

Catastrophe of Climate Change and Urbanization in South Asia Region (SAR): Control Measures

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Summary

In the present research, a detailed analyses has been made on South Asia Region (SAR) comprising countries of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka, accounting for one-sixth of world's population and having diverse geophysical features making it one of the hotspots of almost all natural disasters, which has been facing the challenge of global and regional threat of climate change to its sustainable economic growth. We analyzed huge data set reported during the year 1900-2011 for better understanding of the core issues why and how the uncontrolled processes of varying degree of urbanization, disaster and development in SAR are inter-related to each other under climate change scenario, which in turn help to seek a plausible way out for development of a holistic model for institutional structures for governance and mainstreaming of DRR and CCA synergized with urban local bodies for growth of a sustainable disaster and climate risk resilient urban setup in SAR. An effective Disaster Management Response Cycle (DMRC) has been propounded, for the first time, for the region, demonstrating a new dimension to the risks by the hazard, risk and vulnerability (HRV) associated with the neo-urban risks having bearing on unabated migration of its rural population to new urban centers in search of a better livelihoods supported by an unprecedented annual urban growth rate (AUGR) of 2.53%, as against the global AUGR of 1.98%. A classical approach to DMRC provides a way to Disaster Management Response continuum which shifts the focus of Disaster Manager from existing paradigm of response only during the event of disaster, to the equal focus of response during all the facets of disaster. In this study it is established that there exist a close correspondence of HRV of SAR nations with their respective geographical location, their DRR's, CCA's and Urban Local Bodies (ULB's) governing structure, financial health, management practices, and the coping capacity, which is responsible to address different risk drivers having unique features in different geographical setups for evolving an apt planning. The study envisages to create a common single platform for coherent and joint efforts by all the stakeholders while suggesting

mechanism for strengthening their financial health to enable them carry out the onerous job of making urban life, a sustainable one.

Based on the available constraints for developing a risk resilient urban system for SAR, we suggested three step comprehensive urban risk resilient models for sustainability, which take care of: urban disaster management response Cycle (UDMRC); sustainable and risk resilient urban development mechanism; and risk resilient urban agglomerate (RRUA) setup associated with urban risk resilient wheel of 12-spokes rather than 10-spokes model of UNISDR-2012. We infer that SAR should focus on the economic driver of city life and such mitigation and adaptation measures to be employed which give sustenance to the economic driver for ensuring sustainability to the urban centers as the process of urbanization is not based on laissez-faire phenomena.

In conclusion we stressed up on the fact that the need of hour is to development a plan of Risk Alleviation Platform (RAP), which becomes the instrument to bridge the gap between the institutional frameworks of DRR, CCA and the governing structure of ULBs meant for the Neo-Urban Risk Mitigation and Adaptation (NURMA) with linkages among verticals of the institutional structure of DRR, CCA and the governing body of the State and NURMA by curbing the resource mismatch between its realization and expenditure commitment.

Keywords: Catastrophe; Climate Change; Urbanization; Neo-urban risk; ULBs; DRMC; RAP; NURM; CCA; Laissez-faire phenomena

1. Introduction

The vulnerabilities profile of different countries in the South Asia including the new risks emerging out of climatic change and urbanization make it imperative for the policy makers to factor them in their new socio-economic planning, in order to mitigate their impacts and to make the journey of the mankind's, a sustainable one. Globally a perceptible change is being observed in the changing structure of the nation's GDP, particularly among the developing one, which in percentage terms notices receding trend in contribution coming from the Agricultural Sector. The share of secondary and tertiary sector in the overall GDP varies and depends on the economic potentials of the area. This guides the policy makers to allocate the state's resources to give an impetus to the economic activity accordingly, be it agriculture, mining, manufacturing or services. The role of State is to propel the socio-economic change and growth, for creating employments and a better life for its citizen. While doing so, the foremost concern of the State need to be the sustainability of such efforts which in no way destroy the ecology of the region, degrade the environment and create new hazards and risks to its people and livestock. Given this background, it is important for the regulators, planners and administrator to develop their capacity to understand the nuances of such hazard, risks and vulnerabilities (HRV) and map them for the given area for their sustainable future planning. Several hazards invariably are inherent in the geophysical features of the area. The climate change is now posing a new challenge to the sustainability of the world. Besides them, the development journey also contribute a great deal of new risks and hazards. A new phenomenon of rapid urbanization, contributed primarily by migration of the people from villages to the cities in search of a better life, and one of the reason for changing GDP structure of the developing world, is recognized to contribute a new risk to the sustainable development.

2. Importance of Mapping the risks and vulnerability in the Urban Planning

The first Assessment Report on Climate Change in Cities (ARC3), a project of the Urban Climate Change Research Network (UCCRN) [1] has outlined the importance of estimating the spatially and temporally disaggregated risks for assessing effective and efficient adaptation climate change and mitigation strategies and plans in a complex urban area. It is also important to notice that the neo-vulnerabilities and risks arising out of urbanization are manifesting out of the physical interaction of people with nature and space. Foremost among them is the migration of people from rural to the urban area. Due to absence and lack of their accommodation in the existing urban space, such new arrivals give rise to the growth of slums. This phenomenon is attributed to the outcome of demand driven

developmental approach to the urban settlements. The supply driven advance planning must commensurately cater to the requirements of space for spread of the city, urban economic and social infrastructure to meet the needs and demands of new dwellers and must be driven at pace matching with the growth-rate of urbanization. The migrants to the urban areas are new to the regulations they are subjected to in the cities. These concerns are missing in the overall scheme of developing economy. The city life thus under the new stress and demand-supply gap gradually faces air pollutions, degradation of water supply and water bodies (lakes, ponds and riverbed, etc.). The wastes are generated with no mechanism for their management and disposal. Unmanaged sewage and drainage system lead not only to the health hazard, but chokes the normal flow system, thus leading to water logging, problem of flash floods during rainy season, etc. The city populace is forced to live in hellish and unhygienic conditions.

The greenhouse effects are added and exacerbated due to extensive use of inorganic material, cement, plastic, steel, bricks, stone, etc. The old buildings designed to withstand certain level of pressure and human stress are prone to the geophysical events and seismic conditions making the lives of people settled around such structure vulnerable. For want of regulations, the new buildings coming up in the new settlements add to the already existing vulnerabilities. Concretization happening in the cities adds to the heating effect, thus adding to the GHG emission. Besides the building, the infrastructures coming up in support of urban life such as road, transport, telecommunications and radiations emanating therefrom, compounds the risk.

Such planning, therefore, needs basic informations and data on the hazards, vulnerabilities and risk profiles. The mapping and collections of such data is the first step which the state needs to give attention to.

2.1 Skilling those engaged in Mapping

The IPCC fifth report highlights the capacity gap across the world for risk management. India being second largest in the world in terms of its population and showing the sign of one of the highest urban growth, lacks the per capita availability of accredited planners, even in comparison to the least developed country like Nigeria [2] (Table 1). This sorry state of affair in terms of availability of capacity across the sector is prevelant in most of the developing countries, including the region of South Asia.

Table 1: Planning Capacity Varies Greatly Across the World

(Accredited Planners per 100,000 Population)

UK	Nigeria	India
38	1.44	0.23

Source: World cities report [2].

The lack of knowledge and skill in the administrative structure of the local bodies and in the government about management of such data on disaster risks and vulnerabilities make the communities susceptible to cope with the disastrous events arising out of them in absence of appropriate planning for mitigation and adaptation. Besides the lack of knowledge on DRR management, the measure and resources required for mitigation of such risks and adaptation are not adequately available with these bodies. The coping capacity not getting enhanced and supplemented with skill and technology, further adds to the vulnerabilities of the communities living in this area.

To start with the preparation for DRR, it is imperative for planners to understand the current status of all kind of risks and their sources. Mapping of such risks and to know about the consequences of such risks are the prerequisites for any planning and development to become sustainable. It would help in the quantification of the resources required to mobilize appropriate measures and doses to blunt the sting of the disasters sources, whether happening due to the geophysical features of the region or due to climatic change or because of neo-risks emanating from the urbanization. It should also be a paramount concern of the State to undertake the skill upgradation of the people deployed for mapping of such risk, in view of huge gap of knowledge and skills persisting among them.

2.2 Broad Contours of Mapping:

The mapping of hazard and risk require attention in the following three broad areas.

i. Geophysical hazards:

The High Power Committee Report constituted by GOI in 1999 in India, has categorized various disasters into five broad lists given in Table 2.

Table 2. Categorization of Disasters (HPC – India, 1999) [3]

S.No.	Disasters
1.	Water and Climate related disasters,
2.	Geological related disasters
3.	Chemical, Industrial and Nuclear related disasters,
4.	Accident related disasters,
5.	Biological related disasters.

The geophysical disasters emanate from the geophysical characteristics of a place. These are landslides and mudflows in the hilly regions, earthquake dependent on the seismic features, dam failure or dam burst are again a feature of geology of the place, etc. [4]. Tsunami also results out of earthquake beneath the ocean and is mostly evident in the seismically active region of Japan, Indonesia, the eastern coastal region of India and the islands located in the Indian Ocean. Mapping of these features which put the community at risk must be paramount in the planning of any socio-economic development of the region which has direct bearing emanating from these features and is likely to impact the settlements of people already living in this region.

(i) Risks of climate change:

It is well understood about the possible loss and impact on a relatively smaller and thickly populated area that is the city space due to climatic change which hitherto have extensively been studied at macro level and in a large geographical region. The risks described extensively in the preceding chapters throw light on the possible loss. The climate usually is perceived as an average weather condition and thus risks of climate change should be understood as deviation in the average weather condition likely to bring about loss to mankind and the biosphere in socio-economic terms and the usufructs which the communities have been enjoying from such bio space since time immemorial. The risk of climate change is attributed to emanate from the effect of temperature change. One of the

plausible reasons for such change is due to interaction of demographic shifts with the changes in regional temperature extremes, local heat island, pollution etc. Climatic changes having a bearing on the community at large are featured in the disasters which mostly emanate from hydrological events and are listed generally under water and climate related disasters. These are as listed in Table 3.

Table 3: Climate Change related Hydrological Events

S. No.	Disaster
1.	Floods and drainage management,
2.	Cyclones,
3.	Tornadoes and hurricanes,
4.	Hailstorm,
5.	Cloud burst
6.	Heat wave and cold waves
7.	Snow avalanches,
8.	Droughts,
9.	Sea erosion,
10.	Thunder and Lightening

Source: R.K. Srivastava [3].

The causes of such events and their consequences are of utmost importance for any future planning

(ii) *Urbanization: A Neo Risk:*

The irreversible process of shift of the people from rural to urban area is well recognized.. The change in the components of the GDP structure of the developing economy is reasoned out for giving an impetus to the process of migration leading to urbanization. It is estimated that by 2050 more than two-thirds of the world's population will live in cities, up from about 54 per cent today. The benefits of organized and efficient cities are well understood, but the ~~ise~~ rapid, often unplanned urbanization brings risks of profound social instability, threat to critical infrastructure, potential water crises and the potential for devastating spread of disease. These risks are going to be further exacerbated if this unprecedented transition from rural to urban areas continued [5]. NASA in its satellites study have identified strong Urban Heat Island (UHI) signatures in cities. The Global Rural Urban Mapping Project (GRUMP) of Center for International Earth Science Information Network (CIESIN), a member of the Earth Institute at Columbia University, shows that as much as three per cent of the Earth's land area has already been urbanized, which is double of previous estimates. GRUMP shows that 20 per cent of the world's urban population live in settlements that have populations below 500,000. It further shows that approximately 7 per cent of the world's population now resides in the largest mega-cities, whereas experts had previously estimated this number to be around 4 per cent.[6]. The area witnessing these changes is faced

with global climate risks. In urban areas, climate change is projected to increase risks for people, assets, economies and ecosystems, including risks from heat stress, storms and extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges [30]. The risks associated in the urban space is summarized in Box 1 [64- chapter 8].

