



# Challenges Of Research and Climate Vulnerability and Adaptation

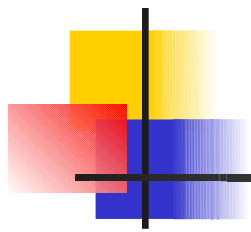
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March 05,2010



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# Methodology



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graph TD; A[Region Specific Vulnerability Assessment] --> B[Vulnerability Groups]; B --> C[Impact & Risk Assessment]; C --> D[Methods & Tools]; D --> E[Adaptation Practices, Measures, Technologies, Programme Design]; E --> F[Implementation (Government and Society)];
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**Region Specific Vulnerability Assessment**

**Vulnerability Groups**

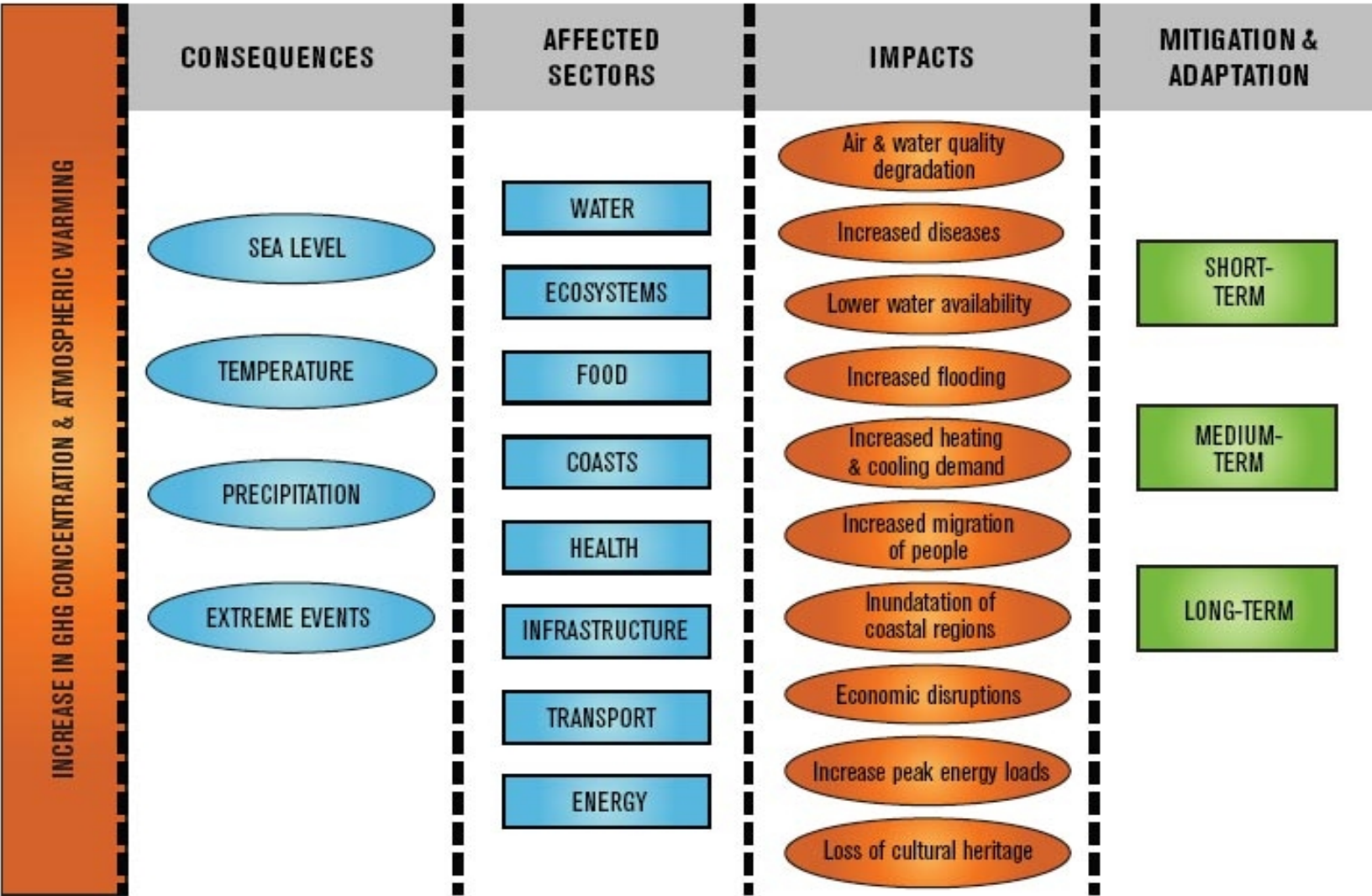
**Impact & Risk Assessment**

**Methods & Tools**

**Adaptation Practices, Measures,  
Technologies, Programme Design**

**Implementation (Government and Society)**

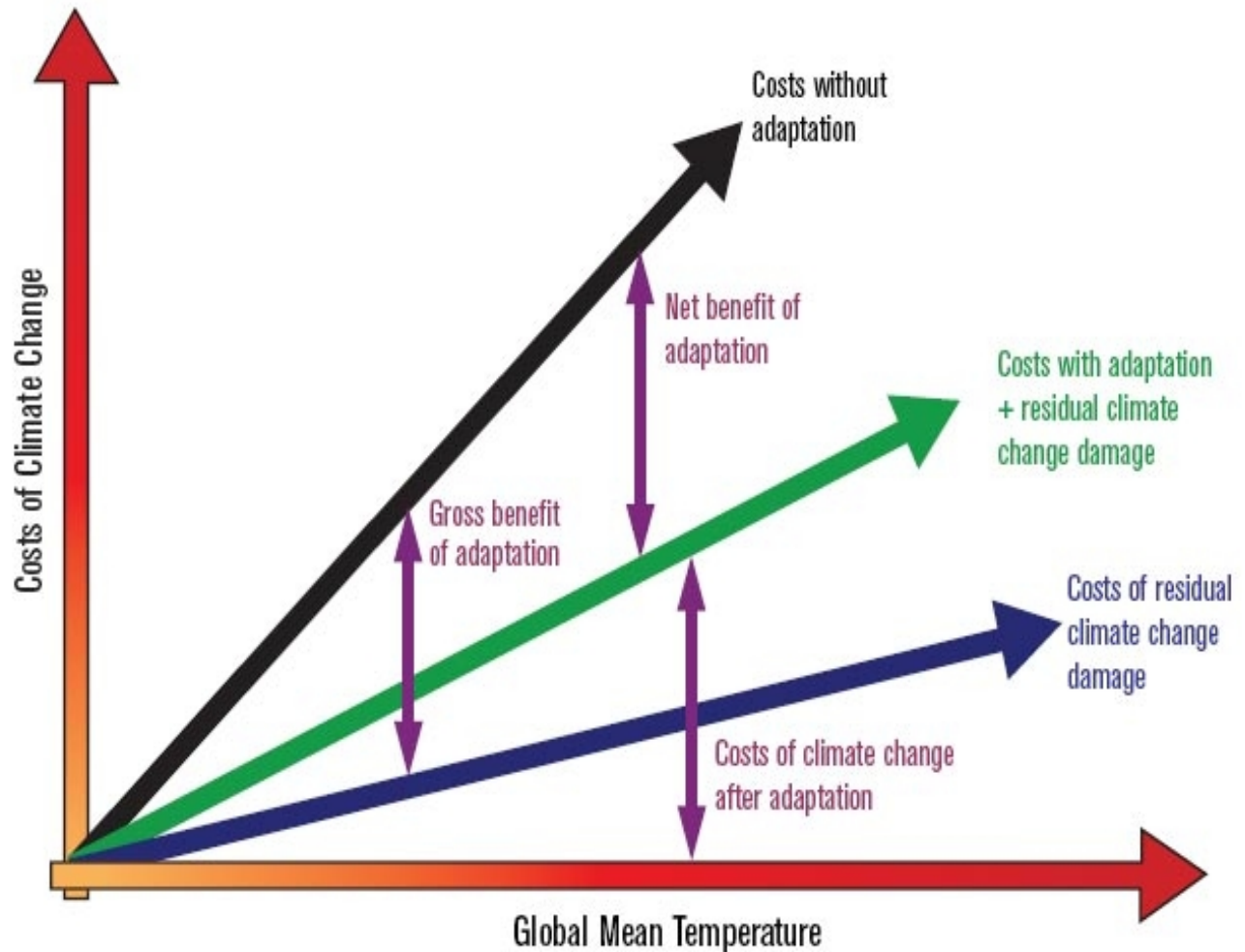
**FIGURE 2.1 /** Linking consequences and sectors with potential impacts and climate change mitigation and adaptation options



# Cost-benefits of adaptation

**FIGURE 2.3** / Relationship between the cost of adaptation and climate change

Source: Stern, N., *Stern Review on the Economics of Climate Change* (Cambridge: Cambridge University Press, 2006).

