of India that offer several entry points for mainstreaming resilience, adaptation and mitigation within the urban sustainable development agenda have been discussed in this publication. In 2008, India announced the National Action Plan on Climate Change (NAPCC) listing eight priority areas for adaptation and mitigation action. Of these Missions, it is the National Mission on Sustainable Habitats (NMSH) that directly focuses on urban areas. Another important Mission by the Government of India is the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) that was launched in 2005 and is operational till 2012. JNNURM offers numerous entry points for sustainability and climate resilience and its primary aim is to create economically productive, efficient, equitable and responsive cities. JNNURM focuses on 65 cities and has two components:

Table 2
Impacts on Urban Systems Due to Changes in Climatic Variable

Changes in Climatic Variables	*Primary and Secondary Impacts*
Temperature extremes	
Rise in average temperatures of a region may lead to warm spells and heat waves	• Heat-related mortality - at high risk being the aged, those with pre-existing ailments such as cardiovascular and respiratory diseases and those with poor housing structures. • Increase in demand for water and impacts on air and water quality, and increased demand for cooling etc.
Heavy precipitation events (which may or may not be associated with cyclones and storm surges)	• Deterioration of the quality of surface and groundwater • Mortality, injury, water-borne and food-borne diseases • Flooding and water-logging • Disruption of mobility • Displacement of settlements • Damages to industry and infrastructure (including drainage, sewerage etc.)
Sea Level Rise	• Land inundation • Salt-water intrusion into groundwater aquifers • Impacts on coastal agriculture and livelihoods etc. • Displacement of coastal settlements • Damage to industry and infrastructure
Climate change may increase the frequency and intensity of **extreme events** such as floods and cyclones	• Mortality and morbidity • Damage to infrastructure, including communication channels, power supply etc. • Spread of water- and food borne diseases etc.

Source: IPCC, 2007 and Prasad *et al.*, 2009).

- '*Urban Infrastructure and Governance*' aiming at reforms and planned development of cities through efficient urban infrastructure and service delivery mechanisms, community participation, and accountability of ULBs/ Parastatal agencies, preparation of City Development Plans, and leveraging financial resources for specific activities.
- '*Basic services to Urban Poor*' aiming at integrated development of slums through initiatives for providing shelter, basic services and other basic amenities for the urban poor.

India's cities are increasingly feeling the impact of climate change and recognizing the need for adaptation as well as resilience in these urban spaces. Urban development had not been a priority for India, a country that relied heavily on rural and agricultural related economic activities. This changed in 2005, when

finances were allocated to Indian cities under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). After several separate initiatives and schemes to address urban problems and several five year plans, JNNURM emerged as a flagship scheme, which adapted reform based funding approach that could help ULBs receive funds for infrastructure development and basic services for urban poor whilst updating their own capacities and systems by implementing mandatory reforms. However, JNNURM did not look at climate change as one of the priority areas for the cities, which was quite understood considering contemporary challenges in Indian cities verses knowledge of climate change impacts that was not clear, uncertain and looked distant. It was only recently when the National Action Plan for Climate Change was released that a separate mission on cities and climate change looked at the issue in an integrated manner.

The use of funds and pace of urban reforms via JNNURM has been inadequate. A study by Mehta and Mehta (2010) argues that this has been due to a lack of infrastructure to implement changes or because the reforms focused on infrastructure at the expense of services delivery. JNNURM is also inadequate because it looks only at 65 cities out of the total 4378*8* urban agglomerations and towns in India. Nonetheless, JNNURM has highlighted the role of municipal financing for cities to decentralize resource allocation, and ultimately to support their resilience and low carbon development. JNNURM also holds potential in its next phase to take up some of the activities proposed under the National Mission on Sustainable Habitat which is one of the Missions under the National Action Plan for Climate Change (NAPCC). NAPCC missions aim to manage India's climate change agenda through multiple components that seem to work without cohesion. It includes a National Solar Power Mission, Enhanced Energy Efficiency Mission, National Water Mission, National Mission on Sustainable Habitat (NMSH), National Mission for Sustaining the Himalayan Ecosystem, National Mission for A Green India, National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change. Climate change features comprehensively and across departments and sectors. Each mission encompasses several sectors that either contribute GHG or will be impacted. The NMSH is the only one that deals specifically with urban areas and constituent needs (Ahmad and Choi, 2010).