Box 1: Climate Risks in the Urban Space[65]

- People living in informal settlements and on the land at high risk from extreme weather,
- People of different age and gender face different level of risks. Infants and elderly people are more sensitive to particular hazard such as heat stress etc.,
- Location specific risks such as different kind of buildings or coastal area, or river sides etc.,
- Deficiencies in infrastructure and services-making adaption difficult. For example, lack of socio-economic infrastructure even aging infrastructure,
- Incompatibilities between demand and supply of goods and services into and out of urban centers with changing demography of the area,
- Regional and context specific Risks-emanating from the differences in level of adaptive capacity,
- Urban temperature variations-Increased frequency of hot days and warm spells exacerbate urban heat island effects-causing heat related health problems,
- Drought and water scarcity- may lead to the shortage of water supply to the urban dwellers, electricity shortage (supply from hydro source),
- Coastal flooding, sea level rise and storm surge-affecting the inhabit out settled near the sea shore, and within low elevation zone, (IPCC-20 estimates for global mean sea level rise are for between 26 and 98 cm by 2100),
- Inland flooding, Hydrological and Geo-Hydrological hazards at urban scale,
- Disease and Epidemiology issues in cities due to climatic change-Temperature extremes would affect health, impact urban air quality.

Source: Based on [64,7]

The course for the policy makers of any nation should therefore be to meet these challenges by recognizing the fact about the demographical shift, taking place from the rural landscape to an urban one and plan accordingly to not allow this phenomena to drift and turn into a man made kind of Disaster. The urbanization brings in, many inherent potential hazard on fore which would turn into an unnatural kind of Disaster. This may broadly be outlined under three

categories of (a) Chemical, Industrial and Nuclear related disasters (b) Accident related disasters (c) Biological related disasters. It constitutes fire, mud flooding, oil spills, building collapse, bomb blasts, stampede, electrical related events, Air, road and rail accidents, epidemics, pest attacks, cattle epidemics, food poisoning etc. [8].

To prevent these events, it is imperative to map the above potential causes and the consequences thereof, (already existent or likely to emerge) plan for them accordingly so that the urbanization do not become cause of concern for the people migrating to opt for an urban life.

3. Preparedness, Mitigation and Adaptation: A Response Continuum

3.1 A Response:

(i) Preparedness: A Classical Approach

Traditionally one of the practices evolved world over, to meet the challenges of disaster is to make the community prepared. A range of interventions are taken before, during and after the disasters to prevent and effectively manage disasters to reduce the impacts. Conventionally Disaster Management Cycle (Figure. 1(a)) shows preparedness of the managers as one of the spoke in the entire management cycle. In the disaster parlance, the preparedness included collection of statistical data, prediction or forecasting of different kind of disaster events and development of standard operating procedures (SOPs) for responding to such disasters. International Federation of Red Cross (IFRC) [9] defines 'Disaster preparedness as measures taken to prepare for and reduce the effect of disasters.' That is to predict and, when possible, prevent disasters, mitigate their impact on vulnerable populations and respond to and effectively cope with their consequences.

(ii) Mitigation: A trend stabilizing as DRR and CCA measure

Mitigation on the other hand, as defined by FEMA [10], is the effort to reduce loss of life and property by lessening the impact of disaster. Its effectiveness depends how well the State and community understands the local risks, addresses the hard choices and invests in long-term community well-being. Mitigation is practices to reduce the risk to the life and property for which structural and non-structural measures are employed.

(iii) Adaptation: A new trend to address climate change,

In the climatic scenario, the practices followed are to mitigate the ill effects of such risks or vulnerabilities of the community and to develop new practices which adapt themselves and lessen the

impacts of such risks. IPCC in its Fifth Assessment Report has identified many such risks and has attempted to point out the relevant adaptation risks measures. Adaption according to UNFCCC [11] is defined as adjustments in the ecological, social or economical systems in response to actual and expected climatic stimulus and then effects an impact. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change. In the climatic change parlance, the emphasis, therefore, is on encouraging the adaptation. The effect on the agricultural practices are emphasized to be mitigated through making changes in the use of right kind of seeds, alternate crops, redetermination of quantum of water used for irrigation, change in the sowing seasons, etc. The adaptation, often with mitigation, is aimed at offsetting the projected negative yield impacts for many crops with the expected change in the global mean temperature.

The IPCC Report emphasizes on the strategies and actions which could increase resilience across a range of possible future climates while helping to improve human health, livelihoods, social and economic well-being and environment quality [12]. Integration of adaptation into policy processes requires a range of tools, methods and technologies at each step of the process [13] which are outlined as follows.

1. Understanding current risk and coping strategies;
2. Estimating future risks and impacts;
3. Using this information to review policies, programmes and projects to determine: (i) how they will be affected by climate change; (ii) how they contribute to adaptive capacity and/or adaptation and (iii) how they contribute to maladaptation;
4. Identifying the reform measures and investment options for minimizing vulnerabilities and supporting adaptive capacity in policies, programmes and projects. This includes assessing the institutional changes and financial means necessary to implement reforms;
5. Implementation;
6. Monitoring and evaluation.

The tools, methods and technologies used at each step of the process will differ according to the scale, sector and user.

One of the challenges for adaptation in the urban area by the State is to bridge the large gap existent in the adaptive capacity with urban centres. There are tens of thousands of urban centres across the SAR with very large and measurable differences in population, area, economic output, human development, quality and coverage of infrastructure and services, ecological footprint and GHG

emissions. No study is taken to quantify the adaptive capacity of such centres. It is, therefore, a difficult task for the State to capacitate them to follow the best practices available for adaptation. Developing a roadmap for adaptation is an important element to take the sustainability forward in urban development. Following guidance for specific roadmap for adaptation have been suggested in the '*Guide to Climate Change Adaptation in Cities*' [14].

- (i) Improving understanding of city-specific climate change impacts, with an introduction to different types of climate change assessments;
- (ii) Developing city adaptation plans, policies and action;
- (iii) Moving from planning to action by setting performance indicators and evaluating and prioritizing potential adaptation actions in cities.

Adaptation is a dynamic process that usually involves multiple sectors, complex and challenging issues, and possibly, large infrastructure projects. The most durable adaptation efforts, thus, require resourcefulness and collaboration. Since strategies to reduce vulnerability and build adaptive capacity commonly involve basic service provisions, cities can seek financial resources from a wide array of local, national and international sources, both public and private, municipal and national finance. Because of their limited financial resources, cities often have to make difficult choices among competing priorities and climate change adaptation may not initially rise to the top of the list of priorities [14].

Future Pathways and Adaptation and Mitigation, and Sustainable Development Adaptation and Mitigation as suggested by IPCC in its AR5 are reproduced in Boxes 2(a) and 2(b). The Synthesis Report is based on the reports of the three Working Groups of the Intergovernmental Panel on Climate Change (IPCC), including relevant Special Reports. It provides an integrated view of climate change as the final part of the IPCC's Fifth Assessment Report (AR5).

Box 2(a): Future Pathways to Climate Change for Adaptation Mitigation and Sustainable Development (2014)

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development.

- Foundations of decision-making about climate change

<p>Effective decision-making to limit climate change and its effects can be informed by a wide range of analytical approaches for evaluating expected risks and benefits, recognizing the importance of governance, ethical dimensions, equity, value judgments, economic assessments and diverse perceptions and responses to risk and uncertainty.</p>
<ul style="list-style-type: none">Climate change risks reduced by adaptation and mitigation
<p>Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally (<i>high confidence</i>). Mitigation involves some level of co-benefits and of risks due to adverse side effects, but these risks do not involve the same possibility of severe, widespread and irreversible impacts as risks from climate change, increasing the benefits from near-term mitigation efforts.</p>
<ul style="list-style-type: none">Characteristics of adaptation pathways
<p>Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change. Taking a longer-term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness.</p>
<ul style="list-style-type: none">Characteristics of mitigation pathways
<p>There are multiple mitigation pathways that are <i>likely</i> to limit warming to below 2°C relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades and near zero emissions of CO₂ and other long-lived greenhouse gases by the end of the century. Implementing such reductions poses substantial technological, economic, social and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges but on different timescales.</p>
<ul style="list-style-type: none">Interaction among mitigation, adaptation and sustainable development
<p>Climate change is a threat to equitable and sustainable development. Adaptation, mitigation and sustainable development are closely related, with potential for synergies and trade-offs.</p>

Box 2(b): Adaptation and Mitigation

<p>Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link mitigation and adaptation with other societal objectives.</p>
<ul style="list-style-type: none">Common enabling factors and constraints for adaptation and mitigation responses
<p>Adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioral and lifestyle choices.</p>

<ul style="list-style-type: none"> ▪ Response options for adaptation
<p>Adaptation options exist in all sectors, but their context for implementation and potential to reduce climate-related risks differs across sectors and regions. Some adaptation responses involve significant co-benefits, synergies and trade-offs. Increasing climate change will increase challenges for many adaptation options.</p>
<ul style="list-style-type: none"> ▪ Response options for mitigation
<p>Mitigation options are available in every major sector. Mitigation can be more cost-effective if using an integrated approach that combines measures to reduce energy use and the greenhouse gas intensity of end-use sectors, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors</p>
<ul style="list-style-type: none"> ▪ Policy approaches for adaptation and mitigation, technology and finance
<p>Effective adaptation and mitigation responses will depend on policies and measures across multiple scales: international, regional, national and sub-national. Policies across all scales supporting technology development, diffusion and transfer, as well as finance for responses to climate change, can complement and enhance the effectiveness of policies that directly promote adaptation and mitigation.</p>
<ul style="list-style-type: none"> ▪ Trade-offs, synergies and integrated responses
<p>There are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses. Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond.</p>

(iv) *Resilience: Bringing the community in forefront:*

The coping capacity of the State and its subject with the challenges of disaster events depend on the resilience embedded or acquired by them over a long period. The term resilience is generally used in relation to an ability to cope with external changes including avoiding harm when exposed to a hazard. This includes people's inability to avoid the hazard (exposure), anticipate it and take measures to avoid it or limit its impact, cope with it and recover from it [15]. In order to promote and make adaptation effective in the urban scenario, developing the resilience among the urban community is of utmost importance. The IPCC in its report outlines as to how the resilience to extreme weather for urban dwellers is strongly influenced by factors already mentioned—the quality of buildings, the effectiveness of land use planning and the quality and coverage of key infrastructure and services. It is also influenced by the effectiveness of early warning systems and public response measures [16, 17] and by the proportion of households with savings and insurance and their ability to afford safe and healthy homes. Safety nets for those with insufficient incomes are also important along with the administrative capacity to ensure these reach to those in need.

For urban areas, Leichenko (2011) [18] has categorized four types of urban resilience studies: (i) urban ecological resilience, (ii) urban hazards and DRR, (iii) resilience of urban and regional economies

and (iv) urban governance and institutions. Boyd et al. (2008) [19] promote resilience as a way of guiding future urbanization that would be better ‘climatized’. The Asian Cities Climate Change Resilience Network is applying a resilience planning framework with attention given to the role of agents and institutions [20].