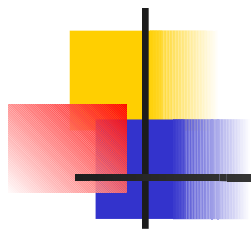




# Adaptation to Major Risks

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- Temperature and precipitation variability
- Sea-level rise
- Environmental health risks
- Disasters and Extreme Events
  - Droughts
  - Floods and extreme rainfall
  - Cyclone and storm surge



**Vulnerability  
and  
Adaptation**

**Natural Resources  
and Ecosystems**

**Risks & vulnerability**

**Agriculture**

**Water Resources**

**Urban Areas**

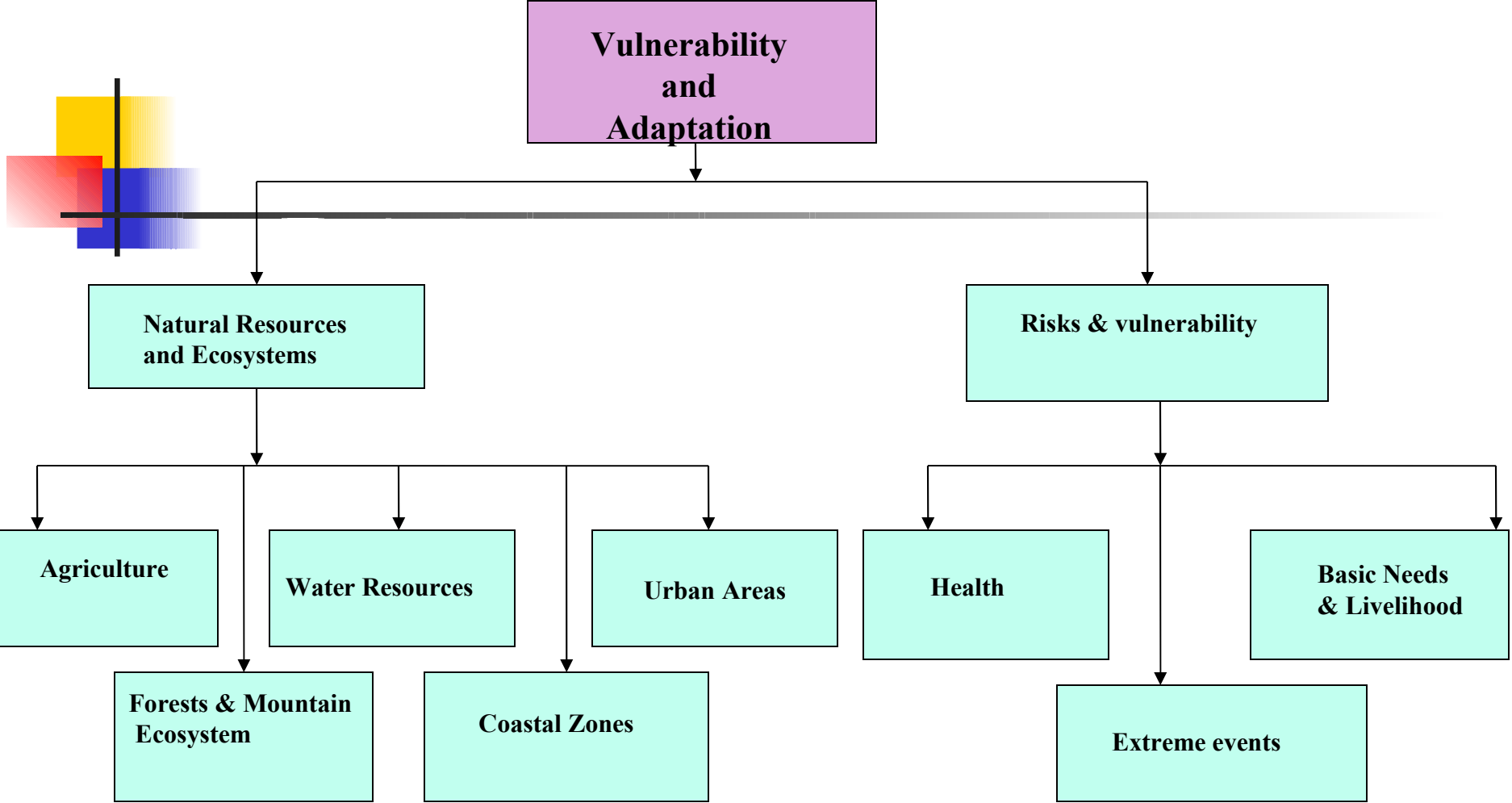
**Health**

**Basic Needs  
& Livelihood**

**Forests & Mountain  
Ecosystem**

**Coastal Zones**

**Extreme events**





# Agriculture and Food Security

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## ➤ *Food security*

- Some project up to a 9% decrease in potential agricultural land by the 2080s and a reduction in yield of up to 10 and 18% for cereals and maize, respectively, by 2050.
- Poor engage in subsistence food production.
- Developing countries most affected
- Weak institutional capacity and precarious financial situation.
- Credit and capacity needed for farmers to engage adaptive farming practices.
- Small farms owned and operated by the poor, often women, who use locally-hired labour.



# Water and Other Resource Shortages

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Climate change may exacerbate existing shortages of water, like -

- Women, largely responsible for water collection
- Water quantity
- Accessibility: time-consuming collection.
- **40-60% reduction in the water level** in the large river basins of the Niger, Senegal, Lake Chad and in South Asia (UNEP).
- Water harvesting and storage systems to deal with shortages will be needed.

**Strengthening water resources and delivering systems will be done best with women's help and involvement.**



# Coastal Zones

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- Rise in sea level affects fishermen and fisherwomen
- Seawater gets into fresh water.
- Livelihoods are affected
- Lands inundated
- Infrastructure is damaged, such as road and houses.
- Large scale migration is expected.
- The National and the State Governments have to build embankments to protect the population and infrastructure in danger.

Poor can be protected and also help protect themselves.



# Forests

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- Forest resources a major source of livelihood for an increasing number of poor.
- Source of nutritional and food supplement providing **alternative nutrients, minerals** and **vitamins** to the usual staple food.
- Shortage of non-timber forest products (NTFP)
- **Malnutrition**
- **Infant mortality.**
- Forest management programmes in Burkina Faso, Mali, Nepal and India contributing to agricultural and community forest management.



# Risks and Insurance

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- Hundreds of new insurance initiatives to tackle climate change and rising weather-related losses in the U.S. and globally.
- However, most insurance companies are still not focused on the climate change issue and fewer still are offering climate-related products.
- **Climate Insurance:**
  - Crops insurance – Draughts/Floods
  - Buildings & Insurance – Draught/Floods
  - Health Insurance - Heat stress, vector born diseases
  - Life Insurance

