

AN ASSESSMENT OF THE IMPACT OF CLIMATE CHANGE ON THE MEGACITIES OF INDIA AND OF THE CURRENT POLICIES AND STRATEGIES TO MEET ASSOCIATED CHALLENGES

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Summary: Providing basic necessities and ensuring safety and quality of life in a changing climate condition have become complicated management issues in the megacities of India. Cities are already under pressure from the rising population and development activities. Existing urban infrastructure is quite inadequate to face these challenges. Water and power have become expensive and the supply is unreliable. Changing climate pattern also causes serious health issues. Increasing intensity and frequency of tropical storms, and the changing sea level pose threat to three of the four megacities. Environmental degradation worsens the impact of climate change. The situation leads to social issues such as competition and conflicts. Current strategies and policies for climate change impact mitigation and control of environmental degradation are not efficient.

Key Words: urbanization, water quality, climate change, urban infrastructure, socio-economic issues, urban water management, policy, adaptation strategy

I. INTRODUCTION

World's urban population increased tenfold in the last century that witnessed abnormal changes in climate. Today, 50 % world's population lives in urban centres, compared to less than 15 % in 1900. In 2000, there were 387 above million population cities and 18 with more than 10 million inhabitants. In the latter half of the last century, most of the growth in the world's urban population was in low- and middle-income nations such as India. By 2000, Asia alone had nearly half the world's urban population and more than half its million cities. Increasing water demand in urban centres and decreasing availability of water due to changes in rainfall pattern, pollution and overdraft of surface and groundwater in urban area have impact not only on the city life, but also on agriculture and rural population, as the water is drawn from distant watersheds (UN-HABITAT, 2006). Providing basic necessities such as reliable water, food and energy, providing clean and healthy urban environment, maintaining public health, and finding shelter to the millions of poor becomes complicated under a changing climate, especially the climate extremes.

Table 1: Urban Agglomerations/Towns in India by Class/Category

Class	Population Size	No.of UAs/Towns
Class I	1,00,000 and above	393
Class II	50,000 - 99,999	401
Class III	20,000 - 49,999	1,151
Class IV	10,000 - 19,999	1,344
Class V	5,000 - 9,999	888
Class VI	Less than 5,000	191
Unclassified		10*
All classes		4378

Source: Census of India – 2001

Situation is worse in the four megacities – Mumbai, Kolkata, Chennai and New Delhi – and the number of million plus large cities of India. India is one of the countries highly vulnerable to the impact of climate change. Exploding population, rapid urbanization and uncontrolled migration add to the severity of the impact of climate change. Most difficult issue is the timely supply of reliable water and the disposal of urban waste water. Indian population has crossed 1.1 Billion and is still growing, expected to stabilise only at 1.5 to 1.75 Billion by the year 2050 - 2075. The net addition of urban population during 1991-2001 has been 6 million, with a percentage decadal growth of 31.2%. The percentage of urban population to the total population stands at 27.8. There has been an increase on 2.1% points in the proportion of urban population during 1991 – 2001. There were 4378 cities and towns in India as on 2001 (Table 1). Indians make up 16.7 % of the world's population with an annual growth rate close to 2%. In Delhi and Chandigarh, almost the entire population is urban. In big states such as Tamil Nadu and Maharashtra, now almost half of the population lives in urban centres (Table 2). About 10.5 % of the national population lives in the million plus 35 cities. Mumbai with a population of more than 16 million is now the world's fourth-largest urban area followed by Kolkata. Studies (citymayers.com, 2008) indicate that by the year 2020, 12 out of the 100 largest cities in the World will be in India, Mumbai being second in the list (Table 3).