NMSH is one of eight missions under the NAPCC and aims to make cities sustainable by targeting energy efficiency in buildings, managing of solid waste and shifting to mass public transport. It targets cities covered by the JNNURM and seeks to make them climate resilient by improving their green coverage. It also aims to promote sustainable energy efficiency as an essential component of urban planning (Das and Dastane, 2010). For example, it includes provisions that would expand the energy conservation building code to optimize the energy demands in the design of new commercial buildings. It also has long-term transportation plans for small and medium cities to ensure efficient public transportation options. It targets urban waste management and recycling provisions and supports the development of technologies that generate power from waste. Apart from JNNURM

and NMSH, the Indian Government has identified 13 Centers of Excellence (COE) to guide the NMSH. These are partner research institutions identified for their expertise and engaged to guide the government's urban sustainability initiatives. 4 centers will focus on urban transportation issues, while 9 centers guide urban development projects. The good thing is that NMSH is not limited to JNNURM cities, even if it views JNNURM as one of the potential carries for NMSH's agenda in cities.

STATUS OF MUNICIPAL SERVICES

The provision of urban infrastructure and services has been the primary functions of government; however, most of municipalities face problems of resources and these are effectively dependent on their respective state governments for allocating or transfer resources to them. In absence of resources, fragmentation of schemes, and increasing stress on services, the quality of basic services is declining. Environmental degradation has also deteriorated the quality of services. The septic tank is the most common mode of sanitation in use with more than one third of the urban population relying on them. Sever line is virtually non-existence in Bihar, Madhya Pradesh, Orissa, and Assam. Punjab, Maharashtra, Gujarat and Tamil Nadu are placed better. Only 70 per cent of India's urban population has adequate excreta disposal facilities. The uncollected solid waste creates hurdles in drainage system in most cities and causing flooding and water lagging in monsoon rains. The congestions in urban transport are gradually increasing due to increase in vehicles and inadequate expansion of road network. The increase in vehicles has caused air pollution and road accidents. Role of public sector in delivery of health and education services is gradually reducing while the quality of infrastructure in schools run by local bodies is found to be poor. Public hospitals are quite inadequate for rapidly expanding urban population. Most of the health centres do not cover the slum populations. The access of poor to health care services managed by government is also declining.

Inadequate coverage, intermittent supplies, low pressure, and poor quality are some of the most prominent features of water supply in the cities of India. With rapid increase in urban population and continuing expansion of city limits, the challenge of delivering water in Indian cities is growing rapidly. About 64 per cent of urban population is covered by individual connections and stand posts in India. Duration of water supply in Indian cities ranges from 1 hour to 6 hours. Per capita supply of water in Indian cities ranges from 37 lpcd to 298 lpcd for a limited duration. Most Indian cities do not have metering for residential water connections. About 70 per cent of water leakages are from pipes for consumer connection and due to malfunctioning of water meters. Non-revenue water (NRW) accounts for 50 per cent of water production. Many large Indian cities have to source water from long distances ranging from 50 to 200 km due to exhaustion or pollution of nearby sources. This increases the cost of raw water and enhances the possibility of leakage during transmission. Even when water supply is adequate, poor maintenance and

inadequate replacement lead to technical losses in the distribution network. Errors in metering, unbilled water consumption and plain theft contribute to commercial losses. The high levels of commercial and physical losses in the distribution network are compounded by the unwillingness of local/state governments to levy adequate user charges. Water utilities in India are typically able to recover only 30-35 per cent of the operations and maintenance (O&M) cost.

