General Knowledge Today

Disaster Management Fundamentals

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Contents

Model Questions

1. What do you understand by Primary, Secondary and Chronic Hazards? Examine the link between human activities and hazards.
2. Differentiate between tangible and intangible Vulnerability? Discuss the politico-institutional, Economic and Socio-cultural causes of vulnerability.
3. What do you understand by Disaster Management Cycle? As an administrator, what activities would you take under DM cycle? Elucidate.
4. Discuss the importance of Mitigation in Disaster Management. Discuss giving examples of mitigation activities.
5. What do you understand by disaster preparedness? Discuss its importance while examining the link between preparedness and mitigation.
6. Discuss various Post-disaster activities in context with Disaster Management.
7. "Indian sub-continent has unique geo-climatic and socio-political conditions that make it vulnerable to both the natural as well as manmade disasters." Discuss.
8. To what extent the Yakohama Strategy for Disaster Reduction and Hyogo Framework of Actions have helped in development of Post-modernist disaster management theory? Discuss.
9. "Natural disasters are not natural, but rather man-made disasters are the consequences of natural hazards and human actions or inactions." Critically examine the statement while focusing on TDRM approach in Disaster Management.
10. Discuss the salient features of Disaster Management Act 2005 while focusing on the three tier disaster management set up in India.
11. Critically discuss the role of communities and local governments in disaster management.
12. What role Information and Communication Technology (ICT) can play in disaster Management? Discuss with examples.
13. Discuss the role of Earth System Science Organization in Disaster Management.
14. What is INCOIS? Discuss its functions and roles.
15. "India's Himalayan region is geologically very active and thus vulnerable to various types of disasters such as earthquakes, landslides, floods, forest fires etc." What are the disaster management challenges in this region? Discuss.
16. "While the NDMA has made progress in establishing overall structure for disaster management, several gaps continue to exist in India's disaster preparedness that require focus." Discuss.
17. "Disasters can both destroy development initiatives and create development opportunities." Explain.

18. What do you understand by community based approach to disaster management? Discuss its importance, advantages and various stakeholders.
19. India is one of the highest flood prone countries around the world. While discussing the flood affected regions, discuss the structural non-structural measures for mitigation of flood related disasters.
20. Why there is a change in course of rivers? While giving example of a river in India, critically evaluate the role of "avulsive shifts" in disaster risk in India.
21. What do you understand by Glacial Lake Outburst Flood (GLOF)? Discuss the risk in India because of GLOF phenomenon.
22. While taking example of recent floods in Chennai, discuss the ENSO and Indian Ocean Dipole link to India's North East Monsoon.
23. "Unprecedented floods in Chennai were the direct result of unregulated urbanisation." Discuss.
24. What are the causes of Urban flooding in India. While tracing the common thread between 2015 Chennai Floods and 2014 Srinagar floods, examine the importance of regulated development in Urban areas of India.

25. "The subject of Flood Management comes under purview of the State Governments, so there is a need to expand the role of the central government." While keeping NDMA guidelines on flood management in focus, suggest what role central government can play in better management of floods in India.
26. How urban flooding differs from rural flooding? While having a focus on NDMA Guidelines on Urban Flooding, discuss the importance of a National Hydro-meteorological Network in India.
27. Make a comparative account of cyclone vulnerability on East vis-a-vis West Coast of India. While discussing the importance of communication in Cyclone Risk mitigation, critically examine the NDMA recommendation to set up a National Disaster Communication Infrastructure (NDCI).
28. While taking examples of bhongas of Kutch and Dhajji diwari of Jammu & Kashmir, critically discuss the risks created by increasing replacement of traditional methods by modern practices.
29. What are the critical areas of concern for the management of earthquakes in India? Discuss in the light of six pillars of NDMA Guidelines on Earthquakes.
30. "Drought differs from other hazards as it has a slow onset, evolves over months to years, affects a large spatial extent, and cause little structural damage." Discuss the importance of

Drought Management Information System in the light of NDMA guidelines.

31. How Bioterrorism is different from various other forms of terrorism? While throwing light on different kinds of bioterrorism agents, critically examine India's Bioterrorism threat.
32. What are the main landslide and Avalanche prone areas in India? As an administrator, what actions would you take to increase efficacy in management of landslides and avalanches in the country? Discuss.

Introduction

Disasters and Disaster Management has been included as a topic in Paper-III of General Studies Mains examination. UPSC has asked one question on disaster Management in 2013, 2014 and 2015 examinations as follows:

CSE-2013

How important are vulnerability and risk assessment for pre-disaster management? As an administrator, what are key areas that you would focus on in a Disaster Management System? [200 words]

CSE-2014

Drought has been recognized as a disaster in view of its spatial expanse, temporal duration, slow onset and lasting effects on innumerable sections. With a focus on the September 2010 guidelines from the National Disaster Management Authority (NDMA), discuss the mechanisms for preparedness to deal with likely El Nino and La Nina fallouts in India.

CSE-2015

The frequency of earthquakes appears to have increased in the Indian subcontinent. However, India's preparedness for mitigating their impact has significant gaps. Discuss various aspects.

We can expect one question on dynamic issues in 2016 examination also. This module has fundamental information on disaster management focusing on various disaster vulnerabilities of India and NDMA Guidelines on prevention, mitigation and preparedness on these vulnerabilities. It has to be supplemented with our efforts in CGS documents on practical policy issues on disaster management.

Vulnerability and Hazard

Understanding Hazard

A Hazard is a *threat and future source of danger* and has potential to cause harm to man, human activities, properties and environment in future. The earthquakes, volcanic eruptions, cyclones, floods, landslides, accidents and other such events are examples of natural or manmade hazards. The hazards represent the "**potential**" to harm rather than the "**harm**" itself. They remain hazards until they really lead to the harms. Once they cause injury or loss of human / animal lives, damage to property, disruption in socio-economic activities or environmental degradations; they become disasters.

How a Hazard turns into Disaster?

- The environmental events themselves are no hazard. The environmental events become hazards **once they threaten** to affect society and/or the environment adversely. For instance, a volcanic eruption which does not affect human beings is a natural phenomenon

but not a natural hazard. If the same volcanic eruption occurs in a populated area, it becomes a hazard.

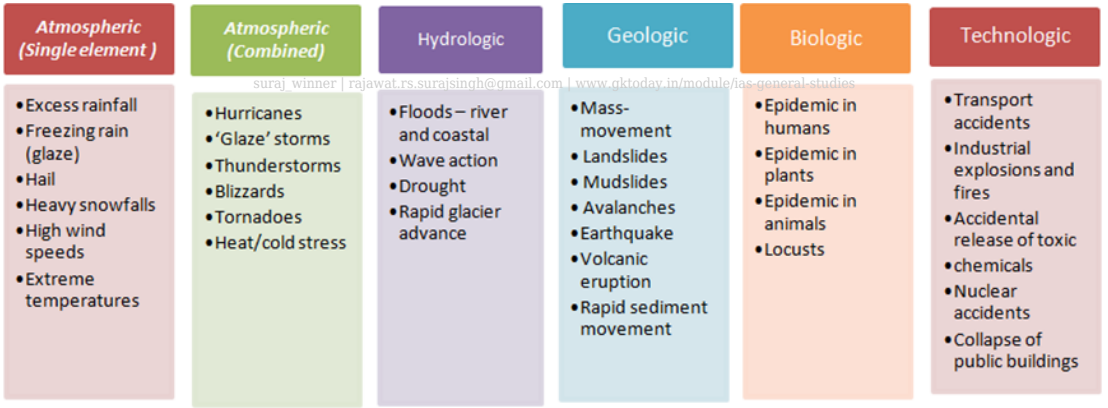
- When a hazardous event causes unacceptably large numbers of fatalities and/or overwhelming property damage; it becomes a disaster. In areas where there are no human interests, natural phenomena do not constitute hazards nor do they result in disasters.

Risk from Hazards

Risk refers to the measure of the **expected losses** due to a hazard event. The level of risk depends upon the nature of the hazard, vulnerability of the people/ area, economic value of the affected elements etc. An area or community is said to be at risk when it is exposed to the hazards and is likely to be adversely affected by these hazards.

Types of Hazards

Hewitt and Burton (1971) classified the hazards into the following five heads viz. Atmospheric (Single element), Atmospheric (Combined elements / events), Hydrologic, Geologic, Biologic and Technologic.



Impact of Human Activities on Hazards

There are two sides of the coin. On one side, the human activities can cause or aggravate the destructive effects of natural phenomena. On the other side, the human activities can also eliminate or reduce the destructive effects. The humans can do little as far as intensity of most natural phenomena is concerned. However, humans have an important role to play in ensuring that the natural events don't turn to natural disasters on their own. The human activities can increase the frequency and severity of the natural hazards. For instance, removing the toe of a landslide may result in movement of earth and burying that settlement. Similarly, the human settlements nearby a volcano to make use of fertile lava soil are hazardous. Similarly, destruction of the forests has led to desertification, which by its very definition is called a manmade natural (or quasi-natural) hazard.

Immutable Events

For some types of hazards the actual dimensions of the occurrence may be altered if appropriate measures are taken; these are called controllable events. For others, no known technology can effectively alter the occurrence itself. Such events are called **immutable events**. For example, construction of levees on both sides of a stream can reduce the extent of inundations, but nothing can moderate the ground shaking produced by an earthquake.

Primary and Secondary Hazards

The secondary hazards follow as a result of other (primary) hazard events. For instance, the Hazards secondary to an earthquake include building collapse, dam failure, Fire, Hazardous material spill, landslide, soil liquefaction, Tsunami etc.

Chronic hazards

Chronic hazards refer to a group of hazards that do not stem from one event but arise from continuous conditions (e.g., famine, resource degradation, pollution, and large-scale toxic contamination), which accumulate over time.

Vulnerability & Risk

Vulnerability is *the extent to which a community, structure, services or geographic area is likely to be damaged* or disrupted by the impact of particular hazard.

Tangible and Intangible Vulnerability

There are two broad types of vulnerabilities viz. Tangible and Intangible. Tangible vulnerability is material. It's easy to see and value of loss can be easily determined. The main characteristics of tangible vulnerability as follows:

- People – lives, health, security, living conditions
- Property – services, physical property loss, loss of use
- Economy – loss of products and production, income
- Environment – water, soil, air, vegetation, wildlife

Intangible or abstract vulnerability is difficult to see and define. The value of loss cannot be easily determined in terms of intangible vulnerability. The key characteristics of intangible vulnerability are as follows:

- Social structures – family and community relationships
- Cultural practices – religious and agricultural
- Cohesion – disruption of normal life
- Motivation – will to recover; government response

Various Reasons of Vulnerability

There can be many reasons of vulnerabilities. Such reasons or factors may be politico-institutional, Economic, or Socio-cultural.

Political-institutional factors

These include:

- Absence / inadequacy of legislations and policies such as land use planning or building regulations.
- Absence / inadequacy of personnel and financial resources
- Lack of coordination among various responsible institutions
- Corruption and vested interests in administration
- Low level of community participation

Economic factors

These include

- Insufficient funds for disaster management
- Poverty / habitation in endangered areas
- Less diversified economy
- Unsustainable consumption of natural resources.

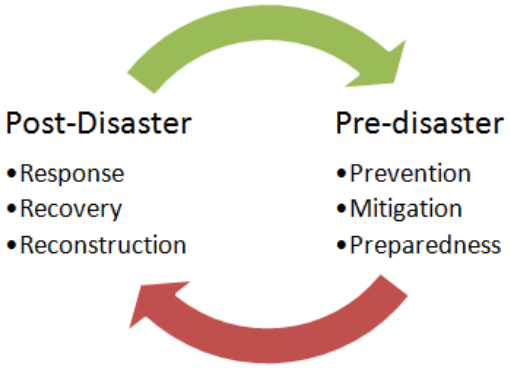
Socio-cultural factors

- Lack of education – insufficient knowledge of cause effect matrix.
- Superstition – belief that all natural disasters are acts of god and inevitable
- Unsustainable farm practices which may result in erosion etc.
- Population pressure

The above political, economic and cultural factors are interconnected with each other in a complex way. They have a reciprocal relationship and often compound each other.

Understanding Disaster Management

Disaster management is fundamentally **disaster risk management**. Sum total of all activities, programmes and measures which can be taken *up before, during and after a disaster* with the purpose to avoid a disaster, reduce its impact or recover from its losses is called Disaster Risk Management. There are three stages of the disaster risk management which are collectively called *Disaster Management Cycle*. Broadly, there are six phases in Disaster Management Cycle viz. Prevention, Mitigation, Preparedness, Response, Recovery and Reconstruction.



While *Prevention, Mitigation and Preparedness* include **Pre-disaster** activities focussed on reducing the human and property losses caused by a potential hazard; *Response, Recovery and Reconstruction* include the *Post-disaster* initiatives taken in response to a disaster with a purpose to achieve early recovery and rehabilitation of affected victims and communities.

Disaster Prevention and Mitigation

Disaster **prevention and mitigation** refers to the activities which are undertaken to prevent or mitigate the adverse effects of a disaster in short and long term. On the one hand they include political, legal, administrative and infrastructural measures; while on the other hand it includes educating vulnerable communities influencing their lifestyle and behaviour in order to reduce their disaster risk.

Disaster Preparedness

The intention of **Disaster preparedness** is to prevent or minimize the losses and damage in case of a disaster. This would include the preparedness of all civic bodies such as civil administration, fire-brigade, hospitals, police etc. Preparedness denotes the third phase of emergency management.

Response, Recovery and Reconstruction

The **response phase** includes the search and rescue; fulfilling basic humanitarian needs of victims ; assistance by regional, national and international bodies etc. R**ecovery phase** starts after the immediate threat to human life has subsided. The immediate goal of the recovery phase is to bring the affected area back to some degree of normalcy. During **reconstruction**, the location or construction material of the property is considered.

Mitigation

Mitigation refers to all actions taken *before a disaster to reduce its impacts*. Mitigation activities fall broadly into two categories viz. Structural Mitigation and Non-structural mitigation. *Structural mitigation* involves the construction projects which reduce economic and social impacts. *Non-structural mitigation* involve the policies and practices which raise awareness of hazards or encourage

developments to reduce the impact of disasters.

Various mitigation activities include:

- Reviewing building codes and building use regulations
- Vulnerability analysis updates
- Zoning and land-use management and planning
- Implementing preventative health measures.
- Educating businesses and the public on simple measures they can take to reduce loss or injury, for instance fastening bookshelves, water heaters, and filing cabinets to walls to keep them from falling during earthquakes.

Examples of Mitigation

- In the aftermath of the Chennai Floods, the Tamil Nadu state government has decided to provide financial support to any new project aimed at reducing the risks of floods.
- In the aftermath of Super cyclone 1999, Odisha government decided to construct multipurpose cyclone shelters along the Orissa coast to provide safe shelters to the vulnerable people during floods and cyclones.
- In October 2015, 11 mountain states of India viz. Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and Uttarakhand adopted a building code separate from the rest of India via a resolution.

Tools of mitigation

Four sets of tools that could be used to prevent or mitigate disasters include:

- Hazard management and vulnerability reduction
- Economic diversification
- Political intervention and commitment
- Public awareness

The first two apply exclusively to disasters caused by natural phenomena while the latter are used to mitigate any other hazards.

Disaster Preparedness

Disaster preparedness is defined as a continuous and integrated process involving a wide range of activities and multi-sectoral resources. Preparedness pays when done well. In order that disaster preparedness is undertaken with rewarding outcomes, those involved in the process must approach it from a mitigative, response, recovery and business continuity perspective of the Disaster Management Cycle.

Four levels of Disaster Preparedness

The four levels of Disaster Preparedness are Global, National, Community and Individual Levels.

Relationship between preparedness and mitigation

Mitigation and preparedness work together. Mitigation aims to reduce vulnerability to disasters such as building earthquake resistant houses. Preparedness is the whole country's readiness to deal with a disaster, including the implementation of mitigation measures. Preparedness is broader and includes issues such as the training and management of people and stockpiling food at strategic locations.

Gender Issues in Disaster Preparedness

Gender issues are important and must be included in all plans of the disaster management cycle to make it more effective and efficient. For instance, the inclusion of women in the formulation of plans may result in more relevant and speedier delivery of relief responses to affected children given their natural proximity to them.

Crop diversification and Disaster Preparedness

The Different crops possess varying degrees of resistance to damage from different disasters. By diversifying crops instead of relying on just one, a farmer will have the resistant crops to depend on despite the destruction of the susceptible ones.

Disaster Response, Recovery & Reconstruction

The objective of disaster response is to provide immediate assistance to maintain life, improve health, and to support the morale of the victim population. Such assistance may range from providing specific but limited aid, such as assisting refugees with transportation, temporary shelter, and food, to establishing semi-permanent settlement in camps and other locations.

Disaster response may also involve initial repairs to damaged infrastructure. During a disaster, humanitarian agencies are often called upon to deal with immediate response and recovery.

The overall aims of disaster response are:

- To ensure the survival of the maximum possible number of victims
- To re-establish self-sufficiency and essential services as quickly as possible
- To repair or replace damaged infrastructure and regenerate viable economic activities.
- In situations of civil or international conflict, the aim is to protect and assist the civilian population.
- In cases involving population displacements (due to any type of disaster) the aim is to find durable solutions as quickly as possible, while ensuring protection and assistance as necessary in the meantime.