Table 2: Urban agglomeration of India

Rank	Urban	Population	Rank	Urban	Population
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	Agglomeration/City	(million)		Agglomeration/City	(million)
1	Greater Mumbai	16.37	19	Ludhiana (MC)	1.40
2	Kolkata	13.22	20	Kochi	1.35
3	Delhi	12.79	21	Visakhapatnam	1.33
4	Chennai	6.42	22	Agra	1.32
5	Bangalore	5.69	23	Varanasi	1.21
6	Hyderabad	5.53	24	Madurai	1.19
7	Ahmedabad	4.52	25	Meerut	1.17
8	Pune	3.75	26	Nashik	1.15
9	Surat	2.81	27	Jabalpur	1.12
10	Kanpur	2.69	28	Jamshedpur	1.10
11	Jaipur (MC)	2.32	29	Asansol	1.09
12	Lucknow	2.27	30	Dhanbad	1.06
13	Nagpur	2.12	31	Faridabad (MC)	1.05
14	Patna	1.71	32	Allahabad	1.05
15	Indore	1.64	33	Amritsar	1.01
16	Vadodara	1.49	34	Vijaywada	1.01
17	Bhopal	1.45	35	Rajkot	1.00
18	Coimbatore	1.45		Total	107.88

Source: Census of India – 2001

Table 3: Indian cities among the 100 largest cities/urban areas in 2020

Rank	City/Urban area	Average annual growth, 2006 to 2020, in %	Population in 2020 (millions)
2	Mumbai (Bombay)	2.32	25.97
3	Delhi	3.48	25.83
11	Calcutta	1.74	18.54
28	Bangalore	2.79	9.92
32	Chennai (Madras)	1.68	8.88
35	Hyderabad	2.21	8.61
39	Ahmadabad	2.73	7.78
41	Surat	4.99	7.72
43	Pune (Poona)	3.46	7.53
78	Jaipur	3.60	4.79
86	Kanpur	2.53	4.44
100	Lucknow	2.72	3.89

Source: citymayors.com

Because of social and economic reasons there has been tremendous increase in migration to cities. Urban economy has far bypassed most of the country's 600,000 villages. Associated with globalisation, there has been a shift in industries from developed countries to developing countries like India, as the labour, energy and natural resources are cheap. As a result, the base of the Indian economy is being shifted from agriculture to industries. Setbacks in rural agriculture due to extremes in climate and negligence to the agricultural sector affect the job security of millions of rural poor, in addition to the food security. Uncertainties in rural life compel the population to migrate to cities in search of a better livelihood. According to the National Sample Survey Organization (2007), about 50% of the farmers think about leaving agriculture, if they find any alternate livelihood. Megacities of India can expect an inflow of

climate refugees not only from the rural areas of India, but also from the neighbouring countries like Bangladesh, where the impacts of climate change will be more severe.

II. CLIMATE CHANGE IMPACT

1. Rainfall, Temperature and Water Availability

Changing rainfall seasonality and severity of extremes affects all major cities of India. Analysis of the rainfall in the four megacities during the last 50 years shows that there is no significant trend in the annual rainfall, but the seasonality and intensity are changing. Increasing seasonality creates water shortage in non-rainy months. Depletion of groundwater level due to long gap in recharge invites salinity intrusion in the aquifers in coastal cities Mumbai, Chennai and Kolkata. Problem is more severe in Chennai where the monsoon rainfall is scanty. Solid wastes accumulate in channels and canals in non-rainy months. Highly seasonal rainfall creates floods, as the drainage pattern is insufficient and the natural flood water evacuation systems such as canals, paddy fields and wetlands have been widely destroyed. Mumbai experienced the worst flood in its history from the exceptionally heavy one day rainfall of 94.5cm on 26 July 2005. Changing frequency and intensity of depressions and cyclones is a threat to the coastal cities. Flash floods and storm surges may further destroy urban infrastructure and deteriorate the water quality. Even a small rise in sea level may inundate large areas of the coastal cities. All the three coastal megacities – Mumbai, Chennai and Kolkata – are under threat from the sea level variations. Estimate using tide gauge data shows nearly 1 mm/year rise in sea level along the Indian coast (Unnikrishnan et al., 2006). Changing climate leads to serious health issues in the urban centres. Heat waves and cold waves have become common in the City of Delhi, killing dozens of people, most of them being poor without proper shelters. Area prone to malaria is likely to extend to Mumbai in near future (Bhattacharya et al., 2006). Extreme weather conditions like floods, droughts and natural calamities leads to psychiatric illnesses in poor people depending on climate sensitive sectors for livelihood (Singh, 2008). Millions of poor in all megacities already face this situation.

