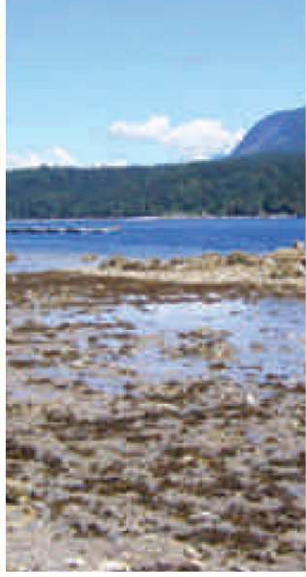




# Environmental Extremes

## DISASTER RISK MANAGEMENT

*Addressing Climate Change*

# ENVIRONMENTAL EXTREMES DISASTER RISK MANAGEMENT

*Addressing Climate change*

Anil K. Gupta  
Sreeja S. Nair

ISBN 978-81-924336-5-3

### **Copyright**

@ NIDM, New Delhi, 2012

Contents of this book can be freely used, cited, translated and referred in any academic, research and capacity development purpose with proper citation of this publication and the respective contributors.

### **Publication developed by**

Dr. Anil K Gupta, Associate Professor

Sreeja S. Nair, Assistant Professor

### **Reviewers**

Jaiganesh Murugesan, DRR Specialist, UN HABITAT, Myanmar

Anup Karanth, Senior Consultant, TARU Leading Edge.

### **Acknowledgements**

The literature including data and photographs, maps, etc. used in this publication have been drawn from a range of sources including published and unpublished material, internet websites, personal communiqué, etc. and their original sources are gratefully acknowledged. Authors are responsible for their useful interpretation in the relevant context. Views expressed are not necessarily of the Government. Authors acknowledge the support of following in developing the publication.

Dr. Satendra, IFS, Executive Director, NIDM

Prof. V K Sharma, Indian Institute of Public Administration, New Delhi

Dr. Akhilesh Gupta, Advisor, Department of Science and Technology, Govt. of India

Dr. Santosh Kumar, Professor, NIDM

Dr. Chandan Ghosh, Professor, NIDM

Dr. Surya Parkash, Associate Professor, NIDM

Shekhar Chaturvedi, Faculty Member, NIDM

Dr. Ritu Raj, Faculty Member, NIDM

Santosh Tiwari, Librarian, NIDM

Hemant Kumar, Computer Programmer

Megha Kohli, Training Assistant, NIDM

Deepika Sharma, Training Assistant, NIDM

Prem Shankar, Training Assistant, NIDM

### **Citation**

Gupta, Anil K. and Nair, Sreeja S. (2012). Environmental Extremes Disaster Risk Management – Addressing Climate change. National Institute of Disaster Management, New Delhi.

### **Published by**

National Institute of Disaster Management, New Delhi.



Vice Chairman  
National Disaster Management Authority  
Government of India

## MESSAGE

The U.N General Assembly had designated 5<sup>th</sup> June as the World Environment Day in the wake of the United Nations Conference on the Human Environment held in Stockholm in June 1972. The objective was to stimulate awareness of the environment and enhance political and public action to protect and improve environment for the benefit of present and future generations. Faltering global economy, food and energy insecurity, conflicts, global climate change, declining ecosystems, extreme poverty and the threat of disease outbreaks are amongst the factors challenging the progress towards improving human well being and economic stability in many developing countries.

The Global Assessment Report on Disaster Risk Reduction: Risk and Poverty in a Changing Climate, 2009, identifies ecosystems decline as a key driver in exacerbating the natural hazards in the future. It is important to analyze and understand the two way linkage between environment and disasters. Disasters can have adverse environmental consequences, while degraded environments cause or amplify the detrimental impacts of disasters. Global climate change accelerate ecosystems degradation and disaster risk due to increasing and extreme weather events like heat and cold waves, floods, landslides and prolonged droughts. Healthy and well-managed ecosystems, on the other hand, are more robust against hazards.

Adopting an integrated approach to environment and ecosystem management for sustainable livelihoods, climate change adaptation and disaster risk reduction is the need of the time. The theme chosen by NIDM on World Environment day "Safeguard the Environment for Disaster Risk Reduction" reflects the pressing need for arresting environmental degradation and improving management of ecosystems and natural resources for achieving Disaster Risk Reduction and adapting to climate risks. Everyone can do their bit. **After all, while we think globally, we have to act locally!**

New Delhi  
01 June 2012

(M. SHASHIDHAR REDDY)



**Dr. SATENDRA, IFS**  
Executive Director



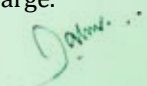
## FOREWORD

Anthropogenic climate change is increasingly been considered as a major environmental threat to the planet and its living world. Human activities, primarily the burning of fossil fuels along changes in land use and land cover are leading to the environmental changes with more serious consequences on global and regional climate. Scientific studies have shown that human health, ecosystems, hydrology and water resources, food and fiber production, coastal systems human settlements and other socio-economic sectors are sensitive to changes in climate, including both the magnitude and rate of climate change as well as to changes in climate variability.

Whereas many regions are likely to experience adverse effects of climate change, in few regions the impacts are potentially irreversible and some effects of climate change are likely to be beneficial as well in certain regions. So far the most policy interventions related to climate change were mitigation centric and were based on the geophysical parameters, whereas the focus is now shifting towards vulnerability centric approach, as reflected in the "IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, 2012". The assessment concerns the interaction of climatic, environmental, and human factors that can lead to impacts and disasters, options for managing the risks posed by impacts and disasters, and the important role that non-climatic factors play in determining impacts.

NIDM's activities and interventions are addressing the key issues of environmental and social dimensions of vulnerability coupled with the scientific analysis through various activities of research, training and policy advocacy. Integration of climate change adaptation and disaster risk reduction are being emphasized within the programmes of NIDM. The Indo-German cooperation project 'Environmental Knowledge for Disaster Risk Management', UNDP's initiative with NIDM on Mainstreaming DRR into Environment Sector, UN-PEDRR joint programme with NIDM on Ecosystem Approach on Disaster Risk Reduction (ecoDRR), are few to mention.

This publication has been developed on climate change and disaster management issues with context of South Asia and more particularly on India. I appreciate the efforts of my faculty colleagues Dr. Anil K Gupta and Ms. Sreeja S Nair who took initiative and developed this publication in a very short time, to be released on the occasion of the World Environment Day 5th June 2012. I hope the publication shall be useful to the readers and will facilitate wider awareness among policy makers, planners and people at large.

  
(Satendra)



## PREFACE

“The development process does not necessarily reduce vulnerability to natural hazards. Instead, it can unwittingly create new forms of vulnerability or exacerbate existing ones, impeding efforts to reduce poverty and promote growth, sometimes with tragic consequences.”<sup>1</sup> This fact is often hard to accept when amongst firm believers of economic and infrastructure growth as panacea to human miseries. The notion of ‘quality of life’ as different of ‘standard of living’ as a key to sustainability thoughts direct those who believe in disaster risk reduction a better and cost-effective strategy than disaster response and consolation, offers the strategies that are interdisciplinary and respects ecology, livelihood, health and living with nature for sustaining the human race. Climate Change awareness has warned us of impending dangers not only to our food security, water and ecosystems, but to the dynamic earth-system encompassing human actions and their socio-polity.

Installing a ‘win-win’ situation may not be always possible, is a hard truth, and for addressing sustainability quests are needed to have ‘check and balances’ – in the earth-systems, ecology and in human-development approaches, and there lies the use of technology and human wisdom. Time Magazine termed ‘climate change’ as the topmost man-made disaster of the century. While recognizing no boundaries exist to apart natural from such man-made disasters that aggravate the furry and havocs of calamitous floods, drought, cyclone, tsunami, landslides, wildfires, pests and epidemics, etc. While we understand that a ‘disaster’ is once ‘hazard’ meet vulnerability and causes ‘loss or damage’ beyond local coping capacity, influence of land-use and landscape changes, drainage alteration, poor and improper waste management, soil alteration and less notices but more important – changing energy flux – can aggravate even earthquake tremor’s effects on buildings, infrastructure and anything on the earth’s surface including landscape. ‘Does climate change affect earthquake?’ is a recent quest for researchers.

However, directly related with the climate change, global, regional and of course - local, are the hydro-meteorological disasters that affect most populations and in variety of ways. The light of Millennium Ecosystem Assessment (2005) that emphasized livelihood and food insecurity as key challenge of human vulnerability is an insight to understand the significant efforts of IPCC, in particular the 4<sup>th</sup> Assessment Report and the recent SREX report – to draw the concerns for South Asia and more particularly for India. The recall of efforts of International-Geosphere-Biosphere programme is due to renewed focus on vulnerability of ecosystems, natural resources and the land as key in realizing disasters. Message is to relook the existing tools and methods, policies and knowledge with needed advances of technology for adaptation to such changes in environment, climate and earth system as sustainable ways to achieve Millennium Development Goals.

NIDM has the credit to initiate integration of disaster management with climate change way back in 2007 even before 4<sup>th</sup> Assessment report’s release. The recent development of ‘ecosystem based disaster risk reduction’, ‘guidelines and tools for mainstreaming disaster risk reduction into environment management’ and programme on ‘environmental knowledge for disaster risk management’ are some strategic programmes in this direction. This publication aiming at reference for the local policy makers and planners, and in general for people at large, tries to concise on challenges, issues and solutions for climate change – adaptation and integration with disaster risk management.

**Anil K. Gupta**  
**Sreeja S. Nair**

---

<sup>1</sup>Tools for Mainstreaming Disaster Risk Reduction: Guidance Notes for Development Organisations. 2007 International Federation of Red Cross and Red Crescent Societies / the ProVention Consortium.

# CONTENTS

|      |                                                                                                            |    |
|------|------------------------------------------------------------------------------------------------------------|----|
| i.   | Message                                                                                                    |    |
| ii.  | Foreword                                                                                                   |    |
| iii. | Preface                                                                                                    |    |
| 1    | <b>Global Environmental Changes</b><br><i>Climate Change Science, Debate and Resolutions</i>               | 1  |
|      | History of global change research                                                                          |    |
|      | Global Warming Vs Climate Change                                                                           |    |
|      | Impacts of Climate Change : IPCC Assessment Reports                                                        |    |
|      | Climate Models: Limitations and Risks                                                                      |    |
| 2    | <b>Special Report on Extreme Weather Events</b><br><i>Concerns for South Asia</i>                          | 7  |
|      | Special Report on Extreme Weather Events to Advance Climate Change Adaptation                              |    |
|      | South Asia and Climate Change                                                                              |    |
| 3    | <b>Climate Change Impacts in India</b><br><i>Hydro meteorological disasters</i>                            | 9  |
|      | Observed climatic changes for Asia                                                                         |    |
|      | India 4X4 Assessment                                                                                       |    |
|      | <b>Viewpoints</b>                                                                                          | 12 |
| 4    | <b>Climate Change and Disasters</b><br><i>Pathways to Consequence</i>                                      | 16 |
| 5    | <b>Addressing Climate Change</b><br><i>Vulnerability Matters in Disaster Risk Management</i>               | 18 |
| 6    | <b>Hydro meteorological Disasters</b><br><i>Risks and Management</i>                                       | 20 |
|      | Cyclone                                                                                                    |    |
|      | Drought                                                                                                    |    |
|      | Flood                                                                                                      |    |
|      | Forest Fire                                                                                                |    |
|      | Epidemics                                                                                                  |    |
| 7    | <b>Natural Hazards and Risks in Mountains</b><br><i>The Potential Impacts of Climate Change</i>            | 24 |
| 8    | <b>Coastal Hazards and Disaster Risk</b><br><i>The Potential Impacts of Climate Change</i>                 | 25 |
| 9    | <b>Climate Change Adaptation</b><br><i>Disaster Risk Reduction</i>                                         | 26 |
|      | Mitigation and adaptation                                                                                  |    |
|      | Resistance and Resilience                                                                                  |    |
|      | Disaster Management and Risk Reduction                                                                     |    |
|      | Convergence of CC Adaptation and DRR                                                                       |    |
| 10   | <b>Disaster Management Planning and Tools</b><br><i>Integrating Adaptation and Disaster Risk Reduction</i> | 30 |
|      | Disaster Management Planning                                                                               |    |
| 11   | <b>Scholar Inputs</b>                                                                                      | 32 |
| 12   | <b>About NIDM</b>                                                                                          | 33 |

# Global Environmental Changes

## Climate Change Science, Debates and Resolutions

The planet is now dominated by human activities. Throughout our history, humans have had significant local effects on the environment. That has now changed. Since the industrial revolution in 1750 humans have grown into a global force to be reckoned with. Human changes to the Earth system are multiple, complex and interacting. They are often exponential in rate and globally significant in magnitude. They affect every Earth system component - land, coastal zone, atmosphere, cryosphere and oceans.

**Climate change** is a phrase that is essentially self explanatory, it is the change in the climate of a country, region, or the world over, and is believed to be caused either directly or indirectly by the activity of the human race. *The Anthropocene* is a recent and informal chronological term that serves to mark the evidence and extent of human activities that have had a significant global impact on the Earth's ecosystems.

### History of global-change research<sup>1</sup>

The United Nations Conference on the Human Environment (the Stockholm Conference) was an international conference convened under United Nations auspices held in Stockholm, during June 5–16, 1972. It was the UN's first major conference on international environmental issues, and marked a turning point. This conference led to a much greater understanding in the wider world about the nature and scale of human impacts on the environment. In 1979, a group of scientists led by a Swedish meteorologist set up the World Climate Research Programme (WCRP) to determine if the climate was changing, whether it could be predicted and whether humans were responsible for the change? In 1987 a programme sponsored by the International Council of Scientific Unions (ICSU), the International Geosphere-Biosphere Programme (IGBP), was launched with eight projects investigating different parts of the earth system and links between them. On IGBP's successful advocacy, the United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO) jointly established the Intergovernmental Panel on Climate Change (IPCC) in 1988. IGBP and WCRP, as international leaders in global-change research work closely with the IPCC, hold joint meetings and scoping. Several scientists involved in the IGBP community contributed to IPCC Assessment Reports.

### A new era in Earth system science

IGBP, WCRP and a third programme, the **International Human Dimensions Programme** (IHDP, founded in 1996), spearheaded a landmark science conference held in Amsterdam in 2001. The conference, Challenges of a Changing Earth: Global Change Open Science Conference, led to the Amsterdam Declaration:

- "In addition to the threat of significant climate change, there is growing concern over the ever-increasing human modification of other aspects of the global environment and the consequent implications for human well-being."
- "Basic goods and services supplied by the planetary life support system, such as food, water, clean air and an environment conducive to human health, are being affected increasingly by global change."
- "The international global-change programmes urge governments, public and private institutions and people of the world to agree that an ethical framework for global stewardship and strategies for Earth System management are urgently needed."

Since the Amsterdam declaration another international programme *DIVERSITAS* from the Earth System Science Partnership, and plan for Planet Under Pressure: new knowledge towards solutions 2012 in London. The term "Earth system" refers to Earth's interacting physical, chemical, and biological processes. Life too is an integral part of the Earth system. Life affects the carbon, nitrogen, water, oxygen and many other cycles and processes. The Earth system now includes human society, our social and economic systems are now embedded within the Earth system. In many cases, the human systems are now the main drivers of change in the Earth system.

<sup>1</sup><http://www.igbp.net>

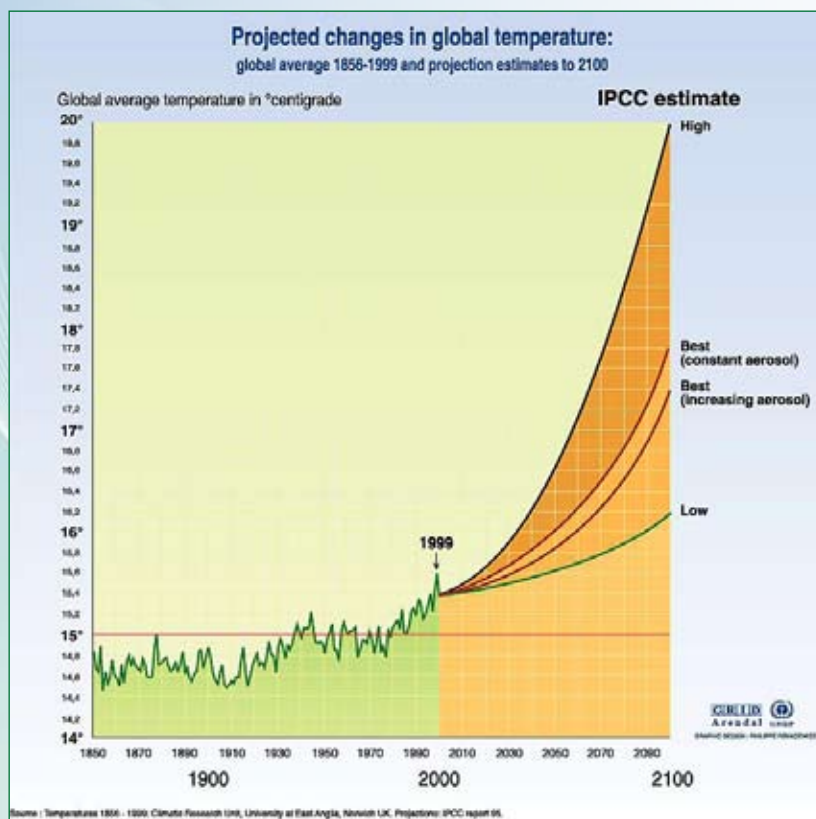


**Figure1.** Projected changes in global temperature: Global average 1956-1999 and projection estimates to 2100. Courtesy GRIDA/UNEP.

## Global change and climate

Climate refers to the long-term average of the aggregation of all components of weather— precipitation, temperature and cloudiness, for example. The climate system includes processes involving ocean, land and sea ice in addition to the atmosphere.

