

Climate Resilient Cities

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Abstract - As evidence of climate change becomes more perceptible around the world including the likely increase in extreme climate scenarios or climate change-related disasters in the coming years; climate change can no longer be considered a distant threat. While local conditions may vary, many cities are facing dramatic increase in climate risks from the combination of rapid urbanization together with increased likelihood of flooding, drought and fluctuating water supply conditions, higher temperatures, sea level rise, and more intense storms. Therefore, considering the adverse impact of climate change on future city's spatial pattern, growth & development; paper highlights such impacts and prerequisites for building climate resilient cities.

Key Words: Climate Changes, Resilient Cities, Urbanization, Vulnerability, Sustainable Development.

1. INTRODUCTION

Throughout the world, the need to withstand and adapt to the adverse effects of climate change has become increasingly evident. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. While local conditions vary, many cities are facing dramatic increases in climate risks in the coming century from the combination of rapid urbanization together with increased likelihood of flooding, drought and water supply pressures, higher temperatures, sea level rise, and more intense storms. (Tyler S. et al., 2014)

As the reality of climate change has become more apparent, it is the urban areas that could be facing the major brunt. With half the world population living in cities it has become necessary to address the vulnerability of these cities. Considering the concentration of goods, services and people in the cities, the above impacts would have grave and far reaching consequences on the countries and on the people residing in the cities. Also, considering the potential devastation associated with future climate change-related disasters, it is vital to change the way we build and manage our cities. (World Bank, 2009)

India's urban population has shot up from 28.5 million in 1901 to 377 million in 2011 (Census of India, 2011). Indian cities face a variety of challenges such as providing basic services to all and a satisfactory quality of life. India has medium risk exposure, but high vulnerability due to climate change and it is expected that climate change will both intensify the current risks faced as well as lead to some new

hazards like sea level rise (DEFRA, MoEF cited on TARU,2010). Climate change in India represents an additional stress on ecological and socioeconomic systems that are already facing tremendous pressures due to rapid urbanization, industrialization, and economic development. With its large and growing population, and an economy that is closely tied to its natural resource base, India's population is vulnerable to the impacts of climate change such as changes in forest and water resources and sea level rise. The direct and indirect impacts of climate change, coupled with resource conflicts may further increase the pace of rural urban migration over the next few decades. This can lead to the possibility of severe stress in urban infrastructure, built and natural environments due to a mix of climate-related impacts such as water scarcity and environmental service breakdowns and flooding, with the consequent risk of waterborne diseases and epidemics (Parikh J., Sandal G., Jindal P., 2013).

Based on their location as well, Indian cities are or would be grappling with various impacts of climate change. For instance, cities located in the hill regions of North India are facing impacts such as flash floods, intense precipitation; those on the coast are facing rise in sea levels, increase in cyclones and storms while those in arid areas are facing issues of water stress, increase in temperatures and as a result health impacts as well. Consequently, all these factors may affect the resilience of cities to the threats posed by climate change impacts. The paper aims to highlight the impacts of climate change on urban areas and the prerequisites for building resilient cities.

2. CLIMATE CHAGE

As per definitions given by Ministry of Environment, Forests and Climate Change (MoEFCC) Govt. of India and IPCC; Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural processes like changes within the climate system or in the interaction between its components. Or, this change can be because of external forcing either for natural reasons or due to persistent changes in the atmospheric composition due to anthropogenic actions or in land use. Climate change includes changes to temperature, rainfall patterns, wind regimes, or ice cover.

3. IMPACT OF CLIMATE CHANGE ON URBAN AREA

According to IPCC’s AR 5, “the global surface temperatures have risen by almost 0.89°C over the period 1901-2012 and about 0.72°C over the period 1951-2012.” It further states that the “global mean sea level has risen by 0.19 m, over the period 1901-2010.” Records indicate that it is likely that the numbers of cold days and nights have decreased and the numbers of warm days and nights have increased across most of Asia since about 1950. Heat wave frequency has increased since the middle of the 20th century in large parts of Asia.