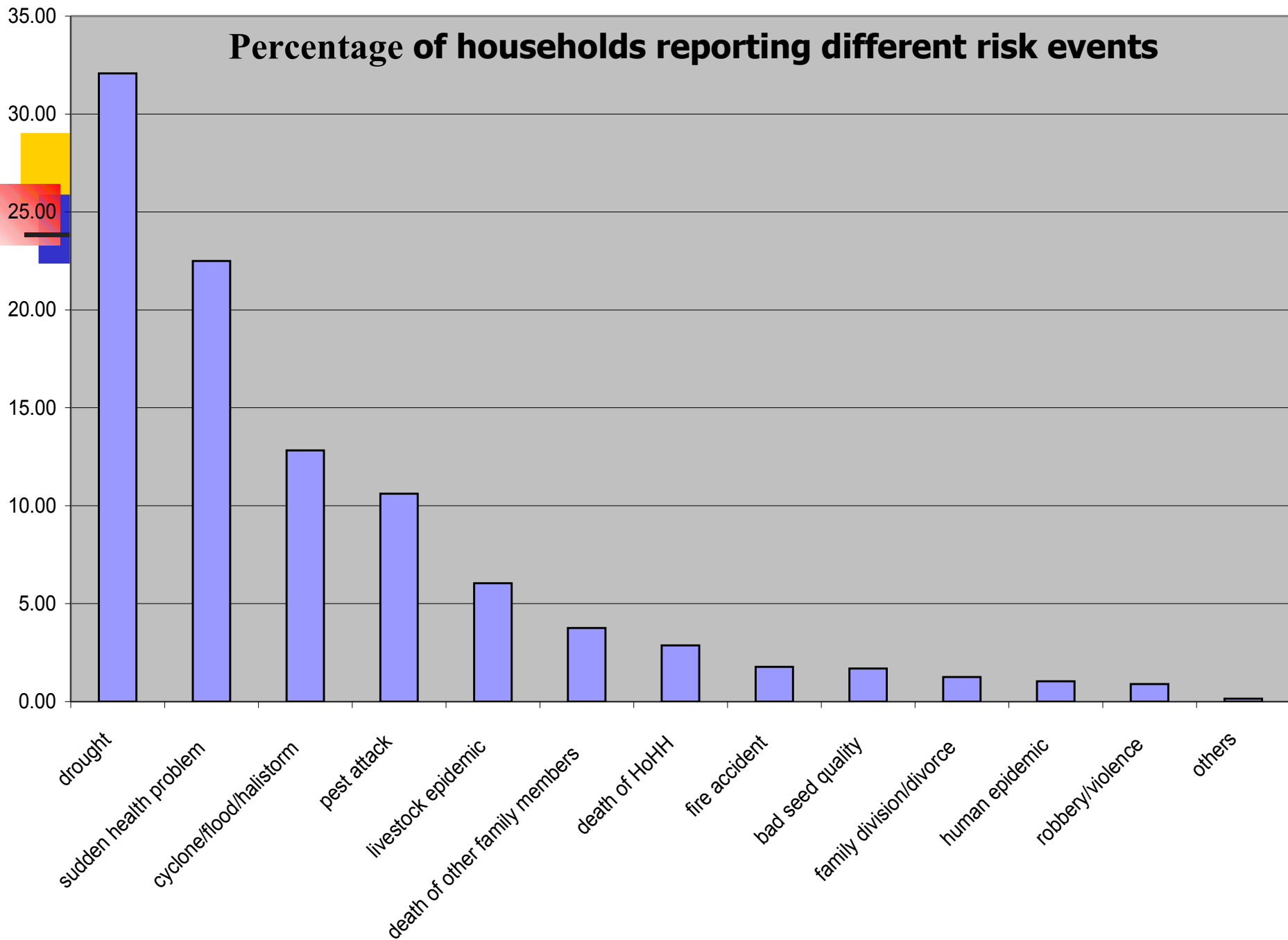


## Climate Adaptation and poverty

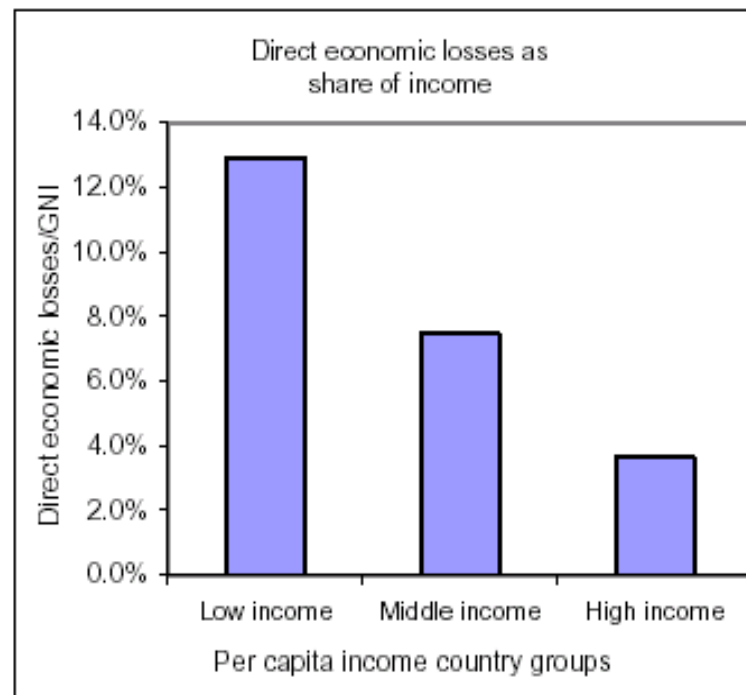
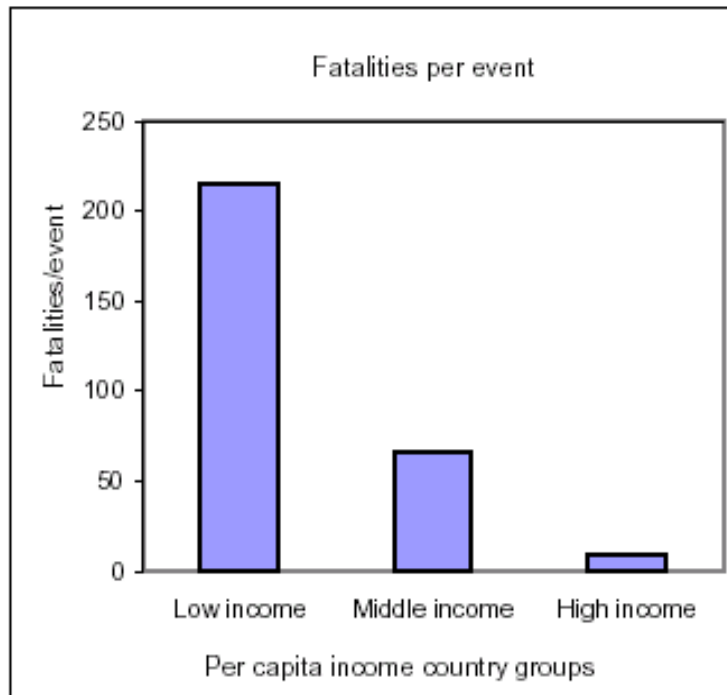
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- Climate change more likely to affect more likely to those who hardly emit.
- People without electricity or LPG, Kerosene etc. likely to suffer more from heat stress, shortage of food, fuel and water.
- Fundamental problem – equity in terms of emissions, impacts and abilities to deal with it.

# Percentage of households reporting different risk events



# Poor suffer disproportionately



Source: Munich Re, 2005



## Increasing extreme events – an example of Orissa, India

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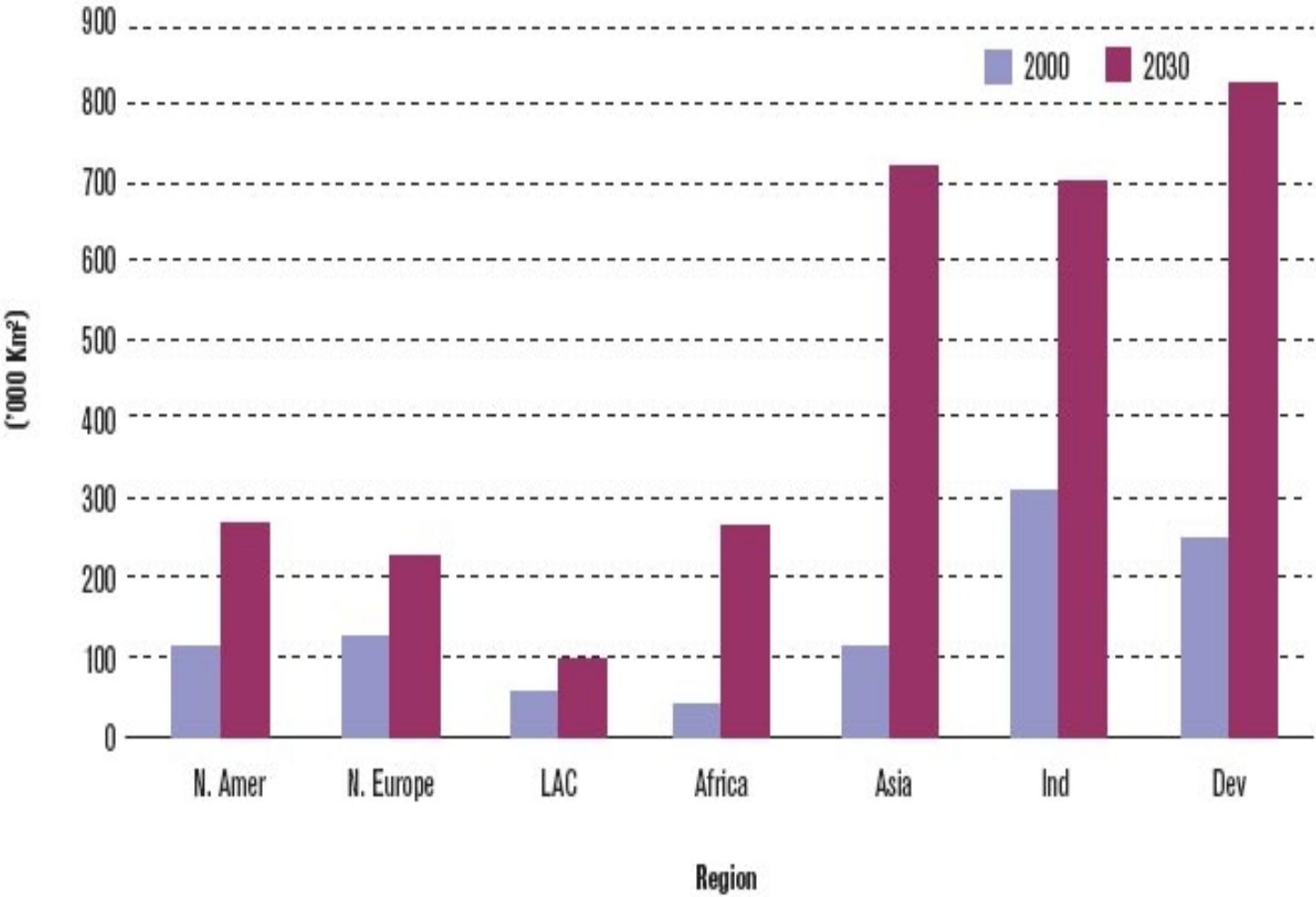
- In the last four years, calamities have claimed more than 30,000 lives.
- Monsoon of 2001 lead to the worst ever flood recorded in Orissa in the past century. Suffered one of its worst droughts in the same year, affecting earlier drought free districts like Sundergarh and Kendrapada.
- The frequency of cyclones has increased on the Orissa coast. In 1999, two cyclones hit the state in quick succession.