The Earth system encompasses the climate system. Many changes in Earth system functioning directly involve changes in climate. However, the Earth system includes other components and processes, biophysical and human those are important for its functioning.

Some Earth system changes, natural or driven by humans, can have significant consequences without involving changes in climate. Global change should not be confused with climate change; it is significantly more, indeed, climate change is part of this much larger challenge.

## Climate change is for real?

The debate is over about whether or not climate change is real. Irrefutable evidence from around the world—including extreme weather events, record temperatures, retreating glaciers and rising sea levels—all point to the fact that climate change is happening now and at rates much faster than previously thought. The overwhelming majority of scientists who study climate change agree that human activity is responsible for changing the climate. The United Nations Intergovernmental Panel on Climate Change (IPCC) is one of the largest bodies of international scientists ever assembled to study a scientific issue, involving more than 2,500 scientists from more than 130 countries. The IPCC has concluded that most of the warming observed during the past 50 years is attributable to human activities. Its findings have been publicly endorsed by the national academies of science of all G-8 nations, as well as those of China, India and Brazil.

## Global warming Vs. Climate change

Many people use the terms “climate change” and “global warming” interchangeably, but there are differences. Global Warming is the overall warming of the planet, based on average temperature over the entire surface. Whereas ‘Climate Change’ denotes the changes in regional climate characteristics, including temperature, humidity, rainfall, wind, and severe weather events. Planet Earth’s current warming trend is based largely on natural warming and cooling cycles that have been happening for eons; as well as human-caused additions to greenhouse gases, which are boosting the atmosphere’s ability to trap heat in the biosphere. Minor factors like an overall increase in the sun’s solar intensity play a smaller role.

*While greenhouse gases are an essential component of a livable planet—they’re what keep Earth protected from being a lifeless ball of ice—anthropogenic increase of greenhouse gas is so quick that is causing the average global temperature to rise much faster than it would naturally.*

Whereas “global warming” refers to increasing global temperatures, “climate change” refers to regional conditions. There are important differences between global warming and climate change, but the two are closely intertwined in determining the climate futures for the regions where we live.

## Impacts of Climate Change: IPCC - IV Assessment (2007)

Results of IPCC work on observed and ongoing/projected impacts on climate change on natural and human environment has been given in its IV assessment report released in 2007 December. The observed impacts have been termed as



the high confidence impacts, whereas the evidence of likelihood are emerging are called as medium confidence impacts. These observations, depicting the global challenges, are summarized below:

### ➤ With regard to snow, ice and frozen ground:

- enlargement & increased numbers of glacial lakes
- increasing ground instability in permafrost regions, & rock avalanches in mountain regions
- changes in some Arctic and Antarctic ecosystems, including those in sea-ice biomes, and also
- predators high in the food chain

### ➤ Effects on hydrological systems

- increased run-off & earlier spring peak discharge in many glacier- & snow-fed rivers
- warming of lakes & rivers in many regions, effects on thermal structure & water quality

### ➤ Effects on terrestrial biological systems

- earlier timing of spring events, such as leaf-unfolding, bird migration & egg-laying
- poleward & upward shifts in ranges in plant and animal species

### ➤ Changes in marine & freshwater systems

*(associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation)*

- shifts in ranges & changes in algal, plankton and fish abundance in high-latitude oceans
- increases in algal & zooplankton abundance in high-latitude and high-altitude lakes
- range changes & earlier migrations of fish in rivers
- The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic with an average decrease in pH of 0.1 units.
- effects of observed ocean acidification on the marine biosphere are as yet undocumented

### ➤ Medium confidence observations (*Effects of temperature increases*)

- effects on agricultural and forestry management at Northern Hemisphere higher latitudes, such as earlier spring planting of crops, and alterations in disturbance regimes of forests due to fires and pests
- some aspects of human health, such as heat-related mortality in Europe, infectious disease vectors in some areas, and allergenic pollen in Northern Hemisphere high & mid-latitudes
- some human activities in the Arctic (e.g., hunting and travel over snow and ice) & in lower elevation alpine areas (such as mountain sports)

## Climate change Impacts

Climate change impacts can be roughly divided into two groups:

### Environmental impacts

- physiological effects on crops, pasture, forests and livestock (quantity, quality);
- changes in land, soil and water resources (quantity, quality);
- increased weed and pest challenges;
- shifts in spatial and temporal distribution of impacts;
- sea level rise, changes to ocean salinity;
- sea temperature rise causing fish to inhabit different ranges.

### Socio-economic impacts

- decline in yields and production;
- reduced marginal GDP from agriculture;
- fluctuations in world market prices;
- changes in geographical distribution of trade regimes;
- increased number of people at risk of hunger and food insecurity;
- migration and civil unrest.

**Table 01:** Change in extremes for phenomena over the specified region and period, with the level of confidence and section where the phenomenon is discussed in detail

| Phenomenon                                                         | Change                                                                                 | Region                                                                         | Period                                          | Confidence                                                           |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------------------------|----------------------------------------------------------------------|
| <b>Low-temperature days/nights and frost days</b>                  | Decrease, more so for nights than days                                                 | Over 70% of global land area                                                   | 1951–2003 (last 150 years for Europe and China) | Very likely                                                          |
| <b>High-temperature days/nights</b>                                | Increase, more so for nights than days                                                 | Over 70% of global land area                                                   | 1951–2003                                       | Very likely                                                          |
| <b>Cold spells/snaps (episodes of several days)</b>                | Insufficient studies, but daily temperature changes imply a decrease                   |                                                                                |                                                 |                                                                      |
| <b>Warm spells (heat waves) (episodes of several days)</b>         | Increase: implicit evidence from changes of daily temperatures                         | Global                                                                         | 1951–2003                                       | Likely                                                               |
| <b>Cool seasons/ warm seasons (seasonal averages)</b>              | Some new evidence for changes in inter-seasonal variability                            | Central Europe                                                                 | 1961–2004                                       | Likely                                                               |
| <b>Heavy precipitation events (that occur every year)</b>          | Increase, generally beyond that expected from changes in the mean (disproportionate)   | Many mid-latitude regions (even where reduction in total precipitation)        | 1951–2003                                       | Likely                                                               |
| <b>Rare precipitation events (with return periods &gt; ~10 yr)</b> | Increase                                                                               | Only a few regions have sufficient data for reliable trends (e.g., UK and USA) | Various since 1893                              | Likely (consistent with changes inferred for more robust statistics) |
| <b>Drought (season/year)</b>                                       | Increase in total area affected                                                        | Many land regions of the world                                                 | Since 1970s                                     | Likely                                                               |
| <b>Tropical cyclones</b>                                           | Trends towards longer lifetimes and greater storm intensity, but no trend in frequency | Tropics                                                                        | Since 1970s                                     | Likely; more confidence in frequency and intensity                   |
| <b>Extreme extratropical storms</b>                                | Net increase in frequency/intensity and poleward shift in track                        | NH land                                                                        | Since about 1950                                | Likely                                                               |
| <b>Small-scale severe weather phenomena</b>                        | Insufficient studies for assessment                                                    |                                                                                |                                                 |                                                                      |

[www.ipcc.ch/publications\\_and\\_data/ar4/wg1/en/ch3s3-8-5.html](http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch3s3-8-5.html)

## Climate Change Reconsidered

A Non-governmental International Panel on Climate Change (NIPCC) was set up to examine the same climate data used by the United Nation's Sponsored Intergovernmental Panel on Climate change (IPCC). NIPCC released its report in 2009 and published as "Climate Change Reconsidered".

As opposed to IPCC findings of anthropogenic GHG concentrations as cause of observed increase in global average temperature, they conclude natural causes as very likely to be dominant cause. On health and disasters issues, NIPCC study concludes 'a warmer world will be a safer and healthier world for humans and wildlife alike'. NIPCC highlights the limitations and drawbacks of models and forecasting systems and procedures as basis of IPCC predictions. For example, on drought in Asia, they conclude "the research summarized in the section 6.1.2 shows the frequency of drought in Asia varies according to millennial, centennial and decadal cycles. Since those cycles predate any possible human influence on climate, they serve to refute the claim that today's relatively dry climate is the result of human activity".

## Climate Models: Limitations and Risks

World leaders are making critical decisions based upon predictions of General Circulation Models or Global Climate Models (GCMs) that humans are causing global climate change or global warming. Global climate models attempt to describe the earth's climate and are used in a variety of applications. These include the investigation of the possible causes of climate change and the simulation of past and future climates. But these models are limited in important ways, including:

- an incomplete understanding of the climate system,
- an imperfect ability to transform our knowledge into accurate mathematical equations,
- the limited power of computers,
- the models' inability to reproduce important atmospheric phenomena, and
- inaccurate representations of the complex natural interconnections.

These weaknesses combine to make GCM-based predictions too uncertain to be used as the bases for public policy responses related to future climate changes. The quality of RCM simulations is of course dependent on the quality of the regional models themselves. Equally important is the quality of the driving data—the boundary conditions. GCMs have skill and suffer from systematic biases. In GCMs, a systematic error in some climate aspect might be due to a non-local process, which of course complicates model improvements.

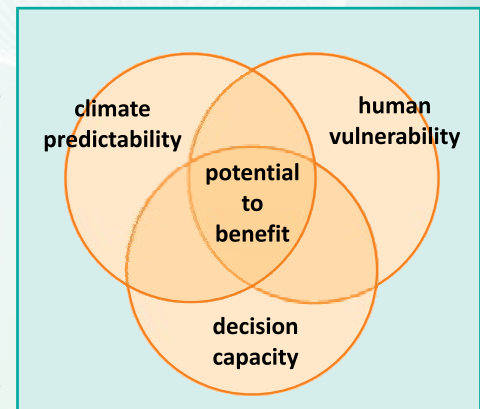


Figure 2. Key aspects of response capacity for managing climate risks

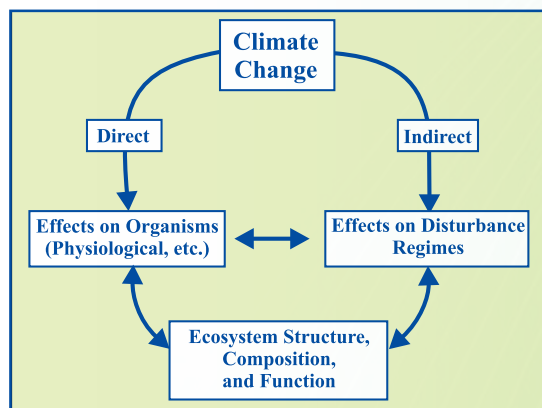


Figure 3. Direct and indirect impact of climate change on Ecosystems

The integrated assessment models (IAMs) that economists use to analyze the expected costs and benefits of climate policies frequently suggest that the "optimal" policy is to go slowly and to do relatively little in the near term to reduce greenhouse gas emissions. This practice rests on several empirically and philosophically controversial hypotheses.

Global climate models (GCMs) tend to describe the global climate statistics reasonably well, they do not provide a representative description of the local climate. Regional climate models (RCMs) do a better job at representing climate on a smaller scale, but their spatial resolution is still fairly coarse compared to how the local climate may vary spatially in regions with complex terrain. This fact is not a general flaw of climate models, but just the climate models' limitation.<sup>2</sup>

<sup>2</sup>Rummukainen, M. 2010, WIREs Climate Change, 1, 82-96; <http://www.realclimate.org>; <http://digitalcommons.unl.edu>

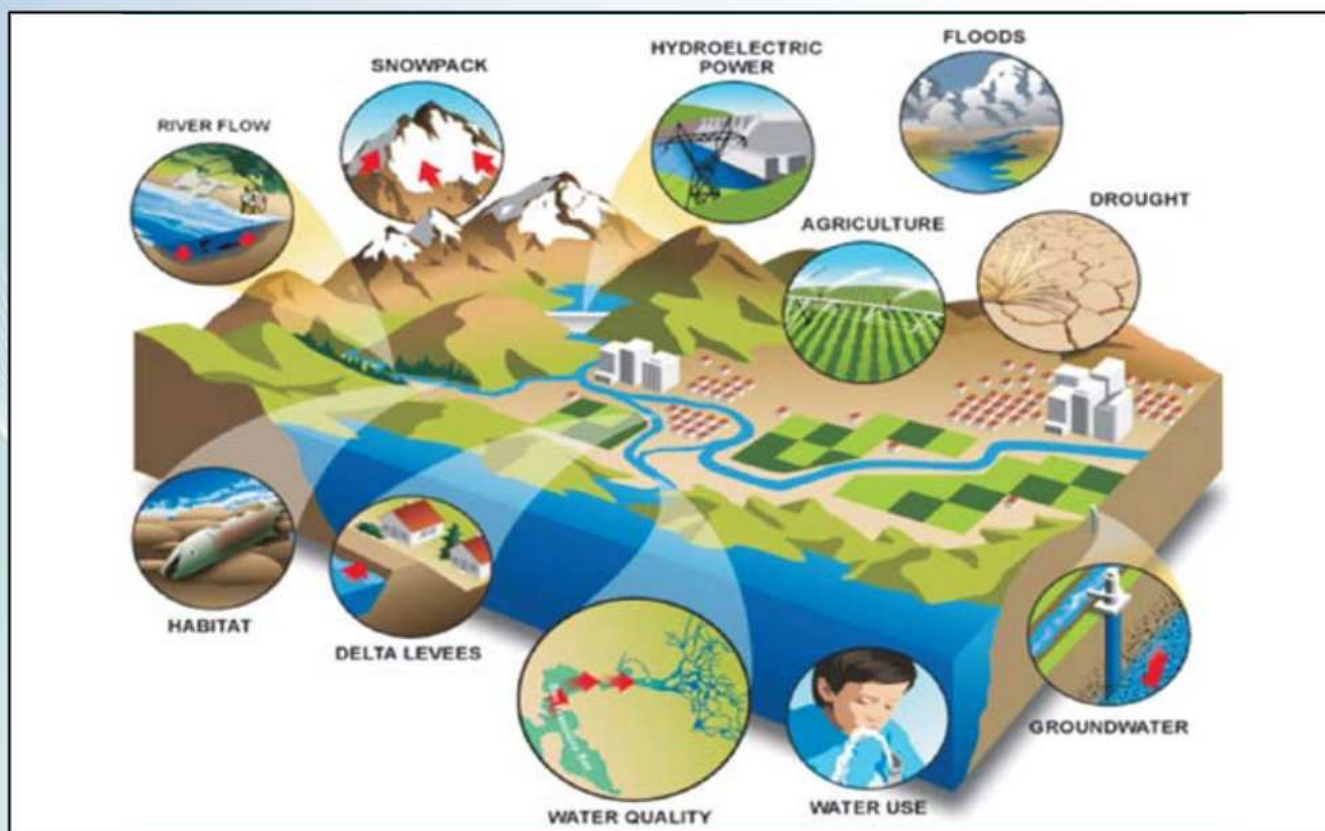


**Figure 4.** Water environment and exposure to climate risks. Source: <http://www.opengreenspace.com>

### Global environmental change

The global environment is a complex dynamic system. Natural evolutionary changes on the earth occurred at very long time scales of thousands to millions of years, and natural systems are very resilient and adaptable at these scales. Past human activities produced only slow, local or minor environmental changes in the Earth's biophysical systems, yet even these caused the collapse of some past civilizations. Now, with accelerating technological progress, a rapidly expanding population and increasing consumption, human-kind is running up against global environmental limits. Human-induced impacts on atmospheric composition, climate, waters, land and biodiversity are occurring so rapidly that natural systems no longer have time to adapt. The resulting degradation to the planet's resources and life-support systems may be irreversible at scales relevant to present human society. In addition, the inertia in many natural processes means that the damage may only become fully apparent years or decades later.

The different elements of environmental change are interlinked through a complex set of physical, chemical and biological processes, changes in one component has ramifications for other components as well. For example, climate change affects biodiversity, alters ecosystems such as forests and coral reefs, and influences the stratospheric ozone layer. Likewise, conversion of forests to other uses can increase greenhouse gas emission, and reduce biodiversity and water resources. Understanding the processes of global environmental change requires a synthesis of the knowledge of each thematic component, and the definition and assessment of their interlinkages. There is, thus, a pressing need to focus the best scientific knowledge and tools on the overall global system.

*(Intergovernmental Panel on Global Environmental Change (IPEC), Excerpt from Discussion Document for The Expert Think Tank Meeting. Losby Gods, Oslo, Norway, 15 January 2003)*

## Special Report on Extreme Events and Disasters

### Concerns for South Asia

The Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) was commissioned by the Intergovernmental Panel on Climate Change (IPCC) in response to a recognized need to provide specific advice on climate change, extreme weather and climate events (extremes).

SREX lessons for Asia were drawn under the aegis of Climate & Development Knowledge Network (CDKN) and highlighted the key findings with an assessment of the science and the implications for society and sustainable development. The SREX report considered the effects of climate change on extreme events, disasters, and disaster risk management (DRM). It examined how climate extremes, human factors and the environment interact to influence disaster impacts and risk management and adaptation options (see Figure).

SREX considers the role of development in exposure and vulnerability, the implications for disaster risk, and the interactions between disasters and development under a broad framework of environmental systems interaction with human-system. It examines how human responses to extreme events and disasters could contribute to adaptation objectives, and how adaptation to climate change could become better integrated with DRM practice. The SREX report represents a significant step forward for the integration and harmonization of the climate change adaptation, disaster risk management and environmental sciences.

Graph shows how often the wettest day in the last 20 years of the 20th century will be experienced by the middle and end of the 21st century; under three different emissions scenarios: B1, A1B and A2.20.

