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URBAN SETUPS IN SOUTH ASIA REGION (SAR) UNDER CLIMATE CHANGE INDUCED RISKS: A SUGGESTIVE URBAN RISK RESILIENT MODEL FOR SAR

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ABSTRACT South Asia region (SAR) is one of the hotspots of almost all disasters in the world because of its complex geo-tectonic settings; bigger flood plain basins, and long coastal belts, which is being severely impacted by climate change induced disaster events. In this study a through analyses of several factors of geophysical, hydro-meteorological and climate change induced disaster events has been made to understand what suggestive steps can be taken for safer and sustainable urban risk resilient model for SAR. It is observed that the city populace of SAR get exposed to the inland flooding, coastal flooding, heat and cold, forest fire, water shortage due to drought, air pollution, mud slides, landslides, wind storm, cyclones etc. With the global warming, the propensity of the event arising out of these hazards is getting changed with the change in the time interval and becoming extreme and intensive in nature. We attempted to explain how the model is significant for planner to understand the trend of the new urban settlement coming up in different geographical locations, for giving them different treatment to mitigate the ill-effect of climate change on the citizen of these places during planning itself. The trend of Urbanization as a result of change in the GDP structure and migration of the rural population to the urban area in search of better livelihood is going to stay in the countries of South Asia region. The growth of new urban areas and addition with expansion of the existing cities, however, is under stress due to supply of urban amenities and socio-economic urban infrastructure that are not getting match with the rising demand. In this study, 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 with ten different spokes.

KEYWORDS : SAR; Climate change; Induced risks; Risk Resilient; UDMRC; RRUA

1. Introduction

It is evident that South Asia region (SAR) is one of the hotspots of almost all disasters in the world because of its complex geo-tectonic settings; bigger flood plain basins, and long coastal belts (Mishra, 2011; Srivastava et al., 2017)[Figure 1]. Such complexities of SAR have subjected the region to undergo worst suffering with uncontrollable losses of lives and property of the people who belonging to ill-planned urban setups. The Urbanization having taken over more than half the world's population is unique in sense that most of its built assets and economic activities get exposure towards destruction. It is well recognised that, a high proportion of the population and economic activities in the urban areas, are at risk from the climate change. It is also understood that a high proportion of global greenhouse gas emissions are being generated by the urban-based activities and its residents.The growing urban centres are observed to generate new patterns of disaster hazard, exposure and vulnerability, as evident in the rising number of localised disasters in the urban areas in many low- and middle- income nations associated with extreme weather (storms, flooding, fires, and landslides) (Douglas et al., 2008; UNISDR, 2009, 2011).Climate change will have profound impacts on a broad spectrum of infrastructure systems (water and energy supply, sanitation and drainage, transport and telecommunication), services (including health care and emergency services), the built environment, and ecosystem services. They interact with other social, economic, and environmental stressors exacerbating and compounding the risks to the individual and household well-being. It is therefore important to understand the complex inter-dependent systems of the cities to leverage support for climate change adaptation via effective city governments supported by cooperative multilevel governance (IPCC 2014).IPCC (2014), in its report outlines many global risks of climate change which are concentrated in urban areas. The steps that build resilience and enable sustainable development can accelerate successful climate-change adaptation globally. Manifestation of heat stress, extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, and water scarcity are characterised to pose the risks in urban areas for people, assets, economies, and ecosystems. It is stated in its report that risks are amplified for those lacking essential infrastructure and are forced to poor-quality housing and exposed areas. It is found that an exposure to weather-related risk in growing urban areas increases when local governments fail to address their responsibilities by expanding or upgrading infrastructure and services and reducing risk through building standards and appropriate land use management **(UNISDR, 2009, 2011).**

Figure 1: Map indicating south Asian coastline

This is typical in countries with low per capita GDPs and weak local governance and can be exacerbated by rapid urban population growth.It is therefore suggested to reduce the basic service deficits, improving housing, and building resilient infrastructure systems which could significantly reduce vulnerability and exposure in urban areas. The key development sectors which are the drivers of urbanisation as well as its sustainability would get affected directly by the climate change in following **Table 1.**

Table 1: Different Sectors affected directly by the Climate Change[*Source: van Aalst and Agrawala, 2005*]
• Human health
• Water supply and sanitation
• Energy
• Transport
• Industry, mining, and construction
• Trade and tourism
• Agriculture, forestry, and fisheries
• Environmental protection
• Disaster management

The urban adaptation benefits from effective multi-level urban risk governance, alignment of policies and incentives, strengthened local government and community adaptation capacity, synergies with the private sector, and appropriate financing and institutional development. Increased capacity, voice, and influence of low-income groups and vulnerable communities and their partnerships with local governments also benefit adaptation.These measures for their applications call for deep understanding of the geographical ambience which surrounds the urban setup and is highly susceptible to climate change. With so many people living in and moving to cities, urban areas are increasingly important in understanding the climate change issue. Under this background, the following attempt is made to give an overview of the urban setup in different geophysical surroundings and the climatic changes, they are subjected to.

The following Table 2 provides a selection of the hazards, key vulnerabilities, key risks, and emergent risks identified by (IPCC report 2014). It is observed that the key risks are determined by hazards interacting with vulnerability and exposure of human systems, and ecosystems or species. The table underscores the complexity of risks determined by various climate-related hazards, non-climatic stressors, and multifaceted vulnerabilities. The examples given in the table show that underlying phenomena, such as poverty or insecure land-tenure arrangements, unsustainable and rapid urbanization, other demographic changes, failure in governance and inadequate governmental attention to risk reduction, and tolerance limits of species and ecosystems that often provide important services to vulnerable communities, generate the context in which climatic change related harm and loss can occur. The study undertaken to impress upon the Policymakers of SAR Countries underlines the premises which the given table illustrates that current global megatrends (e.g., urbanization and other demographic changes) in combination and in specific development context (e.g., in low-lying coastal zones), can generate new systemic risks in their interaction with climate hazards that exceed existing adaptation and risk management capacities, particularly in highly vulnerable regions, such as dense urban areas of low-lying deltas.

Table 2 Hazard, Key Vulnerabilities, Key Risks, and Emergent Risks*(Source: IPCC Report 2014)*

Hazard	Key Vulnerabilities	Key Risks.	Emergent Risks
Inland flooding	Large numbers of people exposed in urban areas to flood events. Particularly susceptible are people in low-income informal settlements with inadequate infrastructure (and often on flood plains or along river banks). These bring serious environmental health consequences from overwhelmed, ageing, poorly maintained, and inadequate urban drainage infrastructure and widespread impermeable surfaces. Local governments are often unable or unwilling to give attention to needed flood-related disaster risk reduction. Much of the urban population unable to get or afford housing that protects against flooding, or insurance. Certain groups are more sensitive to ill health from flood impacts, which may include increased mosquito- and water-borne diseases.	Risks of deaths and injuries and disruptions to livelihoods/incomes, food supplies, and drinking water	In many urban areas, larger and more frequent flooding impacting much larger population. No insurance available or impacts reaching the limits of insurance. Shift in the burden of risk management from the state to those at risk, leading to greater inequality and property blight, abandonment of urban districts, and the creation of high-risk/high-poverty spatial trap
Coastal flooding (including sea level rise and storm surge)	High concentrations of people, businesses, and physical assets including critical infrastructure exposed in low-lying and unprotected coastal zones. Particularly susceptible is the urban population that is unable to get or afford housing that protects against flooding or insurance. The local government is unable or unwilling to give needed attention to disaster risk reduction.	Risks from deaths and injuries and disruptions to livelihoods/incomes, food supplies, and drinking water	Additional 2 billion or so urban dwellers expected over the next three decades Sea level rise means increasing risks over time, yet with high and often increasing concentrations of population and economic activities on the coasts. No insurance available or reaching the limits of insurance; shift in the burden of risk management from the state to those at risk leading to greater inequality and property blight, abandonment of urban districts, and the creation of high-risk/high-poverty spatial traps
Heat and cold (including urban heat island effect)	Particularly susceptible is a large and often increasing urban population of infants, young children, older age groups, expectant mothers, people with chronic diseases or compromised immune system in settlements exposed to higher temperatures (especially in heat islands) and unexpected cold spells. Inability of local organisations for health, emergency, and social services to adapt to new risk levels and set up needed initiatives for vulnerable groups	Risk of mortality and morbidity increasing, including shifts in seasonal patterns and concentrations due to hot days with higher or more prolonged high temperatures or unexpected cold spells. Avoiding risks often most difficult for low-income groups	Duration and variability of heat waves increasing risks over time for most locations owing to interactions with multiple stressors such as air pollution