# Cities and Climate Change

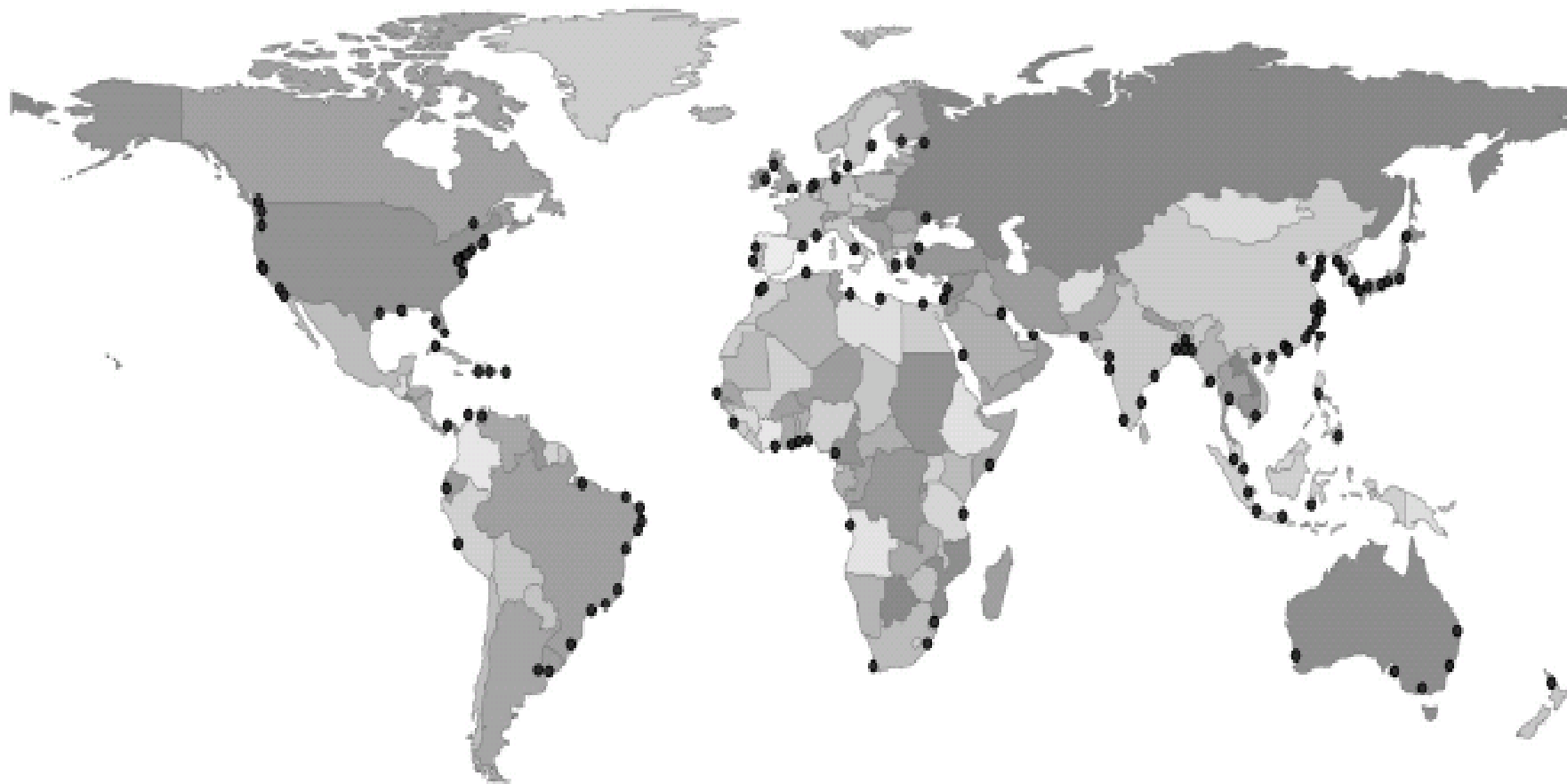
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**FIGURE 1.6 /** Built up area projections by region



Source: Angel, S., S.C. Sheppard, and D.L. Civco, *The Dynamics of Global Urban Expansion* (Washington, D.C.: World Bank, 2005).

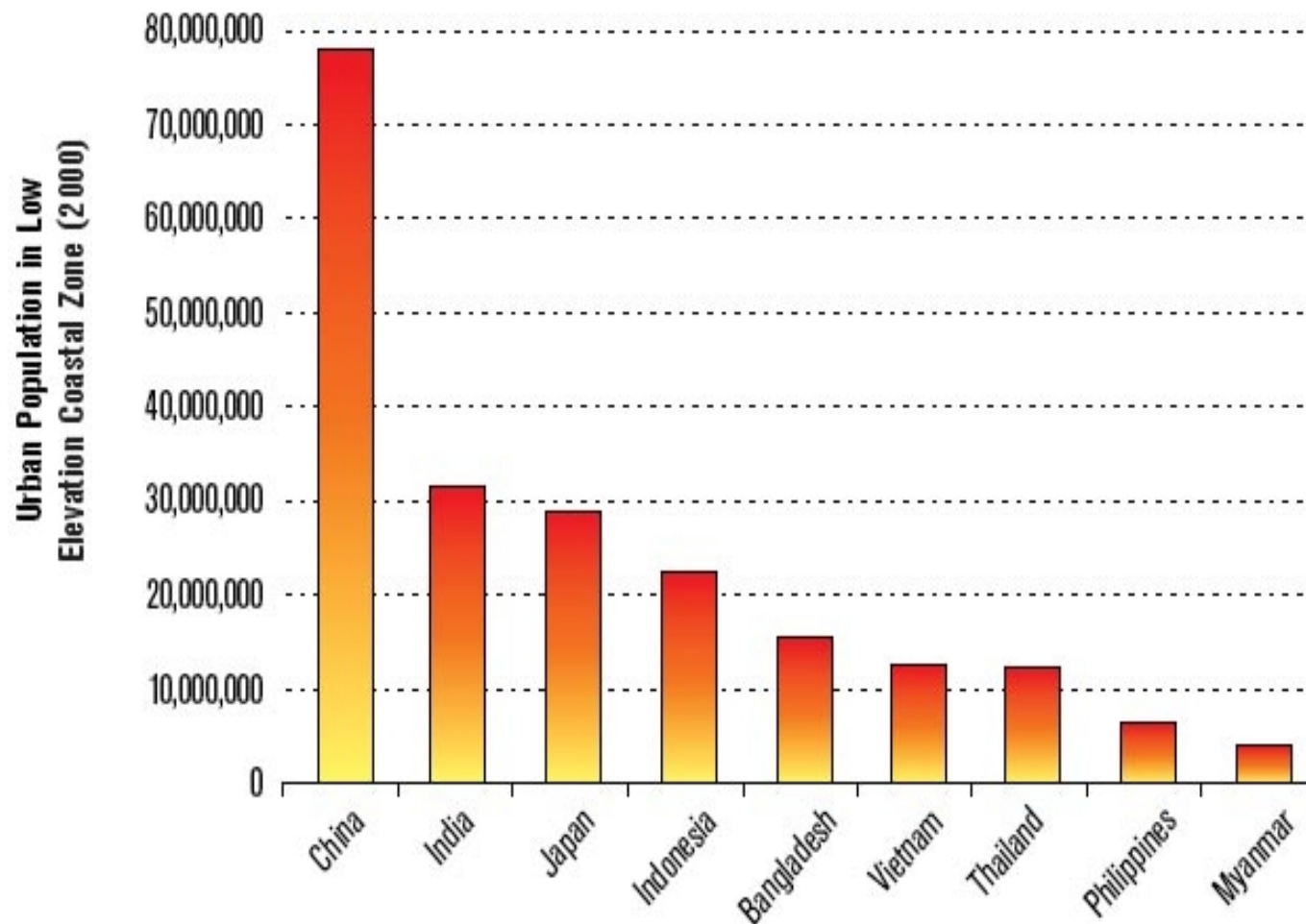
# 136 PORT CITIES around the World have more than 1 Million Inhabitants (2005)



RANKING PORT CITIES WITH HIGH EXPOSURE AND VULNERABILITY TO CLIMATE EXTREMES By R.J. Nicholls (1), S. Hanson (1), C. Herweijer (2), N. Patmore (2), S. Hallegatte (3), J. Corfee-Morlot (4) , J Chateau (4), R. Muir-Wood (2)



**FIGURE 2.5/** Coastal population of select countries that are highly vulnerable to sea-level rise



*Source:* Socioeconomic Data and Applications Center (SEDAC), Low Elevation Coastal Zone (LECS), Urban-Rural Estimates 2007, <http://sedac.ciesin.columbia.edu/gpw/lecz.jsp>.