The challenge of sanitation in Indian cities is acute. With very poor sewerage networks, a large number of the urban poor still depend on public toilets. Many public toilets have no water supply while the outlets of many others with water supply are not connected to the city's sewerage system. Over 50 million people in urban India defecate in the open every day. The National Urban Sanitation Policy of 2008 has laid down the framework for addressing the challenge of city sanitation. The Policy emphasizes the need for spreading awareness about sanitation through an integrated city-wide approach, assigning institutional responsibilities and with due regard for demand and supply considerations, with special focus on the urban poor. More ever 4861 out of the 5161 cities/towns in India do not have even a partial sewerage network (Ahluwalia Committee Report, 2006). Almost 50 per cent of households in cities like Bangalore and Hyderabad do not have sewerage connections. About 18 per cent of urban households do not have access to any form of latrine facility and defecate in the open. Less than 20 per cent of the road network is covered by storm water drains. Only 21 per cent of the waste water generated is treated, compared with 57 per cent in South Africa. Of the 79 sewage treatment plants under state ownership reviewed in 2007, 46 were operating under very poor conditions (Ahluwalia Committee Report, 2006). Waste collection coverage ranges from 70 per cent to 90 per cent in major metropolitan cities, and is less than 50 per cent in smaller cities. Less than 30 per cent of the solid waste is segregated. Scientific disposal of waste is almost never practiced. Proportion of organic waste to total is much higher in India.

India's fragile water resources are stressed and depleting, while sectoral demands (including drinking water, industry, agriculture and others) are growing rapidly accordance to urbanization, population increase, rising incomes and industrial growth . In the era of liberalization and globalization, cities and towns are emerging as the centre of growth. Thus, water supply and sanitation could arise due to urbanization. Intersectoral allocations, planning and management of increasingly fragile water resources have emerged as a major challenge due to declining per capita water availability and deteriorating quality of water.India receives an annual rainfall equivalent of about 4000 billion cubic meters (BCM). This source of water is unevenly distributed both spatially as well as temporarily. Most of the rainfall is confined to monsoon season, from June to September and levels of precipitation vary from 100 mm a year in western Rajasthan to over 9000 mm a year in northeastern state of Meghalaya. India's rivers carry 90 per cent of water during the period from June-November. Thus, only 10 per cent of the river flow is available during the other six months. The utilizable water resource

availability in the country varies from 18417 cubic meters in Brahmaputra valley to as low as 180 cubic meters in the Sabarmati basin. Rajasthan has only one per cent of the country's water resources while Bihar has just five per cent of the water resources. At the Independence India's population was less than 400 million and per capita water availability over 5000 cubic meters per year. Today, the population has grown to over a billion and per capita water availability has fallen to hardly 2000 cubic meters per annum and actual usable quantity is around 1122 cubic meters per annum. Environmental problems including water quality degradation from agro-chemicals, industrial and domestic pollution, ground water depletion, water logging, soil salinization, siltation, degradation of wastelands, eco system impacts and various health related problems have caused concern to policy makers and administrators. Thus, management of water resources is imperative rather than development of the resources. The main water resources of India consist of precipitation on the Indian Territory which is estimated to be around 4000 km^3/ year and Trans boundary flows which it receives in its rivers and aquifers from the upper riparian countries (GOI, 2008). Out of total precipitation, including snow fall, the availability from surface water and replenishable groundwater is estimated to be 1869 km^3. The precipitation over a large part of India is concentrated in the monsoon season during June to September/October. Precipitation varies from 100 mm in the western parts of Rajasthan to over 11000 mm at Cherrapunji in Meghalaya. There are occurrences of both floods and droughts in India. Due to access rainwater, floods, about 40 million hectare of land mass is flood prone which constitutes about 12 per cent of the total geographical area of the country. Droughts are also experienced due to deficient rainfall, accounting for 51 million hectare area and 16 per cent of geographical area. India has 16 per cent of world's population and only 4 per cent of the total available fresh water. Water resource availability in the country is limited. The demand for water is continuously increasing on account of increasing population, growing urbanization and rapid industrialization. The actual water supply in urban centres is low as against water demand. Urban Local Bodies are the service providers for water supply and sewerage management however; PHED has been given the task of capital works and O & M in most of the states. In some cities private operators are responsible for the service provision related to water supply and sewerage management. The institutional structure for service delivery in urban areas varies across states. Tariff does not cover the cost of service provision while the service providers have weak commercial orientation (ICC, 2011). The cost of water supply in urban centres is gradually increasing as the urban local governments are depending on distant water sources such as rivers, lakes, canals and other water reservoirs. The cities like Chennai, Jodhpur, Mumbai, Hyderabad and Bangalore are getting water supply from the distance of more than 100 kms. The production cost of drinking water in most of the cities has gradually increased due to pollution of water sources, increasing electricity charges and distant source. The water charges collected by local governments from the consumers – domestic, commercial and industrial are much lower as against the cost of production.