Disaster Response Activities

The following are typical activities of emergency response:

Warning

- Warning refers to information concerning the nature of the danger and imminent disaster threats.

Evacuation and migration

- Relocation of a population from zones at risk of an imminent disaster to a safer location. The primary concern is the protection of life of the community and immediate treatment of those who may be injured.

Search and rescue (SAR)

- Search and rescue (SAR) is the process of identifying the location of disaster victims that may be trapped or isolated and bringing them to safety and medical attention.

Post-disaster assessment

- The primary objective of assessment is to provide a clear, concise picture of the post-disaster situation, to identify relief needs and to develop strategies for recovery. It determines options for humanitarian assistance, how best to utilize existing resources, or to develop requests for further assistance.

Response and relief

- When a disaster has occurred response and relief have to take place immediately; there can be no delays. It is therefore important to have contingency plans in place.

Logistics and supply

- The delivery of emergency relief will require logistical facilities and capacity. A well-organized supply service is crucial for handling the procurement or receipt, storage, and dispatch of relief supplies for distribution to disaster victims.

Communication and information management

- All of the above activities are dependent on communication. There are two aspects to communications in disasters. One is the equipment that is essential for information flow, such as radios, telephones and their supporting systems of repeaters, satellites, and transmission lines. The other is information management: the protocol of knowing who communicates what information to whom, what priority is given to it, and how it is disseminated and interpreted.

Survivor response and coping

- In the rush to plan and execute a relief operation it is easy to overlook the real needs and resources of the survivors. The assessment must take into account existing social coping mechanisms that negate the need to bring in outside assistance. On the other hand, disaster survivors may have new and special needs for social services to help adjust to the trauma and disruption caused by the disaster.

Security

- Security is not always a priority issue after a sudden onset of disasters. It is typically handled by civil defence or police departments. However, the protection of the human rights and safety of displaced populations and refugees can be of paramount importance requiring

international monitoring.

Emergency operations management

- None of the above activities can be implemented without some degree of emergency operations management. Policies and procedures for management requirements need to be established well in advance of the disaster.

Rehabilitation

- Rehabilitation consists of actions taken in the aftermath of a disaster to enable basic services to resume functioning, assist victims' self-help efforts to repair dwellings and community facilities, and to facilitate the revival of economic activities (including agriculture). Rehabilitation focuses on enabling the affected populations (families and local communities) to resume more-or-less normal (pre-disaster) patterns of life.

Reconstruction

- Reconstruction is the permanent construction or replacement of severely damaged physical structures, the full restoration of all services and local infrastructure, and the revitalization of the economy (including agriculture). Reconstruction must be fully integrated into ongoing long-term development plans, taking account of future disaster risks. It must also consider the possibilities of reducing those risks by the incorporation of appropriate mitigation measures.

India's Vulnerability Profile

Indian sub-continent has unique geo-climatic and socio-political conditions that make it vulnerable to both the natural as well as manmade disasters. *Around 6% of the population of India is impacted annually* by the exposures to disasters. They Key natural disasters in India include floods, droughts, cyclones, earthquakes, landslides and avalanches that have resulted in loss of lives and livelihoods.

According to a Planning Commission report, the key vulnerabilities of India include the following:

- Coastal States, particularly in the East Coast and Gujarat on west coast, are vulnerable to cyclones.
- 4 crore hectare land mass is vulnerable to floods and river erosion.
- 68 per cent of net sown area is vulnerable to drought.
- 55 per cent of total area is in Seismic Zones III-V and vulnerable to earthquakes of moderate to high density.
- Sub-Himalayan/ Western Ghat are vulnerable to landslides.

Vulnerability to disasters or emergencies of Chemical, Biological Radiological and Nuclear (CBRN) origin has increased on account of socioeconomic development. The changing climate also exasperates the vulnerabilities. The occurrence of heat waves, cold waves, floods, droughts, intense cyclones and flash floods is getting increased due to climate change and global warming.

Further, ***Disaster vulnerability is function of poverty*** *and* poverty is inextricably linked to disaster vulnerability. Poverty compels the people to compromise in matters of shelters and dwellings and more and more people live at unsafe places. Moreover, the low cost material used in making the dwellings makes them more unsafe to live.

India's Hazard Profile

India is prone to disasters due to a number of factors; both natural and human-induced, including adverse geo-climatic conditions, topographic features, environmental degradation, population growth, urbanisation, industrialisation, non-scientific development practices etc. Various hazards to which India is prone to can be broadly divided into three categories viz. Hydrological or climate related; Geological and Technological hazards. They have been discussed below:

Hydrological and Climate related Hazards

Floods

Floods can be caused by heavy rainfall, inadequate capacity of rivers to carry the high flood discharge, inadequate drainage to carry away the rainwater quickly to streams/ rivers. ice jams or landslides blocking streams, typhoons and cyclones etc. Further, flash floods occur because of high rate of water flow particularly in areas with less permeability of soil.

Over 40 million hectare of landmass in India is prone to floods. Nearly 75% of the total annual rainfall is concentrated over a short south-west monsoon season of three to four months from June to September. As a result there is a very heavy discharge from the rivers during this period causing widespread floods. Flood problem is chronic in at least 10 states. From October to December each year, a very large area of South India, including Tamil Nadu, the coastal regions of Andhra Pradesh and the union territory of Puducherry, receives up to 30 percent of its annual rainfall from the northeast monsoon (or winter monsoon). These have caused devesatiing floods in Chennai in 2015. Most devastating floods in recent times have been the 2013 Assam floods, 2013 Uttarakhand Floods, 2012 Brahamputra Floods etc.

Cyclones

India has a very long coastline which is exposed to tropical cyclones arising in the Bay of Bengal and Arabian Sea. *Indian Ocean is one of the six major cyclone-prone regions in the world.* In India cyclones occur usually in April-May, and also between October and December. The Eastern coastline is more prone to cyclones as about 80 percent of total cyclones generated in the region hit there. The worst hitting cyclones have been the Andhra Pradesh cyclone of November 1977 and the super cyclone of Odisha in the year 1999. The impact of the cyclones is mainly confined to the coastal districts, the maximum destruction being within 100 Km. from the centre of the cyclones and on either side of the storm track. The principal dangers from a cyclone include the gales and strong winds; torrential rain and high tidal waves (storm surges). Most casualties are caused by coastal inundation by tidal waves

and storm surges.

Heat Waves, Cold waves and Fog

Heat waves refer to the extreme positive departure from the maximum temperature in summers. The fatalities caused by heat waves have increased in recent decades. The problem of heat wave is compounded by a decrease in diurnal temperature Range (DTR). In urban areas, the heat wave is increasing gaining notoriety for more and more fatalities. Cold waves occur mainly due to the extreme low temperature coupled with incursion of dry cold winds from north-west. Most affected areas of country due to the cold waves include the western and north-western regions and also Bihar, UP directly affected by the western disturbances.

Thunderstorm, Hailstorm, Dust Storm etc

India's central, north-eastern, north-western and northern parts are generally affected by these. The southern coastal areas are less prone to thunderstorms, hailstorms and dust storms. The hailstorms are more frequent in Assam, Uttarakhand and some parts of Maharashtra. Dust storms are common in Rajasthan, MP and Haryana. Tornadoes are rare in India.

Droughts

Drought refers to the situation of less moisture in the soil (which makes the land unproductive) and scarcity of water for drinking, irrigation, industrial uses and other purposes, usually caused by deficient/less than average rainfall over a long period of time. Some states of India feature the perennial drought such as Rajasthan, Odisha, Gujarat, Madhya Pradesh etc.

Sixteen percent of the country's total area is drought-prone and approximately 50 million people are affected annually by droughts. In India about 68 percent of net sown area in the country is drought-prone. Most of the drought-prone areas identified by the Government of India lie in arid, semi-arid and sub-humid areas of the country. In the arid and semi-arid zones, very severe droughts occur once in every eight to nine years.

Geological Disasters

Earthquakes

Earthquake is almost impossible to be predicted, so it is the most destructive of all natural disasters. It is almost impossible to make arrangements and preparations against damages and collapses of buildings and other man-made structures hit by an earthquake. More than half of India's total area is vulnerable to seismic activity of varying intensities.

The most vulnerable regions are located in the Himalayan, Sub-Himalayan belt and Andaman & Nicobar Islands. The Himalayan ranges are among world's youngest fold mountains so the subterranean Himalayans are geologically very active. The Himalayan frontal arc, flanked by the **Arakan Yoma** fold belt in the east and the **Chaman fault** in the west make one of the seismically active regions in the world.

Tsunami

Tsunami refers to the displacement of a large volume of a body of water such as Ocean. Most Tsunamis are seismically generated, result of abrupt deformation of sea floor resulting vertical displacement of the overlying water.

The Tsunami waves are small in amplitude and long wavelength (often hundred of kilometers long). The east and west coasts of India and the island regions are likely to be affected by Tsunamis generated mainly by subduction zone related earthquakes from the two potential source regions, viz. the Andaman-Nicobar-Sumatra Island Arc and the Makran subduction zone north of Arabian Sea.

Landslides

Landslides are common in India in Himalayan region as well as Western Ghats. The Himalayan ranges are among the youngest fold mountains of world. They comprise a series of seven curvilinear parallel folds running along a grand arc of around 3400 kilometers. The landslides in this region are probably more frequent than any other areas in the world.

The Western Ghats, particularly Nilgiri hills also are notorious for frequent landslides.

Technologic Disasters

Industrial, Chemical & Nuclear Disasters

The industrial and chemical disasters can occur due to accident, negligence or incompetence. They may result in huge loss to lives and property. The Hazardous industries and the workers in these industries are particularly vulnerable to chemical and industrial disasters.

The most significant chemical accidents in recorded history was the 1984 **Bhopal Gas disaster**, in which more than 3,000 people were killed after a highly toxic vapour, (methyl isocyanate), was released at a Union Carbide pesticides factory.

Total Disaster Risk Management (TDRM) Approach

Yakohama Strategy for Disaster Reduction and Hyogo Framework of Actions

The traditional approach to the disaster management was mainly based on the premise that disasters are sudden occurrences and man has no role to play in its process. The state's capacity can be overwhelmed by the disasters and government / people have limited role to play in disasters. It's further premises were:

- Development and disasters are two separate phenomena so approach to disaster management is to be different from development process
- Victims of disasters are passive receivers to aid and relief. No role for them in disaster management.
- Disaster management generally means post-disaster relief operations.

Thus, the traditional approach was inadequate and minimal as far as confronting with the various disasters is concerned. In the 1990s, when the UN declared the decade as International Decade of

Natural Disasters Reduction, a gradual evolution of new approach started. One of the most important steps to give a concrete shape to new approach in disaster management was the Yakohama Conference. This UN conference was held in 1994. At the end of this conference a new Yakohama Strategy for Disaster Reduction was adopted. This strategy was aimed at minimizing the losses to human lives and property due to disasters. This strategy inter alia included the following:

- A global culture for prevention of disasters must be cultivated
- The vulnerable countries and communities should frame and implement policies of self reliance.
- Education and training mechanisms should be strengthened
- The Community participation to reduce vulnerabilities should be emphasized
- NGOs should be given broader platform to work
- UN agencies should be strengthened.

The Yakohama Strategy was further revised at the World Conference on Disaster Reduction held at Hyogo (Kobe) in Japan in 2005. This conference brought together government officials, non-governmental experts and other specialists from around the world to discuss the growing trend of people affected by natural disasters. The outcome of this conference was ***Hyogo Framework for Action***. The HFA suggests five specific priorities for action:

- Making disaster risk reduction a priority;
- Improving risk information and early warning;
- Building a culture of safety and resilience;
- Reducing the risks in key sectors;
- Strengthening preparedness for response.

The current strategies to disaster management across the globe advocate comprehensive framework and approach for all facets of disaster management. This approach is proactive and holistic and focuses on reducing the risk and vulnerability to disasters through a multidimensional and multilevel coordination among all stakeholders with the guiding principles and priorities in Hyogo Framework for Action and other such instruments. This approach is called **Total Disaster Risk Management Approach** (TDRM).

Total Disaster Risk Management (TDRM) Approach

The objective of **Total Disaster Risk Management Approach** (TRDM) is to integrate the existing knowledge and techniques of disaster reduction and response to risk management.

This approach emphasises that the *natural disasters are not natural, but rather man-made disasters are the consequences of natural hazards and human actions or inactions.* Thus, the human societies have the capacity to recognize the risks and factors that could lead or cause disasters, as well as the appropriate

interventions to control or manage them. In other words, disasters can be prevented or, at least, their destructiveness minimized. So, human action or inaction to high risk and vulnerability to natural hazards could spell the difference in the Disaster Management Cycle. Secondly, the significant progress has been made in disaster management, moving from ad-hoc relief to developmental approach. The basic concept of the disaster cycle that has been widely used in the last two decades has complemented the TDRM. Thirdly, it has been recognized that the community action and management of the disaster cycle are important, and disaster relief and development are linked.

Thus, TDRM has very much logical relevance to current Disaster Management Cycle and every stage of it. The TDRM envisages preventing or mitigating disasters through the enhancement of local capacity and capacity and capability, especially in recognizing and reducing disaster risks and possibly transforming them into development opportunities. It also emphasises to enhance coordination among communities to participate in the decision-making process for disaster management.

As its essential features, TDRM focuses on the underlying conditions of risks generated by unsustainable development, which lead to disaster occurrence. It also endeavours to minimize, if not prevent, disaster losses and to maximize development opportunities. Moreover, its thrust is to increase the capacity of the communities to recognize, manage and reduce risks, and, consequently, the occurrence and magnitude of disasters.

Disaster Management Set up in India

United Nations had declared 1990s as Decade of Natural Disaster Reduction. It called upon nations to formulate national disaster-mitigation programmes, as well as economic, land use and insurance policies for disaster prevention, and to integrate them fully into their national development programmes.

In India, the phrase *disaster management does not find place in any of the lists of the 7th schedule*. So far, the primary responsibility for the management of disaster has been of the state governments with assistance from the central government as per the recommendations of the Finance Commission.

In a sort of firsts, the **National Centre for Disaster Management** (NCDM) was established in 1995. This centre later became the National Institute of Disaster Management (NIDM). The responsibility for handling disasters remained with the Ministry of Agriculture till 2001. However, in August 1999, the government of India set up a High Powered Committee under the chairmanship of Mr. J. C. Pant. This was just prior to the devastating cyclone in Odisha. The J C Pant committee recommended the setting up of a *Disaster Management Ministry*, but this did not fructify in the form recommended.

Thereafter in February 2001, just after the Gujarat earthquake, an All Party National Committee on Disaster Management was set up under the chairmanship of the Prime Minister. This committee recommended the creation of the NDMA under the Ministry of Home Affairs (MHA) and therefore in June 2002, in deference to the recommendations of the **Pant committee**, the responsibility of handling Disaster Management was transferred to the MHA. Later the 2004 **Indian Ocean Tsunami** shook the conscience of the nation and the government decided to enact a law on disaster management to provide for requisite institutional mechanism for drawing up and monitoring the implementation of the disaster management plans, ensuring measures by various wings of Government for prevention and mitigating effects of disasters and for undertaking a holistic, coordinated and prompt response to any disaster situation.

The Disaster Management Act, 2005 was enacted and notified on December 26, 2005

Disaster Management Act 2005: Salient Provisions

The Disaster Management Act, 2005 has been enacted as the central Act to deal with the management of disasters. This act envisaged a three tier Disaster Management structure in India at National, States and District levels. Under the act, the NDMA, SDMA, NEC, NDRF, NIDM and disaster related funds were established.

National Disaster Management Authority

The Disaster Management Act mandates the Central Government to establish NDMA as nodal authority with prime minister as its ex-officio chairperson. Further, it has *maximum nine members* nominated by Chairman (Prime Minister). The Chairman can nominate any of the nine members also as Vice-chairman of NDMA. The NDMA meetings are presided by the Chairman and such meetings are called for as and when PM thinks fit. If Chairman is not available for presiding the NDMA meeting, this job is to be done by Vice President. Officers, employees and consultants to the authority are provided by the Central Government.

Powers and Functions of NDMA

The key responsibilities of NDMA include laying down the policies, plans and guidelines for disaster management for ensuring timely and effective response to disaster. It lays down the policies on disaster management, approve the national plan, and approve plans developed by various ministries of the union, lay down the guidelines to be followed by the state authorities in drawing up state plans. NDMA also is mandated to recommend **guidelines for the minimum standards of relief** to be provided to persons affected by disaster. The minimum standards are as follows:

- Minimum requirements to be provided in the relief camps in relation to shelter, food, drinking water, medical cover and sanitation;
- Special provisions to be made for widows and orphans;

- Ex gratia assistance on account of loss of life as also assistance on account of damage to houses and for restoration of means of livelihood;
- Such other relief as may be necessary.

In case of a disaster of severe magnitude, the NDMA is **empowered to recommend relief in repayment of loans** or for grant of fresh loans to the persons affected by disaster.

Responsibilities of the Central Government

The DM Act puts on central government the obligation to take all measures necessary and expedient for the purpose of disaster management including coordination between ministries and department, state governments, various domestic and international agencies etc. It is also obliged to make proper allocation of funds.