3.2 *Disaster Management: A Response Cycle*

This study proposes a novel Disaster Management Response Cycle (DMRC) that hitherto has been compartmentalized into three different activities from the management view and has been prioritized differently by the disaster managers. In the existing DM Cycle among all the three phases, the response during the event of disaster gets overwhelming attention of the State in order to reach the succour to the affected community including the livestock. The effort of pre-disaster events to mitigate the disaster including the efforts to prepare the community to cope with such events and the measures taken post disaster event to bring the community back to normalcy and to get them engage in their daily chores and economic activity must all be viewed as ‘Response’. Response to the eventuality of disaster and to bring the community back to normalcy are no different than the response to the immediate needs of food, medical care and shelter of the affected community on the occurrence of the disaster.

<i>Anti Disaster Response (ADR)</i>
A response to counter the potential hazard turn into disaster may therefore be known and treated as “Anti-Disaster Response (ADR)” with the same focus and importance as is given to the Response by the State to mitigate the suffering of the people affected during and after the event of disaster.
<i>During Disaster Response (DDR)</i>
The response made by the State during the event of disaster may be termed similarly as “During Disaster Response (DDR)”.
<i>Post Disaster Response (PDR)</i>
The reconstruction, rehabilitation work undertaken after the event is over, may be called as “Post-Disaster Response (PDR)”. This is shown in Figure 1 , representing Disaster Management Response Cycle (DMRC).

It will, thus make the entire management process a continuous Response for dealing the unexpected natural disasters. The first step of response is to start with an effort made right from Hazard, Vulnerability, and Risk (HVR) assessment, prevention, mitigation, preparedness to be known as ADR.

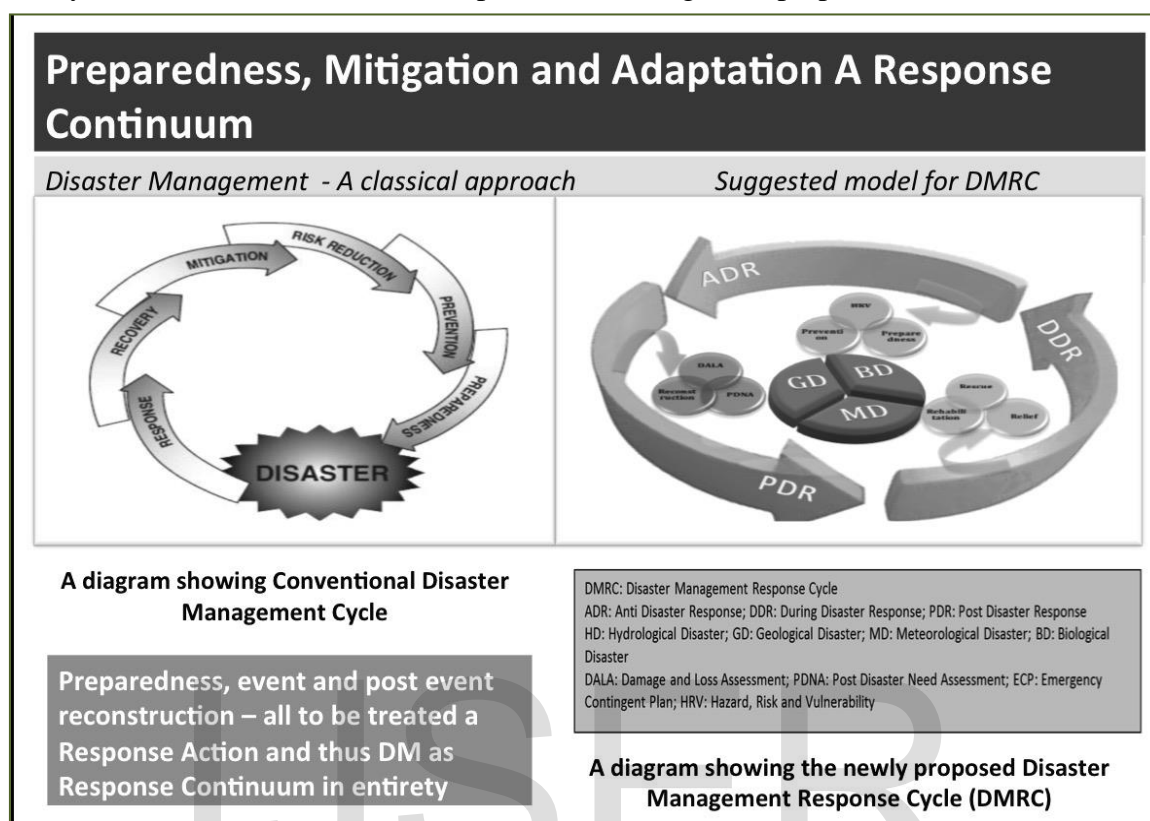


Figure. 1(a): Conventional Disaster Management Cycle; (b): Proposed Disaster Management Cycle

The second stage of Response during the event of disaster towards rescue and relief work may be called as DDR. The third stage of Response starts to bring back the normalcy in the area suffered by the calamity by way of measures taken up for rehabilitation and reconstruction and this stage of response be known as PDR. The present focus of capacity development of the stakeholders in the rescue and relief work (DDR) should, therefore, accordingly shift and encompass people engaged in all the three stages of Response (ADR, DDR, and PDR). It is so because a sound implementation of anti-disaster measures (ADR), prior to occurrence of any natural disaster can ensure a less suffering of the people during the disaster. The careful execution of post disaster response plan under PDR related to the reconstruction and recovery can reinforce the measures taken under ADR in terms of preparedness and prevention for the future disaster. Thus it is warranted to stress much on ADR that guarantees the mitigation of natural hazards of future disasters under the onset of the climate change.

3.3 Constituents of Pre-Disaster Response (ADR):

(i) *Prevention and mitigation:*

Prevention entails activities to provide outright avoidance of the adverse impact of hazards and means to minimize related environmental, technological and biological disasters. Similarly, mitigation embraces all measures taken to reduce both the effect of the hazard itself and the vulnerable conditions to it, in order to reduce the scale of future disasters. In addition to this, the mitigation should also be aimed at reducing the physical, economic and social vulnerability to threats and the underlying causes for this vulnerability.

Mitigation, therefore, may incorporate addressing issues such as land ownership, tenancy rights, wealth distribution, etc. For example, public awareness and education related to fire safety in public buildings could lead to prevention of fire related disasters [21]. This phase of DM, however, gains importance in the scenario where the vulnerability of the community and potential hazards emanate due to the haphazard urbanization which does not subscribe to the even management cycle of Mother Nature which over the years had been giving sustenance to that particular geographical region. ADR thus gains currency to address the issue to save the community from falling prey to the events emerging out of the inherent potential hazards.

(ii) *Preparedness:*

The process embraces measures that enable governments, communities and individuals to respond rapidly to disaster situations to cope with them effectively. Preparedness includes the formulation of viable emergency plans, the development of warning systems, the maintenance of inventories and the training of personnel. It may also embrace search and rescue measures as well as evacuation plans for areas that may be 'at risk' from a recurring disaster. All preparedness planning needs to be supported by appropriate rules and regulations with clear allocation of responsibilities and budgetary provision and it requires following activities to be attended to make preparedness effective [21]. It should include the development and shifting of the early warning system. This is the process of monitoring situations in communities or areas known to be vulnerable to slow onset hazards and passing the knowledge of pending hazard to people. To be effective, warning must be related to mass education and training of the population who know what actions they must take when warned.

(iii) *Adaptation:*

A measure requiring the foremost attention to make the society resilient. IPCC, in its report, has suggested climate associated risk and adaptation issues as given in Table 4.

Table 4: Climate Associated Risk of South Asia and adaptation strategies

Key Risk	Adaptation Issues and prospects
Increased riverine, coastal and urban flooding leading to widespread damage to infrastructure, livelihood and settlement in South Asia	<ol style="list-style-type: none"> 1. Exposure reduction via structural and non-structural measures, effective land use planning and selective relocation. 2. Reduction in the vulnerability of lifeline infrastructure and services (Water, energy, Waste Management, food biomass, mobility, local ecosystem, telecommunication) 3. Construction of monitoring and early warning system, measures to identify exposed areas, assist vulnerable areas and household and diversified livelihood. 4. Economic diversification.
Increased risk of heat related mortality	<ol style="list-style-type: none"> 1. Heat health-warning system. 2. Urban planning to reduce heat islands, improvement of the built environment, development of sustainable cities. 3. New work practices to avoid heat stress among outdoor workers.
Increased risk of drought related water and food shortage causing malnutrition	<ol style="list-style-type: none"> 1. Disaster Preparedness including early warning system and local coping strategies. 2. Adaptive/ integrated water resource management. 3. Water infrastructure and reservoir development 4. Diversification of water sources including water re use 5. More efficient use of water (Improved agriculture practices, irrigation management and resilient agriculture)

(Source: IPCC [7])

The risk management of climate change involves adaptation and mitigation decisions. Adaptation strategies need to consider the dynamics of vulnerability and exposure and their linkages with socioeconomic processes, sustainable development, and climate change. The approach for managing the vulnerability and exposure reduction risk and adaptation to changing climate are found to be overlapping. The mitigation therefore is considered essential work for managing the climate risk for effective adaptation. The recommendations thus for effective adaptation and vulnerability reduction are produced in following Table 5, (IPCC Fifth Assessment Report- 2014).

Table 5: Broad Risks and Recommended Activities

Category	Recommendations
Human Development	Improved access to education, nutrition, health facilities, energy, safe housing & settlement structures, & social support structures; Reduced gender inequality & marginalization in other forms
Poverty alleviation	Improved access to & control of local resources; Land tenure; Disaster risk reduction; Social safety nets & social protection; Insurance schemes.
Livelihood security	Income, asset, & livelihood diversification; Improved infrastructure; Access to technology & decision making forum; Increased decision-making power; Changed cropping, livestock, & aquaculture practices; Reliance on social networks.
Disaster risk Management	Early warning systems; Hazard & vulnerability mapping; Diversifying water resources; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements.
Ecosystem Management	Maintaining wetlands & urban green spaces; Coastal afforestation; Watershed & reservoir management; Reduction of other stressors on ecosystems & of habitat fragmentation; Maintenance of genetic diversity; Manipulation of disturbance regimes; Community-based natural resource management.
Spatial or land-use Planning	Provisioning of adequate housing, infrastructure, & services; Managing development in flood prone & other high risk areas; Urban planning & upgrading programs; Land zoning laws; Easements; Protected areas.
Structural and Physical	<i>Engineered & built-environment options:</i> Sea walls & coastal protection structures; Flood levees; Water storage; Improved drainage; Flood & cyclone shelters; Building codes & practices; Storm & wastewater management; Transport & road infrastructure improvements; Floating houses; Power plant & electricity grid adjustments.