A study by Sridhar and Mathur (2009) presents the data on expenditure and the level of service of water supply for the six cities viz. Bangalore, Chandigarh, Jaipur, Surat, Lucknow and Pune for the period of 1991-2003. The volume of water supply per capita per day in the six cities varies between 196 and 260 litres during the time period of the study. The maximum capital expenditure is Rs. 447.24 per capita in 2001-02 while per capita O & M expenditure is Rs. 473.52 (2002-03). The minimum per capita capital expenditure incurred is Rs. 0.19 in 1999 while the minimum per capita O&M expenditure is Rs. 1.24 in 1995. The study by Sridhar and Mathur (2009) further has made a distinction between cities whose population grew rapidly in the 1990s and those that grew more slowly during the period. Surprisingly, slow growth cities spent more capital and as well as O&M per capita on water and were able to supply higher volume of water per capita. The precipitation is one of the important constituent of climate. The presence of water vapors in the climate, which depends upon on the feed of the moisture from evaporation, both from the seas and the lands, and moment of this moist water, its condensation and the precipitation are the part of the climate process. The regime of water in the hydrologic cycle, thus heavily depends on the climate factors (GoI, 2008). Another important factor which governs the hydrologic regime is the terrain, the geologic and soil related factors. The water regime also depends on the vegetation on the surface of the earth. The effect of climate change is likely to be in two folds. Firstly, the evapotranspiration and the growth of vegetation itself may change due to changes in the precipitation as also due to changes in the evaporation. Secondly, over a longer time period, the type of vegetation which would grow naturally in a part of the earth itself may change either through an adoptive process or through destruction and conquest by other species. The likely change in the snow and glacial regime in the Himalayas due to climate change will affect the intra-annual distribution on the flows available. Due to increase in temperature, the snow and glaciers are likely to melt which will increase the water level considerably. This will also reduce the total mass of the stored water during the spring and summer season. The main concern would be in the alluvium of the Indo Gangetic plains which are depend on the water flow round the year from the Himalayan glacial regime. The concerns can also be express in planning problem by different regions (Table 3). Due to climate change, there are more chances of occurrence of floods, river erosion, droughts in the Himalayan region. In other regions, different water problems will require suitable strategies to address the climate change related issues.

Groundwater is one of the most precious natural resource and has played a significant role in maintenance of India's economy, environment and standard of living. Besides being the primary source of water supply for domestic and many industrial usages, it is the single largest and most productive source of irrigation water. India is a very vast country having diversified geological climatological and topographic setup, giving rise to divergent groundwater situation in different parts of the country. The Central Groundwater Board has recorded a yearly drop of 2.5-

Table 3
Region-wise Planning Problems Due to Climate Change

Regions of India	*Water availability and reliability of outputs*	*Safety against floods and river erosion*	*Safety against droughts*	*Sustainability against sedimentation*	*Adjustments to rise of sea level*
Himalayas	-	Very Important	Important	Very Important	
North & North West alluvial plains	Very Important	Very Important	Very Important		
Central & Eastern Plains	Important	Very Important	Important	Very Important	Very Important
Western Peninsular India	Very Important	Important	Very Important	Very Important	Very Important
Eastern Peninsular India	Important	Very Important	Important	Important	Very Important

Source: Ministry of Water Resources, GOI, 2008.

