Assessment of Vulnerabilities of Indian Cities to Climate Change

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Abstract

India is one of the most vulnerable and risk prone countries in the world. India's urban centers appear to be vulnerable to predicted climate change due high population growth, high population density, poverty and inadequate infrastructure. It has been predicted that climate change has potential to intensify the frequency and intensity of hazards and the probability of extreme events, and also stimulate the rise of sea level and new vulnerabilities with differential spatial and socio-economic impacts. As more than one third of the Indian population lives in the cities and demographic trends of India show that urban growth rate was and slum growth would be higher than population growth of the country. The dual forces of urban development and climate change would have been the key political and economic issue in India due to their significance for economic growth and potential dislocation a large number of populations from coastal cities. The need of time is address challenges by developing a frame of vulnerability assessment of Indian cities, in order to facilitate adaptation-led strategy to reduce climate change risk and increase urban resilience in keeping with India's development priorities and challenges.

Introduction

India is one of the most vulnerable and risk prone countries to projected climate change (International Federation of Red Cross, 2005). Rapid population growth, high density, poverty and high differentials in access to housing, public services and infrastructure have led to an increase in vulnerability over the last few decades, especially in India's urban centers (Revi, A. 2008). It has been predicted that climate change has potential to intensify the frequency and intensity of current hazards and the probability of extreme events, and also stimulate the rise of sea level and new vulnerabilities with differential spatial

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and socio-economic impacts. Today, climate change has become a strategic, economic and political concern as it undermines India's current economic growth and degrades the resilience of poor, vulnerable communities, which constitute between one quarter and one half of the population of the most Indian cities. According to Census of India, 2001, around one third of the Indian population lives in the cities and demographic trends of India show that the overall population growth rate stabilized at two per cent over the past decade, but urban growth rate was as three per cent due to slum growth was as double at five-six per cent in the same period (Hughes, B and E E Hillenbrand, 2006 and Dyson, T and P Visaria, 2004). Mckinsey Global Institute report, India's Urban Awakening: Building Inclusive Cities, Sustaining Economic Growth, states that India's urban population grew from the 290 million reported in the 2001 census to an estimated 340 million in 2008. The report projects that it could soar further to 590 million by 2030. This urban expansion will happen at a speed quite unlike any thing in India has seen before. It took nearly 40 years (between 1971 and 2008) to India's urban population to rise by 230 million. It could take only half that time to add the next 250 million (Mckinsey Global Institute, 2010).

Indian cities may be predicted to be at high risks due to climate change. The predicted regional temperature rise along with the changes in the global climatic system may alter the monsoon system leading to increase of 7 to 20 per cent in the mean annual precipitation and 10 to 15 per cent increase in monsoon precipitation, a decline of 5 to 25 per cent in semiarid and drought prone central India and a decline in winter rainfall in northern India is also projected (Revi, A. 2008). The risks include decline in winter rainfall in northern India, extreme precipitation events near the west coast and central India (Rupa Kumar et al 2006) and a mean sea level rise up to 0.8 meters over the century. In addition, hazards like expected cyclones and storm surges and glacial melt would result in high losses in infrastructure, livelihood and population. Expected increase in incidences of drought due to climate change leads to increased seasonal migration from rural to urban areas.

Therefore, rapid expansion of India cities and climate induced risks to them pose several challenges to resource management and infrastructure planning. It also displays an urgency of the need to adapt city level operations to both current climate variability and future climate change. It is, therefore important to understand a number of processes that are rapidly changing the Indian urban landscape, making cities more prone natural disaster, altering the course of development, that as result affect the vulnerability of many communities. Due to geographical diversity of the country, vulnerability to climate change would vary city to city. Some cities would be more prone to flooding and other would be more affected by sea level rise. Impacts of variation in rain fall and precipitation would also not have uniformity. Therefore, there is an urgent need to assess the vulnerability to climate change of major Indian cities in order to facilitate the adaptation at the city level.