Water shortages and dro ught in urban regions	Lack of piped water to homes of hundreds of millions of urban dwellers. Many urban areas subject to water shortages and irregular supplies, with constraints on increasing supplies. Lack of capacity and resilience in water management regimes including rural–urban linkages. Dependence on water resources in energy production systems	Risks from constraints on urban water provision services to people and industry with human and economic impacts. Risk of damage and loss to urban ecology and its services including urban and peri-urban agriculture.	Cities' viability may be threatened by loss or depletion of freshwater sources—including for cities dependent on distant glacier melt water or on depleting groundwater resources
Changes in urban mete orological regimes lead to e nhanced air pollution.	Increases in exposure and in pollution levels with impacts most serious among physiologically susceptible populations. Limited coping and adaptive capacities, due to lacking implementation of pollution control legislation of urban governments	Increasing risk of mortality and morbidity, lowered quality of life. These risks can also undermine the competitiveness of global cities to attract key workers and investment.	Complex and compounding health crises
Geo-hydrological hazards (salt water intrusion, mud/land slides, subsidence)	Local structures and networked infrastructure (piped water, sanitation, drainage, communications, transport, electricity, gas) particularly susceptible. Inability of many low-income households to move to housing on safer sites.	Risk of damage to networked infrastructure. Risk of loss of human life and property	Potential for large local and aggregate impacts Knock-on effects for urban activities and well-being
Wind storms with higher intensity	Substandard buildings and physical infrastructure and the services and functions they support particularly susceptible. Old and difficult to retrofit buildings and infrastructure in cities Local government unable or unwilling to give attention to disaster risk reduction (limited coping and adaptive capacities)	Risk of damage to dwellings, businesses, and public infrastructure. Risk of loss of function and services. Challenges to recovery, especially where insurance is absent	Challenges to individuals, businesses, and public agencies where the costs of retrofitting are high and other sectors or interests capture investment budgets; potential for tensions between development and risk reduction investments
	Newly exposed populations and infrastructure, especially those with limited capacity for multi-hazard risk forecasting and where risk reduction capacity is limited, e.g., where risk management planning is overly hazard specific including where physical infrastructure is predesigned in anticipation of other risks (e.g., geophysical rather than hydrometeorological)	Risks from failures within coupled systems, e.g., reliance of drainage systems on electric pumps, reliance of emergency services on roads and telecommunications. Potential of psychological shock from unanticipated risks	Loss of faith in risk management institutions. Potential for extreme impacts that are magnified by a lack of preparation and capacity in response
	Large sections of the urban population in low- and middle-income nations with livelihoods or food supplies dependent on urban and peri- urban agriculture are especially susceptible.	Risk of damage to or degradation of soils, water catchment capacity, fuel wood production, urban and peri-urban agriculture, and other productive or protective ecosystem services. Risk of knock- on impacts for urban and peri-urban livelihoods and urban health	Collapsing of peri-urban economies and ecosystem services with wider implications for urban food security, service provision, and disaster risk reduction
Climate change– induced or intensified hazard of more diseases and exposure to disease vectors	Large urban population that is exposed to food-borne and water-borne diseases and to malaria, dengue, and other vector-borne diseases that are influenced by climate change	Risk due to increases in exposure to these diseases	Lack of capacity of public health system to simultaneously address these health risks with other climate-related risks such as flooding

1.1. Cities at Risk in SAR

According to an estimates in 2014 sixty-five cities in South Asia have more than 1 million people each, of which 5 have more than 10 million (Dhaka, Kolkata, Delhi, Mumbai and Karachi), with four other cities (Chennai, Bangalore, Hyderabad and Lahore) closely following. It is discussed in Chapter 2 that Delhi will cross the population of 2 million in 2020 and Dhaka, Kolkata and Karachi by 2025.The uncontrolled and largely unplanned growth of large cities in South Asia has had negative effects on urban dwellers and their environment. The provision of infrastructure facilities and services is lagging far behind the pace of urbanization, and in consequence the urban environment, particularly in large cities, is deteriorating rapidly. Risk of severe ill-health and disrupted livelihoods for large urban populations due to inland flooding in some regions **(IPCCC 2014).**Systemic risks due to extreme weather events leading to breakdown of infrastructure networks and critical services such as electricity,water supply, and health and emergency services.The growth of cities and towns of South Asia in general cannot be said to be following the path of sustainability in view of such setups caught in the cobwebs of demand driven development ethos, thus facing serious shortage of power, water, sewerage, developed land, housing, transportation, communication and other facilities.

The region remains vulnerable to the tropical cyclone.Asian deltas are particularly vulnerable to tropical cyclones owing to their large population density in expanding urban areas **(Nicholls et al., 2007)**. Extreme cyclones in Asia since 1970 caused more than 0.5 million fatalities, for example, cyclones Bhola in 1970, Gorky in 1991, Thelma in 1998, Gujarat in 1998, Orissa in 1999, Sidr in 2007, and Nargis in 2008. Tropical cyclone Nargis hit Myanmar on May 2, 2008 and caused more than 138,000 fatalities. Several- meter high storm surges widely flooded densely populated coastal areas of the Irrawaddy Delta and surrounding areas **(Revenga et al., 2003; Brakenridge et al., 2013)**

1.2 Rural-Urban transition under climatic stress: A new conflict zone

While studying the impacts of climate change on the urban setups, it is important to understand the rural-urban connect, as both the areas are closely interconnected and interdependent. The area transiting from rural to urban has important implications on the sustainability of urban areas in view of its vulnerability emanating from the climate change or because of its geographical features with inherent hazard and risks. IPCC 2014 identifies three critical implications of these interactions,

(i) *Climate extreme in rural areas resulting in urban impacts*- The climate extremes bearing impacts on the resources meant for urban areas, located in peri urban or non-urban area will have downstream impacts in cities (for example; water supply)
(ii) *Events specific to the rural-urban interface* - The transient space between the two setups have its own vulnerability specific to the locations and any impact would result into loss of local agricultural production, economic marginalization and stress on human health.
(iii) *Integrated infrastructure and service disruption* - Urban demand would precede over the rural demand in the peri urban area on the joint resources owing to advantage of urban areas in terms of its political, social and economic importance, a reality to be faced under the condition of any climatic stress.

This being so, the extreme events disruptions in distant resource areas or to the supply chain, and relevant infrastructure can adversely impact the urban areas in the event of drought, which would impact the supply of food and the water source located in the rural surroundings. Related to such interconnect, leads to the migration of the people from the rural to the urban area in search of better livelihood besides other drivers accentuating the migration, and one of them being the climate events impacting the rural area, a phenomenon visible in the deltaic belt of Bangladesh. The interface between the rural and urban landscapes have assumed a mix characteristics of both the backgrounds, more urban in nature due to wide ranging pursuits of income generating, activities, whilefollowing the rural ethos interwoven with traditional social fabric. The area is further characterized with new form of vulnerabilities and risks which includes, urban specific vulnerabilities related to population concentration, dependence on infrastructure and social diversity limiting social support with rural traits of distance, isolation and invisibility to the policy makers **(Pelling and Mustafa 2010).**

It may further be noticed that the peri urban areas are less visible to the policy makers and therefore they loose from both the ends that is losing out from the main stream national agriculture schemes on one hand, and on the other getting isolated in the resource allocation against the mainstream town area. The vulnerability also arises out of the institutional structure governing these areas, which is transition from the informal kind in the rural setup to the formal State and other market institutions governing the urban area. It further leads to a major conflict among the rural and urban mix population, at a time both dependent on the same set of resources, such as supply of water which in climatic stressed condition will exacerbate the tensions where continued water supply to the main town will get precedence over the demand of peri-urban area. It therefore invites an innovative approach to address such conflict.

2. Increasing economic activities and Urbanisation in Coastal area

2.1 Few of the world's coastlines are now beyond the influence of human pressures, although not all coasts are inhabited **(Buddemerier et al., 2002).** Utilization of the coast increased dramatically during the 20th century, a trend that seems certain to continue through the 21st century with increase of economic activities along the coastlines and development of shipping infrastructure in transport. Coastal population growth in many of the world's deltas, barrier islands and estuaries has led to widespread conversion of natural coastal landscapes to agriculture, aquaculture, silviculture, as well as industrial and residential uses.

It is estimated in the IPCC Report 2014 that the population and assets exposed to coastal risks as well as human pressures on coastal ecosystems will increase significantly in the coming decades due to population growth, economic development, and urbanization. The exposure of people and assets to coastal risks has been rapidly growing and this trend is expected to continue. It is assessed the impact of climate change and global sea level would rise up to 0.59 m in the 2090s. The coastal systems are considered to be affected by higher sea levels, increasing temperatures, changes in precipitation, larger storm surges, and increased ocean acidity. The human activities had continued to increase their pressure on the coasts with rapid urbanization in coastal areas and growth of megacities with consequences on coastal resources. Regionally, the South, Southeast, and East Asia, Africa, and small islands are identified as the most vulnerable.