3 mt. in groundwater levels of Ahmedabad urban areas where the rate of exploitation of city's aquifers is 1.23 per cent. The worst affected are the states of Rajasthan, Gujarat, parts of Andhra Pradesh and Western Madhya Pradesh where water was abundantly available 10-15 years ago. The groundwater table in these areas has fallen below 300 mt. now, and drought has become a yearly phenomenon (Pangare, et. al., 2006). As per estimates of 2004, 839 blocks were reported overexploited while 226 blocks were reported to be critical in terms of groundwater development. The proportion of overexploited blocks was reported high in Punjab, Delhi, Rajasthan, Tamil Nadu, Karnataka, Haryana and Andhra Pradesh. There has been gradual increase in the number of dark blocks in India during 1984-85 to 2004. The highest increase has been reported in the states of Andhra Pradesh, Karnataka, Madhya Pradesh, Rajasthan and Tamil Nadu. Four Indian states viz. Punjab, Rajasthan, Haryana and Delhi are depleting at least 30 per cent more of their groundwater resources than previously estimated by government. The scientists report that these states have depleted on an average 17.7 BCM of water annually between August, 2002 and October, 2008. This is more than the government's estimates of 13.2 BCM in the same period. The groundwater depletion in the region was equivalent to a net, irreplaceable loss of 109 BCM, nearly 20 per cent of annual water consumption of 634 BCM (TERRAGREEN, Sept. 2009). Sustainable development groundwater resources and also for mitigating adverse impact on climate change, synergy among various stakeholders is imperative. Although, the groundwater agencies at central and state level are the custodians of groundwater resource, in reality, multiple agencies in public and private sectors are involved as major players in India's groundwater economy. As climate change transforms, groundwater into a more critical and threatened resource, there is dire need for coordinating mechanisms to bring these agencies under an umbrella framework to synergize their roles and actions. India's water policy has focus on the role of

government agencies in water management. Groundwater recharge is the major focus in response to hydro climatic change that needs to be evolved and worked with an integrated groundwater recharge strategy with role and space for various players. India's water policy was introduced in 1987 and was amended in 2002. In future, demands for water would increase considerably both on account of rising population and their rising food and domestic water needs, and also on account of larger industrialization and changing life style. Even without climate change, many areas and basins are likely to become water stress. Thus, changes in water policy and evolving strategies for water management are imperative. Similarly, legal framework for coping with climate change is also to be amended. There is more need on institutional building to enhance capacity of the state governments and stakeholding agencies to cope up with climate change and also to regulate the water use for various purposes. More decentralized mechanism for water development and management will be required. The governance of urban water sector is non-transparent and unaccountable with no mechanism for the citizens to participate in the governance in a bottom of, direct, legally enabled way. Sewerage treatment has not been a priority for the majority of the utilities across India. The sewerage treatment facilities are grossly inadequate besides low level of sewerage network in India. The sewerage treatment plants are not effective functioning due to several reasons (Table 4).

Table 4
Sewage Treatment Plants in Urban India

Sl. No.	*Category*	*No. of Cities*	*No. of Cities with Sewage Treatment Plants*	*No. of Cities with no Sewage Treatment Facility*	*% Cities in the Category with no Sewage Treatment Facilities*
1	Class I Cities (10 lakh and above)	39	29	10	26
2	Class I Cities (5 to 10 lakh population)	32	13	19	59
3	Class I Cities (20-5 lakh population)	119	34	85	71
4	Class I Cities (1-2 lakh population)	224	36	188	84
5	Class II towns (0.5-1 lakh population)	489	22	467	96

Source: Centre for Science & Environment, New Delhi, 2011

Around 600 million people i.e., 55 per cent of country's population do not have access to safe sanitation or any kind of toilet/latrine (ADB, 2009). With around 102 million septic tanks and 60 million latrines (World Bank, 2009), India lacks national septage management policies (CSE, 2011). Inadequate sanitation has a great environmental economic and health impacts in India. There is a need to invest in septage management as a complement to sewerage development. Septic tanks are one of the most common forms of urban sanitation facilities in India. Major part of urban India has not been connected to municipal sewer system which makes people dependent on the conventional individual septic tanks. By 2017 about 148 million

urban people would have septic tanks and about 425 million rural people would have access to improved sanitation (USAID, 2010).