Climate change is influencing the micro-climate of cities, leading to extreme weather conditions which can cause health problems and affect the quality of life of residents. It can also lead to increase in frequency & intensity of climate change associated risks from extreme events like floods, droughts, storms, heat/cold wave, etc. Such disasters which result from and/or worse by climate change can undermine decades of growth through a single catastrophic event.

Furthermore, climate change impacts on urban areas of particular concern due to high concentrations of people, infrastructure and large-scale economic investments. As cities grow in size and number, it becomes important study the impacts of climate change as these may not be confined to increased threat of hazards that could turn into large-scale disasters but extend far beyond it. Climate Change can further aggravate the challenges cities already face with regards to addressing poverty, inadequate services, infrastructure deficits, etc.

extreme winds	<ul style="list-style-type: none"> • Direct effects of wind exposure on heavy vehicles • Contamination of water leads to water born diseases. • Greater risks to public safety, and resources needed to manage flood, rural fire, landslip, and storm events • Changes/reduction in water availability; Changes in biodiversity; Changes in type/distribution of pest species; Groundwater changes; Saltwater intrusion in coastal zones; Need for more shelter in urban spaces
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Table -1: Key climate influences along with their possible effects and urban assets/sector it may impact.

Key Climate Influence	Possible Effects	Affected Assets or Sector
Reduced rainfall, extreme events, and increased temperature	<ul style="list-style-type: none"> • Reduced security of supply (depending on water source); Contamination of water supply 	Infrastructure
Increased rainfall	<ul style="list-style-type: none"> • More intense rainfall (extreme events) will cause more inflow and infiltration into wastewater network; Wet weather overflow events will increase in frequency and volume. • Longer dry spells will increase the likelihood of blockages and related dry weather overflows 	Infrastructure
Extreme rainfall events,	<ul style="list-style-type: none"> • Disruption due to flooding, landslides, fallen trees and lines 	Transport Infrastructure

The urban poor are typically at the highest risk in the event of natural disasters due to the location of low-income settlements. These settlements are often on sites vulnerable to floods and landslides, infrastructure is weak or lacking, and housing is substandard and prone to fire damage or collapse. The urban poor thus face threats to their lives, assets, and future prosperity due to an increase in risks of storms, floods, landslides, and extreme temperature. They are also likely to get unequal distribution of scarce assets such as water, energy supply, and urban infrastructure thereby increasing their vulnerability.

Climate change is a stress that only healthy and sustainable cities can deal with, under normal circumstances, cities need to be fully functioning first. Once it is achieved, resiliency can be aimed for, especially where climate impacts have become evident. In others, stronger and specific action, which may force us going beyond sustainability measures, for city development, especially for coastal, riverine and mountainous regions.

4. VULNERABILITY

The IPCC Third Assessment Report (TAR) describes vulnerability as “The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.”(IPCC, 2001 cited in TARU, 2010). Vulnerability is multidimensional, differential, scale dependent and context specific. It is a dynamic concept that portrays a changing degree of susceptibility to loss by exposure to disaster by individuals, communities and systems. It is important to assess the vulnerability to make our cities resilient.

5. CASE: SURAT, GUWAHATI AND GORAKHPUR, INDIA

For the purpose of this paper, the resilience strategies of three cities- Surat, Guwahati and Gorakhpur have been taken as case examples in order to understand the impacts of climate change at city level and devise possible strategies for building climate change resilience.