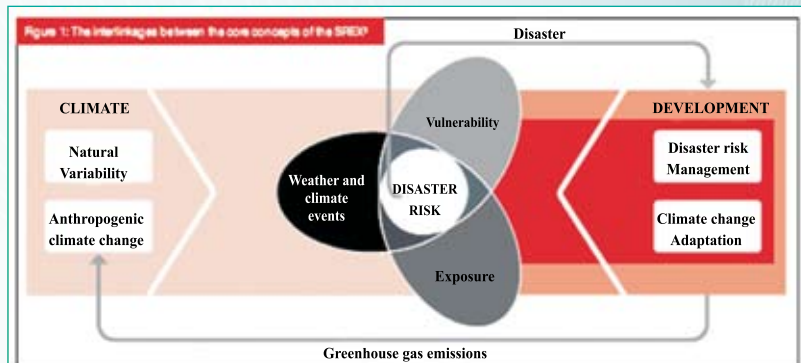
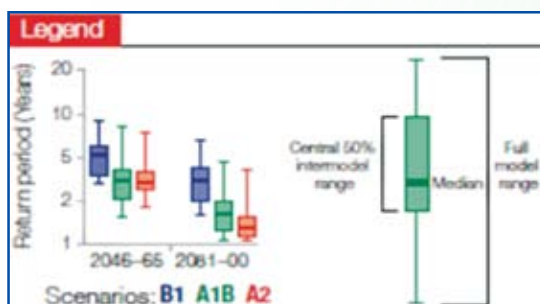
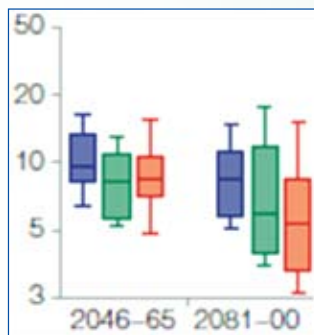


**Figure 5:** Illustration of inter-linkages between the core concepts discussed in the SREX report. This shows how both changes in vulnerability and exposure and changes in weather and extreme climate events can contribute and combine to create disaster risk, hence the need for both disaster risk management (DRM) and climate change adaptation (CCA) within development processes.

#### Impacts of extremes on human systems and ecosystems in Asia

Climate extremes may result in a broad range of impacts on both human and ecosystems including economic losses, impacts on different sectors such as tourism and agriculture, on urban settlements and on small island states. The severity of these impacts will depend strongly on the level of exposure and vulnerability to climate extremes. Collectively such impacts can also have a significant adverse affect on the population and can harm national, regional and global development.

Extreme events have the greatest impacts on sectors that are closely linked with or dependent on the climate, for example water, agriculture and food security, forestry, health and tourism. There is high confidence that changes in the climate could seriously affect water management systems.

(SREX Chapter 4).

**Table 2 A:** Observed changes in temperature and precipitation extremes, including dryness in South Asia since 1950, with the period 1961-1990 used as a baseline (Ref: box 3.1, Chapter 3, SREX).

**B:** Projected changes in temperature and precipitation extremes, including dryness, in South Asia. The projections are for the period 2071-2100 (compared with 1961-1990) or 2080-2100 (compared with 1980-2000) and are based on GCM and RCM12 outputs run under the A2/A1B emissions scenario.

| Scenario | Trends in maximum Sub-region temperature (warm and cold days)                                                                          | Trends in minimum temperature (warm and cold nights)                                                                                       | Trends in heat waves/ warm spells and drought <sup>11</sup>                                                                                     | Trends in heavy precipitation Trends in dryness (rain, snow)                                                                                                                                                                                                                             | Trends in Dryness and drought                                                                                                             |
|----------|----------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| A        |  Increase in warm days (decrease in cold days)        |  Increase in warm nights (decrease in cold nights)        |  Insufficient evidence                                         |  Mixed signal in India                                                                                                                                                                                |  Inconsistent signal for different studies and indices |
| B        |  Likely increase in warm days (decrease in cold days) |  Likely Increase in warm nights (decrease in cold nights) |  Likely more frequent and/or longer heat waves and warm spells |  Slight or no increase in %DP10 index<br> More frequent and intense heavy precipitation days over parts of S. Asia |  Inconsistent Change                                   |

## South Asia and Climate Change

Climate change is already taking place, and the South Asian countries, particularly the poorest people, are most at risk. The impacts of higher temperatures, more variable precipitation, more extreme weather events, and sea level rise are felt in South Asia and will continue to intensify. These changes are already having major impacts on the economic performance of South Asian countries and on the lives and livelihoods of millions of poor people. The impacts result not only from gradual changes in temperature and sea level but also, in particular, from increased climate variability and extremes, including more intense floods, droughts, and storms.<sup>3</sup>

The IPCC 4<sup>th</sup> Assessment Report provided specific information for South Asia region concerning the nature of future impacts. Some of the future impacts include:

- Glacier melting in the Himalayas is projected to increase flooding and will affect water resources within the next two to three decades.
- Climate change will compound the pressures on natural resources and the environment due to rapid urbanization, industrialization, and economic development.
- Crop yields could decrease up to 30% in South Asia by the mid-21st century.
- Mortality due to diarrhea primarily associated with floods and droughts will rise in South Asia.
- Sea-level rise will exacerbate inundation, storm surge, erosion and other coastal hazards.

### Impact on South Asia's Poor

The consequences of the environmental changes in South Asia include following:

- decreased water availability and water quality in many arid and semiarid regions
- an increased risk of floods and droughts in many regions
- reduction in water regulation in mountain habitats
- decreases in reliability of hydropower and biomass production
- increased incidence of waterborne diseases such as malaria, dengue, and cholera
- increased damages and deaths caused by extreme weather events
- decreased agricultural productivity
- adverse impacts on fisheries
- adverse effects on many ecological systems

As a result, climate change could hamper the achievement of many of the Millennium Development Goals (MDGs), including those on poverty eradication, child mortality, malaria, and other diseases, and environmental sustainability. Much of this damage would come in the form of severe economic shocks. In addition, the impacts will exacerbate existing social and environmental problems and lead to migration within and across national borders.<sup>3</sup>

<sup>3</sup> Source: Managing Climate Risk: Integrating Adaptation into World Bank Group Operations, at <http://www-wds.worldbank.org>

## Climate Change Impacts in India

### Hydro-meteorological Disasters

#### Observed Climatic Changes for India

**M**ost significant feature of the Indian-subcontinent climate is its monsoon circulation. The summer (or south-west) monsoon contributes about 80% of the total annual rainfall in a major part of the region. Although the summer monsoon rainfall exhibits a remarkable stability over time - as evidenced by past data of more than a century, displays a variety of temporal and spatial variations. While a large part of the seasonal anomalies in the monsoon is accounted by the inter-annual variability, decadal and longer term changes manifest themselves as changing frequencies of extreme anomalies. Observed changes in climate over India are based on Instrumental records over the past 130 years collected by the India Meteorological Department (IMD) are as follows<sup>4</sup>:

- The monsoon rainfall at All India level does not show any trend but there are some regional patterns. Areas of increasing trend in monsoon rainfall are found along the west coast, north Andhra Pradesh and north-west India, and those of decreasing trend over east Madhya Pradesh and adjoining areas, north-east India and parts of Gujarat and Kerala (-6 to -8% of normal over 100 years).
- A recent study indicates that the intensity and frequency of heavy to very heavy rainfall events is showing an increasing trend during the past 50 years over the region covering parts of Andhra Pradesh, Orissa and Chattisgarh and Madhya Pradesh. However, it is not clear if this increasing trend in the heavy rainfall events is attributable to global warming or not.
- Mean annual surface air temperatures show a significant warming of about 0.5 C/100 year during the last century and recent data indicates a substantial acceleration of this warming after the 1990's. This is comparable to the global warming trends reported.
- The spatial distribution of temperature changes indicated a significant warming trend has been observed along the west coast, central India, and interior Peninsula and over northeast India. However, cooling trend has been observed in north-west and some parts in southern India.
- The year 2006 was the warmest year on record since 1901. The ten warmest years on record are 2006(0.595), 2002(0.59), 1998(0.50), 2004 & 2001(0.47), 2003(0.45), 1958(0.43), 1987 & 1941(0.41), 2005(0.40), 1999(0.39), 1953 & 2000(0.36) and 1980(0.34). Since 1993, annual mean temperature has been consistently above normal.
- Instrumental records over the past 130 years do not show any significant long-term trend in the frequencies of large-scale droughts or floods in the summer monsoon season.
- The total frequency of cyclonic storms that form over Bay Bengal has remained almost constant over the period 1887-1997. Analysis of past tide gauge records for the Indian coastline regions gives an estimate of sea level rise of 1.30 mm/year. Future global projections indicate an average increase of about 4 mm/year.

The occurrence of severe cyclonic events is projected to increase along the east coast of India, which along with sea level rise will cause increased flood risks.

There are evidences that glaciers in Himalayas are receding at a rapid pace.

Gupta et al., 2009, 2010.

#### Future Scenarios of Change

Both, global and regional models have been used for producing climate change scenarios for India. The latest version of Hadley Centre Regional Climate Model, PRECIS developed by Hadley Centre has been used to generate the climate for the present (1961-1990) and a future period (2071-2100) under two different scenarios of emissions determined by development paths. Extensive observational data over the past century and also the reanalysis data have been used for model evaluation.

- The study results indicate an all-round warming over the Indian subcontinent associated with increasing greenhouse gas concentrations, and also a slight increase in summer monsoon precipitation. It is projected that rainfall will increase by the end of the 21<sup>st</sup> century by 15-40%, and the mean annual temperature will increase by 3°C to 6°C.
- The warming is more pronounced over land areas, with the maximum increase over northern India. The warming is also relatively greater in winter and post-monsoon seasons.
- Spatial patterns of rainfall change projections indicate maximum increase over northwest India, but the warming is generally widespread over the country.

## India's 4x4 Assessment

MoEF's Assessment of Climate change Impacts on regions of India in 2030s was released on November 16th 2010 covering four key sectors, namely Agriculture, Water, Natural Ecosystems & Biodiversity and Health, and four climate sensitive regions of India, namely, the Himalayan region, the Western Ghats, the Coastal Area and the North-East Region. The Report prepared by the Indian Network for Climate Change Assessment (INCCA), is the first time an assessment made for the 2030s. Salient Findings of the 4X4 Assessment are following:

### 1. Climate change projections

- Climate change scenarios for 2030s indicate an overall warming for all the regions in focus. The net increase in annual temperatures in 2030s with respect to 1970s ranges between 1.7°C – 2.2°C, with extreme temperatures increasing by 1-4°C, with maximum increase in coastal regions. The extreme maximum and minimum temperatures are also projected to increase.
- All the regions are projected to experience an increase in precipitation in 2030s with respect to 1970s and the maximum increase in the Himalayan region and minimum increase in the North Eastern region. The extreme precipitation events are likely to increase by 5-10 days in all the regions.

### 2. Sea Level Rise and extreme events

- Sea level along the Indian coast has been rising at the rate of 1.3mm/year and is likely to rise in consonance with the global sea level rise in the future. Further projections indicate that the frequency of cyclones is likely to decrease in 2030s, with increase in cyclonic intensity.

### 3. Agriculture

- Irrigated rice in all the regions are likely to gain in yields marginally due to warming as compared to the rainfed crop as the irrigated rice tends to benefit from CO<sub>2</sub> fertilization effect. Maize and sorghum are projected to have reduced yields. Coconut productivity is projected to rise in the western coast and reduce in the eastern coastal region. Observations indicate a reduction in apple production in the Himalayan region.
- In case of marine fisheries some species will gain in yields, as the warming favours their productivity such as Sardines. Some species like Indian mackerel are likely to move upwards to the northern latitudes thus maintaining their yields. Species like Threadfin breams may shift their spawning seasons adjusting to the season which optimally favours spawning temperatures. With overall warming, the thermal humidity index is projected to increase in all the regions, especially in the months of May and June, causing stress to the livestock and hence reducing milk productivity.

### 4. Water

- Water yield (which is a function of precipitation, total surface run off, evapotranspiration and soil properties), is projected to increase in the Himalayan region in 2030s by 5-20%, however, likely to be variable across the North Eastern region, Western Ghats, and Coastal region. In some places in these regions, it is projected to increase and in some places it is projected to decrease.
- Moderate to extreme drought severity is projected in 2030s for the Himalayan region, as compared to the other regions. All the regions are likely to experience flooding which are exceeding existing magnitudes by 10% to 30%.

### 5. Forests

- Change is projected for 8%, 18%, 56%, and 30% of the vegetation grids and increase in Net Primary Productivity by 23%, 20%, 57%, and 31% is projected in Western Ghats, North eastern region, Himalayan region, and the Coastal region.

### 6. Human Health – Malaria

- Malaria is projected to spread in new areas in Jammu and Kashmir in the Himalayan region. In the North eastern region opportunities for transmission is likely to increase for a longer period. In the Western Ghats, no change is observed between in 2030s and the trends observed in 1970s. However, in the Coastal region, especially in the eastern coast a marked decrease in number of months is projected in which that the malaria transmission window would be open.

Source: [www.moef.nic.in](http://www.moef.nic.in)

**Table 3: Climate change projections for India based on an ensemble of four GCM outputs**

| Year  | Temperature change (°C) |           |           | Precipitation change (%) |           |          | Sea-level rise (cm) |
|-------|-------------------------|-----------|-----------|--------------------------|-----------|----------|---------------------|
|       | Annual                  | Winter    | Monsoon   | Annual                   | Winter    | Monsoon  |                     |
| 2020s | 1.36±0.19               | 1.61±0.16 | 1.13±0.43 | 2.9±3.7                  | 2.7±17.7  | 2.9±3.7  | 4-8                 |
| 2050s | 1.69±0.41               | 3.25±0.36 | 2.19±0.88 | 6.7±8.9                  | -2.9±26.3 | 6.7±8.9  | 15-38               |
| 2080s | 3.84±0.76               | 4.52±0.49 | 3.19±1.42 | 11.0±12.3                | 5.3±34.4  | 11.±12.3 | 46.59               |

(Source: Aggarwal, D. and M. Lal, 2001)

**Table 4 : Region wise distribution of climate change effects and their consequences**

| Regions          | Climate parameters                                                                                                                                                                                                                                                                                                                                        | Probable impacts                                                                                                                                                                                                                                                                                                                                               | Emerging Impacts                                                                                                                                                                                                                                                                                                                                                                           |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Himalayan Region | Increase in temperature by 0.9°C to 2.6 0°C by 2030s with respect to 1970s<br>Increase in intensity by 2-12% in 2030s with respect to 1970s                                                                                                                                                                                                               | Increase in Forest fires<br>Increased glacier melt                                                                                                                                                                                                                                                                                                             | Loss in forest litter & wood used for heating purposes in the cold season – morbidity due to extreme cold<br>Flash floods leading to large scale landslides and hence loss of agriculture area affecting food security<br>Increase in incidence of malaria due to opening up of transmission windows at higher latitudes<br>Increase in morbidity due to unprecedented rise in temperature |
| Western Ghats    | Temperature may rise by 1.7°C to 1.8° C in 2030s wrt 1970s<br>Northern areas to experience increase in rainfall while southern areas will remain unaffected<br>Decrease in rainfall over tropical montane cloud forests of Gavi, Periyar, High Ways and Venniyar                                                                                          | Adverse effect on cash crops such as coffee and tea.<br>Large scale flooding and soil erosion as a result of increased rainfall.                                                                                                                                                                                                                               | Increase in morbidity and mortality due to flooding<br>Reduction in employment due to impact on cash crops leading to negative impacts on health and life expectancy.                                                                                                                                                                                                                      |
| Coastal Zone     | In the west coast temperature may rise by 1.7° to 1.8° C in 2030s wrt 1970s<br>In the east coast the surface annual air temperature is set to rise by 1.6° to 2.1° C.<br>Increase in sea surface temperatures<br>Increase in rain fall intensity<br>Rising sea levels<br>Increase in intensity of cyclones and storm surges, especially in the east coast | Decrease in coconut production<br>Increase in salinity due to incursion of coastal waters due to rise in sea level affecting habitats, agriculture and availability of fresh water for drinking<br>Changes in distribution and productivity of marine as well as fresh water fisheries<br>Submergence of habitats and special ecosystems such as the mangroves | Increase in morbidity and mortality due to increase in water borne diseases associated with cholera epidemics and increase in salinity of water<br>Loss of livelihoods due to effect on agriculture, tourism, fisheries and hence impacting health and life expectancy<br>Forced migration, loss of housing and drowning will result due to sea-level rise.                                |
| North-East India | Surface air temperature is projected to increase between 0.8 to 2.1° C<br>Decrease in winter precipitation<br>Increase in intensity of summer precipitation<br>Increase in night-time Temperatures                                                                                                                                                        | Cereal production likely to be benefited, but yield of paddy will be negatively affected due to projected increase of night-time temperature.<br>Tea plantations to be affected due to soil erosion<br>Increase runoff and landslides during summer precipitation<br>Decrease in yields in winters                                                             | Loss of employment and adverse effect on health<br>Expected to face an increase in incidence of Malaria due to temperature and humidity increase.                                                                                                                                                                                                                                          |

Source: MoEF, Govt. of India.

## VIEWPOINTS

### Safeguarding Environment for Disaster Risk Reduction

The most urgent need today is to promote accelerated economic growth coupled with social and gender equity and ecological soundness. Thus sustainable development has several dimensions, namely, environmental, economic and social. Fortunately, we have a democratic system of governance, starting with villages. Therefore, we should promote more and more community involvement at the grassroot level, such as organising cadres of community hunger fighters and community climate risk managers. This will then help us to integrate environmental and development concerns with disaster management practices in a mutually reinforcing manner.