# Most vulnerable populations and elements in a city

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- Slums
- Settlements in low-lying areas
- Industrial and informal service sector workers
- Buildings
- Industrial units
- Lifeline public and private infrastructure
- Ecosystems and the natural environment



# Adaptation Infrastructure and Framework

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## **Disaster management: Floods and Cyclones**

- Building shelters
- Changes and Regulation in land use
- Embankments of Inundation areas

## **Infrastructure: engineering/architectural**

- Inflatable boots for floods
- Flyovers, Bridges, Dykes
- Drainage systems, storm sewers
- Green roofs
- Storage of flood waters for drought periods



# Mainstreaming tools and methods

## Computer-based decision support tools

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- **SERVIR**

SERVIR is a regional visualization and monitoring system for Mesoamerica and Africa that integrates satellite and other geospatial data for improved scientific knowledge and decision making. Developed by USAID, NASA, the Institute for the Application of Geospatial Technology (IAGT), the University of Colorado, and CATHALAC.

[www.servir.net](http://www.servir.net)

- **World Bank Climate Change Portal and ADAPT**

The World Bank Climate Change Portal is intended to provide quick and readily accessible global climate and climate-related data to the development community.

[www.sdwebx.worldbank.org/climateportal/...](http://www.sdwebx.worldbank.org/climateportal/...)

- **ci:grasp**

Aims to provide a sound information basis on climate stimuli, climate impacts, vulnerabilities, and response options in selected threshold countries on an open, web-based platform. Developed by the Potsdam Institute for Climate Impact Research (PIK) and GTZ, funded by the German Federal Ministry for Environmental Protection, Nature Conservation and Nuclear Safety (BMU).

[www.ci-grasp.org](http://www.ci-grasp.org)



- **weADAPT Climate Change Explorer**

The Climate Change Explorer provides users with an analytical foundation from which to explore the climate variables relevant to their particular adaptation decisions. Developed by the Stockholm Environment Institute (SEI).

[www.weadapt.org](http://www.weadapt.org)

- **wikiADAPT**

Flexible, accessible, inclusive medium for enhancing the knowledge base of the climate adaptation community. The wiki is a collaborative project, and the idea is to have a community of contributors. Part of the weADAPT platform.

[www.wikiadapt.org](http://www.wikiadapt.org)

- **Adaptation Learning Mechanism**

Features tools and practical guidance to meet the needs of developing countries, complementing the wide range of adaptation knowledge networks and initiatives already underway such as the Nairobi Work Programme, particularly the 'Methods and Tools' and 'Planning and Practices' areas of work, and the interactive weADAPT platform. Developed by the United Nations Development Programme (UNDP).

[www.adaptationlearning.net](http://www.adaptationlearning.net)



# Adaptation and risk management tools

- **ORCHID and CRISP**

Opportunities and Risks from Climate Change and Disasters (ORCHID): Vulnerability and poverty reduction research, climate change and disaster risk screening of development agency portfolios. The methodology was developed by the UK Department for International Development, an adapted version is known as CRISP.

[www.ids.ac.uk/climatechange/orchid](http://www.ids.ac.uk/climatechange/orchid)

- **Adapting to Coastal Climate Change: A Guidebook for Development Planners**

Developed in conjunction with the US Agency for International Development (USAID), the Guidebook is both a tool itself and a link to other resources valuable for assessing vulnerability, developing and implementing adaptation options, and integrating options into programs, plans, and projects at the national and local levels.

[www.crc.uri.edu/...](http://www.crc.uri.edu/...)

- **ADB Climate Screening Checklist**

The Asian Development Bank (ADB) is helping the region's economies enhance their resilience to adverse climate change impacts through mainstreaming adaptation into national, sectoral and project level plans and actions. To mitigate climate change, ADB is addressing the main causes of emissions in the region. The Climate Screening Checklist is not publicly available.

[www.adb.org](http://www.adb.org)



- **BMZ/GTZ Climate Check**

The "Climate Check" tackles climate change issues from two angles: "Climate Proofing" deals with the impact climate change risks can have on the sustainability of development projects. "Emission Saving" identifies contributions of the cooperation programmes to mitigating climate change and helps maximise these contributions.

[www.gtz.de/climate-check](http://www.gtz.de/climate-check)

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- **CRiSTAL**

The Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL) is designed to help project planners and managers integrate climate change adaptation into community-level projects. Developed by the International Institute for Sustainable Development (IISD), International Union for Conservation of Nature (IUCN), and Intercooperation and Stockholm Environment Institute (SEI).

[www.cristaltool.org](http://www.cristaltool.org)

## Further tools and approaches

- **FAO activities**

The Food and Agriculture Organization of the United Nations (FAO) has created an e-learning tool on climate and flood forecast applications in agriculture. It was developed in collaboration with the Asian Disaster Preparedness Center and the Department of Physical Geography at the University of Freiburg, Germany, to assist interested learners and disaster managers.

[www.fao.org/...](http://www.fao.org/...)

- **PRECIS**

PRECIS stands for "Providing REgional Climates for Impacts Studies." Researchers at the Met Office Hadley Centre (meteorological service and world area forecasting) produce and maintain a range of gridded datasets of meteorological variables for use in climate monitoring and climate modelling.

[www.precis.metoffice.com](http://www.precis.metoffice.com)

- **CEDRA**

Tearfund, a Christian relief and development agency, has developed an environmental field tool for agencies working in developing countries: Climate change and Environmental Degradation Risk and Adaptation assessment (CEDRA). Adaption options are discussed, and decision-making tools are provided to help organisations plan their responses to the hazards identified.

[www.tilz.tearfund.org/...](http://www.tilz.tearfund.org/...)

- **Climate Change Impact and Adaptation in Asian Coastal Cities**

The Japan International Cooperation Agency (JICA) has conducted a Joint Study "Climate Change Impact and Adaptation in Asian Coastal Cities" in cooperation with the World Bank and the Asian Development Bank.



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[www.jica.go.jp/...](http://www.jica.go.jp/...)



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# **Impact Assessment Methodologies: Agriculture**

# Socio-economic Impact Assessment Methodologies

## Agronomic-Economic Approach

- Agronomic models are used first to predict climate change impacts on crop yields and the estimated yield changes are then introduced into economic models to predict output and price changes.

$$Y_i \leq F_1(X_{i1}, X_{i2}, \dots, X_{ik}) * F_2(E_1, E_2, \dots, E_j)$$

- Feasible to model CO<sub>2</sub> fertilization effects.
- Relatively difficult to include *all* possible farm level adaptation options.

Adams et al. (1990, 1999), Rosenzweig and Paryy (1994),  
Kumar and Parikh (2001b)



# Agro ecological Zone Approach

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- Assigns crops to agro ecological zones and estimates potential crop yields. As climate changes, the extent of agro ecological zones and the potential yields of crops assigned to those zones changes. These acreage and yield changes are then included in economic models to assess socio-economic impacts.

Darwin et al. (1995, 2000), Kumar (1998), IIASA (2002)

# Ricardian Approach

- Similar to Hedonic pricing approach of environmental valuation. The approach is based on the argument that, ‘by examining two agricultural areas that are similar in all respects except that one has a climate on average (say) 3°C warmer than the other, one would be able to infer the *willingness to pay* in agriculture to avoid a 3°C temperature rise’.
- Uses statistical analysis of data across geographic areas to separate climate from other factors (such as soil quality) that explain production differences across regions and uses the estimated statistical relationships to assess impacts of climate change.
- Main advantage of this method is that it incorporates *all* private adaptation measures.
- Assumes that relative prices do not change and hence biases the results.
- Not feasible to incorporate CO<sub>2</sub> fertilization effects.

