INTERNATIONAL INSTITUTE OF TECHNOLOGY & MANAGEMENT,
MURTHAL, SONEPAT
E-NOTES, SUBJECT: DISASTER MANAGEMENT, SUBJECT CODE: CE-486B
COURSE: B.TECH, BRANCH: CIVIL ENGINEERING, SEM- 8^{TH} ,
CHAPTER NAME: COMPLETE SYLLABUS
PREPARED BY: MR. SAHIL KAUSHIK, ASSISTANT PROFESSOR, CE

UNIT 1

INTRODUCTION TO DISASTER MANAGEMENT

Introduction

The International Strategy for Disaster Reduction (ISDR) of the United Nations (U.N.) defines a hazard as "a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation." Hazards could be, natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Accordingly, Hazard Analysis entails the identification, study and monitoring of a hazard to determine its potential, origin and characteristics. A fine line separates environmental hazards and environmental resources, as between water out of control (flood hazard) and water under control (reservoir resources).

A disaster is a result of natural or man-made causes that leads to sudden disruption of normal life, causing severe damage to life and property to an extent that available social and economic protection mechanisms are inadequate to cope. Even at the outset, the conceptual distinction between 'hazards' and 'disasters' needs to be brought out clearly. Floods, Cyclones, et al are events in nature until a configuration of factors, which could be man-made or natural or both, cause the hazard to turn to a disaster. Disaster is the actual occurrence of the apprehended catastrophe. Disasters proceed by cause-effect due to endogenous (inherent) and exogenous (external) factors, which combine to excite the phenomenon into a large-scale destructive event. Disasters are a result of vulnerabilities, which go on unabated/unchecked over time, which crystallizes finally in a destructive event of great magnitude, which is a disaster.

With this understanding, Disaster Management is an attempt to inquire into the process of a hazard turning to disaster, to identify the causes and rectify the same through public policy. Administrative factors, such as poor building in an earthquake prone zone, poor land use planning in flood prone areas which lead to housing critical facilities in at- risk zones; allowing habitation in such zones, poor laws that fail to regulate facilities leading to disasters, such as the Bhopal gas leak, general low risk perception among people, more significantly policy-makers that hinders interest articulation for preventive policy for disaster management create conditions that lead to low lying /inherent hazards turning to disasters. This leads us to the issue of sustainable development since study and research in the area of disaster management is increasingly revealing human causatives behind disaster phenomena.

Classification of Disasters:

Disasters are classified as per origin, into natural and man-made disasters. As per severity, disasters are classified as minor or major (in impact). However, such classifications are more academic than real as major disasters could simply be events that received relatively more media coverage (Parasuraman and Unnikrishnan, 2005).

High Powered Committee (HPC) was constituted in August 1999 under the chairmanship of J.C.Pant. The mandate of the HPC was to prepare comprehensive model plans for disaster management at the national, state and district levels. This was the first attempt in India towards a systematic comprehensive and holistic look at all disasters. Thirty odd disasters have been identified by the HPC, which were grouped into the following five categories, based on generic considerations:

- Water and Climate:
    - Floods
    - Cyclones
    - Tornadoes and hurricanes (cyclones)
    - Hailstorms
    - Cloudburst
    - Heat wave and cold wave
    - Snow avalanches
    - Droughts
    - Sea erosion

- Thunder/ lightning

- Geological
  - Landslides and mudflows
  - Earthquakes
  - Large fires
  - Dam failures and dam bursts
  - Mine fires
- Biological
  - Epidemics
  - Pest attacks
  - Cattle epidemics
  - Food poisoning
- Chemical, industrial and nuclear
  - Chemical and Industrial disasters
  - Nuclear
- Accidental
  - Forest fires
  - Urban fires
  - Mine flooding
  - Oil spill
  - Major building collapse
  - Serial bomb blasts
  - Festival related disasters
  - Electrical disasters and fires
  - Air, road, and rail accidents
  - Boat capsizing
  - Village fire

Depending on the type of disaster, a nodal ministry has been assigned the task of coordinating all activities of the state and district administration and the other support departments/ministry.

The following table below vividly gives the information:

Type of Disaster/Crisis	**Nodal Ministry**
Air Accidents	Ministry of Civil Aviation
Civil Strife	Ministry of Home Affairs
Major breakdown of any of the Essential Services posing widespread and protected problems	Concerned Ministries
Railway Accidents	Ministry of Railways
Chemical Disasters	Ministry of Environment
Biological Disaster	Ministry of Health
Nuclear Accident inside or outside the country which poses health or other hazards to people in India	Department of Atomic Energy

It is not the classification but the understanding of the term 'disaster' itself that is important. As reported in the World Disasters Report, 2004, heat waves have been missing from disaster and public health policies, despite mounting death tolls, particularly in Europe. This is probably because sudden high-profile disasters, such as earthquakes evoke greater dread than road accidents, despite evidence that more people die in road accidents than earthquakes. The higher the dread factor, the more people want action to reduce those risks. The challenge for health professionals and disaster specialists is to raise public awareness of the potential harm caused by extreme temperatures and treat the problem as a disaster.

Overview of Natural Disasters in India:

India's Key Vulnerabilities as articulated in the Tenth Plan are as follows:

- Coastal States, particularly on the East Coast and Gujarat are vulnerable to cyclones.
- 4 crore hectare landmass is vulnerable to floods
- 68 per cent of net sown area is vulnerable to droughts
- 55 per cent of total area is in seismic zones III- V, hence vulnerable to earthquakes
- Sub- Himalayan sector and Western Ghats are vulnerable to landslides. The succeeding text analyses in brief vulnerabilities to specific natural hazards in India (Menon and Kalmadi).

A) Floods:

Seventy-five per cent of rainfall is concentrated over four months of monsoon (June - September) as a result of which almost all the rivers carry heavy discharge during this period. The problems of sediment deposition, drainage congestion and synchronization of river floods compound the flood hazard with sea tides in the coastal plains. Brahmaputra and the Gangetic Basin are the most flood-prone areas. The other flood-prone areas are the northwest region of the west flowing rivers like Narmada and Tapti, Central India and the Deccan region with major east flowing rivers like Mahanadi, Krishna and Cauvery. While the area liable to floods is 40 million hectares, the average area affected by floods annually is about 8 million hectares.

B) Droughts:

India has a largely monsoon dependant irrigation network. An erratic pattern, both low (less than 750 mm) and medium (750 - 1125 mm) makes 68 per cent of the total area vulnerable to periodic droughts. A 100-year analysis reveals that the frequency of occurrence of below normal rainfall in arid, semi-arid, and sub-humid areas is 54-57 per cent. Severe and rare droughts occur in arid and semi-arid zones every 8-9 years. The semi-arid and arid climatic zones are subject to about 50 per cent of severe droughts that cover generally 76 percent of the area. In this region, rare droughts of most severe intensity occurred on an average once in 32 years and almost every third year was a drought year.

C) Cyclones:

India has a long coastline. There are two distinct cyclone seasons: pre-monsoon (MayJune) and post-monsoon (October-November). The impact of these cyclones is 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. Most casualties are caused by coastal inundation by tidal waves, storm surges and torrential rains.

D) Earthquakes:

The Himalayan mountain ranges are considered to be the world's youngest fold mountain ranges. The subterranean Himalayas are geologically very active. In a span of 53 years, four earthquakes exceeding magnitude 8 on the Richter scale have occurred in this region. The peninsular part of India comprises stable continental crust. Although these regions were considered seismically least active, an earthquake that occurred in Latur in Maharashtra on September 30, 1993 of magnitude 6.4 on the Richter scale caused substantial loss of life and damage to infrastructure.

E) Landslides and Avalanches

The Himalayan, the northeast hill ranges and the Western Ghats experience considerable landslide activity of varying intensities. River erosions, seismic movements and heavy rainfalls cause considerable activity. Heavy monsoon rainfall often in association with cyclonic disturbances results in considerable landslide activity on the slopes of the Western Ghats. Avalanches constitute a major hazard in the higher reaches of the Himalayas. Parts of the Himalayas receive snowfall round the year and adventure sports are in abundance in such locations. Severe snow avalanches occur in Jammu

& Kashmir, Himachal Pradesh and the Hills of Western Uttar Pradesh. The population of about 20,000 in Nubra and Shyok valleys and mountaineers and trekkers face avalanche hazard on account of steep fall.

Overview of Man-made Disasters:

Man-made disasters refer to non-natural disastrous occurrences that can be sudden or longer term. Sudden man-made disasters include structural collapses, such as building and mine collapse, when this occurs independently without any outside force. In addition, air disasters, land disasters and sea disasters are all man-made (International Red Cross).

The countries in Asia region are densely populated and are low-income economies. Recurrent disasters, specifically, road and rail accidents, fire outbreaks, deaths of pavement dwellers due to heat and cold wave conditions etc., cause serious setback to the developmental process; in fact disasters and development have a chicken and egg relationship in that one is in fact the primary cause of the other. For example, disasters exacerbate poverty conditions in affected regions; and the poor are the worst sufferers in disasters. The fast pace of growth and expansion without comprehensive understanding or preparedness in urban planning, for instance, has brought forth a range of issues that seek urgent attention at all levels. Local administrative weaknesses have allowed the situation to get out of hand.

Institutional weaknesses have created system vulnerabilities over time. In the absence of mitigation measures, growing numbers in our population are at risk of prospective hazards, such as air accidents, boat capsizing, building collapse, electric fires, festival related disasters, forest fires, mine flooding, oil spills, rail accidents, road accidents, serial bomb blasts, and fires. The safeguards within existing systems are limited and the risks involved high. The situation with regard to road accidents is particularly acute.

A comprehensive document prepared by the Transportation Research and Injury Prevention Programme (TRIPP) brings out the magnitude of the problem in India and abroad. It gave the first official data of accidents in 2002, recording 80,118 deaths and 342,200 injuries on Indian roads but conceded at the same time that many cases went unreported and that 1,200,000 required hospitalisation. Of the worldwide annual average of 700,000 road accidents, 10 per cent occur in India. The latest annual statistics indicate that over 80,000 people are killed on Indian roads. These figures do not reflect the human suffering and social problems caused by accidents. Nearly three lakhs per year sustain injuries. Financial losses are staggering. A decade's worth of saving the Rs 50,000 million estimated loss in traffic accidents every year could finance building 7,000 km long, six lane national highway at today's rates.

Nuclear, Chemical and Biological threats are apparent in the present scenario. Deliberate international terrorism or accidental secondary fallouts can be fatal. There has been considerable agitation in India of late over advanced countries dumping hazardous waste in India. This falls within the realm of international relations. Rapid and effective response as also mitigation policy needs intensive research and laboratory support in this regard to frame convincing legislation, which can ensure internal security without jeopardising external relations with foreign countries.

Globalisation would have to be effectively managed through legislation regulating Multi-national and Transnational corporation activity, especially with regard to safety precautions for hazardous facilities. EIAs or environment impact assessments are already underway in India. There is need for better implementation of the same. A good EIA needs good data support to base arguments on, which is presently lacking. Acknowledging the need, Environmental Information Centre (EIC) has been set up to serve as a professionally managed clearing house of environmental information that can be used by MoEF, project proponents, consultants, NGOs and other stakeholders involved in the process of environmental impact assessment in India. EIC caters to the need of creating and disseminating organised environmental data for various developmental initiatives all over the country.

Regarding oil spills, experts opine that satellite imagery should be used to mark out vulnerable areas and mitigation measures put in place, as for example, restricting habitation in the areas. In India, the man- made disaster category also

includes communal riots, which affect parts of India periodically, as in the wake of the Babri Masjid demolition or unabated violence against Dalits, the sub-ethnic North-East tangle, and others.

Vulnerability studies in this regard would require empirical unearthing of facts with regard to the socio- economic profile of the regions with a view to pinpointing the exact cause (s) of recurrent violence in the area (s). In this regard, generation of awareness among communities, strengthening/ generating positive social capital proactively, through measures like mustering opinion in support of measures to ameliorate the situation, lending active state support to social workers involved in movements towards the same would be some of the desirable activities.

Vulnerability profile of India:

Vulnerability is defined as "the extent to which a community, structure, service, or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrain or a disaster prone area". The concept of vulnerability therefore implies a measure of risk combined with the level of social and economic ability to cope with the resulting event in order to resist major disruption or loss. This susceptibility and vulnerability to each type of threat will depend on their respective differing characteristics. The 1993 Marathwada earthquake in India left over 10,000 dead and destroyed houses and other properties of 200,000 households. However, the technically much more powerful Los Angeles earthquake of 1971 (taken as a benchmark in America in any debate on the much-apprehended seismic vulnerability of California) left over 55 dead.

Physical Vulnerability

Physical vulnerability relates to the physical location of people, their proximity to the hazard zone and standards of safety maintained to counter the effects. For example, people are only vulnerable to a flood because they live in a flood-prone area. Physical vulnerability also relates to the technical strength of buildings and structures to resist the forces acting upon them during a hazard event. The Indian subcontinent can be primarily divided into three geophysical regions with regard to vulnerability, broadly, as, the Himalayas, the Plains and the Coastal areas. The topographic and climatic characteristics of each region make them susceptible to different type of disasters (study along with map given in the text).

Socio-economic Vulnerability

The degree to which a population is affected by a calamity will not purely lie in the physical components of vulnerability but in contextual, relating to the prevailing social and economic conditions and its consequential effects on human activities within a given society. Disparate capacities of people are exposed during disasters, which explains differential vulnerability/losses, which are explained in disaster literature as socio-economic vulnerabilities. Disaster effects are seen to be directly proportionate to the poverty gap and poverty intensity in the society/location as it is the poor that normally live in high concentration in marginal areas (unstable slopes, flood plains) with little infrastructure and fewer resources to cope. Research in areas affected by earthquakes indicates that single parent families, women, handicapped people, children and the aged are the particularly vulnerable social groups.

Bad land use planning in seismic and flood prone zones; unplanned and inadequate developmental activity in high- risk areas is a cause for increased losses during disasters. One million houses are damaged annually in India apart from high human, social and other losses. Urban growth and concentration of limited resources are realities of our times, while the rural sector faces lack of access. This compounds the problems of disaster vulnerability, especially during earthquakes. Informal settlements that house most of the urban and rural poor give way easily to physical stress, during earthquakes and floods, causing large scale fatalities during disasters such as earthquakes and floods. Single scale event fast turns into a compound phenomenon as the infrastructure gives way, leading to fire breaks, deaths due to electrocution, besides making response ever more difficult.