An important requirement for disaster risk management in agriculture is the conservation of local agrobiodiversity. Biodiversity management committees at the local level, as provided under the National Biodiversity Act can help to launch an era of biohappiness arising from the conversion of local bioresources into jobs and income in an environmentally and socially sustainable manner. At the moment we witness the sad state of coexistence of prosperity of nature and poverty of people. We should end this dichotomy and launch an era of biohappiness.

Prof. M S Swaminathan, FRS,  
Member of Parliament (Rajya Sabha)  
Chairman, M S Swaminathan Research Foundation, Third Cross Street, Taramani Institutional Area,  
Chennai - 600 113 (India)

Disasters are not what they used to be. In the old days, major disasters were the result of natural forces, most of them outside the control of human societies. An occasional forest fire here or a landslide caused by a road-building project there – but there were few events big enough to cause large scale damage. And people's homes and workplaces were usually built out of reach of floods or avalanches, anyway.



Today, our day-to-day actions can cause huge calamities and we live more and more directly in the path of their consequences. We can destroy whole forests and rivers, eliminate species, and change the climate. Each such outcome then rebounds on us in the form of “natural” (actually man-made) disaster. Global data on the costs of disaster-related damage grows exponentially every year, more or less in line with our economic activity.

For their own protection, communities now have to rethink the possible after effects of the way they live – particularly those that result from our impact on the environment. If we want a safe and secure future for our children, we have to reduce the risk of such disasters, which means we have to change our lifestyles to reduce our impacts on the environment.

Dr. Ashok Khosla  
President, International Union for Conservation of Nature (UN-IUCN)  
Chairman, Development Alternatives, New Delhi

"It is truly gratifying that the National Institute of Disaster Management is organizing an awareness campaign on "Safeguarding Environment for Disaster Risk Reduction". It is even more praiseworthy that this Institute in the short period since its inception has developed a programme of action that promises to be effective in dealing with a range of disasters that Indian society faces. An area of considerable importance that carries possible risks to human lives and property is the increase in some extreme events and disasters as a result of climate change. Changes in the frequency, timing, magnitude and characteristics of extreme events pose challenges to the goals of reducing disaster risk and vulnerability, both in the present and in the future. Enhancing the capacity of social-ecological systems to cope with, adapt to, and shape change is central to building sustainable and resilient development pathways in the face of climate change.



Climate change can magnify many preexisting risks through changes in the frequency, severity, and spatial distribution of weather-related hazards, as well as through increases in vulnerability due to climate impacts (e.g., decreased water availability, decreased agricultural production and food availability, or increased heat stress). Disaster risk reduction may be anticipatory (ensuring that new development does not increase risk) or corrective (reducing existing risk levels). Given expected population increases in hazard-prone areas, anticipatory disaster risk reduction is fundamental to addressing the risk associated with future climate extremes. At the same time, investments in corrective disaster risk reduction are required to address the accumulation of exposure and susceptibility to existing climate risks, for example, those inherited from past urban planning or rural infrastructure decisions.

In general, creating awareness on the nature and magnitude of the potential problem and on possible solutions is the first essential step in disaster risk reduction and creation of appropriate capacity to deal with the challenge ahead. Einstein was right when he stated that problems cannot be solved at the level of awareness that created them."

Dr. R K Pachauri  
Chairman, Inter-Governmental Panel on Climate change (IPCC)  
Director-General, TERI, New Delhi

As I write this my city Delhi is drowning. It started raining early this morning and within a few hours the city has come to a standstill. The television is showing scenes of traffic snarled up for hours, roads waterlogged and people and vehicles sunk deep in water and muck.

The meteorological department records that some 60 mm of rain has fallen in just about 6 hours; 90 mm in 24 hours; and with this the city has made up for its deficit of rainfall this season. In other words, in just about 24 hours Delhi and its surrounding areas got half as much rain as they would in the entire month of September. Delhi, like all growing cities of India, is mindless about drainage. Storm water drains are either clogged or do not exist. Our lakes and ponds have been eaten away by real estate. Land is what the city values, not water. So when it rains more than it should the city drowns.



This month almost all parts of the country are hit by rain and flood. We don't know the extent of damage because putting together news from across the country is difficult and the national media, obsessed as it is with corruption and the antics of politics, fails to present us with the scale and magnitude of breakdown and suffering. Then we also take for granted that at this time of the year there will be rains and then floods. We do not look for news in these events; that there is something unusual about the ferocity of the rain and the extent of the damage. I say this as a keen recorder of these events. Each year, unfailingly, around this time I end up chronicling the floods in most parts of the country. But each year, as I learn and write, I find the floods grow in intensity. Each year, the rain events get more variable and more extreme. Each year, the economic damage because of floods and rain increases.

This year, for instance, the Himalayan state of Himachal Pradesh says its bill for rain damage is Rs 334 crore, roughly half the year's budget for roads and infrastructure. As many as 30 lives have been lost as rivers have broken their banks, landslides have destroyed homes, hydropower stations have been shut and roads and crops damaged. What is worrying is the emerging pattern. Chief Minister Prem Kumar Dhumal says that in his state rains were normal in June, deficient in July and hyperactive in August. A record 342 mm of incessant rain within 24 hours on August 13 left the state shell-shocked and deeply damaged. In Gujarat rains have left behind trails of damage. Over the past two months in different regions of the state, there have been cloudbursts and torrential rains, which have led to flash floods, ravaged homes and killed 140 people. The common thread

in the events is the manner in which the rains have come—abnormally heavy rains with huge sub-regional variations. For instance, earlier this week, Becharaji taluka in Mehsana district of north Gujarat recorded 62 mm of rain, equivalent to a third of its annual average. On one single day, the otherwise dry region of Kachchh got nearly as much rain—some 250 mm—as it gets in a year.

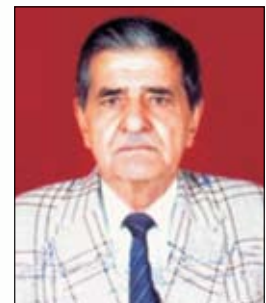
Even as I write this, another region of India, Odisha, is struggling to cope with floods of high magnitude. Some 0.7 million people are already displaced as the Mahanadi has burst its banks at many places. My colleagues tracking developments there say this is mainly because there has been heavy rainfall in the catchment of the vast Hirakud dam. As a result in less than 24 hours the Hirakud managers, without warning and notice, opened all its 59 gates, releasing huge volumes of water into the already swollen river. This part of the country, which was recorded to have deficient rains of 40 per cent, is now in surplus. In just three days enough water has fallen to make up for the shortfall. There is no doubt, therefore, that something strange is afoot. Scientists will tell you that there is a difference between weather and its natural variability and climate change, a pattern brought about by human emissions heating up the atmosphere faster than normal. Scientists who study the monsoons will tell you that they are beginning to make that distinction between “normal” monsoon and what is now showing up in extreme rain events. This when the monsoons are a capricious and confounding natural event, hard to predict and even harder to pin down.

Clearly, it is time to accept that we are beginning to see the impact of climate change. It is time to demand that the world change its ways to mitigate emissions. It is equally important we change the way we deal with water. The opportunity lies in making sure that every drop of the rain is harvested for future economic use. Since rain will come in more ferocious events we must engineer for its drainage and storage. Channelising and holding rain water must become the nation’s mission.

This does mean that every waterbody, every channel, drain and nullah and every catchment has to be safeguarded. These are the temples of modern India. Built to worship rain. Built for our future.

Sunita Narain  
Director, Centre for Science and Environment (CSE)  
New Delhi

All aspects of sustainable development are linked to integration of environment and disaster risk management. Hydromet disasters contribute to over 90% of the disaster damages. As such sustained efforts are needed to make people aware and also respond to early warning system. Again the damages in the rural economy and rural people are removed after a long effort as the urban economy is tuned to recover fast.



Dr. Dev Raj Sikka  
Eminent Atmospheric Scientist, Former Director,  
Indian Institute of Tropical Meteorology,  
40 Mausam Vihar, New Delhi- 110 051

The focus on integration and realistic approaches, acknowledging political realities and the need to reconcile different definitions of risks and paradigms of how to address disasters and adaptation, is applaudable. The report highlights the need for Asian countries to integrate climate change further into disaster risk assessments. The Indian Ministry of Environment and Forests and GIZ are developing and testing an approach of using a combination of different methods for vulnerability assessments at state level, in order to better understand the risks posed by climate change. Following this, the challenge is to integrate climatic changes and extreme weather events into policy and planning. GIZ is working with Indian Government Departments on Climate Proofing selected public schemes, identifying how the schemes are supporting adaptation and devising ways in which adaptation benefits can be maximised. Through reviewing both technical interventions and governance processes, the Indian Government is therefore taking steps to augment the risk reducing effects of public schemes. Such initiatives will contribute to the incremental and transformative changes in processes and institutions called for in the CDKN compilation “Lessons from the IPCC SREX report”.



Dr. Ilona Porsché  
Project Director, Climate Change Adaptation in Rural Areas of India, GIZ  
Deutsche Gesellschaft fuer Internationale Zusammenarbeit, GmbH, Germany

The recent special report of IPCC on extreme events and disasters (SREX) makes us to recall the early emphasis of International Geosphere Biosphere Programme (IGBP). The renewed understanding and policy focus on underlying causes of vulnerability of people's resources, habitat and ecosystems to the impact of natural hazards, which are known to be aggravating under climate change effects, is certain to help enabling effective integration of climate change adaptation with disaster risk reduction. In fact the overlap and cohesion between the two is natural and genuine, but, however, it has to be accepted professionally and within the Governance. Academic world need to play key role in investigating and promoting the cause of science based wisdom for sustainability.



Prof. Mohammad Yunus  
Head, Department of Environmental Sciences  
Babasaheb Bhimrao Ambedkar Central University, Lucknow

Vulnerability to climate change can be attributed to exposure to climatic stress or stimuli coupled with a host of environmental and developmental factors that influence sensitivities and adaptive capacities of the vulnerable systems. These environmental and developmental factors can further be affected by changes in the climate, through pathways that lead to increased exposure, changes in the natural resource base, poverty levels and disparities in terms of access to resources among others. The IPCC SREX report highlights that integration of disaster risk management and adaptation with specific environmental and socio-economic developmental policies can offer significant opportunities for achievement of sustainability in the form of co-benefits. Though, tradeoffs between adaptation, disaster risk reduction and developmental priorities may exist, such integrated efforts can be instrumental in leveraging developmental benefits in the short-term and vulnerability reduction in the longer term.



Sreeja Nair,  
Associate Fellow, Centre for Global Environment Research  
The Energy and Resources Institute (TERI), New Delhi  
(From – Singapore Centre; views are individual)

**Table-5:** Disaster risk related changes in climate and weather indicators as observed to be seriously influenced due to climate change (IPCC, 2007)

| Geo-physical                                                                                                                                                                                                        | Climatic                                                                                                                                                                                                                                                                               | Disaster                                                                                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>● Ocean temperature</li><li>● Sea level</li><li>● Snow cover</li><li>● Mountain glaciers</li><li>● Arctic sea-ice extent</li><li>● Permafrost extent</li><li>● GLOF</li></ul> | <ul style="list-style-type: none"><li>● Wind patterns</li><li>● Air temperature</li><li>● Precipitation patterns<ul style="list-style-type: none"><li>- Rainy days</li><li>- Rainfall</li><li>- Spatial distribution</li></ul></li><li>● Evaporation</li><li>● Transpiration</li></ul> | <ul style="list-style-type: none"><li>● Floods</li><li>● Heat waves</li><li>● Tropical cyclones</li><li>● Cold days and nights</li><li>● Hot days and nights</li><li>● Hot extremes</li><li>● Droughts</li><li>● Desertification</li></ul> |

India is highly disaster prone country and much of the nation's land mass falls in high risk zones. It is estimated that over 44 million people are affected by natural disasters every year in India. More than 70% of the population occupy, 80% of its geographical area that is vulnerable to cyclones, floods, landslides, drought, earthquakes as well as other localized hazards.

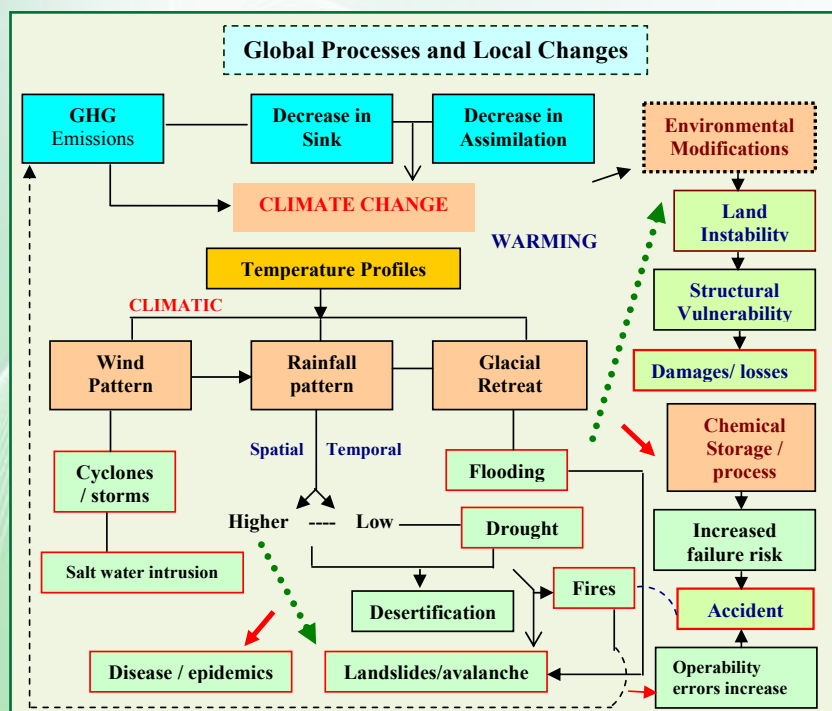


**Figure 6.** *Environment, climate change and disasters – Schematic network*

High Power Committee has identified 33 different types of disasters out of which 12 are of hydro-metrological origin affecting one on other region of the subcontinent. The vulnerabilities to these disasters are compounded by the low socio-economic conditions of the communities, which significantly increase the losses to lives, livelihoods and property. Further it has been recognized that Climate Change is going to pose impacts on global and regional scales. Rapid changes in climate (**table 2**) has already resulted in glacial retreat, global sea level rise, changes in temperature and rainfall patterns and also affecting the natural resources productivity and quality, and also lead to increase in the frequency and intensity of hydro-meteorological disasters like drought, floods, heat and cold waves, desertification and coastal hazards like cyclone, coastal and sea erosion, storm surges and flooding.

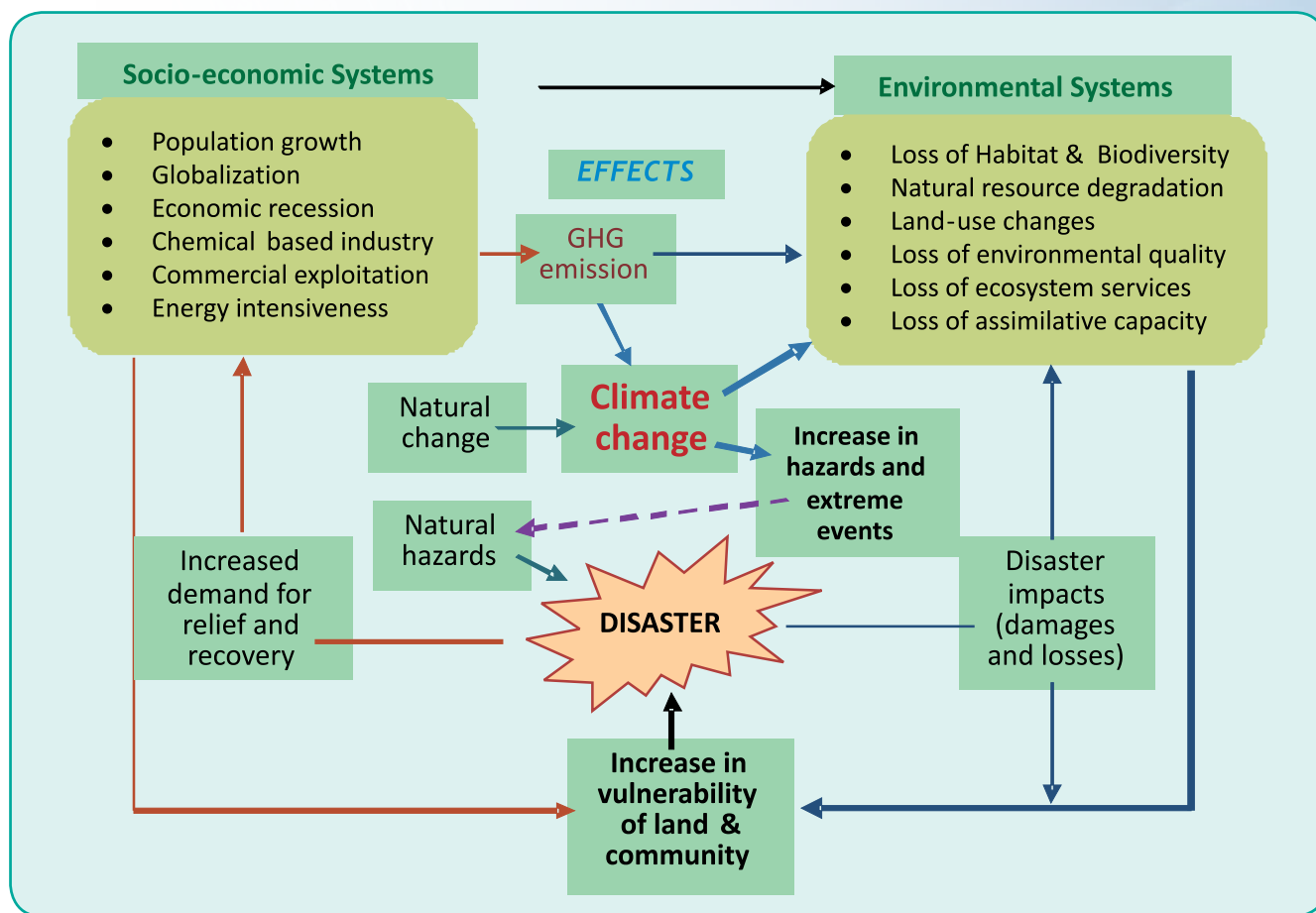


**Figure 7.** Interaction between socio economic, environmental systems and disasters

Interrogating, for example of Cyclones, the varying intensity, invariably accompanied by storm surges, creates havoc along the thickly populated coastal areas almost every year. Over the years flood risk has increased both in intensity and frequency. Floods now affect much larger populations due to poor land-use planning, environmental degradation and other related development processes. The country has seen increased occurrence of landslides and cloudbursts in the states of West Bengal, Uttaranchal, Himachal Pradesh and almost the entire North-Eastern Region. Disaster risk related changes in climate and weather indicators as observed to be seriously influenced due to climate change (IPCC, 2007; Gupta and Nair, 2009) is shown in the table 5.