Anomalies in global climate pattern pose serious threat to the urban water that is already under stress from human impact. According to IPCC (2004), by the year 2030, the Himalayan glaciers will shrink from 500,000 Km² to 100,000 Km², affecting north Indian rivers where 50% water is from snowmelt. Reduction in summer water flow in River Yamuna will make life more uncomfortable in Delhi that is already under water stress. Changes in water availability in the states/territories in which the megacities are located have been estimated (Table 4) as per predicted change in climate and population, using the water balance procedure of Thornthwaite (1948) and Thornthwaite and Mather (1955), modified by Nair (1987) and based on the climate change scenario of IPCC and the report of the Census of India. Water availability is calculated from the water surplus that represents excess water from precipitation after evapotranspiration and soil moisture recharge. Computing water balance for urban centres alone is of little practical use, as all cities bring water from far away sources.

Table 4: Changes in water availability in different States of India

States	Per capita water availability (M ³)	
	Year 2005	Year 2035
Delhi (New Delhi)	0	0
Maharashtra (Mumbai)	277	101
Tamil Nadu (Chennai)	224	113
West Bengal (Kolcutta)	243	102

In all States, seasonal water deficiencies show an increasing trend and the seasonal surpluses show a decreasing trend. Present per capita water availability from surplus (not fully utilisable) will be reduced by more than 50% in decades. Even today, Capital Delhi has no annual surplus water from precipitation. India with different climate regimes, characteristics of the water cycle variables differ from one region to the other and these are reflected in the water availability. Rather than total amount, rainfall seasonality and antecedent moisture conditions determine the water availability and even slight rise in temperature considerably reduces it. However, in India, when water availability is considered, population increase is a more serious issue compared to the effect of global warming on water resources.

2 Environmental and technical issues

Extremes in climate add to the water crisis and further deteriorate the urban environment. Most of the existing water supply schemes in the cities were designed and installed decades earlier and are now highly inadequate to meet the increasing demands. Cities are also not well-planned to accommodate the current population. Water supply and waste disposal are becoming increasingly difficult. Untreated domestic wastes deteriorate both surface and groundwater resources. Water is highly contaminated from a variety of pollutants including toxic materials, from automobiles, households and industries. Even the urban air pollution alters the water chemistry. Cities still lack an adequate water treatment mechanism. Improper design of drainages and their poor maintenance in Mumbai and Kolcutta cause urban flooding when the rainfall intensity is high, and the logged water infiltrates into groundwater. Rivers passing through the city limits bring agricultural, industrial and domestic pollutants from far away.

The urban water supply and sanitation sector is suffering from inadequate service, widening gap between demand and supply, poor sanitary conditions, deteriorating financial and technical performance and after all, an operating mechanism without much sincerity. According to Central Public Health Engineering Organisation (CPHEEO) under the Ministry of Urban Development, nearly 90% of urban population has access to potable water supply. But in most cities, the supply is highly erratic and unreliable. Transmission and distribution networks are old and poorly maintained. Loss in distribution system is very high, more than 50% in some cities. Water loss through evaporation in rivers and open canals are increasing with rising temperature. Loss in soil moisture also reduces the water availability. Low pressures and intermittent supplies allow back siphoning, which results in contamination of water in the distribution network. Pipelines for water delivery run closer to pipelines for waste disposal. They also run through dirty canals and sewerages. Climate change is a threat to the energy security that has large impact on cities. Frequent power failure and low and unsteady voltage affect pumping of water. Water is available for only on few hours in a day in most parts of the cities. India's electricity requirement is expected to double in about 5 years from now, adding to the crisis in cities (Subramaniam, 2007).

