

# URBAN CLIMATE CHANGE RESILIENCE

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## Training Modules for Urban Local Bodies

August, 2015





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# MODULE 1

## DEFINITIONS

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# DEFINITIONS

## Green House Gases and Effect

The trapping of the sun's warmth in a planet's lower atmosphere is called the **Greenhouse effect**.

- About 30% of the radiation striking Earth's atmosphere is immediately reflected back out to space by clouds, ice, snow, sand and other reflective surfaces.
- The remaining 70% of incoming solar radiation is absorbed by the oceans, the land and the atmosphere.
- As they heat up, the oceans, land and atmosphere release heat in the form of IR thermal radiation, which passes out of the atmosphere and into space.
- It's this equilibrium of incoming and outgoing radiation that makes the Earth habitable, with an average temperature of about 15°C.
- Greenhouse effect could be natural or man-made (Figure 1).

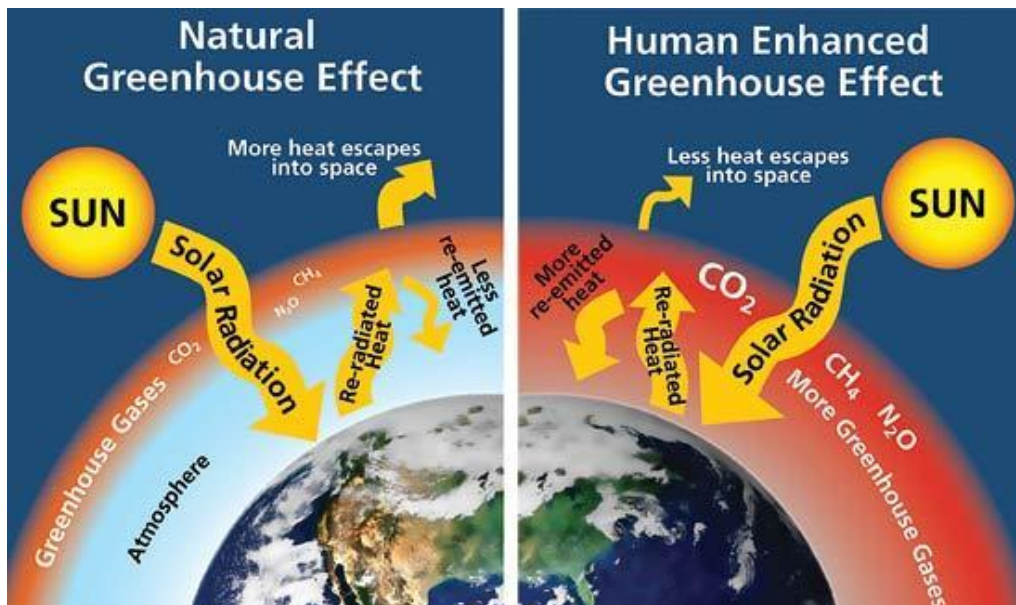
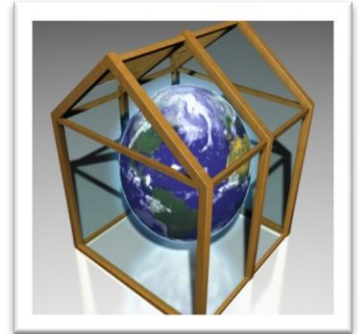
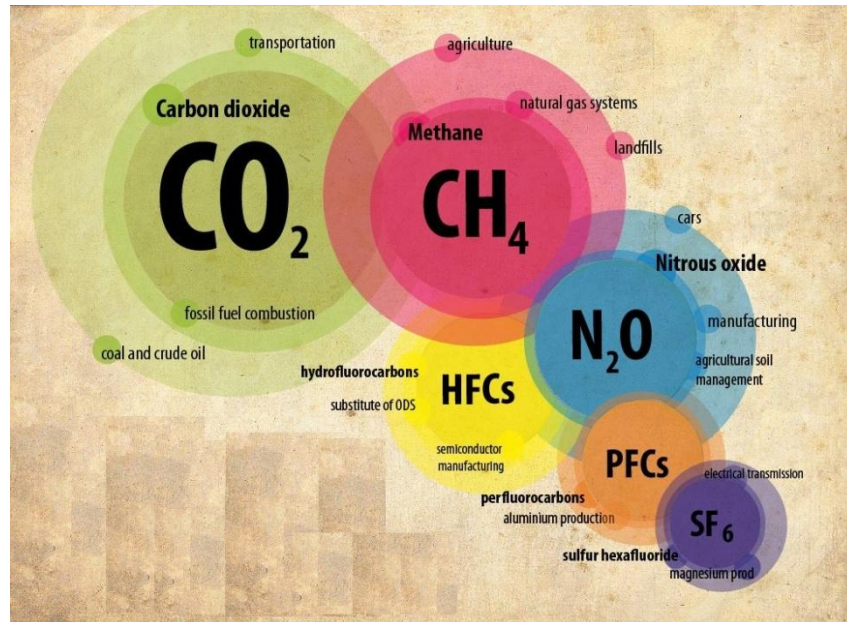


Figure 1: Natural and human enhanced greenhouse effect

The gases that cause green house effect are called **Green House Gases (GHG)**.

- Water vapour, CO<sub>2</sub>, methane, and nitrous oxide (N<sub>2</sub>O) are some of the GHGs.



**Figure 2: Different GHGs and their contributors**

GHGs absorb radiation and gradually heat the Earth's atmosphere and surface. This phenomenon is called **Global Warming**.

## Weather

It is state of the atmosphere with respect to wind, temperature, cloudiness, moisture, pressure, etc. Weather is the condition of the climate in a particular place at a particular time.



## Season

A season is a division of the year, marked by changes in weather, ecology and hours of daylight.

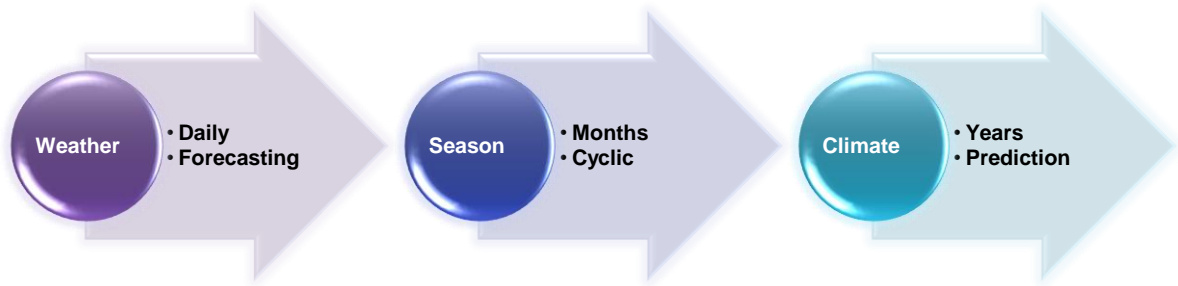
- Seasons result from the yearly orbit of the Earth around the Sun and the tilt of the Earth's rotational axis relative to the plane of the orbit.

## Climate

Climate refers to the weather conditions prevailing in an area in general or over a long period.

- Climate is the average weather in a place over many years.

- While the weather can change in just a few hours (short-term), climate takes hundreds, thousands, even millions of years to change (long-term).



## Climate Variability

Climate variability refers to the climatic parameter of a region varying from its long-term mean. Every year in a specific time period, the climate of a location is different. Some years have below average rainfall, some have average or above average rainfall.

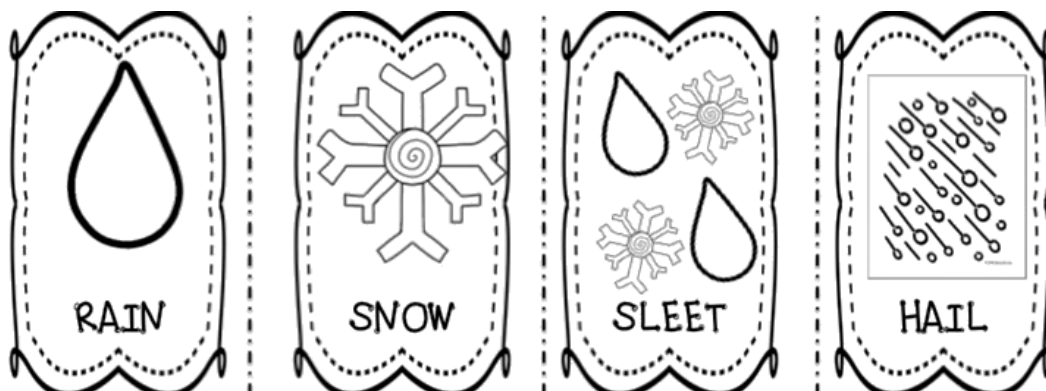
## Climate Change

Identifiable change in the climate of Earth as a whole that lasts for an extended period of time (decades or longer), it may be due to

- natural processes (usually referred to as global climate variability)
- human activities that change the atmosphere

## Precipitation

Any form of water, such as rain, snow, sleet, or hail that falls to the earth's surface.



## Vulnerability

Characteristics of a person or system that influences their capacity to cope, resist and recover from the impact of a natural or anthropogenic (manmade) hazard.

## Exposure

Exposure is what is at risk from climate change, e.g., population, resources, property along with the change in climate system e.g., change in Sea level, temperature, precipitation and extreme events.

## Risk

It is the probability of harmful consequences, or expected losses (deaths, injuries, disruption to livelihoods and economic activity, and damage to property or the environment) resulting from interactions between natural or human-induced hazards and vulnerable conditions.

## Hazard

A dangerous phenomenon, substance, human activity or *condition* that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage

## Disaster

It is a serious disruption which exceeds the ability of the affected community or society to cope using its own resources.

## Climate Mitigation

It is measures taken to limit the rate and extent to which human activity alters the global climate.



## Adaptation

It is adjustments (ecological, social or economic) or actions taken to limit the negative impact of climate change on human systems.

## Resilience

It is the ability of a system to bounce back or recover from effects of a disaster in a timely and effective manner.



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*\*NOTE: This module only gives a short definition of the terms that have been elaborately discussed in the next modules.*

# MODULE 2

## URBANIZATION & CLIMATE CHANGE

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IMPACTS, RISKS, & VULNERABILITIES



# URBANIZATION & CLIMATE CHANGE

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## IMPACTS, RISKS, AND VULNERABILITIES

### Learning Objectives

- To understand the bidirectional relationship of urbanisation and climate change
- To develop an understanding of direct and indirect impacts of climate change in urban areas and hence, different urban sectors
- To know and comprehend the risks of climate change in urban areas and their mapping

### Urbanization

#### Urban Age

- 54% of world's total population currently resides in urban areas (WHO, 2014)
- India's urban population is 377 million (Census of India, 2011) which is 31% of Indian population and is more than the total population of US.



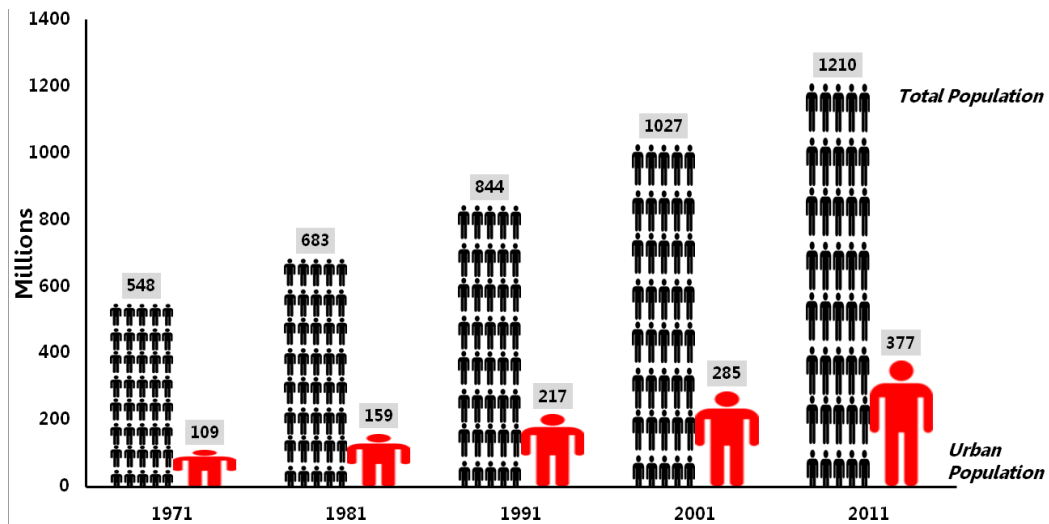


Figure 3: India - Total and urban population

## Process of Urbanization

- Urbanization is described as increase in proportion of people living in urban areas (town and/cities) in comparison to those living in rural areas.

Various **push** and **pull** factors drive urbanization (Figure 4).