National Executive Committee

Apart from NDMA, the central government also constitutes a National Executive Committee which is responsible for assisting NDMA in execution of various functions for disaster management. The secretary of the ministry which is responsible for disaster management is chairperson of NEC. The secretaries in the ministries of agriculture, atomic energy, defence, drinking water supply, environment and forests, finance (expenditure), health, power, rural development, science and technology, space, telecommunication, urban development, water resources and the Chief of the Integrated Defence Staff of the Chiefs of Staff Committee will be members of the NEC.

Powers and Functions of NEC

- Assist NDMA in its functions
- Implementing the plans and policies of NDMA
- Ensuring compliance with the directives of Central Government.
- To act as a coordinating and monitoring body for disaster management
- Prepare the National Plan to be approved by the NDMA
- Prepare guidelines for different ministries with respect to disaster management.
- Provide technical assistance to state governments and authorities.
- Monitor the implementation of the National Plans and plans of various ministries
- Monitor implementation of the guidelines laid down by the NDMA
- Coordinate response in case of a disaster.
- Advise and assist various ministries and departments.

National Plan

The National Plan is a Disaster Management Plan for the entire country. It is prepared by the NEC in consultation with the state governments and various bodies in the field of disaster management. Once prepared, NDMA approves it. The basic things to be included in national plan are as follows:

- What measures are to be taken for the prevention of disasters, or the mitigation of their

effects?

- What measures are to be taken for the integration of mitigation measures in the development plans?
- What measures are to be taken for preparedness and capacity building?
- What will be the roles and responsibilities of different Ministries or Departments?

A National Plan has to be reviewed and updated annually. The central government would finance the measures to be carried out as per the plan. The copies of the plan shall be distributed to all ministries and departments and using this plan, the ministries would develop their own plans.

State Disaster Management Authority

A state Disaster Management Authority is to be established by every state government. The Chief Minister of the state is the chairperson of SDMA. There are maximum 9 members other than the chairperson. In case of a Union Territory with no assembly (Delhi and Puducherry), the Lieutenant Governor or the Administrator is the chairman of the SDMA. The SDMA will meet as and when the chairperson (CM) decides. Other employees and staff of the SDMA are appointed by the State Government.

Powers and Functions of SDMA

- To lay down the disaster management policies and plans for state
- To lay down state disaster management policy
- Approve state plans as per guidelines of national plans.
- To lay down guidelines to be followed by departments of the state.
- The act maintains that the CM , in case of emergency, would have the power to exercise all or any of the powers of the State Authority but the exercise of such powers shall be subject to ex post facto ratification of the State Authority.

State Executive Committee

The state government also creates a State Executive Committee to assist the State Authority in the performance of its functions and to coordinate action in accordance with the guidelines laid down by the State Authority and ensure the compliance of directions issued by the State Government under this Act.

Its powers and functions are almost a replica of the NEC at state level. Further, it can also among others can:

- Control and restrict, vehicular traffic to, from or within, the vulnerable or affected area
- Control and restrict the entry of any person into, his movement within and departure from, a vulnerable or affected area;
- Remove debris, conduct search and carry out rescue operations; provide shelter, food, drinking water, essential provisions, healthcare and services in accordance with the standards

laid down by the National Authority and State Authority;

State Disaster Management Plan

Every State Executive Committee prepares a state disaster management plan as per the guidelines of the NDMA. State plan are approved by the State DM Authority. The state plan would comprise various vulnerabilities, measures to be adopted for prevention and mitigation, Capacity building measures, roles and responsibilities of various departments etc. The state plan has to be reviewed every year. The state government will finance the measures listed out in state plans.

District Disaster Management Authority

The DDMA are set up by state government via a notification in the state budget. It consists of Chairperson and seven members. The collector or District Magistrate or Deputy Commissioner would be the chairman. The Co-chairperson will be elected members of the local government. In the Sixth Schedule areas, the Chief Executive Member of the district council of autonomous district, shall be the co-Chairperson. The members will include Superintendent of the Police, Chief Medical Officer and other district level officers as nominated by the state government.

Powers and Functions of DDMA

The DDMA works as a district planning, coordinating and implementing body for disaster management. It will coordinate with the upper two tiers of the structure and will plan the implementation of the prevention, mitigation and preparedness at local level.

National Institute of Disaster Management

National Institute of Disaster Management has been established as a statutory body under DM Act. This institute is responsible for planning and promoting training and research in the area of disaster management, documentation and development of national level information base relating to disaster management policies, prevention mechanisms and mitigation measures. Its key functions include:

- Development of training material
- Formulate a comprehensive human resource plan
- Provide inputs to governments
- Develop educational materials for disaster management including academic and professional courses
- Promote awareness
- Conduct study courses

National Disaster Response Force

The act envisages constitution of the National Disaster Response Force for the purpose of specialist response to a threatening disaster situation or disaster. The general superintendence, direction and control of the Force shall be vested and exercised by NDMA.

National Disaster Response Fund

The DM Act 2005 calls upon the central government to constitute the National Disaster Response Fund for meeting any threatening disaster situation or disaster. The central government will be able to use the money from this fund to meet expenses for emergency response, relief and rehabilitation. Here we note that the erstwhile National Calamity Contingency Fund (NCCF) which was constituted as per the recommendations of the 11th Finance Commission has been merged into National Disaster Response Fund (NDRF) in line with the recommendation of the 13th Finance Commission. The amount collected from National Calamity Contingent Duty (NCCD) is transferred to the NDRF.

National Disaster Mitigation Fund

The act also calls upon the government to constitute a National Disaster Mitigation Fund for projects exclusively for the purpose of mitigation. They money from this fund is to be used by the NDMA for mitigation purposes.

The Disaster Management Structure in India

As per mandate of the Disaster Management Act 2005, the government created the NDMA as opposed to a separate ministry recommended by the **Pant Committee**. The disaster management set up was structured at three levels viz. national, state and district. The NDMA was set up as the apex body at the national level, while at the state level State Disaster Management Authorities (SDMA) were set up. These were headed by the Chief Ministers. At the district level District Disaster Management Authorities (DDMA) were set up. These were headed by the District Collectors and co-chaired by elected representatives of the local authorities. All these authorities were charged with the responsibility of formulating holistic and integrated plans for disaster management and ensuring the implementation of these plans when required.

The executive committee of the NDMA is called National Executive Committee (NEC). It coordinates the response on behalf of the NDMA. It consists of 14 Secretaries of the government of India as well as the Chief of the Integrated Defence Staff. To assist the NDMA two other bodies have been created called the National Institute of Disaster Management (NIDM) and the National Disaster Response Force (NDRF). The structure of the NDMA, evolved for disaster management at the national level, is shown in the adjacent graphics.

Various Stake-holders in Disaster Management

According to the United Nations International Strategy for Disaster Reduction (UN/ISDR), there are several key parties that play major roles in the disaster management process. These include communities, particularly those most vulnerable; local governments; national governments, regional institutions; NGOs, Corporations, Media and scientific communities. They have been discussed below:

Communities

Communities, particularly those most vulnerable are the key stakeholders in disaster management. These are most vital to people-centred early warning systems. Their input into system design and their ability to respond ultimately determine the extent of risk associated with natural hazards.

Key issues in context with the communities are as follows:

- The vulnerable communities need to be aware of hazards and potential negative impacts to which they are exposed and be able to take specific actions to minimize the threat of loss or damage.
- The most essential determinant of the selection of the disasters on which system should focus is the geographical location of such communities.
- For example, while the coastal communities need to be educated and prepared for the possibility of a tsunami, a community in Himalayas can be educated to respond to an early warning system for landslides and earthquakes.

Local governments

The local governments need to have considerable knowledge of the hazards to which their communities are exposed. Thus, the local governments must be actively involved in the design and maintenance of early warning systems. It should also have capacity to instruct or engage the local population in a manner that increases their safety and reduces the potential loss of resources on which the community depends.

National governments

The national Government are responsible for policies and frameworks that facilitate early warning. They are also responsible for the technical systems necessary for the preparation and issuance of timely and effective hazard warnings for their respective countries. The key issues with national governments are:

- The national government should ensure that warnings and related responses are directed towards the most vulnerable populations through the design of holistic disaster response and early warning frameworks that address the specific needs of the related micro- and macro-level actors.
- The provision of support to local communities and local governments to develop operational capabilities is an essential function to translate early warning knowledge into risk reduction practices.

Regional institutions and organizations

These should provide specialized knowledge and advice in support of national efforts to develop or sustain the operational capabilities of countries that share a common geographical environment.

International bodies should provide support for national early warning activities and foster the

exchange of data and knowledge between individual countries. Support may include the provision of advisory information, technical assistance, and policy and organizational support necessary to ensure the development and operational capabilities of national authorities or agencies responsible for early warning practice.

Non-governmental organizations (NGOs) play a critical role in raising awareness among individuals and organizations involved in early warning and in the implementation of early warning systems, particularly at the community level. In addition, they play an important advocacy role to help ensure that early warning stays on the agenda of government policy makers.

The private sector has a diverse role to play in early warning, including developing early warning capabilities in their own organizations. The private sector is also essential as they are usually better equipped to implement ICT-based solutions. The private sector has a large untapped potential to help provide skilled services in the form of technical manpower, know-how, or donations of goods or services (in-kind and cash), especially for the communication, dissemination and response elements of early warning.

The media plays an important role in improving the disaster consciousness of the general population and in disseminating early warnings. The media can be the critical link between the agency providing the warning and the general public.

The scientific community has a critical role in providing specialized scientific and technical input to assist governments and communities in developing early warning systems. Their expertise is critical to analysing the risks communities face from natural hazards, supporting the design of scientific and systematic monitoring and warning services, fostering data exchange, translating scientific or technical information into comprehensible messages, and disseminating understandable warnings to those at risk.

Role of ICT in Disaster Prevention

The importance of timely disaster warning in mitigating negative impacts can never be underestimated. Although damage to property cannot be avoided, some of the developed countries have been able to reduce loss of life much more effectively than developing countries mainly because of the implementation of effective *disaster warning systems and evacuation procedures*.

For instance, during the Hurricane Katrina, although the economic loss and damage to property were much higher, the number of deaths was remarkably less than that resulting from the Indian Ocean tsunami in Sri Lanka and India. This was largely because the effective disaster warning systems were not in place in Sri Lanka and India.

Information and Communication Technology (ICT) play a significant role in highlighting risk areas, vulnerabilities and potentially affected populations by producing geographically referenced analysis

through a geographic information system (GIS). The role of information technology can be divided into three broad categories as follows:

- Channels that spread disaster warning to vulnerable communities.
- GIS (Geographical Information System)
- Remote Sensing

Channels for Disaster warning

This includes Radio and Television, Mobile Telephony and Fixed Phones, SMS, cell broadcasting, Satellite Radio, Internet / email and Amateur Radio. Each of them has played specific role in several instances.

GIS

GIS can be loosely defined as a system of hardware and software used for storage, retrieval, mapping and analysis of geographic data. This data is mainly of two types vis. **Spatial data** and **descriptive attributes**.

Spatial features are stored in a coordinate system (latitude, longitude, state, plane, etc.) that references a particular place on the earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis.

GIS can be used for scientific investigations, resource management and development planning. As disaster management work usually involves a large number of different agencies working in different areas, the need for detailed geographical information in order to make critical decisions is high.

By utilizing a GIS, agencies involved in the response can share information through databases on computer-generated maps in one location. Without this capability, disaster management workers have to access a number of department managers, their unique maps and their unique data. Most disasters do not allow time to gather these resources. GIS thus provides a mechanism to centralize and visually display critical information during an emergency.

Remote Sensing

Remote sensing is the measurement or acquisition of information about an object or phenomenon by a recording device that is not in physical or intimate contact with the object.

Remote Sensing is not used in isolation but in synergy with the GIS in disaster management. There is an obvious advantage to using a map with remote sensing or GIS inputs instead of a static geographical map. A static map is mostly analogous and is not interactive. On the other hand, a vulnerability map with GIS input provides dynamic information with cause and effect relationship.

Role of Earth System Science Organization in Disaster Management

Earth System Science Organisation (ESSO) is a **virtual organisation** set up by Ministry of Earth

Sciences GOI in 2007 and it is the executive arm of MoES. It has three major branches of earth sciences viz., Ocean Science & Technology, Atmospheric Science & Technology and Geosciences and Technology. The sole purpose of the endeavour was to address the problems relating to earth processes for understanding the variability of earth system and for improving forecast of the weather, climate and hazards for societal, economic and environmental benefits including climate change science, climate services and integrated Himalayan meteorology, the ESSO is also responsible for development of technology towards the exploration and exploitation of marine resources in a sustainable way for the socio-economic benefit of the society by taking into account the global developments in the field of marine environment.

- The overall vision of the ESSO is to excel in knowledge and technology enterprise for the earth system science realm towards socio-economic benefit of the Indian sub-continent and in the Indian Ocean region.
- The ESSO contributes to the areas of Weather (General), Weather advisories specific to agriculture, aviation, shipping, sports, etc. *Monsoon, Disasters (cyclone, earthquake, tsunami, sea level rise), Living and non-living resources (fishery advisory, poly-metallic nodules, gas hydrates, freshwater etc), Coastal and Marine Ecosystems and Climate Change, Underwater Technology.*

These policies/programmes are being pursued through its centres viz., autonomous bodies and subordinate offices such as. IMD, IITM, National Centre for Antarctica and Ocean Research (NCAOR), National Institute of Ocean Technology (NIOT), Indian National Centre for Ocean Information Services (INCOIS), Centre for Marine Living Resources (CMLRE) and Integrated Coastal and Marine Area Management (ICMAM) were grouped under the ESSO. These institutions are under Earth System Science Organization (ESSO), managed by the ESSO Council. Each centre has been created with a specific well defined mandate. The ESSO operates through ESSO council, an apex body to formulate policies and plans, and provide program directions for the Centres/Units and review the implementation of programmers.

Indian Tsunami Early Warning Centre

Tsunami Early Warning Centre is a part of **Indian Nation Centre For Ocean Information Services** (INCOIS). INCOIS has a **data warehouse** of ocean related information gathered from various institutions in India. These institutions are involved in Marine Data Collection, Ocean Observation and Ocean/Atmospheric sciences.

INCOIS translates data into deliverable products to a range of users such as:

- Fishing community
- State Fishery Department Officers
- Planning Commission

- Ports and Harbours
- Shipping Industry, Navy, Coast Guards, NHO Central Pollution Control Board
- MHR – Ministry of HR etc

The Indian Tsunami Early Warning System incorporates the needs of storm surge forecast too. The System design is based on end-to-end principle encompassing:

- 24X7 Dedicated Tsunami Warning Centre
- Near-real time determination of earthquake
- Comprehensive real time Ocean observational network
- Radar-based Coastal Monitoring Stations
- Developing numerical models for Tsunami and Storm Surges
- Generating Coastal inundation and Vulnerability maps
- Capacity building, training, education of all stakeholders
- International connectivity.

Indian Initiative for the Dual-use Early Warning System covers the two known Tsunamigenic zones that affect Indian Ocean region. It is an end-to-end system that is scientifically and technically sound. It is comprehensive and covers the required observations, modelling, data communication, warning centre, capacity building.

How it works?

For issuing a warning, the system uses the data it receives from seismic stations, sea level gauges, bottom pressure recorders (tsunami buoys) and the numerical models to predict the water level changes expected at various locations along the Indian coast. **So far this system has worked well**.

Rangachang

In order to forecast Tsunami early, the National Institute of Ocean Technology (NIOT) has installed the Early Tsunami Warning System (ETWS) at Rangachang in Andaman and Nicobar Islands. The system can forecast a tsunami within 3 minutes after the initial tremors are felt and can send alerts.

Following the alerts sent from the Tsunami Warning System, the tsunami alerts can be issued to the risk zones via Centre in consultation with Indian National Centre for Ocean Information Services, INCOIS at Hyderabad.

INCOIS has 22 sea-level gauges at Aerial Bay, Chennai, Ennore, Garden Reach, Haldia, Kandla, Karwar, Krishnapatnam, Marmagao, Machilipatnam, Nagapattinam, Paradeep, Port Blair, Vadinar, Visakhapatnam, among others, and three bottom pressure recorders. Such recorders get triggered to tsunami mode due to the arrival of seismic waves. In addition to the Indian systems, INCOIS also accessed the data in real-time, near real-time from similar observing systems maintained by other

countries in the Indian and Pacific Ocean to follow the progress of the tsunami wave.

Issues in Disaster Management in Mountainous Regions of India

India's Himalayan region is geologically very active and sensitive. In this region, every year, one or other types of disasters such as earthquakes, landslides, floods, forest fires etc. occur very frequently. Though at the time of disaster, various rescue and relief operations are carried out and plans for long term strategies are formed, yet the long term strategies are easily forgotten as memory fades.

- It is observed that disaster management in the area is just like fire fighting and very negligible or conscious attempt is made for long term strategies.
- Partial failure of the administration and other agencies to counter the situation results in further deterioration of the condition.
- Unemployment, diseases, scarcity of livelihood, food and water shortage, shelter housing problem, failure of communication and other infrastructures, environmental degradation etc. are some major problems which are being faced due to one or the other form of disasters in the area.
- In the recent past, mainly due to increasing population pressure and various other man made/natural factors, the intensity and severity of disasters have increased many times and subsequently the problem of rehabilitation has become more tenuous, particularly in this region of the country.