While looking at extreme weather events the case of India appears relatively much serious. For a country that has more than 70% of its population relying on agriculture directly or indirectly, the impact of extreme weather events is critical for its food security. In the last decade India has been repeatedly battered by successive monsoons, flooding and droughts. For example, for the last 100 years in the state of Orissa, 49 years have experienced floods, 30 have had droughts, and 11 faced cyclones. These extreme weather events are not mutually exclusive. It is not unusual for a year to have a combination of droughts, floods and cyclones. In addition, the number of villages in India experiencing drought is increasing. For example, in the state of Gujarat, only 2000 villages experienced drought in 1961, but by 1988, over 145,000 villages were affected. With respect to cyclones, India is particularly vulnerable because of the relatively large percentage of the population living in coastal districts that often lie in the path of cyclones.



## Addressing Climate Change

### *Vulnerability Matters in Disaster Risk Management*

Climate change is emerging as a major global issue and will undoubtedly be a significant preoccupation of India's external negotiations and domestic bargains in the foreseeable future. On the one hand, India does not want any constraints on its development prospects. On the other, it also wants to be seen as an emerging global power that requires a leadership role on key global issues like climate change (Kapur et al., 2009 EPW). There is a broad scientific consensus that continued emissions at or above current rates will cause further warming and induce many changes in the climate system during the 21<sup>st</sup> century that will likely to be larger, with more adverse impacts, than those seen during the 20<sup>th</sup> century. For instance, a first-time global scale analysis done by the International Union of Forest Research Organizations shows that forests could become carbon sources not sink, if temperatures continue to rise. The carbon storing capacity of global forests could be lost entirely if the earth heats up 2.5°C above pre-industrial levels.

The term 'mitigation' refers to broad range of activities starting from prevention of a stress to tolerance, remediation and resilience of the exposed 'component' of the environment of 'socio-economy', and thereby, has a different notion in climate change remediation than in disaster management context. Mitigation refers to anthropogenic interventions to reduce the sources or enhance the sinks of greenhouse gases, and 'adaptation' is concerned with addressing the consequences of climate change. Their codependency (e.g. planting trees in urban areas both increases greenhouse gas sinks (mitigation) and acts to cool surrounding areas (adaptation) calls for or climate change policies that address the two responses simultaneously. Also, many experts see little utility in isolated climate data if they are not supported by those on socio/economic/natural resources and environment (UNEP, 2008). For example, biodiversity in all its components (e.g. genes, species, ecosystems) increases resilience to changing environmental conditions and stresses. Genetically-diverse populations and species-rich ecosystems have greater potential to adapt to climate change. The selection of crops and cultivars with tolerance to abiotic stresses (e.g. high temperature, drought, flooding, high salt content in soil, pest and disease resistance) allows harnessing genetic variability in new crop varieties if national programmes have the required capacity and long-term support to use them (FAO-UN, 2007).

Things may get much worse when the climate changes, as hundred-year return period floods become ten-year floods; coastal storm surges are amplified by sea level rise and more frequent, powerful hurricanes; destructive tornados increase in frequency and magnitude; drought-induced wildfires become larger and more widespread; and farmers are forced to cope with unfamiliar weather regimes. Where large numbers of people have settled in y of historical hazard zones, rapid expansion of those zones may lead to huge losses before settlement patterns adapt. And the effect may be compounded if the climate keeps changing in fits and starts, rather than slowly and predictably. Vulnerability is understood as the degree to which people, property, resources, systems, and cultural, economic, environmental, and social activity is susceptible to a harm. Vulnerability refers to the inability to withstand the effects of a hostile environment. A Window of Vulnerability (WoV) is a time frame within which defensive measures are reduced, compromised or lacking. In short, understanding climate change vulnerability requires information on potential human impacts covering all important environmental, social and developmental aspects.

The potential impacts of climate change on the environment and socio-economic systems can be understood in terms of sensitivity, adaptability and vulnerability of the system. Both the magnitude and the rate of climate change are important

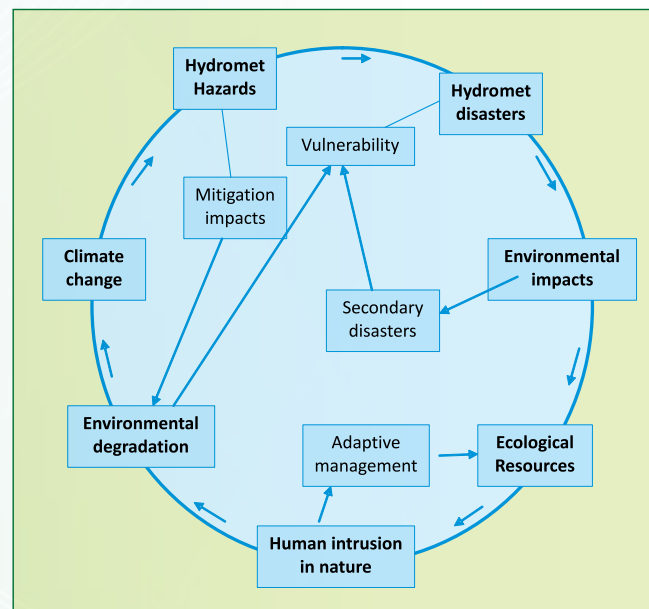
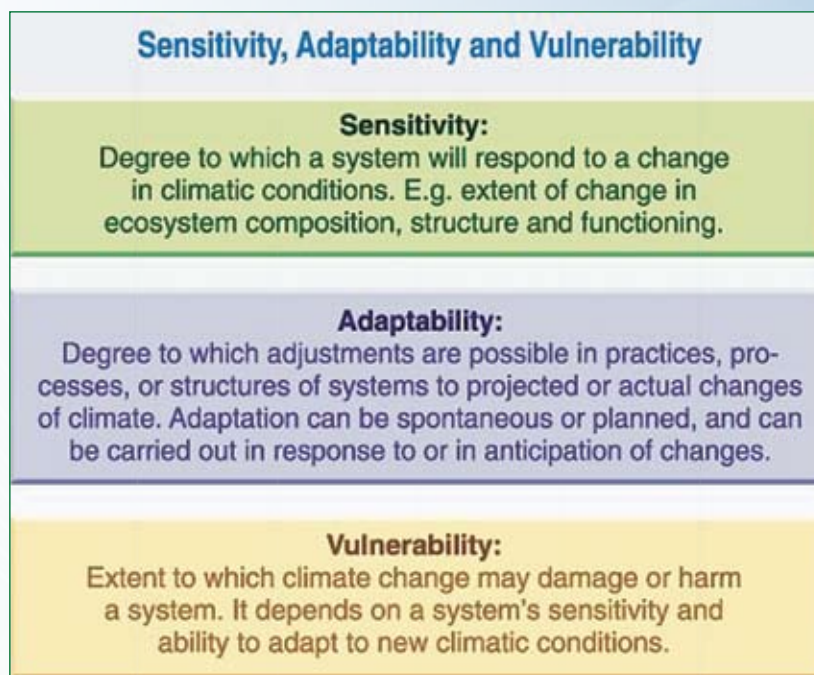


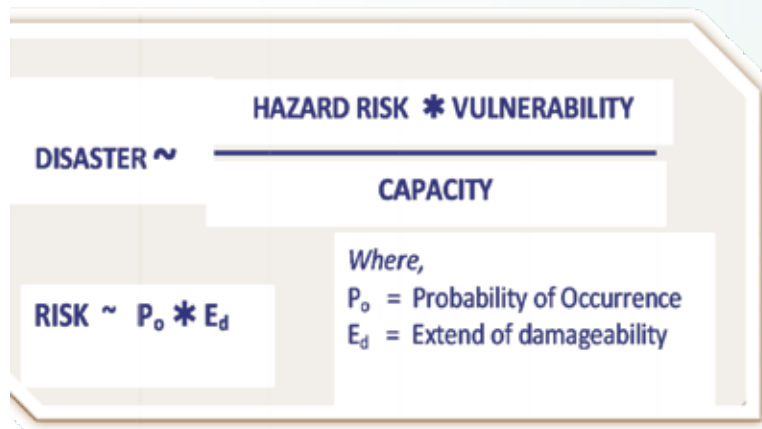
Figure 8. Vulnerability in relation to disasters and environment

in determining the sensitivity, adaptability and vulnerability of a system. Although much progress has been made, there are large uncertainties in predicting regional climate changes, future conditions in the absence of climate change, or to what degree climate will become more variable. All these factors are important in predicting the potential impacts of climate change. There are large uncertainties in our understanding of some key ecological processes. Current ability is also limited in predicting regional-scale climate changes, future conditions in the absence of climate change, or to what degree climate will become more variable. All these factors are important in predicting the potential impacts of climate change (UNEP, GRID Arendal, 2007)<sup>5</sup>.

According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability to climate change is a function of: (A) Exposure to climate variability and change, which refers to the degree of



Source : Climate change 1996. UNEP & WMO, Cambridge Press University



climate variability and change that an entity (a country, community, individual or ecosystem) experiences; (B) Sensitivity to climate shocks and stresses, which is an assessment of the amount of impact climate factors have on the entity; and, (C) Adaptive capacity, which describes the ability of the entity to manage the negative impacts and take advantage of any opportunities that arise.

In the context of disaster management, vulnerability can be defined as the diminished capacity of an individual or group to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard.<sup>6</sup>

<sup>5</sup> [http://www.grida.no/climate/ipcc\\_tar/wg2/pdf/wg2TARchap19.pdf](http://www.grida.no/climate/ipcc_tar/wg2/pdf/wg2TARchap19.pdf)

<sup>6</sup> <http://www.ifrc.org>



## Hydro-meteorological Disasters

### Risks and Management

**A**mong all observed natural and anthropogenic adversities, hydro-meteorological disasters are undoubtedly the most recurrent, and pose major impediments to achieving human security and sustainable socio-economic development, as recently witnessed with disasters such as the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, Cyclone Sidr in 2007, Cyclone Nargis in 2008 and many others. During the period 2000 to 2006, 2,163 water-related disasters were reported globally in the EM-DAT database, killing more than 290,000 people, afflicting more than 1.5 billion people and inflicting more than US\$422 billion in damages. The factors that have led to increased water related disasters are thought to include natural pressures, such as climate variability; management pressures, such as the lack of appropriate organizational systems and inappropriate land management; and social pressures, such as an escalation of population and settlements in high-risk areas (particularly for poor people). The United Nations University Institute for Environment and Human Security (UNU-EHS) warns that unless preventative efforts are stepped up, the number of people vulnerable to flood disasters worldwide is expected to mushroom to two billion by 2050 as a result of climate change, deforestation, rising sea levels and population growth in flood-prone lands (Bogardi, 2004).

In general, all water-related disasters events increased between 1980 and the end of the twentieth century. Floods and windstorm events increased drastically from 1997 to 2006, but other types of disaster did not increase significantly in this period. Floods doubled during the period 1997 to 2006 and windstorms increased more than 1.5 times. Drought was severe at the beginning of the 1980s and gained momentum again during the late 1990s and afterwards. The numbers of landslides and water-borne epidemics were at their highest during the period 1998–2000 and then decreased. Waves and surges increased between 1980 and 2006. A brief description of certain hydro-meteorological disasters is given below:

### Cyclone

The extreme weather events like cyclone and sever local storms are most devastating and deadly weather events all over the world. The tropical cyclone can be defined as a low-pressure area with strong winds rotating anti-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. The nomenclature of the cyclone is region specific. It is referred to as tropical cyclone, hurricane, typhoon over tropics, Atlantic and pacific region, respectively. Conceived over warm tropical oceans and nurtured by the converging moisture, the mature tropical cyclones are associated with violent wind, torrential rainfall and the worst of all, the cumulative effect of storm surges and astronomical tides are the three major elements of tropical cyclone disaster. Though early warning system for cyclone have been in operation for centuries, now the recent developments of coastal zone environmental - development management to reduce disaster vulnerability has evolved the concept of cyclonedisasterriskmanagement. The new paradigm focuses on integrated approach of better warning/communication in the very background of sustainable habitat locations, occupations, and environmental management/conservation including ecosystem approach, land-use, erosion control, and structural resistance against disaster risk.

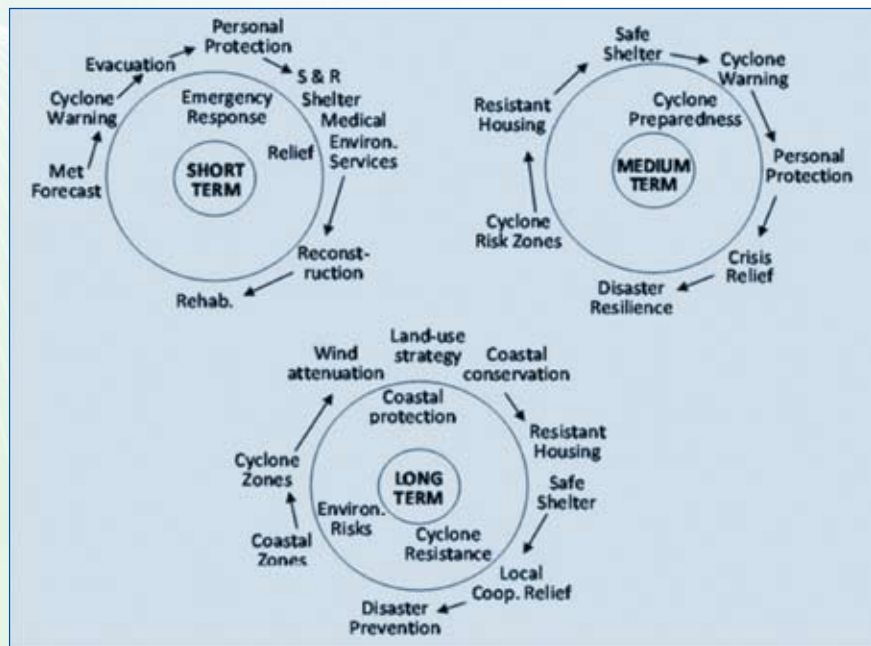


**Figure 9.** Coastal management framework for short-term and long-term mitigation for cyclone disaster

## Drought

The word 'drought' indicates scarcity of water for agriculture and human use, resulting in failing crops, livestock, livelihoods and human health. Drought is a complex and least understood natural disaster whose impacts often depend upon the nature of ecological, social and economic background in the region, and is affecting more people than any other disaster. In 'disaster management' it should not be viewed only as a meteorological or physical phenomenon but must be assessed as an environmental-social challenge.