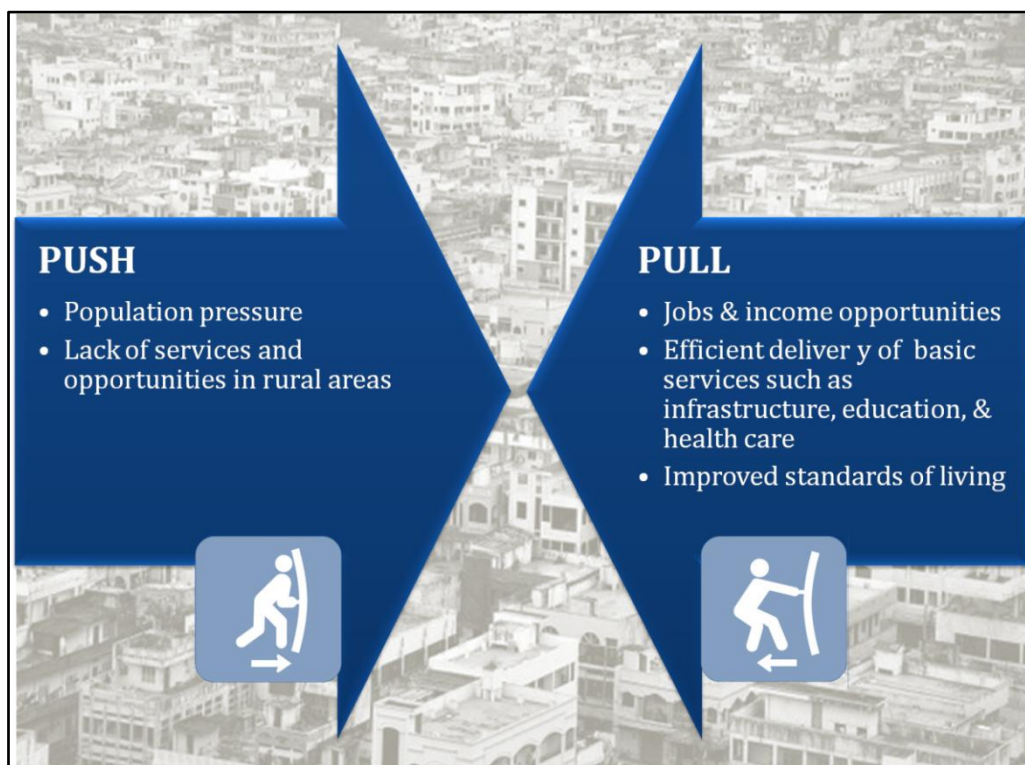


Figure 4: Push and pull factors driving urbanization



## HOW DO YOU DEFINE URBAN?

### As per the Census of India

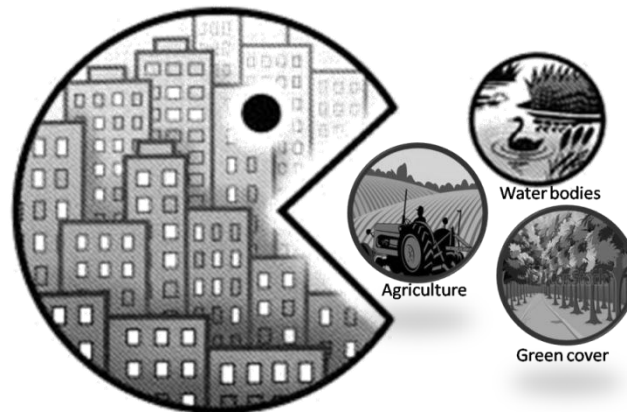
- All places with a municipality, corporation, cantonment board or notified town area committee, etc.
- All other places which satisfied the following criteria:
  - A minimum population of 5,000;
  - At least 75 per cent of the male main working population engaged in non-agricultural pursuits; and
  - A density of population of at least 400 persons per sq. km.



## Urbanization and Climate Change

### Urbanization as Climate Change Driver

- Urbanization requires land for housing and other uses (transport, industry, etc).
- The rising demand for land compels conversion of rural lands to urban.



- Green House Gas (GHG) emissions result in climate change. Sources of GHG in urban areas are:
  - Energy
  - Industries
  - Transport
  - Land use change
  - Waste

This disturbs the ecological balance through destruction of habitats, loss of biodiversity and vegetation

Urban areas affect the climate of the area in various ways:

- Buildings obstructing the wind flow

- Fall in ground water recharge due to construction of various structures, pavements and roads
- Increased runoff
- Increased absorption of heat by buildings
- Increased air pollutants which absorb more heat

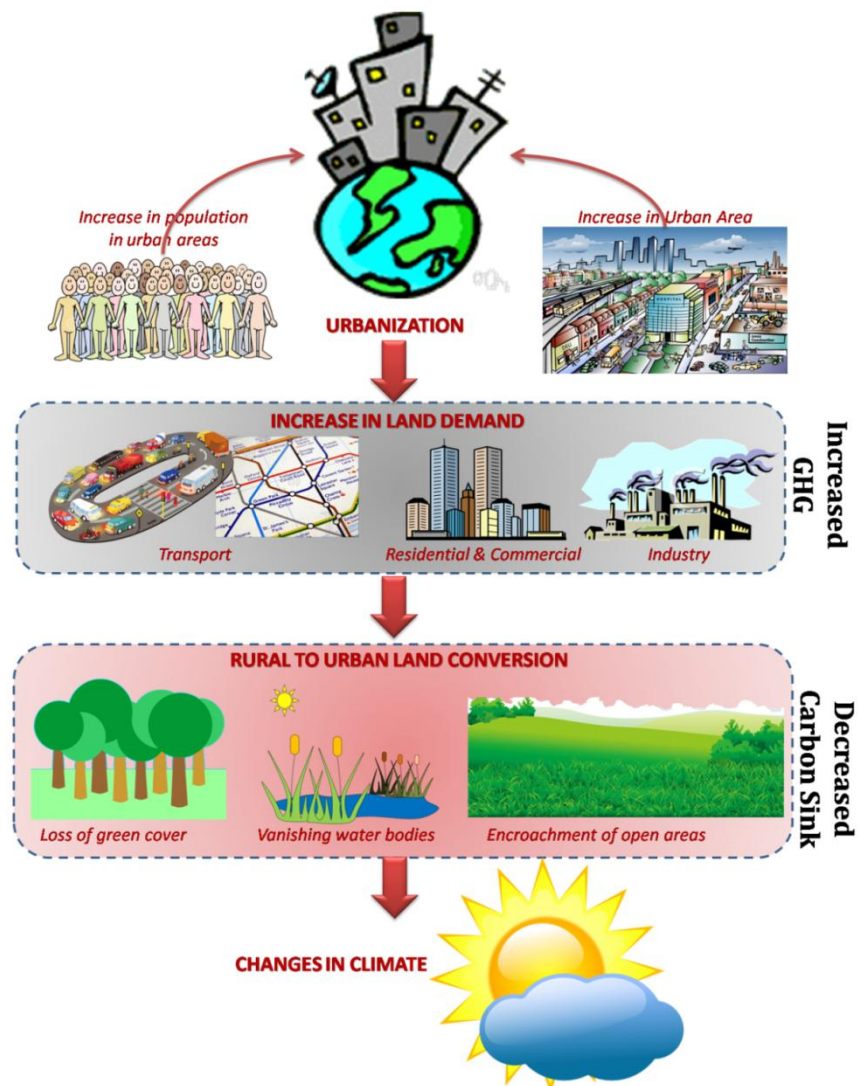





Figure 5: Process of urbanization and climate change

## Climate Change Impacts Urban Areas

- Changes in climate impacts urban areas, highlighting a two-way relationship between urban areas and climate change (Table 1).
- Climate related impacts of urbanization vary in form from local to regional to global scales.



**Table 1: Various climate change drivers and climate change impacts on urban areas**

CLIMATE DRIVERS	Temperature increase	Changes in rainfall/ snowfall pattern	Warming of oceans and sea level rise
IMPACTS			
<i>Direct</i>	Urban Heat Island (UHI)	Flooding	Coastal flooding
	Heat Waves	Droughts & Water scarcity	Increased number and intensity of tropical cyclones
	Droughts		
<i>Indirect</i>	Worsening of smog	Impact on hydroelectricity generation	Increased ground water salinity in coastal areas
	Increased electricity demands	Threat to food security	Threat to marine biodiversity
	Threat to food security		Heavy rains in coastal areas

## Future Climate Predictions

- IPCC makes predictions for future climate scenarios.
- The latest report of IPCC, Assessment Report-5 (AR-5), has predicted;
  - Increase in Earth's average temperature (1.5 °C to 2.0 °C)
  - Modification in the patterns and amounts of rainfall/ snowfall
  - Reduction in ice and snow cover, as well as permafrost
  - Rise in sea level and increase in the acidity of the oceans.

## Predictions for India 2030s (With Respect To 1970s)

### TEMPERATURE

- Net annual temperatures will increase from 1.7 to 2.2°C
- Extreme temperatures to increase by 1 to 4°C, especially in coastal regions



### PRECIPITATION

- Mean precipitation during monsoon will increase
- Maximum increase in precipitation will be in Himalayan region, and north-east will experience the minimum increase
- An increase in extreme rainfall events in some parts of the country, with weaker rainfall events over central India.



### SEA LEVEL RISE AND OCEAN WARMING

- Mean sea level rise is slightly less than 1 mm/yr along the Indian coast.



### EXTREME WEATHER EVENTS

- Cyclone frequency will decrease and intensity will increase
- Eastern coast will be more vulnerable to extreme weather events
- Floods, droughts and extreme precipitation (during monsoon) will increase, with a decline in seasonal rainfall



## Specific Examples

- Mahanadi river basin in India will see an increased possibility of floods in September while an increased possibility of water scarcity in April.
- Delhi is one of the world's five most populated cities that are located in areas with high risk of floods.

(Source: Down To Earth, 2014)

## Impacts of Climate Change On Cities

This section highlights the major climate change drivers and the impacts of climate change on cities. We here discuss the scale of impacts, the climate phenomenon responsible, their causes and manifestations (Table 2).

## Temperature

- Urban Heat Island (UHI)
  - Cities' air and surface temperatures are higher as compared to surrounding rural areas. This phenomenon is termed as Urban Heat Island (Figure 6).
  - As the climate change is expected to further raise the Earth's average temperature, the problem of UHI will worsen.
  - It will increase the energy demand for cooling (not limited to peak summers). For tropical country like India, summers are usually harsh, this can have serious implications for energy.
  - It can also adversely affect human health and comfort due to rise in heat related morbidity and heat mortality cases.



## Precipitation

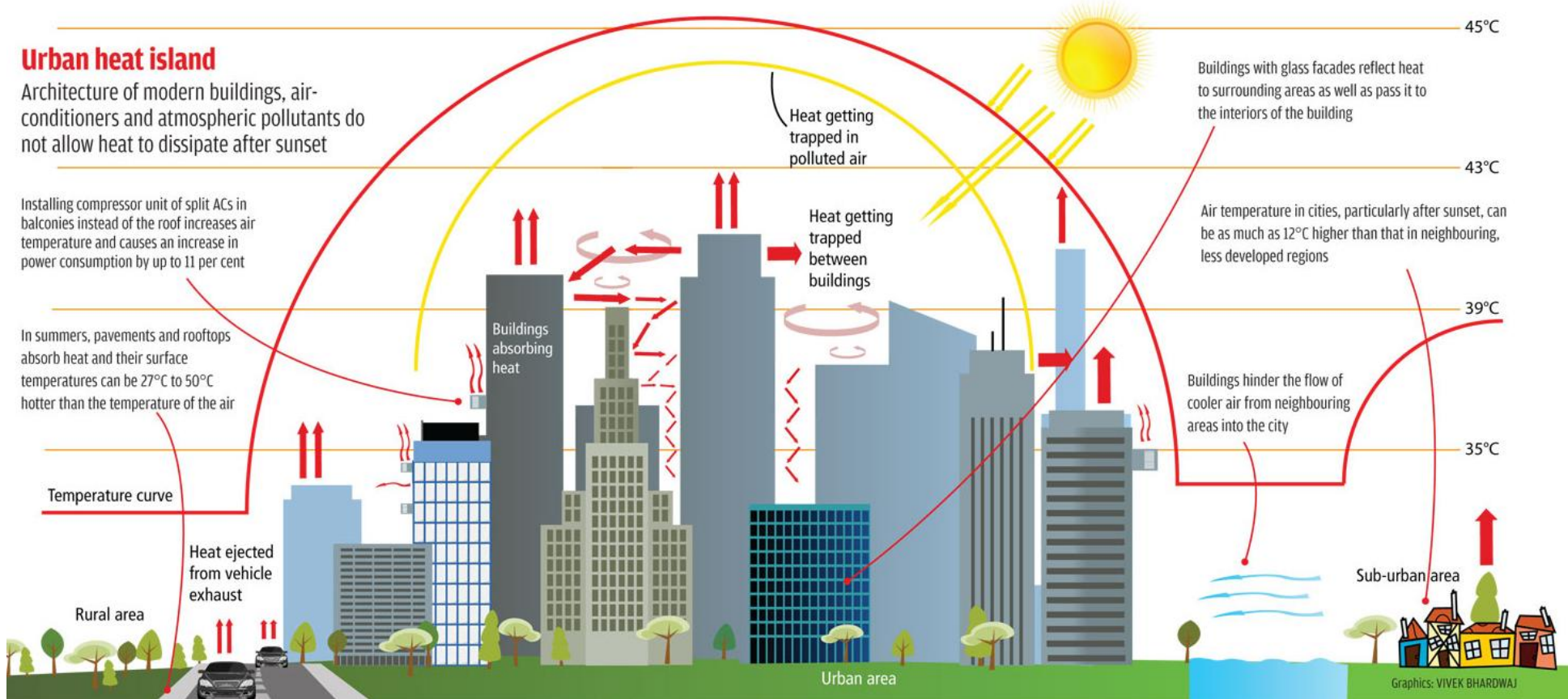
- Inland flooding:
  - Extreme precipitation events (with heavy rainfalls) are expected in future which are likely to increase the risk of urban flooding in Indian cities.
  - Sewerage and drainage systems in most Indian cities cannot cope with the amount of water during rains which often results in water logging and flooding in some cases.
  - The impervious nature of urban structures, often aggravate the flooding by increasing the runoff.
  - As cities are crowded with people, this increases the vulnerability to damage due to flooding especially in high exposure areas such as low lying areas, poor quality housing, settlements along the river banks, to mention a few.
  - Thus even moderate storms can create havoc in urban areas.
  - Urban areas also tend to augment the thunderstorm activity by modifying the local air circulation patterns owing to UHI and aerosol effects.
  - Flooding damages the urban utilities such as transport systems (rail and road), electricity network and other critical infrastructure and services such as hospitals and schools.
  - It affects health directly and indirectly. Direct health impacts could be through injuries, while indirect health impacts could be due to infections from contaminated water and food; and vector-borne diseases (such as dengue, encephalitis, malaria, chikungunya).