	<p><i>Technological options:</i> New crop & animal varieties; Indigenous, traditional, & local knowledge, technologies, & methods; Efficient irrigation; Water-saving technologies; Desalinization; Conservation agriculture; Food storage & preservation facilities; Hazard & vulnerability mapping & monitoring; Early warning systems; Building insulation; Mechanical & passive cooling; Technology development, transfer, & diffusion.</p> <p><i>Ecosystem-based options:</i> Ecological restoration; Soil conservation; Afforestation & reforestation; Mangrove conservation & replanting; Green infrastructure (e.g., shade trees, green roofs); Controlling overfishing; Fisheries co-management; Assisted species migration & dispersal; Ecological corridors; Seed banks, gene banks, & other ex situ conservation; Community-based natural resource management.</p> <p><i>Services:</i> Social safety nets & social protection; Food banks & distribution of food surplus; Municipal services including water & sanitation; Vaccination programs; Essential public health services; Enhanced emergency medical service</p>
Institutional	<p><i>Economic options:</i> Financial incentives; Insurance; Catastrophe bonds; Payments for ecosystem services; Pricing water to encourage universal provision and careful use; Microfinance; Disaster contingency funds; Cash transfers; Public-private partnerships.</p> <p><i>Laws & regulations:</i> Land zoning laws; Building standards & practices; Easements; Water regulations & agreements; Laws to support disaster risk reduction; Laws to encourage insurance purchasing; Defined property rights & land tenure security; Protected areas; Fishing quotas; Patent pools technology transfer.</p> <p><i>National & government policies & programs:</i> National & regional adaptation plans including mainstreaming; Sub-national & local adaptation plans; Economic diversification; Urban upgrading programs; Municipal water management programs; Disaster planning & preparedness; Integrated water resource management; Integrated coastal zone management; Ecosystem-based management; Community-based adaptation.</p>
Social	<p><i>Educational options:</i> Awareness raising & integrating into education; Gender equity in education; Extension services; Sharing indigenous, traditional, & local</p>

	<p>knowledge; Participatory action research & social learning; Knowledge-sharing & learning platforms.</p> <p><i>Informational options:</i> Hazard & vulnerability mapping; Early warning & response systems; Systematic monitoring & remote sensing; Climate services; Use of indigenous climate observations; Participatory scenario development; Integrated assessments.</p> <p><i>Behavioral options:</i> Household preparation & evacuation planning; Migration; Soil & water conservation; Storm drain clearance; Livelihood diversification; Changed cropping, livestock, & aquaculture practices; Reliance on social networks.</p>
<p>Sphere of change</p>	<p><i>Practical:</i> Social & technical innovations, behavioral shifts, or institutional & managerial changes that produce substantial shifts in outcomes.</p> <p><i>Political:</i> Political, social, cultural, & ecological decisions & actions consistent with reducing vulnerability & risk & supporting adaptation, mitigation, & sustainable development.</p> <p><i>Personal:</i> Individual & collective assumptions, beliefs, values, & worldviews influencing climate-change responses.</p>

(Source: Fifth Assessment Report, IPCC [7]).

3.4 During Disaster Phase of Response (DRR):

The measure taken during the event of disaster finds an utmost focus during the entire Response Cycle. The disaster event refers to the “real-time event” of a hazard occurring and affecting elements at risk. The duration of the event will depend on the type of threat; ground shaking may only occur for a matter of seconds during an earthquake while flooding may take place over a longer sustained period.

The response and relief required to be in readiness generally refers to the first stage response to any calamity, which include setting up control room, putting the contingency plan in action, issue warning, action for evacuation, taking people to safer areas, rendering medical aid to the needy etc., simultaneously rendering relief to the homeless, food, drinking water, clothing etc. to the needy, restoration of communication, disbursement of assistance in cash or kind. The emergency relief activities undertaken during and immediately following a disaster, which includes immediate relief, search, rescue, and damage needs assessment and debris clearance. Assessment of damage is very

important activities, which however need to be least, attended during the response and relief operations as a result the community having suffered the impact of disaster do not get initiated into the recovery and reconstruction phase.

3.5 The Post- disaster Phase of Response Cycle (PDR):

(a) *Recovery*: Recovery is used to describe the activities that encompass the three overlapping phases of emergency relief, rehabilitation and reconstruction [21]. This may be viewed as transition phase between the relief, rehabilitation and the final phase of reconstruction when the community is expected to enter into the even tempo of life.

(b) *Rehabilitation*: Rehabilitation includes the provision of temporary public utilities and housing as interim measures to assist longer-term recovery (DMC- NIDM, i).

(c) *Reconstruction*: Reconstruction attempts to return communities to improved pre-disaster functioning. It includes the replacement of buildings; infrastructure and lifeline facilities so that long-term development prospects are enhanced rather than reproducing the same conditions, which made an area or population vulnerable in the first place [Box 3, 21].

Box 3: A case study of Tsumani in Indian Ocean 2004.

Future strategy for Sustainable coastal risk management for safer cities under climate change scenario

An earthquake (Mw 9.3) originated in the Indian Ocean off the western coast of Northern Sumatra on 26th December 2004 was one of the worst impacted tsunamis in the annals of the disastrous events that caused catastrophe in Coastal regions of the Indian Ocean. It was observed that lack of knowledge, complete ignorance about preparedness for tsunami induced risk mitigation, and unavailability of tsunami early warning system at the place compelled the Indian coastal regions to witness wide-scale damages to lifes and infrastructures which generated public panic and traumas in the region. An attempt is made by Priya Singh et. Al. in their study to address issues from the lesson learnt that involved into intricate tsunami generating processes as well as to understand what viable approaches to be adopted for tsunami risk mitigation for better coastal risk management with principal aim to assist emergencycoastal

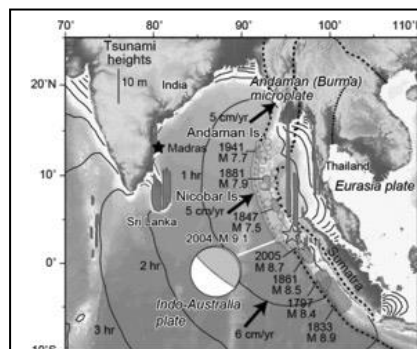


Figure. 2: A diagram showing the location of the 26th December 2004 Sumatra-Andaman earthquake (Mw 9.3).

Note: The tsunami heights measured by field surveys are shown by red bars (NOAA NGDC Tsunami Database). The yellow circles and beach ball show the one-day aftershocks and the focal mechanism. Computed tsunami fronts are shown for every hour. Black arrows indicate the direction and speed of Indo-Australian plate. Past earthquakes with their years of occurrences and the respective magnitudes are also shown with filled polygons and ovals (Adapted from Satake, 2014).

managers and stakeholder sintaking judicious actions to reduce the losses of lives, properties, flora, faunas, and environmental degradation in the affected region for risk resilient safer coastal cities. These authors have realized that the climate change is a major factor in causing more disasters (tsunamis) as compared to early times, rising temperature ultimately leading to melting of glaciers, which in turn leads to rise in sea level, so even small shaking of sea floor leads to huge water displacement, leading to tsunami. It is suggested by them a tsunami induced coastal hazards risk mitigation model for the region, which is having utmost significance once integrated with multi-disciplinary techniques of coastal risk mitigation. A sustainable coastal risk management program under climate change scenario may bce effective only when identification of the tsunami generating parameters along with the deciphering of factors responsible for the coastal hazards are made judiciously. Implementation of extensive capacity building programs on tsunami risk mitigation measures is an essential ingredient for developing risk resilient safer coastal cities for tsunami risk-prone region.

It is learnt that damage scenario of Andaman-Nicobar was dictated by two main factors: (i) Strong Ground shaking by earthquake, (ii) Hydrostatic pressure of water in waves. Thus damaged to the well built buildings and wash out of buildings both were reported, which infer that there were complete lack of preparedness on both aspects: earthquake risk and tsunami risk preparedness. It is therefore suggested to educate people on tsunamigenic earthquake processes and to learn the skill how to mitigate the tsunami hazards. It is so because tsunamis was very under-rated hazards in India. The reason of it can be the change in the climate, which is majorly connected to the rise in temperature, that cause melting of glaciers and ultimately the rise in sea level, which results in flooding and in severe cases it cause tsunami. It is realized that Inhabitants located nearing to the Sea needs to have suitable engineering and scientific solutions for their dwellings so that tsunami risks can be sufficiently mitigated in the coastal regions of India, which is only possible by developing a sound system of socio-scientific-administrative-Managerial coordination group to address the hazard inducing factors as the pre- disaster risk response measures. It is thus suggested to create a platform for coordination among different stakeholders, which includes people engaged for ADR, VDR and PDR so that the management of these kind of disaster having for reaching impacts on the community, do not suffer the ordeal of such events for a very long period of time and the even tempo of life is restored at the earliest. (Priya Singh and R.K. Srivastava et al [22])

3.6 Development planning as Response Measure:

In an evolving economy, development process is an ongoing activity. The long term prevention or disaster reduction measures like construction of embankments against flooding, irrigation facilities as drought proofing measures, increasing plant cover to reduce the occurrences of landslides, land use

planning, construction of houses capable of withstanding the onslaught of heavy rains and wind speed and shocks of earthquakes are some of the activities that can be taken up as part of development plans [21]. Many countries like India and others have institutionalized the mitigation and prevention activity as part of the development or components of the development as disaster proofing.

The example of ADR may be served from several structural measures taken in the past, particularly in the cities around the sea coasts. For such urban areas, coastal protection is cost-efficient in reducing the impacts. Past and current adaptation practice also confirms this, such as the cities like Tokyo and Shanghai are protected against local sea level rise of several metres during the twentieth century and the Dutch and UK governments protected urban Netherlands and London against twenty-first century sea level rise above 1m. Not protecting cities such as Amsterdam, Rotterdam and London during the twenty-first century is not an option. On the other hand, there are coastal areas such as small islands where protecting against several metres of sea level rise in the long term is not a viable option. Thus preparedness, mitigation prevention or adaption should not be viewed as a mere developmental actions but rather as Response measure [Figure 1] to the imminent danger waiting to strike at the place in the area having high index of the vulnerability.

4. Interconnectedness of Risks

Climate change and disaster risk are fundamental threats to sustainable development and the eradication of poverty. While hazards are natural, disasters are not [23]. Further to this, there is growing awareness about interconnectedness of risk posed by climate change and disasters coupled with neo-risks of urbanization. At present, both disasters and climate change are increasingly being considered and integrated as part of this development continuum, instead of as isolated events. The scientific community has pointed out that the current drivers of risk are linked to poor policies and practices in land-use planning, governance, urbanization, natural resource management, ecosystem management as well as increasing poverty levels. Over the last many years there has been an evolving recognition that action on climate change and disaster risk reduction is a prerequisite for achieving sustainable development. It thus makes a strong case for measures to be taken for poverty reduction, social protection and sustainable development. This calls for the need of adaptive, inclusive, equitable, risk sensitive and climate and disaster resilient development [23, 1]. Figure 2 as given below indicate how the hazard, vulnerability and exposure together increases the risk.