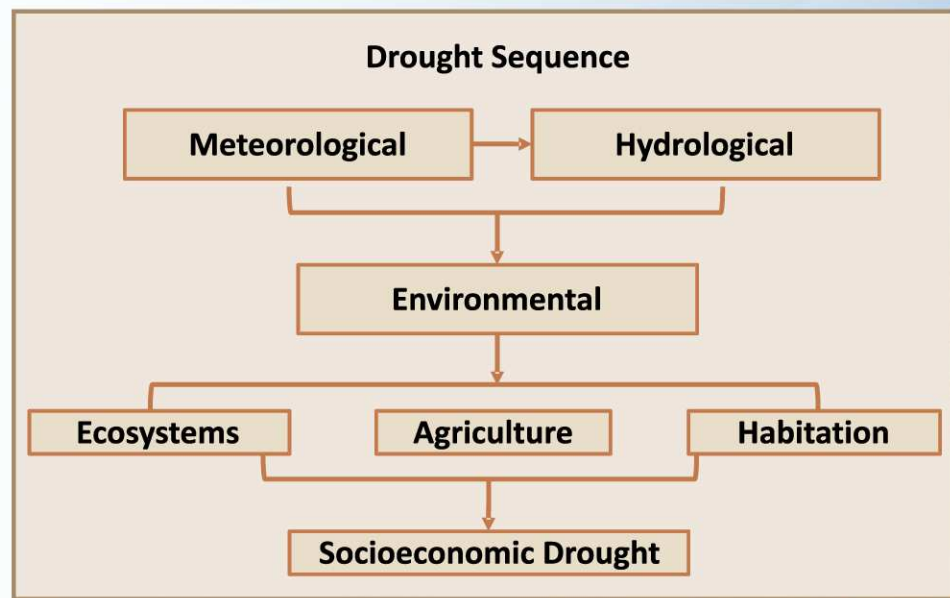


Figure 10. Drought sequence and progressing

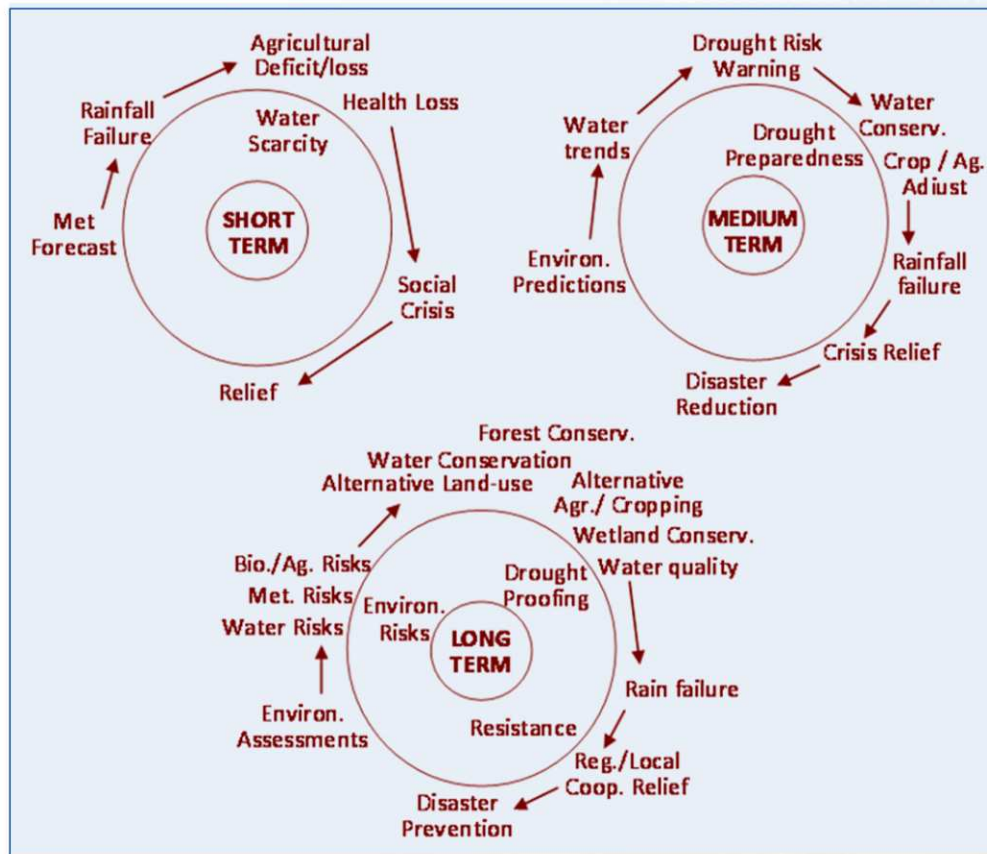


Figure 11. Short-term and sustainable mitigation framework for drought disaster management

Drought may have short-term to long-term impacts sometimes lasting many years and thus is a very serious case if consecutive drought in particular region/area. Rainfall departure is a key cause for meteorological drought whereas water scarcity may equally be attributed to rain failure or less rain, un-suitability of available water, water-losses to evaporation, exploitation, wastage, huge water use in non-agri and non-human purposes, etc. In case of meteorological drought, the departure from normal rainfall in the region is basis for declaring drought which is statistically correct but scientifically or ecologically viewed as a rough calculation as drought being a complex environmental phenomenon where many factors of land-air-water-bio system play significant role. Hence, a category of 'environmental drought' that encompasses

'hydrological drought' and 'biological drought (including agricultural drought)' has been envisaged.

Indian agriculture virtually linked to the monsoon performance has suffered several onslaughts from recurring droughts. The droughts of 1985, 1986 & 1987, 2000, 2001&2002, and 2008 & 2009 are recent examples of how potentially severe disasters were presented before humankind.

## Floods

A flood is an excess of water (or mud) on land that is normally dry or semi-dry. Flood is an event of inundation caused by high flow, or overflow of water in an established watercourse, such as a river, stream, or drainage ditch; or ponding

of water at or near the point where the rain fell. Floods are recurrent phenomenon since time immemorial and always a process of natural environment. With the increase in population and developmental activities, there has been tendency to occupy the flood plains which has resulted in more serious nature of flood damages over the period. Poor or inappropriate environment management including land-uses, waste disposal, landscaping, housing in the urban/peri-urban areas, and increasing erosion, catchment degeneration, siltation, landslides, blockades due accelerated due to deforestation, forest-fire, overgrazing, and developmental activities like mountain-tourism, mining, roads, construction, in the originally natural areas, etc. have increased the flood

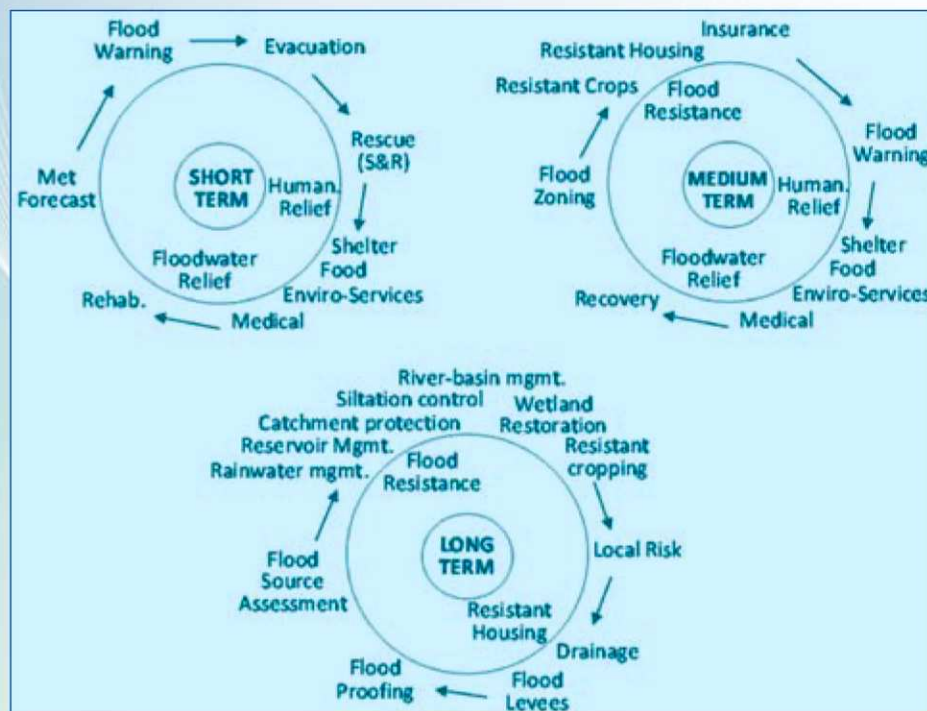


**Figure 12.** Short-term, medium and long-term mitigation framework for flood disaster management

occurrences and intensities over the last 50-60 years. Floods are one of most devastating disaster events due to increased vulnerability, and are affecting not only many parts of India, but various parts of the world including South Asia. Flooding results when amount of water exceeds the capacity of river channel. Floods are also caused by delay in the drainage of the rainwater due to high stages of the river at the outfall and stagnation of water behind embankments. In coastal areas, floods are caused by cyclones and typhoons, increasing intensities due to coastal environmental destructions, mangrove losses and coral reef devastations, sand-dune mining, sewage/effluent discharge, erosion, debris/waste disposal, etc. Flash flood occurs in areas near foot hills and more often in the case of cloudburst, dam/ lake/embankment breach. Urban floods are now common in most of India's cities and towns and same way in many cities in the world and other Asian countries.

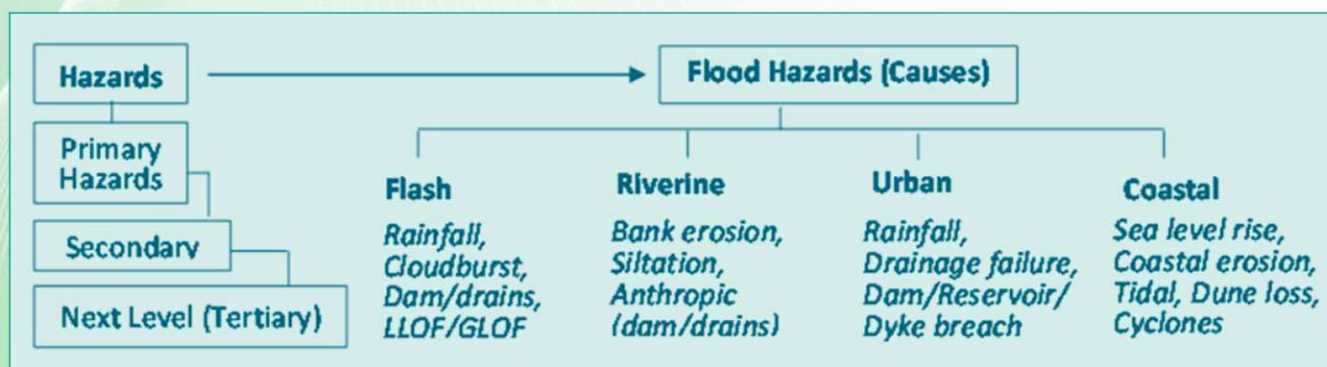


**Figure 13.** Flood hazards causes

## Forest Fire

A forest fire is a natural disaster consisting of a fire which destroys a forested area, and can be a great danger to people who live in forests as well as wildlife. Forest fires can damage or affect nearby agriculture and livestock. Forest fires are generally known to be started by lightning, but most often by human negligence or arson, or intent and can burn thousands of square kilometers.

Forest fires, also known as wildfires, vegetation fire, grass fire, brush fire or bush fire, is common in vegetated areas where climates are sufficiently moist to allow the growth of trees, but feature extended hot and dry periods. Forest fires are caused by the drying out of branches, leaves and therefore becomes highly flammable.

Forest fires also pose serious health hazards by producing smoke and noxious gases, as the events in Indonesia after the forest fires on the islands of Sumatra and Borneo in 1977 have shown. The burning of vegetation gives off not only carbon dioxide but also a host of other, noxious gases (Green house gases) such as carbon monoxide, methane, hydrocarbons, nitric oxide and nitrous oxide, that lead to global warming and ozone layer depletion. Consequently, thousands of people suffered from serious respiratory problems due to these toxic gases. Burning forests and grasslands also add to already serious threat of global warming. Recent measurement suggest that biomass burning may be a significant global source of methyl bromide, which is an ozone depleting chemical.

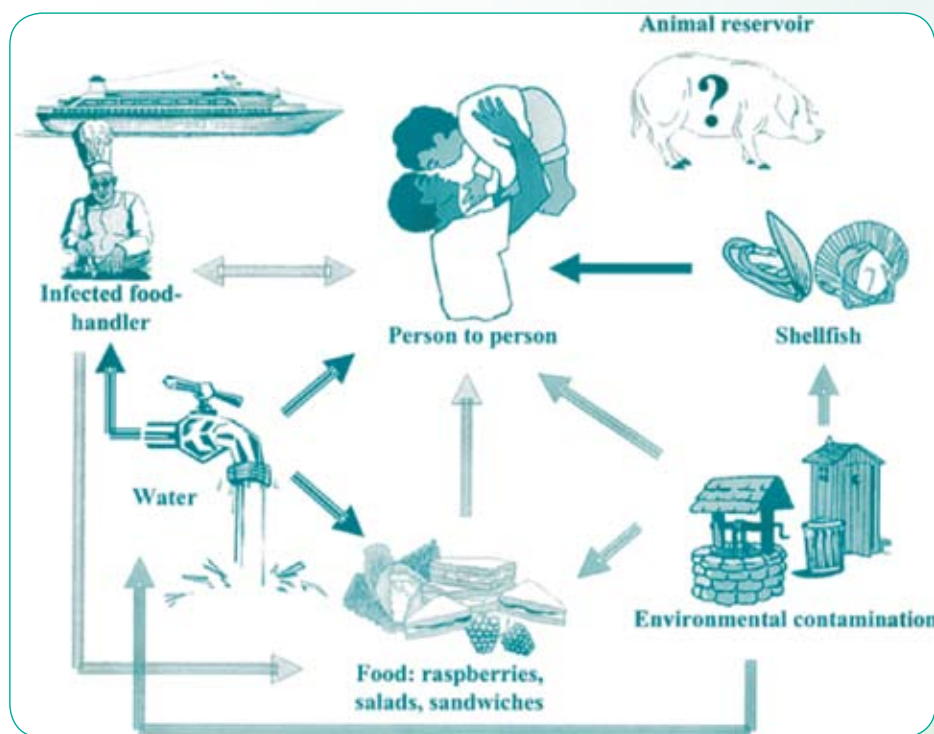


**Figure 14.** Root causes of Epidemics

## Epidemics

Epidemics are disasters by themselves but can emerge in the aftermath of other disasters as well. India is endemic to many diseases such as Malaria, Kala-azar, Cholera, and Tuberculosis. These erupt in epidemic when conditions are favourable for their spread. In the recent past, two epidemics, viz. plague and dengue inflicted the Indian population very badly at Surat and Delhi, respectively. However, these occurred by themselves and not as aftermath of any other disaster.

The impact of climate change on health status is different in developing versus industrialized countries. In developing countries, rising temperatures and humidity

have facilitated the spread of many vector borne infectious diseases including malaria, dengue and encephalitis. The increasing prevalence of and mortality from these infectious diseases has had several negative consequences: decreasing economic productivity, increasing medical costs, and taxing already tenuous health care systems in poor countries. The rising frequency of extreme climatic events such as floods and droughts, render developing countries with increasingly less time to recover.

## Natural Hazards and Risk in Mountains

### *The Potential Impacts of Climate Change*

**M**ountains occupy 24% of the global land surface area and are home to 12% of the world's population. About 40% of the world's population depends indirectly on mountains for ecosystem services including water, hydroelectricity, timber, biodiversity and niche products, mineral resources, recreation, and flood control (Schild 2008).

There is growing scientific evidence that many mountain regions have become increasingly disaster-prone in recent decades, and that a disproportionately high number of natural disasters occur in mountain areas. In addition to relief and geology, human activities influence hazards and their impacts. Destruction of mountain forests or inappropriate farming practices can accelerate erosion and expose land to the risk of landslides, floods and avalanches. Current migration from rural to urban areas

and from higher to lower areas is a significant factor that has led to greater concentrations of population in valleys, increasing environmental degradation and vulnerability to large-scale disasters. Often, migration is linked to poverty, which by itself exposes people to higher risk, especially where access to safe housing and safe land is left unconsidered (UN/ISDR, 2002).

Globally, climate change is very likely to increase the pressure exerted by non-seismic hazards. Higher temperatures will enhance the hydrological cycle and it is predicted that they will alter rainfall patterns and intensity. In the mountain regions of South and Southeast Asia, for example, changing monsoon patterns, including increased severity and frequency of



Table 6: Climate Change and Incidence of Hazards in mountain regions

| hazard                      | Trend of expected Change | Confidence in trend of Projection | Most Affected Regions                                    | Economic Importance |
|-----------------------------|--------------------------|-----------------------------------|----------------------------------------------------------|---------------------|
| Seismic hazard              | →                        | high                              | South America, Southeast Asia, North and Central America | Very high           |
| Snow avalanches             | →                        | medium                            | Northern hemisphere. New Zealand                         | low                 |
| Droughts                    | ↗                        | high                              | Africa, Caucasus, Eastern Himalaya                       | high                |
| Landslides and mud flows    | ↗                        | high                              | Southeast Asia, Central and South America                | medium              |
| Glacier late outburst flood | ↗                        | high                              | All regions with valley glaciers                         | low                 |
| Floods                      | ↗                        | medium                            | Asia, Africa, North America                              | high                |
| Forest and bush fires       | ↗                        | medium                            | Africa, North and Central America, Eurasia               | medium              |
| Insect-borne diseases       | ↗                        | medium                            | Africa, Southern Asia, Central and South America         | medium              |

Source: Ch.Marty 2009 based on IPCC (2007), lyngararasan (2002), and UNEP-WCMC Mountain Watch (2002)

storms as projected by climate models, may threaten agricultural production, food security and the livelihoods of millions of people, and damage vital infrastructure. Accelerated river erosion can destabilize slopes, with dramatic effects where these slopes are saturated with water after prolonged intense rains. Effects will not be limited to changes in precipitation: Global warming reduces snow cover, melts away glaciers, and degrades permafrost (Bavay et al., 2009). As vegetation development on such sites is a slow process, they may remain unprotected against erosion for decades or even centuries. As a result, slope failures, rock fall and debris low will pose increasing threats (Beniston, 2005). Global warming is likely to increase the incidence of insect borne diseases at higher altitudes. The already fragile mountain eco-system is coming under severe strain. Remote terrain and scattered community habitations impair access of common people to health, education, communication, response mechanisms etc.

## Coastal Hazards and Disaster Risk

### *The Potential Impacts of Climate Change*

Coastal ecosystems and associated watersheds provide a wide range of services to coastal communities, including food provision, natural shoreline protection against storms, tsunamis, flooding etc. The Indian coastline is about 7517 km, about 5423 km along the mainland and 2094 km the Andaman and Nicobar, and Lakshadweep Islands. The coastline comprises of headlands, promontories, rocky shores, sandy spits, barrier beaches, open beaches, embayment, estuaries, inlets, bays, marshy land and offshore islands.



Source : NASA 2008

Shoreline erosion in the northern regions of Chennai, Ennore, Visakhapatnam and Paradip ports has resulted due to construction of breakwaters of the respective port. At present, about 23% of shoreline along the Indian main land is affected by erosion.

The Orissa Super Cyclone in India, 1999, Indian Ocean Tsunami of 2004, Cyclone Sidr in Bangladesh, 2007 and the Cyclone Nargis in Myanmar, 2008; highlights the impacts on coastal development and its effect on lives, livelihoods and the coastal ecosystem. The 2004 Indian Ocean tsunami specifically highlights the impact of coastal hazards on social and economic development of the countries.