## Extreme Events

- In the US, extreme heat events take more lives annually than hurricanes, lightning, tornadoes, floods, and earthquakes combined. Such events are also often associated with droughts (climatecommunication.org, 2015).
- High temperatures result in 'bad air days' posing threat to human health such as; irritation in eyes, respiratory diseases like asthma, and skin diseases.
  - Increasing temperatures are known to increase the ozone smog formation.
- Droughts
  - Pose direct threat to water supplies of the cities, and indirectly affects the hydroelectric power generation.
  - Droughts also put pressure on the food production that ultimately threatens food security resulting in inflation in food and commodity prices.





**Figure 6: Urban Heat Island**

(<http://www.downtoearth.org.in/dte/userfiles/images/20140731-47-1.jpg>)

## Sea Level Rise and Ocean Warming





- Sea level rise and storm surge
  - With changing climate, the ice sheets and glaciers (on land) are melting adding more water to oceans.
  - Increasing temperatures are warming the oceans and increase the volume of ocean/sea waters.
  - Both factors jointly contribute in increasing the sea levels.
  - With sea level rising, coastal flooding is expected to be worsened posing great risk to numerous coastal cities in India threatening the lives, properties, infrastructure and livelihood in coastal areas.
- Rising sea levels are expected to increase the ground water salinity and are also found to be pushing salt water further up the streams. This can have major implications for water supplies.






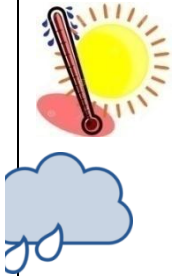


Figure 7: New Moore island submergence due to sea level rise



**Table 2: The major climate change impacts at local, regional and global levels**

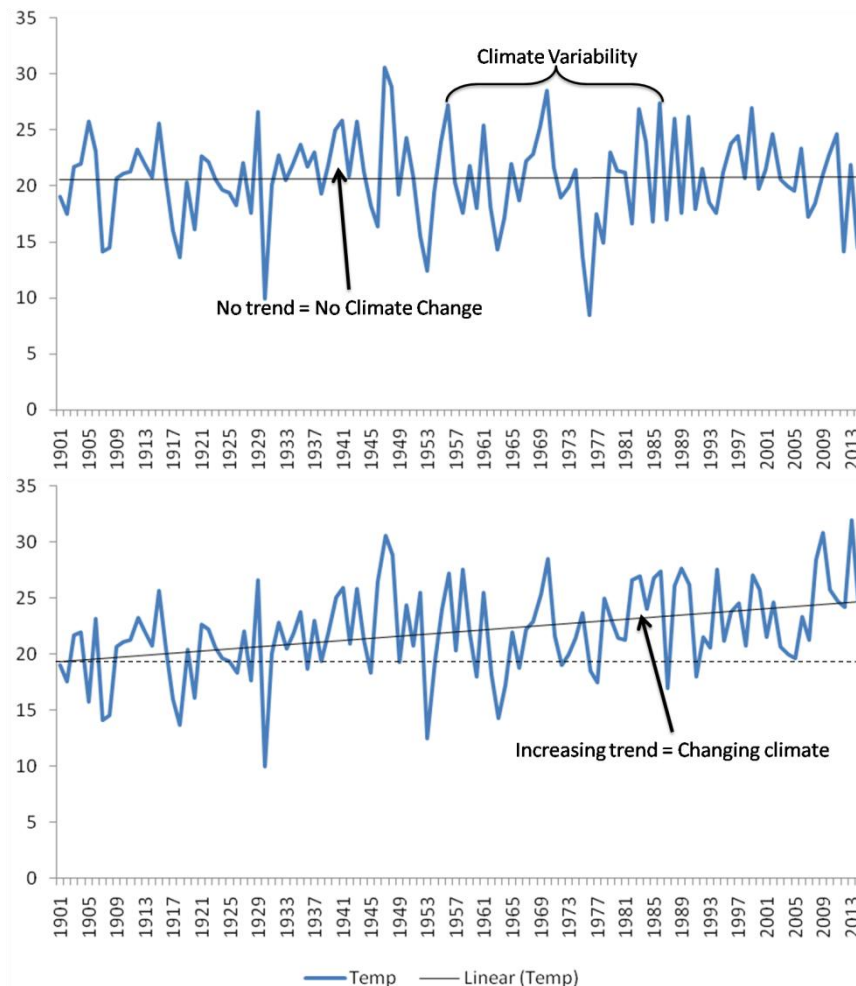
SCALE	PHENOMENON	CLIMATE DRIVERS	CAUSES	POSSIBLE EFFECTS
	<b>Urban Heat Island (UHI)</b>		<p>Urban areas absorb more heat and retain it for longer time due to thermal properties of</p> <p>Materials used for construction</p> <p>Air pollutants and emissions released</p> <p>Tall buildings obstruct wind movement and do not allow heat to escape</p> <p>Decreased vegetation cover and lack of water bodies result in decreased cooling</p>	<p>Increased energy demand</p> <p>Impacts on health (heat stroke, respiratory diseases etc.)</p> <p>Air quality deterioration: Smog formation</p>
	<b>Flooding</b>		<p>Impervious pavements and increased runoff</p> <p>Concrete structures</p> <p>Improper drainage systems</p>	<p>Increased water &amp; vector borne diseases</p> <p>Loss of property &amp; infrastructure</p>

SCALE	PHENOMENON	CLIMATE DRIVERS	CAUSES	POSSIBLE EFFECTS
	<b>Impact on regional climate</b>		<p>Heat release from human activities</p> <p>Changes in surface temperatures</p> <p>Influence on regional rainfall (changes in surface convergence, aerosol effects)</p> <p>Changes in day-night temperature range</p>	<p>Impacts on regional biodiversity</p> <p>Impacts on human health</p> <p>Increase in extreme events e.g. flooding and drought</p>
	<b>High intensity cyclones</b>		<p>Warming of oceans</p> <p>Warm air holding more moisture</p>	<p>Damage to life and property</p> <p>Damage to crops</p>
	<b>Floods and droughts</b>		<p>Increasing temperatures</p> <p>Changing patterns of precipitation and climate systems in general</p>	<p>Loss of human lives</p> <p>Damage to infrastructure and property</p> <p>Damage to crops resulting in price rise and threat to food security</p>

SCALE	PHENOMENON	CLIMATE DRIVERS	CAUSES	POSSIBLE EFFECTS
	<b>Ecological imbalance</b>		<p>Loss of habitats</p> <p>Deforestation: Loss of biomass and carbon stock</p> <p>GHG</p> <p>Warming of oceans</p>	<p>Impacts on biodiversity</p> <p>Increased extreme events</p> <p>Increased global temperatures</p> <p>Increased species extinction</p>
	<b>Warming of oceans</b>		<p>Decrease in forest cover</p> <p>Increased GHG emissions</p> <p>Melting of glaciers</p> <p>Global warming</p>	<p>Sea level rise - Threat to coastal habitats</p> <p>Loss of marine biodiversity</p> <p>Impacts on life cycle of plants</p> <p>Ocean acidification</p>
	<b>Threat to food security</b>		<p>Increased threat to crop; pests attacks, vector borne diseases, invasive species etc.</p> <p>Huge impacts on life cycle of crops (e.g. flowering)</p> <p>Urbanization led land use land cover changes;</p> <p>Direct– urban land use such as housing &amp; industries</p> <p>Indirect– demand for energy crops</p>	<p>Malnutrition</p> <p>Inflation in food and commodity prices</p>

## Climate Change and Variability

- Climate variability is the natural variations (due to internal processes) in yearly climate above or below a long-term average value.



**Figure 8: Climate change and climate variability (using temperature data)**

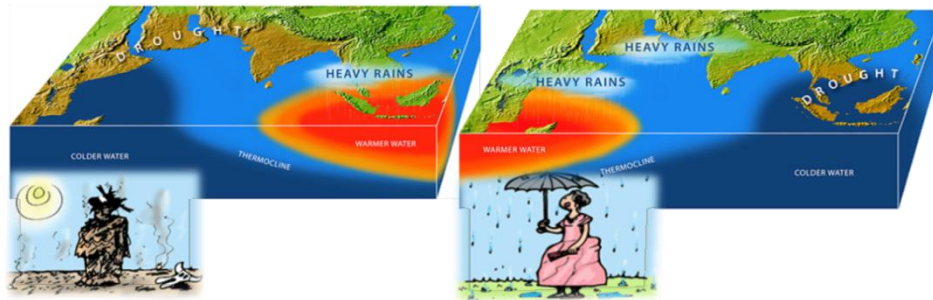
- This is measured on long-term climate data using various statistical parameters, such as average, range, standard deviation or simple trend detection.
- Climate variability may occur due to natural processes such as El Nino, La Nina, volcanic eruptions, sunspots etc. (*La Nina and El Nino can impact weather around the world by changing the movement of winds and high and low pressure systems*)
- Climate Change is a long-term continuous change (increase or decrease) to average weather conditions (e.g. average temperature) or the range of weather (e.g. more frequent and severe extreme storms) due to factors such as human activities.

## El Nino

- Large-scale ocean-atmosphere climate interaction
- Warming of sea in central and east-central equatorial pacific
- Adversly impacts monsoons

## La Nina

- Large-scale ocean-atmosphere climate interaction
- Below average sea temperature in central and east-central equatorial pacific
- Brings rainfall to Asia and Australia



## Risks

- 'Risk' is a situation involving exposure to hazard.
- It is the probability of occurrence of hazardous events and the impacts associated with these events.
- The interaction of vulnerability, exposure, and hazard results in risk.
- Climate change poses risks for humans and natural systems, and also it causes shifts in the patterns of risks, both spatially (geographically) and temporally (over the time)
  - **Srinagar floods** - The city never expects heavy rainfall, but 2014 floods show that the city has now become prone to extreme rainfall (Change in spatial pattern of rain).
  - **Mumbai floods** - in year 2005, the city received very heavy (~ 994 mm) rainfall within a day that severely flooded the city (Shift in temporal pattern of rain).
- Climate change poses risks in cities for lives, property, infrastructure, and ecosystem as well due to:
  - Heat stress
  - extreme rainfall/ snowfall(low and/or high)
  - flooding
  - landslides (hill cities)
  - flash floods
  - water scarcity

- These risks get amplified due to;
  - lack of essential infrastructure and basic facilities
  - development and housing in vulnerable areas (high exposure and low adaptive capacity)
- Providing basic services, improving housing quality and location (low exposure areas) and building resilient structures can reduce the exposure and vulnerability.

## Urban Vulnerability to Climate Change

- 'Vulnerability' is the tendency to be adversely affected and Vulnerability to climate change is a 'measure of possible future harm'.
- Vulnerability largely depends on the sensitivity or susceptibility to harm, and lack of capacity to cope and/ or adapt.
- For each impact of climate change, a group of urban dwellers face higher risks and are often classified as *vulnerable groups*.
- These can be identified based on a number of factors;
  - Age (e.g. infants and elderly are more sensitive to heat hazards)
  - Health status (e.g. asthma patients are more sensitive to bad air days)
  - Site and location (e.g. settlements along river banks are more prone to flooding)
  - Coping capacity (e.g. poorer sections of society lacking coping capacity are at greater risks)
  - Women in some cases may be more vulnerable.

## Exposure and Sensitivity

- Exposure and sensitivity impact vulnerability.
- *Exposure* is defined as 'the *presence* of people, livelihoods, species/ecosystems, infrastructure, and resources etc. *in places and settings that could be adversely affected*.'
- The two main elements to be considered in exposure are;
  - Things that can be affected by climate change (populations, resources, property, etc.), and
  - The change in climate itself (sea level rise, rainfall/ snowfall and temperature changes, etc.).

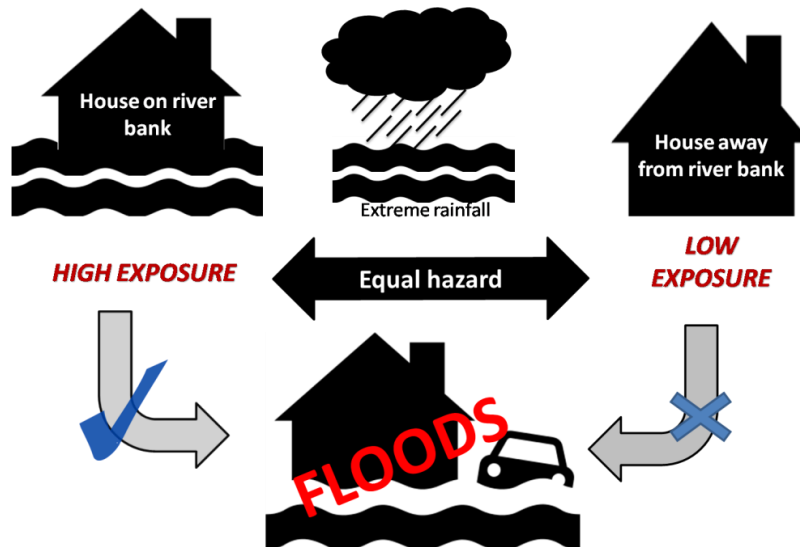


Figure 9: Exposure as component of vulnerability

- More is the exposure, more will be the vulnerability.
- *Sensitivity* is the degree to which a system will be affected.
- Sensitivity can be altered by socio-economic changes. For example, drought resistant crop varieties would be less sensitive to climate change, hence reducing the vulnerability.