Performance benchmarking is a powerful tool to make service providers more accountable, and to measure progress while improving performance. The review made by World Bank has examined the performance benchmarking in over 30 urban water utilities across Bangladesh, India, and Pakistan since 2003, with the support of their respective governments and the Water and Sanitation Program– South Asia. The findings reveal that most utilities are performing poorly, and just how dire the state of service provision really is across the towns and cities of South Asia: No water utility in Bangladesh, India or Pakistan provides its customers with continuous water; the average is five hours a day. Water utilities do not serve at least a third of urban residents. High nonrevenue water—frequently estimated above 40 per cent— means a large volume of water is being lost through leaks, instead of being available to improve and extend supply. Operating expenditure far exceeds income in many utilities, and tariffs bear no relation to costs. Most utilities rely on subsidies and ad hoc grants from government (WSP, 2010).

Urban Local Bodies need to ensure *scientific disposal of solid waste to achieve* the desired public health and environmental outcomes. Ministry of Urban Development, Govt. of India initiated Service Level Benchmarking in 26 cities in 14 states and One UT in 2003. Two rounds of SLB data were collected for 2003-04 and 2005-06 and third round of SLB during 2009 (Table 6 & 7). Grading benchmarking of municipal services particularly water supply and sewerage in selected cities during 2005 show grim scenario. The water supply in urban centres is limited to a few hours except a few cities. Non-revenue water proportion against the water supply is reported significantly high in most of the cities. It is estimated that about 28254 million liters per day of wastewater is generated in urban centres comprising of Class-I and Class-II cities and towns having population of more than 50,000. The municipal wastewater treatment capacity developed so far is about 11787 million liters daily which is about 31 per cent of waste water generation.

IMPACTS OF CLIMATE CHANGE ON URBAN SERVICES

Water Supply and Sanitation

- Changes in precipitation patterns may lead to reductions in river flows, falling groundwater tables and, in coastal areas, saline intrusion in rivers and groundwater-all leading to a net decline in the water resources available for supply to urban areas.
- Water quality problems may also increase where there is less flow to dilute contaminants introduced from natural and human sources. The increase in water temperature can alter the rate of operation of bio-geo-chemical processes (degrading and cleaning) and lower the dissolved oxygen concentration of water (Khatri and Vairavamorthy, 2007). This may lead to increased load on water

treatment plants for bringing the water to a recommended standard before it can be released for human consumption and use in the cities.

- Water-supply abstraction and treatment plants, which are generally situated near water sources, may be affected due to disasters such as floods. In severe riverine floods with high flow velocities, pipelines, electrical switchgear and pump motors may get damaged (Satterthwaite *et al.*, 2007).
- Climate related disasters such as floods, cyclones, storm surges etc can also increase the vulnerability of sanitation infrastructure to structural damage. The main impact of climate change would be, on on-site sanitation systems such as pit latrines, is likely to be through flood damage (IPCC, 2007).
- Flooding may also cause septic tanks and sewers to overflow. Since sanitation infrastructures (or the lack of them) are the main determinant of the contamination of urban floodwater with faecal material, damage to these presents a substantial threat of enteric and other water-borne diseases.

Solid Waste Management

Climate change has the potential to impact waste management services and sites (Bebb and Kersey, 2003), by:

- Damaging some on-site waste management facilities such as some gas and leachate collection systems, weighbridges etc
- Disruption of transport facilities impacting the collection of waste from source points and delivery of waste to the management site.

Sewerage and Storm Water Drainage

An adverse impact on water supply is most likely to have negative effects on sewerage and drainage systems in the city. In case precipitation is very high, it can decrease the capacity of the system making it susceptible to flooding and sewer overflow during rainfall extremes. It is important to note that the existing urban drainage system maybe designed to operate under specific weather conditions for a specific area. The age of the system can vary and, in some parts these may not be adequate to deal with future conditions of intense flooding (Berggren et al, 2008).