Table 3: Land Loss Due To Sea level Rise in SAR[Nicholls &Muinuri, 1998]

Country	Sea-level Rise (SLR) Scenario	Land loss	
Coastal Country of SAR	(cm)	Km^2	%
Bangladesh	100	29846	20.7
India	100	5763	0.4
Pakistan	200	1700	0.2

The global-mean sea-levelcontinues to rise and is attributed to certain impacts of global warming. It manifests in the form of an increased flood risk and submergence, salinization of surface and ground waters, and morphological change, such as erosion and wetland loss. The actual impacts will depend on factors such as the amount of sea- level rise coming as result of climate change, including a number of factors which are human-controlled such as coastal land use and management approaches.The coastal zone has been the most attractive destination for human habitation and economic activity since time immemorial. For 1990, it is estimated that 1.2 billion (or 23%) of the world's population lived in the near-coastal zone1, at densities about three times higher than the global mean **(Nicholls and Small, 2002; Small and Nicholls, 2003).**The global-mean sea-level rise does not translate into a uniform rise in sea level around the world. Over the main time scale of human concerns (102 to 103 years), relative sea level is the sum of the following components **(Church et al., 2001**, Case study on sea-level rise impacts by **Robert J. Nicholls 2003).**

- *Global-mean sea-level rise:*It represents an increase in the global volume of the ocean. In the 20th/21st Century, this is primarily due to thermal expansion of Upper Ocean as it warms and the melting of small ice caps due to human-induced global warming **(Church et al., 2001).**
- *Regional metero-oceanographic factors:* This is indicative of spatial variation in thermal expansion effects, changes to long-term wind fields and atmospheric pressure, and changes in ocean circulation such as the Gulf Stream (e.g. **Gregory, 1993).**
- *Vertical land movement:* It represents subsidence and uplift due to various geological processes such as tectonics, neo-tectonics, glacial-iso-static adjustment (GIA2), and consolidation **(Emery and Aubrey, 1991).**

It is reported by IPCC(2014) that the Low Elevation Coastal Zone (LECZ) constitutes 2% of the world's land area but contains 10% of the world's population (600 million) and 13% of the world's urban population (360 million), based on year 2000 estimates **(McGranahan et al., 2007).** About 65% of the world's cities with populations of greater than 5 million are located in the LECZ **(McGranahan et al., 2007).** The global population exposed to the 1-in- 100-year extreme sea level (i.e., the sea level that has a 1% chance of being exceeded every year) has increased by 95% from 1970 to 2010, with about 270 million people and US$13 trillion worth of assets being exposed to the 1-in-100-year extreme sea level in 2010

(Jonkman et al., 2012). For many locations, population and assets exposure is growing faster than the national average trends owing to coastward migration, coastal industrialization, and urbanization **(McGranahan et al., 2007; Seto, 2011; Smith, 2011).** The aggregated result of Impacts of flood events in different South Asian Countries is elaborated in the **Table 3, 4, 5, and6.**

Table 4: Historical floods of Bangladesh and its impact[Bnagladesh Report]

Year	Affected People	People killed	Economic damage(US$x1000)
2007	13,771,380	1110	-
2004	36,000,000	-	2,200,000
1998	15,000,050	1050	4,300,000
1995	12,656,006	-	-
1993	11,469,537	-	-
1988	45,000,000	2379	2,137,000
1987	29,700,000	2055	727,500
1984	30,000,000	1200	-

Table 5: Flood affected areas and damages in India (1953-2004)*[DM in India, Srivastava, R.K.et.al.]*

Item	Unit	Average During(1953-2004)	years	Maximum Damage(Year)
Area Affected	Million Hectare	7.63	1978	17.50
Population affected	Million	32.92	1978	70.45
Human Lives Lost	No. in thousand	1597	1977	11316
Cattle lost		94	1979	618
Cropped Area Affected	Million Hectare	3.54	1988	10.15
Value of Damage crops	Rs. Crore	708.57	**Q**	4246.6
Houses Damage	Thousand in Number	1235.61	1978	3508
Value of damaged houses	Rs. Crore	251.05	1995	1307.9
Value of Damage Public Utilities	Rs. Crore	813.69	2001	5604
Value of total damage to Houses, Crops and Public Utilities	Rs. Crore	1817.07	2000	8864

[Source:DM in India(SrivastavaR.K.et.al.)]

Table 6: Coastal flooding in Pakistan [Pakistan Report, 2015;*https://en.wikipedia.org/wiki/List_of_floods_in_Pakistan]*

Year/ Month	Area affected	Perople killed
2003	Sindh, Thatta, Karachi	484
July –August 2007	Khyber-Pakhtunkhwa, Sindh, Coastal Baluchistan	130 in Khyber-Pakhtunkhwa in july and 22 in August. 815 died in Baluchistan and Sindh.
2010	Whole Pakistan	2000
September 2011	Sindh Province	361
September 2012	Khyber Pukhtunkhwa,Southern Punjab and Upper Sindh	100
August 2013	Whole Pakistan	80 died
September 2014	Flooding in river Chnab and Jhelum	280 people died

Table 7: Flood events in Srilanka 1974-2007*[Disaster Management Center,Srilanka, March 2009(draft repor]*

No. of event	Percentage	Death	Number of people affected	Houses damaged	Agriculture loss
1,397	**9.7**	**419**	**13,485,520**	**232,236**	**312,580**

2.2 Flood events in Maldives

IPCC projects sea level rise of up to 0.88m by 2100 will submerge the Maldives with coastal flooding which is recurring hazard for the country. Since the 1950s, sea level in and around the Maldives has been rising at a rate of 0.03–0.06 inches (0.8–1.6 millimeters) per year. Because of the Maldivian topography, small changes in sea level translate into extensive land inundation.

2.3 New Urban Setup and the Impact of increasing population on Coastal belt

Sea has been used as a great medium for transport and navigation while being a great source of fish supply since time immemoral. However, increasing demand of such supply and mechanized harvesting in some of the areas, fisheries activities has reduced endemic coastal fish stocks to 10 to 30 percent of the supply that existed 30 years ago. It is estimated that in the 20th century,50 percent of all mangroves, and nearly 60 percent of the world's coral reefs are seriously degraded — in some cases would go beyond recovery — would or threatened by development and other human activities. These challenges are particularly acute for island countries, where coasts such as Maldivesoften comprise the entire country. Such countries may also be threatened by the rising sea levels, a possible consequence of climate change **(Population Reference Bureau, 2003).**

The ecological richness of South Asia, however, has been subjected to great pressure through over extraction of resources, enhanced pollution, and physical alterations in coastal ecosystems. Mangroves have been exploited for timber, fuel wood, and other purposes. For about 200 years, large mangrove areas have been cleared for agricultural activities and for shrimp farming, particularly in India and Pakistan. Mangroves, coastal wetlands, and other coastal habitats also have been severely affected by discharges of untreated industrial and domestic sewage, freshwater interceptions for irrigation, and dredging and re-suspension of contaminated silts. Oil pollution also increasingly threatens coral reefs, often located in areas where large-scale petroleum industries, tourism, and fishing industries flourish. Most of the shallow water coral reef habitats of Sri Lanka, the Maldives, and India have been severely damaged as a result of bleaching **(Mitra et. al., 2010).**

Around the Bay of Bengal, according to one estimate the region has suffered loss of 13 million people due to cyclone, in the past 200 years **(Small and Robert, 2003).** More than10 million people, mostly in Asia suffer due to storm surges **(Mimura, 2000).** Major recent coastal flood includes flood of 1991 in Bangladesh in which 140,000 people died and 10 million become homeless. According to one estimate by the year 2100, with the rise of sea level by 59 cm, a 100 year storm surge could inundate areas in Asia with a population of 362 million, out of the total projected population **(Mimura, 2000).** The direct impacts of human activities on the coastal zone have been more significant over the past century than impacts that can be directly attributed to observed climate change **(Scaviaet.al., 2002; Lotze et al.,2006).** The major direct impacts include drainage of coastal wetlands, deforestation and reclamation and discharge of sewage, fertilizers and contaminants into coastal waters. Extractive activities include sand mining and hydrocarbon production, harvests of fisheries and other living resources, introductions of invasive species and construction of seawalls and other structures.

The engineering structures, such as damming, channelization and diversions of coastal waterways, harden the coast, change circulation patterns and alter freshwater, sediment and nutrient delivery. The Natural systems are often directly or indirectly altered, even by soft engineering solutions, such as beach nourishment and fore dune construction (Nordstrom, 2000; Hamm and Stive, 2002). The ecosystem services on the coast are often disrupted by human

activities. For example, tropical and subtropical mangrove forests and temperate saltmarshes provide goods and services (they accumulate and transform nutrients, attenuate waves and storms, bind sediments and support rich ecological communities), which are reduced by large-scale ecosystem conversion for agriculture, industrial and urban development.

2.4 Fishing and Aquaculture

Marine fisheries and aquaculture (the controlled cultivation and harvesting of freshwater and marine organisms) produce close to 100 million tons of fish, shellfish, and edible plants every year, providing a livelihood for about 35 million people, most of who live in developing countries. Overharvesting to meet the global consumers growing demands for sea food deplete many species and alter the biological structure of coastal ecosystems. Aquaculture, the world's fastest growing food production activity, with an annual growth rate of about 10 percent in the 1990s, can lead to the destruction of mangroves and may lead to irreversible damage to both estuarine and offshore fisheries by introducing biological, chemical, and organic pollutants (such as antibiotics and pesticides) and by modifying habitats.**(PRB, 2003)**

2.5 The new challenges of climate change in the coastal area

Managing the population pressures in coastal zones is becoming increasingly difficult because those regions encompass many physical, social, and regulatory divisions. In addition, multiple competing economic sectors, including tourism, fishing, agriculture, aquaculture, forestry, manufacturing, oil and gas extraction, waste disposal, marine transportation, and real estate development have created interestsamong people cutting across the sector,hinterland and irrespective of the region they belong to,whether coming from the rural area or fromthe area in the vicinity of the coastal zones. In a growing number of countries, coastal zone managers are adopting integrated, multidisciplinary approaches to resource management that incorporate the perspectives of all stakeholders, including governments, the private sector, nongovernmental organizations (NGOs), and individuals Integrated coastal management (ICM), an internationally accepted approach to managing theresources. ICM is based on the United States' 1972 Coastal Zone Management Act, which allows the policymakers and planners to take population issues into account when looking at the pressures, threats, and opportunities facing coastal areas. ICM has been endorsed repeatedly in the international conferences, including the 1992 UN Conference on Environment and Development in Rio de Janeiro, Brazil, and the 2002 World Summit on Sustainable Development in Johannesburg, South Africa. ICM attempts to forge a balance between users of water and natural resources while ensuring that long-term environmental health and productivity are not compromised. **(PRB 2003, f)**