Table -2: Comparative study of climate change resilience strategies

	SURAT	GUWAHATI	GORAKHPUR
Regions	Coastal	Riverine	Plains
Existing/ Projected change in the climate	<ul style="list-style-type: none"> Increased precipitation Flooding Sea level rise and associated inundation 	<ul style="list-style-type: none"> Both Max. and Min. temperature shown an increasing trend Decreasing trend in overall seasonal but increase in extreme 	<ul style="list-style-type: none"> Average intensity of rainfall in the summer months has increased.
Expected Climate Change impacts	<ul style="list-style-type: none"> Submergence of land and flooding due to rise in sea levels 	<ul style="list-style-type: none"> Prolonged duration of water logging/flooding. Increase in vector borne diseases post flood events. 	<ul style="list-style-type: none"> Flooding and water logging due to excess/intense rainfall. Rise in diarrheal diseases.
Climate hazard risk	<ul style="list-style-type: none"> Coastal storm and cyclones Major floods in the last 2 decades 	<ul style="list-style-type: none"> Flooding due to high rainfall intensity. Landslides due to flooding & soil characteristics 	<ul style="list-style-type: none"> Floods almost every year since 1998. (2009, 2007, 2001, 2000, 1999 etc.)
Factors that increase vulnerability	<ul style="list-style-type: none"> Lies 13m above sea level Majority of slums are located in low-lying areas facing high flood risk 	<ul style="list-style-type: none"> Unplanned / unregulated urbanization. Lack of storm water drainage. 	<ul style="list-style-type: none"> Water logging due to: Creation of low-lying areas due to shifting of Rapti river bed to western side of the city.

	<ul style="list-style-type: none"> due to Tapi river and Khadi floods and sea level rise 	<ul style="list-style-type: none"> Pollution & encroachment of water bodies Significant no. of slums located in area prone to floods & landslides. 	<ul style="list-style-type: none"> City's bowl-shaped topography. Has increased in the recent year due to choked drains and lack proper solid waste management. Energy shortage
Climate Resilient Strategy	<ul style="list-style-type: none"> Structured around four main principles Build on current and planned initiatives. Demonstrate resilience-building projects to leverage further action. Multi-sectoral information generation, and shelf of project. Build synergy with state and national level institutions. 	<ul style="list-style-type: none"> Sector wise recommendations. Watershed management 	<ul style="list-style-type: none"> Identification of three pilot projects on Peri urban agriculture, solid waste management and micro-level resilience Planning. Micro-resilience planning include addressing multiple sectors, such as agriculture and livelihoods, solid waste and drainage management, water and sanitation, housing, health and education.

6. HENCE, SOME OF THE MAJOR INFERENCES THAT CAN BE DRAWN FROM THE ABOVE CASES AREA AS FOLLOWS:

- Due to inter-linkages of services within an urban environment and consequently the highly connected nature of risks, policies relating to urban resilience essentially needs to address multiple sectors and dimensions. For example, land use planning, watershed management etc.

- Improving basic service provision can be essential to building resilience, as is developing effective institutions to assess and address problems.
- Building micro-level resilience can improve understanding of links between climate change and development mechanisms in a city.
- People's participation in framing strategies to build to the changing climate can help in increasing ownership of problems and empowered them to take collective action.

7. RESILIENT CITY/URBAN RESILIENCE

The Oxford English dictionary defines Resilience as the ability of a substance or object to spring back into shape after having been subjected to an external stress; elasticity or "the capacity to recover quickly from difficulties; toughness". Resilience is also one of the characteristics of natural ecosystems. When applied to social-ecological systems, it can be defined as "the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity. "Concept of resilience is central to the understanding of urban area vulnerability.

In the recent years, climate change and its induced (and/or aggravated) disaster risk has come up as one of the biggest challenges cities will face. Therefore, in view of the grave long term threats posed by the changing climate, building resilience of nations, communities and urban systems has become necessary. Urban resilience or a resilient city has been defined by authors, various international, independent and non-governmental agencies working in this field. As per those definitions urban resilience constitutes as the ability of a city or urban system to resist, absorb and/ or withstand, recover/'bounce back' rapidly, manage/maintain certain basic functions and structures as well as learn and adapt to/from shocks and stresses like adverse impacts of climate change, disaster risk, energy scarcity, economic shocks etc. to its social, economic, and technical systems. As per ACCCRN (2009),

"Resilient cities create, enable, and sustain the services and institutions required for basic ongoing survival and are characterized by their ability to generate new opportunities for their residents."