Following steps are imperative for the vulnerability assessment and preparedness in high-risk zones:

- Identification of various hazard prone areas. Preparation of detailed vulnerability profiles, mapping food insecurity, aviation hazard, landslide hazard etc.
- Vulnerability and risk assessment of buildings
- Developing disaster damage scenarios
- Developing technical guidelines for hazard resistant constructions
- Upgrading of hazard resistance of existing housing stock by Retrofitting, and
- Crafting techno-legal regime to be adopted for infrastructure development.

Conclusion:

Disaster is an unwelcome guest. It disrupts normal life and puts the developmental targets out of gear. Disasters can result from natural or man-made causes or a combined effect of both. The impact of disasters are felt more strongly when the affected community is more vulnerable, either in terms of physical exposure or vulnerable socio-economic conditions. Therefore, disaster management is a public administration issue, since disaster mitigation has to be achieved in time through public policy. In line with postmodernism, sustainability of progress/ development is being accorded primacy, currently. It could be termed as coming full circle in some ways. Thus development, as is the perception now, in itself may not be sustainable if it runs counter to environmental concerns. Environmental concerns are therefore gaining importance, since environmental factors are increasingly having the adverse impact of the frequency and intensity of disastrous events. Sustainable development is being considered largely in terms of sustainable city growth. More than rural development, it is urban development that has to be stabilised/regulated through well-meaning/planned policies. Rural development partakes by way of spin-off effects from public good externalities from nearby/surrounding urban areas, as rightly pointed out in the Tenth Plan. Areas of concern are urban risks, since the concentration of populations in urban areas is constantly increasing with inadequate corresponding investment in safety measures. Disaster management needs to be seen in a developmental context and pre-emptive action needs to be taken to reduce the impact of disasters.

Important Definitions:

- Hazards: A precise definition of hazard is difficult. The International Strategy for Disaster Reduction (ISDR) has defined hazard as a potentially damaging physical event, phenomenon or human activity that may cause loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards have both natural and human components. For example, flood problems may be exacerbated by fluctuations in climate, such as increased storm frequency, and also by certain human activities, such as land drainage and deforestation. The loss of life caused by a tropical cyclone will depend to some extent on storm severity but it can be greatly reduced by means of a warning system. Attempt has continually been made to employ science and technology to harness nature and evolve better living conditions.
- Biological Hazards: Processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Examples of biological hazards are outbreaks of epidemic diseases, plant or animal contagion, insect plagues and extensive infestations (ISDR).
- Geological Hazards: Geological hazards include internal earth processes or tectonic origin, such as earthquakes, tsunamis, volcanic activity and emissions as well as external processes such as mass movements: landslides, rockslides, rock falls or avalanches, surface collapse, expansive soils and debris or mud flows. Geological hazards can be single, sequential or combined in their origin and effects floods, debris and mud floods; tropical cyclones, storm surges, thunder/hailstorms, rain and wind storms, blizzards and other severe storms; drought, desertification, wild land fires, temperature extremes, sand or dust storms; permafrost and snow or ice avalanches (ISDR).

- Hydro Meteorological Hazards: These hazards are of atmospheric, hydrological or oceanographic nature. Hydro-meteorological hazards include: floods, debris and mud floods; tropical cyclones, storm surges, thunder/hailstorms, rain and wind storms, blizzards and other severe storms; drought, desertification, wild land fires, temperature extremes, sand or dust storms; permafrost and snow or ice avalanches. Hydro-meteorological hazards can be single, sequential or combined in their origin and effects (ISDR).
- Physical Vulnerability: Vulnerability of the landmass to natural hazards such as earthquakes owing to natural factors is explained as physical vulnerability. Vulnerability of the physical landscape as well as the infrastructure is included in physical vulnerability.
- Socio-economic Vulnerability: Poverty predisposes people to disaster losses/suffering. The poor mostly inhabit flood prone/multi-hazard prone areas perforce. These areas are cheaper to access and also provide certain advantages like fertile land near volcanoes and flood plains. Poverty also reduces resilience to epidemics that hit an area along with/in the aftermath of a disaster.

DISASTER MANAGEMENT CYCLE

The concept of Disaster Management Cycle has entered disaster management efforts over the past few years, especially since the Yokohama Conference (1994). Hitherto, disaster management had been perceived as a short-term relief undertaking, which lasted till sometime after a disaster. Other purposive activities undertaken in the pre or post-disaster stages on the part of civil society or the government towards mitigating the impact of disasters or tackling long -term vulnerabilities and dealing with newer threats in the wake/ aftermath of a disaster were not included in disaster management activities. They were rather classified, developmental activities or 'social action' on the part of civil society actors(s), motivated by philanthropic concerns.

The concept of Disaster Management Cycle integrates isolated attempts on the part of different actors, government and nongovernment, towards vulnerability reduction or disaster mitigation, within the enveloping domain of disaster management, as phases occurring in different time periods in disaster management continuum, though essentially relating to/comprising disaster management. This has facilitated a planned approach to disaster management in that post- disaster recovery and pre -disaster mitigation planning are perceived as integrated/related activities and not separate. Thus, prevention, mitigation and preparedness form pre-disaster activities in the Disaster Management Cycle and, response, comprising relief, recovery and rehabilitation are post-disaster activities. Whilst emergency relief and rehabilitation are vital activities, successful disaster management planning must encompass the complete realm of activities and situations that occur before, during and after disasters. These phases can best be represented as a cycle, which if followed through public policy can obstruct future development of disasters by impeding the vicious cycle of cause and effect. These activities are implemented at specific times, the length of any one phase depending on the type of disaster, its breadth and scale. Therefore, one of the key issues in disaster management planning is the allocation of resources at all stages of the disaster cycle, which optimises the total effectiveness of risk reduction activity and maximises the overall impact of disaster management.

This approach has imparted a more holistic perception to disaster management and has served to integrate disaster management with development planning in that most predisaster activities, involve activities for vulnerability reduction like poverty reduction, employment provision etc. which are also mainstream development concerns. Thus disaster management cycle implies development is essentially/conceptually related to disaster management.

STAGES IN DISASTER MANAGEMENT

Disaster Management efforts are geared towards disaster risk management. Disaster Risk Management "implies the systematic process of using administrative decisions, organisation, operational skills, and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impact of natural hazards and related

environmental and technological disasters. These comprise all forms all activities including structural and non- structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects to hazards".

There are three key stages of activities in disaster management:

1) Before a disaster: to reduce the potential for human, material, or environmental losses caused by hazards and to ensure that these losses are minimised when disaster strikes;

2) During a disaster: to ensure that the needs and provisions of victims are met to alleviate and minimise suffering; and 3) After a disaster: to achieve rapid and durable recovery which does not reproduce the original vulnerable conditions.

Common perception of disaster management, as explained earlier, is limited to emergency relief and post- disaster rehabilitation. This is so because these two elements are by far the strongest in terms of high profile visibility, political support and funding provision. Instead of allocating funds before an event to reduce future disasters, action normally only takes place after an event has occurred. The situation is similar to that of preventive health care where curative medicine is relatively well funded whilst preventive medicine is not. The focus on emergency relief also depends on risk perception; that is, whether there is belief that disaster could be avoided. If disasters were believed to be of such a scale that it is believed, nothing could be done to reduce either the phenomenon or the risk involved, and risk mitigation would not be pressed for/attempted. However, once belief develops that disaster losses are exacerbated by human agency, and could be curbed thereby, disaster risk mitigation would be attempted.

THE DISASTER CYCLE

The different phases of disaster management are represented in the disaster cycle diagram overleaf. The Disaster Cycle consists of three stages:

I) The Disaster Event

This refers to the real-time event of a hazard occurring and affecting the 'elements at risk'. The duration of the event will depend on the type of threat, for example, ground shaking may only occur for a few seconds during an earthquake while flooding may take place over a longer period of time. Disasters have tremendous modifying impact on the physical landscape. Within a few minutes, an entire region is reduced to rubble in the event of an earthquake.

The recent Tsunami has permanently altered the physiography of affected coastal areas in Sri Lanka, Andaman and Nicobar islands. The impact leads to loss of life and property in affected areas; losses being directly correlated to the vulnerability of the region, physical and socio-economic. Physically weak structures, especially in illegal/informal settlements give way easily and cause large-scale losses. Vulnerability is also socio-economic. Weaker sections of society, viz. women, children,

aged and handicapped, mentally infirm, etc., suffer a lot more than their stronger counterparts. Studies have also unearthed positive correlation between poverty and vulnerability.

The poor inhabit the most hazardous physical areas because they are easier to procure and offer added advantages, like proximity to sea for fishermen or fertile soil for farmers near flood prone areas etc., that makes them prone to losses, both of assets and life. The poor also lack the resilience to recover from shock in the aftermath of a disaster. For example, fishermen loose their boats, street side vendors, the homeless, orphans, widows and beggars fall easy prey to epidemics and insidious activities of unsocial elements like thieves, robbers, pimps, etc.

This brings to light the need for multi-faceted response to disasters, which takes account of all social political and economic ramifications. Issues to be addressed range from physical, relating to damaged structures and physical vulnerability of areas and infrastructure to social and economic vulnerability of weaker sections that suffer more relative to other, better placed. The following diagram is a vivid description of the disaster cycle.

II) Disaster Response

A Disaster is a cataclysmic event that has severe modifying impact. Consequences are both physical and social/ human. Communication is disrupted; infrastructure is affected adversely, many buildings giving way completely, critical facilities are disturbed, economic losses accrue, loss of employment, ranging from temporary to permanent occurs, development is rendered a severe set-back, law and order situation worsens, social fabric is disturbed, in that parochial tendencies are seen to come forth, such as on caste, communal, linguistic et al lines, and most importantly, people lose lives. Disaster Response has to tackle all aforesaid challenges. Disaster response entails restoring physical facilities, rehabilitation of affected populations, restoration of lost livelihoods and reconstruction efforts to restore the infrastructure lost or damaged. There are inherent important lessons to be learnt from disaster response.

Retrospectively, it brings to light flaws in efforts pertaining to policy and planning with respect to location and type of infrastructure and social schemes to improve the social positioning of the under privileged, particularly with respect to access to resources of the underprivileged. Disaster aftermath is evaluation time for the administrative set up in that disaster response exposes system weaknesses. Disaster is the ultimate test of administrative efficiency, in the sense of positive impact on the environment, preparedness, procedural simplicity, logistics, speed and expertise. There are inherent important lessons to be learnt for the future. Strong infrastructure and service support base is the fundamental and the most important requirement, which is often found wanting in poor third world countries.

Disaster event simply exacerbates the losses that accrue almost every time/ unabated due to poor health and hygiene arrangements in vulnerable pockets, inefficient municipal administration, top-down orientation in policy making and administration, poor institutionalization of development planning and administration at the local level, implementation bottlenecks, unchecked poverty, unresponsive administration, poor informational and logistical arrangements et al. Such critical evaluation as also articulation of displeasure on the part of the people through the electoral mechanism is not as effective in third world countries where elections are fought less on 'rational' criterion and more on ascriptive 'traditional'/ 'charismatic' criteria, which shifts attention/ focus away from performance to rhetoric which are designed to excite inherent social differentiations based on caste, language or community, etc., which is political demagoguery. Disaster event brings to the fore such inherent failings of a system; hence is explained the reliance on outside aid which is often found misdirected and misused due to lack of familiarity with local circumstances in recipient countries and rampant corruption in disbursements due to poor administrative infrastructure. Since Risk Perception of disasters is low in developing countries, pressure for policy in this regard is not strong enough. Hence, pressure for disaster management policy/planning in developing countries is articulated externally, that is, on the part of external/ international bodies like the International Red Cross and Red Crescent Societies, and the UNDP, the ISDR etc., based in the United Nations which may not always be guided by local concerns.

Hence, proactive planning for disaster response on the part of governments, especially in developing countries with regard to administrative reforms is imperative to protect development and/by lessening the disaster potential of a catastrophe, natural or man-made or otherwise by way of policy interventions to ensure:

- Better institutional preparedness;
- Countering contrary pulls such as lack of social cohesion owing to irrational differentiations that effectively impede response, in the sense of self- help and 'communitarianism'; and
- Long- term mitigation policy to counter vulnerabilities, structural and non- structural by enabling legal provisions and honest implementation of the same.

Significance of Response

Response has immediate mitigation impact. Disaster losses can be minimised to a large extent by effective response on the part of government and civil society. Sheer impact of disasters on life and property endorses the significance of response. Globally, natural disasters account for nearly 80 per cent of all disaster-affected people. The insurance industry estimates that natural disasters represent 85 per cent of insured catastrophe losses globally (World Disasters Report, 1997).

World Disasters Report (2003) focuses on ethics in humanitarian aid. It looks at how humanitarian agencies and governments can best help disaster-affected communities to recover, to become stronger and more resilient. It addresses issues like how the gaps between short-term relief and longer-term recovery can be bridged. There is growing concern over politicisation of disaster relief. "Millions of the world's most vulnerable remain beyond the reach of humanitarian assistance and protection. Saving lives alone is not sufficient. Respecting people's dignity and livelihoods is equally important. Humanitarian organisations bear two responsibilities. They must operationalise humanitarian principles by developing field indicators to put principles into practice and disseminate good practice in humanitarian judgement." Acting in tandem with local communities, particularly the vulnerable segments, this could be done.

There is also criticism of over-reliance on high-profile aid operations to save lives when long-term investment in disaster mitigation at the local level has proven to be much more effective. No international aid effort was necessary when the worst hurricane since 1944 hit Cuba in 2001 but only five people died. Local mechanisms were in place to evacuate 700,000 people from Havana and other threatened areas.

The World Disasters Report of 2002 states that thousands of lives are lost and millions of people left weakened each year because of donor reluctance to invest in measures that reduce the impact of disasters. Last year alone, the lives of 170 million people worldwide was disrupted by disasters.

Investing in mitigation issues like building long- term resilience of vulnerable communities would better serve the purpose of disaster management. There are reports of widespread corruption/leakage in disaster relief disbursements. Besides, business interests press on public policy, as there are huge profits involved in reconstruction activities. It is also asserted that disaster mitigation as part of the development process can minimise economic losses from disasters. However, Disaster Mitigation refers to a future perspective of development. Immediate concern of minimising disaster losses can be attended only by efficient and quick disaster response.