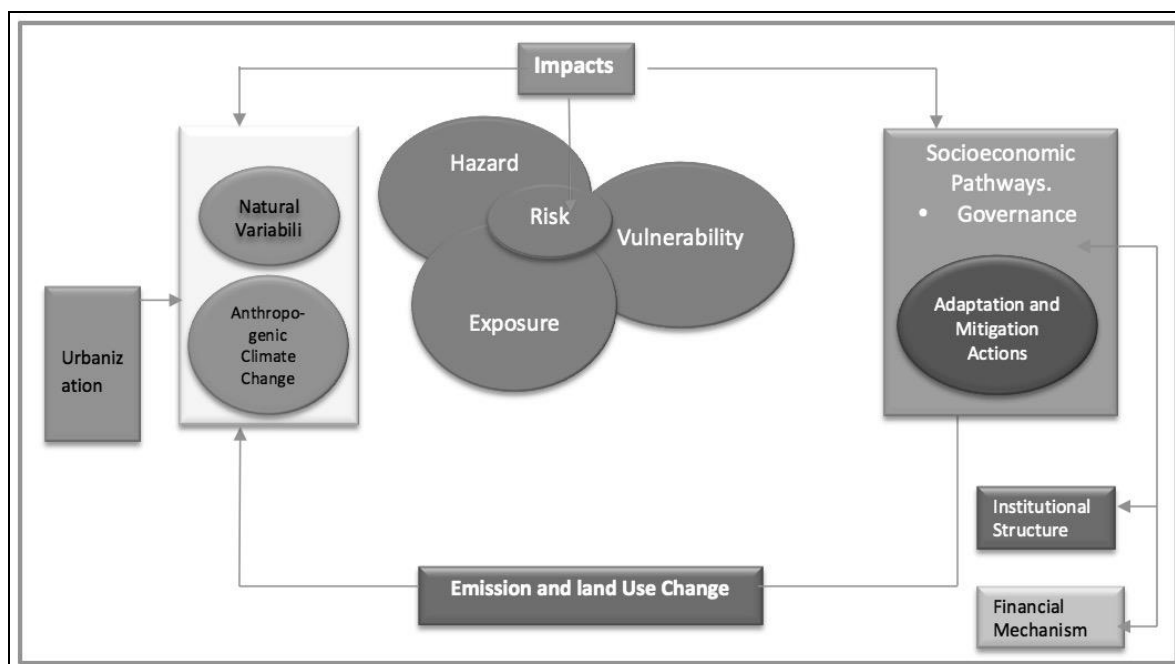


Figure. 2 : Climate Change and Disaster Risk Reduction

(Ref: B.Jimenez-Cisneros et.al [24])

It is observed that climate change poses multiple threats for disasters events. The empirical evidence suggests increase in the frequency and intensity of weather and climate hazards such as floods, tropical cyclones, heat waves and drought. There are other such likely changes due to climatic effect such as ecosystem degradation, reduced availability of food and drinking water and impacts on the livelihoods which together reduce the capacity of community to cope with the natural hazards, especially in developing countries [25]. Many countries, both in the policy and practical action, are now taking up various initiatives for DRR and CCA. These are aimed to reduce the vulnerability of local community, thereby enhancing their resilience to cope with the adverse impacts of disaster risks and climate changes. The focus is now shifting for joint initiative to address both CCA and DRR thus emphasizing the multi-sectoral development-based approach for strengthening the local institutions of democratic governance and building the community's resilience so as to ensure the sustainable development.

5. Addressing the Hazards, Risks and Neo Vulnerabilities- An Integrated Approach

5.1 IPCC and its initiatives:

The IPCC¹ Fifth Assessment Report, outlines the impacts of climate change on sustainable development which are observed through both the slow-onset events (for example sea level rise, increasing temperatures, ocean acidification, glacial retreat and related impacts, salinization, land and forest degradation, loss of biodiversity and desertification) and extreme weather events. Climate change poses one of the greatest threats to the food security for mankind in the twenty-first century. It is observed that its impacts on the livelihoods are discernible in many parts of the world, particularly those who have been lax and dependent on predictable temperature and rainfall, clean water availability and arable land. The world over, the awareness about the impact of such changes have now reached to the level of maturity and the attempts are on to factor the mechanism in their policy and developmental planning to address and include their mitigation measures. With the threat of increased disasters from climate change, many countries are already taking steps to reduce their vulnerability to weather and climatic hazards such as floods, cyclones, heat-waves and droughts [23].

5.2 Adaptation- A major initiative:

Adaptation to climate change has never been the practice in the civilizational journey, which has witnessed many such disasters in the past. It is relatively a new strategy to meet the challenges of climate change. However, over a span of time and with the changes occurring in the geographical space, rich traditions and practices have also been maturing to reduce the disaster risks. The increasing global disaster risks and hazards and threatening development gains are not limited to the hydro-meteorological events, geographical contours and climate change. It embraces the neo-risks emerging from the demographical changes taking place due to new economic pattern enveloping the entire world making it a close-knit big village where every nation is interdependent and it also exposes mankind to a new socio-economic order. For want of supply-driven plan and policy, the trend of globalization driven with new economic forces give rise to a mix of unplanned urban development, vulnerable livelihoods and ecosystem degradation and inducing the climate change [23].

In such a scenario, the community has to adapt itself to the changes for their survival and sustenance. It is observed throughout history that people and societies have adjusted to and coped with climate, climate variability and extremes with varying degrees of success [7].

¹ IPCC reports cover 'the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation.

Adaptation is becoming embedded in some planning processes with more limited implementation of responses. Engineered and technological options are commonly implemented adaptive responses often integrated within existing programmes such as disaster risk management and water management. There is increasing recognition of the value of social, institutional and ecosystem-based measures and of the extent of constraints to adaptation. Adaptation options adopted to date continue to emphasize incremental adjustments and co-benefits and are starting to emphasize flexibility and learning. Most assessments of adaptation have been restricted to impacts, vulnerability and adaptation planning, with very few assessing the processes of implementation or the effects of adaptation actions [7].

5.3 Importance of Imbedding the Risk Factors in all the Developmental Policies:

It has been observed that the current drivers of risk are linked to poor policies and practices in land-use planning, governance, urbanization, natural resource management, ecosystem management as well as increasing poverty levels. By 2050, seventy per cent of the world's population is expected to live in the urban areas, two thirds of this, in low- and middle-income nations. It is observed that much of the urban growth taking place in different locations are already prone to the earthquakes, cyclones, floods and droughts. These risks posed by the slow-onset processes of climate change and urbanization with the existing geophysical hazards would have the biggest impact on the poorest and most marginalized strata of the society by maintaining the gender inequality, age, disability or any other factors who are the most susceptible to the risk [23]. It is, therefore, important for policymakers to factor the potential risks in their developmental policies particularly into those meant for urban areas.

5.4 Integrating DRR and CCA:

Currently, as decades of disaster risk data shows, more than 226 million people globally are affected on average by disasters associated with natural hazards every year. These include both geophysical events (for example, earthquakes, tsunamis, volcanoes) and hydrometeorological events such as, floods, cyclones and droughts. Weather-related disasters comprise about 81 per cent of all events, causing 72 per cent of all economic losses and 23 per cent of fatalities [23]. The concept of CCA and DRR over period of time evolved and got introduced in governance to reduce the associated respective vulnerability. They however share many similarities which have made researchers, policymakers and practitioners to charter a path to integrate CCA and DRR. Even though there are many discussions on integrating CCA and DRR, less is happening on the ground as there are many challenges to integrate

CCA and DRR. These challenges are further increased due to the gaps in the existing legal and policy backgrounds in most of the countries [26].

Building the resilient and sustainable societies means addressing both the climate and disaster risks and integrate these risks as well as potential opportunities into development planning and budgeting. The socio-economic movement resulting in urbanization should, therefore, be integrated into the developmental planning as the existent disaster risks coupled with the climatic change resulting from the geological evolution and due to human intervention into the geographical system are going to impact the neo-urban settlements. This hitherto has been missing in the planning for development of social or economic infrastructure. A laissez faire mindset among the planners and policymakers need to be changed and they need to be made sensitive to the adaptive measures required to address the risks inherent in the ongoing socio-economic advancement alongwith climate and demographical change at the global level.

5.5 Global efforts for integration of DRR & CCA:

(i) Global initiatives on Roll:

The global efforts made to strengthen the actions on the climate change alongwith DRR measures to address the natural hazards are part of the international development agenda which have been outlined in the preceding chapters. These efforts further need to be taken forward with the managers (at the national and sub-national level) engaged with the mitigation, adaption and preparedness agenda of CCA as well as DRR for applying the same in an integrated way to avert the ill-effects of urbanization. While urbanization generates and expands the economy, its dwellers, however, get subjected to neo risks generated in developmental process undertaken to give them a better life. This is a concern for the state as the urbanization process now cannot be rolled back.

(ii) UNFCC efforts:

In recent years, progress has been made at the global level to help guide and drive regional and national processes on climate change and adaptation measures. In 2010, at the 16th Conference of the Parties (COP 16) of the UNFCC, the Parties committed to a global goal to reduce GHG emissions so as to hold the increase in global average temperature below 2° celsius and to consider a 1.5° celsius limit in the near future. Through the Cancun Agreements adopted at COP 16, parties to the UNFCCC also established a series of institutions for implementing this agreement [27]. These included,

- (a) The Cancun Adaptation Framework which introduced National Adaptation Plans, a work programme on Loss and Damage and the establishment of the Adaptation Committee to coordinate implementation of adaptation;
- (b) A Technology Mechanism consisting of the Technology Committee and Climate Technology Centre and Network to increase design, development and dissemination of climate friendly technologies; and
- (c) The establishment of the Green Climate Fund to manage financing in support of developing countries' actions on climate change. Also, developed countries expressed their broad agreement to mobilize 100 billion USD per year both for adaptation and mitigation by 2020 [28].

(iii) *National Appropriate Mitigation Actions (NAMAs):*

Many developing countries have initiated appropriate mitigation actions (NAMAs) for developing low carbon growth strategies. At the Durban Climate Change Conference in 2011, Parties established the Ad-Hoc Working Group on the Durban Platform for Enhanced Action, for identifying the path towards a future legal climate framework that will cover all countries. Under the Second Commitment Period of the Kyoto Protocol launched in Doha in December 2012, the developed countries committed themselves to reduce their average GHG emissions by 18 per cent in the 2013–2020 period [29].

(iv) *Climate Change 2014 Synthesis Report : Summary for policy makers (SPM)*

IPCC in its fifth report (AR-4), based its finding has made several recommendation for policy makers which are tabulated and produced as stated in Box 4.

Box 4: IPCC- Suggested Policy Measures

Suggested Policy Measure's
SPM- 1 Observed Changes and their Causes
Human influence on the climate system is clear, and recent anthropogenic emissions of green- house gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.
<i>SPM 1.1 Observed changes in the climate system</i>
Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and

ice have diminished, and sea level has risen.

SPM 1.2 Causes of climate change

Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are *extremely likely* to have been the dominant cause of the observed warming since the mid-20th century.

SPM 1.3 Impacts of climate change

In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate.

SPM 1.4 Extreme events

Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions.

SPM 2. Future Climate Changes, Risks and Impacts

Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.

SPM 2.1 Key drivers of future climate

Cumulative emissions of CO₂ largely determine global mean surface warming by the late 21st century and beyond. Projections of greenhouse gas emissions vary over a wide range, depending on both socio-economic development and climate policy.

SPM 2.2 Projected changes in the climate system

Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is *very likely* that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea

level to rise.
<i>SPM 2.3 Future risks and impacts caused by a changing climate</i>
Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development.
<i>SPM 2.4 Climate change beyond 2100, irreversibility and abrupt changes</i>
Many aspects of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped. The risks of abrupt or irreversible changes increase as the magnitude of the warming increases.
SPM 3. Future Pathways for Adaptation, Mitigation and Sustainable Development
Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21 st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development.
<i>SPM 3.1 Foundations of decision-making about climate change</i>
Effective decision-making to limit climate change and its effects can be informed by a wide range of analytical approaches for evaluating expected risks and benefits, recognizing the importance of governance, ethical dimensions, equity, value judgments, economic assessments and diverse perceptions and responses to risk and uncertainty.
<i>SPM 3.2 Climate change risks reduced by mitigation and adaptation</i>
Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21 st century will lead to high to very high risk of severe, wide-spread and irreversible impacts globally (<i>high confidence</i>). Mitigation involves some level of co-benefits and of risks due to adverse side effects, but these risks do not involve the same possibility of severe, widespread and irreversible impacts as risks from climate change, increasing the benefits from near-term mitigation efforts.
<i>SPM 3.3 Characteristics of adaptation pathways</i>
Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change. Taking a longer-term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance

future options and preparedness.