And, according to Prasad et al. (2009)

"Resilient cities in the light of climate change should be able to develop plans for future development and growth, bearing in mind the climate impacts that the urban systems are likely to face."

8. PREREQUISITES FOR BUILDING URBAN RESILIENCE

Resilience is greatly influenced by the quality of urban governance and the level of infrastructure and services provided by the government. For cities, resilience is enhanced by knowledge of risks and tools and resources available to confront threats and build on opportunities.

The resilience of cities also increases by enhancing their autonomy and their governance system that rely on active collaboration between the different stakeholders. The resilience of urban areas is also greatly enhanced by disaster-resistant infrastructure by engaging the government and several urban / national level businesses and organization to guide the city-level strategies that can address climate change. Initiatives to curb carbon emissions and air pollution in the centre of the city in order to alleviate the urban heat island effect. Towards this establishment of several low carbon zones in the city to reduce local carbon emissions. Other initiatives like planting trees to green the city and de-carbonize its energy supply while capturing heat 'waste', can also be implemented.

From the urban infrastructure perspective, there is a need to protect lifeline buildings of the city and maintain them so that they don't contribute to the risks already faced by the cities. The resilience of urban infrastructure and services is critically important for emergency response and the quick recovery of a community and its economy as well. This is to make these infrastructure systems more 'robust' i.e. to withstand the impacts of hazard events without significant damage or loss of function and 'flexibility and diversity i.e. services may be supplied via a number of pathways, using distributed resources and multifunctional equipment. If one pathway fails, another can be used to achieve the same service. Water supply and wastewater systems, energy and communications, and transportation systems deserve particular attention because they are vital for the quick recovery of a community and the livelihoods of people. Hence, by paying attention to these focus areas we will be able to make our cities resilient.

REFERENCES

- [1] Asian Cities Climate Change Resilience Network (ACCCRN), 2009 Responding to the Urban Climate Challenge. Eds. ISET, Boulder, Colorado, USA, 60 pp.
- [2] Asian Cities Climate Change Resilience Network (ACCCRN), 2013. Climate Change Resilience [online] Available at: < <http://www.acccrn.org/uccr/what-urban-climate-change-resilience> > [Accessed on 3.05.2016]
- [3] Divya Sharma, Raina Singh & Rozita Singh (2014): Building urban climate resilience: learning from the ACCCRN experience in India, International Journal of Urban Sustainable Development[online] Available at:< <http://dx.doi.org/>

10.1080/19463138.2014.937720> [Accessed on 3.05.2016]

- [4] Census of India, 2011
- [5] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland
- [6] Parikh J, Jindal P, Sandal G., COE-IRADe, 2013. Climate Resilient Urban Development, Vulnerability Profiles of 20 Indian Cities
- [7] Tyler S. et al, 2014. Developing Indicators of Urban Climate Resilience, Climate Resilience Working Paper Series #2
- [8] TARU, 2011 Surat Resilience Strategy.
- [9] TERI, 2010a. Climate Resilient and Sustainable Urban Development
- [10] TERI, 2012b. Mainstreaming Climate Resilience in Urban Areas-A case of Gorakhpur City
- [11] TERI, 2013c. Risk Assessment and Review of Prevailing Laws, Standards, Policies and Programmes to Climate Proof Cities- Synthesis Report for Guwahati.
- [12] World Bank, 2009 Climate Resilient Cities: A Primer on reducing vulnerabilities to disasters [pdf] Accessed online:
<<https://openknowledge.worldbank.org/bitstream/handle/10986/11986/9780821377666.pdf?sequence=1>> [Accessed on 3.05.2016]