2.6 Cyclonic Storms, Storm Surge & Coastal Flooding

The most important climate change induced risk which SAR is going to face is that of cyclonic storms, storm surge and accompanying coastal inundation. A sea surface temperature (SST) rise of 2 to 4º C, is expected to induce a 10 to 20 percent increase in the cyclone intensity emanating from Indian Ocean **(Aggarwal and Lal, 2001).** Since cyclone formation frequency in the Bay of Bengal is about five times that of the Arabian Sea **(IMD, 1979, 1996, TARU, 2005),** India's east coast is clearly at more risk.This therefore puts India and Bangladesh's eastern coast, asextremely highly vulnerable zone in this region. Evident to this is the 1999 Orissa and 1991 Bangladesh super cyclone which killed over 10,000 and 139,000 people respectively besides causing loss of economic assets across several coastal and inland districts, as a result of a mixture of devastating storm surge, cyclonic winds and coastal flooding. **(TARU/ BMTPC 2000, Benson and Clay, 2002).**

The cyclone and storm surge would have a devastating impact on large urban centres including the mega cities of Mumbai and Chennai, the million cities of Vishakhpatnam, Surat, Bharuch, Bhavnagar and Jamnagar apart from causing critical bottlenecks in important ports such as Kandla **(GSDMA/TARU, 2005, TARU, 2005)**. The metroes localised in the coastal region according to one estimate going to be exposed manifold in terms of their population and assets (Table 8, Nicholls et al., 2008, OECD, Paris). According to one estimate about 12 percent of the risk to the state and a potential loss of over 11,000 lives is accounted for a probabilistic 100-year event (GSDMA/TARU, 2005). Losses could rise considerably with increased migration to the coast, drawn by huge investments in coastal infrastructure, settlements and enterprise located largely unmindful of future risk distribution.

With regards to India it is observed that the Eastern Coast is more vulnerable than the Western Coast in terms ofthe frequency of occurrence of extreme events like cyclones and depressions (Figure 1). Orissa and Andhra Pradesh are the most vulnerable on the east coast, even compared to Tamilnadu because of it geophysical shape hitting the Bay of Bengal. The following table shows the district wise distribution of the three types of cyclones i.e. depression, storm and severe storm from 1877 to 1990, in the districts of these two coastal states.

Table 8: District Wise Distribution of Cyclones in Orissa and Andhra Pradesh (1877-1990) [UmeshPatnaik, and K. Narayan, Research Scholar, IIT, Mumbai]

District	Frequency of Sense storms, Storms and depressions
Puri	84
Cuttack	80
Balasore	76
SriKakulam	70
Visakhapatnam	31
East Godavari	31
Nellore	30
Ganjum	28
Krishna	25
Prakasam	7
Vizianagaram	5
Guntur	2
West Godavari	2

Table 9: Population and assets exposed to coastal flooding*(Nicholls et.al (2008) OECD, Paris)*

Urban Agglomeration	Country	Exposed poplation 2005	Exposed Assets-2005 (Billion Dollor)	Exposed Population 2070	Exposed assets 2070(Billion Dollor)
Kolkata	India	1,929,000	31.99	14,014,000	1,961.44
Mumbai	India	2,787,000	46.20	11,418,000	1,598.05
Dhaka	Bangladesh	844,000	-	11,135,000	-
Rangoon	Mayanmar	510,000	-	4,965,000	-

2.6. Measures taken up by many coastal states and com munities:

- The State's exposed to national hazard like storm, storm surge have taken up several mitigation activities preventive and adaptive measures to address these challenges and risks,
- Restoring natural storm surge buffers and incorporating climate change into coastal habitat restoration plans,
- Building or repairing dikes, seawalls, and other structures that protect cities from erosion and storms,
- Modifying building codes to enable structures to withstand higher water levels,
- Expanding setbacks (the distance between a structure and the shoreline) and instituting other land-use arrangements, to enable wetlands and beaches to migrate inland,
- Upgrading and redesigning infrastructure such as bridges, roads, culverts and storm-water systems,
- Evaluating drinking water supplies with respect to climate change,
- Mapping coastal hazards and developing emergency response plans with regard to sea level rise. (UNFCCC).

• 3. Urban Set ups in the Flood Basin

The cities created on the river side in different basin are now in stress. As the globe continues to warm, more water-induced disasters are expected especially in the Himalayan region, where very little is studied as to how the global warming would affect the climate and hydrological processes. The cities and the river had a close relationship from the time immemorial. They evolved and developed into a great political, cultural religious and economic center by the sides of river as a result of easy access to water supplies and navigation and also for defense. Whether in Asia or in Europe, the great cities like, Patliputra, Varanasi, Kolkata on the river Ganges in India or Paris on the Saine, or London on Thames and many such historical cities are located on the banks of major river of that country. These centers on the bank of river however have suffered the onslaught of flood from time to time which arise due to regional floods on major rivers, the floods caused by snow melt, local river over flow or flooding on small urbanized street on account of choking of the natural drainage system by the settlements in these areas.

Indian subcontinent has long exchequered History of urbanization in the early period of known civilization and their collapse (An environmental History by IAN Douglus).With the gradual advent of warmer and wetter condition since early Holocene (10000-7000 years BC), the Indus River saw its flow at full strength and gave rise to the growth of Harappa and Mohanjodaro's urban civilization on the north and south of its stream. The cities along the bank of Indus river however are estimated to show the signs of decline since 1800 BC, due to possibly to the climate change besides the tectonic events having possibly redirected the rivers in Punjab. The study of the impact of climate change in the different river basin are thus important to understand for developing the mitigation strategy to address the challenges posed by the growing urbanization in this region. The Urban setups in SAR 'sriver basin is given in **Table 10.**

Table 10: Cities of SAR located on major river banks*(Source: http://www.wikipedia.org/)*

Counntry	River	Area covered	City
Pakistan	Indus river	The Indus is the longest and most important river in Pakistan and one of the most important rivers on the Indian subcontinent. Originating in the Tibetan plateau in the vicinity of Lake Mansarovar, the river runs a 3200 kilometer (2000 mile) course, through Ladakh district in Kashmir and Northern Areas, flowing through the North in a southerly direction along the entire length of country, and merges into the Arabian Sea near Pakistan's port city Karachi. The Indus Valley Civilization extended from Balochistan to Gujarat, with an upward reach from east of River Jhelum to Rupar on the upper Sutlej. The coast settlements extended from SutkaganDor at Iranian border to Lothal in Gujarat. There is an Indus site on the Oxus river at Shortughai in northern Afghanistan. The major cities of the Indus Valley Civilization (IVC), Harappa and MohenjoDaro, dating to around 3300 B.C.E., represent some of the largest human habitations of the ancient world. settlements of Gandhara grave culture of the early Indo-Aryans flourished in Gandhara from 1700 to 600BCE.	Haramosh, Chilas, Dassu, Attock, Mianwali, DeraIsmail Khan, Punjab, Kashmore, Sukkhr, Moee, Sehwan, Haiderabad, Thatta, Karachi.
Bangladesh	Buriganga	In the distant past, a course of the Ganges river used to reach the Bay of Bengal through the Dhaleshwari river. When this course gradually shifted and ultimately lost its link with the main channel of the Ganges it was renamed the Buriganga.TheBuriganga is economically very important to Dhaka. Launches and country boats provide connection to other parts of Bangladesh, a largely riverine country. When the Mughals made Dhaka their capital in 1610, the banks of the Buriganga were already a prime location for trade. The river was also the city's main source of drinking water.	Dhaka
	Padma river	The Padma enters Bangladesh from India near ChapaiNababganj and meets the Jamuna near Aricha and retains its name, but finally meets with the Meghna near Chandpur and adopts the name "Meghna" before flowing into the Bay of Bengal.Rajshahi, a major city in western Bangladesh, is situated on the north bank of the Padma. The course of the Padma, as the main course of the Ganges is known in Bangladesh, changed considerably during the period 1600 to 2000 AD. It is difficult to trace accurately the various channels through which it flowed, but the probability is that it flowed past Rampur Boalia, through ChalanBeel, the Dhaleshwari and Buriganga rivers, past Dhaka into the Meghnaestuary. The Padma forms the whole of the southern boundary of the Pabna District for a distance of about 120 kilometres (75 mi).	Nawabganj, Rajshali, Pabna, Kushtia, Faridpur, Rajbari, Chandpur .
	Jamuna	The Jamuna River is one of the three main rivers of Bangladesh. It is the main distributary channel of the Brahmaputra River as it flows from India to Bangladesh. The Jamuna flows south and joins the Padma River (Pôdda), near GoalundoGhat, before meeting the Meghna River near Chandpur. It then flows into the Bay of Bengal as the Meghna River. The Jamuna is a very wide river. During the rains it is about 5–8 miles (8.0–12.9 km) from bank to bank. Even during the dry season when the waters subside, the breadth is hardly less than 2–3 miles (3.2–4.8 km).	Mymensingh
	Lower Brahmaputa	Below the Teesta, the Brahmaputra splits into two distributary branches. The western branch, which contains the majority of the river's flow, continues due south as the Jamuna (Jomuna) to merge with the lower Ganges, called the Padma River (Pôdda). The eastern branch, formerly the larger but now much smaller, is called the lower or old Brahmaputra (Bromhoputro). It curves southeast to join the Meghna River near Dhaka. The Padma and Meghna converge near Chandpur and flow out into the Bay of Bengal. This final part of the river is called Meghna. In the past the course of the lower Brahmaputra was different and passed through the Jamalpur and Mymensingh districts. In a 7.5[4] magnitude earthquake on April 2, 1762, the main channel of the Brahmaputra at Bhahadurabad point was switched southwards and opened as Jamuna due to the result of tectonic uplift of the Madhupur tract.	Dhaka, Jamalpur
Nepal	Bagmati	The BagmatiRiverruns through the Kathmandu Valley of Nepal and separates Kathmandu from Patan. The Bagmati River is considered the source of Nepalese civilization and urbanization. Flowing generally south although with many curves, the Bagmati reaches the edge of the Kathmandu Valley and enters Chobar Gorge near the Dakshinkali temple complex. The Bagmati also crosses the lower Sivalik Hills before reaching the Terai, then crosses into India at Dheng. It flows across Bihar districts Sitamarhi, Sheohar ,Muzaffarpur where the Lakhandei joins it, Darbhanga and finally Khagaria where Kamala river joins it just after meeting it Bagmati joins Koshi. It has caused widespread sufferings to the people in Teraiand northern districts of Bihar. In 1993, people have seen the worst destruction by this river.	Kathmandu