Issues in Disaster Response

The key word in disaster response is coordination between actors involved, viz. the government and civil society, including international donor organisations. For effective coordination, local government infrastructure has to be strong as response effort is channelised/ concentrated at the local level. Unfortunately, local governance has not been sufficiently institutionalised in India. That makes service delivery inefficient. Common administrative problems, like, maintenance of health and hygiene in their respective areas, good drainage, open spaces in settlement vicinities, largely go unattended.

This creates vulnerability to disease owing to system failure; manifested as water accumulation following floods, physical vulnerability of informal settlements wherefrom most deaths are reported during catastrophes like earthquakes etc. Coupled with institutional failure, are negative sociological dynamics like rural to urban migration, which exacerbate problems like congestion and poor basic services in urban areas and possibly, ethnic and communal tensions.

Civil society is contributing significantly to all aspects of disaster management cycle, particularly, relief. Civil society is the new hope of the new world order in the face of state and market failure in different respects. It is being seen as the answer/alternate / counterpoise to globalisation and weakening states. Civil society is hence, the buffer against state excesses and the market; the latter now developing in collusion with state governments, hence sharing interests with it, especially in the third world. In the newfound nexus, citizen could be a mute spectator, unless there are optional protection mechanisms. Civil society, in this respect offers new hope in that it has fought successfully for human causes round the world, such as landmine ban, protection of environment etc. It has also successfully challenged arbitrary political regimes such as Marcos's in Philippines.

As articulated in the India Disasters Report, 2005, crises in Marathwada and other places in India showed that the involvement of local people and civil society groups in rescue and relief was not a clearly defined process. According to Parasuraman and Unnikrishnan in the India Disasters Report, (2005), the specific arenas where civil society participation is desirable should be specifically laid down to avoid chaos and confusion in emergency situations. Those are; training project staff, information dissemination, programmes monitoring, housing, and social and economic rehabilitation measures. They, in turn, must be given adequate room to explore and innovate. The agencies must submit a time-bound plan of action, outline their approach unambiguously, clearly defining their specific roles, articulating a programme management strategy, and must establish that they have the necessary resources to see the things through.

III) Recovery

The recovery phase involves implementation of actions to promote sustainable redevelopment (reconstruction, rehabilitation) following a disaster. It covers long-term measures like, rebuilding of houses, assets, infrastructure, school building, hospital buildings, and other public buildings. It is a process undertaken by a disaster-affected community to fully restore itself to pre-disaster level. Recovery is the activity that returns infrastructure systems to minimum operating standards and guides long-term efforts designed to return life to normal or improved levels after a disaster. Recovery is also sometimes used to describe the activities that encompass the three overlapping phases of emergency relief, rehabilitation and reconstruction.

The chief behavioural attribute required in recovery is resilience. As highlighted in the World Disasters Report, 2004, community resilience is a big factor in disaster recovery. Recovery is used to describe the activities, which encompass the three overlapping phases of emergency relief, rehabilitation and reconstruction.

1) Emergency Relief

Emergency relief refers to the period immediately following the disaster when steps are taken to meet the needs of survivors with regard to shelter, water, food and medical care. Activities undertaken during and immediately following a disaster, include, immediate relief, rescue, damage and needs assessment and debris clearance. Rescue and relief are critical elements of response. As expressed in the India Disasters Report (2005), voluntary effort on the part of people, if recognised and institutionalised as supplementary to official government effort, could substantially minimise loss of life if not property to that extent. This would necessitate institutional/ organisational improvements by way of better delegation to field agencies, improvements in decision-making and communication processes, incorporation of indigenous traditional knowledge on warning signs, a cartographic knowledge of safe and unsafe areas, survival methods, and traditional forms of insurance built around kinship and families. The most crucial aspect in relief and rescue is communication across

involved agencies. Disaster zone is often equated with a war zone, where communication is the critical factor, often, crucial, in fact, the deciding factor between success and failure.

2) Rehabilitation

Rehabilitation implies activities that are undertaken to support the victims' return to normalcy and re-integration in regular community functions. It may include the provision of temporary housing and public utilities as interim measures to assist longer-term recovery through permanent housing and infrastructure. Besides physical elements, rehabilitation programmes also include economic rehabilitation through livelihood recovery and support actions and finding alternate employment options for those who cannot get back to their original occupations due to irreparable damage. Rehabilitation also includes psycho-social rehabilitation for those who are badly traumatised and need support in terms of psychosocial counseling or even medication in some cases.

Rehabilitation therefore includes the provision of temporary employment and restoration of lost livelihoods. Actual strategy adopted in rehabilitation would be dictated by circumstances, condition of the physical landscape, state of economic activity, whether relocation of affected communities is necessary, or whether resumption of normal life could take place in that region itself. It is important to incorporate past lessons in rehabilitation. Vulnerability mapping is recommended for identifying areas where access is to be completely restricted and the safe areas for viable construction activity.

Rehabilitation policies suffer due to short-term perspective, in that they are pursued as unplanned, ad-hoc measures. Rehabilitation is not factored in wider development strategy. A study conducted by the UNDP in the 1980s which focused on disaster mitigation efforts in Bangladesh, Ethiopia, and Ecuador, concluded that disaster preparedness and prevention is most effective only when it is built into the larger scheme of sustainable development, which enhances social opportunity and economic growth (India Disasters Report, 2005). Desired approach was followed in Marathwada with conspicuous benefits. Those affected by the later Uttarkashi earthquake, or the even more recent Jabalpur earthquake suffered for lack of policy in this regard. (India Disasters Report, 2005).

Crucial factor in rehabilitation as borne out by experiences from past disasters is training of personnel in various aspects of rehabilitation, such as, special concerns of widows and orphans, with respect to health and livelihood requirements besides community participation in damage and loss assessment and vulnerability analysis.

3) Reconstruction

Reconstruction attempts to return communities to improved pre-disaster functioning. It includes the replacement of buildings, infrastructure and lifeline facilities such as roads, bridges and communication links, so that long-term development prospects are enhanced rather than reproducing the same conditions which made an area or a population vulnerable in the first place. Mitigation measures can effectively be incorporated into reconstruction since there is generally"openness" to change and improved safety following a disaster event. Hence, this is mainly the technocrat's arena of function/action.

Post-modern thinking, as also referred earlier, is impacting urban planning in a major way. Instead of 'modernist' emphasis on uniformity, diversity is being lauded as the desired virtue. Accordingly, indigenous knowledge is being incorporated in modern engineering technology to produce viable structures in earthquake, flood and cyclone prone areas. Physical vulnerability of structures causes maximum disaster casualties. Hence, stress is also on retrofitting old structures with a view to making them disaster-resistant besides making new ones with disaster-resistant technology. Also, instead of the old cluster approach to housing which, as more in consonance with industrialisation would be changed for more differentiated housing and open spaces, which would provide for more aesthetic and safer cities. From a social perspective, modern cities have increased isolation and alienation of human beings.

This has led theorists in the West to talk about 'social capital' as it is increasingly getting scarcer in modern societies that are getting 'atomised'. Social capital is an intangible resource that invests in social ties, which proves an invaluable resource in recovery during emergences. In simple terms, it means people reaching out to each other and helping rebuild lives. Isolation is counter- effective of social capital.

IV) Development

The inclusion of development as a phase in the disaster cycle is intended to ensure that following the natural disaster, societies factor hazard and vulnerability considerations into their development policies and plans in the interest of overall progress. The rationale behind the use of the expression 'disaster management cycle' is that disaster and its management is a continuum of inter-linked activities. It is sometimes also referred to as the 'disaster-development cycle', implying that disasters are periodic phenomena and occur regularly in such a way that there is development, followed by a disaster, then back to development till the next disaster. Yet, such expressions are slightly deceiving in that they suggest that the periodic occurrence of disasters is something inevitable, always requiring the same response. On the contrary, if effective prevention and preparedness measures are implemented, natural disasters may be avoided by limiting the adverse impact of inevitable natural phenomena.

Illustration of Disaster Cycle through Case Study

The processes covered by the disaster cycle can be illustrated through the case of the Gujarat Earthquake of 26 January 2001. The devastating earthquake killed thousands of people and destroyed hundreds of thousands of houses and other buildings. The State Government as well as the National Government immediately mounted a largescale relief operation. The help of the Armed Forces was also taken. Hundreds of NGOs from within the region and other parts of the country as well as from other countries of the world came to Gujarat with relief materials and personnel to help in the relief operations.

Relief camps were set up, food was distributed, mobile hospitals worked round the clock to help the injured; clothing, beddings, tents, and other commodities were distributed to the affected people over the next few weeks. By the summer of 2001, work started on long-term recovery. House reconstruction programmes were launched, community buildings were reconstructed, and damaged infrastructure was repaired and reconstructed. Livelihood programmes were launched for economic rehabilitation of the affected people. In about two year's time the state had bounced back and many of the reconstruction projects had taken the form of developmental programmes aiming to deliver even better infrastructure than what existed before the earthquake. Good road networks, water distribution networks, communication networks, new schools, community buildings, health and education programmes, all worked towards developing the region.

The government as well as the NGOs laid significant emphasis on safe development practices. The buildings being constructed were of earthquake resistant designs. Older buildings that had survived the earthquake were retrofitted in large numbers to strengthen them and to make them resistant to future earthquakes. Mason and engineer training programmes were carried out at a large scale to ensure that all future construction in the State is disaster resistant. Since the state is also drought and cyclone affected, building construction for cyclone resistant housing was propagated in the coastal areas, and water harvesting systems were given a thrust for drought mitigation.

A preparedness programme was taken up in earnest by the government and the NGOs. Community awareness campaigns were carried out on dos and don'ts for different kinds of disasters. These told people what to do and what not to do before, during and after a disaster. School safety programmes were taken up under which, teachers, students and parents were trained on how to prepare for a disaster and how to respond to one. Disaster management plans were prepared for the state, districts, local areas and schools. A system of drills and plan updating was established. All of this contributed to a higher level of preparedness in the state.

Subsequently, hazardous events struck the state again. There was a cyclone warning in 2004, which was responded to with a very efficient evacuation implemented by the government and the NGOs. The community was already aware of the evacuation plan and was trained how to react. Similarly, major floods hit the state in June-July 2005. Once again, the role allocation was clear to all the concerned stakeholders in the government as well as the NGOs and the community too knew how to help the relief teams help them. Losses were minimised, and the relief and rehabilitation process went off smoothly.

This case study shows how there was a disaster event during the earthquake, followed by immediate response and relief, then by recovery including rehabilitation and retrofitting, then by developmental processes. The development phase included mitigation activities, and finally preparedness actions to face future disasters. Then disaster struck again, but the impact was less than what it could have been, primarily due to better mitigation and preparedness efforts. The disasters were again followed by response and recovery, and the cycle goes on.

RESPONSE MECHANISM IN INDIA

In India, there is integrated administrative machinery for management of disasters at the National, State, District and sub-District levels. The primary responsibility of undertaking rescue, relief and rehabilitation measures is that of the State governments. The Central government supplements the efforts of the state governments by way of physical and financial resources, if need arises. The extent/necessity of Central response/assistance depends on the severity and scale of the calamity and the requirements of Central assistance for augmenting the financial resources at the disposal of the State Government. The effort is more in the nature of support to the state governments. Drawing from the Ministry of Home Affairs', official document," National Policy", Union government's response could be in two ways:

1) Policy Response, provided by the Prime Minister, Cabinet Committees, and the Home Affairs and/or Agriculture Minister; and

2) Administrative Response

The Central response can be:

- Policy response, keeping in view the short and long-term policy objectives of the government
- Administrative response, broadly relating to:
    - Operational requirements
    - Provision of Central assistance as per existing policy.

Central initiatives are in the form of:

- Visits of the calamity affected areas by President, Prime Minister and other dignitaries;
- Activating the administrative machinery for assisting in relief measures; and
- Setting up machinery for implementing, reviewing and monitoring of relief measures.

The operational aspects of the administrative response could, further, be classified into:

- Primary relief functions, and
- Secondary relief functions.

The primary relief functions of the Central Government relate to:

- Forecasting and operation of warning system
- Maintenance of uninterrupted communication
- Wide publicity to warnings of impending calamity, disaster preparedness and relief measures through TV, AIR and Newspapers

- Transport with particular reference to evacuation and movement of essential commodities and petroleum products
- Ensuring availability of essential commodities at reasonable prices particularly the commodities through the Public Distribution System
- Ensuring availability of medicines, vaccine and drugs
- Preservation and restoration of physical communication links
- Investments in infrastructure; and ix) Mobilisation of financial resources.

The secondary functions of the Central Government which supplement the States' relief efforts, would relate to:

- Flood/inflow forecasts from the Central Water Commission
- Relief, rehabilitation and restoration through military aid to civil authorities
- Contingency plans for crops, cattle preservation nutrition and health measures
- Technical and technological inputs for provision of drinking water
- Technical assistance in the water budgeting and water management for various uses; and Coordination of the activities of the State agencies and voluntary agencies.

CONCLUSION

Disaster management encompasses a range of activities, which are envisaged as a cycle involving, disaster event, response, preparedness and mitigation in that sequence. In the immediate aftermath of a disaster, search and rescue and immediate relief activities are imminent. Long-term risk reduction or mitigation measures include rehabilitation, securing/ restoring livelihoods and infrastructure restoration. Later, development strategy incorporates lessons learnt from the past, as safe development practices. This is known as mitigation. In addition, preparedness activities need to be carried out in the sense of instituting infrastructure and crafting required policy for effective disaster response and vulnerability reduction for reduced disaster losses in the future.

Disaster mitigation includes preparation of disaster management plans, pre-positioning of equipment and materials, and practice and drills of response procedures. The cycle is a visual depiction of activities in disaster management and the logical sequence of their instance. The Total Disaster Risk Reduction Management discussed above, involves; human resource development, hazard mapping, vulnerability and risk assessments, information management systems, communication, coordination and funds, among others, as articulated in the regional workshop on TDRM held in Kathmandu on Aug. 9, 2002, organised by the ADRC and OCHA, UN.

Disaster occurrences are cyclic phenomena. Hazards exist in nature, which when the vulnerability conditions allow, turn into disastrous events with devastating impacts on populations. Following disasters, communities slowly recover and get back to life. Normal developmental processes set in after some time, till disaster strikes again, setting the cycle into motion all over again. During or immediately after a disaster, search and rescue, immediate relief and shelter activities are taken up. In the longer-term rehabilitation, housing, livelihoods and infrastructure restoration are carried out. Later, during non-disaster times, it is important to ensure safe development practices so that there is lesser impact of disasters in the future. In addition to this, preparedness activities need to be carried out for responding to a disaster. This is put to use when the next disaster happens, and the cycle goes on.