Realizing the seriousness of the problem and its adverse impact on the socio-economic status of the people of the region, it is high time that some appropriate strategic approach is applied for proper disaster management in the area.

Issue of Public Awareness in Disaster Management

In terms of the public awareness about impending floods, droughts, earthquakes, cyclones etc., India has achieved widespread but low levels of scattered mixed results. The important activities taken by NDMA include preparation of guidelines, and improvements in risk assessment, early warning systems, capacity-building, and expanding communication networks.

However, despite of the wide array of activities, there is a widespread lack of public appreciation for disaster preparedness.

Moreover, despite a complex structure of disaster management, there is a limited policy interest in disaster risk reduction (DRR).The key areas such as shelter, infrastructure, and industry remained largely unfocussed in India.

In our country, there has been a need to establish institutions at all levels to create awareness of disaster and the ways to effectively respond to disasters. Thus, the direst need for the effective disaster management is the building of knowledge base of local people and strong institutions.

The prevention pays when it is done well. To achieve results, India needs to impart its people the sector-wide awareness about disaster risks. This can be done via the central administration and well-targeted help of the United Nations Development Programme (UNDP), through a series of training activities aimed at local leaders, institutions and rural women in using the Hyogo Framework for Action (HFA).

While the NDMA has made progress in establishing overall structure for disaster management, several gaps continue to exist in India's disaster preparedness that require focus. One key gap is NDMA's oversight in articulating a list of natural and manmade disasters for which the National Disaster Response Force (NDRF) would apply to. This lack of clarity has left funding options for relief and rehabilitation more ambiguous. Moreover, partially as a result of this gap, so far the guidelines have not been backed up with the resources to implement them; institutions lack resources and are often incapable in carrying out the necessary activities. Thus, building the capacity of institutions and increasing the flow of resources must become a critical priority of NDMA.

- It must also aim to raise public awareness through collaboration with non-governmental organisations (NGOs), local government bodies, and primarily through panchayati raj institutions.
- India has entered multiple multilevel partnerships with the United Nations (UN), international NGOs, investment banks and the private sector to improve its knowledge and response muscle. The UNDP plays a critical role in coordination and sectoral interventions of national and state governments although the amounts involved are very small. It also works with educational institutions, the International Labour Organisation (ILO), various other UN agencies, bilateral agencies including, but not limited to, the United States Agency for International Development, the Australian Agency for International Development, Norwegian Agency for Development Cooperation, and Japan International Cooperation Agency.
- With the support from the government, the Central Board of Secondary Education (CBSE) has incorporated a short disaster management course in the school curriculum which includes activities targeted at both teachers and students
- India has performed well with certain elements of post-disaster reconstruction and recovery in particular geographic areas. For instance, the Asian Disaster Reduction Centre highlighted good practices in the Gujarat Earthquake 2001 response such as creating a viable framework for cooperation among different stakeholders, sound needs assessment, capacity-building and implementation with a view towards sustainability and resiliency via strengthening local institutions.

- Nonetheless, these achievements are not widespread and are lacking in many disaster-prone areas.

Disaster and Development

Disasters and development are closely linked. Disasters can both destroy development initiatives and create development opportunities. Development schemes can both increase and decrease vulnerability.

In the traditional approach to disasters, the attitude was that the disasters, especially natural ones, were an act of god and as such were beyond human control; accepting death and damage to property was part of the costs. With such an attitude, most development plans were designed without consideration for the effect disasters would have on community plans and vice versa. When a disaster did occur, the response was directed at meeting emergency needs and cleaning up.

In the current approach, it has been realized that much more can and need to be done to reduce the severity of hazards and disasters. A growing body of knowledge on the relationships between disasters and development indicates four basic themes as follows:

- Disasters set back development programming, destroying years of development initiatives.
- Rebuilding after a disaster provides significant opportunities to initiate development programmes.
- Development programmes can increase an area's susceptibility to disasters.
- Development programmes can be designed to decrease the susceptibility to disasters and their negative consequences.

Thus, the policy makers cannot ignore the relationship between the disaster and development. Projects are thus being designed to include disaster recovery programmes and with long term development needs in mind. Disasters can significantly impede the effectiveness of development resource allocation.

Community Based Approach to Disaster Management

All governments are responsible for protecting their citizens and endorsing the 2005 **Hyogo Declaration** which states that: "*strengthening community level capacities to reduce disaster risk at the local level is especially needed, considering that appropriate disaster reduction measures at that level enable the communities and individuals to reduce significantly their vulnerability to hazards.*"

Members of a community are the immediate victims of adverse effects of a disaster. They have the best knowledge about their local surrounding in terms of the most disaster-prone areas, the demography of their community and their social and traditional organisation. It is important that they have the capacity to cope with the impacts of a disaster and are involved in the development of disaster management activities right from the initial planning stages. Community participation can

also make them more confident in their capabilities to act in the event of a disaster leading to a self-reliant community.

Moreover, the community based approach to disaster management becomes important due to the following shortcomings of the present system:

- The same plan, regardless of the regional characteristics, is implemented or imposed everywhere.
- Local knowledge, experiences, skills, resources and techniques are not given due importance. Rather external resources and techniques are proposed to be utilized.
- Negligence about local cultural instincts and heritage.
- Prioritisation is decided by an outsider and not the stakeholders or the community itself.
- Local community does not have any information about the disaster management plans for their area and the role of different sectors in helping the community during disasters.

Advantages of Community-based Disaster Risk Management

- Feelings of coordination and self belonging to the society are developed.
- Local geo-climatic and socio-cultural characteristics get attention of the people in development and disaster management.

- Local initiatives begin and community provides assistance to the executing agencies involved in disaster management.
- There is exchange of knowledge, information, skills and techniques between the community and the experts involved from outside.
- Community comes forward to put forward its ideas for selection of appropriate programmes suitable to their locality and society.
- Community can monitor the quality of works being done in its locality. It will also generate a sense of responsibility among the community.
- It will lead to capacity building of the community on issues of disaster-safe developmental activities.

Bottom up Participatory Approach

- Every community has members who can be ignorant of events around them especially when these events do not affect them directly or more frequently. This type of attitude can also be gradually changed by involving members of the local community in decision-making processes such as planning national disaster management plans or even designing awareness programmes.
- This bottom-up, participatory approach can make community members more receptive of new knowledge and information presented to them. Local residents who speak or understand

their native language only may be hesitant to accept non-native people conducting education and awareness programmes for them.

Stakeholders in Community Based Disasters Management

An effective and successful community-based approach in reducing disaster risks is often attributed to the spontaneous participation and involvement of the following stakeholders:

- Government
- Non-governments (NGOs)
- Regional and International Organisations/Donor Agencies
- Local governments / Municipalities / Zilla Parishads
- National/Local Organisations (youth groups, schools, etc)
- Community workers
- Trainers
- Disaster Managers (Local and National)
- Policy Makers
- Grass-roots people
- Religious Denominations

There is a need for coordination in the Community-Based Approach among all the stakeholders.

Floods

Overview of Recent Floods in India

Floods are most common natural disasters in India and the country is one of the highest flood prone countries around the world. As per the National Flood Commission report, around 4 crore hectare land in India is prone to floods. India has more flood deaths than any country except Bangladesh. Apart from loss of precious human and animal lives, Floods cause damage to houses, industries, public and private property.

Floods in Kosi River

Almost every year, Kosi River is subject to floods affecting around 20 thousand km² area of fertile lands in Bihar and Nepal. It caused devastating floods in 1953-54. In 1987, the Kosi floods had affected around 30 districts, claiming lives of around 1400 people and 5500 animals. Another disastrous flood experienced by Kosi was in August 2008 when the river *changed its course* and created havoc in a densely populated area.

Assam Floods, 1998, 2012, 2015

Floods are a part of life in Assam. The state has network of Brahmaputra and Barak rivers and their more than 50 tributaries. These cause floods almost every year during monsoon. Almost 40% of the total land area in the state is flood-prone. Further, the flood and erosion problem of Assam is

different from other states in terms of extent and duration of floods and magnitude of erosion. The most severe floods occurred in Assam in 1998. In that year, Brahmaputra remained above the danger mark for almost three months and all districts of Assam remained flooded. In 2012 and 2015 floods also many people lost life. In these floods, the Kaziranga National Park was affected claiming lives of several Great Indian Rhinos.

Maharashtra Floods, 2005

In 2005, Maharashtra witnessed deadly floods that killed around 5000 people.

Ladakh Floods, 2010

In August 2010, a major cloudburst and heavy rainfall triggered mudslides, flash floods and debris flow in Ladakh which claimed 250 lives.

Uttarakhand Floods, 2013

The June 2013, Uttarakhand was hit by one of the most disastrous floods in history of India. The cloudbursts triggered flash floods and massive landslides trapping nearly one lakh Hindu Pilgrims at Kedarnath and Badrinath. Around 1000 people were confirmed dead and around 5,700 people were "presumed dead." Indian Army launched one of the most severe rescue operations in its history to save those trapped in the valley.

Jammu & Kashmir Floods, 2014

In 2014, Jammu and Kashmir witnessed worst flood due to incessant rain and flash floods.

South Indian Floods, 2015

In November and December 2015, the annual North-East monsoon generated heavy rainfall in south India causing floods along the Coromandel Coast in Tamil Nadu, Andhra Pradesh and Pondicherry. Chennai and surrounding area were hardly hit by these floods. These floods caused displacement of around 18 Lakh people and claimed lives of around 500.

Flood Prone Areas in India

The total flood prone area in India is more than 4 crore hectares. This area can be divided into four regions viz. Brahmaputra Region; Ganga Region; North West Region; and Central India and Deccan region.

Brahmaputra River Region

The Brahmaputra & Barak Rivers and their tributaries cover 7 states of north east India and northern parts of West Bengal state. The rivers catchment regions receive heavy rainfall in the range of 110-635 cm mostly in June-September period. It causes severe floods in the region. The region is also prone to landslides. Many times the floods cause spillage of rivers over their banks, drainage congestion and change of course by rivers.

Ganga River Region

River Ganga and its tributaries cover as many as ten states. The rainfall in this region varies from

60-190 cm. The flood problem is mostly confined to the areas on the northern bank of the river Ganga. Ganga's northern tributaries spill over their banks and change their courses. The flood problems increase from South to North and from West to East. North Western parts of the region and some eastern parts face the problem of drainage congestion. The flooding and erosion problem is more in the States located in the downstream.

North West River Region

The Sutlej, the Beas, the Ravi, the Chenab and the Jhelum are the main rivers in the region. They carry substantial discharge during the monsoon season along with huge volumes of sediment from the Himalayas. They change their courses frequently and leave behind tracts of sandy waste. The flood problem is less in the region when compared to the Ganga and the Brahmaputra river region. The major issue is that of inadequate surface drainage which causes inundation and water logging over vast areas.

Central India and Deccan Region

The major rivers in this region are the Narmada, the Tapi, the Mahanadi, the Godavari, the Krishna and the Cauvery. These rivers have stable courses expect in the delta area. The lower reaches of rivers of East coast have been embanked and thus the problem of floods has been largely eliminated.

Government Initiatives on Flood Management

The subject of floods control is not particularly mentioned in any of the three legislative lists of the Constitution. However, Drainage and Embankments are mentioned in State list. Thus the primary responsibility to deal with floods is of states. The role of central government is technical and advisory in nature. The states have to prepare plans for flood control based on the local needs.

Presently India has two tier flood management systems viz. state level mechanism and central government mechanism. The State Level Mechanism includes the Water Resources Departments, Flood Control Board and State Technical Advisory Committee. The Central Government Mechanism includes several organizations and various expert committees to enable the State Governments in addressing flood problems in a comprehensive manner.

Central Water Commission (CWC)

It was set up in 1945 for promoting measures of flood control, conservation and utilization of water resources throughout the country in the areas of beneficial uses, irrigation and hydropower generation, flood management and river conservation.

Brahmaputra Board

It was set up in 1980 and its jurisdiction includes all States of North East region in Brahmaputra and Barak Basin.

Brahmaputra Board prepared master plans for the flood management for river Brahmaputra and Barak.Besides this, the Board has undertaken survey and investigations for preparation of master

plans for tackling the problems of flood, erosion and drainage congestion including DPRs for multipurpose projects.

Ganga Flood Control Commission

It was set up in 1972. It has prepared comprehensive plans for flood management of the 23 sub-basins in the Ganga Basin and also drawn out a phased programme of implementation of these works.

Farakka Barrage Project Authority

It carry out anti-erosion and river bank protection works in near river vicinity of the Barrage.

Government's Initiatives and Policies on Floods

The Government of India took several initiatives and constituted a number of Committees to study the problem of floods in the country. They are:

- Policy Statement – 1954
- High Level Committee On Floods – 1957 & Policy Statement of 1958
- National Flood Commission (Rashtriya Barh Ayog) – 1980.
- Expert Committee to Review the Implementation of the Recommendations of National Flood Commission-2003 (R Rangachari Committee)

National Water Policy (1987/ 2002/2012)

The National Water Policy (1987) adopted by the National Water Resources council recommended that sufficient flood cushion should be provided in water storage projects to facilitate better flood management. Along with physical flood protection works like embankments and dykes it laid emphasis on adoption of non-structural measures such as flood forecasting and warning and flood plain zoning etc.for the minimization of losses.

The National Water Policy (2002) adopted by the National Water Resources Council recommended the following guiding principles:

- Preparing master plan for flood control and management for each flood prone basin.
- Along with physical flood protection works, non-structural measures should be given more emphasis.
- Regulation of settlements and economic activity in the flood plain zones along with flood proofing, to minimize the loss of life and property on account of floods.
- Coastal States should prepare a comprehensive coastal land management plan, keeping in view the environmental and ecological impacts, and regulate the developmental activities accordingly.

The National Water Policy (2012) adopted by the National Water Resources Council recommended similar guiding principles as recommended in the National Water policy (2002).

General Flood Management Measures Practiced in India

Based on the nature work, the flood protection and flood management measures may be broadly categorized as engineering/structural measures and administrative/non-structural measures.

Engineering or Structural Measures

These engineering measures that bring relief to the flood prone areas by reducing flood flows and thereby the flood levels are: creation of artificial reservoirs behind dams across rivers; a natural depression suitably improved and regulated; diversion of a part of the peak flow to another river or basin without any damages from the diversion; and construction of parallel channels.

The engineering methods of flood protection that do not reduce the flood flow but reduce spilling are: construction of embankments; and channel and drainage improvement.

Reservoirs

Reservoirs can reduce the intensity and timing of the incoming flood. Their effectiveness depends on the available reservoir capacity. Reservoirs are more effective for flood management if specific flood space is earmarked, as in the case of Damodar Valley Corporation dams across the Damodar and its tributaries. To improve the efficiency of the reservoirs, arrangement for inflow forecasts should be made.

Detention basins

They are formed by improving the capacity of natural depressions/ swamps and lakes. The Ghaggar detention basin in Rajasthan is a good example. This method is relatively inexpensive as the land under marshes may hardly require much compensation.

Embankments

Embankments confine the flood flows and prevent spilling, thereby reduce the damage. These are cheap and quick method of flood protection. Erosion along the embankments and natural banks of the river systems has been a serious problem. The embankment shave to be suitably protected by spurs, pitching and other suitable anti-erosion measures. This method of flood management should be undertaken only after carrying out necessary hydrological and other studies regarding their favourable and adverse effects.

Channelization of rivers

While channelizing rivers, it must be keep in mind to give the river certain freedom to flow and right of way to pass its flood waters and silt load within its natural waterway.

Channel improvement

It involves improving the hydraulic conditions of the river channels by desilting, dredging, lining etc. But this method is associated with high costs and other problems. This method is economically justifiable if the channel is used for navigation purpose.

Drainage improvement

Inadequacy of natural or artificial drainage channels for carrying the storm water discharge in a

reasonable time causes damage. Therefore, it is essential to improve drainage conditions by construction of new channels or improvement in the discharge capacity of the existing drainage system.

Diversion of flood waters

This method can be used in case of unusual floods around cities. Important projects under construction or under planning are the supplementary drain in Delhi, the Thottapally Spillway diversion in Kerala, the Kolleru lake diversion into the sea in Andhra Pradesh, etc.

Watershed Management

It include measures for developing and conserving the vegetative and soil covers and also construction of structural works like check-dams, detention basins, diversion channels, etc.

Administrative or Non-structural measures

The administrative methods focus on mitigation of flood damages by:facilitating timely evacuation of people to safer areas through advance warning of incoming flood; and discouraging creation of valuable assets/settlement in frequent flood prone areas. However, providing absolute protection all flood prone areas is practically impossible and economically unviable.

Flood Plain Zoning

Under this concept, it is recognised that the flood plain of a river is essentially its domain and any intrusion of developmental activities into it must recognise the river's right of way. Flood-plain zoning involves demarcation of areas likely to be affected by floods of different magnitudes and frequencies. State governments are encouraged to implement the flood plain zoning approach.

Flood Proofing

Flood proofing measures involve raising villages above the pre-determined floods levels.