	SetiGandaki	The Seti originates from the snow fields and glaciers around the twin peaks of Api and Nampa in the south facing slopes of the main Himalayas. The area is near the trijunction of the borders of Nepal, India (Kumaon, Uttarakhand), and China (Tibet). The river first flows in a south-easterly direction, then turns and flows in a south-westerly and finally south-easterly again before joining the Karnali or Ghagra River. It has cut a spectacular gorge across the Mahabharat Range and appears to be lost amongst caves and tunnels for a short distance.	Pokhara
	Narayani or Kale Gandaki	The Narayani in southern Nepal is one of the major rivers of Nepal and a left bank tributary of the Ganges in India. In Nepal the river is notable for its deep gorge through the Himalayas and its enormous hydroelectric potential. It has a total catchment area of 46,300 square kilometers (17,900 sq mi), most of it in Nepal. The basin also contains three of the world's 14 mountains over 8,000 metres (26,000 ft), Dhaulagiri, Manaslu and Annapurna I. Dhaulagiri is the highest point of the Gandaki basin. It lies between the similar Kosi system to the east and the Karnali (Ghaghara) system to the west. The river forms the western border of Chitwan National Park. Along the stretch in Nepal, the river carries heavy amounts of glacial silt, imparting the river a black color.	Lo Manthang, Jomsom, Beni, Baglung, Kusma, Ridi, Devghat, Bharatpur, Valmikinagar and Triveni.
	Rapti	The Rapti River flows from east to west through the Chitwan Valley in Nepal, forming the northern border of the Chitwan National Park. It joins the Narayani River inside the protected area.	Bharatpur
Bhutan	Raidak	The Raidak River (also called Wang Chhu or Wong Chhu in Bhutan) is a tributary of the Brahmaputra River, and a trans-boundary river. It flows through Bhutan, India and Bangladesh.The Wang Chhu, or Raid k, rises in the Himalayas. In its upper reaches it is also known as the ThimphuChhu. The main river is a rapid stream, running over a bed of large boulders. Between Thimphu and the confluence with the ParoChhu, the course of the river is not severely confined but, after leaving the confluence, it runs through a narrow defile between very steep cliffs. It subsequently flows southeast through a comparatively open valley, its course strewn with large boulders against which the water foams violently. It is joined by several small tributaries flowing from nearby mountains. Just above ParoDzong a considerable feeder, the Ta Chhu, joins it from the left. To the west, the Ha Chhudrains into the Wong Chhu. At TashichhoDzong the bed of the river is about 2,121 metres (6,959 ft) above sea level and at the point of its exit in the Dooars its elevation is only 90 metres (300 ft)	Thimpu, Tufanbganj
Afghanistn	Kabul river	Kabul river is a 700-kilometre (430 mi) long river that emerges in the Sanglakh Range of the Hindu Kush mountains in Afghanistan and empties into the Indus River near Attock, Pakistan. It is the main river in eastern Afghanistan and is separated from the watershed of the Helmand by the Unai Pass. The Kabul River passes through the cities of Kabul and Jalalabad in Afghanistan before flowing into Khyber Pakhtunkhwa in Pakistan some 25 kilometres (16 mi) north of the Durand Lineborder crossing at Torkham. The major tributaries of the Kabul River are the Logar, Panjshir, Kunar, Alingar, Bara andSwat rivers.	Kabul, Jalalabad
	Arghandab	Arghandab is a river in Afghanistan, about 400 km (250 mi) in length. It rises in the Hazarajat country north-west of Ghazni, and flows south-west falls into the Helmand 30 km (19 mi) below Girishk. In its lower course it is much used for irrigation, under the control of the Helmand and Arghandab Valley Authority, and the valley is cultivated and populous;	Kabdhar
	Hari River	Hari or "Herat River is a river flowing 1,100 kilometres (680 mi) from the mountains of central Afghanistan to Turkmenistan, where it disappears in the Kara-Kum desert. The river originates in the Baba mountain range, part of the Hindu Kush system, and follows a relatively straight course to the west. In western Afghanistan the Hari flows to the south of Herat. The valley around Herat was historically famous for its fertility and dense cultivation. After Herat, the river turns northwest, then north, forming the northern part of the border between Afghanistan and Iran. Farther north it forms the south-eastern part of the border between Iran and Turkmenistan.	Herat
India	Ganga	The Ganges also Ganga is a trans-boundary river of Asia which flows through the nations of India and Bangladesh.The Ganges begins at the confluence of the Bhagirathi and Alaknanda rivers and originate from Gangotri glacier. The 2,525 km (1,569 mi) river rises in the western Himalayasin the Indian state of Uttarakhand, and flows south and east through the Gangetic Plain of North India into Bangladesh, where it empties into the Bay of Bengal. It is the third largest river in the world by discharge.	Uttrakhand, UP, Bihar,Jharkhand, West Bengal
	Brahamputra	The Brahmaputra also called Tsangpo-Brahmaputra, is a trans-boundary river and one of the major rivers of Asia It is the tenth largest river in the world by discharge, and the 29th longest. With its origin in the Angsi glacier, located on the northern side of the Himalayas it flows across southern Tibet and into Arunachal Pradesh (India), where it is known as Dihang or Siang It flows southwest through the Assam Valley as Brahmaputra and south throughBangladesh as the Jamuna . In the vast Ganges Delta, it merges with the Padma, the popular name of the river Ganges in Bangladesh, and finally the Meghna and from here it is known as Meghna before emptying into the Bay of Bengal.[6] About 1,800 mi (2,900 km) long, the Brahmaputra is an important river for irrigation and transportation.	Assam , ArunanchalPradesh
	Satluj	The Sutlej River is the longest of the five rivers that flow through the historic crossroads region of Punjab in northern India and Pakistan. It is the eastern most tributary of the Indus River. The source of the Sutlej is near Lake Rakshastal in Tibet. The waters of the Sutlej are allocated to India under the Indus Waters Treaty between India and Pakistan, and are mostly diverted to irrigation canals in India. There are several major hydroelectric projects on the Sutlej, including the 1,000 MW Bhakra Dam, the 1,000 MW KarchamWangtoo Hydroelectric Plant, and the 1,530 MW NathpaJhakri Dam.	Punjab, haryana
	Tapti	The Tapi River (also known as Tapti River) is a river in central India. It is one of the major rivers of peninsular India with a length of around 724 kilometres (450 mi). It is one of only three rivers in peninsular India that run from east to west - the others being the Narmada River and theMahi River. The river rises in the eastern Satpura Range of southern Madhya Pradesh state, and flows westward, draining Madhya Pradesh's Nimar region, Maharashtra's Kandesh and east Vidarbha regions in the northwest corner of the Deccan Plateau and south Gujarat, before emptying into the Gulf of Cambay of the Arabian Sea, in the Surat District of Gujarat.	Madhya Pradesh, Guijrat

Under the climatic changes, the millions of people who live in small cities the Ganges Basin Floods in small cities may be affected by short-duration, highly intense rainfall. Other natural factors that may induce floods include landslides, reduced channel conveyance and the sudden failure of inhibiting structures, such as the collapse of landslide dams, ice jams or glaciers blocking glacial lakes.

Infrequently, the catastrophic failure of an artificial dam can be the direct cause of intense downstream flooding. Within a flooding event, the extent of inundation can be influenced by dike breaches and the blockage of bridges and culverts by debris **(Kundzewicz et al. 2012).**

Globally large and damaging floods occur every year. The floods are consequences of unique hydro metrological and monsoonal events occurring every year with different surge and intensity. The South-west monsoon (SWM) following the summer months and the north-east monsoon immediately after SWM synchronizing with the onset of winter pour this region with maximum rainfall. While India, Bangladesh, Pakistan Nepal and Bhutan receive 70-80% of rainfall during spell of SWM. Maldives, Sri-Lanka and part of South India receives maximum of the rainfall from North Earth Monsoon (NEM) during winter.