Disaster Preparedness

Preparedness and focuses on plans to respond to a disaster threat or occurrence. It takes into account an estimation of emergency needs and identifies the resources to meet these needs. It also involves preparation of well-designed plans to structure the entire post-disaster response, and familiarising the stakeholders, particularly the communities through training and simulation exercises. Preparedness has to be supported by the necessary legislation. means a readiness to

cope with disasters or similar emergencies which cannot be avoided. The first objective of preparedness is to reduce the disaster impact through appropriate actions and improve the capacity of those who are likely to be affected most (that is, marginalised, poor and handicapped) to get maximum benefit out of relief. The second is to ensure that ongoing development continues to improve the capacities and the capabilities of the system to strengthen preparedness efforts at community level. Finally, it guides reconstruction so as to ensure reduction in vulnerability. The best examples of preparedness activities are the development of local warning and community evacuation plans through community education, evolving local response structures such as Community based Disaster Management Teams (DMT) and administrative preparedness by way of stockpiling of supplies; developing emergency plans for rescue and relief.

Since disasters affect economic and social processes, preparedness and mitigation must emphasise the socioeconomic rather than just the physical aspects. If disasters demonstrate the vulnerability of the social system, then any policy for disaster management must include the potential reduction of such vulnerability.

Important Components of Preparedness Plan

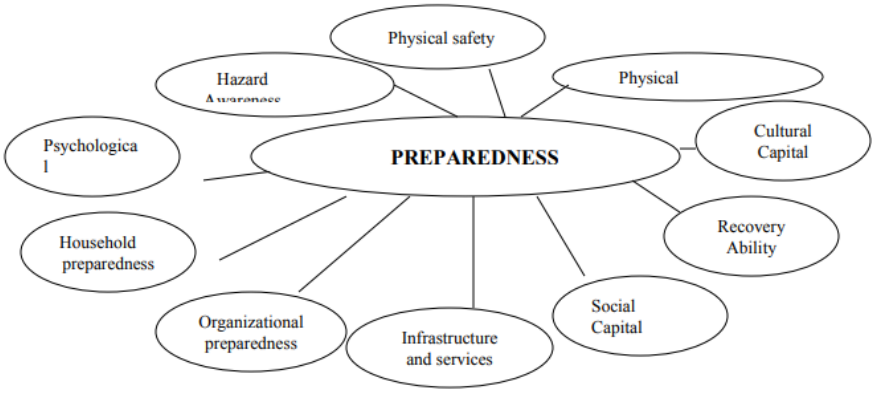
Generally community preparedness depends upon following four major component: -

- Population characteristics (number of children, squatter settlement etc)
- Building and critical infrastructure such as road, drinking water, communication network, health and sanitation
- Physical environment
- Social environment (social groups)

In view of these components risk assessment study has been conducted and identified that Delhi is densely built and consists of a high number of urban population. Any major earthquake or fire/chemical explosion can affect district very badly. Although various steps have been taken by the Delhi Government but still a high degree of awareness and training is required to lay down an organization system within communities.

Looking at the complexity of repose mechanism during disasters two sets of components have been studied to prepare this plan i.e. components of community preparedness and administrative response.

Components of Community Preparedness



Plan Several previous attempts have been made by researchers to measure community preparedness within various indicators. Some of the important components of measuring preparedness are given below:

- Physical Safety: i.e. how safe community members are in view of the physical danger from these hazards? The parameters essentially tries to measure how effective structural mitigation measures are e.g. resistance of building structures for earthquakes, availability of safe shelters and its capacity etc.
- Hazard awareness i.e. awareness level about hazards which have a reasonably higher probability of occurrence

- Organization preparedness i.e. how far the community is organized to face a disaster i.e. existence of committee at community level, task forces, volunteers of civil defence and other local volunteers, trained disaster management teams and community disaster management plan etc.
- Infrastructure and services which tries to measure current state of these services and how well restoring critical services as and when disruptions occur.
- Recovery ability i.e. ability of the community members to recover from the impact of the hazard.
- Physical environment i.e. state of environment to face hazards e.g. Condition of subsurface aquifers and vegetation etc.
- Social capital i.e. degree to which social networking and cooperation exists among community members.
- Psychological preparedness i.e. how safe and prepared do community members feel in view of these hazards.
- Cultural capital i.e. cultural richness such as existence, recognition and use of traditional mechanism to cope with such disasters.
- Household preparedness i.e. preparedness at a house hold members.

Components of Administrative Preparedness

Administrative preparedness is also an important component which helps in reducing relief and response time in a disaster situation. Preparedness plan is based on below-given components:

- Operation readiness of facilities, equipments and stores in advance
- Maintaining response inventory of equipments and materials required for response
- Assignment of responsibilities to agencies and organizations
- Management training of crisis group members, desk officers and officers of respective departments likely to be assigned management duties
- Specialized trainings of district disaster committee members, officials, community organizations through seminars and workshop
- Training of taskforces
- Raising community awareness
- Improving response mechanism through conducting practice drills etc
- Annual updating of State, District and community level plans

Disaster Mitigation

Disaster mitigation focuses on the hazard that causes the disaster and tries to eliminate or drastically reduce its direct effects. The best example of mitigation is the construction of dams or leevies to prevent floods or coordination of release of water from various irrigation dams to avoid flooding in the downstream areas. Other examples include strengthening buildings to make them earthquake resistant, planting of crops that are less affected by disasters, controlling land-use patterns to restrict development in high-risk areas and diversification of economic activities to act as insurance to offset losses in different sectors. A mitigation strategy however, cannot be successful unless it has the backing and support of all concerned – the administrative machinery, the research institutions, the non-officials and the community. So, it also becomes imperative to have built-in institutional arrangements and/or legislative backing to oversee the mitigation strategy over a period of time.

The main elements of mitigation strategy which can further broadly divided into nonstructural and structural mitigation measures are:

- Risk Assessment and Vulnerability Analysis
- Applied Research and Technology Transfer

- Public Awareness and Training
- Institutional Mechanisms
- Incentives and Resources for Mitigation
- Land Use Planning and Regulations

Non-Structural Mitigation:

Many of the non-structural mitigation measures are being carried out by the Government under the Disaster Risk Management Programme.

1. Promotion of research & Technology

Objective: To promote research projects for studies like microzonation, risk assessment, systematic study on evaluating construction typology, identification of cost effective methods to improve seismic safety and to facilitate the implementation of research outcomes.

Strategies:

- Ensure availability of adequate funds
- Ensure applicability of study to state specific hazard risk reduction
- Monitor, review and evaluate the research activities

Outcomes: The results of microzonation study will enable the professionals to improve planning and design to achieve better performance and reduced hazard risk. The study for Cost effective techniques to retrofit existing structures in order to provide life safety will offer more options to the decision makers.

2. Capacity Building & Awareness Generation

Objective: To generate awareness about various types of hazards and associated vulnerabilities among professionals, policy makers, and the general public making them better prepared and enabling them to make effective decisions about reducing losses from earthquakes and to encourage them to undertake effective implementation action.

Strategies:

- Increase public awareness through mass media campaigns
- Development of Information, Education and Communication Material
- Including the subject of Disaster Risk Management in the Syllabi of different courses.
- Sensitization of officers from the Administration, Ministry of Education, Ministry of Disaster Management, Delhi Police, Delhi Fire Service, Delhi Jal Board, Delhi Vidyut Board, Mahanagar Telecom Nigam Ltd. and all other parallel agencies.

Outcomes: Government officials, policy makers, professionals and public will be better educated and aware of their vulnerabilities and will have a positive attitude towards mitigation measures. The preparedness will reduce losses in the event of any disaster and considerably reduce the funds required for relief and response activities in a post disaster situation.

3. Insurance Covers for the disasters

Objective: To develop a better understanding and general awareness of the insurance procedures and develop strategies for reducing the premium cost for a complete cover. Insurance brings quality consciousness in the infrastructure and a culture of safety by insisting to follow building codes, norms, guidelines, quality materials in construction. It would enforce safety standards by bringing accountability. Hazardous area should be announced, notified and publicly displayed so that

people would be motivated not to settle in those areas and insurance be mandatory in insurance prone areas. Premiums can be changed on the basis of risk proneness. Government may provide special incentives to cover the people in the areas not yet covered by insurance and district administration and other development agencies may take up steps to facilitate it. Issuing I-cards and preparation of insurance policy etc can also bring awareness and also facilitate insurance oriented information. In due course of policy, the provisions of compensation should be taken over by insurance.

Strategies:

- Meetings with the heads of Insurance agencies and brainstorming on possible strategies for making insurance a better and cost effective option
- Review of tariff rates for Fire, Earthquake and STFI (Storm, tempest flood and inundation) cover with the help of Tariff Advisory Committee
- Implementation of the revised policies and tariffs by Insurance Regulatory and Development Authority (IRDA)
- Encourage insurance agencies to promote insurance against fire and other hazards by way of advertisements in media.

Outcomes: Public will be more aware about the benefits of insurance. Revised policies and tariffs for insurance will lead to cost effective mitigation.

STRUCTURAL MITIGATION

Structural mitigation is typically much more complex than non-structural mitigation, and usually has a higher associated cost. Mitigation plan for Delhi shall include all the activities that prevent a hazard or lessen the damaging effects of unavoidable hazards. Investing in preventive mitigation steps now such as repairing deep plaster cracks in ceilings and foundations, retrofitting of existing buildings and following local seismic building standards will help reduce the impact of earthquakes in the future.

Broadly the components of this plan shall be

A. Ensure all existing lifeline buildings remain operational immediately after a Seismic event by 2015:

The Bureau of Indian Standards(BIS) has developed its first code on a seismic design in 1962 (IS:1893-1962). However, till date there is lack of efficient legal framework to implement seismic code provisions in Delhi. As a result most of the building in Delhi does not meet codal requirements on seismic resistance. Even if new constructions may fulfill the requirement of seismic code provisions in their buildings, still a very large inventory of old buildings will remain deficient for seismic safety. Therefore, we need to develop a rational seismic retrofitting plan for the government- owned buildings and private constructions on priority bases. Generally public buildings are given first priority because they are lesser in number and at the time of disaster people can take shelter in these public buildings. Some of the important public buildings are schools, hospitals, government officers, community halls, fire and police stations, cultural buildings, communication buildings, cinema halls, meetings halls, historical monuments and important installations etc. the second priority goes to the buildings like offices, warehouses, residential colonies, factories and hostels etc.

Following strategies are being adopted:

- Actual Retrofitting of the five critical buildings identified under the Delhi Earthquake Safety initiative and subsequent identification of more life line buildings spread geographically around the state.
- Involvement of more agencies like MCD, DDA, NDMC etc for retrofitting of their own buildings as well as other critical buildings.
- All the concerned departments to make financial commitments and earmark funds in their budget plans every year for retrofitting.

- Develop appropriate policy instrument for budget allocation for carrying out retrofitting of identified life line structures.
- Identification and development of Retrofitting plans for all Lifeline buildings in Delhi by 2010 using the current project as a model.
- Complete retrofitting of all Lifeline Buildings by 2015.
- Training of all departments in Retrofitting methodologies.
- Establish seismic performance standards for all life line buildings.
- Promotion of retrofitting technologies.

B. Ensure all existing lifeline bridges and fly-overs remain operational after a Seismic event

- Establishment of Seismic performance standards for all lifeline bridges and flyovers.
- Identification, assessment and development of Retrofitting plans for all Lifeline bridges and flyovers in Delhi by 2010.
- Complete retrofitting of all Lifeline bridges and flyovers by 2015 to existing codal provisions of the day.

C. Ensure all new Governmental constructions are Earthquake resistant:

- Setting up of Hazard Safety cells in various departments to oversee all Governmental constructions (Only a few departments have constituted this so far)
- Developing integrated approach to seismic design
- Developing methodologies for seismic retrofit including minimum standards and enhanced performance- based standards for structural elements of buildings.
- Training of all departments in Earthquake Resistant design and construction.

D. Construction Control

The best mitigation measure is to build strong built-in environment in the State. The State must ensure the implementation of building codes. The quality of buildings measured by their seismic resistance has its fundamental importance. Minimum designs and constructions standards for earthquake resistant structures legislated nationally are an important step in establishing future minimum level of protection for important structure. India has building codes and regulations for seismic resistant design which needs to be enforced by municipal bodies.

IMPORTANT DEFINITIONS:

Mitigation: Mitigation is a long-term measure to reduce vulnerabilities, both physical, which is of infrastructure, and socio-economic, that is, pertaining to social positioning that predisposes vulnerable sections to disaster losses. Mitigation is an integral aspect of planning. Post-Yokohama, countries have been exhorted to follow the path of mitigation which mandates dovetailing vulnerability reduction measures in development planning, through resource allocation with the added perspective of disasters in sectoral schemes. It implies treating disaster mitigation as a plan commitment and not a non-plan contingency issue, as had been the approach up till now. The rationale for mitigation comes from repeated occurrence of disasters in recent times and the unsustainable impacts.

Preparedness: Preparedness is explained as a state of readiness of the administrative apparatus to respond to a disaster quickly and in a way that minimises the loss of life and property that could accrue, implying, minimum time lag and maximum effectiveness.

Prevention: Disaster Prevention entails measures to preempt a disaster by controlling a potentially threatening hazard. For example, water harvesting can prevent droughts. To that end, it entails advance planning to forestall a disaster.

Risk Reduction: As per DMTP, 1994, "risk reduction is a long-term measure to reduce the scale, and/or the duration of eventual adverse effects of unavoidable or unpreventable disaster hazards on a society which is at risk by reducing the vulnerability of its people, structures, services and economic activities to the impact of known disaster hazards. Typical risk reduction measures include improved building standards, flood plain zoning and land use planning, crop diversification and planting windbreaks. Disaster mitigation, prevention, risk reduction are often used interchangeably. Hence, it is the activity and not the semantics that are/should be stressed.

Risk perception: Risk perception is the degree to which people are aware of disaster risks and willing to budget for the same. It applies to general people as well as policy makers in government. Awareness generation through proactive measures, like television programmes and door-to-door campaigns improve the level of Risk Perception in society. Risk perception is generally low in developing countries and high in the developed world.

Unit 2

Disaster Management Act, 2005

The Disaster Management Act, 2005, (23 December 2005) No. 53 of 2005, was passed by the Rajya Sabha, the upper house of the Parliament of India on 28 November, and the Lok Sabha, the lower house of the Parliament, on 12 December 2005. It received the assent of The President of India on 9 January 2006. The Disaster Management Act, 2005 has 11 chapters and 79 sections. The Act extends to the whole of India. The Act provides for "the effective management of disasters and for matters connected there with or incidental thereto.