Coastal hazards are those that occur at the interface between the ocean and the shoreline. These chronic and episodic hazards include human-caused actions and natural events that threaten the health and stability of coastal ecosystems and communities. The natural hazards in the coastal areas can be divided into discrete (occasional) coastal events and those due to continuing changes over the long period.



Source : Pasadena.edu 2009



Shoreline Erosion

## Climate change Adaptation

### Disaster Risk Reduction

The word ‘adaptation’ has been widely and variedly defined and used primarily in ecology, physiology/medical science and now a broader perspective in the sense of ‘adaptation to climate change’ as an explanation of ecological adaptation by humankind. Following are few definitions or concepts of ‘adaptation’.

#### ADAPTATION

- Something, such as a device or mechanism, that is changed or changes so as to become suitable to a new or special application or situation.
- A composition that has been recast into a new form: The play is an adaptation of a short novel.
- The responsive adjustment of a sense organ, such as the eye, to varying conditions, such as light intensity (Physiology).
- Change in behavior of a person or group in response to new or modified surroundings.
- Change in an organism so that it is better able to survive or reproduce, thereby contributing to its fitness. (Source: PHC)

Thus, the term “adaptation” refers to the ability of different species with different genetic make-ups to cope with a specific range of circumstances such as climate, food supply, habitat, defense and movement. Adaptation to climate is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides (Olmos, 2001). Adaptive capacity is known as the potential or capability of a system to adapt to (to alter to better suit) climatic stimuli whereas the ‘Adaptability’ is understood as the ability, competency or capacity of a system to adapt to (to alter to better suit) climatic stimuli.

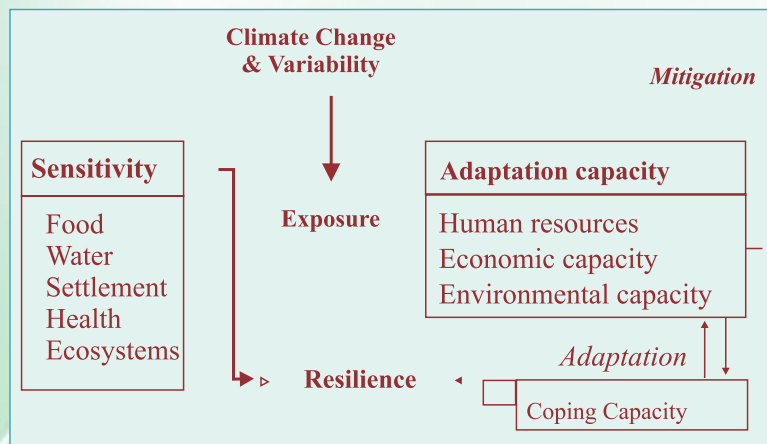


**Figure 15.** Sensitivity-adaptation framework to climate change

Adaptation is often the result of interactions between climatic and other factors: Adaptations vary not only with respect to their climatic stimuli but also with respect to other, non-climate conditions, sometimes called intervening conditions, which serve to influence the sensitivity of systems and the nature of their adjustments. For example, a series of droughts may have similar impacts on crop yields in two regions, but differing economic and institutional arrangements in the two regions may well result in quite different adaptive responses, both in the short and long terms. (Smit et al. 2000: 235). It is important to highlight that the relationship between a changed climate system (e.g., higher temperatures, altered precipitation regime, etc.) and impacts on human systems is not necessarily linear—as early approaches used in climate impact studies (e.g., crop yields research and various analyses of land and regional production potentials—as applied in studies of agricultural impacts of climate change) seemed to imply. Human agencies and institutions can play a crucial role in minimizing the adverse impacts of—and in seizing opportunities resulting from—climate change. In particular, the role of adaptation (whether reactive or anticipatory, spontaneous or planned, etc.) is crucial for assessments of potential impacts of climate change (Smit et al. 2000). A schematic showing (figure) examples of sensitivity in terms of environmental resources along their exposure and against their resilience and on the other hand various components of adaptive capacities as a part of disaster mitigation for developing resilience towards climate change impacts and variability.

## Mitigation and Adaptation

Mitigation refers to anthropogenic interventions to reduce the sources or enhance the sinks of greenhouse gases, and 'adaptation' is concerned with addressing the consequences of climate change. Their codependency (e.g. planting trees in urban areas both increases greenhouse gas sinks (mitigation) and acts to cool surrounding areas (adaptation)) calls for or climate change policies that address the two responses simultaneously. Also, many experts see little utility in isolated climate data if they are not supported by those on socio/economic/natural resources and environment (UNEP, 2008). For example, biodiversity in all its components (e.g. genes, species, and ecosystems) increases resilience to changing environmental conditions and stresses. Genetically-diverse populations and species-rich ecosystems have greater potential to adapt to climate change. The selection of crops and cultivars with tolerance to abiotic stresses (e.g. high temperature, drought, flooding, high salt content in soil, pest and disease resistance) allows harnessing genetic variability in new crop varieties if national programmes have the required capacity and long-term support to use them (FAO-UN, 2007). Thus, 'adaptation' to climate change and its implications towards disaster management, aims at developing a set of abilities to sustain in the given complex scenario of influences along human environment.

Table 7 The components of adaptation, therefore, refer to following:

|                                                           |                         |                     |                      |
|-----------------------------------------------------------|-------------------------|---------------------|----------------------|
| (a) Reducing the risk of occurrence of a hazard event by: | (i) hazard prevention   | (ii) mitigation or  | (iii) control        |
| (b) Reducing exposure to hazardous event:                 | (i) avoidance/migration | (ii) resilience     | (iii) impact control |
| (c) Capacity to contain:                                  | (i) prevent damages     | (ii) prevent losses | (iii) early normalcy |

## Resistance and Resilience

'Disaster Resistance' as a part of climate change adaptation agenda, and similarly on the other hand 'climate change adaptation' as a core facilitator of 'disaster risk reduction' paradigm is the set of focused activities comprising of exposure or impact reduction due to likely hazard event, thus by avoiding, controlling or responding in a prepared and organized ways. 'Adaptation' entails to a series of naturally occurring or designed adjustments with the prevailing and upcoming environmental characteristics including resources (agriculture, forestry, soil, animals, industry, health, etc.) lifestyles, practices, socio-economic patterns and overall development. Search for alternatives, whether for example, alternative livelihood options, or alternative crops or alternative cropping patterns, alternative production systems – be it nature or industry, are the indicative features of adaptation regime. Thus, adaptation is aimed towards adjustment for sustainability – environmental, social and also economic. It opens up many new and innovative opportunities for growth and productivity, for example search of the suitable economic species that may be grown in usar (waste or dry) lands, suitable agro forestry model, or land-water integrated management for year-round water availability and also flood control in the rainy season, alternative foodstuffs with nutritional values, local medicinal knowledge, disaster preparedness, etc. Diversification of livelihood and production systems reduces the risk of damages and losses to a greater extent providing disaster resilience in the communities. Hazard prevention or control actually implies of developing sound awareness and understanding that what (may be due to climate change impact or) local-regional environmental alternations may result in a hazardous condition that may, in case of occurrence, may result in a disaster, for example, flood, drought, landslide, etc. Thus, reducing the chance of a flood occurring to a certain level of heavy rainfall by improving catchment conditions, channel features, storages, etc. are actually considered as disaster reduction. The following options are containing the disaster event from affecting land-uses and resources. And ultimately, in case of an occurrence of breach of disaster management, reducing the impact by putting in place the coping capacity and response mechanism are the actions to be envisaged within the framework of adaptive capacity.

## Disaster Management and Risk Reduction

The approach to disaster management especially in the developing countries like India has been much of an ad-hoc type during last century. 'Relief' was actually been understood as synonym to 'disaster management, and role of environmental disciplines or interdisciplinary sciences has ever been neglected due to poor awareness and lack of proactive will. The paradigm shift from 'response and relief' centric approach to 'proactive – prevention and mitigation' centric approach has recently been visualized worldwide and therefore also in India.

Many new initiatives have been taken in this direction at local, national, regional and global levels. Indian, with the enforcement of Disaster Management Act 2005 has established an institutional mechanism at national, state,

district and local levels. Like in several other programmes and provision, district is a command unit for managing disaster preparedness and responses. However, the unit for adaptation oriented activities or disaster risk reduction interventions are not strategically clear. A point to understand is the questionable relevance of district as a unit for environmental planning and decisions, alternatives to think are – agro-climatic zones, eco-geographic units, etc. with at least some level of common features in terms of what is to be adapted and similarity of risk regimes.

Disaster Management

planning at state and district level has been provisioned under the DM Act, however, the procedures are not clear. UNDP-Disaster Risk Management (DRM) project initiatives in India have developed modules for District level Disaster Management Plan (DDMP) with Hazard-Risk, Vulnerability and Capacity (HRVC) Analysis as a pre-requisite. The approach of HRVC is equally important in DRR strategy development at various levels but the care has to be taken for focusing of reducing the risk of conditions having potential of hazardous occurrences. We, as yet do not have control over the climate change phenomenon, although climate change mitigation separately on go, the DRR focus is to adjust our human environment, resources, lifestyles, economic activities, and governance in a way that either loss events do not take place or the exposure of these are minimum or events contained from posing impacts. Besides this, some level of preparedness to face the challenge of emergencies, but is much effective and organized way required for dealing with the result of abrupt variabilities. Thus, DRR centric disaster management when embedded into developmental planning may be called as ‘Sustainable Disaster Management’. The major strategic issues for DRR to develop are following:

- **From immediate-term to long-term:** it has to be long-sighted, interdisciplinary, integrated and participatory
- **From known to unknown:** adapting and adjusting the development for the unknown situations of hazards are the challenge, besides preventing the already visualized conditions
- **Project/event to Policy/ strategy:** instead of ad-hoc approach or segregated efforts, the strategically planned and assessed programmes on long-term basis
- **Imposed Vs. Infused:** mainstreaming the adaptation and disaster resistance features as habits in all aspects of living, commerce/trade, industry, environmental practices including resource management, production, services, health, etc.
- **Regulatory Vs. Participatory:** inculcating the ‘culture of prevention’ has to be the focus of DRR-CCA task at any level, and based on motivational, facilitating, incentives and security based, rather than only command, control or penalization.

Thus the DM journey from ‘Disaster Relief’ via ‘Disaster Risk Reduction’ to ‘Sustainable Development’ has to undertake proper interrogations, understanding and evaluations for ‘Planning and Decision Making’ at various stages. Suitable and reliable data, and especially in the desired format is most often crucial for implementing ambitious projects, for example, the challenges faced by UNDP-DRM project in India.

**Table 7:** Potential conditions of hazards, DRR-Adaptation and mainstreaming options

| Hazards and disaster risks                                                                                                                                                                                                                                                                                                  | Adaptation                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                          | Development Goals                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                             | Risk Reduction (pro-active)                                                                                                                                                                                                                                                                                                                                                                                                                                             | Disaster Response                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>➤ Desertification</li> <li>➤ Drought</li> <li>➤ Floods</li> <li>➤ Cyclones</li> <li>➤ Landslides</li> <li>➤ Earthquakes - effects</li> <li>➤ Geo-chemical hazards</li> <li>➤ Fire (Forests/ Mine/ Residues)</li> <li>➤ Biological</li> <li>➤ Diseases/ epidemic/ pandemic</li> </ul> | <ul style="list-style-type: none"> <li>➤ Soil-water management</li> <li>➤ (a) erosion control</li> <li>➤ (b) wasteland reclamation</li> <li>➤ Slope protection &amp; remediation</li> <li>➤ Afforestation</li> <li>➤ Crop diversification/ Alternative patterns</li> <li>➤ Forestry-produce</li> <li>➤ Wetlands</li> <li>➤ Fisheries/aquaculture</li> <li>➤ Housing designs</li> <li>➤ Land-use</li> <li>➤ Alternative employment</li> <li>➤ Fiscal measures</li> </ul> | <ul style="list-style-type: none"> <li>Emergency response.</li> <li>Medical, Response, Relief/ Rehabilitation</li> </ul> | <ul style="list-style-type: none"> <li>➤ Agriculture production and sustainability</li> <li>➤ Natural Resources renewal and management</li> <li>➤ Water resource / supply</li> <li>➤ Health &amp; nutrition</li> <li>➤ Poverty eradication and employment</li> <li>➤ Housing</li> <li>➤ Urban development</li> <li>➤ Transport/Roads</li> <li>➤ Service sectors</li> <li>➤ Industrial development</li> <li>➤ Economic/ equity</li> </ul> |

## Convergence of CC Adaptation and DRR

In order to implement the sustainable development agenda through policies, programmes or projects, the options of convergence between the programmes of adaptation development and disaster risk reduction have to be understood. In countries like India, and in most of the developing countries, the life, livelihood, occupational environmental and governance, all have inextricable links with the nature and its resources, whether being harvesting, explored, degraded, managed, restored, or whatever, but confirming the development a direct relation with environment. Visualization of CC Adaptation has two major virtues for DRR, i.e. (a) what to adapt for – the conditions or events of hazards, and (b) what is to be adapted – resources, culture, practices, living, etc. Thus, it is clear that the adaptation and DRR programmes may be infused along the programmes of (a) environmental resources and management – agriculture, forestry, land-water, wasteland development, wetland, watershed, drinking water mission, dryland agriculture, coastal zone management, protected areas, river conservation, rainwater harvesting, etc, (b) industry – process, technologies, raw materials, alternative products, storage conditions, etc. (c) lifestyles – waste management, energy conservation, safety culture, accountability, sanitation, participation, etc. and (d) governance and policy making – planning, decisions, financial mechanisms and allocations, recoveries, penalties, incentives, etc.

For designing DRR and/or adaptation, the concern of regional environmental features including geomorphologic, geographic and developmental features are central for understanding the hazard conditions. For example, in typical mountain areas the conditions may prevail for the disasters like - flash floods, landslides, debris flow, erosion, drought/ water scarcity, earthquake impacts, NRM conflicts, and livelihood loss and socio-political instabilities, displacement, etc. On the other hand, the conditions impending to pose disaster risks are coastal erosion, flooding, drought/ water scarcity, multi-hazard risks including chemical/oil, storms surges, NRM conflicts, livelihood loss, and landslides, many types common but typically different in nature of impacts, exposure and vulnerability. Relationship between natural degeneration, vulnerability and natural disasters have been depicted in the figure.

United Nations Millennium Development Goals (UN-MDGs 2015) are the driving motivation for governments and policies for designing and developing programmes for development and sustainable development at various levels. The major objective of MDGs-2015 are (i) Eradicate extreme poverty and hunger (ii) Achieve universal primary education (iii) Promote gender equality and empower women (iv) Reduce child mortality (v) Improve maternal health (vi) Combat HIV/AIDS, malaria and other diseases (vii) Ensure environmental sustainability and (viii) Develop a global partnership for development. So, drawing motivation from MDGs, the DRR-CCA framework of implementation may utilize the channel of programmes for infusing climate sensitivity, disaster resistance and sustainability notions that present a greater opportunity of converging DRR and adaptation towards reducing the vulnerability of the communities and systems.

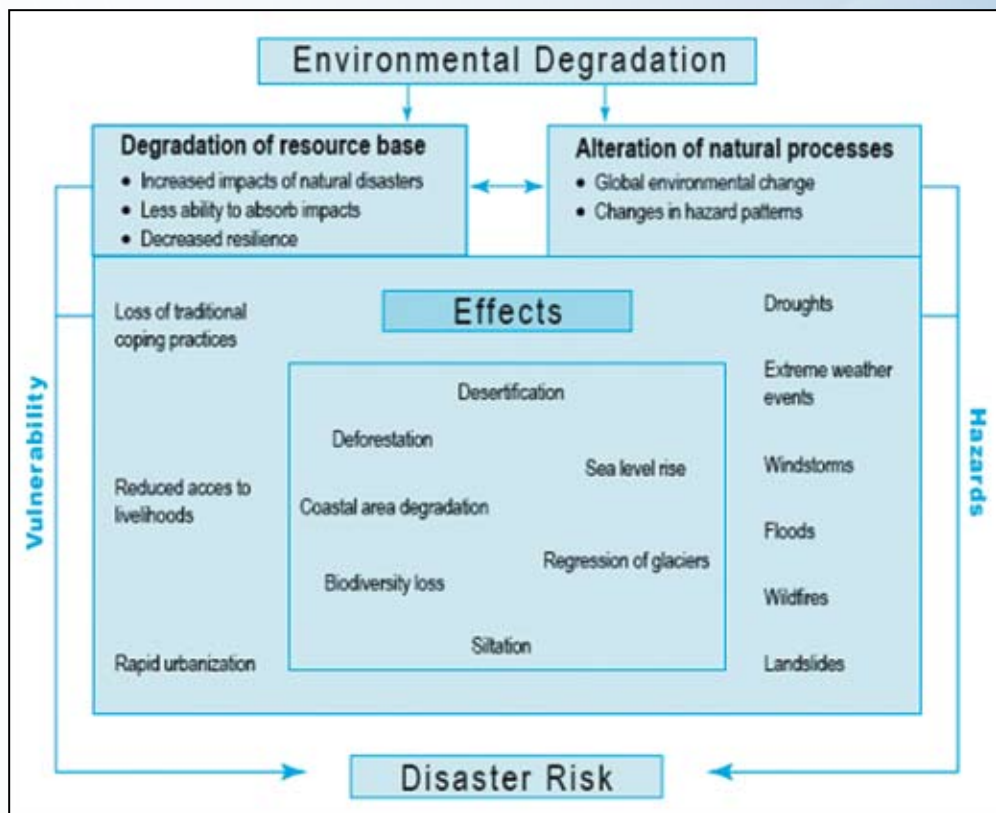


**Figure 16** Link between environmental degradation, natural disasters and vulnerability (UN/ISDR, *Living with Risk*, Figure 2.8)

## Disaster Management Planning and Tools

### Integrating Adaptation and Disaster Risk Reduction

#### Disaster Management Planning

Disaster Management is a continuous and integrated process of planning, organizing coordinating, and implementing measures which are necessary for Prevention of danger or threat of any disaster Mitigation or reduction of risk, Capacity Building, Preparedness Prompt Response, Severity or Magnitude assessment, Evacuation, Rescue, Relief, rehabilitation & reconstruction.