According to the World Bank (2001), among the million plus populated Asian cities, Chennai and Delhi are ranked as the worst performing metropolitan cities in terms of hours of water availability per day, while Mumbai and Calcutta are ranked as second and fourth worst performers respectively. Cities carry water from far away rivers and lakes. The water bodies on which the city of Chennai depends are facing water shortage associated with climate anomalies and anthropogenic impacts. Unscientific storage system in Chennai causes tremendous water loss due to evaporation. Rising demands create more dependency on groundwater and the current rate of extraction using tube wells is not at all sustainable. In Delhi, nearly 10-15 % water is from groundwater reserves and remaining from the Yamuna River (<http://www.rainwaterharvesting.org>, 2008). In the coastal cities Mumbai, Chennai and Kolcutta, overextraction through deep bore wells leads to salinity intrusion in groundwater. High rainfall seasonality and intensity allows less time for groundwater recharge and large volume of water is lost due to fast runoff.

3 Social, political and economic issues

Administrative mechanisms fail to find a solution to urban water problems, due to various political and financial reasons. Gap between the water demand and deliveries often leads to severe conflicts among different classes of people and this is likely to go worse in the coming years. Water disputes over allocation have halted water related development activities in India for decades. Some of the severe conflicts such as the 200 years old Cauvery issue could not be solved even with the orders of the tribunals and the Supreme Court. This is mainly because of the vested regional politics that keeps the issue sensitive for temporary gains. Even inside the city, there is inequity in water supply - 70 % of Delhi gets less than 5 % of the water, while parts where government officials and the richest reside get a 400-500 litres per capita daily. Disputes worsen when the monsoon fails.

Unaccounted population in slums is a prominent factor that makes the urban development programmes a failure. Urban slum areas are home to more than 40 million Indians or 22.6% of India's urban population. More than 600 Indian towns and cities incorporate slum areas. Mumbai has the largest slum population of more than one million (48.9%) (<http://www.citymayors.com>, 2008). Major hurdle in slum removal is the vote bank politics. Politicians compete to provide them with ration card or right for vote so that it is difficult for the local governments to evacuate them. Attempts for slum removal have not become a success till now. When they are offered new houses, they often sell or rent it and return to slums. If the entire slum is removed, there will be a shortage of workers for low class works like cleaning. Impact of climate change is large on these people.

The CPHEEO has estimated that INR1729 Billion is required for complete coverage of the urban population under safe water supply and sanitation services by the year 2021 (<http://cpheeo.nic.in/>, 2008). Government may be compelled to access financial resources from the market and to incorporate the private sector in urban development programmes. Even when the Governments struggle for money to implement water supply schemes, they fail to collect the money for the water already supplied. Financial loss due to theft of water may be more than this.

Development projects in India always lag for even decades due to administrative, legal and social problems. Corruption and misappropriation of money, slow administration, non-cooperation among various Government Departments, vested political interests etc are

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hurdles in urban water development schemes. All this happens when there are challenges ahead such as globalisation, industrialisation and climate change. Industrialisation and urbanization are dividing the society in terms of income and facilities. Industrial overuse and destruction of water bodies for special economic zones has already invited violent protests. The ongoing national river linking project is running against the interest of water rich states. All these issues are likely to worsen under a changing climate when the competition increases for better living conditions.