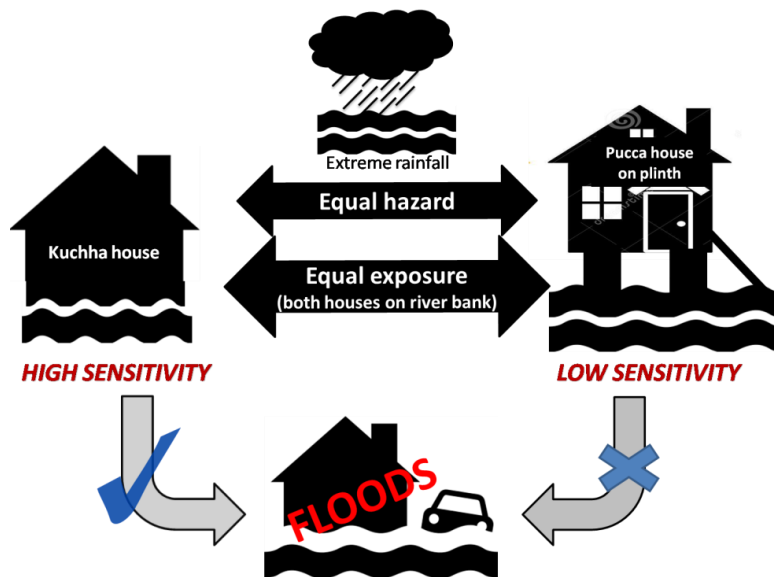


Figure 10: Sensitivity as component of vulnerability

## Levels of Vulnerability

- Climate vulnerability can exist at three levels;
  - Individual/Community level
  - Sectoral level
  - Systems level

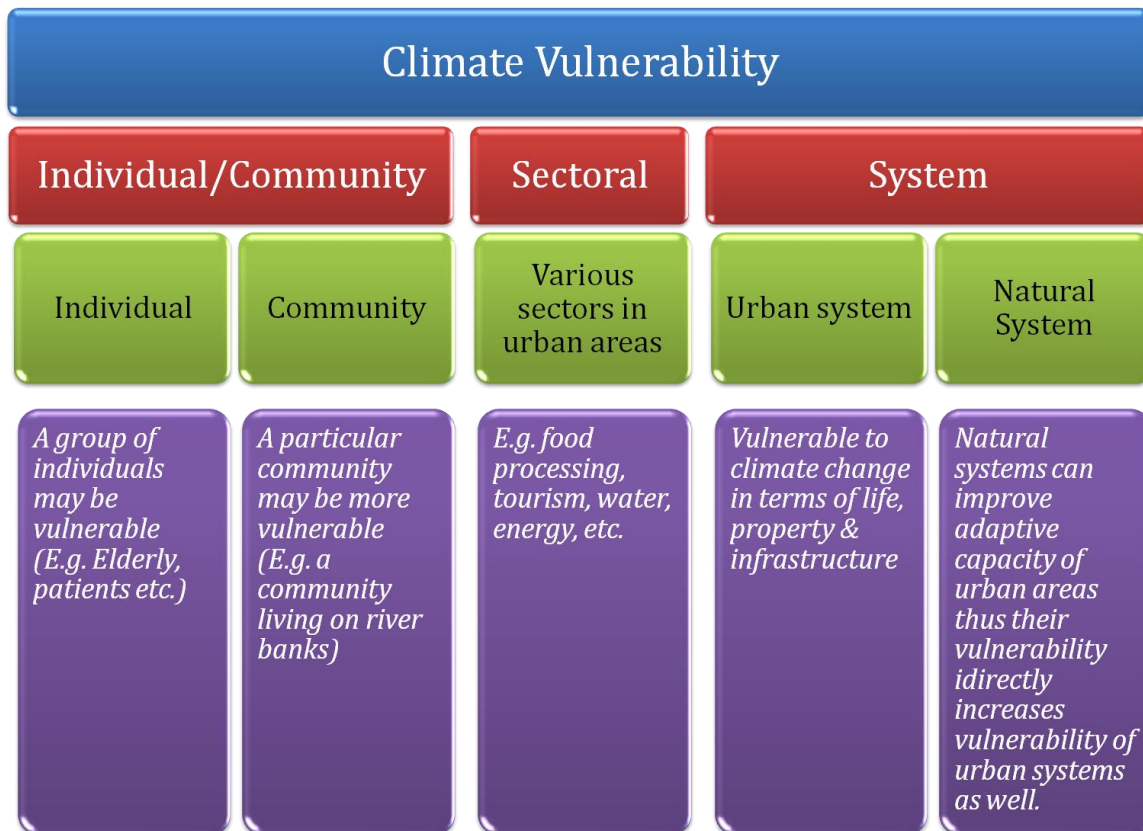


Figure 11: Climate variability at different levels in urban areas as identified by IPCC

## Vulnerability Assessment

- There could be several criteria regarding impacts, based on which key vulnerabilities can be identified. These consist of the intensity and extent of impact, its timing, its nature, probability and confidence of occurrence, scope for adaptation, its geographical distribution and the importance of the system under threat. These have also been summarized in Figure 12.

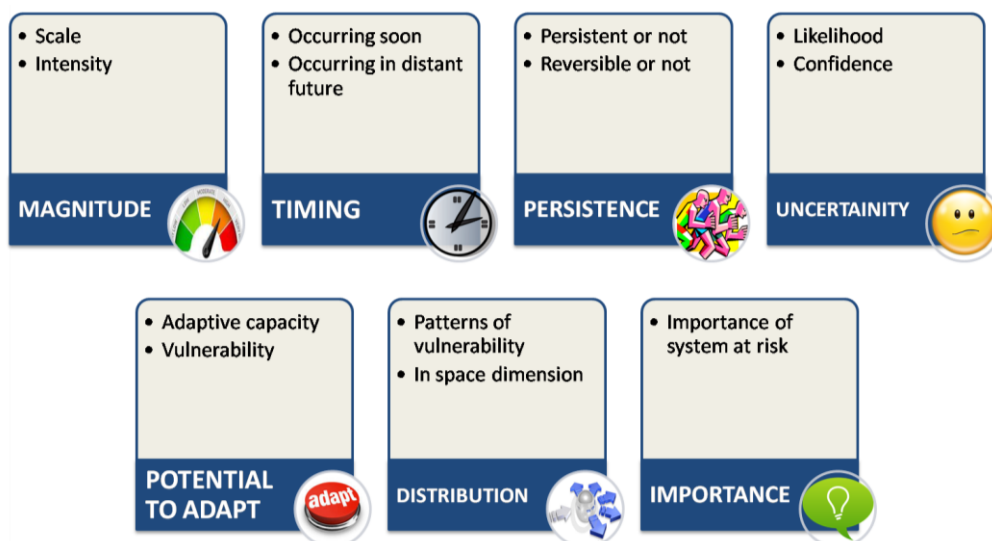


Figure 12: Factors determining vulnerability



## VULNERABILITY ASSESSMENT TOOLS

- Various kinds of tools can be used to assess vulnerability.
- These depend on the sectors, regions, and hazards.
- Vulnerability *is* Potential impact *minus* Adaptive capacity
- Quantitative assessment of vulnerability is usually done by constructing some kind of 'vulnerability index'.
- Index construction is a multi-step process.
  - Selection of study area
  - Selection of indicators for the hazard, risk, exposure and adaptive capacity.

## **MODULE 3**

# **MAINSTREAMING CLIMATE CHANGE ADAPTATION (CCA) AND URBAN CLIMATE CHANGE RESILIENCE (UCCR) INTO CITY PLANNING & DEVELOPMENT**

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# MAINSTREAMING CCA/UCCR INTO CITY PLANNING AND DEVELOPMENT

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The present module is aimed at getting participants to understand and mainstream climate change adaptation/ resilience into urban development and planning. The module addresses the sector specific impacts of climate change and what adaptation measures can be taken to deal with the impacts.

## Learning Objectives of the module

Following are the learning objectives of this module:-

- To enhance the capacity of participants to understand the linkage of key sectors to climate change, climate variability and associated risks.
- To integrate climate change adaptation/resilience aspects in city planning and development strategies
- To comprehend elements of developing city resilience strategy

## Why Climate Change Adaptation?

- Most of the climate change impacts are likely to be experienced through
  - Floods
  - Droughts
  - Temperature rise
  - Unpredictable levels of rainfall.
- These will put at risk the lives of people and infrastructure and affect the health of millions of people, especially the poor.

## Disaster Risk Reduction and Climate Change Adaptation

- **Disaster Risk Reduction (DRR)** aims to reduce the damage caused by natural hazards like earthquakes, floods, droughts and cyclones, through an ethic of prevention (UNISDR).
- Climate Change is expected to affect the frequency and intensity of climate related disasters such as cyclones, floods, droughts etc.
- **Climate Change Adaptation (CCA)** means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause. It has been shown that well planned, early adaptation action saves money and lives later (European Commission).
- Examples of adaptation measures include:
  - using scarce water resources more efficiently;
  - adapting building codes to future climate conditions and extreme weather events;

- building flood defences and raising the levels of dykes;
- developing drought-tolerant crops; and
- choosing tree species and forestry practices less vulnerable to storms and fires;

## Impacts of Climate Change on Different Services

- Climate change can manifest itself in changes in -
  - Rainfall pattern
  - Rainfall intensity
  - Temperature rise
  - Changes in humidity etc.
- These changes may lead to:
  - Floods,
  - Drought,
  - Heat waves,
  - Change in number of hot days and cold days,
  - Alter the area of vector and vector borne diseases.
- These changes will impact urban areas.

## Mainstreaming Climate Change Resilience and Adaptation

Climate Change Adaptation and Resilience can be mainstreamed at all three levels of government viz. national, state and city.

### Entry Points for Mainstreaming Resilience at Various Levels of Government

National Level	Subnational/State Level	City Level
1. National Missions as part of the National Action Plan on Climate Change (NAPCC) 2. Sectoral policies (water, transport, buildings, energy, etc.) 3. Five Year Plans	1. State Agendas and Action Plans on Climate Change 2. Sectoral Policies 3. State Five Year Plans	1. Master Plans 2. City Development Plans 3. Disaster Management and Resilience Plans 4. City Mobility Plans 5. City Sanitation Plans

Source: Mainstreaming Urban Resilience Planning in Indian Cities: A Policy Perspective, TERI, May 2011

## Sectoral Climate Change Adaptation and Resilience Planning

This section of the module will cover the following sectors:

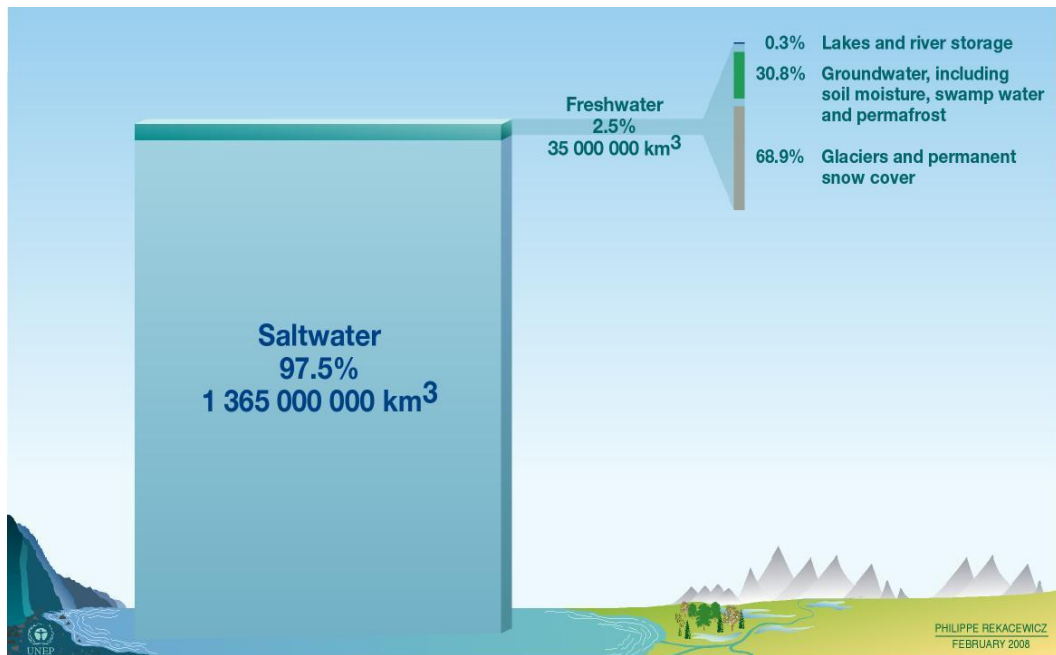
- A. Urban Water Supply and Sanitation**
- B. Urban Drainage**
- C. Built Environment / Human Settlement**

### Urban Water Supply and Sanitation

- Water supply and sanitation are basic to public health and they also impact the economy and development of cities.
- Climate change is likely to have significant impact on water resources, which is also affected by pollution.
- The challenge of climate change comes from -
  - variability in rainfall patterns
  - high intensity rainfall
  - rise in temperature and extreme events
  - flooding
  - salt water intrusion
  - sea level rise
  - contamination of ground water
  - droughts
  - glacial melt
- All the above will affect water supply to urban areas.
- Water resource is not infinite in nature. The fresh water is present in different forms on earth and is not abundant.