Mendelsohn et al. (1994), Dinar et al. (1998), Kumar and Parikh (2001a)

# Impacts on Indian Agriculture –Literature

- Sinha and Swaminathan (1991) – showed that an increase of 2°C in temperature could decrease the rice yield by about 0.75 ton/ha in the high yield areas; and a 0.5°C increase in winter temperature would reduce wheat yield by 0.45 ton/ha.
- Rao and Sinha (1994) – showed that wheat yields could decrease between 28 to 68% without considering the CO<sub>2</sub> fertilization effects; and would range between +4 to -34% after considering CO<sub>2</sub> fertilization effects.

Aggarwal and Sinha (1993) – using WTGROWS model showed that a 2°C temperature rise would decrease wheat yields in most places.

- Lat et al. (1996) – concluded that carbon fertilization effects would not be able to offset the negative impacts of high temperature on rice yields.
- Saseendran et al. (2000) – showed that for every one degree rise in temperature the decline in rice yield would be about 6%.

Aggarwal et al. (2002) – using WTGROWS and recent climate change scenarios estimated impacts on wheat and other cereal crops.

All these studies focused only on agronomic impacts of climate change.

# Socio-economic Impacts of Climate Change and Climate Variability

## Some recent estimates for India

### Results Based on Agronomic-Economic Approach

These results are obtained by incorporating crop yield changes associated with various equilibrium climate change scenarios into an applied general equilibrium model, and the reported figures correspond to the terminal period of the simulation.

Variable	GFDL	GISS	UKMO
GDP (%)	-1.8	-2.5	-3.4
Cal per cap (%)	-18.2	-19.5	-21.6
Pop. prop. in bottom two expenditure classes - rural (base 0.183)	0.283	0.294	0.311
Pop. prop. in bottom three expenditure classes – urban (base 0.145)	0.208	0.214	0.226

# Socio-economic Impacts of Climate Change and Climate Variability

Some recent estimates for India

## Results Based on Ricardian Approach

These results are based on climate response function estimated using district level time-series observations on farm management and crop output. Reported figures indicate percentage change in total net-revenue and the 95 percent confidence interval are given in brackets.

$\Delta T \setminus \Delta P$	0%	+7%	+14%
+1.0°C	-3.1 (-2.3 to -3.9)	-1.3 (-0.5 to -2.2)	+0.5 (+1.5 to -0.4)
+2.0°C	-9.6 (-8.5 to -10.7)	-7.8 (-6.7 to -8.9)	-6.0 (-4.7 to -7.2)
+3.5°C	-27.5 (-25.5 to -28.8)	-25.7 (-23.6 to -27.0)	-23.7 (-21.6 to -25.2)

# Socio-economic Impacts of Climate Change and Climate Variability

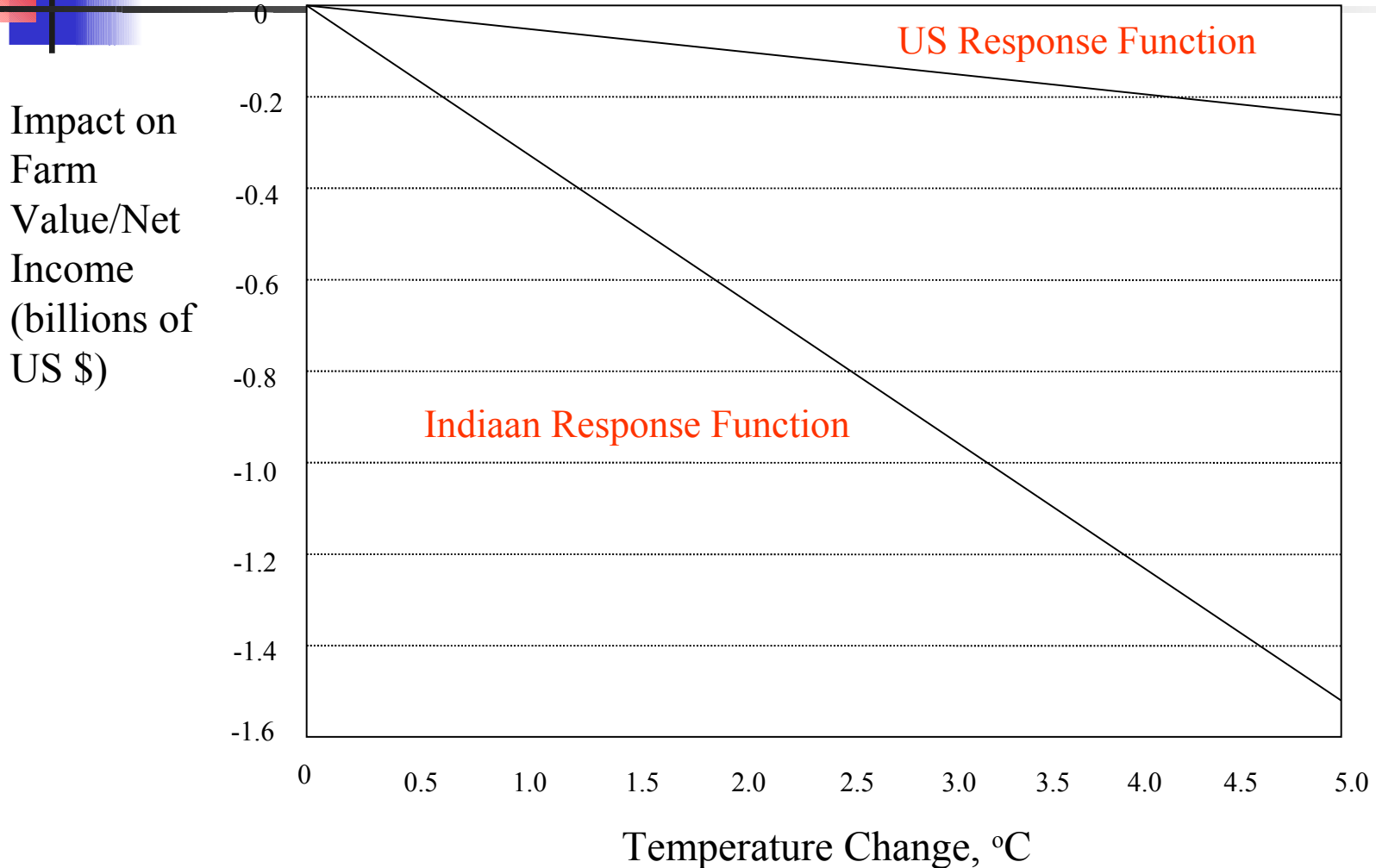
Some recent estimates for India

## Ricardian Estimates with Climate Variation

$$R = f(T, P, DVarT, YVarT, K)$$

$\Delta T/\Delta P$	Impacts as percentage of Net Revenue		
	Without Variation Terms	With Variation Terms	With Variation Terms and 5% Higher Variation
2°C/7%	-7.8	- 6.8	-9.5
3.5°C/14%	-24.0	- 17.8	-28.1

# Climate Sensitivity Functions of the US and India – Applied to India



Source: Mendelsohn and Dinar (2000)

# Limitations of current estimates

- The impacts estimated using agronomic-economic approach are likely to be upwardly biased (compared to the Ricardian estimates) as they do not account for adaptation.
- On the other hand the Ricardian estimates by not capturing the carbon fertilization effects tend to over estimate the impacts.
- The use of cross-section variation to predict time series behavior requires many assumptions to be satisfied: (a) that variations over time and space are equivalent, (b) only one steady state occurs per set of exogenous conditions, and (c) that a few climatic variables (say, average temperature and precipitation and perhaps a simple measure of variability) capture all the relevant information about climate change and its impacts on agriculture.



## Excluded from the estimates

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- Present estimates do not account for impacts due to extreme weather events, whose frequency and intensity is likely to get altered with climate change.
- A number of agronomic links – such as impact of climate change on behavior of pests and diseases - are still not very clearly understood and hence their economic implications are also not incorporated in the current estimates.