National Authority:

The Act calls for the establishment of National Disaster Management Authority (NDMA), with the Prime Minister of India as chairperson. The NDMA may have no more than nine members including a Vice-Chairperson. The tenure of the members of the NDMA shall be five years. The NDMA which was initially established on 30 May 2005 by an executive order, was constituted under Section-3(1) of the Disaster Management Act, on 27 September 2006. The NDMA is responsible for "laying down the policies, plans and guidelines for disaster management" and to ensure "timely and effective response to disaster". Under section 6 of the Act it is responsible for laying "down guidelines to be followed by the State Authorities in drawing up the State Plans".

National Executive Committee

The Act under Section 8 enjoins the Central Government to Constitute a National Executive Committee (NEC) to assist the National Authority. The NEC is composed of Secretary level officers of the Government of India in the Ministries of home, agriculture, atomic energy, defence, drinking water supply, environment and forests, finance (expenditure), health, power, rural development, science and technology, space, telecommunication, urban development, and water resources, with the Home secretary serving as the Chairperson, ex officio. The Chief of the Integrated Defence Staff of the Chiefs of Staff Committee, is an ex officio member of the NEC. The NEC under section of the Act is responsible for the preparation of the National Disaster Management Plan for the whole country and to ensure that it is "reviewed and updated annually".

State Disaster Management Authority

All State Governments are mandated under Section 14 of the act to establish a State Disaster Management Authority (SDMA). The SDMA consists of the Chief Minister of the State, who is the Chairperson, and no more than eight members appointed by the Chief Minister. State Executive Committee is responsible (Section 22) for drawing up the state disaster management plan, and implementing the National Plan. The SDMA is mandated under section 28 to ensure that all the departments of the State prepare disaster management plans as prescribed by the National and State Authorities.

District Disaster Management Authority

The Chairperson of District Disaster Management Authority (DDMA) will be the Collector or District Magistrate or Deputy Commissioner of the district. The elected representative of the area is member of the DDMA as an ex officio co-Chairperson, (Section 25).

National Disaster Response Force (NDRF)

The Section 44–45 of the Act provides for constituting a National Disaster Response Force "for the purpose of specialist response to a threatening disaster situation or disaster" under a Director General to be appointed by the Central Government. Recently in September 2014 Kashmir-floods NDRF along with the armed forces played a vital role in rescuing the locals and tourists, for which NDRF was awarded by the government of India.

Other Provisions

Section 42 of the Act calls for establishing a National Institute of Disaster Management. Section 46-50, mandates funds for Disaster Mitigation at various levels. The Act provides for civil and criminal liabilities for those who violate the provision of the Act.

Details about the Act:

- **Chapter I -Definition** Section 2 of the Act defines '**Disaster**' as a catastrophe, mishap, calamity or grave occurrence in any area, arising from either natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering, or damage to and destruction of property or damage to or degradation of environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area. '**Disaster Management**' is defined as a continuous and integrated process of planning, organizing, coordinating and implementing measures which are necessary or expedient to prevent danger or threat of any disaster, mitigation or reduce the risk or severity or consequences of any disaster, capacity-building and preparedness to deal with any disaster, prompt response to any threatening disaster situation or disaster, assessing the severity or magnitude of effects of any disaster, evacuation, rescue and relief, rehabilitation and reconstruction.
- **Chapter II- National disaster management authority** The Act empowers the Central Government to appoint the National Disaster Management Authority with the Prime Minister of India as the Chairperson and such number of other members, not exceeding nine. The Central Government is to provide the National Authority with such officers, consultants and employees, as it considers necessary for carrying out the functions of the National Authority. The National Authority has the responsibility to lay down, approve the policies, plans and guidelines for disaster management prepared by various departments of Government of India to ensure timely and effective response to disaster. Further the chapter also details about the meetings, executive committee and plans.
- **Chapter III - State Disaster Management Authorities** Similar to National Authority at the Centre, the State Government is to establish a State Disaster Management Authority for the State. The State Authority is to be headed by the Chief Minister of the State as the Chairperson and such number of other members, not exceeding nine. The State Authority is empowered as and when it considers necessary to constitute an advisory committee, consisting of experts in the field of disaster management. The State Authority is supposed to lay down the State disaster management policy, approve the State Plan in accordance with the guidelines laid down by the National Authority. Chapter III also specifies on meetings, state executive committee and plans.
- **Chapter IV - District Disaster Management Authorities** Every State Government, in turn is to establish a District Disaster Management Authority for every district in the State with the Collector or District Collector or Deputy Commissioner as the Chairperson and such number of other members, not exceeding seven. The District Authority is to act as the district planning, coordinating and implementing body for disaster management and take all measures for the purposes of disaster management in the district in accordance with the guidelines laid down by the National Authority and the State Authority.
- **Chapter V - Measures by the Government and International Agencies for Disaster Management** The Central Government is empowered to take measures as it deems necessary or expedient for the purpose of disaster management like deployment of naval, military and air forces, other armed forces of the Union or any other civilian personnel as may be required for the purposes of this Act, coordination with the United Nations agencies, international organizations and governments of foreign countries for the purposes of this Act and establish institutions for research, training and developmental programmes in the field of disaster management. It is also empowered to deal with all such other matters as it deems necessary or expedient for the purpose of securing effective implementation of the provisions of the Act.

- **Chapter VI - Local Authorities** Subject to the directions of the District Authority, the local authorities shall ensure that the officers and employees are trained, resources are so maintained as to be readily available, carry out relief rehabiliation and reconstruction activities in the affected areas and may take such other measures as may be necessary for the disaster management.
- **Chapter VII - National Institute of Disaster Management:** The Central Government is empowered to constitute an institute to be called the National Institute of Disaster Management. The institute functions within the broad policies and guidelines laid down by the National Authority and 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.
- **Chapter VIII - National Disaster Response Force** A National Disaster Response Force for the purpose of specialist response to a threatening disaster situation or disaster is to be constituted. The general superintendence, direction and control of the Force shall be vested and exercised by the National Authority and the command and supervision of the Force shall vest in an officer to be appointed by the Central Government as the Director General of the National Disaster Response Force.
- **Chapter IX - Finance, Accounts and Audits** The Central Government is empowered to constitute a fund to be called as the National disaster Response fund for meeting any threatening disaster situation or disaster and there shall be credited thereto an amount which Centarl Government may, after due appropraiation made by parliament by law in this behalf provide any grants that may be made by any person or institution for the purpose of disaster management.
- **Chapter X -Offences and Penalties** The Act imposes punishments to persons/companies for contravening the provisions of this Act, 2005 such as obstructing or abandoning, refusing to comply with any of the provisions of this Act, making false claims, misappropriation of money or materials or false warning, etc. The punishment in such cases could be imprisonment or fine or both.
- **Chapter XI-Miscellaneous** The National Authority, the State Authority, or a District Authority is empowered to recommend the Government to give direction to any authority or person in control of any audio or audiovisual media or such other means of communication as may be available to carry any warning or advisories regarding any threatening disaster situation or disaster, and the said means of communication and media as designated shall comply with such direction.
- **Recent Initiatives** Coordinated mock drills under simulated situations like terror attack, earthquake, bomb blast, fire breakouts, flyover collapse etc., are being organised by the National, State & District Management Authorities from time to time. The most calamitous situations had been planned out to test Delhi's disaster preparedness and the venues included Metro stations, schools, colleges, markets, temples, government buildings and five star hotels. Mock drills will built the awareness of the general population and increase their coping capacity during disaster. This will help all the stakeholders especially the community to know what needs to be done to prevent and safeguard and avoid casualty.

Conclusion Disaster results not only in the loss of life & shelter but also creates lack of food, increase in diseases and disturb socio-economic activities. Therefore it is one of the major area of concern for a developing country like India. Disaster Management has to be a multi-disciplinary and pro-active approach. Besides various measures for putting in place institutional and policy framework, disaster prevention, mitigation and preparedness initiatives taken by the Central and State Governments the INGOs and NGOs, the community, civil society organizations and the media also have a key role to play in achieving the goal of moving together, towards a safer India.

National Disaster Management Authority

- The National Disaster Management Authority (NDMA) is the apex **statutory body** for disaster management in India.

- The NDMA was formally constituted on **27th September 2006,** in accordance with the Disaster Management Act, 2005 with **Prime Minister as its Chairperson** and nine other members, and one such member to be designated as Vice-Chairperson.
- **Mandate:** Its primary purpose is to coordinate response to natural or man-made disasters and for capacity-building in disaster resiliency and crisis response. It is also the apex body to lay down policies, plans and guidelines for Disaster Management to ensure timely and effective response to disasters.
- **Vision:** To build a safer and disaster resilient India by a holistic, proactive, technology driven and sustainable development strategy that involves all stakeholders and fosters a culture of prevention, preparedness and mitigation.

Evolution of NDMA

- In recognition of the importance of Disaster Management as a national priority, the Government of India set up a **High-Powered Committee (HPC) in August 1999** and a **National Committee after the Gujarat earthquake (2001),** for making recommendations on the preparation of Disaster Management plans and suggesting effective mitigation mechanisms.
- The Tenth Five-Year Plan document also had, for the first time, a detailed chapter on Disaster Management. The Twelfth Finance Commission was also mandated to review the financial arrangements for Disaster Management.
- On 23 December 2005, the Government of India enacted the Disaster Management Act, which envisaged the creation of NDMA, headed by the Prime Minister, and State Disaster Management Authorities (SDMAs) headed by respective Chief Ministers, to spearhead and implement a holistic and integrated approach to Disaster Management in India.

Functions and Responsibilities of NDMA

- Approve the National Disaster Plan
- Lay down policies on disaster management
- Approve plans prepared by Ministries or Departments of the Central Government in accordance with National Plan
- Lay down guidelines to be followed by State Authorities in drawing up State Plan
- Lay down guidelines to be followed by different Ministries or Departments of Central Government for purpose of integrating measures for disaster prevention or mitigation of its effects in their development plans and projects
- Coordinate enforcement and implementation of disaster management policy and plan
- Recommend provision of funds for the purpose of mitigation
- Provide such support to other countries affected by major disasters as determined by Central Government
- Take such other measures for prevention of disasters or mitigation or preparedness and capacity building for dealing with threatening disaster situation or disaster as it may consider necessary
- Lay down broad policies and guidelines for the functioning of National Institute of Disaster Management

Achievements of Disaster Planning in India

- Cyclone Fani, was one of the worst cyclones to hit India in last two decades.

- Odisha's preparedness, efficient early warning system, timely action, and well-planned large-scale evacuation strategies helped 1.2 million people move safely into nearly 4,000 cyclone shelters, thereby saving the lives of vulnerable population in the sensitive coastal region.
- The United Nations office for Disaster Risk Deduction (UNISDR) and other organizations have hailed government and volunteer efforts that have ensured the levels of destruction to keep minimum.
- Similarly, Andhra Pradesh demonstrated an equally excellent evacuation strategy for millions during **cyclone Hudhud** in 2014.

- There has been significant **reduction in mortality rate** from the loss of over 10000 lives in 1999 during Super Cyclone in Odisha to a mortality of 16 in 2019 during cyclone Fani.
- NDMA runs intensive earthquake and extreme weather events awareness campaigns and provides guidelines regarding natural and man-made disasters.
- NDMA has released Guidelines on School Safety, Hospital Safety and Minimum Standards for Shelter, Food, Water, Sanitation and Medical Cover in Relief Camps. The Authority worked closely with the States in mitigating the impact of Heat Wave and the number of casualties came down drastically.
- NDMA conducts mock exercises for better crisis management during a disaster situation.

Shortcomings and challenges

- Questions were raised about the role of NDMA during **Uttarakhand Flooding in 2013,** where it failed to timely inform people about the flash floods and landslides. The post disaster relief response had been equally poor. Experts blamed the **poor planning of NDMA** that lead to unfinished projects for flood and landslide mitigation.
- A CAG report noted that there were **delays in completion of projects under the flood management programmes.** It noted the projects were not taken up in an integrated manner and blamed NDMA for institutional failures for **poor flood management.** It held that there were huge **delays in completion of river management activities** and works related to border areas projects which were long-term solutions for the flood problems of Assam, north Bihar and eastern Uttar Pradesh.
- Devastations during **Kerala Floods in 2018** and **Chennai Floods in 2015** were eye-opening for the institutions regarding preparedness for the disaster situation. CAG report on 2015 Chennai Floods termed it to be a "man-made disaster" and holds Tamil Nadu government responsible for the catastrophe.
- The NDRF personnel lack sufficient training, equipment, facilities and residential accommodation to tackle the crisis situation properly.
- **Misutilization of Funds-** Government constituted **National Disaster Response Fund** and State Disaster Response Fund to deal with the disasters. Audit findings reveal that some states have mis-utilized funds for expenditures that were not sanctioned for disaster management.
- There was in a few cases significant delay in releasing funds. Additionally, some States didn't invest the funds thereby incurring huge interest losses. This shows financial indiscipline in states management of funds.

Way Forward

- **Policy guidelines at the macro level are needed** that would inform and guide the preparation and implementation of disaster management and development plans across sectors.

- **Building in a culture of preparedness and mitigation** is the need of the hour.
- Operational guidelines should be framed for **integrating disaster management practices into development,** and specific developmental schemes for prevention and mitigation of disasters.
- **Robust early warning systems coupled with effective response plans** at district, state and national levels should be put in place.
- **Community, NGOs, CSOs and the media should be involved** at all stages of disaster management.
- **Climate risk management should be addressed** through adaptation and mitigation. A dynamic policy is required to develop disaster-resilient infrastructure through proper investment in research. ISRO, NRSA, IMD and other institutions have to collectively provide technological solutions to enhance capabilities to tackle disasters.
- India should **learn from best global practices.**
    - Countries such as Hong Kong, China, Japan and Korea have built a robust infrastructure over the years to effectively tackle typhoons and other disasters.

National Disaster Relief Force:

The National Disaster Response Force (NDRF) is a specialized force constituted "for the purpose of specialist response to a threatening disaster situation or disaster" under the Disaster Management Act, 2005: section 44–45 The "Apex Body for Disaster Management"[citation needed] in India is the National Disaster Management Authority (NDMA). The Chairman of the NDMA is the Prime Minister.