### Water Availability

- Water available for human use is only 0.3% of the total fresh water available which includes water in rivers, lakes and water vapour in the atmosphere.
- Ground water is not readily available everywhere and is not renewed with ease. If exhausted, an aquifer takes years to get recharged and be available for use again.
- Urban areas draw water from distant sources due to growing urban demand and depletion or pollution of nearby water resources.
- With changes in climate, the per capita water availability of water will reduce.
- Drawing water from long distances leads to high energy cost, transmission cost, and high O&M cost. With low cost recovery in water supply, ULBs have very little money to repair and maintain the water supply system and lay new pipeline for water distribution or sewerage network.



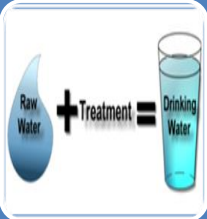
**Figure 13: Composition of Global Water**

(Source of image is <http://www.unep.org/dewa/vitalwater/jpg/0101-water-quantity-EN-2.jpg>)




- Water sourced from distant sources
- Cost for govt. increases
- ULBs unable to meet or recover cost

***Indiscriminate GW withdrawal***



- Raw water quality poor
- Cost of treatment for govt. increases
- ULBs unable to provided treated water to all

***Health impacts and growth of bottle industry***



- Water supply source polluted
- Reduction in water availability
- Further pressure on ULBs to meet demand

***Polluted rivers/ lakes and GW. Further reduction in supply***

**Figure 14: Urban water supply and sanitation**

**Table 3: Impacts of climate change on urban water supply and sanitation:**

Sector / components	Probable Impacts	Adaptation Measures
<b>Water Supply</b>	<ul style="list-style-type: none"> <li>• <b>Variability in flow</b> of water in perennial and non-perennial rivers will affect water availability.</li> <li>• <b>Variability in rainfall</b> will affect ground water recharge.</li> <li>• <b>Reduction in water levels</b> in tanks and dams will be seen due to rise in temperature and variability of precipitation.</li> <li>• <b>Scarcity of water</b> will rise over the time and geographically.</li> <li>• <b>Water supply systems</b> such as jackwells, pumping stations, water treatment plants, will get affected due to floods</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Water conservation</b> – promoting efficiency in water supply and consumption; demand management</li> <li>• <b>Reducing water leakages</b> to increase water availability</li> <li>• Promotion of <b>dual pipeline system</b> to separate drinking water supply from other. This will reduce treatment and energy costs and help set realistic tariff for water.</li> <li>• Improve <b>communication with citizens</b> to inform them of the changing water situation to prevent water conflicts and over use.</li> <li>• <b>Conjunctive water management</b> – optimal use of local resources such as rainwater, surface water, groundwater, treated wastewater and water from distant sources.</li> </ul>
<b>Water source</b>	<ul style="list-style-type: none"> <li>• Springs and rivers will be <b>more seasonal in nature</b> due to variability of rainfall and rise in extreme rainfall events.</li> <li>• Reservoirs/dams/lakes will <b>register sharp decline</b> due to high temperatures and reduced catchment inflow of water. Storage in dams and reservoirs will dwindle.</li> <li>• <b>Ground water table will fall</b> rapidly in over exploited areas, as recharge of aquifers will reduce due to change in rainfall patterns (more extreme rainfall events leading to high run off).</li> <li>• Coastal cities will face additional problem of <b>salt water intrusion</b> that will affect ground water supply due to sea level rise and salt water ingress due to over exploitation of ground water.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Rainwater harvesting</b> - making it mandatory in Building Bye-laws.</li> <li>• Conservation and rejuvenation of water bodies to <b>check surface run off</b> and preserving fresh water.</li> <li>• <b>Basin level approach</b> to manage water resources.</li> <li>• Selecting multiple and decentralized sources of water.</li> </ul>

Sector / components	Probable Impacts	Adaptation Measures
Water Treatment	<ul style="list-style-type: none"> <li>• <b>Sediment load will rise</b> in rivers/streams, especially during rainy season and extreme spells of rain, which will reduce treatment capacity, hampering water supply.</li> <li>• Seasonal deficit of water and reduced availability of ground water will <b>increase the pollutant load</b>, impacting treatment.</li> </ul>	<ul style="list-style-type: none"> <li>• Invest in augmentation of treatment capacity.</li> <li>• Innovations in engineering to settle silt and use the water for storage or percolation.</li> <li>• Locate <b>new pumping stations</b> in places which don't get flooded.</li> <li>• Augment storage by adding new water tanks</li> </ul>
Water supply - Vulnerable sectors and sections	<ul style="list-style-type: none"> <li>• Change in rainfall patterns and rise in temperature could affect water level in dams which will <b>impact hydel power generation</b>, even thermal and nuclear power plants would be affected due to reduced availability water.</li> <li>• <b>Industrial output will be impacted</b> both due to water shortage and energy deficit.</li> <li>• <b>Biodiversity</b> in eco-sensitive zones like the Himalayan belt, western and Eastern Ghats <b>will be affected</b> by changes in the rainfall pattern and rise in temperature. This will impact the water holding capacity of these ecosystems.</li> <li>• The <b>urban poor</b>, who are the <b>most vulnerable</b> section of the society, will be affected due to rise in temperature and water scarcity.</li> </ul>	<ul style="list-style-type: none"> <li>• Technologies to <b>reduce the intensity of water use</b> in industries.</li> <li>• <b>Re-use, Recycling</b> of grey water for peri-urban agriculture, landscaping. Peri-Urban agriculture can hold flood waters and can be a resilience measure.</li> <li>• <b>Industries to use recycled water</b> to the extent possible.</li> <li>• <b>Focus on mini hydel power projects</b> rather than large hydel power projects.</li> <li>• Choosing other options for power generation like <b>solar</b>, pine needle.</li> <li>• Identifying vulnerable people and providing relief to them</li> </ul>
Sewerage system	<ul style="list-style-type: none"> <li>• Infiltration of flood waters into sewers – creating pollution impacting health.</li> <li>• Pollution of water downstream.</li> <li>• Due to high temperature &amp; reduced water supply reduced flow may choke sewers and early decomposition may take place resulting in <b>deposits in the network</b>.</li> <li>• Increase in harmful <b>sewer gases</b>.</li> <li>• Due to change in precipitation biological treatment process of STPs will be disturbed.</li> <li>• Open sewers may overflow due to heavy</li> </ul>	<ul style="list-style-type: none"> <li>• Separate sewerage and drainage systems.</li> <li>• Put up decentralized sewage treatment systems where possible.</li> <li>• Clean sewers regularly and especially before monsoons.</li> <li>• Regular operation and maintenance of the system.</li> <li>• Install STPs to treat all wastewater and prevent water pollution.</li> </ul>



Sector / components	Probable Impacts	Adaptation Measures
	<p>rains and threat of epidemic may increase.</p> <ul style="list-style-type: none"> <li>The scouring velocity in the sewerage system may get disturbed due to change in rainfall.</li> </ul>	
<b>Sanitation- Pit Latrines</b>	<ul style="list-style-type: none"> <li>Pits would get inundated from below due to heavy rainfall, polluting ground water and soil.</li> <li>Open defecation would spread faecal matter during heavy rainfall and flooding causing serious health problems.</li> <li>Silt load carried with flood water would settle in septic tanks and sometimes there would be backflow of sewage. This would indirectly contribute to water borne and vector borne diseases in flooded localities.</li> </ul>	<ul style="list-style-type: none"> <li>Protect water supply sources.</li> <li>Empty septic tanks regularly and co-compost septage and solid waste.</li> <li>Provide toilets to all and make cities open defecation free.</li> </ul>

## Policies and Schemes of Government of India supporting Water and Sanitation

Government of India has various policies and schemes addressing water and sanitation in urban areas. These policies and schemes have components like institutional development, capacity building and infrastructure up-gradation, which also have co-benefit of climate resilient development.

- Jawaharlal Nehru National Urban Renewal Mission.
- Urban Infrastructure Development Scheme for Small and Medium Towns.
- Urban Infrastructure Development Schemes in Satellite Towns.
- Integrated Housing and Slum Development Program.
- National Mission on Sustainable Habitat (Sub-Mission NAPCC).
- National Water Mission (Sub-Mission NAPCC).
- National Urban Sanitation Policy.
- National Water Policy 2012.
- Drought Management Guidelines.

**Note:** NAPCC is National Action Plan on Climate Change.

## Urban Drainage

Flooding in urban areas is an emerging climate change related problem, because of the following reasons:

- Climate change is increasing the unpredictability of rainfall.
- Rapid urbanization in the country is leading to unplanned growth of urban areas,
- Usurping of wetlands, water bodies and natural drains for construction of buildings
- Encroachment on flood plains and natural drainage has made the phenomenon of flooding more destructive in nature.
- This interaction between climate and non climate factors will be crucial and decisive.

## What is Flooding?

As per NIDM, a **flood** is an excess of water (or mud) on land that is normally dry and is a **situation** where the inundation is caused by high flow, or overflow of water in an established water course, such as a river, stream, or drainage ditch; or pond of water at or near the point where rain fell<sup>1</sup>.

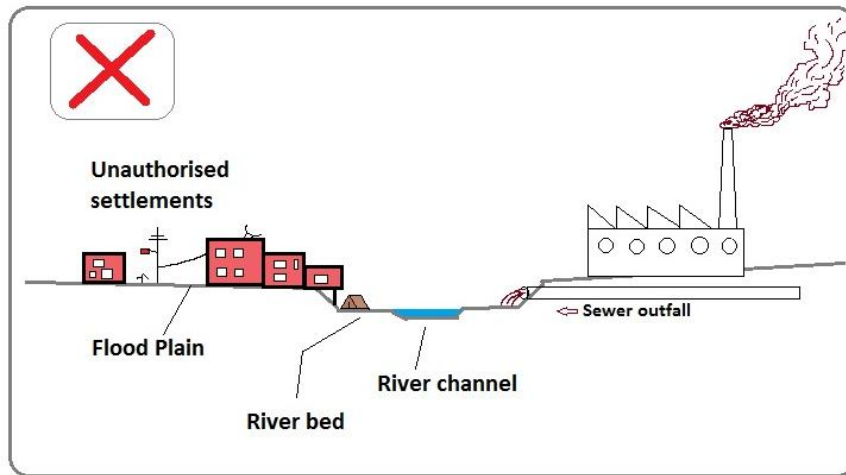
## Causes of Flooding

Flooding is caused due to both natural and anthropogenic reasons such as:

- Heavy rainfall /cloud burst
- Cyclones
- Silting of river bed and other water bodies
- Alteration of natural course of rivers/streams
- Encroachment on water bodies - lakes, ponds, natural drainage
- Inadequate or poor management of drainage system
- Deforestation
- Lack of flood control measures

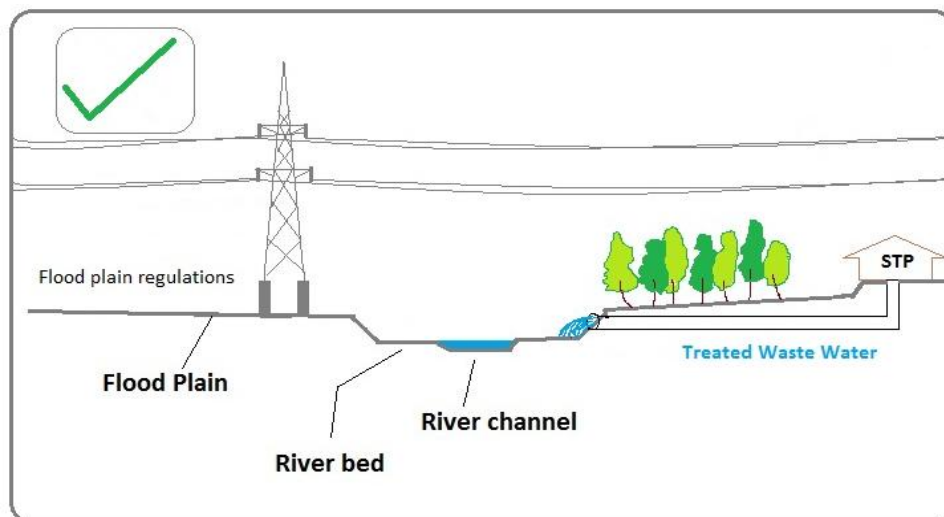
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<sup>1</sup> <http://nidm.gov.in/idmc/Proceedings/Flood/B2%20-%2036.pdf>



**Figure 15: Scenario 1 – Development on flood plains**

Unauthorised settlements, key infrastructure, industries are come up close to river bed, on the flood plain. In the event of heavy or extreme rainfall, the river channel rises and claims the flood plain, leading to loss of life and property.



**Figure 16: Scenario 2 – Expected development on flood plains**

Floodplain of a river should be cautiously developed. Any vital infrastructure should be built on plinth or stilts. Vegetation should be promoted on the flood plain, if possible flood resistant in nature.