Further to the areas falling in the river basins ,the confluences of rivers with seas are also going to be impacted by Climate change. Deltaic region is going to be the most prone to the climate change as may be seen from the study by Rahman S., et al., in their study on th impact of the climate extremes and challenges to infrastructure development in the coastal cities in Bangladesh (Figure 2).Characterised by the interplay between rivers, lands, and oceans and influenced by a combination of river, tidal, and wave processes, deltas are coastal complexes that combine natural systems in diverse habitats (e.g., tidal flats, salt marshes, mangroves, beaches, estuaries, low-lying wetlands) and human systems (e.g., houses, agriculture, aquaculture, industry, and transport). They are low-lying coastal landforms formed by riverine sediments in the areas around river mouths, mostly during the last 6000–8000 years of relatively stable sea level and have a population density more than 10 times the world's average **(Ericson et al., 2006; Foufoula-Georgiou et al., 2011).** As low-lying plains, the deltas are highly sensitive to changes inthe sea level. They are subject to climatic impacts from rivers upstream (e.g., freshwater input) and oceans downstream (e.g., sea level changes, waves) as well as within the deltas themselves. At the same time, they are affected by human activities such as land use changes, dam construction, irrigation, mining, extraction of subsurface resources, and urbanization **(Nicholls et al., 2007).**

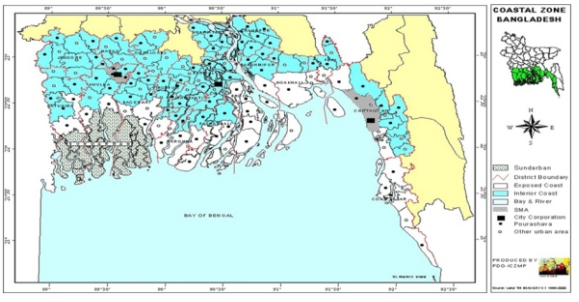


Figure 2: Impact of Climate extreme in the Deltaic Region of Bangladesh

(Source: RahmanS. et al., Climate extremes and challenges to infrastructure development in coastal cities in Bangladesh)

The changing land use is expected to affect freshwater systems strongly in the future. Freshwater ecosystems are considered to be among the most threatened on the planet **(Dudgeon et al., 2006; Vörösmarty et al., 2010).** Fragmentation of rivers by dams and the alteration of natural flow regimes have led to major impacts on freshwater biota **(Pringle, 2001; Bunn and Arthington, 2002; Nilsson et al., 2005; ReidyLiermann et al., 2012).** Floodplains and wetland areas have become occupied for intensive urban and agricultural land use to the extent that many are functionally disconnected from their rivers **(Tockner et al., 2008).**

It is estimated that the increasing urbanization would aggravate the propensity of flood hazards and decrease groundwater recharge. Of particular importance for freshwater systems is future agricultural land use, especially irrigation, which accounts for about 90% of global water consumption and severely impacts freshwater availability for humans and ecosystems **(Döll, 2009).**Pollution from cities and agriculture, especially nutrient loading, has resulted in declines in water quality and the loss of essential ecosystem services **(Allan, 2004).**

4. Urban Set-up in and around Forests

4.1 According to the FAO report 2010 globally, forests cover 4 billion hectares (ha) of land, or 1% of the Earth's land surface. In 2005, 3.5 billion of wood of 434 billion of growing stock were removed from the forests. It is estimated that the rate of deforestation shows sign of decreasing trend but countries need to remain alarmingly high. South Asian and Africa continue to have the largest net loss of forest (Figure 3& 4). The green cover houses the carbon contents of the atmosphere. The forest therefore store about 289 gigatonnes (Gt) of carbon within biomass alone. The majority of the forest land is covered with primary (36%) and modified (53%) natural forests. The primary forest area has been slowly decreasing by 6 million ha annually since 1990s. This rate is especially high in Brazil and Indonesia. These two countries are responsible for the loss of 4.9 million ha of forests annually. The forest loss tends to occur in low-income countries, largely in the tropics.

The impact of urbanization on the biodiversity and on the nation species are least studied. Urban development however causes extinction of native species. Species threatened by urbanization also tends to be threatened by many of the activities and practices such as agriculture, recreation, roads and many other human impacts. There is no study conducted about urbanization in the forest belt, or its growth at or around the forest cover. There appears to be very little material available over the Status of forests in the South Asia at one place. The urban forestry however has been gaining the ground with the passage of time, and with awareness spreading among the masses about the positive impacts of green cover in developing and improving the ecosystem of urban area. It has come into practice by the direct intervention of State, Municipal bodies, environmentalist, city planners and residential Welfare Association etc.

Urbanization directly impacts the forest ecosystem and indirectly affects the hydrology, altering nutrient cycle and introducing non-native species and changing the atmospheric conditions. The human activities affect the landscape of the area by reducing the forest cover and area under agricultural practices. Urban agglomerate around the metro and small cities fragment the agriculture as well as the forest patches around such development. The Fragmentation, one of the most significant negative effects of human activities on biodiversity of the area is getting accelerated in almost all the developing countries particularly in Asia Pacific and Africa. The urbanization not only account for the loss of green cover, it adds to the loss of bird species, animals and green cover, it adds to the loss of bird species and animals beside altering the water flow in the interface, increasing in impervious surface , decrease in infiltration, increase in surface runoff. It also alters the flooding regimes. It is estimated that in the low density residential area, (< 1 house per acre) roads may account for more than 60 percent of the impervious surface and exert a greater effect on the aquatic systems than rooftops. The urbanization alters the composition of plants and animals species in both the terrestrial and aquatic systems. It is observed that while the richness of plant species increase from rural to urban landscapes, the richness of amphibian,reptiles, mammals and bird decreases.

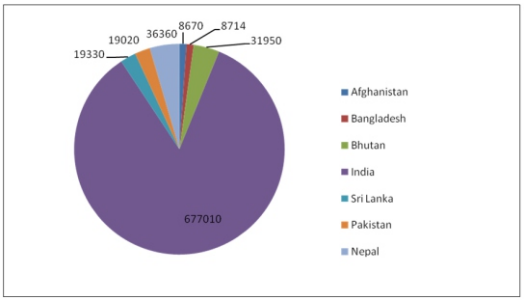
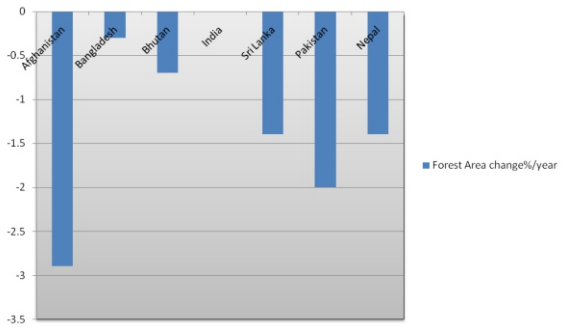


Figure 3: Forest Extent (km2) AndIts Yearly Rate Of Change In SAR

(Source: FAO Global Forest Resource Assessment)



4.2 Urbanization and forestry

Urbanization is a logical and well anticipated consequence along the development of thecities. The role of urban forest in ameliorating urban habitats and improving quality of life is significant. The cities occupy less than 3% of the global terrestrial surface but accounts for 78% of the carbon emissions. In 1900 just 10% of the global population was living in urbanareas which now exceeds 50% and is expected to rise to 67% in next 50 years.

Table 11: Forest cover and area per city dweller for some districts of India (2011)

(Source:Urbanization and Greening of Indian Cities-Effortsfor Green Delhi, R K. Sinha, Director, MOEFCC, GOI.)

State	District	Geographical Area	Total Cover	% of Geographical Area	Population	Forest areas per city dwellers
NCT of Delhi	Central Delhi	25	5.05	20.20	578671	34.91
NCT of Delhi	EastDelhi	64	2.99	4.67	1707725	2.73
NCT of Delhi	North-East Delhi	60	4.0	6.83	2240749	3.05
NCTof Delhi	North-West Delhi	440	16.49	3.75	3651261	4.52
NCT ofDelhi	New Delhi	35	16.31	46.60	133713	121.98
NCT ofDelhi	NorthDelhi	59	4.81	8.15	883418	5.44
NCT ofDelhi	SouthDelhi	250	78.32	31.33	2292363+ 2733752*	15.58
NCT ofDelhi	WestDelhi	129	6.33	4.91	2531583	2.50
Gujarat	Ahmedabad	87.07	1.44	1.65	7208200	0.20
Gujarat	Gandhinagar	649	42	6.47	1387478	30.27
Karnataka	Bangalore Rural	5815	812	13.96	Combined Withurban	2.17
Karnataka	Bangalore Urban	2190	150	6.85	9588910	
Maharashtra	MumbaiCity	157	2	1.27	3145966	0.635
Maharashtra	Mumbai Suburban	446	120	26.91	9332481	12.86
Rajasthan	Jaipur	14069	631	4.49	6663971	94.688
TamilNadu	Chennai	144	9	6.25	4681087	1.92
WestBengal	Kolkata	185	0	0	4486679	32.540

From the above Table 10, it is clear that in course of urbanization, greening is likely to be most affected unless well planned approach towards it, is taken in advance. It may be noted how diverse is greening in Indian cities, and how percentage wise it differs even in the same cities such as in NCT of Delhi.Many of the cities either require immediate action for its greening and legal provision in place to protect the green cover and prevent its diversion.