The responsibility of managing disasters India is that of the State Government. The 'Nodal Ministry' in the central government for management of natural disasters is the Ministry of Home Affairs (MHA).

When 'calamities of severe nature' occur, the Central Government is responsible for providing aid and assistance to the affected state, including deploying, at the State's request, of Armed Forces, Central Paramilitary Forces, National Disaster Response Force (NDRF), and such communication, air and other assets, as are available and needed.

National Disaster Response Force (NDRF) is under the National Disaster Management Authority. The head of the NDRF is designated as Director General. The Director Generals of NDRF are IPS officers on deputation from Indian police organisations. Director General wears the uniform and badges of rank of an army three-star general.

The NDRF is a top-heavy organisation which in addition to the Director General has several Inspector Generals (IG) and Deputy IGs, who fly flags and wear army-style badges of rank

Composition:

National Disaster Response Force (NDRF) is a force of 12 battalions, organised on para-military lines, and manned by persons on deputation from the para-military forces of India: three Border Security Force, three Central Reserve Police Force, two Central Industrial Security Force, two Indo-Tibetan Border Police and two Sashastra Seema Bal. The total strength of each battalion is approximately 1149. Each battalion is capable of providing 18 self-contained specialist search and rescue teams of 45 personnel each including engineers, technicians, electricians, dog squads and medical/paramedics.

NDRF in addition to being able to respond to natural disasters has four battalions capable of responding to radiological, nuclear, biological and chemical disasters.

Deployment:

These NDRF battalions are located at twelve different locations in the country based on the vulnerability profile to cut down the response time for their deployment. During the preparedness period/in a threatening disaster situation, proactive deployment of these forces will be carried out by the NDMA in consultation with state authorities.

NDRF in Action:

During the Kosi breach in Bihar in August 2008, which was declared a national calamity by Prime Minister Shri Manmohan Singh, NDRF personnel actively engaged themselves in rescue operations and relief duties in districts Supaul, Madhepura, Araria and Purnia. About 780 NDRF personnel trained in flood rescue operations along with 153 high capacity inflatable boats and other rescue equipment were deployed in the flood affected areas. The swift and highly skilled operations of NDRF saved more than 100,000 people trapped in swirling waters of river Kosi. NDRF personnel distributed relief supplies including drinking water to the stranded flood victims. Medical camps were also established to provide medical care to the flood affected people. Impressed with prompt and efficient response of NDRF, Chief Minister of Bihar Shri Nitish Kumar approached Prime Minister Shri Manmohan Singh for a NDRF Bn to be stationed in Bihar and offered 65 acres (260,000 m2) of land at Bihar near Patna.

NDRF commendable rescue operations were no less appreciated during the 2008 floods in Odisha, Maharashtra, Kerala and Assam.

On 25 May 2009 Cyclone Aila hit West Bengal coast with a fury unprecedented in recent history. It took at least 94 lives, seven of them in Kolkata, and affected over 40 lakh people. More than six lakh houses were destroyed completely or damaged partially. NDRF promptly responded to the devastating situation and 600 personnel of NDRF with 84 boats and other rescue equipment started rescue and relief operations at cyclone affected areas of district 24 Pargana North and South of West Bengal. During the operations NDRF personnel rescued around 2000 trapped persons and distributed 50 truckloads of relief materials to the affected people.

On 1 October 2009 in the wake of worsening flood situations in the States of Andhra Pradesh and Karnataka, the State Government of both the states sent their requests for deployment of National Disaster Response Force (NDRF) for rescue and relief operations. NDMA mobilised 963 flood rescue trained personnel (including some deep divers) and 308 inflatable motorised boats from 05 NDRF Bns located at Arakkonam (Chennai), Pune, Mundali (Odisha), Greater Noida and Bhatinda and airlifted on 2–3 Oct 2009 in Air Force IL-76 and AN-32 aircraft from nearest Air Force bases and Civil Airports. The rescue personnel deployed in 04 districts of Andhra Pradesh (Kurnool, Vijayawada, Mehboob Nagar and Nandhiyal) and 04 districts of Karnataka (Bagalkote, Raichur, Gadag and Vijaypur) and immediately started rescue and relief operations in the flood affected districts of both the states.

NDRF rescued tens of thousands of persons marooned in the floods at these two States and distributed over 40 quintals of food and drinking water. The medical teams of NDRF at these districts administering medical first response and distributing medicines to the flood victims.

On 26 January 2010 a five-storied under-construction residential building collapsed at Bellary, Karnataka with about 50 people trapped under the huge debris. 3 rescue teams (102 personnel) of NDRF Bn Pune promptly airlifted to Bellary and NDRF personnel carried out round the clock operation with the help of search & rescue equipments and dogs for 09 days. In the meticulously carried out operation under huge debris the NDRF managed to rescue 20 live persons. The last person was rescued on the 9th day. NDRF also retrieved 27 dead bodies trapped under debris, rescue operations in Kerala(2018).

Training at NDRF:

While the NDRF is being trained, re-trained and equipped as a specialist force for level three disasters, it is equally important to ensure capacity building of state police personnel who are invariably the first responders in any natural or man-made disasters. To ensure this, a two-pronged strategy is being suggested to the states: firstly, to train state police

personnel in the basics of disaster management and secondly, to train at least one battalion equivalent out of their state armed police units as State Disaster Response Force (SDRF) on lines of the NDRF. In addition to police personnel, the SDRFs may be constituted from existing resources of the Fire Services, Home Guards and Civil Defence. NDRF Bns and their training institutions will assist the States/UTs in this effort. The State/UTs will also be encouraged to set up DM training facilities in their respective Police Training Colleges and include this subject in their basic and in-service courses.

205 police personnel from 21 states of the country have been trained.

TROPICAL CYCLONES

What is a cyclone?

A "Cyclone" is an intense vortex or a whirl in the atmosphere with very strong winds circulating around it in anti-clockwise direction in the Northern Hemisphere and in clockwise direction in the Southern Hemisphere.

Characteristics:

- Cyclones are intense low pressure areas – from the centre of which pressure increases outwards
- The amount of the pressure drop in the centre and the rate at which it increases outwards gives the intensity of the cyclones and the strength of winds.
- Cyclones are of two types: Temperate cyclone and Tropical cyclone. Tropical Cyclones are among the most destructive phenomena.

Tropical Cyclones:

- It is a system of low pressure occurring in tropical latitudes
- The differential heating over land and sea probably causes a small area of low atmospheric pressure to develop.
- Tropical cyclone activity is at its maximum in late summer and early autumn
- Tropical cyclones follow a parabolic path; their axis being parallel to the isobars.

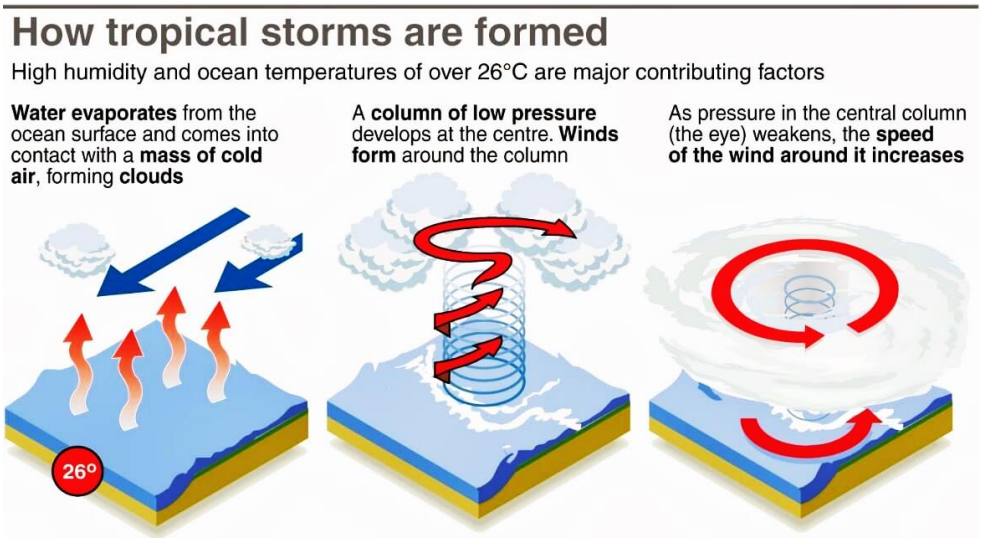
Necessary Conditions for development of a tropical cyclone and Formation:

- Continuous supply of abundant warm and moist air
- Sea temperature in lower latitudes should be around 27°C
- A distance from the Equator is necessary, so that it allows the Coriolis effect to deflect winds blowing toward the low pressure centre. They develop in inter-tropical convergence zone
- Pre-existence of weak tropical disturbances
- Presence of anticyclonic circulation at the height of 9 to 15km above the surface
- Low vertical wind shear between the surface and the upper troposphere. Vertical wind shear is the magnitude of wind change with height.

Formation of a Tropical Cyclone:

- To form a cyclone, warm, moist air over the ocean rises upward from near the surface. As this air moves up and away from the ocean surface, it leaves is less air near the surface. So basically as the warm air rises, it causes an area of lower air pressure below.
- Air from surrounding areas with higher air pressure pushes in to the low pressure area. Then this new "cool" air becomes warm and moist and rises, too. And the cycle continues

- As the warmed, moist air rises and cools the water in the air forms clouds. The whole system of clouds and wind spins and grows, fed by the ocean's heat and water evaporating from the ocean surface.
- As the storm system rotates faster and faster, an eye forms in the centre. It is very calm and clear in the eye, with very low air pressure. Higher pressure air from above flows down into the eye
- Tropical cyclones usually weaken when after they hit land (landfall), because they are no longer being fed by the energy from the warm ocean waters.

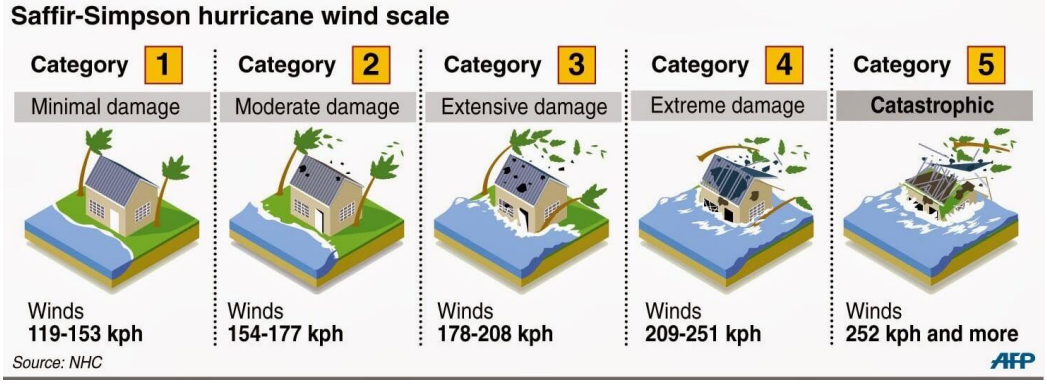


How are Cyclones named?

- In the beginning, storms were named arbitrarily.
- The tradition of naming cyclones started with hurricanes in the Atlantic Ocean, where tropical storms that reach sustained wind speeds of 39 miles per hour were given names
- In 1953, the US weather service officially adopted the idea and created a new phonetic alphabet (international) of women's names from A to W, leaving out Q, U, X, Y and Z.
- Male names were included in 1978.
- The process of naming cyclones involves several countries in the region and is done under the aegis of the World Meteorological Organization.
- For the Indian Ocean region, deliberations for naming cyclones began in 2000. A formula was adopted in 2004

How has naming a cyclone helped?

- It helps in the quick identification of storms in warning messages
- Names are presumed to be far easier to remember than numbers and technical terms.
- Giving names to storms makes it easier for the media to report on tropical cyclones, heightens interest in warnings and increases community preparedness



Tropical Cyclone Scale by Indian Meteorological Department

S. No.	Intensity	Strength of wind	Wave height (m)
1.	Depression (L)	31- 49 kmph (17-27 knots)	1-4
2.	Deep Depression (DD)	50 - 61 kmph (28-33 knots)	4-6
3.	Cyclonic Storm (CS)	62 - 87 kmph (34-47 knots)	6-9
4.	Severe Cyclonic Storm (SCS)	88-117 kmph (48-63 knots)	9-14
5.	**Very Severe Cyclonic Storm (VSCS)**	**118-166 kmph (64-89 knots)**	**14+**
6.	**Extremely Severe Cyclonic Storm (ESCS)**	**167-221 kmph (90-119 knots)**	**14+**
7.	**Super Cyclonic Storm (SuCS)**	**222+ kmph (120+ knots)**	**14+**

Damage Associated with Cyclone:

Intensity	**Damage expected**	**Measures to be taken**
Depression **Deep Depression**	• Minor damage to unsecured structures	• Fishermen advised not to venture into the open seas.
Cyclone	• Damage to thatched huts. • Breaking of tree branches. • Minor damage to power and communication lines.	• Total suspension of fishing operations
Severe Cyclone	• Extensive damage to thatched huts. • Flooding of escape routes.	• Coastal hutment dwellers to be moved to safer places.
Very Severe Cyclone	• Extensive damage to kutcha houses. • Minor disruption of rail and road traffic. • Potential threat from flying debris.	• Mobilise evacuation from coastal areas.
Extremely Severe Cyclone	• Extensive damage to kutcha houses. • Large-scale disruption of power and communication lines. • Disruption of rail and road traffic due to extensive flooding.	• Extensive evacuation from coastal areas. • Diversion or suspension of rail and road traffic.

Super Cyclone	• Extensive structural damage to residential and industrial buildings. • Total disruption of communication and power supply. • Extensive damage to bridges causing large-scale disruption of rail and road traffic. • Large- scale flooding and inundation of sea water.	• Large-scale evacuation of coastal population. • Total suspension of rail and road traffic.

Impact of Cyclone Titli:

The Odisha government, with support from the World Bank National Cyclone Risk Mitigation project, increased disaster preparations including building shelters, evacuation planning, conducting drills and strengthening embankments. It had initiated Mission zero causality for all disasters. However, its Cyclone risk management has been primarily focussed on coastal areas. The unique nature of Titli-its recurvature and retention of intensity even after landfall had posed serious challenge and led to death and destruction in non-coastal areas.