Approach and Methodology

To assess vulnerabilities to climate change of a few major Indian cities, the paper has adopted three analytical and comparative approaches. An indicator approach used in the paper to identify, a specific set or combination of indicators and quantify vulnerability by computing indices, averages or weighted averages for those selected variables or indicators. The major limitation of this approach is unable to capture the dynamics of complex interaction of the various systems related to vulnerability studies. However, the indicator approach is the best option to monitor trends and explore conceptual frameworks. These parameters of vulnerability are not only used by policy makers to understand vulnerability but also help in decision making. Analysis and findings of the research study is based on the interpretation of a set of variables which consist of climate and topography, temperature, rainfall, demographic and socio economic facets of 14 selected cities of India. The set of variables used for assessment of relative vulnerability of selected cities are shown in table 1.

Table 1: Indicators Used for Assessment of Vulnerability

Category/Group	Indicative Variables	Sensitive to Urban System
Climatological Variables	Temperature	↑
	Average Rainfall, Precipitation	↑ ↓
Topological	Altitude	↓
Demographic	Population Density	↑
Social	Slum population	↑
	Literacy rate	↓
Economic	Employment	↓
↑ - Increase	↓ -Decrease	

The decision to choose the variables listed in table 1 is based on wide-ranging literature review as well as from a systematic point of view (relative importance of the sector) and data availability.

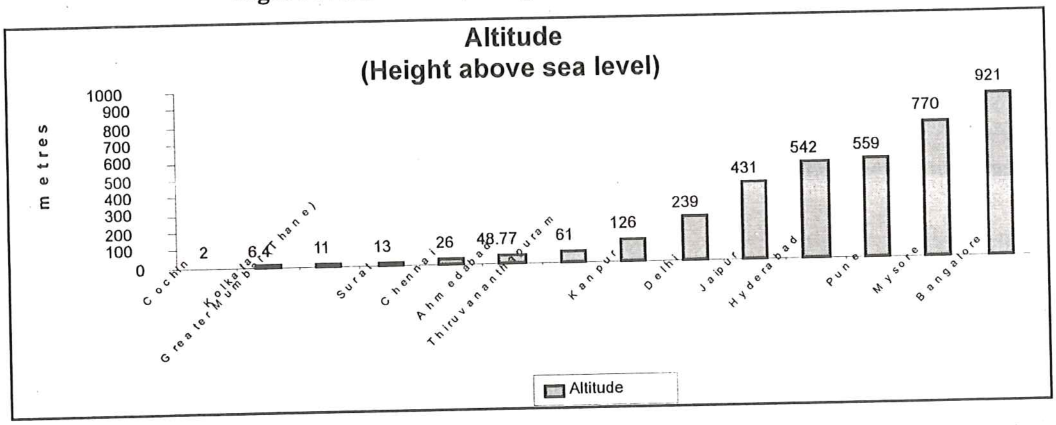
The vulnerability analyses of urban areas are complex processes because uncertainty of extreme events and also the change in natural dynamics of cities are amplified by human intervention and collisions. The method most commonly used is to obtain data for the components of the index, with each component representing a facet of vulnerability. A composite vulnerability index (VI) was computed by aggregating the indicators of the components of the vulnerability. There are many possible choices to derive a composite index from a set of variables. The choice of appropriate method depends upon the type of problems, nature of data and objective of analysis. Having considered the theoretical determinants of urban vulnerability and selected appropriate indicators for its capture, the standardization process has to be carried out to ensure that all the variable area comparable (unit free). In the methodology range equalization techniques used by United Nations Development Programme (UNDP) for Human Development Index (HDI) to make the variables scale free by setting values vary from 0 and 1 and also uses equal weights. The values of each variable are normalized to the range of values in the data set by applying the following general formula:

The highest percentage of projection is 4.39 percent in Surat in it has been followed by Cochin and the lowest percentage is -0.69 per cent in Jaipur. Slight variation has been predicted in the case of Mysore, Hyderabad, Chennai and Kolkatta.