Urban Forestry is an important contributory factor in the cities for environmental enhancement, control of air and noise pollution, micro climatic modification and recreational purpose of the urban population.Before the city expands further a proper plan for greening in the city especially with respect to land availability in the form of parks and gardens, forest patches and road side plantation should be in place. In addition to avoid illegal diversion of green cover of the city for taking up developmental works or otherwise a legal framework should be in place. And therefore plan for urban forestry should be integrated into overall planning of the urban areas in advance otherwise greening of the urbanized area becomes more difficult once these settlements takes place specially in identifying the land for the same and in greening the same.

The higher-income countries however have reversed their earlier forest losses and have moved forwards forest expansion. Only 3% of the forest land is covered with productive forest plantations. This area however had grown rapidly by 2 million ha annually in the 1990s and by 2.8 million ha through this decade. The plantations have taken place largely in the tropics and subtropics, e.g., Brazil and Indonesia, but also in high productivity temperate regions, e.g., Chile and China. (Kirilenko AP et.al, 2007).

4.3 Climatic impacts on forest ecosystems around urbanising landscape

Climate change is expected to have impact on the temporal and spatial dynamics of (potential) pest species, influencing the frequency and consequences of outbreaks as well as their spatial patterns, size and geographical range. The changes in climatic variability may be as important or even have larger effects for both trees and forest organisms as changes in the average climate. For many species, it is expected that performance and survivorship will not be affected by slight, progressive changes in climatic conditions, but by the likelihood or nature of catastrophic events. A clearer understanding of how climatic extremes affect insect populations in the long term is demanded as to what are the basic relationships between extreme climatic events and development rate, population growth.

According to FAO report 2010, the current role of forest in mitigating the impact of climate change and their potential in future mitigation are both dependent on the impact of ongoing and environmental change in forest ecosystem ,Fires, Insects, Pathogens, and Extreme Events. For forestry, the climate change-induced modifications of frequency and intensity of forest wildfires, outbreaks of insects and pathogens, and extreme events such as high winds, may be more important than the direct impact of higher temperatures and elevated CO2 (UNEP).The vulnerability of mangrove ecosystems is particularly relevant to the Asia-Pacific region, which is home to a larger area of this unique forest type than either Africa or Latin America. The protection that mangroves provides to coastal communities in the face of storms and other extreme events underlines their value in reducing the vulnerability of coastal communities in Asia and the Pacific to climate change. However, because mangroves are often viewed as being of low economic value, there is considerable pressure to clear mangroves for other uses.

Shrimp aquaculture accounts for the loss of 20 to 50 percent of mangroves worldwide . Indonesia, which has the world's largest intact mangroves, is projected to lose 90 percent of mangrove areas on the islands of Java and Sumatra by 2025.

REDD (reducing emissions from deforestation and forest degradation) is widely acknowledged by Asia-Pacific governments as a significant element of climate change mitigation strategies, which also has the potential to generate income, modernize the forestry sector and contribute to national climate change adaptation strategies.

Thus, Climatic changes are expected to bring many complex effects on the forests. Rising atmospheric CO2concentration, higher temperatures, changes in precipitation, flooding, drought duration and frequency will have significant effects on trees growth. These climatic changes will also have associated consequences for biotic (frequency and consequences of pests and diseases outbreaks) and abiotic disturbances (changes in fire occurrence, changes in the frequency and intensity of wind storm) with strong implications for forests ecosystems. Forest fires are severally under reported at the global lines. The outbreak of forest insect pests damage some 35 million hectors of forest annually, primarily in the temperate and boreal zone. There has been significant improvement in the management of forest and great emphasis has been laid on the virtues of social forestry. A significant change noticed over a period of time, that the forestry is no more viewed as a means of resources for the state, rather the expenditure on forestry has far outpaced with the revenue collection.

5 Impacts on the socio-economically vulnerable urban groups

Vulnerabilities in most of the urban areas, impinge the low-income groups, including migrants, who face large climate change risks because of poor-quality, insecure, and clustered housing, inadequate infrastructure, and lack of provision for health care, emergency services, flood exposure, and lack of measures for disaster risk reduction**(IPCC 2014).**It is observed in the increased food prices and food insecurityduring emergency arising out of extreme events.The Urban-marginalised population by and large remain unprotected due to substandard housing and inadequate insurance. The marginalised rural population with multidimensional poverty and limited alternative livelihoods, on migration get insufficient local governmental attention to disaster risk reduction.

Migration from rural to urban area has become a new trigger to the generation of new urban risk. Displacement risk increases when populations with low income lacking the resources for planned migration experience higher exposure to extreme weather events, in developing countries particularly in SAR.Expanding opportunities for mobility can reduce vulnerability for such populations. Changes in migration patterns can be responses to both extreme weather events and longer-term climate variability and change, and migration can also be an effective adaptation strategy.

Food insecurity is closely tied to poverty; globally about 25 to 30% of poor people, measured using a US$1 to US$2 per day standard, live in urban areas **(Ravallion et al., 2007; IFAD, 2010).**It is found that in Latin America, poverty is more skewed to urban areas, with roughly two-thirds of the poor in urban areas. It is observed to be growing in the past decade. The same is the scenario in South Asian Nations. The recent experience of global climate patterns affecting food security indicates the potential nature and magnitude of increased variability. An impact assessment of the 2010 Pakistan floods surveyed 1800 households 6 months after the floods and found that 88% of the households reported income losses of up to 50%, with significantly higher rates in rural than urban areas **(Kirsch et al., 2012).**

6 Food Security in South Asian Region- A new challange

Food security is a complex issue and its definition has evolved over time. The question of food security has a number of dimensions that go beyond production, availability and demand for food. South Asian Countries have seen high annual economic growth rate, but relatively low growth rates in agriculture during the period 1993-2006 (Figure 5). These countries also witnessed an increase, high level of growth in food consumption, primarily due to high population growth. However, despite the high growth rate in food consumption, the region has the highest concentration of the poor and under nourished (299 million in 2003-WDR 2008) and accounts for 40 % of the world's hungry. An annual 1.7% reduction in the absolute numbers of the under- nourished something that remains a major cause of concern.

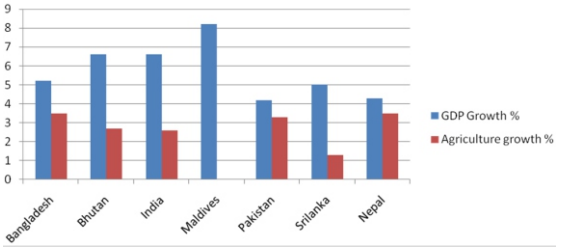


Figure5: Average Annual Rate of Growth in agriculture in major cities of SAR, 1993-2006.

The Agriculture Development Report 2008 ranked South Asia as the second most under nourished malnourished and food insecure region in the world. The FAO estimate indicate that by 2010, Asia will still account for about one – half of the world's malnourished population, of which two-third will be from South-Asia. The food security indicators for South Asia are presented in table below. These show the poor stats of food security in the region.

Table 12: Food insecurity Indicator of South Asia(ADR, 2008)

Indicators	Bangladesh	India	Maldives	Nepal	Pakistan	SriLanka
	2002-04	**2002-04**	**2002-04**	**2002-04**	**2002-04**	**2002-04**
Population(million)	146.7	1065.4	0.32	25.2	153.6	**19.1**
Food Supply (kcal/person/day)	2200	2470	2600	2430	2320	**2390**
Number of undernourished (million)	44	209.5	31.9	4.4	37.5	**4.2**
Proportion of undernourishment (%)	30	20	10	17	24	**22**
Dietary energy consumption (kcal/person/day)	2200	2440	2560	2450	2340	**2390**
	2000	**2000**		**1996**	**1999**	**1996**
National (Poverty headcount, (%) of population))	49.8	28.6	-	42	32.6	**25**
Rural (Poverty headcount, (% of population)	53	30.2	-	44	35.9	**27**
Urban (Poverty head count, (%) of population))	36.6	24.7	-	23	24.2	**15**
	2000	**1999-00**		**1995-96**	**1998-99**	**1995**
Gini of income (%)	32	33	-	37	33	**34**

	1981-82	1990	1995	1995	1988	1986
Gini of dietary energy consumption (%)	18	18	14*	15*	18	16

7. A SUGGESTIVE URBAN RISK RESILIENT MODEL FOR SOUTH ASIA REGION (SAR)

To develop a strategic model for urban risk management is a challenge for town planners and disaster managers because of several intricate issues involved into it. In this study, we attempted to addressed those issues by providing a corrective steps and measures into the existing set up for evolving an urban risk resilient model for SAR.