The Ministry of Urban Development and the Ministry of Urban Employment and Poverty Alleviation constitute the nodal authorities at the national level responsible for formulating policies and guidelines, designing programmes, coordinating and monitoring activities of various central, state and urban local bodies concerning all issues of urban development in the country. A number of policies and programs, schemes and development projects are already under implementation for various urban sectors and services. These include:

- **Jawaharlal Nehru National Urban Renewal Mission** (JNNURM), which aims at improving urban service levels in a financially sustainable manner in

63 identified cities. The JNNURM Directorate has also launched the **Peer Experience and Reflective Learning** (PEARL) to facilitate sharing of success stories and best practices (GoI, 2009). For the cities not covered under JNNURM, GoI had launched the **Urban Infrastructure Development Scheme for Small and Medium Towns** (UIDSSMT). UIDSSMT seeks to improve the urban infrastructure in towns and cities by enhancing public-private partnership in infrastructural development, and promoting planned integrated development of towns and cities.

- The Ministry of Urban Development has **Standardized Service Level Benchmark** (SSLBs) for benchmarking certain indicators for key urban services such as water supply, sewerage, solid waste management and storm-water drainage (TERI, 2009).
- Government of India announced the **National Urban Sanitation Policy** (NUSP) in November 2008 to comprehensively deal with the challenges in urban sanitation in India's cities. The policy envisages transforming all towns and cities of India into 100 per cent sanitized, healthy, and livable spaces; and ensuring sustained public health, and improved environmental outcomes for all its citizens. The main components of the policy are awareness generation and bringing about behavior change; achieving open defecation-free cities; sanitary and safe disposal of waste; promoting proper usage and maintenance of household, community, and public sanitation facilities; extending access to sanitation facilities for poor communities and un-served settlements; and strengthening Urban Local Bodies (ULBs) to provide sanitation services by supporting need-based capacity building and training at the state level.
- The **Rajiv Awas Yojana** (RAY)was announced in 2009 and aims at providing low-cost housing for the urban poor. National Urban Housing and Habitat Policy 2007 emphasizes on in-situ development of slums and preparation of a special action plan for slum dwellers with particular reference to the socially disadvantaged groups of urban population. Recognizing that the rise of slums is rooted in the lack of proper urban planning, the RAY focuses on issues that lead to the development of slums- such as shortage of land, housing infrastructure and basic services (Mathur, 2009). If the RAY is oriented towards urban reforms, it can also be an important vehicle to mobilize the National Strategy for Inclusive Growth as well as the National Urban Housing & Habitat Policy 2007 that aims at improving the living conditions in slums and providing low-cost and alternate housing (Singh, 2010). The specific activities as envisaged under the RAY include:
    - Integrated development of notified and non-notified slums
    - Provision and/or improvement of access and provision of basic services to the urban poor. These include water supply, sewerage, drainage, solid waste management, road access, street lighting, community toilets, market access, livelihoods centres etc.

- Liaisoning with other schemes for the urban poor, related to water and sanitation, health, education, livelihood support, infrastructure, connectivity etc.
- Development of low-cost and affordable houses along with basic infrastructure and services (for ownership, rental or both).

Cities may be viewed as hubs of the intensive resource demand, environmental degradation and greenhouse gas emissions. However, cities may play a critical role in promoting low carbon development through use of renewable energy, energy efficiency, green buildings and mitigating emissions from urban transport. Mainstreaming climate resilience into urban development is essential because climate risks may only be one of the several factors defining poverty level, well-being, economic growth and development in an urban environment. Strategic urban planning directly supports urban resilience as a tool for sustainable development. Urban local governments must actively coordinate and mainstream mitigation, adaption and resilience into urban planning process to prepare cities to deal with climatic risks and impacts. The Supreme Court of India has played a catalytic role for greening cities in the country. The court identified critically polluted cities and suggested an action plan to reduce the level of pollution in these cities. The immediate problems of India's cities relate to inadequate institutional arrangements for solid waste management, drainage, sewage treatment and disposal and sanitation services. Thus, it is imperative to improve the municipal services, particularly sanitation services and urban local governments adopt the integrated urban planning for climate resilience and addressing the environmental problems.