CWC National Flood Forecasting Network

The duty of flood forecasting and warning in India is entrusted with the Central Water Commission (CWC). Currently there are more than 850 Hydrological and Hydro-meteorological sites being operated by CWC across the country covering 20 river basins for observing the discharge, sediment & water quality. The flood forecasting comprises level forecasting and inflow forecasting. Level forecasting helps for evacuation of people to safer areas. The inflow forecasting is used by dam authorities for operation of reservoirs for safe passage of flow downstream.

Kosi Floods: The River That Runs Away

Kosi River is known as Bihar's sorrow. Almost every year, the river is subject to floods affecting around 20 thousand km² area of fertile lands in Bihar. During floods, its average water flow multiples by as much as 18 times of average water flow, thus creating havoc for the rural economy of Bihar. It caused devastating floods in 1953-54. In 1987, the Kosi floods had affected around 30 districts, claiming lives of around 1400 people and 5500 animals. Another disastrous flood experienced by

Kosi was in August 2008 when the river *changed its course* and created havoc in a densely populated area. The 2008 floods brought wide scale destruction in over 8 lakh acres of agricultural land in the state.

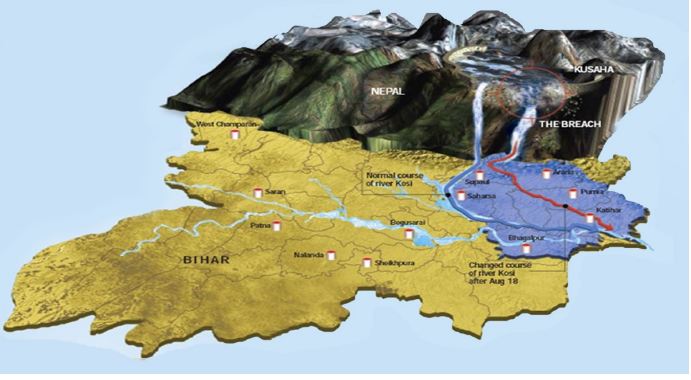
Saptakoshi

Kosi River is one of the largest tributaries of the Ganges and also known as Saptakoshi due to seven of its tributaries. It originates in Tibet. It joins Ganges near Kursela in Katihar district of Bihar.

Kosi and its avulsive shifts

In terms of geography, avulsion refers to rapid abandonment of existing channels and formation of new channels by a river. Avulsive shifts occur as a result of channel slopes that are much less steep than the slope that the **river** could travel if it took a new course. Although avulsions have a strong impact on river morphology and present a major natural hazard, surprisingly little is known about the factors that control avulsion.

Kosi River is notorious for the meandering behaviour of its east-to-west course. It has a very dynamic regime; very high sediment load *and frequent "avulsive shifts."* The avulsive shifts in Kosi River have been well documented and are thought to occur as westward movement of the river channels in last 200 years. But surprisingly, in 2008, the river shifted 120 kilometers *eastward* and breached an afflux bund at Kusaha in Nepal, 12 kilometers upstream of the Kosi Barrage.



This avulsion diverted the 80-85% of the flow of river to a new course; and has been called as one of the greatest avulsion in any large river system in world in recent times.

Why Kosi Floods are more dangerous?

The Kosi's alluvial fan has fertile soil and abundant groundwater. The agricultural land in these areas is in great demand. Poverty is prevalent and farmers try to compromise on threat of floods with that of farming in flood prone area. This is the reason that this area is densely populated and subject to

heavy loss of life.

Why do rivers change course?

It's natural for a river to keep shifting its course. It's a part of its natural evolution. There are several factors that cause change in course of rivers. *Firstly,* the fast flowing rivers are generally prone to silting up as they surge down the hills and spread out on the plains; thereby allowing sand and suspended matter to deposit in their slower, wider depths. Over time, the deposits create resistance, forcing the river to move to an area of lower resistance. This is why rivers change their courses. *Secondly,* the nature's fury such as earthquakes, landslides and hurricanes can also change a river's course. *Thirdly,* human activity and climate change are also responsible for change in river course. For example, climate change has triggered the melting of glaciers more quickly thus, the volume of water in rivers has been on the rise, resulting in greater force of flow. Therefore, even relatively lesser amount of rain during the monsoon can lead to a catastrophe.

Uttarakhand Floods 2013: Manmade or Natural Disaster

In June 2013, the hills of Uttarakhand were subjected to unusual intense rainfall (370 Millimetres recorded at Dehradun). Instances of such extreme precipitation of 370 millimetres or more have been witnessed in July, August and September and also in January, April and May, **but never in June**. It was the high amount of rainfall that created havoc in the state. This heavy rainfall was not confined to the Mandakini Valley of the Uttarakhand but also a large region of western and central Himalayas. There were high floods in Nepal also, but not much loss of life was there due to early warning system.

Location of Kedarnath

The Kedarnath temple is situated in the Mandakini valley below the Chorabari glacier. Chorabari Glacier is the source of the Mandakini. The altitude of Kedarnath is 3590 metres above sea level. The altitude of Gandhi sarovar or Chorabari taal is 3900 metres above sea level. Chorabari is a compound valley glacier having a total catchment area of 67 square kilometres (up to Rambara). Hill slopes upstream of Kedarnath are devoid of vegetation.

How the Disaster Happened?

It is still not completely clear what actually happened in the Mandakini valley upstream of Kedarnath which generated so much of water and debris flow over a short time. Google Earth imagery of this area was taken in winter so the whole area is covered by snow so it was not of much help. Some images available from the Indian CARTOSAT satellite available on the Bhuvan show a number of streams approaching Kedarnath town. Possible reasons for the disaster include a **Glacial Lake Outburst Flood (GLOF)** due to the failure of Chorabari Taal. The Chorabari Taal is approximately 800 metres long and 200 metres wide, situated upstream of Kedarnath and a catastrophic landslide in

the upper region. As a result of failure of this lake, large volumes of water reached the town, having picked up huge amounts of loose sediment en route. The heavy and unprecedented rainfall triggered a collapse event on the mountain, which turned into a debris flow downstream.

According to a report based on high resolution satellite data collected using the RISAT-1 and available on Internet, the debris flow from northwest was initiated by a landslide high on the hillside, which then ran down the slope entraining debris en route. At the slope toe it was channelized by the glacier into a narrow gully. The flow eroded out a large amount of material in this gully. The area down slope of the failure was already a zone of active erosion, so the likelihood of carrying along of particles in a current was very high.

Kedarnath was struck by an earlier flow from the northeast, then a later flow from the northwest.

Was there any failure of dam?

Some people are of the opinion that the Kedarnath disaster was caused due to construction of hydropower projects in the Upper Ganga basin. However, the project nearest to Kedarnath is about 10 kilometres **downstream** and is under construction. Obviously, hydropower projects had no direct role in the catastrophic event.

Was it a manmade Disaster?

Excessive rainfall and **Glacial Lake Outburst Flood** provides only a partial explanation for why Kedarnath was battered beyond measure. The extreme and unseasonable rainfall that created havoc indicates us a *global warming-induced climate change phenomenon.* Warmer air due to global warming has the capacity to hold more moisture, leading to more intense bursts of rainfall. The natural monsoon cycle in India has already been badly disrupted, and a new cycle of extreme rainfall events and prolonged droughts has been reported from all over the country in the recent past. Thus, Uttarakhand disaster is not all natural and it is no less man-made than the other contributors to the tragedy.

Uttarakhand Floods and the Chaotic Development

Man's excesses and follies have also been a factor in the destruction that nature has wrought. It is evident that the problem of **poor soil stability on the steep slopes in this fragile region** has been compounded by man-made factors such as indiscriminate deforestation and mindless construction. In Uttarakhand, a chaotic process of "development" that goes back many years exacerbated the effects of this extreme rain. Extensive deforestation of mountain tracts by the state and more recently due to "development" projects led to soil erosion and water run-off, thus destabilising mountain slopes and contributing to more intense and frequent landslides and floods. Unchecked hill tourism has resulted in the huge growth of vehicular traffic, spread of roads not suitable to this mountainous terrain, and the construction of poorly designed and unregulated hotels and structures,

many near rivers. Sand mining along river banks has intensified water flows into rivers. Most of all, the construction and planning of hundreds of small, medium and large dams across the Himalayan states, from Himachal Pradesh and Uttarakhand in the northern Himalayas to Sikkim and Arunachal Pradesh in the east, have destabilised an already fragile ecosystem and threatened biodiversity.

Glacial Lake Outburst Flood

Glacial Lake Outburst Flood (GLOF) refers to the glacier floods caused by the drainage of naturally dammed lakes in the glacier, on or at the margin of glaciers. Glacial lakes form when a glacier retreats, leaving the debris mass at the end of the glacier – the end moraine – exposed. The moraine wall can act as a natural dam, trapping the melt water from the glacier and leading to the formation of a lake. The moraine dams are composed of unconsolidated boulders, gravel, sand, and silt. As with landslide dams, they can eventually break catastrophically, leading to a glacial lake outburst flood or GLOF.

GLOFs are common in Himalayan region. Many big glaciers melted rapidly, forming a large number of glacial lakes. Such lakes are inherently unstable and can be subject to catastrophic drainage, which is a potential source of danger to people and property in the valleys below them. These result in serious death tolls and destruction of valuable natural resources, such as forests, farms, and costly mountain infrastructures. The Hindu Kush-Himalayan region has suffered several GLOF events originating from numerous glacial lakes, some of which have trans-boundary impacts. Nepal has experienced several Glacial Lake Outburst Floods originating from numerous glacial lakes. (Source of this information- India Environment Portal)

This term was making news because of rumours that the Kedarnath tragedy of last year was caused by a GLOF. However, it was confirmed later that this tragedy was not caused due to GLOF but due to a combination of several factors viz. early rainfall, movement of southwest monsoon winds, and the formation of a temporary lake.

2015: South Indian Floods

In November and December 2015, the annual North-East monsoon generated heavy rainfall in south India causing floods along the Coromandel Coast in Tamil Nadu, Andhra Pradesh and Pondicherry. Chennai and surrounding area were hardly hit by these floods. These floods caused displacement of around 18 Lakh people and claimed lives of around 500.

The El-Nino Link

A clear link between El Nino and North-East Monsoon is not yet established, but studies and observations reveal that El Nino normally results in excess rainfall in Tamil Nadu. Years 2015 and 2015 are expected to witness the strongest El Nino ever and 2016 may be the hottest year on record. Scientists believe that it was the El Nino with record intensity this year that set stage for South India Floods. Most parts of India receive rains via the South-West Monsoon in summer. However, in

winters, the North-East monsoon winds push back across the nation. This monsoon has a drying effect in most part of the country because they bring cool, dry air from interior Asia. But as these pass over the bay of Bengal, they pick up the moisture and precipitate along the coromandel coast. Chennai typically received its most of rains this way. Its worth note that El Nino causes deficient rains in India during South-West Monsoon, it becomes cause of heavy rains during North-East Monsoon.

Indian Ocean Dipole Link

The Indian Ocean Dipole is the difference in sea surface temperature between two areas- a western pole in the Arabian Sea and an eastern pole in the eastern Indian Ocean south of Indonesia. It is basically a miniature version of El Nino – La Nina phenomenon in Indian Ocean. It has negative and positive phases. A 2004 study linked Indian Ocean Dipole to the strength of the northeast monsoon. It found that a positive IOD was associated with heavier northeast monsoonal rains in South India. In 2015-16, IOD is in a strongly positive mode and thus caused heavier rains this year in South India.

Unregulated urban planning and illegal construction

Unprecedented floods in Chennai were the direct result of unregulated urbanisation. In Chennai, each of its lakes has a natural flood discharge channel which drains the spill over. However,

development over many of these water bodies has blocked the smooth flow of water. A CSE study finds that Chennai had over 600 lakes in the 1980s, but a master plan published in 2008 showed only a fraction of them to be in a healthy condition. The area of 19 major lakes shrank from 1,130 hectares in the 1980s to around 645 hectares in the early 2000s, reducing their storage capacity. Further, the drains carrying surplus water have been encroached upon, water drains are clogged and require immediate desilting.

Centuries old Chennai has a natural network of drains and canals for flood waters to flow out and ponds and lakes to collect and store the water. These natural means of hydraulic balance in the city have fallen into disrepair, got silted and stuffed with garbage. Due to this, the water brought in by unusually heavy rains gets trapped. Thus, due to lack of adequate attention to natural water bodies in Chennai and other most urban areas of India has been the primary reason of havoc created by unusually heavy rains. This was coupled with filling up of canals and ponds by greedy developers; spread of slums across the water bodies (for example Adyar River in Chennai); Dredging the cooum and the Adyar river and absence of a rain water disposal system.

2014 Jammu & Kashmir Floods

In September 2014, continuous unprecedented heavy rainfall had caused Jhelum, Chenab and Tawi rivers and their tributaries to flow above the danger mark. They had flooded the catchment areas, particularly low lying ones for more than two weeks in the state which had severely affected

livelihoods and had damaged the basic infrastructure in the state. After the floods, Union Government had given 2,602 crore rupees to the state. It included 770 crore rupees from Prime Minister Relief Fund, 1,602 crore rupees was released under State Disaster Relief Fund (SDRF) and National Disaster Relief Fund (NDRF).

The primary reasons for Kashmir floods were high rainfall in the catchment areas over short period of time, that amounted to the cloud bursts and less capacity of the drainage system to hold the quantum of water resulting in overflowing of banks.

Unplanned urbanization and encroachment over lakes, ponds and wetlands is key factor of aggravating such tragedies in Jammu & Kashmir. There are around 1230 lakes and water bodies in J&K. In the last 100 years, more than 50% of these water bodies have been encroached upon for constructing buildings and roads. The natural drainage system of the state has collapsed due to massive degradation of the network of lakes. This has been worsened by the excessive siltation in the lakes and water bodies from the massive deforestation in the Jhelum basin.

Institutional Framework on Floods

In India, the subject of Flood Management falls within the purview of the State Governments. Central Government provides technical, advisory, catalytic and promotional support to the flood affected areas. Further, Central Government also releases assistance to states for effective flood management time to time.

Rashtriya Barh Arog (National Commission on Floods)

The union government had commissioned the Rashtriya Barh Ayog (RBA) in 1980. This commission had assessed the 40 million hectare area of country in 21 states and one Union Territory and examined at considerable length the various factors that cause heavy floods in different river basins and deltas, and indicated the measures that need be taken for affording such flood protection as may be feasible in such areas.

Task Force on Flood Management and Erosion Control in 2004

The Central Government had constituted several committees to study the flood problem and suggest ways and means to minimize the damage and recurrence of floods. The 2004 Task Force on Flood Management and Erosion Control had recommended immediate, short term and long term measures of flood management and erosion control in NE region and Ganga Basin States.

NDMA and NEC

Like all other disasters, the most notable policy initiative has been enactment of DM Act 2005 and setting up of NDMA, which has been assigned to deal with all types of disasters including the floods. The National Executive Committee (NEC) assists NDMA in discharge of its functions and ensure compliance of the directions issued by the central government apart from preparing the National

Disaster Management Plan.

SDMA

The state governments are mandated to set up State Disaster Management Authorities (SDMAs) and State Executive Committees (SECs) to perform similar functions at the state level.

NDMA Guidelines on Flood

The National Disaster Management Authority (NDMA) issued guidelines on management of floods in 2008. The summary of the recommendations are as follows:

1. Embankments/flood walls/flood levees have to be constructed for prevention of flooding after carrying out detailed hydrological and morphological studies regarding their favourable and adverse effects.
2. The CWC and the state governments have to study the problem of rise in river beds in a scientific manner and explore the techno-economic viability of desilting/dredging as a remedial measure to mitigate the effects of rise in the river beds.
3. Appropriate channel improvement works have to be taken up to increase the velocity and/or the area of flow and reduce the flood level in the river depending upon site-specific conditions.
4. State governments should prohibit the blocking of the natural drainage channels and sluices with an appropriate law and improve their capacity and construct new channels and sluices to ensure flow of excess rainwater in the area.
5. State governments should study the feasibility of implementing the schemes for diverting excess water to existing or new channels by bye-passing towns and cities to prevent flooding.
6. Watershed management measures such as afforestation, check dams, detention basins etc.,have to be implemented in the catchment of rivers to prevent soil erosion, enhance water conservation and minimise water and sediment runoff.
7. State governments should consider appropriate anti-erosion measures such as revetments, slope pitching, permeable and impermeable spurs using conventional materials and/or geo-synthetics for protection of towns, cities, industrial areas, groups of thickly populated villages, railway lines, roads and embankments from erosion by rivers in a time-bound manner.
8. Sea walls/coastal protection works has to be planned and executed by the respective coastal states/port authorities, keeping in view the complexity of sea behaviour and other environmental aspects.
9. The state governments has to provide adequate number of raised platforms/flood shelters at suitable locations in the flood plains with basic amenities such as drinking water, sanitation, medical treatment, cooking, tents, lantern etc. for the people to take shelter during floods.