# Adaptation Options

Possible at various levels - farmer, economic agent, macro

Potential and costs of adaptation - possibly through historic analysis of technology penetration

- For example, Reilly and Schimmelpfennig (1999) show the relative speed of adoption of various measures:

Adaptation Measure	Adjustment Time (years)
Variety Adoption	3-14
Dams and Irrigation	50-100
Variety Development	8-15
Tillage Systems	10-12
Opening New Lands	3-10
Irrigation Equipment	20-25
Fertilizer Adoption	10

# Work Done In Field Of Urban Development and Climate Adaptation

By

Center of Excellence



**IRADe** Integrated Research and  
Action for Development



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## **A. Rapid Vulnerability Assessment (preliminary)**

- 1) Literature Review( international and national institutions and organizations)**
- 2) IRADe Methodology**
- 3) Execution (for 14 select cities)**

## **B. Case Studies**

### **1) Literature Review –Surat**

- Disaster events study for Surat**
- Study structure for Surat**
- Primary and secondary data collection and analysis**



# Adaptation in the urban areas

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*Cities will need to adapt for future floods, droughts, storms and heat waves through following:*

- **Remodeling drainage system that can accommodate sudden downpour.**
- **High Capacity water supply and storage systems for drought periods.**
- **Embankments of low-lying areas especially for coastal cities.**
- **Stronger buildings, bridges, flyovers, also water supply and treatment plants that withstand storms.**



# IRADe Approach for RVA

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**It involves key elements of Urban Socioeconomy for mitigation and adaptation**

- **Climatological Variables**
- **Topological**
- **Demographic**
- **Social**
- **Economic**
- **Infrastructure**
- **Urban Design**
- **Governance**
- **Transport**
- **Energy Application**



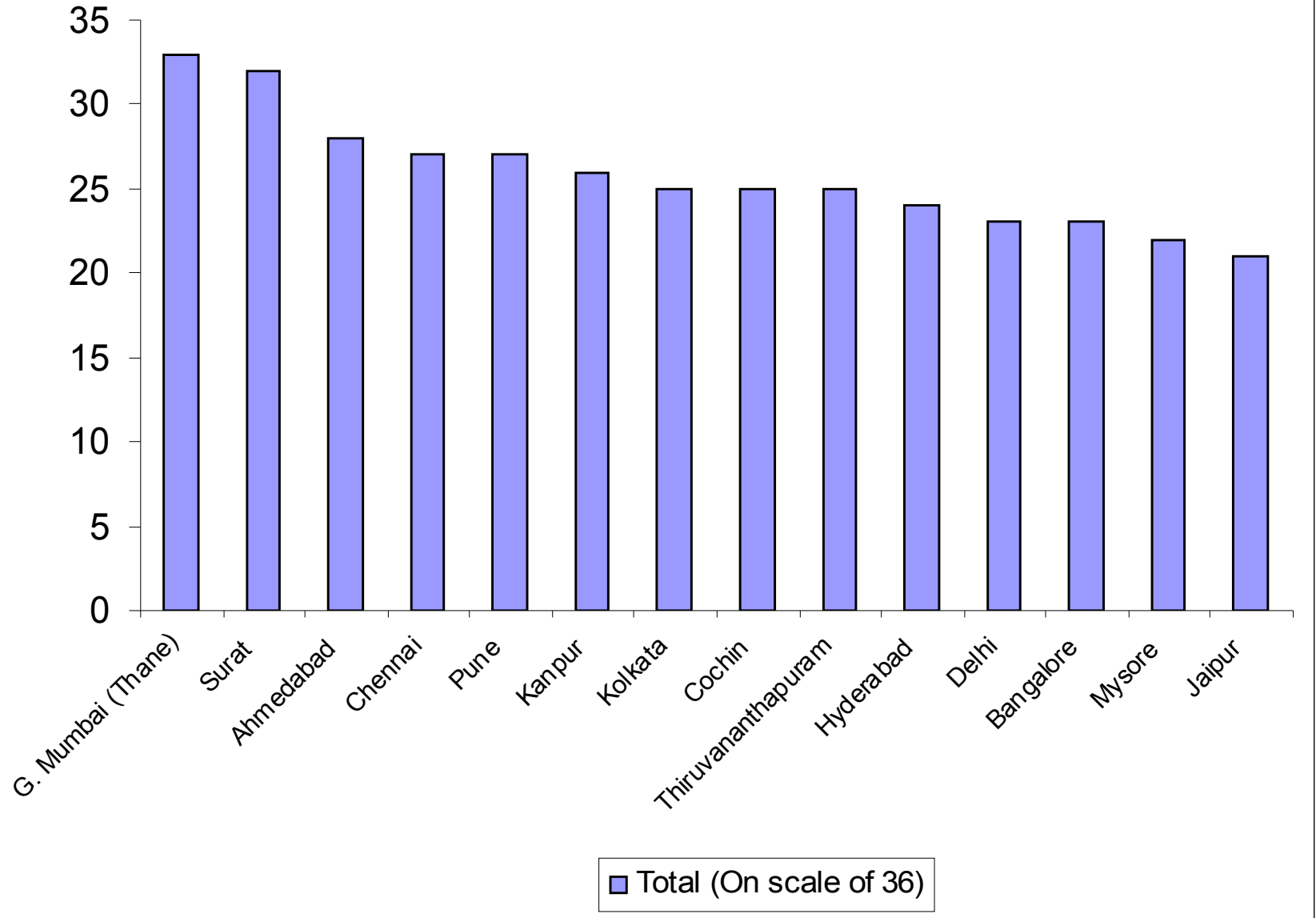
## A3. Rapid Assessment Variables

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It includes the following variables

- **Climate**
  - **Temperature**
    - **Maximum & Minimum**
    - **Temperature Increase 2030 & 2080**
  - **Rainfall**
    - **Average**
    - **Precipitation Increase 2030 & 2080**
- **Topological**
  - **Altitude**
- **Demographical**
  - **Population density**
- **Social**
  - **Slum Population**
  - **Literacy Rate**
- **Economic**
  - **Employment**

# Rapid Analysis(Preliminary stage)





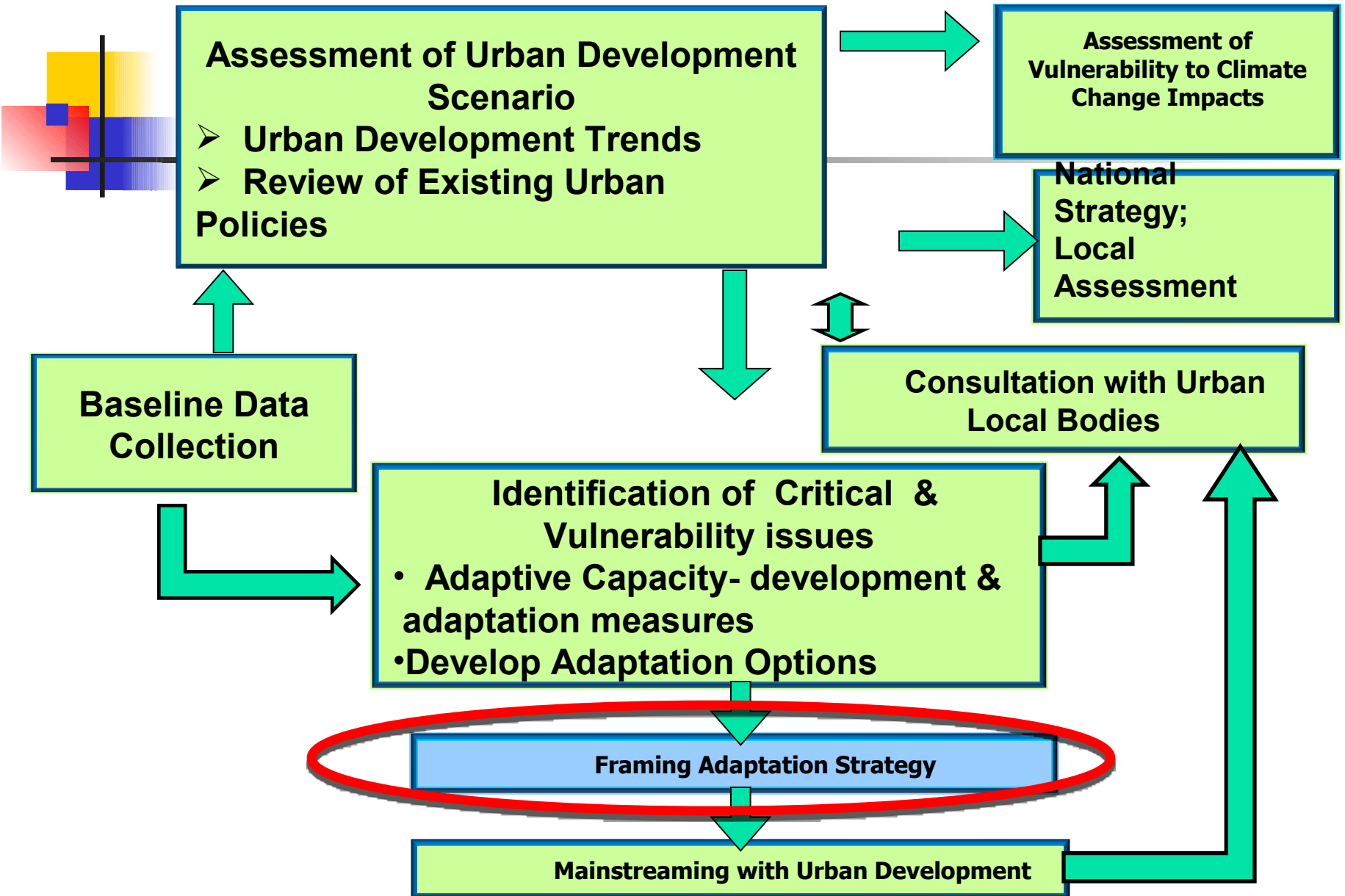
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**Framework**