Warning of Tropical Cyclone:

- Detection of any unusual phenomena in the weather leading to cyclones has three main parameters: **fall in pressure, increase in wind velocity, and the direction and movement (track) of storm.**
- Monitoring is also done by aircraft which carry a number of instruments including a weather radar.
- Cyclone monitoring by satellites is done through very high-resolution radiometers to obtain an image of the cloud cover and its structure.
- Today, it is possible to detect a cyclone right from its genesis in the high seas and follow its course, giving a warning at least 48 hours before a cyclone strike.
- However, the predictions of a storm course made only 12 hours in advance do not have a very high rate of precision.

4-Stage IMD Warning System for Tropical Cyclone

IMD and Cyclone Disaster Management

- 1999, IMD introduced a 4-Stage warning system to issue cyclone warnings to the disaster managers.

Pre-Cyclone Watch

- Issued when a depression forms over the Bay of Bengal irrespective of its distance from the coast.
- The pre-cyclone watch is issued at least 72 hours in advance of the commencement of adverse weather.
- It is issued at least once a day.

Cyclone Alert (Colour code Yellow)

- Issued at least 48 hours before the commencement of the bad weather when the cyclone is located beyond 500 Km from the coast.
- It is issued every three hours.

Cyclone Warning (Colour code Orange)

- Issued at least 24 hours before the commencement of the bad weather when the cyclone is located within 500 Km from the coast.
- Information about time/place of landfall are indicated in the bulletin.
- Accuracy in estimation increases as the cyclone comes closer to the coast

Post-landfall outlook (Colour code Red)

- It is issued 12 hours before the cyclone landfall when the cyclone is located within 200 km from the coast.
- More accurate information about time/place of landfall and associated bad weather are indicated in the bulletin.

Disaster Management of Cyclone in India

- Pre-Disaster
  - Structural Measures: Structural measures include construction of cyclone shelters, construction of cyclone resistant buildings, road links, culverts, bridges, canals, drains, saline embankments, surface water tanks, communication and power transmission networks etc.
  - Non-Structural Measures: Non-structural measures include early warning dissemination systems, management of coastal zones, awareness generation and disaster risk management and capacity building of all the stakeholders involved.
- During Disaster: Immediate rescue operations, supply of water, medicines, food and other necessary items, Damage assessments
- Post Disaster: Rehabilitation, Providing financial assistances, arrangements of relief measures.

Government Initiatives

National Cyclone Risk Mitigation Project (NCRMP)

Aim: The scheme aims to:

- upgrade cyclone forecasting, tracking and warning systems,
- build capacity in multi-hazard risk management
- Construct major infrastructures including multi-purpose cyclone shelters and embankments.

Principal Components**:** The major components under the scheme are:

1. Community mobilisation and training
2. Cyclone Risk Mitigation Infrastructure (construction of cyclone shelters, roads/missing links and construction/repair of Saline Embankments etc.)
3. Technical assistance for capacity building on Disaster Risk Management (risk assessment, damage and need assessment)
4. Capacity Building and knowledge creation along with project management and implementation support

Integrated Coastal Zone Management Project (ICZMP)

It is a World Bank assisted project which aims at national capacity development for implementation of comprehensive coastal management in India. Broad objectives of the project include:

- Cyclone forecasting
- Tracking and warning systems
- Cyclone Risk Mitigation and Capacity Building
- Major infrastructure to be constructed under multipurpose cyclone shelters, access roads, underground cabling and saline embankments
- Disaster Mitigation
- Lowering loss of lives, property in vulnerable states

NDMA Guidelines:

- Establishment of exclusive eco-system monitoring network to study the impact of climate change
- Adoption of Aircraft Probing of Cyclone (APC) facility to fill the critical observational data gaps and significantly reduce the margin of error in predicting cyclone track, intensity and landfall
- Establishment of a comprehensive Cyclone Disaster Management Information System (CDMIS)
- Establishment of a state-of-the-art cyclone early warning system (EWS) involving observations, predictions, warnings and user friendly advisories
- Structural mitigation should be taken up which include- improvement in structural lifeline infrastructure, construction of multi-purpose cyclone shelters and cattle mounds, ensuring cyclone resistant design standards in rural and urban housing schemes, building all-weather road links, bridges, culverts and saline embankment
- Management of coastal zones should include mapping and delineation of coastal wetlands, patches of mangroves and shelterbelts and identification of potential zones for expanding bio-shield spread based on remote sensing tools.

Way Ahead

- The Early Warning System for cyclones should be strengthened to ensure timely and accurate information about cyclone- its track, intensity, time of landfall and likely impacts.
- A rare cyclone like Titli highlighted the lack of impact-based actionable early warning information and prior experience in addressing such disasters. Therefore, research and detailed assessment is necessary combat such disasters in future.
- It is important to ensure timely dissemination of warning. IMD's cyclone alerts should be disseminated by broadcasters to all levels of governance and public
- The disaster management authorities should be more proactive in search and rescue operation after a cyclone disaster so that the loss of life can be negated.
- There should be proper coordination between the Centre, State and several Government agencies, and trained personnel for prompt and organised response after a cyclone.
- Structural measures such as designing and building of robust cyclone proof shelters, ensuring availability of essential infrastructure is important.
- Rapid urbanization and increasing encroachment in coastal areas is a major problem. Coastal Regulation zone norms should be strictly enforced.
- Awareness generation among all stakeholders is important for cyclone risk mitigation.
- Odisha State Disaster Management Authority should learn lessons from Cyclone Titli to evolve measures to minimize impacts in both coastal and non-coastal regions more effectively in future.

FLOODS

Floods have been recurrent phenomena in India from time immemorial. Almost every year floods of varying magnitude affect some parts of the country or the other. Different regions of the country have different climates and rainfall patterns and, therefore, while some parts face devastating floods, other parts may, at the same time, experience drought conditions. The monsoon regime is a regular phenomenon. Year-to-year variations occur with regard to the onset of the monsoon, its progress over the Indian landmass, and the amount of rainfall distribution. In some years the variation is quite significant. Nevertheless, there is a fundamental regularity and dependability about the monsoon that sets the seasonal rhythms of life, although it also causes unfortunate losses across much of this part of the world. The annual precipitation including snowfall over India is estimated at 4,00,000 crore cubic meters (4,000 Billion Cubic Meters [BCM]) with the seasonal rainfall in the monsoons being of the order of 3,00,000 crore cubic meters (3,000 BCM). The Indian subcontinent receives maximum rainfall during the south-west (SW) monsoon (summer monsoon) for a period of about 100 days, starting from the first week of June to the end September. Normal area-weighed rainfall over the Indian land mass is 89 cms during this period. Around 80 per cent of the annual total rainfall over India occurs in the SW monsoon season. The balance (20 per cent) rainfall is mainly due to convective activities in the pre-monsoon period (March-June) in the form of local storms/thunderstorms, cyclones and post-monsoon cyclones (October-mid December). Winter rains/snowfall over the northern part of India caused by western disturbances and the northeast (NE) monsoon in the state of Tamil Nadu and adjoining region also contribute to the total rainfall. The normal annual rainfall varies from less than 600 mms in the north-western part to over 2,500 mms in the north-eastern part. It varies from about 1,200 mms in the north to 2,900 mms in the south.

Causes of Floods:

Inadequate capacity of the rivers to contain within their banks the high flows brought down from the upper catchment areas following heavy rainfall, leads to flooding. The tendency to occupy the flood plains has been a serious concern over the years. Because of the varying rainfall distribution, many a time, areas which are not traditionally prone to floods also experience severe inundation. Areas with poor drainage facilities get flooded by accumulation of water from heavy rainfall. Excess irrigation water applied to command areas and increase in ground water levels due to seepage from canals and irrigated fields also are factors that accentuate the problem of water-logging. The problem is exacerbated by factors such as silting of the riverbeds, reduction in the carrying capacity of river channels, erosion of beds and banks leading to changes in river courses, obstructions to flow due to landslides, synchronisation of floods in the main and tributary rivers and retardation due to tidal effects.

Flood Dimensions:

Floods have different dimensions - inundation due to spills over the banks, drainage congestion due to poor drainage characteristics and erosion due to changes in water courses.

Flood Prone Area's Estimate:

According to the estimate of the National Commission on Floods, the area prone to floods in the country is of the order of 400 lakh hectares. It is considered that 80 per cent of it, i.e., 320 lakh hectares can be provided with a reasonable degree of protection.

Regions in the Country Prone to Floods:

India can be broadly divided into the following four regions for a study of flood hazard. In addition the Andaman and Nicobar Islands and Lakshadweep have peculiar characteristics, which result in drainage congestion, flooding and erosion in coastal areas.

- The Brahmaputra River Region: This region consists of the rivers Brahmaputra and Barak and their tributaries, and covers the states of Assam, Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Tripura, Nagaland, Sikkim and the northern parts of West Bengal.
- The Ganga River Region: The river Ganga has many tributaries, the important ones being Yamuna, Sone, Ghaghra, Raphti, Gandak, Burhi Gandak, Bagmati, Kamla Balan, Adhwara group of rivers, Kosi and the Mahananda. It covers the states of Uttarakhand, Uttar Pradesh, Jharkand, Bihar, south and central parts of West Bengal, Punjab, parts of Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh and Delhi.
- The North-West River Region: The main rivers in this region are the Indus, Sutlej, Beas, Ravi, Chenab and Jhelum. These rivers are the tributaries of the Indus. This region covers the states of Jammu and Kashmir, Punjab and parts of Himachal Pradesh, Haryana and Rajasthan. Compared to the Ganga and the Brahmaputra river regions, the flood problem is relatively less in this region.
- The Central Indian and Deccan Region: Important rivers in this region are the Narmada, Tapi, Mahanadi, Godavari, Krishna and Cauvery. This region covers the states of Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Orissa, Maharashtra, Gujarat and parts of Madhya Pradesh. The region does not have serious flood problem except that some of the rivers in Orissa State namely Mahanadi, Brahmini, Baitarni, and Subarnarekha are prone to floods every year.

Flash Floods:

Flash floods are characterised by very fast rise and recession of flow of small volume and high discharge, which causes high damages because of suddenness. This occurs in hilly and not too hilly regions and sloping lands where heavy rainfall and thunderstorms or cloudbursts are common. Depression and cyclonic storms in the coastal areas of Orissa, West Bengal, Andhra Pradesh, Karnataka, and Tamil Nadu also cause flash floods. Arunachal Pradesh, Assam, Orissa, Himachal Pradesh, Uttarakhand, the Western Ghats in Maharastra and Kerala are more vulnerable to flash floods caused by cloud bursts. Sudden release of waters from upstream reservoirs, breaches in landslide dams and embankments on the banks of the rivers leads to disastrous floods. Severe floods in Himachal Pradesh in August 2000 and June 2005, and in Arunachal Pradesh in 2000 are a few examples of flash floods caused by breaches in landslide dams. Floods in Assam, Bihar, Uttar Pradesh, Orissa and Andhra Pradesh are generally caused by breaches in embankments. Incidents of high intensity rainfall over short durations, which cause flash floods even in the area where rains are rare phenomena, are on the rise and the problem needs to be tackled in a scientific manner.

Other reasons of flooding:

- Monsoon/Cyclones/Cyclonic circulation: Floods in the Indian river basins are also caused by rainstorms which are generally associated with low-pressure systems like well-marked lows, depressions or tropical cyclones. During the past 100 years, over 1000 tropical cyclones, depressions and low-pressure systems originating in the Bay of Bengal and Arabian Sea moved across the Indian subcontinent. Nearly 466 cyclones of which about 40 per cent were severe, affected the country during the past century. The passage of such storms in quick succession over a river basin invariably leads to severe floods. Parts of the country, mainly the coastal areas of Andhra Pradesh, Assam, Orissa, Tamil Nadu and West Bengal, experience such cyclones leading to extensive flooding. The flood caused by the super cyclone combined with a huge storm surge during October 1999 in the coastal belt of Orissa was the worst in recent history.
- Cloudbrust: Due to peculiar climatic conditions, some parts of the country experience sudden unprecedented heavy rain known as cloud bursts. Principal rain bearing meteorological systems that lead to short duration heavy rainfall and which may also cause floods are:
    - monsoon depressions.
    - fluctuations in the intensity and location of the monsoon trough over the plains of India.
    - a mid-troposphere circulation/low pressure off the coasts of India particularly over Gujarat.

- off shore vortices. Apart from these, land-based lows or depressions during monsoon cyclones and persistence of low-pressure areas over adjoining coastal areas may sometimes lead to floods.
- Hilly areas in Himachal Pradesh, Uttarakhand, the northern areas of West Bengal, Sikkim, Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Nagaland and Tripura and the coastal areas in the states of West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Maharashtra and Gujarat and Union Territories (UTs) of Andaman and Nicobar Islands and Lakhshadweep are more prone to such phenomena. Such events have also occurred in the states of Rajasthan, Chattisgarh, Madhya Pradesh and Uttar Pradesh.

- Snow melts/ Glacial Outburst: Snowmelt is a gradual process and usually does not cause major floods. Glacial melt is usually slower than snowmelt and is not capable of causing severe flood. But sometimes glaciers hold large quantity of bounded water, which may be suddenly released with melting of ice block resulting into Glacial Lake Outburst Floods (GLOFs). The rivers originating from the Himalayas in the northern part of the country, which are also fed by snowmelt from glaciers, are prone to flash floods. In 1929, the outburst of the Chong Khundam glacier (Karakoram) caused a flood peak of over 22,000 m3 / second at Attock. Glacial outburst is one of the suspected reasons for the flash flood experienced in Sutlej River on the night intervening 31July and 1 August 2000. The blockage in the course of the Parechu in China (Tibet) caused by the landslide in 2004 gave way in 2005 and caused severe flooding and damage to infrastructure in Himachal Pradesh.

Agencies in India related to Flood Management:

1. The Central Flood Control Board

In 1954, when for the first time the flood programme in the country attracted the serious attention of the GOI, the Central Flood Control Board (CFCB) was constituted to draw up a comprehensive plan of flood control with the following functions:

- to lay down general principles and policies in connection with flood control measures;
- to consider and approve master plans for flood control submitted by the states/river commission; and
- to arrange for necessary assistance in connection with planning and execution of flood control works. As a follow-up to a decision of the CFCB in 1954, a Flood Wing was added to the then Central Water and Power Commission; the Flood Wing served as the Secretariat of the CFCB.

In 1977, it was decided to merge the CFCB with the Conference of State Ministers of Irrigation. The first meeting after the amalgamation of the CFCB with the ministers' conference was held in February 1979; thereafter the meeting has been held almost every year.