WAY FORWARD

- There is a need to prepare a comprehensive, flexible and user friendly framework for planning and policy analysis under climate variability and uncertainty scenario.
- It is imperative to establish and strengthen ground water monitoring network through construction of observation wells, sanctuary wells for coastal aquifer management and water quality monitoring.
- It is high time to review the National Water Policy with a view to ensure integrated water resource management in the context of climate change challenges in water sector.
- It is imperative to develop inter-ministerial and inter-departmental coordination for vulnerability analysis, mitigation and addressing of climate change challenges both at the state and centre level.
- Integrated Energy Policy, introduced in 2006, should be effectively enforced to promote energy efficiency in all sectors with emphasis on mass transport, renewable energy resources development and clean energy technologies.

- Promotion of cleaner technologies, strengthening of emission standards, introducing economic incentives and strengthening of monitoring and reporting system is imperative in order to control the industrial pollution.
- State specific water policies need to be prepared. Ground water legislation needs to be promulgated in all states to promote sustainable water uses and water development. Emphasis should be given to developing surface water use and taking measures for rainwater harvesting to increase water resource availability.
- It must be made mandatory to install rainwater harvesting systems in both public and private buildings, including industrial and commercial establishments. Buildings having a courtyard should allocate a prescribed proportional area for rainwater harvesting and recharging. The ULBs should make ensure such provisions before approving building plans.
- Environmental taxes can potentially be levied in a wide range of settings for effluent/emission charges for industrial pollution, and user fees for municipal solid waste, to taxes on the use of agricultural inputs such as fertilizers and pesticides and carbon taxes. The small scale industries may also be imposed taxes in accordance with polluter pays principle.
- It is imperative to develop and evaluate adaptation strategies in all the major hydro geological environments to mitigate negative impacts of climate change and variability.
- Integrating climate change adaptation considerations into policy process and decision making across a range of sectors and skills is critical in managing the impacts of climate change. There is need to develop, disseminate and implement the knowledge, tools and technologies required to effectively engaging in an integrated approach.
- A long term national programme for supporting public participation in environmental management including climate change adaptation measures aimed at educating and building capacity of all stakeholders is imperative. The most serious attention should be given to building civil society's capacity to understand the environmental issues and linkages to sector activities, to effectively engage in public participation forums; and promoting innovative and more interactive approaches to public participation that increase public ownership of environmental action.
- A comprehensive urban air quality management strategy should be formulated that includes information related to urban planning, ambient air quality, emission inventory, and air quality dispersion models.
- Water use efficiency programmes including water conservation, water recycling, piped water system, metering and regulation of water use and rationalizing energy supply need to be adopted.

- Most environmental amenities (such as clean air and water) are being overexploited and thus, there is a need to introduce market based instruments for judicious use of such environmental amenities.
- Capacity building and institutional strengthening for environmental management including climate change adaptation measures is called for. There is need to improve the overall quality of governance, particularly at the state and local levels in order to effectively implement the environmental policies and legislations.
- There is an urgent need to reach out the poor and the marginalized groups for improving the access of water supply and sanitation services. In view of the poor state of sanitary facilities and inadequate hygiene awareness, physical infrastructure and awareness building are equally important.
- Vehicular pollution control in metropolitan cities and other cities deserve top priority. A practical strategy should be devised that reduces both emission and congestion.
- Technological intervention is required to enhance effective treatment of waste water. Strengthening of waste water and sewerage/effluent treatment plants should be undertaken on priority basis.
- Enhancing public and private investments for raising plantations for enhancing the cover and the density of forest is called for. Effectively implementation of Greening India Programme is to be ensured to increase the forest cover and vegetation. In-situ and ex-situ conservation of genetic resources, especially of threatened flora and fauna may be adopted for conserving biodiversity.
- Fostering climate resilient reforms in agriculture and water resource management is imperative to promote agricultural research and extension services for better suited agricultural crops in the context of climate risk and variability.

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