**For**

**Cities and Climate Adaptation**

# Frame Work Methodology for Urban System





# Storm Water Management

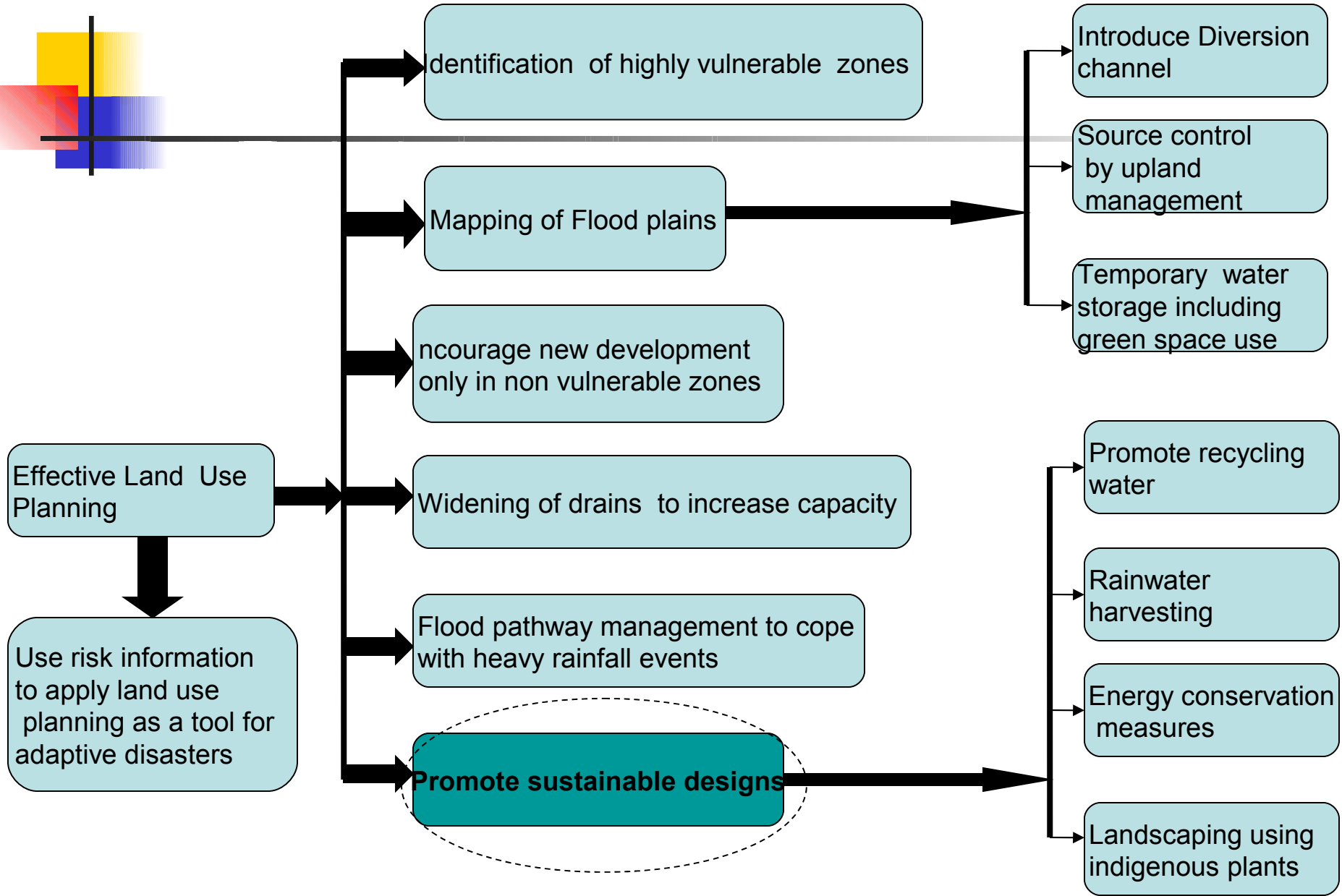
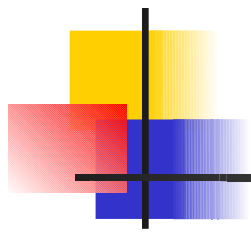
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- Rapid conversion of land to urban and suburban areas has altered the water flow pattern.
- During the flood increased volume of water and pollutants reduces the water quality.

## **The following adaptation strategy can be followed**

- Reduce the volume of storm water.
- Reuse and Reduce water logging to maintain smooth flow.
- Reduce the pollution levels of storm water.

# Urban Design & Climate Resilience





# Surat:

## Vulnerability assessment (preliminary)

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### Strengths

- 95% house ownership
- Dependable Water supply
- High Access to informal credit
- Existence of a Disaster Management Plan with community linkage

### Weaknesses

- Flood accounts for maximum damage through a disaster every year
- Dependency ratio of less than 1:5 ( earning member to dependants)
- Low access to Semi-Formal financial institutions
- Low community support system
- Poor awareness and knowledge of the disaster management plan a



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## **Socio-economic**

- **education level of the population**
- **Income dependence on local economy for sustenance**
- **Level of exposure of population under 10, 20 year flood plains etc**

## **Infrastructure**

- **percentage of the city population serviced with basic infrastructure- water supply, roads, sewers, etc**
- **Future assessment of the Surat's growing demand and supply plan in place to mitigate climate change**

## **Transport**

- **Evaluation of accessibility of population to public transport.**
- **Networks and quality of connections by assessment of square feet of surfaced roads**
- **Evaluation of adequacy of future projects planned relating to urbanization pressures.**

# Example: Services and infrastructure evaluation

*Source: Surat City Development Plan*

<b>Service</b>	<b>Population serviced (current)</b>	<b>Future Demand (2021)</b>	<b>Future Supply planned</b>
<b>Water Supply</b>	<b>95%</b>	<b>29.8% (from 2011)</b>	<b>44%(wastage not accounted for)</b>
<b>Sewerage System</b>	<b>97.10%</b>		
<b>Storm Water Drainage</b>	<b>85%(city area) but mostly lack leader lines to support natural system.</b>	<b>No evaluation of future demand present in CDP.</b>	<b>24.74% increase in length of drains.</b>
<b>Roads</b>	<b>25% of the area of SMC. 93% asphalt roads unsuited to topography</b>	<b>Not quantified in the CDP</b>	<b>Up-grading 65 % to C.C roads along with ring roads and bridge constructions</b>
<b>Flood Embankment</b>			<b>Ongoing project for building Tapi embankment for 1.5 lacs cusecs discharge</b>

# Secondary variables (based on impact)

Climate Sensitive Systems	Food supply	Infrastructure	Health	Water resources	Migration and conflict	Aggregate market impacts and distribution
Criteria for vul.						
magnitude of impacts,	Y	Y	Y	Y	Y	Y
timing of impacts		Y	Y	Y		
persistence and reversibility of impacts			Y (irreversibility)			
likelihood (estimates of uncertainty) of impacts and vulnerabilities and confidence in those estimates						
potential for adaptation	Y	Y	Y	Y	Y	Y
distributional aspects of impacts and vulnerabilities	Y	Y	Y	Y	Y	Y
importance of the system (s) at risk						
<i>Source: IPCC (Assessment Report 4)</i>	MODERATE	HIGH	VERY HIGH	HIGH	MODERATE	MODERATE



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## Disaster Management

- Incorporate Disaster Management Plan as part of the Master Plan
  - Build stronger database for the city to increase preparedness
  - Frame higher safety standards for contractors and builders
- 
- **Flood control initiatives**
  - No Encroachment /Construction in risk area
  - Protective hard embankment
  - River trenching
  - Emergency response centre
  - Emergency plan – Place & training



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## Urban Transport( reducing resource consumption and pollution)

- Address connectivity issues while creating alternative means of transportation networks
  - for cyclists
  - Improving walkability
- Explore opportunities for a public transportation system through completion of a comprehensive traffic and transportation master plan.



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# **International Issues requiring immediate Attention**



# Mitigating GHGs emission

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- How did GHG accumulation take place?
- who emitted how much?
- what to do to reduce them?
- what are differentiated responsibilities?
- can per capita emission be the criterion to decide permissible emission levels?



# Issues regarding Adaptation

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- What impact is caused, who will suffer, and who should pay for this?
- How do we share the burden of suffering, reduce vulnerabilities and innovate on ways to deal with adaptation through technologies, infrastructure, knowledge-sharing and financing?
- The calls for climate justice is not just about equal access to global environmental space; it is also about compensating the victims.



Thank you

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