III. GOVERNMENT POLICIES AND INITIATIVES

Lack of adequate funds is a major hurdle in implementing climate change adaptation strategies. Government is trying to overcome the financial constraints in water development in different ways. The Ministry of Urban Development has initiated institutional, fiscal and financial reforms. One of the key elements in the policy is enhancing the productivity of urban sector that contributes 60% to GDP. The Central Government has advised the States to minimize subsidies and to place urban development plans and projects on a commercial format and to collect additional taxes to minimise the difference in cost of operation and income. Municipalities issue tax-free bonds to find money for infrastructure development. Government is also seeking private sector participation in providing reliable water supplies and to train the stakeholders. It is thinking of amending existing laws for the increased transparency and accountability of utilization of public funds for the development of urban sector. Removal of the restrictions in foreign direct investment has invited hot debate states over the conditions put forward by the investing agencies that is against the policies of some political parties.

Government is taking measures to ensure the efficient management of cities, aimed especially at better infrastructure and alleviation of urban poverty. Ministry of Urban Development is planning for a City Challenge Fund for the improvement of urban economy and an urban academy to carry out study and research on urban matters such as water supply, sanitation, transport, urban governance, finance, etc. The 74th Amendment of Constitution Act 1992 aimed at better governance and urban management gave much freedom to the urban local bodies. India has developed national urban transport policy and national housing policy. But, in spite of the rapid growth in urban sector and worsening issues in different urban sectors, country has not developed an appropriate urban policy incorporating all sectors. The task forces constituted for this purpose could not function satisfactorily. Though water is a hot matter, even the revised national water policy of India (2002) has not considered urban water issues as serious. The National Commission of Urbanisation has already pointed out the critical deficiencies in the various items of infrastructure, issues of the urban poor, the acute disparities in the access of basic services, deteriorating environmental quality and the impact of poor governance. To realise the vision of slum-free cities, the Centre has constituted a national core group on urban poverty to draft a holistic policy regarding livelihood, shelter and basic amenities. Government has planned to create a 'Special Fund' of 28000 Million rupees in the 11th Plan to meet provisions providing water supply, sewerage, roads, drains and sanitation services in the unauthorised colonies, community and miscellaneous services (the pioneer, 2007).

Major water projects are under way in the megacities. Mumbai is trying to minimise impact of urban floods through the 12 Billion rupees Brihanmumbai Storm Water Drain Project aimed at overhauling the city's age-old drainage system by widening and deepening drains to increase its storm-water carrying capacity. In Delhi, the Yamuna action plan to tackle the

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river pollution is going through its second stage, lagging by almost five years and causing waste of millions of rupees (Down to earth, 2005). Urban water demands continue to grow because of significant population increases and the establishment of new urban centres. Even with the implementation of aggressive water conservation programs, providing adequate water supply will become more and more complicated.

The national climate change policy released in 2008 does not provide any strong guidelines for the implementation of adaptation strategies for the cities. The coastal zone regulation act prohibits development activities in the coastal zone within 200 meters of the High Tide Line and restricts such activities between 200 and 500 metres. However, it is difficult to strictly implement the regulation in the coastal cities because of population pressure. The act is being continuously violated, as the law is not properly enforced.

IV. CONCLUSION AND SUGGESTIONS

Changing climate, rapid urbanization and uncontrolled urban migration make urban water management a very challenging issue in India. As the trends in climate are often uncertain, cities should prepare for the extremes. However, there are several options to minimise the increasing impact of climate change, especially in the water sector. Changes in government policies and social setup make more and more population urban dependent. Demands in water increases sharply in all cities whereas, the available resources are being fast deteriorated. Changing climate conditions and conflicts over allocation adds to the water crisis. Slow and incapable administrative mechanism often fails in providing basic facilities, controlling illegal settlements and in preventing degradation of resources. Since population is fast rising and agricultural production is falling, another agricultural revolution may become necessary. Measures for food security always demand more water and this will further cut the water supplies to the cities.