10. Basin-wise flood hazard mitigation models have to be developed.
11. A mechanism has to be developed wherein representatives of the CWC, IMD, NRSA and the states interact with each other, exchange data on a real-time basis and formulate the flood forecasts and warnings.
12. With co-operation from Nepal, Bhutan and the China, data has to be collected on real-time basis.
13. The state governments have to enact and enforce appropriate laws for implementing flood plain zoning regulations.
14. The reclamation of the existing wetlands/natural depressions has to be prohibited by state governments and they must formulate an action plan for using them for flood moderation.
15. Training and capacity building measures have to be taken up for designated authorities dealing with the disaster.
16. A number of organizations, like NGOs, self-help groups, CBOs, youth organizations such as NCC, NYKS, NSS etc., women's groups, volunteer agencies, Civil Defence, Home Guards, etc. must be encouraged to volunteer their services in the aftermath of any disaster.
17. The state governments have to utilise different types of media, especially print, radio, television and Internet, to disseminate timely and accurate information.
18. A team comprising a social worker, a psychologist and a psychiatrist should provide counselling to victims.
19. Measures should be taken to strengthen Ganga Flood Control Board and Brahmaputra Board.

Policy suggestions for Flood Management

- The subject of Flood Management comes under purview of the State Governments, so there is a need to expand the role of the central government.
- The chronically flood affected areas should be treated as backward areas, and special measures instituted for dealing with their problems, and promoting their economic development.
- In the development master plans, necessary steps should be included if the areas fall in flood plains. Flood frequency, duration, depth etc. should be taken into account to define the chronically flood affected areas.
- A single department in states should deal with all flood plains. There should be a comprehensive scheme to mitigate the flood losses.
- Crop damage is one of the worst damages causes in floods. There should be appropriate cropping strategy in flood affected areas. The flood tolerant cropping systems should be made popular.

- Regarding the damage caused to houses, property and infrastructure, strengthening of house structure, raising the level of whole villages or providing ring bunds around villages have been considered as possible alternatives. Each of these alternatives has positive and negative aspects; yet the fact remains that something has got to be done to provide protection to the human settlement.
- The total investment for plan / flood Management may be to at least 1% of the total Plan outlay.
- Earmarking funds in the State sector as Additional Central assistance for maintenance of embankments.

Urban Flooding

Urban flooding differs from rural flooding as urbanisation leads to developed catchments which increases the flood peaks and flood volumes. As a result, flooding occurs very quickly due to faster flow times, sometimes in a matter of minutes. As urban areas are centres of economic activities, any damage to vital infrastructure has a bearing not just locally but could even have global implications. Both rich and poor living cities suffer due to flooding. Urban flooding associated with damage to property and loss of life. There is a possibility of secondary issues of possible epidemics and exposure to infections. Therefore, management of urban flooding has to be accorded top priority.

Urban Flood Risk in India

In the past several years, there is an increasing trend of urban flood disasters in India. The notables of them are Hyderabad in 2000, Ahmedabad in 2001, Delhi in 2002 and 2003, Chennai in 2004, Mumbai in 2005, Surat in 2006, Kolkata in 2007, Jamshedpur in 2008, Delhi in 2009, Guwahati and Delhi in 2010, and Chennai in 2015. Heavy rainfall during monsoons is a special feature in India. Storm surges can also affect coastal cities/ towns. Sudden release or failure to release water from dams can also have severe impact. The urban heat island effect and global climate change is resulted in episodes of high intensity rainfall events occurring in shorter periods of time. Coastal cities are also facing threat from sea-level rise.

Issues with urban flooding

Storm water drainage systems in the past were designed for rainfall intensity of 12 – 20 mm. But the average rainfall in Indian cities far exceeds the capacity of drainage system. The designed system capacities do not work due to poor maintenance. Encroachments are another big problem in many cities and towns. Consequently the capacity of the natural drains has decreased, resulting in flooding. Improper disposal of solid waste, including domestic, commercial and industrial waste and dumping of construction debris into the drains also contributes significantly to reducing their capacities.

Role of Science and Technology

The management of urban flooding has to be treated holistically in a multi-disciplinary manner. Science and technology can play a significant role for improved monitoring, modeling/ forecasting and decision-support systems. One method for improving the preparedness for urbanflooding is by setting up a vulnerability-based geospatial framework to generate and analyse different scenarios. It helps in identifying and planning for the most effective/ appropriate actions in a dynamic way to incorporate day-to-day changes that take place in urban areas, having the potential to alter the prevailing vulnerability profile.

NDMA guidelines on management of urban flooding

The National Disaster Management Authority (NDMA) has issued guidelines on management of urban flooding in 2010. Key guideline was to create a *National Hydro-meteorological Network*. The guidelines say that for providing early warning, the Central Water Commission (CWC) should maximize the real-time hydro-meteorological network to cover all the urban centers in dealing with urban flooding. The requirement should consider all cities/ towns which are particularly located on river banks, upstream and downstream of major and medium dams and island cities. Based on that assessment, CWC will initiate the process to prepare a plan and implementation strategy.

Other recommendations:

1. Use of *Doppler Weather Radars* to be expanded to cover all urban areas in the country.
2. Coordination mechanism to be established among all agencies for deriving maximum benefit from the efforts of each individual organization.
3. A dedicated high bandwidth communication channel is to be built, for ensuring smooth underlying sensor web flow of all available information and products.
4. State-of-the-art automatic water level recorders must be installed throughout the drainage network of the watershed, which may sometimes extend beyond the administrative boundary of the ULB.
5. Technical Umbrella for urban Flood Forecasting and Warning to be established at national and state level.
6. An inventory of the existing storm water drainage system to be prepared. The inventory will be both watershed based and ward based.
7. Catchment to be the basis for planning and designing the storm water drainage systems in all ULBs.
8. Contour mapping of urban areas to be prepared at 0.2 to 0.5 m contour interval for detailed delineation of the watershed/ catchment for planning drainage systems.
9. Pre-monsoon desilting of all major drains to be completed by March 31 each year.
10. Suitable interventions in the drainage system like traps, communitors, trash racks can be

provided to reduce the amount of solid waste going into the storm sewers.

11. All future road and rail bridges in cities crossing drains to be designed such that they do not block the flows resulting in backwater effect.
12. Inlets to be provided on the roads to drain water to the roadside drains and these has to be designed based on current national and international practices.
13. Every building in an urban area must have rainwater harvesting as an integral component of the building utility.
14. Concept of Rain Gardens to be incorporated in planning for public parks and on-site stormwater management for larger colonies and sites those are to be developed.
15. Low-lying areas in cities have to be reserved for parks and other low-impact human activities.
16. Encroachments on the drain should attract penal action.
17. Flood hazard assessment has to ascertain level of acceptable risk of flooding on the basis of projected future scenarios of rainfall intensities and duration and land use changes.
18. Flood damage has to be according to the physical characteristics of the area such as land use, topography, drainage area, outfall system and the capacity of the existing stormwater drainage system.
19. Ward level Information System has to be developed using high resolution satellite images/aerial photos, integrated with socio-economic data covering natural resources and infrastructure facilities on appropriate scale (1:1000) at community level.
20. States/UTs have to build partnerships with public/ private insurance companies and civil society to sensitive communities about available schemes and also develop appropriate micro-insurance schemes targeted at low-income groups.
21. The database of the National Urban Information System (NUIS) will be expanded to cover infrastructure facilities at community level integrated with socio-economic data.
22. Urban Flooding has to be dealt as a separate disaster, de-linking it from riverine floods which affect the rural areas.
23. Storm water drainage concerns will be made a part of all EIA norms.
24. Buildings have to be designated as Flood Shelters and all necessary arrangements have to be ensured ahead of the flood season. Children, women, the aged and the differently-abled persons has to be given special attention.
25. Post-floods, restoration of power, telecommunications, road and railway transport will get top priority.
26. Media, corporate, NGOs has to be involved in awareness generation.

Cyclones

India's coastal regions in the North Indian Ocean Basin are extremely vulnerable to cyclones and associated hazards such as storm tides.

Storm Tides

Storm Tides refers to the combined effects of *storm surge* and *astronomical tide*. Storm surge is the an abnormal rise in the level of water along a shore, primarily as a result of the high winds and low pressures generated with tropical cyclones; generally affects only coastal areas but may intrude some distance inland. Astronomical tides refers to tidal levels and character which would result from gravitational effects, e.g., of the Earth, Sun and Moon, without any atmospheric influences.

About 8% of the area in the country is prone to cyclone-related disasters. Recurring cyclones account for large number of deaths, loss of livelihood opportunities, loss of public and private property and severe damage to infrastructure, thus seriously reversing developmental gains at regular intervals.

Reasons for Cyclone Vulnerability

There are several reasons for this vulnerability. India has a long coastline of around 7,516 km, its coastal terrain is flat and continental shelf is shallow. Further, most coastal cities have high population density. Although the frequency of Tropical Cyclones (TCs) in the NIO covering the Bay of Bengal and the Arabian Sea is the least in the world (7% of the global total), their impact on the east coast of India as well as the Bangladesh coast is relatively more devastating. This is evident from the fact that in the last 270 years, 21 of the 23 major cyclones (with a loss of about 10,000 lives or more) worldwide occurred over the area surrounding the Indian subcontinent (India and Bangladesh). This is primarily due to the serious storm tide effect in the area.

Affected States and UTs

Thirteen coastal states and Union Territories (UTs) in the country, encompassing 84 coastal districts, are affected by tropical cyclones. Out of them, the most vulnerable on East coast are four states viz. Tamil Nadu, Andhra Pradesh, Orissa and West Bengal and one UT (Puducherry) while on west coast is one state Gujarat.

National Cyclone Risk Mitigation Project

The National Cyclone Risk Mitigation Project (NCRMP), to be implemented with financial assistance from the World Bank, is envisaged to have four major components:

- Component A: Improvement of early warning dissemination system by strengthening the Last Mile Connectivity (LMC) of cyclone warnings and advisories.
- Component B: Cyclone risk mitigation investments.
- Component C: Technical assistance for hazard risk management and capacity-building.

- Component D: Project management and institutional support.

These components are highly interdependent and have to be implemented in a coherent manner. The planned framework of activities under this project provides end-to-end solutions for effective Cyclone Disaster Management (CDM) in all the 13 coastal states and UTs.

National Guidelines of Management of Cyclones

The NDMA had come up with its National Guidelines of Management of Cyclones in 2008. The basic premise of these guidelines is that the mitigation has to be multi-sectoral. Salient points in these guidelines are as follows:

Early Warning System

Government would establish a state-of-the-art cyclone EWS involving observations, predictions, warnings and customised local-scale advice for decision-makers (national/state/district level) for managing the impact of cyclones.

Aircraft Probing of Cyclone (APC) facility

The government would commission an Aircraft Probing of Cyclone (APC) facility for India with a combination of manned aircraft and high altitude Unmanned Aerial Vehicles (UAV) which can effectively fill the critical observational data gaps in the case of cyclones over the Bay of Bengal and the Arabian Sea to a great extent. An actual flight by an aircraft into and around the tropical cyclone during various stages of its development and movement can provide invaluable data for studying and understanding the structure and movement of a cyclone, thus reducing track and intensity prediction errors significantly.

National Disaster Communication Infrastructure (NDCI)

Government would commission National Disaster Communication Infrastructure (NDCI) at the NDMA/MHA, State Disaster Management Authorities (SDMAs) of coastal states/UTs and District Disaster Management Authorities (DDMAs) of the 84 coastal districts vulnerable to cyclones with the adoption of state-of-the-art operational infrastructure covering the following:

- High End Computing (scalable 30–50 Teraflops peak performance), Storage (800 Terabytes) and Communication Network (Gigabit Ethernet) Infrastructure;
- 3-D Virtual Reality Visual Studio;
- Centralised Comprehensive Databank for Cyclone Risk Management with nodes in various coastal states over a fail-safe communication backbone between the OCs (Operation Centres) of NDMA, SDMAs and DDMAs (for Information and Data Fusion involving collating, analysing, interpreting, translating and monitoring of early warnings from line departments based on state-of-the-art scientific and technological know-how); and
- Comprehensive state-of-the-art OC for effective coordination of Disaster Response Actions at the state and local levels.

Expanding the warning dissemination outreach

Government would be expanding the warning dissemination outreach by using the services of Direct-To-Home (DTH) transmission in remote and rural areas (Panchayats) which cannot be otherwise covered, to introduce weather channel and broadcast cyclone warnings from high-power coastal radio stations including the use of satellite radio service like World Space, Ham radios, community radio and VHF network.

Other Actions

- Structural safety of lifeline infrastructure in coastal areas
- Establishing a robust system of locating multi-purpose cyclone shelters and cattle mounds
- Ensuring cyclone resistant design standards are incorporated in the rural/ urban housing schemes in coastal areas
- Building all-weather road links to all coastal habitations, between habitations and cyclone shelters/cattle mounds
- Maintaining the full designed carrying capacity of main drains and canals along with feeder primary/secondary/ tertiary channels, creating additional flood flow canals in frequently inundated areas

- Construction of saline embankments to prevent ingress of saline water associated with cyclonic storm surge
- Encouraging public-private partnership with corporate/trusts.
- Mapping and delineation of coastal wetlands, patches of mangroves and shelterbelts, identification of potential zones for expanding bio-shield spread based on remote sensing tools.
- Regulating infrastructure and development activities in coastal zones.
- Monitoring of water quality as well as the carrying and assimilative capacities of open waters with institutionalised remedial measures.
- Developing Integrated Coastal Zone Management (ICZM) frameworks for addressing the sustainability and optimal utilisation of coastal resources as also cyclone impact minimisation plans.
- Evolving eco-system restoration plans for degraded ecological zones.
- Developing delta water management and freshwater recharge/management options.
- Coastal bio-shields spread, preservation and restoration/ regeneration plans.
- Implementing coastal flood zoning, flood plain development and flood inundation management and regulatory plans.
- Groundwater development and augmentation of freshwater requirement in coastal urban centres.

- Development of Aquaculture Parks in the identified potential zones.
- Setting up of an exclusive eco-system monitoring network to study the impact of changing climate.
- Developing integrated hazard mitigation framework taking into account cyclone and associated storm surge, wind hazard, rainfall-runoff, river flood and Geographical Information System (GIS) models for estimating possible areas of inundation along with the depth of inundation (levels), possible damage to infrastructure, crops, houses, etc., evaluating not only the vulnerability but also the changing profile of vulnerability from time to time.
- Integrate ongoing efforts of the Survey of India, Department of Space under National Spatial Data Infrastructure, National Database for Emergency Management and MoEF initiatives for speedy completion of digital spatial data generation to cover 84 coastal districts that are vulnerable to cyclones, for evolving holistic cyclone risk reduction strategies on priority. High resolution (at least 0.5 m interval) coastal Digital Elevation Models (DEMs) are to be developed for micro-scale delineation of cyclone risk, hazard and vulnerability.

Earthquakes

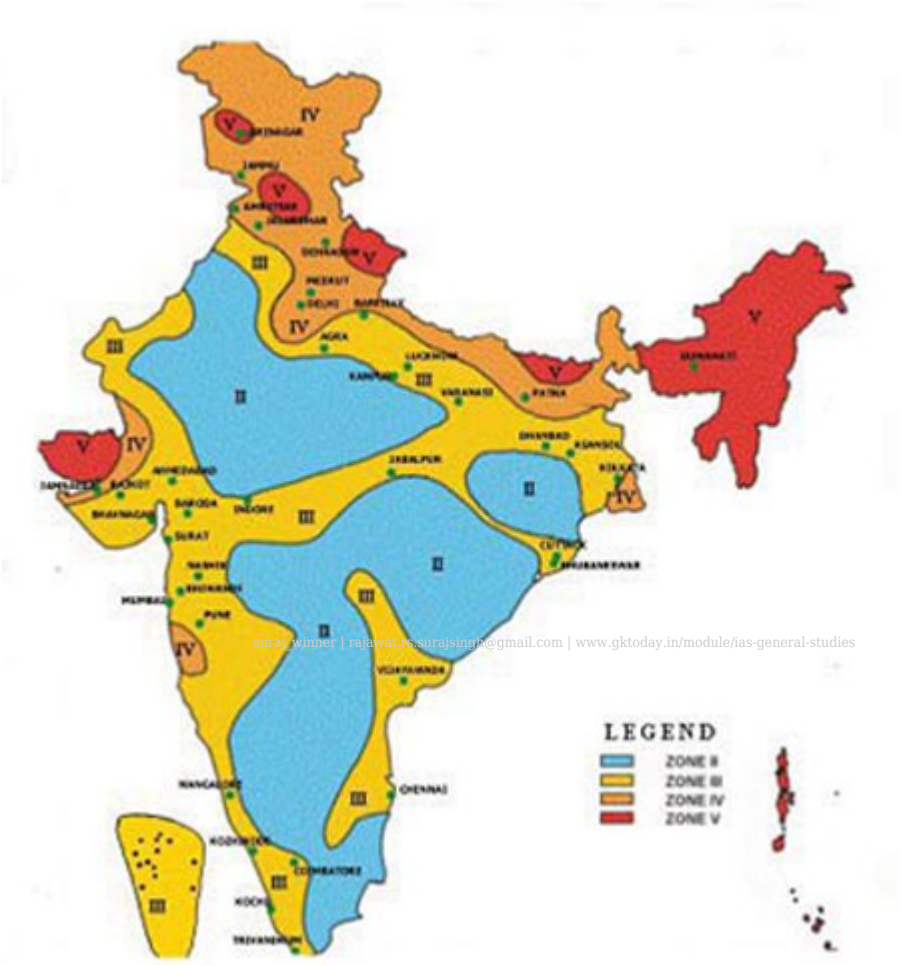
India has a very high frequency of great earthquakes. The reasons of high magnitude earthquakes in India are hidden in the tectonic setting of India. India is currently penetrating into Asia at a rate of approximately 45 mm/year and rotating slowly anticlockwise. This rotation and translation results in left-lateral transform slip in Baluchistan at approximately 42 mm/year and right-lateral slip relative to Asia in the Indo-Burma ranges at 55 mm/year. At the same time, deformation within Asia reduces India's convergence with Tibet to approximately 18 mm/year. Since Tibet is extending east-west, there is a convergence across the Himalaya that results in the development of potential slip available to drive large thrust earthquakes beneath the Himalaya at roughly 1.8 m/century.