SPM 3.4 Characteristics of mitigation pathways

There are multiple mitigation pathways that are *likely* to limit warming to below 2°C relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades and near zero emissions of CO₂ and other long-lived greenhouse gases by the end of the century. Implementing such reductions poses substantial technological, economic, social and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges but on different timescales.

SPM 4. Adaptation and Mitigation

Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives.

SPM 4.1 Common enabling factors and constraints for adaptation and mitigation responses

Adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioral and lifestyle choices.

SPM 4.2 Response options for adaptation

Adaptation options exist in all sectors, but their context for implementation and potential to reduce climate-related risks differs across sectors and regions. Some adaptation responses involve significant co-benefits, synergies and trade-offs. Increasing climate change will increase challenges for many adaptation options.

SPM 4.3 Response options for mitigation

Mitigation options are available in every major sector. Mitigation can be more cost-effective if using an integrated approach that combines measures to reduce energy use and the green-house gas intensity of end-use sectors, decarbonize energy supply, reduce net emissions and enhance carbon sinks in land-based sectors.

SPM 4.4 Policy approaches for adaptation and mitigation, technology and finance

Effective adaptation and mitigation responses will depend on policies and measures across multiple scales: international, regional, national and sub-national. Policies across all scales supporting technology development, diffusion and transfer, as well as finance for responses to climate change, can complement and enhance the effectiveness of policies that directly promote adaptation and mitigation.

SPM 4.5 Trade-offs, synergies and interactions with sustainable development

Climate change is a threat to sustainable development. Nonetheless, there are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses. Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond.

Source: IPCC. 2014. Climate Change 2014: Synthesis Report [30]

(iv) Hyogo Framework of Actions (HFA):

HFA also served as the global framework for international cooperation on disaster risk reduction as a foundation for national, regional and international development agendas. The overall expected outcome of the HFA is the “substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries”, and is supported by three strategic goals, five priorities for action, and four crosscutting issues. It served as the guideline for the world, to contribute to the achievement of the internationally agreed goals through 2015.

(v) Other Initiatives:

Besides the above there have been number of well-established inter-governmental agreements outside the climate change and disaster risk reduction policy processes that supported and delivered disaster risk reduction and adaptation outcomes as ‘co-benefits’. These included, the UN Convention on Biological Diversity, the UN Convention to Combat Desertification, the Ramsar Convention and the Beijing Declaration and Platform for Action, the Committee on World Food Security etc.

Several other initiatives and efforts have been made in the past to strengthen the linkages between climate change, disaster risk reduction and other relevant issues such as food security, health, traditional knowledge, gender and humanitarian responses, bringing different communities together at all levels to guide and implement integrated approaches. The cross-cutting nature of climate change and disaster risk and the importance of integrating solutions for poverty reduction, gender equality, disaster risk reduction and climate change to ensure lasting solutions to global vulnerabilities and achieving sustainable development have been found to be inherent.

5.6 Integrating the Climate change & Urban Adaption with Planning Process:

(i) Addressing the economic driver of city life

It is established and reported in several of the IPCC reports how climate change will have profound impacts on a broad spectrum of city functions, infrastructure and services. It is going to

interact with and may exacerbate many existing stresses. According to IPCC, these impacts can occur both in situ and through long-distance connections with other cities and rural sites of resource production and extraction [31, 32]. The interaction between climate change and existing environmental stresses would lead to a range of synergies, challenges and opportunities for adaptation with complex interlinkages and are often highly uncertain or nonlinear processes [33]. The urban centres would face different kind of challenges and would be the platform for main economic base which sustains the city and city life and would govern predominately the advancement of the city. For example, the city serving prosperous agricultural regions would be sensitive to climate change which in turn would likely impact the water supply. This would in turn put the crops at risk. The urban centres catering to tourism may suffer on account of weather becoming stormy or excessively hot or cold. It would stress the infrastructure by systemic and cascading climate risks [34]. The mitigation and adaptive measures, therefore, need to be responsive to such economic drivers that do not disturb the even tempo of city life and put them under undue stress.

(ii) *Climatic Smart Urban Planning:*

The climate stresses, particularly extreme events, will have effects across interconnected urban systems within and across multiple sectors [35] and especially would be evident in the water, sanitation, energy, transport, and communications sectors, owing to the often tightly coupled character of urban infrastructure systems [36]. This, therefore, calls for a 'climate smart' (a word coined in IPCC report) infrastructure planning which emphasizes to combine the pro-poor development and climate change adaptation and mitigation. The planning needs to take care of replacing the aging infrastructure and to integrate climate considerations into the new infrastructure decision-making processes of the urban centres.

(iii) *Adoption of Multi Risk Resilient structural designs:*

The damage scenario during different disaster events suggest that SAR has no robust mechanisms for enforcing the implementation of safe design of various structures and infrastructures. This may be either on account of unavailability of area-specific structural design codes or due to socio-economic-politico factor inhibiting enforcement of such regulations in countries of SAR for urban planning. This is evident from the recent damages during Nepal earthquake of 2015 to the structures located in India and Nepal border where dwellings and infrastructures located in both the countries could have been saved had they followed the existing design codes [37]. Similarly, damages to the structures during flashfloods or transboundary floods of Kosi river in 2008, multi-disaster events of

Kedarnath, Uttarakhand in 2013, Kashmir floods in 2014, urban floods of Mumbai and many parts of India in 2005, and 2010 floods in Pakistan could have been reduced to a great extent had the multirisk resilient structural code been in place and enforced. In the background of this scenario, it is observed that countries of SAR are oblivious of the importance of ensuring safety in the design itself which in the long run is a cost-effective expenditure for the state beside being a life saving measures for its citizen. This can be achieved by generating geo-mechanical parameters responsible for providing the scope of assimilating efficient multi-risk resilient design code by deploying state-of-the-art technique based on the detailed investigations using the methodology of seismic microzonation [38].

(iv) *Housing: A major issue of urban planning*

In the parlance of disasters, along with the lives, the loss of properties, particularly housing, often finds mention. Extreme events ensuing as a result of natural disaster or the climatic change induced one or those resulting from the urban activities such as chemical one or nuclear or stampede, etc. are going to inflict a heavy loss. Those in the vulnerable sections coming from the lower rung of income would be the most susceptible to such loss, particularly in the housing infrastructure. The changing pattern of windstorms, particularly in the coastal area and with peak gusts would impact the buildings. Besides this, the change in temperature pattern, precipitation shifts and other associated variables would have bearing on the materials used in the building structures and would permeate beyond the boundary of buildings and would take other urban amenities in its fold to suffer the negativity in its endurance [39, 40, 41, 42, 43].

(v) *Addressing the climatic impacts on Urban Water Supply:*

The impact of climate change on water supplies in rapidly developing cities, need to be addressed to cater to the growing population, growing demand and economic pressures. Climate change is potentially heightening water stress and negative impacts on the natural resource base with effects on water quality and quantity. It is well studied as to how the projected reductions in rainfall at specific times in particular locations would aggravate the water shortage to people living in that region [44]. It is further observed in the studies how climate change would alter relationships among water users, exacerbating tensions and conflicts between the various end users (residential, commercial, industrial, agricultural and infrastructural) [45, 46].

(vi) *Challenges before Sanitation System*

Similarly wastewater and sanitation systems would increasingly be overburdened during extreme precipitation events if attention is not paid to maintenance, the limited capacity in old cities or lack of provision for drainage in most unplanned settlements and in many urban centres [47, 48, 49].

(vii) *Developing flood resilient urban drainage system*

Flooding is going to worsen if uncontrolled city development chokes the natural drainage channels and flood plains or if the drainage channels are not maintained. These problems are most evident in cities where there are no drains or sewers to help cope with heavy precipitation [50] and there is no service to collect solid wastes [51]. The same is going to be the story in high-income nations.

(viii) *Ensuring sustainable energy supply to the urban area*

The energy systems that provide the 'life blood' to the cities are as complex and diverse as cities themselves. The relationship between economic development and energy over time is discussed and illustrated by data from China, India and South Africa and some other countries. It concludes that energy plays an important role as a productivity enhancing factor in economic development and in human well-being. Several policy goals related to sustainable development, energy and climate can be integrated. However, meeting all these policy goals requires a special effort and has significant cost implications [52].

Urban energy systems serve as either a key accelerator or brake on the vitality and prospects of a city or urban region. Because of this, the local energy system can be of great interest to policymakers in a city. To date, there have been several studies analyzing how climate change would affect energy demand [53]. The analyses generally conclude that for the regions examined, both total electricity demand and peak electricity demand will increase as a result of climate change, although peak demand will increase at a much faster rate. Infrastructure systems and services, particularly those dependent on energy, are vulnerable to changes in climate. Using historical climate data and four climate change scenarios, Jollands et al.,[54] modelled the impact of climate change on aspects of water supply and quality, transport, energy demand, public health and air quality.

In one of the analysis made in Finland reveals that many of Hamilton City's infrastructure systems demonstrated greater responsiveness to population changes than to gradual climate change. It is further observed during one of the damage-causing storms in Finland at the end of July 2010, a total of some 35,000 kilometres of electric power network were destroyed or damaged. The long power cuts caused significant disturbance to other functions vital to society, such as communication networks, water supply and transport infrastructure. The investigation impressed upon the measures to improve safety and develop preparedness concerning electricity network for their reliability [55]. The thermal systems employed may have significant health impacts within or near the home, because of differing levels of smoke or other pollutants emitted while operational. Technology choices, market structures and

ownership responsibilities are all important considerations as we look towards a future involving changing climatic conditions. Market structures vary across cities and countries, as do current-day economic and climatic conditions. Technology decisions made long ago that reflect past market and policy/regulatory realities continue to influence choices made today and plans looking toward the future. Understanding the problem is the first step. The data collection efforts should continue to facilitate comparative analyses and informed policymaking at the local, state/national, and international level. Local authorities can begin or expand outreach to the public on these issues to heighten awareness of the unique challenges facing ‘their’ city and the role that citizens can play in ensuring the success of local energy and climate initiatives [53].

(ix) *Developing Climatic Resilient Transport System (Road, Port and Other Means)*

The extreme events due to climate change would affect urban transportation and telecommunication infrastructure. It includes capital stock, bridges and tunnels, roads, railways, pipelines and port facilities, data sensors and wire and wireless networks. It is important to assess possible disruptions of transport networks within cities and urban systems and planning, therefore, should accordingly factor the State’s intervention for disaster response and recovery efforts. Climate change related shifts in weather patterns in all likelihood will cause infrastructure disruptions. Clear patterns are that precipitation affects road safety by increasing accident frequency and also increases congestion, especially during peak hours. [56].

Results call for the introduction of adaptation in long-term urban planning, as one part of a comprehensive strategy to manage the implications of climate change in the city [57]. A transport system that cannot withstand the emerging impacts of climate change would prove burdensome [58]. Policies, plans and codes need to be aligned with local vulnerabilities to current and future climate change so as to enable adaptation [59]. Economic infrastructure such as ports are central to the State’s economy and revenue reports. It impacts the international trade, should the climate change bring substantial challenges to the exposed locations in coastal zones, low-lying areas and deltas [60, 61]. It is found that in absence of adaptation, sea level rise would significantly increase flood risks in the city of Copenhagen. Sea shipping, including port infrastructure and services, lies at the heart of the debate on sustainable transport development. With 80 per cent of international merchandise trade by volume and over two thirds by value being carried by sea, achieving sustainability and resilience in maritime transport is a necessary condition for the sustainability and resilience of global freight transport systems, externalities, such as energy resource depletion, environmental degradation and climate change impacts.