**Table 2: Impacts of climate change due to urban flooding and possible adaptation measures**

Sector	Probable Impacts	Adaptation Measures
<b>Storm water drainage</b>	<ul style="list-style-type: none"> <li>• Floods damage life and property</li> <li>• Damage to roads, bridges; power and telecommunication, transport systems; water and sewerage systems etc.</li> <li>• Flooding of essential services (hospitals, power, telecommunication), paralysing of emergency response systems</li> <li>• Flood waters will recede at a slower pace if outfall points are encroached</li> <li>• Loss of business and assets; loss to economy</li> <li>• Riverine cities: Overflow of river due to breach in embankments due to heavy rainfall and silting; inundation of settlements and infrastructure especially in low lying areas.</li> <li>• Himalayan cities: incidence of landslides, mud and debris damage houses, buildings and infrastructure</li> <li>• Coastal cities: high tides could cause additional problems aggravating floods, reduce the rate of draining of water into the sea</li> <li>• Silt drying and stagnation in drainage line due to rise in temperature can loosen construction joints of storm water drains</li> </ul>	<ul style="list-style-type: none"> <li>• Separate sewerage and storm water drainage systems.</li> <li>• Ensure solid waste does not choke the drains.</li> <li>• Regular de-silting of drainage network and natural water bodies – rivers , lakes, ponds.</li> <li>• Preserve natural drainage while planning.</li> <li>• Make water permeable pavements.</li> <li>• Construct retention ponds and restore water bodies.</li> <li>• Riverine cities: Ban construction in high flood risk zones; construct bunds and dykes to prevent flooding; permit flood resistant agriculture on river banks and peri-urban areas.</li> <li>• Himalayan cities: Afforest steep slopes and do not allow construction in landslide prone zones; position key post disaster infrastructure on safer height.</li> <li>• Coastal cities: Construct houses on stilts in deltaic and other flood prone areas.</li> <li>• Removal of encroachment on natural drains.</li> <li>• City sanitation plan and drainage plan should be prepared</li> <li>• Procure de-watering equipments</li> </ul>
<b>Unauthorised colonies / slums</b>	<ul style="list-style-type: none"> <li>• Flooding of low lying areas and poorly drained areas.</li> <li>• Health risks due to waste water and solid waste getting mixed with flood water.</li> <li>• Damage to immovable property in flood affected zones, especially those next to streams and rivers.</li> </ul>	<ul style="list-style-type: none"> <li>• Early Warning System to prevent loss of movable assets and lives.</li> <li>• Mobile Urban Health Clinics in strategic locations for optimal outreach.</li> <li>• Insurance against losses due to floods.</li> <li>• Identifying flood risk areas and</li> </ul>

Sector	Probable Impacts	Adaptation Measures
	<ul style="list-style-type: none"> <li>• Drinking water scarcity due to flooding and contamination of sources.</li> </ul>	<ul style="list-style-type: none"> <li>• make climate proofing plans by involving community.</li> <li>• Public awareness on emergency action plan and evacuation routes.</li> </ul>
<b>Other sectors</b>	<ul style="list-style-type: none"> <li>• Stress on water treatment capacity due to excessive sediment load and contamination.</li> <li>• Longer commuting hours due to traffic jams caused by water logging.</li> <li>• Emergency services will be hit (esp. health and fire).</li> </ul>	<ul style="list-style-type: none"> <li>• Set up Public Information System to alert people about water logged and flooded roads,</li> <li>• Awareness campaign on dos and don'ts during floods by administration and municipality in high flood risk areas.</li> <li>• Construct boundary walls to protect water treatment plants, sewage treatment plants from getting flooded.</li> <li>• Procure generators for WTP and STP functioning.</li> <li>• Construct of innovative Green Infrastructure like swales and detention basins adjacent to critical flooding locations.</li> </ul>

### Importance of preserving natural drainage and wet lands:

- Wetlands are not only bio diversity hotspots, but are also natural sponges which absorb sudden rush of water due to extreme rainfall, which the man made drainage networks are unable to channelize fully.
- Natural drainage must be preserved and left un-encroached. What happened in July 2005 in **Mumbai** is a grim reminder of how man has interfered with the natural systems and has faced dire consequences. On 26th July 2005, Mumbai received an unprecedented 994 mm (39.1 inches) of rainfall, the eighth heaviest ever 24-hour rainfall recorded. Even if the entire existing drainage network was working very well, with this amount of rainfall it would not have been possible to drain out the water. The anthropogenic causes of the Mumbai floods include the alteration of the course of Meethi river, and encroachment on the river banks which reduced the width of it's mouth. Had the Meethi river not been dumped with Construction and Demolition waste from various sites in Mumbai, the outflow would have been relatively faster and many lives and property may have been saved. Therefore, instead of letting the river become a drain, it should be maintained with regular dredging and preservation of its embankments. The Mumbai floods led to loss of lives, assets, disrupted normal life and resulted in massive economic loss, not to forget the trauma which surviving people still suffer from.

- Other Urban Flooding incidences in recent years:
  - Srinagar (March 2015)
  - Srinagar (September 2014)
  - Guwahati (August 2012)
  - Mumbai (July 2005)
  - Chennai (December 2005)



**Figure 17: Flooding in Uttarakhand**  
 (Source of image is <http://www.weleadindia.com/>)

### Case: End-to-end Early Warning System in Surat

The need to address Surat's flood: Surat is the most flood-prone city in the state of Gujarat, with high vulnerability amongst the poor population and industries. The floods of 2006, resulting from an emergency release from the Ukai dam, inundated 75% area of the city and cost the city several hundred billion Rupees.

*Climate change risks:* Since the dam's construction in 1971, the increasing building of embankments and new infrastructure along both sides has reduced the safe discharge of the river between the banks and narrowed the mouth of Tapi, which will likely be exacerbated by sea level rise. Climate change scenarios for Surat indicate rainfall variability, leading to more emergency dam releases and flooding.

The End-to-end Early Warning System Project has developed an integrated meteorological, hydrological and reservoir modelling system in order to improve reservoir operations for flood mitigation. The system informs the city administration to take action in case of extreme precipitation events. The project also builds community disaster response capacity. This project addresses the issue of flooding in a multi-scalar and multi-institutional manner, looking at upstream causes of flooding beyond the administrative boundary of the city.

With this project the city gets more time (four days) to act in response to flood warning, which was negligible before this system was installed. This also gives sufficient time for staggered and controlled release of dam water, thereby minimizing flood-related damages and the vulnerability of the poor, whose houses are located in flood-prone areas

The End-to-end Early Warning System directly benefits roughly 75% of the city population. Over 20% of the city's poor households along creeks and rivers, and nearly 50% of the total households will benefit from reduced risks due to more controlled releases and sufficient respite time to shift to safer locations. Almost all the households and industries will be prevented from livelihood and business disruptions.

Source: <http://www.acccrn.org/initiatives/india/surat/city-projects/end-end-early-warning-system>

## Solid Waste Management

### Solid Waste

- Any material, which are discarded after use and arises from human activities that are normally solids are called solid waste. There are many negative impacts, if solid waste is not managed properly. Some of the major impacts are:
  - Thrown in drains they cause blockage which result in flooding
  - Breeding of disease causing vectors such as flies, rats etc.
  - Cause of air and water pollution (burning, leaching and surface run off).
  - Dumping in water bodies like lakes, ponds, riversides causes water pollution and reduces their absorptive capacity
  - Dumping in low lying areas causes ground water pollution and vector breeding
  - If used to fill low lying areas to reclaim land and construct dwellings, the houses can have cracks due to land subsidence and accumulation of gases
- Solid wastes on the basis of their sources of generation are mainly of five types. These are:
  - Municipal Solid Waste
  - Hospital Solid Waste
  - Industrial Waste
  - Hazardous Waste
  - E- waste
- Municipal solid waste consists of:
  - Household waste,
  - Construction and demolition debris,
  - Sanitation residue, and
  - Waste from streets - mainly from residential and commercial complexes.
- With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing.
- Generation of solid waste by cities and towns:
  - In 1947 cities - an estimated 6 million tonnes
  - In 1997 - about 48 million tonnes; and
  - In 2014 – about 62 million tonnes
- It is important to understand that although the GHG contribution from waste and waste water is about 8% of the urban GHG emissions in India, its impact on environment and health is significant. Therefore management of solid waste if done by urban local bodies,

can not only check these emissions, but also co-benefit other urban systems and increase their efficiency.

**Table 4: Implications for Climate Change due to urban flooding and possible adaptation measures**

	<b>Impacts</b>	<b>Possible solutions</b>
<b>Solid Waste and Climate Change</b>	<ul style="list-style-type: none"> <li>Waste management - both solid and liquid waste, account for about 8% of the GHGs contributed by urban areas.</li> </ul>	<ul style="list-style-type: none"> <li>Promoting at-source segregation of waste.</li> <li>IEC activities – people, institutions and businesses.</li> <li>Recycle and re-use waste material to prevent loss of forests, reducing energy demand for producing goods afresh.</li> <li>Reducing consumption.</li> </ul>
<b>Solid Waste and Water</b>	<ul style="list-style-type: none"> <li>Open dumping deteriorates quality and quantity of water.</li> </ul>	<ul style="list-style-type: none"> <li>Drinking water sources (wells, lakes, ponds and canals) should not be accessed near waste dumpsites.</li> </ul>
<b>Solid Waste and Sewerage</b>	<ul style="list-style-type: none"> <li>Block sewer lines.</li> <li>Can reduce quantity of waste water reaching STP.</li> </ul>	<ul style="list-style-type: none"> <li>Covering manholes.</li> <li>Regular maintenance.</li> </ul>
<b>Solid Waste and drainage</b>	<ul style="list-style-type: none"> <li>Obstructs drainage;</li> <li>Impacts flow of water causing floods.</li> </ul>	<ul style="list-style-type: none"> <li>Cover entire city with storm water drains.</li> <li>Storm water drains should be covered in all parts of the city or town with perforated slabs</li> </ul>
<b>Solid Waste and Air</b>	<ul style="list-style-type: none"> <li>Causing air pollution through emissions from burning, incineration and unsafe recycling and increasing GHGs</li> <li>High risk of Burning at dumping sites</li> </ul>	<ul style="list-style-type: none"> <li>Ban and penalise open burning.</li> <li>Turn organic / kitchen waste into manure or biogas.</li> </ul>



<b>Solid Waste and Soil</b>	<ul style="list-style-type: none"> <li>• Causing soil pollution through leachate formation, which will increase with increase in rainfall.</li> <li>• Causing damage to flora and fauna by reducing soil aeration.</li> <li>• <b>Increase in weight of waste</b> due to increase in rainfall</li> </ul>	<ul style="list-style-type: none"> <li>• Mixed solid waste tied up in plastic bags should not be allowed to be flung out of windows to land on hill slopes and make them unstable and fragile.</li> <li>• Sanitary landfill sites should be constructed, dumping of mixed waste in unlined pits/ low lying areas should be avoided.</li> <li>• Fencing of slopes at vulnerable spots in hilly areas.</li> </ul>
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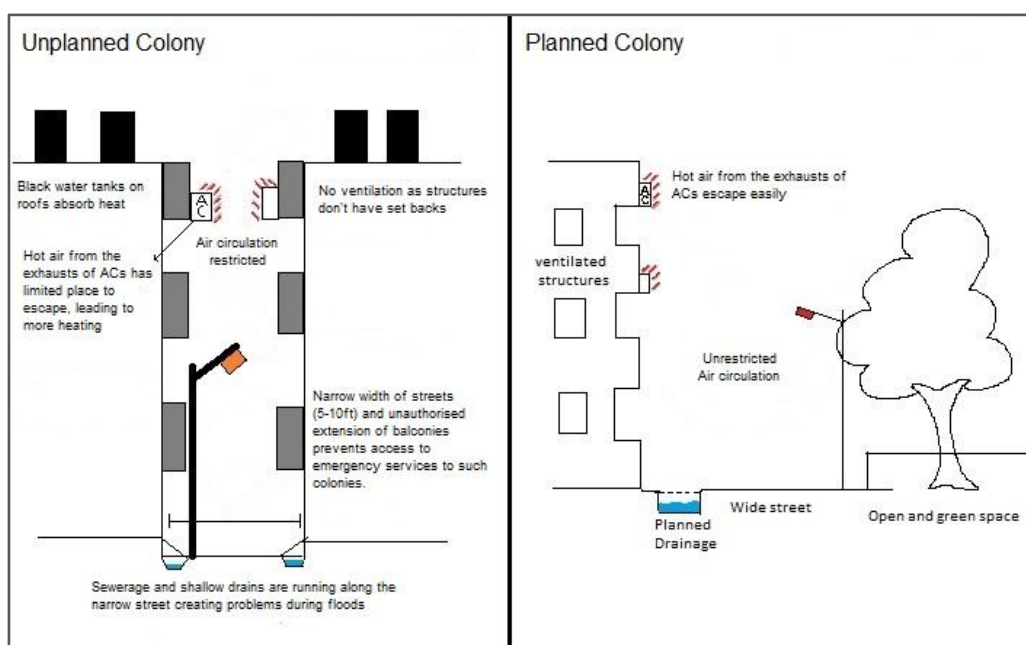
### Case: Waste Wise - Panaji

Municipal Solid Waste is a pressing issue in every city and town. The Corporation of the City of Panaji has tried many methods of solving the issue. However the only successful solution to disposal of MSW is segregation at source. Over the years, CCP has improvised on its methods of segregation. Waste Wise is one of the initiatives of the CCP which aims to spread awareness among schools & households about the role of segregation to dispose off MSW with minimum use of landfills. At the moment the program is introduced in schools in & around Panaji. Since Waste Wise is an incentive based program, students registered can exchange their clean dry waste for stamps. These stamps can be redeemed for goodies like - Caps, T-shirts, Key chains & even cycles. In the future Waste Wise will involve more citizens through housing colonies & resident welfare association. This campaign is a part of the city initiative to make Panaji, India's 1st Zero Waste City. The partners of the campaign include corporates like Coca-Cola & Tetra-Pak, with local support from the Magsons Group & Bavish. Special software is being created by Karbens to manage the logistics of the program.