Seismic Zoning of India

Indian subcontinent has a long history of devastating earthquakes, partially due to the fact that India is driving into Asia. More than 50% area of Indian Subcontinent is vulnerable to earthquakes. According to the IS 1893:2002 [(It is the latest code of Bureau of Indian Standards (BIS) which lays down the criteria of for earthquake resistant design of structures)], India has been divided into four seismic zones viz. Zone-II, -III, -IV and -V unlike its previous version which consisted of five zones for the country. After some revisions in the previous zoning, Zone I was altogether removed.

This zoning has been done on the basis of MSK-64 scale and a IS code Zone factor has been assigned by the BIS to each of them. The zone factor of 0.36 is indicative of effective (zero period) peak horizontal ground acceleration of 0.36 g (36% of gravity) that may be generated during MCE level earthquake in this zone. They are presented in the following table with IS code.

Seismic Zoning of India		
MSK-64	Seismic Zone	Zone Factor
VI. Strong	Zone II This region is liable to MSK VI or less and is classified as the Low Damage Risk Zone	0.1
VII. Very Strong	Zone III The Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this lone. This zone is classified as Moderate Damage Risk Zone which is liable to MSK VII.	0.16
VIII. Damaging	Zone IV This zone is called High Damage Risk Zone and covers Indogangetic Basin, Delhi, Jammu and Bihar	0.24
IX. Destructive	Zone V Zone 5 covers areas with the highest risk zone that suffers earthquakes with intensity of IX and greater. It includes Kashmir, Punjab, Western and central Himalayas, North East India and Rann of Katch	0.36



Earthquake Vulnerability of India

As per the latest seismic zone map, around 59 per cent of India's land area is vulnerable to moderate or severe seismic hazard, implying that it is prone to shaking of MSK intensity VII and above. In the recent past, most Indian cities have witnessed the phenomenal growth of multi-storied buildings, super malls, luxury apartments and social infrastructure as a part of the process of development. The rapid expansion of the built environment in moderate or high-risk cities makes it imperative to incorporate seismic risk reduction strategies in various aspects of urban planning and construction of new structures.

Vulnerability of Himalayan Zone

The entire Himalayan Region is considered to be vulnerable to high intensity earthquakes of a magnitude exceeding 8.0 on the Richter Scale, and in a relatively short span of about 50 years, four

such earthquakes have occurred viz. Shillong, 1897 (M 8.7); Kangra, 1905 (M.8.0); Bihar–Nepal, 1934 (M 8.3); and Assam–Tibet, 1950 (M 8.6). Scientific publications have warned that very severe earthquakes are likely to occur anytime in the Himalayan Region, which could adversely affect the lives of several million people in India.

Earthquake Vulnerability and Traditional Housing Construction in Rural Areas

There are several indigenous earthquake-resistant house constructing processes in India, for example:

- *bhongas* in the Kutch Region of Gujarat
- *dhajji diwari* buildings in Jammu & Kashmir
- *brick-nogged wood frame constructions* in Himachal Pradesh
- *ekra* constructions made of bamboo in Assam.

These traditional methods are increasingly being replaced with modern Reinforced Cement Concrete (RCC) buildings, often without incorporating earthquake resistant features and without compliance to building codes and bye-laws.

It is thus necessary to empower communities to ensure the seismic safety of the built environment by encouraging the use of simple, easy and affordable technical solutions and institutional arrangements. These make use of indigenous technical knowledge and locally available materials in the construction of earthquake-resistant buildings in suburban and rural areas.

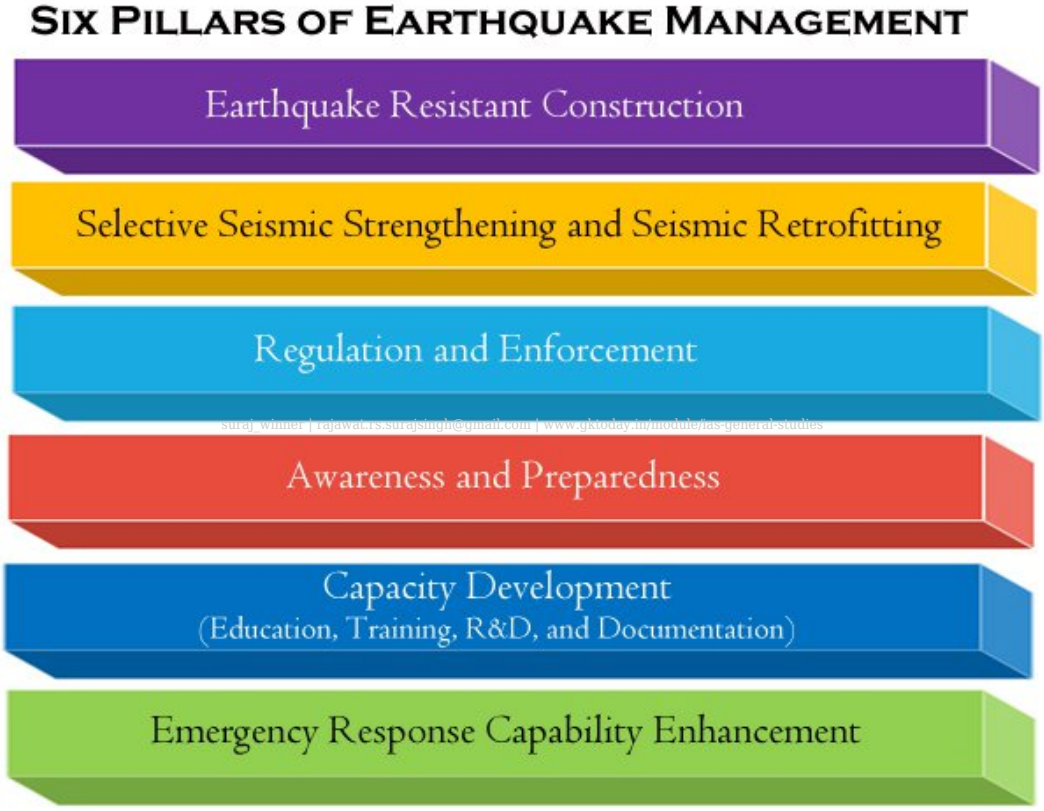
Critical Areas of Concern for The Management Of Earthquakes In India

Today, majority of the buildings constructed in India, especially in suburban and rural areas, are non-engineered and built without adhering to earthquake-resistant construction principles. Most contractors and masons engaged in the construction of these buildings are also not familiar with the earthquake-resistant features specified in the building codes. The critical areas of concern for the management of earthquakes in India include the:

- Lack of awareness among various stakeholders about the seismic risk;
- Inadequate attention to structural mitigation measures in the engineering education syllabus;
- Inadequate monitoring and enforcement of earthquake-resistant building codes and town planning, bye-laws;
- Absence of systems of licensing of engineers and masons;
- Absence of earthquake-resistant features in non-engineered construction in suburban and rural areas;
- Lack of formal training among professionals in earthquake-resistant construction practices; and
- Lack of adequate preparedness and response capacity among various stakeholder groups

NDMA Guidelines 2007 on Earthquakes

NDMA had released its details earthquake guidelines in 2007. The guidelines prescribe measures for Central Ministries and Departments and State Governments to prepare disaster management plans having specific components on earthquake risk management. The basic premise of these guidelines includes six pillars of Earthquake management to be implemented in three phases:



Earthquake-Resistant Design and Construction of New Structures

In most earthquakes, the collapse of structures like houses, schools, hospitals and public buildings results in the widespread loss of lives and damage. Earthquake also destroys public infrastructure like roads, dams and bridges, as well as public utilities like power and water supply installations. Past earthquakes show that over 95% of the lives lost were due to the collapse of buildings that were not earthquake-resistant. Though there are buildings codes and other regulations which make it mandatory that all structures in earthquake-prone areas in the country must be built in accordance with earthquake-resistant construction techniques, new constructions often overlook strict compliance to such regulations and building codes. Faculty members in engineering colleges,

architecture colleges, Industrial Training Institutes (ITIs) and polytechnics will also be provided adequate exposure to earthquake resistance design and construction techniques, so that students are made aware of earthquake-resistance design and construction. While the implementation of these Guidelines in areas within seismic Zone III will be initiated during Phase I, these efforts will be intensified in these during Phase II.

Seismic Strengthening and retrofitting of Lifeline and Priority Structures

There are approximately 12 crore buildings in seismic Zones III, IV and V. Most of these buildings are not earthquake-resistant and are potentially vulnerable to collapse in the event of a high intensity earthquake. As it is not practically feasible or financially viable to retrofit all the existing buildings, these Guidelines recommend the structural safety audit and retrofitting of select critical lifelines structures and high priority buildings. Such selection will be based on considerations such as the degree of risk, the potential loss of life and the estimated financial implications for each structure, especially in high-risk areas, i.e. seismic Zones III, IV and V. While these Guidelines indicate an illustrative list of such buildings and structures, the state government/SDMAs will consultation with their SEMCs and Hazards Safety Cells (HSCs), review their existing built environment, and prepare such lists.

Regulation and Enforcement

A periodic revision of the codes and standards relating to earthquake-resistant construction will be undertaken by drafting groups within a fixed time-frame of five years or even earlier on priority basis, in keeping with international practices. Other than the BIS, there are a number of other bodies that develop design codes and guidelines in the country, e.g. the Indian Roads Congress (IRC), Ministry of Shipping, Road Transport and Highway (MoSRTH), Research Designs and Standards Organisation (RDSO), Ministry of Railways (MoR), and the Atomic Energy Regulatory Board (AERB), Department of Atomic Energy (DAE). Codes developed by these organisations will also be updated and made consistent with the current state-of-the-art techniques on earthquake-resistant design and construction. These agencies also have a number of construction practices regulated through internal memos, the review of which will also be undertaken at the earliest.

Design provisions are required on many topics that have been addressed so far in the existing codes or guidelines in India. Such topics include:

- Seismic design of non-structural elements and components of buildings and structures.
- Seismic design of reinforced masonry structures.
- Seismic evaluation and strengthening of structures.
- Seismic design of buried and above ground pipelines.
- Seismic design and ductile detaining of steel structures.

- Seismic design and ductile detaining of bridge piers.
- Seismic design, construction and manufacture of facilities, structures and components related to electrical power generation, transmission and distribution.
- Seismic design of tunnels.

Awareness and Preparedness

A comprehensive awareness campaign will be developed and implemented on the safe practices to be followed before, during and after an earthquake. This campaign will also emphasise the prevalent seismic risk and vulnerability of the states as well as highlight the roles and responsibilities of all communities and stakeholders in addressing this risk.

Creation of Public Awareness on Seismic Safety and Risk Reduction

- The guidelines say that a handbook on earthquake safety will be prepared for the general public highlighting the safety of persons (i.e., indoors, outdoors, and driving), buildings and structures and non-structural contents of buildings. {This handbook is available on NDMA site}.
- A homeowners seismic safety manual will be prepared emphasising earthquake-resistant techniques for new buildings and for the seismic strengthening and retrofitting of existing buildings.

- A manual on structural safety audit of infrastructure and lifeline buildings will be prepared.
- Translations of the above documents into local and regional languages will be undertaken for easy comprehension.
- Video films will be prepared for the general public to articulate the earthquake risk, vulnerability and preparedness and mitigation measures.

Capacity Development (Including Education, Training, R&D and Documentation

The developments of high-quality education materials, textbooks, field training and the improvement of the quality of teaching at all levels will be given due emphasis. Education and training programmes will be designed, with greater attention on developing the capacity and skills of trainers and trained teachers. Appropriately designed science and technology courses will be introduced to orient all targets groups including school teachers and health professionals in the subject. The central and state government will encourage knowledge institutions to undertake research, teaching and training, which will further contribute to improving earthquake education in India.

Response

The management and control of the adverse consequences of future earthquakes will require coordinated, prompt and effective response systems at the district and the community levels. Many of the components of response initiatives are the same for different types of disasters and systems

need to be developed considering the multi-hazard scenario of various regions in order to optimally utilise available resources. Ensure the incorporation of earthquake-resistant design features for the construction of new structures. Facilitate selective strengthening and seismic retrofitting of existing priority and lifeline structures in earthquake-prone areas. Improve the compliance regime through appropriate regulation and enforcement. Improve the awareness and preparedness of all stakeholders. Introduce appropriate capacity development interventions for effective earthquake management (including education, training, R&D, and documentation). Strengthen the emergency response capability in earthquake-prone areas.

Some Great Indian Earthquakes

India has suffered some of the greatest earthquakes in the world with magnitude exceeding 8.0. For instance, in a short span of about 50 years, four such earthquakes occurred: Assam earthquake of 1897 (magnitude 8.7), Kangra earthquake of 1905 (magnitude 8.6), Bihar-Nepal earthquake of 1934 (magnitude 8.4) and the Assam-Tibet earthquake of 1950 (magnitude 8.7). Here are some important notes:

Katch Earthquake of 1819

This 8.3 magnitude earthquake took place on the west coast of India and caused ground motion which was perceptible as far as Calcutta. It created a fault scarp of about 16 mile long and about 10 foot high which was later named as "Allah Bund".

Assam earthquake of 1897

This 8.7 magnitude earthquake caused severe damage in an area of about 500 km radius and caused extensive surface distortions in the area. The earthquake caused extensive liquefaction in the alluviated plains of Brahmaputra.

Bihar – Nepal Earthquake of 1934

This 8.4 magnitude earthquake caused wide-spread damage in the northern Bihar and in Nepal. Due to extensive liquefaction, most buildings tilted and slumped bodily into the ground in an area of about 300 km long and of irregular width. This area was termed as the "slump belt".

Koyna Earthquake Of 1967

This 6.5 magnitude earthquake occurred close to 103 metre concrete gravity dam at Koyna. Prior to this earthquake, the area used to be considered aseismic. However, after the construction of dam and filling up of reservoir in 1962, the seismic activity increased significantly.

The main shock of December 10, 1967 caused widespread damage, killing about 200 persons and injuring more than 1500 persons. This was an example of the reservoir-induced seismicity in India.

The dam, designed keeping in mind the possible seismic activity, performed quite well with only nominal damage to the dam. This earthquake lead to the revision of Indian seismic zone map wherein the area around Koyna was brought in zone IV from zone I, and seismic zone for Bombay

was upgraded from zone I to zone III.

Uttarkashi Earthquake Of 1991

This 6.6 magnitude earthquake shook the districts of Uttarkashi, Tehri, and Chamoli of current Uttarakhand.

Killari (Latur) earthquake of 1993

This was a magnitude 6.4 earthquake that shook the area near village Killari in Latur district killing about 8,000 persons. Until this earthquake the area was considered non-seismic and placed in the lowest seismic zone (zone I) by the Indian code (IS:1893-1984).

The affected area did not have any modern towns, modern buildings or major industries. In some of the villages more than 30% of the population was killed. This earthquake will be known for outstanding rescue, relief and rehabilitation.

Jabalpur Earthquake Of 1997

This magnitude 6.0 earthquake is only example of such earthquakes which occurred close to a major Indian city in recent times.

2004 Indian Ocean earthquake and tsunami

The 2004 Indian Ocean earthquake was an undersea mega thrust earthquake with an epicentre off the west coast of Sumatra, Indonesia, and it is known as Sumatra–Andaman earthquake or 2004 Indian Ocean tsunami or South Asian tsunami, Indonesian tsunami, and the Boxing Day tsunami. It killed 230,000 people in fourteen countries, and inundating coastal communities with waves up to 30 meters.

Sikkim Earthquake 2011

The September 18, 2011 earthquake of **magnitude 6.9** occurred near the boundary between the India and Eurasia plates at India Nepal border affecting Sikkim state in India. This earthquake was unique for some reasons. Most of the earthquakes in India occur because of the thrust faults formed due to under-thrusting of the Indian plate below the Eurasian plate. However, the Sikkim Earthquake is thought to have occurred between two **transverse faults** represented by Tista and Gangtok lineaments where two segments of Himalayas have moved in a horizontal direction.

Droughts

Drought Vulnerability of India

Drought differs from other hazards as it has a slow onset, evolves over months to years, affects a large spatial extent, and cause little structural damage. Its onset and end and severity are often difficult to determine. Droughts impact span economic, environmental and social sectors.

In India, droughts occur in areas of high rainfall as well as areas with meagre rainfall. Water scarcity conditions in the Himalayan region are also not uncommon. Drought is not just related to scarcity or the absence of rainfall, but also related to inefficient water resource management. Requirement of

over 80-90 % of the drinking water and over 50 % for irrigation is met from groundwater. Without any large scale rainwater harvesting measures in India, the recharge levels are very limited. *Analysis of incidence of droughts over the last two centuries in India does not show any increase in the incidence of droughts in recent years. However, their severity appears to have increased.* In 2002, India experienced its worst drought in 20 years. However the probability of drought in India varies from once in 2 years in Western Rajasthan to once in 15 years in Assam.