Building resilience in transport will require tools and approaches to allow climate and disaster risks to be systematically identified, prioritized and built into investment planning and decision-making processes. The World Bank has applied a range of tools and approaches to its engagement in building resilient transport systems, including upstream sectoral and spatial planning, post-disaster risk and recovery support, the enabling environment and the supporting resilient infrastructure solutions. Resilient solutions are designed to reduce the impacts of current and future climate risks. They span a broad range of investments, from physical infrastructure and new technologies to community-based adaptation and approaches that focus on maintenance planning.

With lack of supply driven urban settlements, a large section of the urban population in low- and middle-income nations is forced to live without all-weather roads which inhibits access of emergency vehicle to reach such areas affected by emergency for rapid evacuation. Chittagong in Bangladesh has got extremely narrow roads. It limits emergency access to most informal neighbourhoods. It puts the population at risk during emergencies relating to their health and during outbreak of fire [62]. It does not remain limited to the State's lack of providing for the amounts of economic or social infrastructure. It is observed that urban residents of the low-income group, suffer during and after extreme weather events that damage critical public transit links. As a result they are exposed to water-borne pathogens while wading barefoot through floodwaters [63, 64].

6. Outlining strategy for Anti-Disaster Response

It is now well established that the management of disaster cycle starts from the assessment of HVR taking seismo-geotectonic, geo-hydrological and hydro-meteorological regime into account. The occurrences of geological and hydro-meteorological disaster generally reinforce the impact of biological disasters (for example, pandemics, epidemics, etc.). It is pertinent to note that the area which is prone to natural disasters, generally, lacks the damage and loss assessment (DALA) and post disaster need assessment (PDNA) strategies under recovery strategy thus delaying the onset of processes for recovery.

6.1. Disaster Management Response Cycle:

In this study, we realized that conventional disaster management cycle having ingredient of preparedness, prevention and response does not work effectively in managing the disaster risks for urban agglomerates because of constraints in allocations of resources and efforts among different elements of DRR. Accordingly, a novel disaster management response cycle (DMRC) is suggested in para 3.2 which

may be adopted instead of conventional disaster management cycle to make DRR responsive and prioritize the mitigation and adaptation in pre-disaster phase to minimize the loss of lives and properties and to make the journey of human civilization a sustainable one.

The present focus of capacity development of the stakeholders only to those engaged in the rescue and relief work (DDR) should also accordingly shift and encompass all the people engaged in all the three stages of Response (ADR, DDR and PDR). A sound implementation of anti-disaster measures (ADR) by managers engaged for this stage, if are trained appropriately with good practices and technologies would ensure a muted and subdued suffering of the people during the disaster event. The community also likewise need to enhance their resilience and coping capacity with appropriate capacity development methods. The careful execution of post disaster response plan under PDR related to the reconstruction and recovery can reinforce the measures taken under ADR in terms of preparedness and prevention for the future disaster. Thus, it would be desirable to stress much more on ADR that guarantees the mitigation of natural hazards of future disasters under the onset of climate change.

The regime of HFA (2005–2015) has gone a long way to sensitize the SAARC countries to make an effort towards mitigating the different kinds of hazard and vulnerabilities. There are ample empirical evidences to suggest that the countries, such as the USA and Japan, very vulnerable to the hydro-meteorological (for example, cyclone, storm surge, floods, etc.) and geological (for example, earthquake, tsunamis, landslides, etc.) events, suffer far less in terms of loss of lives and properties than the developing countries of Latin America, South Asia and other regions. Therefore, the prevention and mitigation effort to reduce the hazard and vulnerability from turning into a disaster must also be provided with due importance. A response to counter the potential hazard turn into disaster may be treated as ‘Anti-Disaster Response (ADR)’ with the same focus and importance as is given to the Response to mitigate the effects of disasters during the event.

The tools and techniques used for DRR such as HRV analysis, risk assessment and monitoring, risk mitigation, early warning systems need to be integrated with CCA strategies particularly in the management of the important sectors like water, agriculture, human health, food security, urban development, forestry, tourism, etc. There are success stories and good practices on the integration measures which should be replicated and scaled up further.

The enabling mechanisms for integrating DRR and CCA through appropriate technologies should be standardized by discussion among different response structures. The spatial extent and significant amount of built environment of cities have significant impacts on the local and regional energy balance and associated weather, climate and related environmental qualities such as air quality. It

is understood that the city-coastal interactions has bearing on the hydrological cycle and pollutant removal processes which generally manifests through the development of fog, clouds and precipitation in cities and adjoining coastal areas. Rapid urban population growth in the last decade has been marked by growth in the vertical density in SAR (high-rise living and working). Higher density living per se offers better opportunities for resource conservation. However, it poses challenges to the habitants of such living if a proper planning and urban management are not undertaken by the local bodies.

Finally, any ADR [Figure 1] depends on the resource that it has got on its command. The measures suggested in para 8.6 to augment the resource of local bodies need to be acted upon if the socio-economic development has to take place on a sustainable path for the welfare and happiness of mankind. On the surface, the goal of achieving 'resilience' is a component of ADR universally embraced as the ideal at the individual, organizational and community level. Yet, given the diverse network of stakeholders in an organism as complex as a city it would be difficult to create a framework of resilience in a way that allows all actors to align this into their current mission and goals. San Francisco (California) uses the 'Resilience Wheel', with its eight functional areas, to show the partners, both inside and out of government, how their organization's mission connects with those of other stakeholders who may work in sectors perceived to be quite different from theirs, that is agencies which work to advance financial independence in poor communities and emergency managers doing outreach for disaster preparedness.

As mentioned in the previous sections that the risk management under climate changes involves adaptation and mitigation decisions, the Adaptation strategies need to consider the dynamics of vulnerability and exposure and their linkages with socio-economic processes, sustainable development and climate change. The approach for managing the vulnerability, exposure and risk reduction together with the adaptation to changing climate are discussed extensively in the chapter on DRR and Climate Change respectively and found to be overlapping. The mitigation, therefore, is considered essential for managing the climate risk for effective adaptation.

6.2. A New Approach Towards Resilience and Sustainable Development:

United Nations International Strategy for DRR (UNISDR) in its recent report suggested several pertinent measures for development of the strategic approach to take disaster risk resilient urban agglomerate forward under climate change [65]. The study, however, suggested a comprehensively modified model [66] that can involve institutions of political, social, environmental and economies of the SAR as shown in Figure 3.

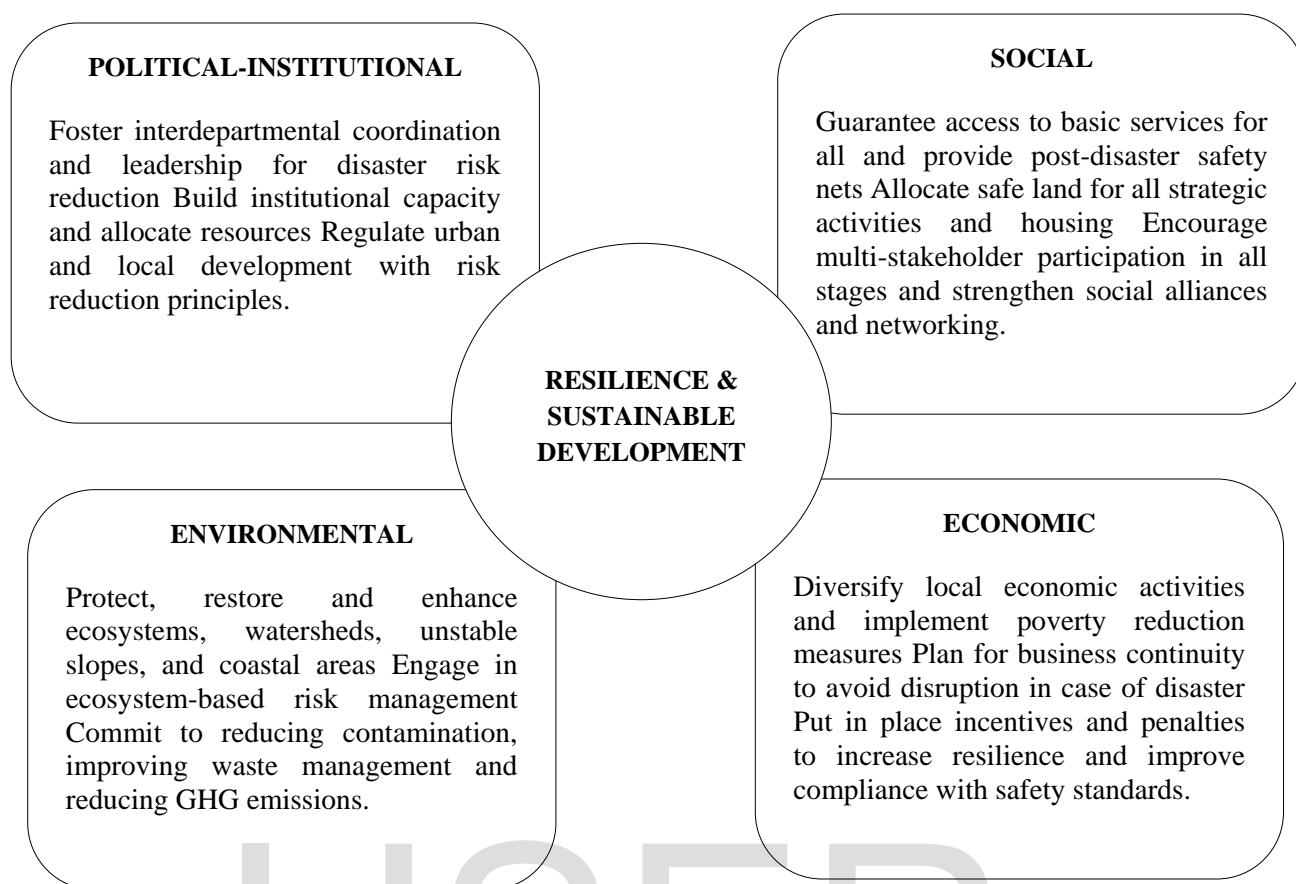


Figure 3: A proposed sustainable and risk resilient urban development mechanism based on the environmental, economic, social and political spheres for SAR. (Modified from UNISDR-2012) [65,66]

6.3 Risk Resilient Setup for Urban Agglomerate (RRSUA)

Under climate change scenario, a great challenge is faced to develop a comprehensive risk resilient urban agglomerate (RRUA) model. In this study it is proposed a modified model as shown in Figure 4, that can ensure the strategic approach for Disaster Risk Resilient Urban Agglomerate under Climate Change scenario.