Altitude

Altitude determines temperature as well as topography that may be conducive to land falls on one hand and less water lagging on the other. Altitude is a vital condition in the circulation of vegetation in mountainous region because temperature decreases with increasing altitude. The Altitude (meters above mean sea level) in the study area is considered under three categories: 1- (200-900m), 2- (40-200m) and 3- (0-40m). The peak is 26m at Chennai and the lowest projection is 239m at Delhi

Figure 6: Altitudinal Range in the Selected 14 Cities

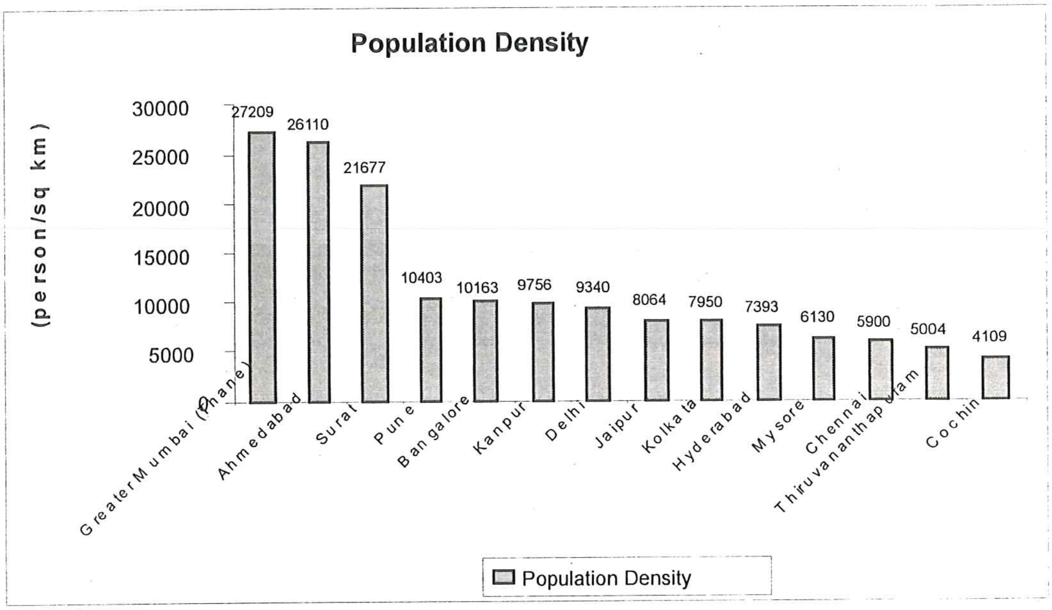


Source: Stratus Consulting 2007, and National Center for Atmospheric Research (Institute for the Study of Society and Environment) and Regional Climate-Change Projections fro m Multi-Model Ensembles

Demographic and Socio-Economic Indicators

The relationships among population growth, resource scarcity and conflict have emerged as increasing environmental awareness. Population growth and resource scarcity are two important facets for sustainable development. In addition, larger population leads to large emission rates too. Population growth multiplies the adverse impacts of climate change in the densely populated areas and is unsustainable ecologically when it is beyond the carrying capacity of system. The poorest peoples will be the most affected.

Figure 7: Population Density in the Selected 14 Cities



Source: *Census of India 2001*

Population density (Per/Sq.Km) in the study area is considered under three categories: a- (<15000), b- (15000-25000) and c- (>25000). Figure 7 illustrates that Greater Mumbai is most densely populated city with 27,209/sq.km, it is followed by Ahmadabad and Surat. Pune and Bangalore are above ten thousand marks, where population density is 10403/sq km and 10163/sqkm respectively. The population density of eight of total 14 selected cities appears to be below 10 ten thousands marks. Delhi is very close to it. Cochin is the least dense city.