Classification of drought

The National Commission on Agriculture in India classified three types of drought viz. meteorological, agricultural and hydrological. Meteorological drought occurs when there is significant decrease from normal precipitation over an area (i.e. more than 10 %). Hydrological drought is due to prolonged meteorological drought resulting in depletion of surface and sub-surface water resources. In case of agricultural drought, the soil moisture and rainfall are inadequate to support healthy crop growth. Drought is also classified on the basis of time of onset as early season, mid-season and late season.

The Indian Meteorological Department (IMD) recognizes

- A drought week; when rainfall in a week is less than half of its normal amount,
- An agricultural drought; when four drought weeks occur consecutively during mid-June to September
- A seasonal drought; when seasonal rainfall is deficient by more than the standard deviations from the normal
- A drought year; when annual rainfall is deficient by 20 % of normal or more and
- Severe drought year; when annual rainfall is deficient by 25-40% of normal or more.

Drought Risk

Drought vulnerability depends on a region's risk of water shortage and the exposure of the communities to the problems arising thereafter. It is critical for countries to better understand drought and how it varies temporally and spatially to establish comprehensive and integrated drought early warning systems by incorporating climate, soil, and water supply functions such as precipitation, temperature, soil moisture, snow pack, reservoir and lake levels, ground water levels, and stream flow.

National Disaster Management Guidelines on Management of Drought

The NDMA guidelines on management of drought are issued in 2010. The recommendations are as follows:

1. Creation of *Drought Monitoring Cells* (DMCs) cells at state level with requisite staff.
2. Preparation of *vulnerability maps* for each state by the State DMCs.

3. *Development of real-time drought related information* by using information and communication technology.
4. The *watershed development approach* would be taken up for drought management.
5. Integration of ground-based information with the space-based information for *comprehensive reporting*.
6. Assessment of damage would include agricultural production, depletion of water resources, livestock population, land degradation and deforestation as well as human health.
7. Revamping of *Drought Management Information System* of Department of Agriculture.
8. To enable micro level analysis and forecasting, automatic weather station and rain-gauges to be put in place.
9. Development of drought resistant crop varieties through large scale research.
10. The mitigation measures to be taken would include cloud-seeding and conduct of pilot studies in all categories of drought prone areas for suggesting long term mitigation measures.
11. Formulation of a cloud seeding policy.
12. Promoting crop diversification through sprinklers/Drip irrigation systems (micro irrigation techniques).

13. Prompt provision of credit in the drought affected areas; and extension of marketing and price support.
14. Afforestation with subabul, seemaruba, casurina, eucalyptus and bio diesel plantation like Jatropha and pongomia.
15. Development of insurance products for different agro-climatic zones providing coverage against drought. Crop insurance to be extended to post-harvest losses. Promotion of price linked insurance products to avoid distress sales of farm produce. Use of satellite derived crop condition images as surrogates to crop yield estimates for settling insurance claims.
16. Framing a realistic national training and capacity building programme for drought management. Officers at PRIs and ULBs to be provided with required training.
17. Encouraging NGOs, PRIs and ULBs for generating awareness among farmers.
18. Updating the syllabi of graduate and under-graduate courses in agriculture to include drought management.
19. Fodder, Cattle feed and mineral mixture to be supplied to all productive animals to prevent distress sales of cattle.
20. Wherever necessary and feasible, the corporate sector should also be involved in supporting drought risk management efforts as part of CSR.

DPAP

Drought Prone Areas Programme (DPAP) is the "**earliest area development programme**" launched by the Central Government in 1973-74 to tackle the special problems faced by those fragile areas which are constantly affected by severe drought conditions.

These areas are characterized by large human and cattle populations which are continuously putting heavy pressure on the already fragile natural resources base for food, fodder and fuel.

The major problems are continuous depletion of vegetative cover, increase in soil erosion, fall in ground water levels due to continuous exploitation without any effort to recharge the underground aquifers.

Current Status of DPAP

Please note that in 1977-78, **Desert Development Programme** (DDP) was launched for hot desert areas of Rajasthan, Gujarat, Haryana and cold desert areas of Jammu & Kashmir and Himachal Pradesh. Similarly, in 1989, **Integrated Watershed Development Programme (IWDP)** was launched under the aegis of National Wasteland Development Board for development of wastelands on watershed basis.

In this context, In 1994, a Technical Committee under Chairmanship of Professor **C.H. Hanumantha Rao** was appointed to appraise the impact of DPAP / DDP and suggest measures for improvement. The committee recommended a common set of operational guidelines and expenditure norms for the three programmes of Ministry of Rural Development.

Accordingly, the Guidelines for watershed Development were framed and brought into force from 1st April 1995. These guidelines were changed in 2001 and further in 2003 and were named " **Haryali Guidelines**". Later, the 11th Plan has stressed upon developing concerted action plans for rainfed areas in close consultation with the State Governments. Accordingly, the Common Guidelines for Watershed Development, 2008 have been issued and made effective from 1.4.2008. Since 26.2.2009, the three watershed programmes of the Department of Land Resources namely DPAP, DDP and IWDP have been consolidated as a comprehensive programme named '**Integrated Watershed Management Programme (IWMP)**'.

Integrated Wastelands Development Programme

So, at present, the Integrated Wastelands Development Programme (IWDP), Drought Prone Areas Programme (DPAP) and Desert Development Programme (DDP) are running as a consolidated single programme named **Integrated Watershed Management Programme** (IWMP) in place of all the above mentioned three Area Development Programmes. (Information related to this topic is outdated in most books). This programme comes under Ministry of Rural Development.

Biological Disaster

Bioterrorism Threat and India's Bioterrorism Preparedness

Bioterrorism is Intentional & deliberate release of biological agents (bacteria, viruses, or toxins) to cause mass illness or death of people, animals, or plants. It is said that if the 20th century was the century of physics, the 21st century will be the century of biology. Thus, Bioterrorism is posed to be the next possible threat the civilized world faces. The *first disease used as a tool for bioterrorism was Bubonic Plague in 14th century*. It was used to infiltrate enemy cities. This coupled with less advanced medical technologies cause the bubonic plague quickly move across all of Europe, destroying a large portion of its population. Anthrax was used during First World War by Germany to infect the mules and horses of enemies. In September and October 2001, several cases of anthrax broke out in the United States in the 2001 anthrax attacks, caused deliberately. Letters laced with infectious anthrax were delivered to news media offices and the U.S Congress. The letters killed 5. Bioterrorism is different from various other forms of terrorism because of the following:

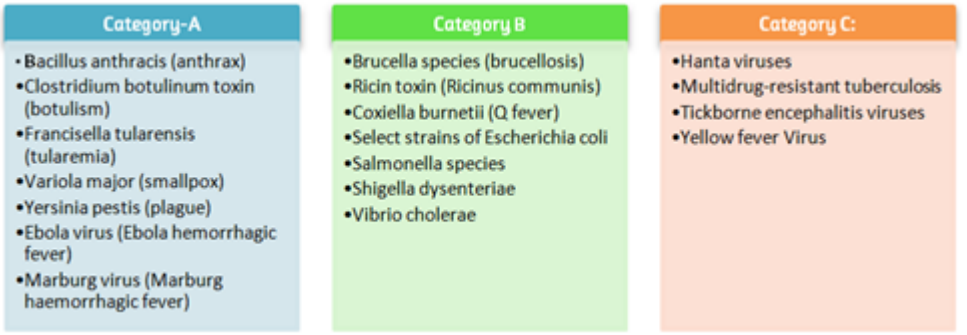
- Biological agents are
  - relatively easy and inexpensive to obtain
  - can be easily disseminated
  - can cause widespread fear and panic beyond the actual physical damage they can cause.
- Risk of massive destruction in the form of life is too high
- Exposure to minute quantities of a biological agent may go unnoticed, yet ultimately be the cause of disease and death.
- They don't work immediately. The incubation period of a microbial agent can be days or weeks; unlike a bombing, knifing, or chemical dispersion, a bioterrorism attack might not be recognized until long after the agent's release.
- However, it is quite difficult to keep bio-weapons as military asset because there are certain important limitations. One is that bio weapons cannot differentiate between foes and friends. So far, Biological weapons have been used to create mass panic only.

Different kinds of Bioterrorism agents

There are basically 3 types of agents used based on the ability and extent of damage that can be caused. They are:

- **Category A:** High-priority agents which result in high mortality rates and have potential for a mass impact. The intensity and speed of impact can trigger panic in local populations.
- **Category B:** Moderate-priority agents cause relatively less damage
- **Category C:** Low-priority agents are emerging pathogens that are readily available and can thus be easily mutated or engineered to get desired results in a short span of time.

Examples of the above three categories are shown below:



More details about the above agents can be found here on Wikipedia. Apart from the above, the latest entrants on the scene are the designer substances such as designer viruses, which are used to target specific organs which can possibly incapacitate or kill the host on contact.

Mode of Attack

The bioterrorist agents are highly sophisticated and thus have the ability to pass through many screen tests. They can thus be spread either by human contact, via any material like books, letters, sprays in crowded places like Cinema halls, Malls, etc., drones, robots, scud missiles etc.

Bioterrorism threat to India and our Bioterrorism Preparedness

There had been several sporadic incidents bioterrorism in past but the October 2001 use of anthrax letters in United States was one incident that killed five people and triggered a worldwide alarm. There are no confirmed incidents of bioterrorism attack in India yet, in 2001, the office of the Deputy Chief Minister of Maharashtra had received an envelope having anthrax culture. It wakes up Indian security agencies and consequently several incidents were suspected to be acts of bioterrorism. Some of them are as follows:

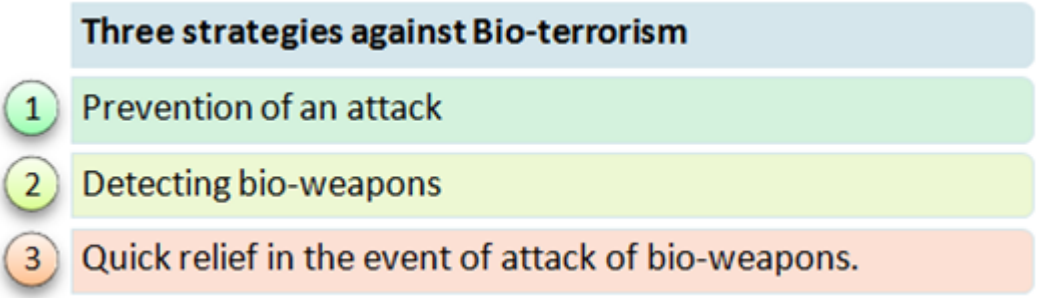
- 1994, Pneumonic plague attack in Surat
- 1996, Dengue hemorrhagic fever attack in Delhi
- 1999, Anthrax attack in Midnapore
- 2001, the Mystery 'encephalitis attack in Siliguri.

To strengthen the area of bio-defence, though United States passed the 'Bioterrorism Act of 2002' but in India, we still have no such dedicated law. The Bioterrorism Act of 2002 makes provision of an essential element of national preparedness against bioterrorism in United States and it focuses on safety of drugs, food and water from biological agents and toxins. India's has so far, put efforts mainly via NDMA, NDRF and DRDO. Some DRDO labs are active in this area of research and have developed protective systems and equipments for protection of Indian troops against the nuclear, biological and chemical warfare. The efforts can be enumerated as follows:

- National Disaster Management Authority (NDMA) has taken several initiatives has existing battalions of National Disaster Response Force (NDRF), trained to deal with chemical, biological, radiological, and nuclear (CBRN) threats.
- Installing specific surveillance systems that have the capacity to recognise patterns of non-specific threats.
- Disease Surveillance Project (IDSP), a decentralized and state-based surveillance program, 2004 which integrates the public sector, private sector, rural and urban health system, and has incorporation of communicable and non-communicable systems (unusual clinical syndromes may be included during public health emergencies).

Issues to meet the challenge of bioterrorism

There is a need for coordinated and concerted efforts of different government agencies viz. the intelligence agency, the army, the BSF, SSB, law enforcement machinery, health departments and civil administration etc. to meet the challenge of bioterrorism. The threat of bioterrorism places a heavy demand on India's public health system which would need to mitigate and ameliorate the consequences of a bioterrorism attack. Our country lacks an effective public health system and that is why, any event of bioterrorism can create havoc in the country.



Thus, making a strong public health system is prerequisite to effectively handle the threat. For this, the various components of the Public Health System such as surveillance, assessment, medical management, information and education, etc. needs to be made stronger. Further, there is a need to make the national stockpile of drugs readily available in case of an incidence. Some other fundamental steps needed are

- Spread of awareness
- Readiness with drugs and medicines
- Readiness with decontamination procedures.

Landslides and Snow Avalanches

Landslide refers to downward and outward movement of slope materials such as rocks, soil etc. due

to gravity. Primary reason of Landslides includes gravity and accumulation of soft soil, debris and rocks on a steep slope. The other factors that increase the risk include erosion, weakening of rocks and soils due to heavy rains, deforestation, earthquakes, volcanic eruption etc.

Landslide prone areas in India

As per the Geological Survey of India, *around 15% of Indian landmass is prone to landslides*. The landslide prone areas listed by the National Disaster Management Authority include Himalayan states, Arakan-Yoma belt in the north east, Meghalaya plateau, Western Ghats and Nilgiri hills. Various kinds of Landslides have been experienced in 22 states and parts of Union Territories of Puducherry and Andaman and Nicobar Islands.

The Himalayan regions and north east hilly tracts are *most vulnerable because of tectonic reasons and on account of their being young fold mountains*, created by the collision of the Indian landmass with the Eurasian plate. Himalayan mountains have rugged topography, high seismicity and high rainfall. Each of these reasons contributes to the region's high vulnerability to landslides.

In comparison to the Himalayan states, Western Ghats and Nilgiri Hills are less prone. The major reason for Landslide vulnerability in Western Ghats is the deposits of overburden materials such as loose soil, tumbling stones, debris etc. on the steep hill slopes. The landslides and flash floods in this area are triggered by intense rainfall. Nilgiri hills, which are located at the convergence zone of the Eastern and Western Ghats are prone to landslides mainly due to overburden deposited on the slopes.

The Geological Survey of India (GSI) was declared as the nodal agency for landslides. The responsibilities as the nodal agency include coordinating all the activities related to landslide hazard mitigation, and monitoring the occurrence of landslides in the country.

Snow Avalanche

Snow Avalanche is a rapid, down slope movement of large detached mass of snow, ice and associated debris such as rock fragments, soil and vegetation.Small avalanches, or sluffs, occur in large numbers whereas large avalanches that may encompass slopes a kilometre or more in length with millions of tons of snow, occur infrequently bust cause lot of damage.

There are two basic types of avalanches viz. loose snow avalanches and slab avalanches.Loose snow avalanches form in snow masses with little internal cohesion among the individual snow crystals. Such an avalanche originates at a point and grows wider as it sweeps up more snow in its descent.Slab avalanches originate in snow with sufficient internal cohesion to enable a snow layer, or layers, to react mechanically as a single entity. A slab release may take place across an entire mountainside, with the fracture racing from slope to slope to adjacent or even distant slide paths.

Causes and effects of Snow Avalanches

Avalanches occur due to combination of fixed (prime factors) and variable factors (exciting factors). The prime factors include topographic factors and vegetative factors. The variable factors include weather conditions and the weight of the snow cover.

The force generated by a medium to large avalanches can damage or destroy man-made structures. The debris from even small avalanches is enough to block a highway or rail-road and in some cases passing vehicles can be swept away and destroyed. Generally, use of avalanche areas in the summer does not constitute any hazard.

Avalanche prone areas in India

In India, Himalayan region is well known for occurrence of snow avalanches particularly the Western Himalayan region (snowy regions of Jammu and Kashmir, Himachal Pradesh and Uttarakhand).

NDMA guidelines on Landslides and Snow Avalanches

The main objectives of the NDMA guidelines are to institutionalise the landslide hazard mitigation efforts, to make society aware of the various aspects of landslide hazard in the country and to prepare the society to take suitable action to reduce both risks and costs associated with this hazard. The recommendations include:

1. Continuously updating the inventory of landslide incidences affecting the country.
2. Landslide hazard zonation mapping in macro and meso scales after consultation with the Border Roads Organization, state governments and local communities.
3. Pilot projects to be taken up in different regions of the country to carry out detailed studies and monitoring of select landslides to assess their stability status and estimate risk.
4. Setting pace setter examples for stabilization of slides and also setting up early warning systems depending on the risk evaluation and cost-benefit ratio.
5. Completion of site specific studies of major landslides and plan treatment measures, and encourage state governments to continue these measures.
6. Institutional mechanisms have to be set up for generating awareness and preparedness about landslide hazard among various stakeholders.
7. Training and capacity building measures to be taken up for professionals and organizations working in the field of landslide management.
8. New codes and guidelines to be developed on landslide studies and existing ones have to be revised.
9. An autonomous national centre for landslide research, studies and management has to be established.

Implementation of above action points would increase efficacy in management of landslides and

avalanches in the country. The above measures should be duly backed by requisite operational, legal, institutional, and financial support.