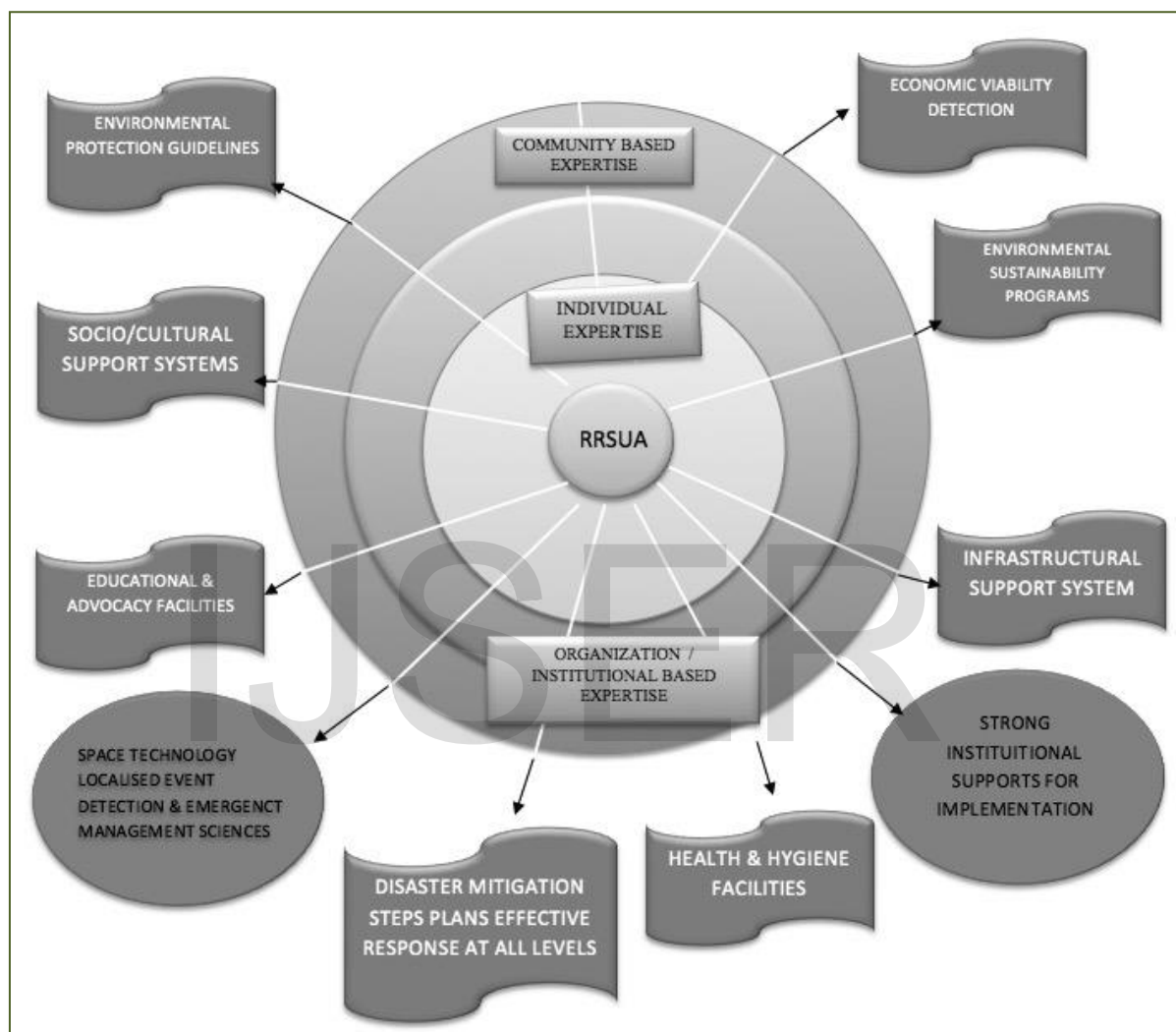


Figure 4 : A Diagram showing the Recommended Urban Resilience Wheel under Climate Change Scenario.

Source: RRSUA- Risk Resilient setup for Urban Agglomerate [66-69]

In the modified model proposed by Srivastava et al. [66 - 68] for RRSUA (Figure 5), corroborated with the interpretation presented by Mall et al [69] for adopting the risk mitigating steps, which are shown under the urban resilience wheel. An attempt is made to consider requisite feedbacks available from the community-based, individual-based as well as organizational and institutional based expertise, to deal with ten essential spokes of the urban resilience wheel under climate change scenario. Those ten spokes of the wheel consisted of environmental protection guidelines; economic viability detection; socio-cultural support systems; environmental sustainability programmes; education and

advocacy facilities; infrastructural support system; space technology for localized event detection and emergency management sciences; disaster mitigation plans for effective response at all levels; health and hygiene facilities and at the last but not the least, a strong institutional support for implementation. It is expected to help in evolving a sustainable urban risk management model for SAR. A successful implementation of urban resilience wheel may provide a guarantee for better urban risk resilient agglomerate for South Asian cities under climate change scenario.

Based on this piece of study, ten essentials are identified as most important yardsticks for making urban agglomerates risk resilient which is found in a good agreement to those essentials adopted by UNISDR under contribution to the global campaign (2010–2015) in March 2012 for making the cities resilient [65] (Box 5). It may be observed from the essentials enumerated in this report, that the emphasis is on building resilience through the measure which essentially falls in the category of ADR.

Box 5: Measures for Building Resilience (UNISDR-2012)

ADR	<p>1. Stress upon the coordination among various stakeholders and organization to understand the genesis of disaster events and steps for mitigating disaster risks through involvement of identified victim community by encouraging participation of citizen groups and civil society. Setting up local alliances with proper mechanism to ensure that all departments understand their role in disaster risk reduction and preparedness.</p>
	<p>2. Allocate a budget for disaster risk reduction embedded with suitable plan for giving incentives and reward points for supporting homeowners, low-income families, communities, businesses and the public sectors having leverage to invest in reducing the risks of which they face.</p>
	<p>3. Proper data management on hazards and vulnerabilities. Ready with risk assessment information and data for using in urban development plans and decisions, ensure that this information and the plans for the specific city's resilience are readily available to the public and fully based on intimation to the concerned.</p>
	<p>4. Proper mechanism for investment to maintain critical infrastructure that reduces disaster risk, such as flood drainage, adjusted where needed to cope with climate change.</p>
	<p>5. A thorough plan for making assessment for the safety of all the schools, health facilities, prisons, vital and critical structures and upgrade these as necessary.</p>

6. Strict application and enforcement of realistic, risk compliant building regulations and land use planning principles. A comprehensive plan having proper identification of safe land for low-income citizens and plan to upgrade informal settlements, wherever feasible.

7. Strict implementation of disaster risk resilient plan through capacity development and advocacies by ensuring education programs and training on disaster risk reduction and it should be in place in schools, hospitals, municipal corporations, prison shells, and local communities.

8. Plans for protecting ecosystems and natural buffers to mitigate floods, storm surges and other hazards to which the city may be vulnerable under climate change scenario. Awareness for adapting to climate change by building on good risk reduction practices.

9. Setting up of early warning systems and implementing the emergency management capacities in city and hold regular public preparedness drills.

DDR & PDR Measures

10. Strict implementation of post disaster response plans to ensure that the needs of the affected population are placed at the center of reconstruction, with support for them and their community organizations to design and help implement responses, including rebuilding homes and livelihoods though defining their role in disaster risk reduction.

Source: *Modified from UNISDR (2012)* [65]

7. Future Approach

Much remains to be done for the SAR to evolve a comprehensive model for better understanding of the rural-urban transition and hidden causative factors that lead to widespread migration of vast population to semi and urban areas which force them live within limited resources. This leads multiplication and thickening of the neo-urban risk strata of SAR. Such scenario is going to be much more aggravated under climate change processes in absence of tangible and promising plan for safer and sustainable risk resilient urban agglomerates. The research and development in this field to be continued in future studies is summarized further [66-70].

1. *Effective mechanism for generating quality-based primary dataset for making real-time vulnerability assessment*

SAR is a dynamic region in every aspect, so inference derived from the analysis of secondary data source may not be as convincing as that from the secondary archival data set. In order to assimilate a comprehensive risk mapping of SAR there is a need to adopt earth observation based on space technology for generating huge quantity of quality based data on different disaster themes so that appropriate assessment of HVR can be made with high degree of confidence.

2. *Advanced statistical tools for data processing and analysis:*

The statistical tools have their own bias in assessment of the significance of the data storage. However, there is a need of adopting advanced tools of data processing and analysis that can have lesser error and more tolerance for generating plausible models for risk resilient urban system having better solutions that the present models suggest in this study for institutional arrangement at regional, national and local levels.

3. *To study a limitation of anthropogenic factors in inducing climate change in the overall planning of climate change:*

Climate change is not a new phenomenon, as it happened in every geological epoch and period in inter glacial ages. It is, therefore, suggested to conduct extensive study on earth system science that has profound influence on diurnal and secular motions of the earth that gets influenced by tilting of axis of rotation. Now time has come to include scientific research conducted to understand the extent of the anthropogenic (reason for GHG) factors contributing to the climate change by identifying the natural factors responsible for earth dynamics and contribute to sea-level rise. Such study may reduce the public panic and help in adopting long-term development planning for the region.

4. *Furthering DRR and CCA integration keeping sensitivity of stakeholders in mind:*

DRR and CCA are complimentary to each other. Bringing the stakeholders of both the domains are found to be very sensitive issues, as traditionally the people working in their respective silos resist losing their turf and comfort enjoyed in the administrative structure. The government has not evolved any mechanism as yet to coordinate effectively with their line ministries for use of the resources most optimally. The extensive study on this may help developing a holistic model for urban risk resilient system to facilitate development planning.

5. *To Institutionalize DALA and PDNA in PDR:*

Post Disaster Loss Assessment and Post Disaster Need Assessment are a major challenge for recent years as future development planning depends much on the available resources in the sense of reducing the level of vulnerability for urban set ups. SAR is completely devoid of it. The Sendai Framework for DRR in SAR needs to work as per the global standards embedded with legal and financial safeguards which can be another topic of further research for Risk Resilient Urbanized SAR.

6. *To bring Seismic Microzonation in forefront of ADR in seismic prone area:*

Maximum use of sound building design codes derived from Seismic Microzonation needs to be used for constructing disaster risk resilient structures or disaster risk proof structures for the urban set ups which must be an ultimate goal of CCA.

7. *New paradigm in strategizing Response Mechanism to Disaster, Climate Change and Urbanization in view of emerging software development and artificial intelligence:*

The world has changed ever since emergence of personal computer and IT. The emerging software in every domain and sector have fast been changing the human interactions with themselves, with the nature and also the way of possession and acquisition of materials. The traditional industries and their layout are undergoing change with the advent of 3D technology. Solar power is fast replacing traditional generation of thermal power. IT has entered into the domain of advising the clients in varied areas, from legal services to purchasing the appropriate groceries, garments, medical or health care, etc. IT and software would impact the possession of cars, houses and need for living in urban space and, therefore, need for congregation and proliferation of urban agglomeration. There is every likelihood of reverse migration from metro to the region of less hussel and buzzel. So, it is highly likely that there would be change in the way agriculture is practiced today. The business opporutinities and job sectors are likely to face major upheavel. This would change the many elements which hitherto were considered to induce anthropogenic causes for climate change. The study on the extent subject, therefore, needs to be brought on the new platform to consider the influence of the fast changing technology on causal elements of GHG and global warming which traditionally were thought to impact the human lives.

The entire endeavour of making SAR resilient from the impacts of catastrophe of climate change induced disaster events can be achieved by SAARC Disaster Management Centre (SDMC) of India through its rapid response regional cooperation mechanism in accordance to its mandate and vision [71]

In conclusion, the concept of urbanization is based on dynamic theory of modernizing the infrastructures as a whole under uncontrollable population explosion and unpredictable climate change

with the evolving earth and there is no reason to suppose that inferences of the present study are the last word [72-73]

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