Source: <http://www.wastewiseindia.com/> (accessed on 21/4/2015)

## Built Environment and Settlement

Built environment is man-made environment, comprising structures for residential, commercial, institutional use, network of roads, and other utilities. Events like heat waves, drought, high humidity and high temperature, flooding due to heavy rainfall or cyclone etc. impact cities differently, depending on their density patterns and settlement types (e.g. planned/illegal colonies/slums). Built environment is a key determinant of the phenomena called **Urban Heat Island**.



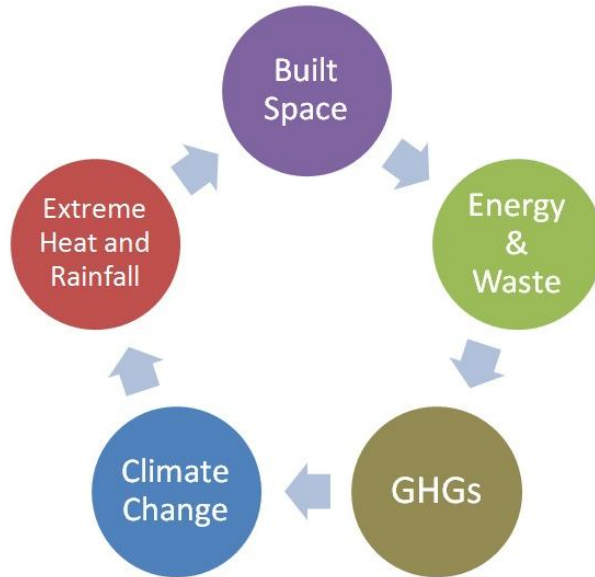
**Figure 18: Built environments and its impact on micro climate**

Built environment has a profound impact on the energy and water consumption. Built space consists of two – Structure and Space. Both have various elements which are key determinants of comfort, well being of the people using the structure and space.

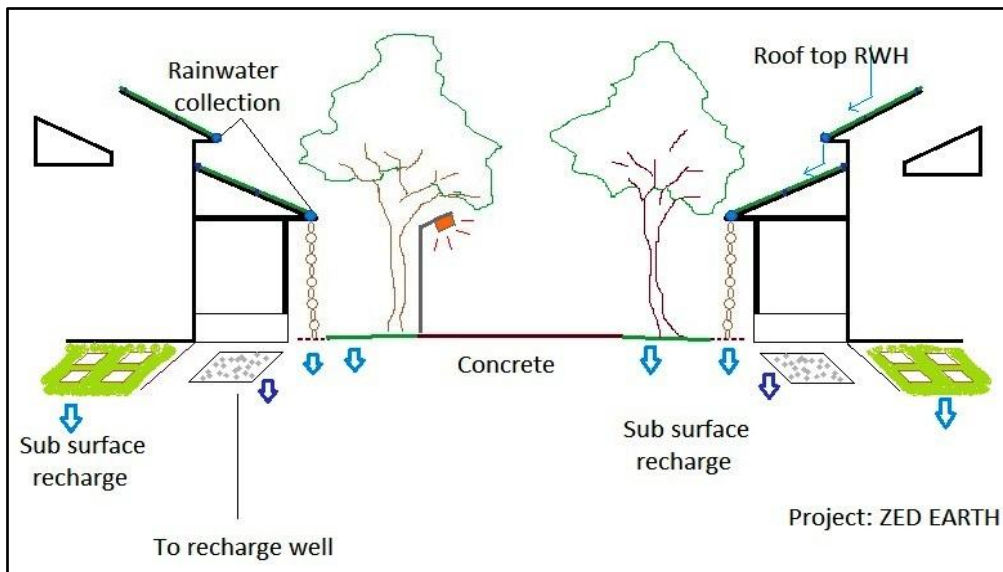
**Table 5: Elements of structure and space**

Structure	Space
Ventilation	Native flora
Set-backs around the structure as per norms	Provision of green spaces
Hollow bricks / pattern in which bricks are laid	Intermittent paved and unpaved areas

Green roof / cool roof	Rain water harvesting system
Water efficient faucets	
Provision of recycling grey water / RWH	
Energy efficient appliances	



**Figure 19: Built Space and its linkage with Climate Change**



**Figure 20: Street profile of ZED EARTH project in Bangalore**

ZED homes in Bangalore is a kind of initiative where all above mentioned elements have been implemented, making the settlement grid free in terms of water and partially independent in terms of power and solid waste management.

**Table 6: Impacts of climate change on urban built form and possible adaptation measures**

	Probable Impact	Adaptation Measures
<b>Built Space</b>	<ul style="list-style-type: none"> <li>• Settlements on dangerous slopes susceptible to landslides.</li> <li>• Urban Heat Island along with humidity will add stress.</li> <li>• Roof materials like asbestos, tin, plastic etc. add to indoor air temperature.</li> <li>• High energy demand for cooling could lead to power outages and blackouts during extreme heat events.</li> <li>• Restricted air circulation in the streets/lanes due to high density of built structures.</li> <li>• Reduction of open areas in high density areas.</li> </ul>	<ul style="list-style-type: none"> <li>• Promoting vernacular / traditional construction methods.</li> <li>• Water permeable pavements.</li> <li>• Water harvesting systems.</li> <li>• Preserving natural drainage while planning.</li> <li>• GRIHA Certification for new public projects.</li> <li>• Discharge capacity of existing drains to be revamped.</li> <li>• Ventilated houses, built on stilts.</li> </ul>
<b>Residents</b>	<ul style="list-style-type: none"> <li>• Heat stress, especially for senior citizens and children.</li> <li>• Hazards – fire hazards due hanging wires, health risks due to stagnant water because of poor drainage or choked drainage.</li> <li>• Access to services limited in the interiors of the unauthorised / slum settlement.</li> <li>• Lack of toilets and absence of solid waste collection add to health risks in slum settlements.</li> <li>• Negative impact on productivity of working population.</li> <li>• Emergency services absent, excessive load on existing health functionaries in the area.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Early Warning System</b> to prevent losses of lives due to heat and flooding.</li> <li>• Identifying flood risk areas and make climate proofing plans by <b>involving community</b>.</li> <li>• <b>Evacuation routes</b> and emergency plans for communities in their consultation.</li> <li>• <b>Public information system and public awareness campaigns</b> to alert people on extreme heat event and floods.</li> <li>• <b>Insurance</b> of lives and assets against loss due to fire and floods.</li> <li>• <b>Mobile urban health clinics</b> in strategic locations for optimal outreach to needy people.</li> </ul>

### Case: Surat Municipality's Initiative – Green Building Council

The Diamond City has started taking baby steps on the green path, it is moving towards becoming the first city in India to have a Green Building Council (GBC) that would ensure that the new buildings coming up follow a green building code.

The future constructions would have openings for sun light to filter in. They could even have ground floor and basement totally dedicated to plants treating impurities, while the terraces will be covered with vegetation ensuring better oxygen content.

GBC will work proactively and provide plans based on the **green code**. It will also provide technical expertise and knowhow for retrofitting of existing structures so that they can be converted into green buildings.

The green code envisages new constructions to have three basic facets of availability of water recharging, air cooling through natural draft and maximum use of natural light.

Till now only Hyderabad has an Indian Green Building Council that will assist Surat to form its own GBC. "The Council is being formed in collaboration with Confederation of Indian Industries (CII) and will have members from Surat Municipal Corporation (SMC), South Gujarat Chamber of Commerce and Industry (SGCCI), Climate Change Trust, Surat Builders Association, Confederation of Real Estate Developers Association of India and Architecture Council," said SG President Kamlesh Yagnik.

## Health

- Climate Risk Assessment indicates that climate change is responsible for
  - 2.4% of global burden of diarrhoea;
  - 2% of global burden of malaria (<6% areas);
  - 17% of protein-energy malnutrition;
  - 88% of the impact is on children under the age of 5 yrs; and
  - 150,000 premature deaths (99% in poor countries; 46% in SE Asia).
- Climate change induced extreme events like heat wave, cold wave, and extreme precipitation can make people vulnerable to health hazards. If frequency of such extreme weather events increases, the coping capacity of exposed population reduces, ultimately making more people vulnerable.

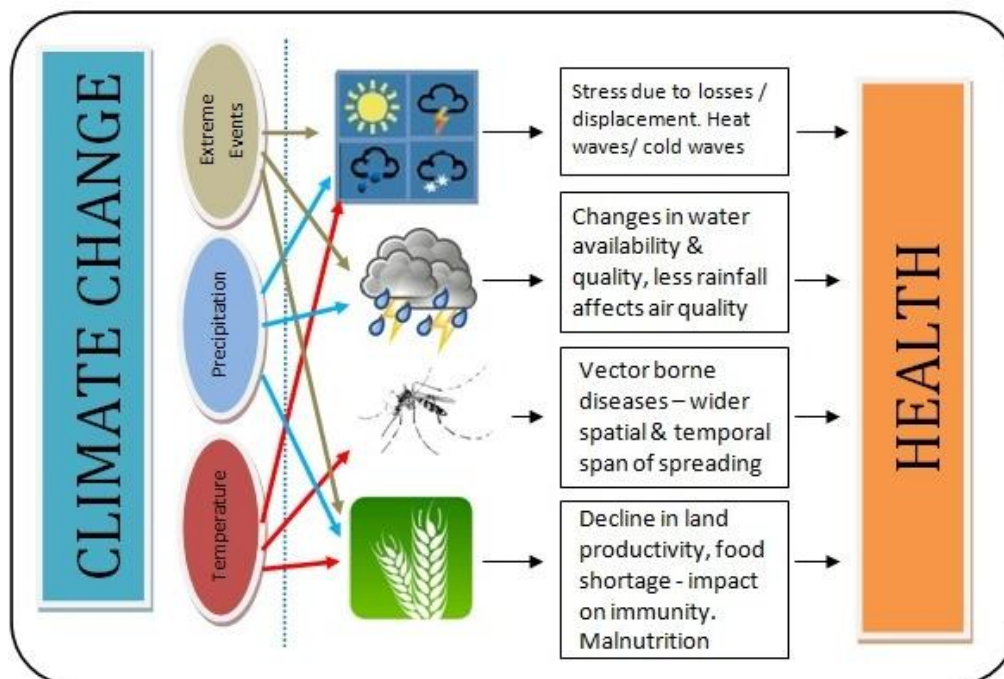


Figure 21: Linkages of Climate Change and Health

## Health Problems and Climate Change

- Climate change does not present new problems per se, but may worsen and shift the geographic distribution of existing problems. Some sections of population may be more at risk:
  - Children, aged and disabled
  - Those living in flood plains and with poor quality housing.
- For a city to build its resilience against health impacts, it needs to work on building health facilities, emergency handling staff with equipments, public awareness, etc. along with improved water, sanitation and solid waste management services.

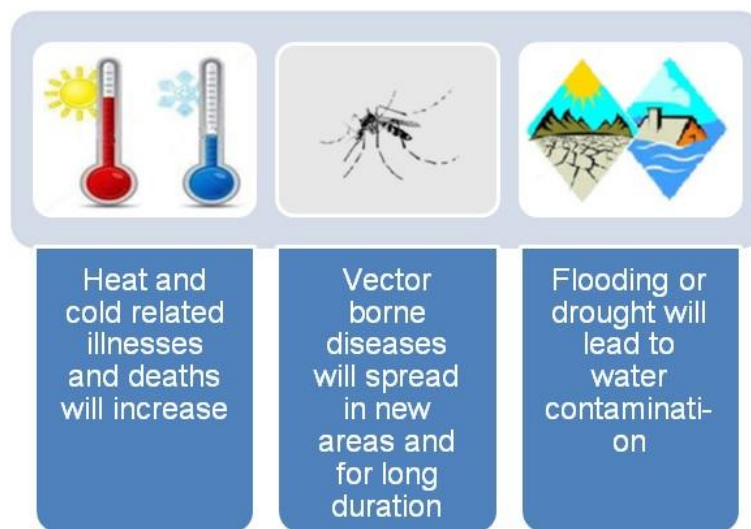


Figure 22: Different types of Health problems due to climate change

**Table 7: Health and Climate Change Linkage and Adaptation Measures**

Health and its linkage	Adaptation Measures
<p><b>Health + Water + Climate Change (CC)</b></p>	<ul style="list-style-type: none"> <li>• <i>Both water availability and quality impact health of people, and these will be impacted by climate change.</i></li> <li>• The following measures can be taken to improve water availability and quality:</li> <li>• <b>Rainwater harvesting</b> - making it mandatory in Building Bye-laws. Rainwater harvesting can help in recharging ground water.</li> <li>• Conservation and rejuvenation of water bodies to <b>check surface run off</b> and preserve fresh water.</li> <li>• <b>Reducing water leakages</b> to increase water availability. Less leakage also means less contact with contaminants.</li> <li>• <b>IEC activities</b> - informing people how to use water judiciously and how to purify water at home, in case the quality of water is not good.</li> <li>• <b>IEC activities by NGOs:</b> Identifying vulnerable population and implementing community owned and managed water purification system. For example – Indore RO plant in a low income area.</li> <li>• <b>Demand management</b> – metering of supplies and appropriate tariff setting.</li> </ul>
<p><b>Health + Extreme Weather + CC</b></p>	<p><i>Extreme weather events like heat wave, cold wave, heavy precipitation (causing floods), etc. can create health risks and also create stress. The vulnerable sections of society are at greatest risk in such events</i></p> <p>The following adaptation measures can help:</p> <ul style="list-style-type: none"> <li>• <b>IEC activities</b> - informing people how to handle extreme weather events, for example - heat stroke during heat wave and respiratory problems during cold wave.</li> <li>• <b>Coordination between municipality and health services &amp; NGO</b> – ambulances, clinics, nursing homes and hospitals, and community organisations to handle any extreme weather related health crisis.</li> <li>• <b>Municipality's line departments must coordinate with each other</b> to provide night shelters along with food, water, basic medicines and blankets.</li> </ul>
<p><b>Health + Diseases + CC</b></p>	<p><i>With changes in temperature and rainfall, the spatial and temporal window of diseases and their carriers is also changing. While vectors affect humans directly, pests affect the crops, which ultimately impact food supply.</i></p> <p>The following adaptation measures can help:</p> <ul style="list-style-type: none"> <li>• <b>IEC activities by Urban Health Centres and NGOs</b> – Provide information to people on vector borne diseases and water borne</li> </ul>