Level of pollution in urban centres, especially near industrial sites is far above all safety limits. Release of gases from industries and vehicles add to the rise in temperature related to global change, creating urban heat islands. Industrial outflow is to be continuously monitored (industries release water in the night during tides). Polluting industries should be severely penalized. Innovative and cost-effective methods are to be employed in urban water purification, stormwater harvesting and stormwater treatment. Wells, ponds and incoming canals to cities are to be protected to maintain water quality and water availability. Careless disposal of solid wastes obstructs water flow in the drainages and is a major reason for urban water logging. Cities should have adequate mechanism for the timely removal of wastes and treatment of wastewater. Recent ban on thin plastic carry bags have some positive effect on this. Households should minimise the usage of detergents and also of fertilizers and pesticides in gardens. Use of biofertilizers and biological pest control are to be encouraged. Household waste may be segregated from industrial waste so that less toxic water can be treated and then used to non-drinking purposes. Water treatment is expensive for the local governments, but collecting money from the poor for this is unjust. Small treatment plants may be made mandatory for posh residential areas and big industries, or the expense for treatment to be met by additional tax from the high income group that consume most of the water.

Measures are to be taken to reduce the theft and misuse of water. A special squad is necessary for this. Rules and regulations have become farce because of the monitory and political influence. Amount of potable water misused by a rich family in a day may meet the demands of a poor family for a week or more. In houses with swimming pools, the usage is manifold.

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Studies indicate that less than 10% of the population uses water sufficient for 50%. There should be a mechanism to supply treated wastewater for the purposes like flushing, gardening, car washing etc. An appropriate tariff is to be fixed, charging heavily for overuse, while providing water free to the extreme poor. In cities like Bangalore, price of water from private parties is not affordable even to middle class families.

Since groundwater provides considerable share of water supply in many cities, it is important to ensure its recharge. Concreting in unnecessary parts of premises is to be discouraged. Instead, either tiles with gaps in between or gravel is advisable. This will also lessen the severity of floods. Paddy fields and wetlands are natural water purifiers and flood controllers and they have to be protected from further encroachment. Deep borewells are to be banned immediately. In coastal cities, they invite salinity intrusion. In rich rainfall zones, rainwater harvesting should be made mandatory for all buildings. Several States such as Kerala have already done this.

Disputes over resources allocation can be solved only by consensus, equity sharing and impartial political decisions. Administration is to be made stricter and corruption free and different departments should be more cooperative in implementing projects and avoiding delays. Better institutional capacity and good governance could improve the urban life. Planners should be able to foresee the changes in land-use, population and climate in coming decades. Water development schemes for the city should be separated from the remaining area. In urban planning, separate guidelines should be there for the wet and dry cities. What works for Mumbai need not be ideal for Chennai.

Low voltage and lack of timely availability of power is a major issue that affects pumping. Wherever the water is brought from highlands gravitational force may be utilised for this. Tremendous amount of water is lost in conveyance. This may be minimized by the proper maintenance of the existing pipelines and the using pipelines instead of open canals.

Since government sector in India is of low efficiency and reliability, private sector participation becomes necessary for the success of development projects. Government should have a control over them. Aid from the multilateral agencies for urban water development is always with conditions. They are against subsidies. But, in a country like India with millions below poverty line, one cannot ignore the realities in society.

With the current rate of urbanization and urban migration, governments will have to struggle hard to provide basic necessities, especially water. There should be a strict control in urban migration and the spreading of slums. This can be done by provide facilities in satellite cities and shifting industries to out of the city limits wherever possible. For rehabilitation in slums, it is better to provide free accommodation rather than giving permanent ownership, to avoid the renting and selling of houses. Requirements of the thousands of people coming to the city for work during daytime are to be counted. India urgently needs a comprehensive and appropriate urban policy with maintaining urban water quality and ensuring satisfactory supplies of water as important objectives. In climate change adaptation strategies, special care is to be given for the urban sector.

A joint effort of the governments, civil society and the private sector and an impartial political interest with a national vision only can save the urban centres of India from the challenges associated with climate change and population impact.

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