7.1. Urban Disaster Management Response Cycle

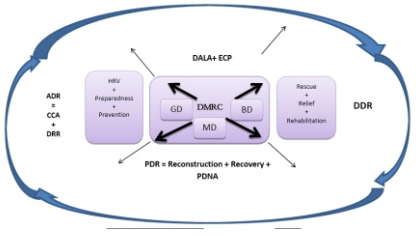
In this study, we realized that conventional Disaster Management cycle having ingredient of preparedness, prevention, and response does not work effectively in managing the disaster risks, it is therefore we suggested a novel Disaster Management Response Cycle (DMRC) as shown in Figure 6 that can be adopted instead of conventional disaster Management Cycle, which hitherto have 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 phase, the response during the event of disaster gets overwhelming attention of the State in order to reach the succor to the affected community including the live stocks. The effort of pre disaster event to mitigate the disaster including the effort to make the community prepared to cope with such events and the measures taken post disaster event to make the community back to normalcy and to get them engaged into their daily chores and economic activity must all be viewed as "Response". Response to the eventually 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.

(a) Anti Disaster Response: 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.

(b) During Disaster Response: The response made by the State during the event of disaster may be termed similarly as "During Disaster Response (DDR)".

(c) Post Disaster Response: 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).



DMRC: Disaster Management Response Cycle
ADR: Anti Disaster Response; DDR: During Disaster Response; PDR: Post Disaster Response
HD: Hydrological Disaster; GD: Geological Disaster; MD: Meteorological Disaster; BD: Biological Disaster
DALA: Damage and Loss Assessment; PDNA: Post Disaster Need Assessment; ECP: Emergency Contingent Plan; HRV: Hazard, Risk and Vulnerability

Figure 6: A diagram showing the newly proposed Disaster Management Response Cycle (DMRC)

ADR: Anti Disaster Response; DDR: During Disaster Response; PDR: Post Disaster Response; CCA: Climate Change Adaptation; DRR: Disaster Risk Reduction; GD: Geological Disasters; BD: Biological Disasters; MD: Meteorological Disaster; HD: Hydrological Disaster; DALA: Damage and Loss Assessment; PDNA: Post Disaster Need Assessment; ECP: Emergency Contingent Plan; HRV: Hazard, Risk and Vulnerability.

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. 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.

7.1.1. Constituents of Pre disaster Response (ADR)

(a) 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. Therefore, mitigation 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 (DMC- NIDM, f). This phase of DM however gains importance in the scenario where the vulnerability to the community and potential hazards are emanating due to the haphazard urbanisation which does not subscribe to the even management cycle of the Mother-Nature which over the years had been giving sustenance to that particular geographical region. Hence, thus ADR gains currency to address the issue, as the activity no other than an Anti Disaster Response in order to save the community lest it should fall prey to the inherent potential hazards.

(b) Preparedness: The process embraces measure 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 (DMC-NIDM, g) and its requires following actives to be attended to make preparator effective. It should include the development and sifting up of the early Warningsystem.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.

(c) Adaptation: A measure requiring the foremost attention to make the society a resilience one. IPCC in its report has suggested climate associated risk and adaptation issues as given in following figure.

Table 13: Climate Associated Risk of South Asia and adaptation strategies (IPCC-20)

Key Risk	Adaptation Issues and prospects
Increased riverine, coastal and urban flooding leading to widespread damage to infrastructure, livelihood and settlement in South Asia	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	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	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)

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 discussed extensively in the chapter, on DRR and Climate Change respectively and found to be overlapping. The Mitigation therefore is considered essential work for managing the climate risk for effective adaptation. United Nations International Strategy for Disaster Risk Reduction (UNISDR) in its recent report suggested several pertinent measures for development of the strategic approach for disaster risk resileinet urban agglomerate under climate change (UNISDR, 2014). In this study, however, we suggested a comprehensively modified model that can involve institutions of political, social, environmental, and economic of the SAR as shown in Figure 7.

In our proposed model of RRSUA expressed as the urban resilience wheel, we attempted to consider requisite feedbacks available from the community-based, individual-based as well as from 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 programs; education and advocacy facilities; infra-structural support system; space technology for localized event detection & Emergency Management Sciences; Disaster Mitigation plans for Effective Response at all levels; Health & Hygiene Facilities; and at the last but not least strong institutional supports for implementation, can help in evolving sustainable urban risk management model for SAR. Successful implementation of urban resilience wheel may provide a guarantee for better urban risk resilient agglomerate for South Asian cities under climate change scenario.

7.1.2 Strategic Approach for Disaster Risk Resilient Urban Agglomerate

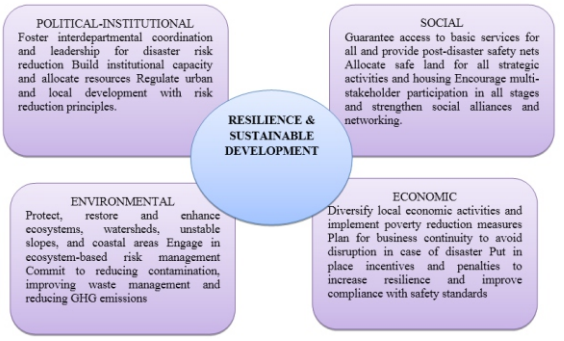


Figure 7: A proposed sustainable and risk resilient urban development mechanism based on the environmental, economic, social and political spheres for SAR (modified from UNISDR-2012)

7.2. Risk Resilient Setup for Urban Agglomerate (RRUA)

Under climate change scenario, there is a great challenge to develop a comprehensive risk resilient urban agglomerate (RRUA) model what we proposed in this study as shown in **Figure 8.**

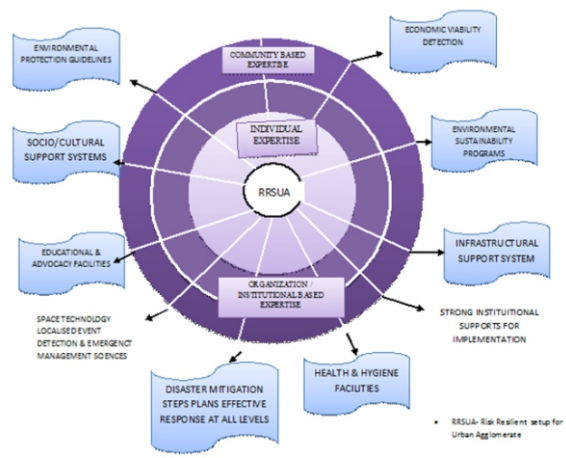


Figure 8: A diagram showing the recommended urban resilience wheel under climate change scenario.

8. Conclusions

This study infers that South Asia is more vulnerable to climate change induced disaster events because of its association with complex Himalayan tectonics, global warming, continuous Sea-level rise, and rapid glacial melts in the South Asia Region (SAR). Rapid population growth with low-level of income and high degree of poverty of the region further reinforce the degree of exposure to the climate change induced disasters because of lack of suitable climate change adaptation plans for the first responders in SAR. The trend of Urbanization as a result of change in the GDP structure and migration of the rural population to the urban area in search of better livelihood is going to stay in the countries of South Asia region. The growth of new urban areas and addition with expansion of the existing cities, however, is under stress due to supply of urban amenities and socio-economic urban infrastructure that are not

getting match with the rising demand. The urban setups may already be under the stress of existing risk and vulnerabilities due to their geo-physical surroundings and, therefore, urban belts of SAR become more prone to the events arising out of the natural hazards. These setups are now getting further exposed to the manmade activities and the global climate change. The urbanization itself is emerging as one of the reason for climate change. While on the other hand, the citizens living in the cities are getting affected with the impacts of emerging risks and vulnerabilities arising out of the climate change. We made an attempt to understand the conditions of urban setups in the South Asia region under the influence of the risks and vulnerabilities emerging out of the climate change.

Irrespective of the climate change, the city populace get exposed to the inland flooding, coastal flooding, heat and cold, water shortage due to drought, air pollution, mud slides, landslides, wind storm, cyclones etc. With the global warming, the propensity of the event arising out of these hazards is getting changed with the change in the time interval and becoming extreme and intensive in nature. Therefore, it is important for planner to understand the trend of the new urban settlement coming up in different geographical locations, for giving them different treatment to mitigate the ill-effect of climate change on the citizen of these places during planning itself.

The population contributing the share in different GDP sectors is undergoing change. The migration towards urban areas from rural areas is result of this, as, the percentage of population living in the primary sector of the economy having outgrown the sustenance level, will be pushed to other sectors such as, services or manufacturing for better livelihood. This is the paramount reason for migration of people to urban areas. The cities acting as a magnet to such populace needs to create the urban infrastructure keeping the climatic change in mind to absorb such people and sustain them, failing which the migration itself will become one of the cause for climate change as the aberration of such settlement in the form of growth of slums, creation of waste, pressure on urban transport, non-availability of potable water, shortage of housing, non-availability of the land for settlement will accentuate the causes of climate change. Keeping this in view the authors have made an attempt to understand the challenges faced by the urban settlements in the coastal areas, different river basin, forest area etc.

The haphazard growth of urban settlements have impacts on the socio-economic lives and have impact on the vulnerability profile of such people, which comes in the form of food in-security, lack of health amenities, un-employment, etc. The urban planner therefore, needs to account for the new demand coming up due to migration of people from rural to urban area, the factors accentuating the hazard profile inherent in the geo-physical nature of the location, the demand for urban amenities such as availability of water, health measure, housing, educational institutions, green space, public transport etc. The urban local bodies would also require to be empowered for governance to strengthen the system of urban risk resilient system financially capable to meet such demands in order to make the urban living sustainable.

Based on the available constraints for developing a risk resilient urban system for SAR, in this study, 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.

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