Health and its linkage	Adaptation Measures
	<p>diseases.</p> <ul style="list-style-type: none"> <li>• <b>Mapping the vulnerable populations and areas at risk</b> slum dwellers/poor, aged, people living near drains, on slopes etc.,</li> <li>• <b>Fumigation</b> in localities or areas which are prone to diseases like dengue and malaria.</li> <li>• Municipality's Health department to coordinate with all hospitals and nursing homes, etc., set up <b>disease surveillance</b>.</li> <li>• Distribution of nets, chlorine tablets, and regular preventive vaccinations.</li> </ul>
<p><b>Health + Pollution + CC</b></p>	<p><i>Pollution levels of water and air are directly linked to temperature and rainfall. Particulate matter and dust settles down with rainfall. Higher temperature increases the ozone concentration near the land surface. Dry conditions can increase the dust particles in the atmosphere. All this, apart from the pollution, are due to anthropogenic activities. Changes in climate will alter the pollution load on health.</i></p> <p>The following adaptation measures can help:</p> <ul style="list-style-type: none"> <li>• <b>Use of renewable fuels</b> for transport sector – Compressed Bio Gas, Compressed Natural Gas etc. which have lower emissions.</li> <li>• Immediate <b>clearance of soil and construction debris</b> from the sites where Municipality or any other department does its civil works to prevent dust from polluting the air.</li> <li>• Preserving green covers and city forests;</li> <li>• More <b>planting</b> of trees – along roads, traffic junctions, round-about, green areas.</li> <li>• Municipalities to coordinate with the meteorological department to issue an alert in the event of haze, smog, dust squalls and associated dos and don'ts.</li> <li>• Hospitals and other health services should be made aware of the adverse weather forecast which may raise pollution levels and cause breathing problems.</li> </ul>



### **Case: Surat's Urban Health and Climate Resilience Centre (UHCRC)**

Surat is a city prone to vector-borne diseases, rainfall variability, flooding and prolonged periods of water logging. Although the city has one of the best public health care services and delivery infrastructure in the country, it was felt that the system needs to be strengthened in order to meet the demands of rapid urbanization and climate change. Therefore, under the ACCCRN project, it was felt that an urban health and climate resilience centre should be set up to build on the knowledge and operating procedures already established in Surat, in order to provide support to the state and central level urban health support systems that incorporate climate change resilience issues.

The Urban Health and Climate Resilience Centre (UHCRC) in Surat, launched in March 2013, has been established with the goal of improving urban health management through evidence-based research, improved surveillance, and the development of operating procedures among city lifeline services departments. The UHCRC has been set up through Surat City Climate Trust in which Surat Municipal Corporation is a main stakeholder.

The focus areas of UHCRC are vector borne diseases/water borne diseases surveillance system; inter disciplinary research, convergence network development, community and social inclusion in relation to climate change and disasters; training and documentation of the practice.

The entire city's population benefits from UHCRC, especially the poor and vulnerable groups prone to infectious diseases and vector borne diseases. A reduced disease burden will mean steadier incomes and reduced cost of medical support. Dr. Vikas Desai who heads the UHCRC has also started Urban Health Society of India, which has over 200 members and plans to have regular interaction with health professionals to promote urban health programmes throughout the country.

Source: <http://uhcrc.org/home>,

# MODULE 4

## UCCR IN PRACTICE

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# UCCR IN PRACTICE

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This section gives examples of ACCCRN cities which have taken initiatives to build resilience to climate change in their cities.

## Learning Objectives

- To recapitulate the concepts of urban vulnerability, risk assessment and related terminologies.
- To understand, through examples, how the ACCCRN cities have planned and implemented resilience strategies.
- To enable the use of tools for assessing vulnerability and risks and building scenarios.
- To appreciate the importance of forming partnerships for strengthening collaborative action.
- To identify appropriate adaptation and mitigation projects that will help cities reduce the impact of climate change.
- To actively participate in networks to share and learn on a continuous basis.

## Background

There is increasing awareness of climate change as well as requirement of coordinated, well aimed and executed measures to meet emerging challenges of climate change impacts.

There is a strong felt need to support the urban local bodies, civil society and other stakeholders to implement resilience strategies. Resilience requires building capacity of urban local bodies to effectively respond to changing climate and its impacts. This can be achieved by sharing knowledge on practices, tools, methodologies, and forging partnerships to devise long term sustainable solutions for cities. Such shared learning and co-production of knowledge, build both formal and informal networks cutting across sectors. These measures help in promoting inclusive climate resilience development.

Cities contribute to climate problems but proper planning of cities can also provide solution to these problems. Appropriate urban policies and programmes can promote infrastructure that can withstand climate hazards and limit the exposure and vulnerability of people to climate change threats. This could be achieved through an integrated planning approach addressing both adaptation and mitigation<sup>2</sup>.

Under the ACCCRN project, Gorakhpur, Indore and Surat developed a plan for tackling climate change threats by preparing a city resilience strategy. A brief of the city profile, the climate change threats, and key points of the resilience strategy of these cities is given below.

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<sup>2</sup> J. Corfee-Morlot et. al, Cities, Climate Change and Multilevel Governance, OECD Environment Working Paper No. 14, 2009

<http://www.oecd.org/dataoecd/10/1/44242293.pdf>

## Gorakhpur

### City Profile:

- Located in eastern Uttar Pradesh; in central TARAI region
- Area - 147 sq. km divided into 70 wards
- Population – 671048 (2011) census with average density of 4,559 per sq. km.
- Topography of the city is largely plain with marginal gradient/slope from north to south.

### Climate Change threats to Gorakhpur

- Rapid change in climate
  - Increasing problem of intense precipitation event
  - Climate models predict increase in maximum temperature in all four seasons
- Thus, the city is vulnerable to flooding, water logging, sewerage and sanitation, solid waste and deteriorating eco system.

### Civic Problems

- Unplanned growth, poor expansion of the sewage network, encroachment onto water bodies - 44% of the city affected and about 20% of the area suffers acute water logging; Lack of any centralized sewerage network. Only 22% of the city has access to sewerage system. Remaining 78% rely on other means or have no access to sanitation.
- Solid waste disposed off in various informal dumping grounds. This waste clogs drains resulting in water logging, drinking water contamination and enhanced public health hazards.
- These coupled with potential impact on precipitation could have significant impacts on local water availability, agriculture and incidence of water and vector borne diseases.

### Key Actions

- Vulnerable points identified.
- Gorakhpur Environment Action Group (GEAG), with support from ISET and ACCCRN launched various campaigns to address these issues -
  - **Sanitation and waste** – leaflet distributed to *educate* citizens, also *encouraged* to change their habits regarding waste and recycling,
  - **Ecosystem Management** – Conservation of Ramgarh Lake
  - **Solid waste management** – Decentralized and *cost-effective* SWM measures encouraged and promoted *involving* residents.

### Outcomes

- The city prepared and implemented a resilience strategy through active engagement of stakeholders.

- Led to implementation of ward level resilience project in one ward; combined and integrated training, capacity building, drainage, flood resistant urban agriculture and flood resistant housing.

## Indore

### City Profile:

- Part of the Malwa plateau drained by two rivers; Khar and Saraswati
- Population (2011 Census) - 1,960,631 with total slum population of 529,370 (about 27% of the total population)
- City spread over an area of 202 sq km. with density of 9,718 / sq. km
- Temperature rises sharply in the summer season and it drops sharply during the winter season.

### Climate Change threats to Indore

- City faces potential threat of climate change through changes in average minimum temperature. This would add to urban heat island effect and result in precipitation changes.
- The impact of these changes would increase flood risk and water logging. It would also create associated health problems. These factors are also going to impact water availability.
- Many parts of the city are low lying and have limited sewerage and storm water infrastructure.

### Key Actions

- **Awareness** about climate risks created and citizens were *encouraged* to demand from the urban local body; Efforts for synergizing inter-governmental relations were also emphasized; Generation of municipal information system to analyze gaps in the infrastructure and its availability; Based on these, mid-term and long terms strategies were devised to create a sustainable infrastructure to deal with challenges emerging from climate change.
- **Water** - Comprehensive water management plan was drawn; Inter linking and gridding of various water supply projects were undertaken; Improvement in the redundancy of water supply system including ground water recharge and waste water recycling introduced; Efficiency improvement measures taken, such as metering, pressure monitoring, helpline maintenance were undertaken; Emphasis on developing alternatives in water supply, e.g. rain water harvesting, technological options in waste water recycling were stressed.
- **Energy** - Encouraging energy efficiency through Building codes under Energy Conservation Act 2001; Emphasis on building redundancies to meet demands and control prices, meet shift in energy demands

- **Natural Disaster Management** - Efforts to reduce risk and exposure (especially for the poor) undertaken; for better disaster management warning and forecasting devices in event of extreme weather events were put in place. Mapping of flood plains including flood plain risk zoning with advanced warning system were undertaken for better identification of water logging prone areas and rain water harvesting options were also strengthened. Stress was laid on improving disaster response plan including evacuation of people from water logging zones.
- **Sewerage, waste management and public health** – An integrated approach was designed for waste management that included awareness campaigns, encouraging waste segregation, and waste processing facility on scientific principles for waste recycling. Drainage passing through the city should be cleaned and settlement developed along these should be resettled to reduce the impact of water logging on them.

### Outcomes

- Created awareness about the impact of climate change on the city and generated bottom up demand
- A municipal information data base on information about the city helped in identifying gaps and strategies to address them. This developed cross learning mechanisms
- By analyzing risks and vulnerabilities, the city was able use this opportunity to address requirement in perspective of climate change impacts.

## Surat

### City Profile:

- Located on the banks of river Tapi, is a port city and major industrial hub and is second largest city of Gujarat with population of 44,61,206 million (2011 census).
- Area - 326.5 sq km with total density of 3,662 persons/sq km (2011 census).
- The city has recorded unprecedented growth and 10 fold increase in its population. The city resultantly has spilled over the peripheries.
- The city has a flat terrain, and being near coast it has a humid climate with extreme temperatures in summers and has moderate to high rainfall.

### Climate Change threats to Surat

- Analysis of climate in the region indicates increase in maximum and minimum temperatures.
- Since it's a coastal city, increase in the water yield in the Tapi river basin and potential threat of sea level rise and prolonged high tides in seas will result in increase of extreme events like floods and droughts, salination of water sources.
- Temperature increase in expected to lead towards shrinking of water bodies and increase in pathogens.

- In case of any extreme climate change event like flood, the storm water runoff might mix with sewage and discharge in the river. This will increase river pollution and shortage of water availability. There is also potential threat of vector borne and water borne disease. Silt brought by river Tapi to the Gulf of Cambay may result in inundation in parts of the city.

### Key Actions

- Based on vulnerability assessment, the resilient strategy was designed and prioritized on short term, midterm and long term roll out. Key sectors were identified and potential strategies were suggested:
- **Water** - Robust water supply infrastructure and its expansion to deal with the emerging challenges of climate change; Water conservation practices such as water audits, expansion of metering of water supply system were introduced; Surat Municipal Corporation (SMC) introduced metering policy in 2008.; A consumer sensitization campaign for saving water; Monitoring of water quality from source to tap on a real-time basis; Information on this linked to other departments for public health surveillance; Recycling of waste water
- **Sewerage and solid waste management** - System significantly improved including its O&M. Measures such as widening of roads to provide these services and has mobilized the administration to extend the existing storm water drainage ensuring quick recovery from major floods; Four sewerage treatment plants were built to reuse water and prevent pollution. The reused water supplied to industries.
- **Public Health** - A real time disease surveillance, quick diagnosis and vector control operationalized with active participation of over 350 doctors across the city. This will significantly contribute in reducing the disease spread.
- **Enabling city preparedness** - River embankments strengthened to enable it to withstand moderate discharge from the Ukai dam. SMC has put in place a Disaster Preparedness and Municipal Response Plan; Disaster management plan at the ward level; Rain water harvesting in new large buildings are being implemented; Skill enhancement of the SMC staff through capacity augmentation initiatives.

### Outcomes

- SMC started to initiate projects keeping the opportunities of climate change proofing as a central issue. The strategy for climate change will henceforth build on the initiatives of SMC to leverage further actions. Henceforth, smaller projects were emphasized to replicate at the city level.
- “Multi-scalar approach” enabled the SMC to address physical and socio economic issues.
- The relationships with state and national level institutions were emphasized to incorporate lessons into national urban development policies.
- Based on the generation of municipal information of various sectors and interactions with multiple stakeholders, the resilience strategy devised short, medium and long term interventions.