The poorest of poor would be the hardest hit by the climate change because they have very limited coping capability. In the context of urbanization and climate change in the in cities, high birth rate and uncontrolled migration are cause of concern. Stabilization and relative growth rate of populations, both globally and nationally, by encouraging lower fertility and balanced migration, is an essential component of policies to mitigate and adapt to climate change. It has been realized that an urgent attention is required to address the problem.

Slum Population

Slum population density (in per cent) in the study areas is considered under three categories based on the alterations: 1- (0-5%), 2- (5-15%) and 3- (15-25%).

Thiruvananthapuram appears to be low in the ranking as is it tenth vulnerable city in the selected 14 cities vulnerability index by relative ranking and 13th by range and PCA method, where temperature variability and 0.84 °C and precipitation variability 2.41 per cent respectively. Employment rate is 32.91 per cent and literacy rate is almost 90 per cent. Slum population is merely 2 per cent. In this context, the city appears to be less vulnerable to climate change. Bangalore ranks second last in the vulnerability index of 14 Indian cities by relative ranking, eleventh and twelfth by PCA and range methods respectively, where temperature variability 0.87 °C Celsius and 1.08 per cent respectively. Population density is 10163 and slum population is 10 per cent. Employment rate is 38 per cent and literacy rate is 83.91 per cent. Both indicators are very high. The maximum temperature of the city is 33 and minimum temperature is 19. Mysore is the 14th vulnerable city of the selected 14 cities by relative ranking and twelfth and seventh by PCA and range methods respectively, where temperature variability 0.87 °C Celsius and precipitation variability 0.39 per cent respectively. The population density is 6130 people per sq km and slum population is 10 per cent. Literacy rate is around 63 per cent which is below national average. Employment rate is 33.28 per cent. The maximum temperature 30 °C and minimum temperature is 19 °C. As figures show that city would be a slight variation in precipitation and temperature.

Conclusion and Policy Recommendations

To sum up, it has been evidently shown in the index that major Indian cities are highly vulnerable to climate change. Since impacts of climate change are uncertain, and will also aggravate the current problems. Disaster had not been included as one of indicators for assessment in this study. Further, it has been planed to include the disaster in the assessment of vulnerability study, which would change the ranking of the cities. It has been predicted population of the cities, particularly megacities is going to be rise rapidly; therefore there is an urgent need to apply the technologies to strengthen the basic infrastructure, for instance metro, which has dramatically transformed the public transport in Delhi, it has also generated the demand in the other cities too. E-governance/ m-governance has potential to transform the public services delivery mechanism too. Finally, it is just a start to assess the vulnerability of the later depth analysis would be done for a comprehensive report on the subject. Since the extent of vulnerability varies city to city, therefore, there is need to adopt the city specific coping mechanism to climate change.

- There is a need of base line data (climatic, socio-economic, institutions and governance) for each and every city of India.

- Development of better scenario, for temperature, precipitation and extreme events at the local scale.

- To construct dynamic models of climate, ecosystems and socio-economic factors of urban systems taking in account nature of development and time varying nature at different scales.

- To quantify the risk of climate change in Indian cities at regional scale i.e. sea level changes or storm surge taking a fuller range of possible climate change outcomes.

- To develop a better understanding of the impact of future socio-economic development pathways like urbanization, population growth, increase in assets values, change in ground water level and changing land use pattern with their relative effect on risk from climate and raking of these cities.

- To develop a better understanding of adaptation responses to these climatic variability, especially the cost and effectiveness of protection, adaptive capacity including structural, behavioral and institutional barriers to cost-effective adaptation of individual cities. This would provide a stronger empirical basis for analysis;

- Integrated assessment of sectors (city specific) going to be affected climate change in near future.

Acknowledgement:

The authors wish to acknowledge Ministry of Urban Development officers viz Shri R. Ramachandra, Shri A K Mehta, Joint Secretary, Ms Nivedita , Under Secretary Priyank Jindal has also contributed to the research effort.

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