#### DISASTER

Disaster means a catastrophe, mishap, calamity in any area, arising from natural or man made causes, or by accident or negligence which results in substantial loss of life or human suffering, damage to or destruction of property or damage to or degradation of environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area (2 (d) of DM Act, 2005)

For achieving Disaster Risk Reduction and effective management it is important to have planning well in advance planning. Planning is required at the national, state, district, panchayat and village and even family and individual levels. High Powered committee, constituted by Govt. of India also reemphasized the need of the disaster management planning at various levels. Disaster Management Act, 2005 in India made it mandatory that all the districts prepare a Disaster management Plan. At the district level, the DM Act 2005 provides for the constitution of District Disaster Management Authorities under the chairmanship of the District Magistrate/ Collector while the elected representative of the local authority would be the co-chairperson. In those districts where Zilla Parishads exist, the Chairman would be the ex-officio co chairperson of the District Disaster Management Authority. The District Authority shall act as the planning, coordinating and implementing body for disaster management in the district and take all measures for the purposes of disaster management in the district in accordance with the guidelines laid down by National and State Authorities.

The concept of disaster management plan at different levels has received a new orientation with the enactment of the Disaster Management Act. Earlier such plans were being prepared at the district level only. Under the UNDP-DRM programme, Plans for

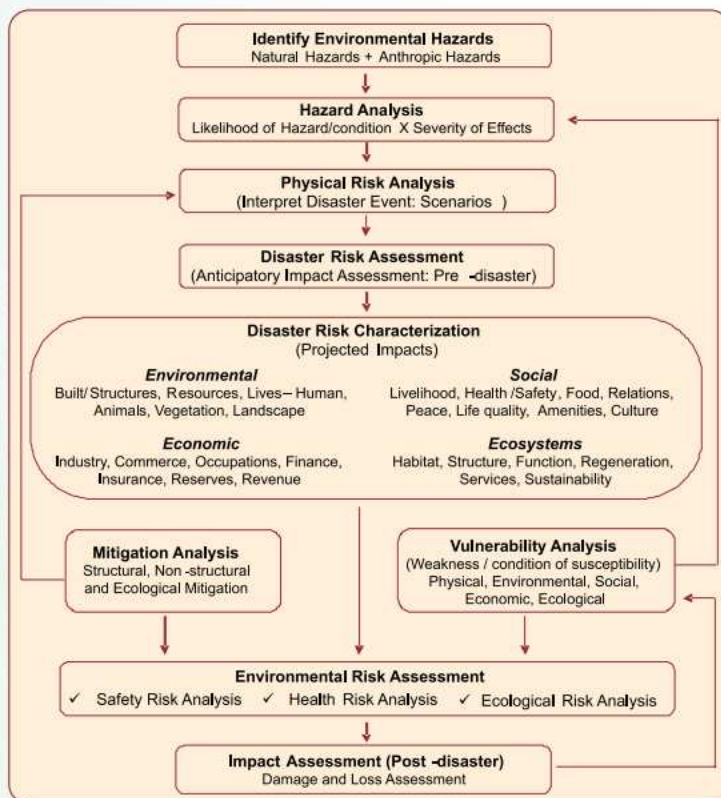


**Figure 17.** Risk Analysis Framework for a Holistic Strategy of Disaster Management and Risk Reduction Integrated with Environmental Planning and Actions

### DMP Structure

The Disaster Management Plan (DMP) has three components:

1. HRVC (Hazard-Risk & Vulnerability Assessment),
2. Mitigation Plan (Prevention, Preparedness, and Sustainable Development),
3. Response Plan (Emergency Coordination and Relief Management).

At the state and district levels, the same structure has been followed.

disaster risk management were promoted at the village level as well. The planning process has been carried down to the sub-divisional, block and village levels. Each village in multi-hazard prone district will have a Disaster Management Plan. The Disaster Management Committee which draws up the plans consists of elected representatives at the village level, local authorities; and Government functionaries. Disaster Management Plan should be addressing on these issues.

A Disaster Management Plan focuses on hazard, risk, vulnerability and resource assessment to help improves the level of response following a calamity on the one hand and provides insights to link it with development initiatives, on the other. The district administration is the focal point for implementation of all government plans and activities. Therefore, planning at the district level is crucial for efficient management of all disasters.

### Policies for Disaster Risk Reduction

Policies that provide an umbrella motivation for taking up the initiatives for disaster risk management and climate change adaptation together are possible to be drawn from a wider set of strategies on natural resources, environment and disaster management, which are related to each other, overlapping in some contexts and are complementary in nature. Following are the major policies of concern:

- National Environment Policy 2006
- National Disaster Management Policy 2009
- National Water Policy 2002 (under revision 2012)
- National Forest Policy
- National Urban Sanitation Policy
- National Agriculture Policy
- National Land-use Policy (draft/pending)
- Strategy on Climate change (National Action Plan)

At National Level, an Action plan on Climate change with 8 National Missions have been declared under the chairmanship of the Prime Minister of India. At state levels, may states have come up State Environment Policy, Disaster Management Policy and are coming up the State Action Plans for Climate change. Looking to the need of emphasis on climate change adaptation and disaster management convergence with overall environmental planning and sustainable development framework, approach of integration district planning with the inputs from regional EIA and strategic environmental assessment shall be of greater importance towards developing developmental plans.

### Tools in Disaster Management and Adaptation Integration

- Strategic Environmental Assessment
- Environmental Impact Assessment (Regional EIA, Project EIA)
- Hazard Risk and Vulnerability Analysis (Risk Assessment)
- Disaster Management Plans (National, State, District, Local bodies, village levels, and for each Departments)
- Rapid EIA of Disasters (REIA)
- Disaster Impact Assessment (anticipatory, part of a developmental project's EIA)
- Post-Disaster Impact (Damage & Loss and Needs) Assessment
- Environmental Needs Assessment for Relief and Recovery
- Recovery Plan (for Sustainable reconstruction, Green Recovery)
- Cost-Benefit Analysis of Mitigation and Management Options/Interventions

### Legislations for Disaster Risk Reduction and Climate change Adaptation

Laws provide set of enactments and rules to guide the planning process, incentives, decision making, and governance at various levels. There is Disaster Management Act, 2005, directly meant for climate related disaster risk management, whereas the laws on environment and natural resources for example, Environmental Protection Act, 1996, Forest Protection Act, Biodiversity Act, Wildlife Protection Act, Land-use Laws, Ground water Laws/ rules, Standards and Codes provide for principles and practices to foster climate change adaptation linkage with mitigation and disaster risk management at national, state and district levels. Different states have also come up with their set of such legislation and rules accordingly and need to look into their provisions of relevance.

## Scholar Inputs

### Climate Change Impacts and Gorakhpur Floods, Uttar Pradesh<sup>2</sup>

Flood disasters are the most frequent and devastating natural disaster in the north east India, and like disasters in general, their impacts have grown in spite of our improved ability to monitor and describe them. For the past thirty years the number of floods disasters has increased compared to other forms of disaster. Climate change compounds the existing challenges of Managing floods. Not all social groups are equally vulnerable to flood-related disasters nor are they exposed to the same combinations of involuntary risks (Blaikie *et. al.*). Gorakhpur is one the most flood prone district of eastern Uttar Pradesh, India. It is vulnerable to disasters due to its geographical location in the *tarai of Nepal Himalayas* and the region being prone to floods. Approx 80% people are living in rural areas. Agriculture is the main occupation of the rural population in this district. Climate change is the major factor to increase the flood frequency in this area people are marginalized and their socio-economic profile is not supported them to fight with adverse impact of climate change. In the past decade, the district has experienced major ups and downs in temperature and rainfall. There has been a continuous change in the annual maximum and minimum temperature of the district. Approximately 9.51 % increase in the maximum temperature during 2003-2004 has been observed in the district, whereas, the annual minimum temperature reflected a decreasing trend like in the year 2002, it was 19.63°C which came down to 15.98°C. Thus, 22.84 percent decrease in the minimum temperature from the year 2002 to 2008 has been noted. This way, tremendous fluctuations in temperature of summer and winter has been observed. People have started experiencing these changes on their daily lives and adapting it their unique manner. In recent years, heavy precipitation events have resulted in several damaging floods in Gorakhpur. Sometime it's also creates the drought conditions. We observed that last decade was showing the adverse climate impact, in year 1998, 2001, 2007 and again 2008 district affected by severe floods in other hand 2002 and 2004 district affected by drought. A report reveal that "Earlier the monsoon season would start in June and end in September; and most villages to get flooded twice or thrice in July and August. But in 2009 the rain arrived on May 24 people were ill prepared and severely affected by flood. Odd weather patterns with floods becoming more frequent due to heavier rainfall in this district. Due to unplanned land use planning people are also suffering from water logging problem.



Richa Arya

### Climate Change and Bundelkhand Drought<sup>3</sup>

Bundelkhand has an odd predicament of being essentially an agro-dependent economy and simultaneously a semi-arid region. So the region is acutely vulnerable to climate change since it is dependent on climate dependant livelihoods such as agriculture, fisheries, forestry and its adaptive capacities are adversely affected by its dry climate. The most recent and continued period of poor rainfall recorded in Bundelkhand was in 2004-10, when below average and erratic rain was reported in most part of the region in all the years. There had been the usual drought implications such as late arrival of rains, early withdrawal, and long break in between, lack of sufficient water in reservoirs and drying up of wells leading to crop failure. The current practices of agriculture have been carried on since the green revolution was initiated in 1966. It largely depends on the usage of submersibles and deep bore tube wells which had proliferated aggressively due to government subsidies. This is partly responsible for aggravation of the already existent problem. The climatic modeling experiments by United Nations Institute for Training and Research (UNITAR) has predicted that by the end of this century in the Bundelkhand region, temperatures are likely to be higher by about 2 to 3.5°C. The effects of climate change emphasized by diminished rainfall, less availability of surface water, sinking ground water level, and repeated crop failures are already festering in Bundelkhand. There needs to be proper and scientific exploitation of water from rivers to help rural areas located near rivers and renovate the thoroughly neglected canal system. There is a huge scope for improving available water resources by traditional methods of irrigation like haveli system of irrigation, restoration of Bundela and Chandela tanks, construction of check dams and age-old practices of mulching. The region went through indiscriminate deforestation under the colonial rule and is still recovering.



Oishanee Ghosh

<sup>2</sup>Richa Arya is Rajiv Gandhi Research Fellow with Prof. Mohd. Yunus (BBAU Lucknow) and Dr. Anil K Gupta (NIDM) for her Ph.D. on Gorakhpur flood management using EIA approach.

<sup>3</sup>Oishanee Ghosh is Research Fellow with Dr. Anil K Gupta and Sreeja S Nair (NIDM) in ICSSR Project on Bundelkhand Drought Research.

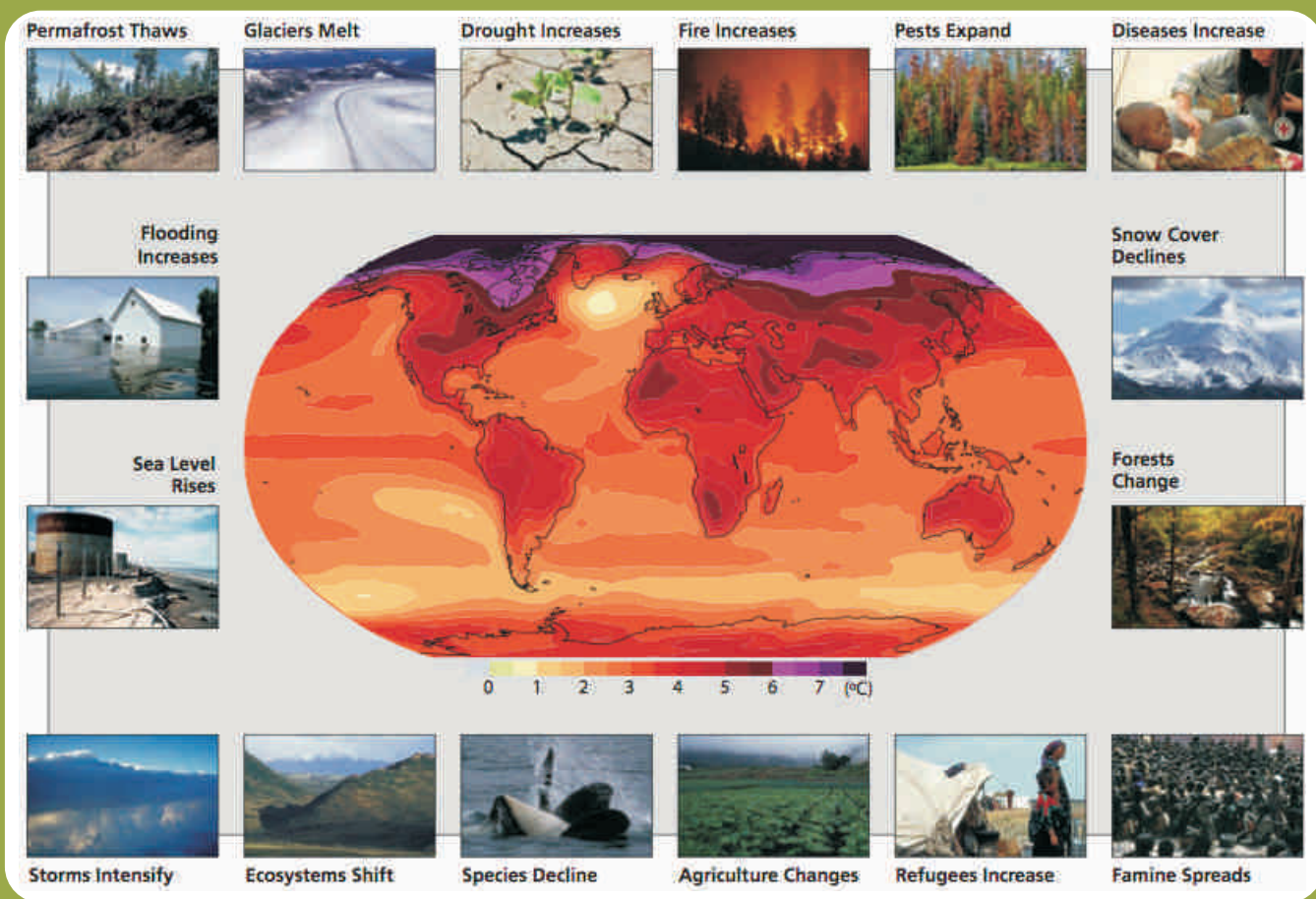
## About NIDM

National Centre for Disaster Management (NCDM) was set up under the Department of Agriculture and Cooperation, Ministry of Agriculture in March 1995. NCDM has been upgraded into full fledged **National Institute of Disaster Management** in October 2003. Under the Disaster Management Act, 2005, the Institute has been entrusted with the nodal national responsibility for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management. NIDM is steadily marching forward to fulfill its mission to make a disaster resilient India by developing and promoting a culture of prevention and preparedness at all levels. Both as a national Centre and then as the national Institute, NIDM has performed a crucial role in bringing disaster risk reduction to the forefront of the national agenda. It is our belief that disaster risk reduction is possible only through promotion of a “Culture of Prevention” involving all stakeholders. We work through strategic partnerships with various ministries and departments of the central, state and local governments, academic, research and technical organizations in India and abroad and other bi-lateral and multi-lateral international agencies.



## NIDM's Activities in Climate Risk Mitigation and Adaptation

Recognizing the definite linkages between disaster risks and climate change, and understanding the significance of climate resilience in achieving disaster risk reduction, NIDM has been actively involved in various activities related to Climate change adaptation. An International Symposium on Impact of Climate Change on Cultural Heritage was organized by NIDM in collaboration with International Council on Monuments and Sites (ICOMOS) Paris and Institute of Archeology Delhi on 22 May 2007. NIDM started offering the training programme on Climate Change since August 2007. Further Climate change adaptation has been included as key thematic session during the first and second India Disaster Management Congress held during 2006 and 2009 respectively. The International Workshop: Risk to resilience organized in February 2009 in collaboration with ISET, NOAA and WII. The focus of the workshop was on evaluating the costs and benefits of disaster risk reduction under changing climatic conditions and the benefits of pro-active disaster risk management to meet the needs of vulnerable communities in South Asia. NIDM acted as a nodal agency for capacity building for the MoEF- UNDP, GEF project to address climate change adaptation within the disaster risk reduction framework. Under the NIDM- ICIMOD project study on Role of Policy and Institutions in Local Adaptation has been carried out. NIDM jointly with Kyoto University and SEEDS carried out a study under the Climate and Disaster Resilient Initiative (CDRI) umbrella initiative during 2009-10 on climate resilience of cities. Climate and Disaster Resilience Index based on five dimensions: natural, physical, social, economic and institutional was developed for 12 cities of India under the study. NIDM was one the key implementing partners of the ISDR campaign for safer cities to promote the concept of disaster resilient cities. Further climate change adaptation, natural resource management and ecosystem approach to Disaster Risk Management etc were included as key component of the ongoing NIDM-GIZ cooperation initiative Environmental Knowledge for Disaster Risk Management.



**NATIONAL INSTITUTE OF DISASTER MANAGEMENT**  
 IIPA Campus, 5-B, IP Estate, New Delhi - 110002  
 Website: [www.nidm.gov.in](http://www.nidm.gov.in)