2. The Central Water Commission:

The Central Water Commission (CWC) is an apex agency in the field of water resources including flood management in India. The River Management Wing headed by the Member (RM) and ex-officio Additional Secretary to the Government of India looks after FM in the country excepting the Ganga and the Brahmaputra river basins for which the GOI has created separate organisations. Member (RM) is required to advise the MOWR and also look after policy issues and other aspects of the FM in the whole country including the Ganga and the Brahmaputra basins. This wing is also responsible for flood forecasting and the hydrological observations' network in the country. It has offices under its control throughout India for performing these functions.

3. The Ganga Flood Control Commission

The Ganga Flood Control Commission (GFCC) was set up by GOI in 1972 for the preparation of comprehensive plan of flood control for Ganga basin and to draw out a phased coordinated programme for the implementation of works. It has also been assigned the work of monitoring and appraisal of FM schemes of Ganga basin states. The Task Force on Flood

Management/Erosion control – 2004 has recommended its strengthening to enable it to play a more effective role in FM in the Ganga basin.

4. **The Brahmaputra Board**:

Floods and erosion in the Brahmaputra and Barak basins are regional problems. Both, the Brahmaputra and the Barak and most of their major tributaries are inter-state as they flow in more than one state. The Brahmaputra Board was set up by the GOI as a statutory body, under the Brahmaputra Board Act, 1980. It has been given the task of carrying out surveys and investigations in the Brahmaputra valley and preparing a Master Plan for control of floods, bank erosion and improvement of drainage, planning and integrated implementation of measures for control of floods and bank erosion in the Brahmaputra and Bark valleys. The Board, with the approval of the central government, is also to take up the construction of multipurpose dams and works connected therewith proposed in the Master Plan and operate such dams and works.

5. **The Indian Meteorological Department:**

The IMD established in 1875, is responsible for the National Meteorological Service and the principal government agency in all matters relating to meteorology, seismology and allied subjects. The IMD is mandated as follows:

- To take meteorological observations and to provide current and forecast meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc.
- To warn against severe weather phenomena like tropical cyclones, northwesterly dust storms, heavy rains and snow, cold and heat waves, etc., which cause destruction of life and property.
- To provide meteorological statistics required for agriculture, water resource management, industries, oil exploration and other nation building activities.
- To conduct and promote research in meteorology and allied disciplines.
- To detect and locate earthquakes and to evaluate seismicity in different parts of the country for development projects.

6. **National Centre for Medium Range Weather Forecasting**
7. **National Remote Sensing Agency**
8. **National Flood Management Institute**
9. **State & District Level Organizations**

National Flood Mitigation Project:

The NDMA has proposed to take up a National Flood Mitigation Project in the Eleventh Five Year plan whose aims and objectives will be evolved in due course. Broadly, it will address the following issues:

- assessment of the risk and vulnerabilities associated with various flood disasters;
- mitigation and reduction of the risk, severity or consequences of floods;
- capacity development including enhancing the capabilities of communities and training functionaries.
- effective preparedness to deal with floods;
- improving the promptness and efficacy of response to impending threats of floods or actual occurrence;
- ensuring that arrangements are in place to organise rescue, relief and rehabilitation;
- improving the quality and increasing the speed of rehabilitation and reconstruction processes;
- creating awareness and preparedness and providing advice and training to the agencies involved in flood DM and the community.

Tentatively the component-wise activities including structural and non-structural measures (e.g. infrastructural, equipment, stores, capacity–building, etc.) that will be funded under the project include:

- Carrying out special studies on threat perception/vulnerability analysis/flood disaster risk assessment of the flood prone areas.
- Facilitating the establishment of state-level training institutions for imparting training for flood disaster preparedness/mitigation etc creating awareness of flood disaster, and training and educating people to cope up with floods at district/block levels.
- Securing prompt and people-friendly dissemination of information to the public.
- Establishing a dedicated communication network that can remain functional during floods.
- Setting up of Flood shelters.
- Suitably locating flood disaster relief centres/basic infrastructure like hospitals, stores, etc., on high ground, so that they remain functional during floods.
- Creating and maintaining an adequately trained disaster response force.
- Identifying road transport/rail/ communication networks that connect flood disaster relief/supply centres to flood prone areas and including construction of new rail/road infrastructure that may be reliably used during floods.
- Identifying suitable high grounds where people can be shifted during floods.
- Strengthening the flood forecasting and warning network.

Flood Prevention, Preparedness & Mitigation

On account of frequent occurrence of floods since time immemorial, people have learnt to live with them. They have generally set up settlements away from frequently flooded areas, which have been used for less important activities such as agriculture, grazing of cattle etc. The crops that can sustain submergence, are grown in the flood prone areas, during monsoon. The crops grown in the areas that were inundated during floods, result in bumper yields. Traditional methods based on locally available resources have been used to minimise the damage during floods. With the increase in population, these areas have been occupied and as a result floods cause huge damage to lives, cattle, property and infrastructure. The FM measures can be categorised into structural and non-structural measures. Structural measures for FM are physical in nature and aim to prevent flood waters from reaching potential damage centres, whereas nonstructural measures strive to keep the people away from flood waters.

Structural Measures for Flood Management

The main thrust of the flood protection programme undertaken in India so far has been on structural measures.

- Embankments/Banks, Flood Walls, Flood Levees: The embankment system in the river restricts the river to its existing course and prevents it from overflowing the banks. Embankments are constructed generally with earth easily available from nearby areas. In developed areas where adequate space is not available or land is very expensive, concrete or masonry floodwalls are constructed. Embankments (including ringbunds and town-protection works) are the most popular method of flood protection and have been constructed extensively in the past. Embankments are designed and constructed to afford a degree of protection against floods of a certain frequency and intensity or against the maximum recorded flood depending upon the location protected and their economic justification. Embankments have provided positive benefits by ensuring protection against floods and river spills. Embankments with proper roads have provided useful communication link in the area. These are generally the only means of communication during floods and thereafter. They also provide shelter to the villagers during floods. However, breaches in them have resulted in large-scale flooding in the protected areas. Poor drainage in the protected area also leads to drainage congestion. The embankments may lead to deposition of silt and rise in bed levels, thus decreasing the carrying capacity of the river and aggravating drainage congestion. They

interfere with natural drainage and deprive protected areas of fertile soil and groundwater recharge. They are also generally unable to withstand erosion unless adequately protected. These concerns can, however, be taken care of while designing the embankments i.e. by locating them away from active river edge, keeping sufficient space between the embankments on two banks of the river, keeping height, width, side slopes and slope protection to withstand the design flood, providing required number of sluices of adequate size for drainage and spilling sections/ breaching sections for allowing water to spill/flood the protected area after water level in the river reaches a certain stage etc.

- Dams, Reservoirs and other Water Storages: Lakes, low lying depressions, tanks, dams and reservoirs store significant proportions of flood water and the stored water can be released subsequently when the flood has receded. The stored water can also be used subsequently for irrigation, power generation, and meeting industrial and drinking water needs. In the case of large multipurpose reservoirs, a proper reservoir regulation schedule can be worked out for optimum benefit from the project as a whole. Keeping the importance of these measures in view, a separate chapter has been devoted to these works.
- Channel Improvement: A channel can be made to carry flood discharge at levels lower than its prevailing high flood level by improving its discharge carrying capacity. Channel improvement aims at increasing the area of flow or the velocity of flow (or both) to increase its carrying capacity. Channel improvement has not been resorted to widely in India mainly because of the high costs involved and topographical constraints. However, it is of advantage to take up such work for local reaches.
- Desilting/Dredging of Rivers: The studies carried out so far indicate aggradation/degradation of riverbeds in certain reaches, but they do not confirm the common belief of a general rise in river beds. Silting at places where the rivers emerge from the hills into the plains, at convex bends and near their outfall into another river or lake or sea, is a natural phenomenon. Accordingly, rivers exhibit a tendency to braid/meander/form deltas. Various committees/ experts appointed to look into this problem have not recommended desilting/dredging of the rivers as a remedial measure. Selective desilting/dredging at outfalls/confluences or local reaches can, however, be adopted as a measure to tackle the problem locally.
- Drainage Improvement: Surface water drainage congestion due to inadequacy of natural or manmade drainage channels results in flooding in many areas. In such cases constructing new channels and/or improving the capacity of existing channels constitute an effective means of flood control. However, the possibility of drainage congestion and flooding in the downstream area is to be kept in mind while formulating such schemes.
- Diversion of Flood Water: Diverting all or a part of the discharge into a natural or artificially constructed channel, lying within or in some cases outside the flood plains is a useful means of lowering water levels in the river. The diverted water may be taken away from the river without returning it further downstream or it may be returned to the river some distance downstream or to a lake or to the sea. This measure can be used successfully to prevent flooding around cities. The flood spill channel skirting Srinagar city and the supplementary drain in Delhi are examples of diverting excess water to prevent flooding of the urbanised areas.
- Catchment Area Treatment/Afforestation: Watershed management measures such as developing the vegetative cover i.e. afforestation and conservation of soil cover in conjunction with structural works like check dams, detention basins etc. serve as an effective measure in reducing flood peaks and controlling the suddenness of the runoff. This, however is not very effective during a large flood although, it does help in reducing the siltation of reservoirs and to some extent, silt load in the rivers as well.
- Anti-erosion Works: Alluvial rivers are usually meandering in nature and, therefore, raise problems of erosion and silting at various locations. This is a natural phenomenon and results in loss of land at one location and gain at some other. Generally, there is a tendency of the meander to shift progressively downstream. The process of bank erosion is, therefore, consistently active and measures for protection of banks are a recurring necessity. Anti-erosion works are normally taken up only for protection of towns, industrial areas, groups of thickly populated villages, railway lines and roads where re-location is not possible on socio-techno-economic grounds, long lengths

of vital embankments benefitting large areas in case retirement is not technically or otherwise feasible and agricultural lands where the cost-benefit ratio justifies such works.

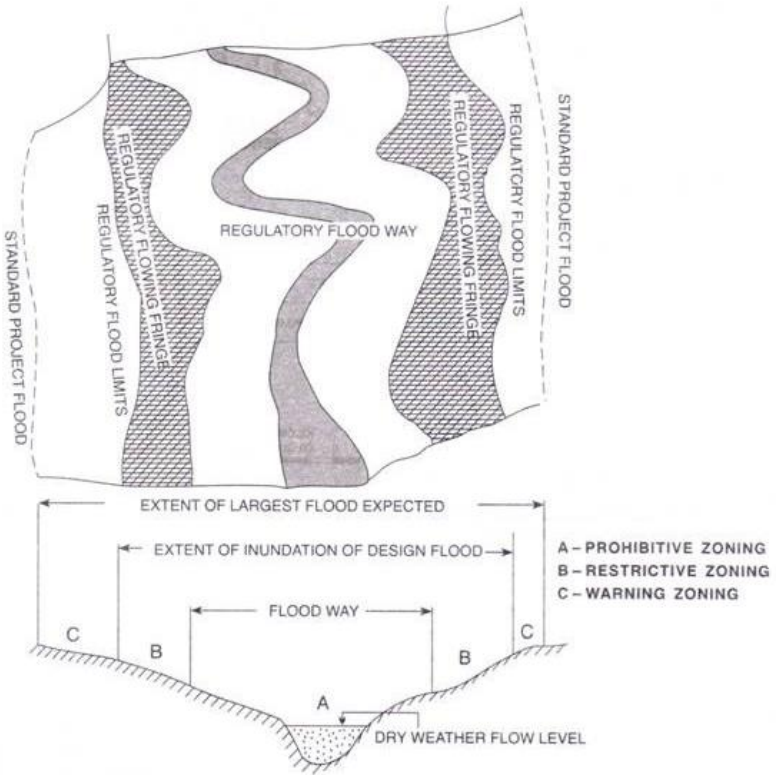
- Sea Walls/Coastal Protection Works: The erosion of land by the sea waves in coastal areas is a serious problem. Sea walls/coastal protection works in the form of groynes etc. are constructed to prevent flooding erosion in coastal areas by sea water.
- Alignment, Location, Design and Provision of Waterway i.e. Vents, Culverts, Bridges and Causeways in National Highways, State Highways, District and Other Roads and Railways Embankments. Roads and railway embankments cut across the drainage lines and may lead to increase in vulnerability of the area, through which they pass, to flooding and drainage congestion, if they are not properly aligned, located and designed. Inadequate waterway in the form of vents/culverts/ bridges/causeways is another cause of increase in vulnerability to floods. Further, breaches in them may result in huge loss of life and properties. Insufficient height of embankments may result in overtopping and breaches.
- Inspection, Rehabilitation and Maintenance:
    - Structural works require a periodic and systematic inspection, rehabilitation and maintenance programme to ensure that the design capabilities are maintained. For example, embankments and levees may be subjected to weakening due to erosion during a flood event and during post-flood period by the action of burrowing animals, or the construction of utility lines such as water and gas pipelines, power cables etc. Of particular importance is an inspection programme and restoration/strengthening of vulnerable spots.

Non-Structural Measures

Non-structural measures strive to keep people away from flood waters. It contemplates the use of flood plains judiciously, simultaneously permitting vacating of the same for use by the river whenever the situation demands. This technique allows the use of flood plains by reducing the disaster dimension, while retaining its beneficial effects.

- Flood Plain Zoning
    - It is natural for a river to overflow its banks in the event of heavy rainfall in its upper catchments and spill into the flood plains, which are basically its domain. Extensive and often unplanned use of flood plains by man disregarding the basic fact that it is part and parcel of the river leads to damage. This is one of the main factors responsible for the flood damage reported from different parts of the country in spite of substantial investments in the flood sector. The basic concept of flood plain zoning is to regulate land use in the flood plains in order to restrict the damage due to floods, while deriving maximum benefits from the same.
    - The basic concept of flood plain zoning is to regulate land use in the flood plains to restrict the damage caused by floods. Flood plain zoning, therefore, aims at determining the locations and the extent of areas for developmental activities in such a fashion that the damage is reduced to a minimum. It, therefore, envisages laying down limitations on development of both the unprotected as well as protected areas. In the unprotected areas, boundaries of areas in which developmental activities will be banned, are to be established to prevent indiscriminate growth. In the protected areas, only such developmental activities can be allowed, which will not involve heavy damage in case the protective measures fail. Zoning cannot remedy existing situations, although, it will definitely help in minimising flood damage in new developments.
    - Flood plain zoning is not only necessary in the case of floods by rivers but it is also useful in reducing the damage caused by drainage congestion particularly in urban areas where, on grounds of economy and other considerations, urban drainage is not designed for the worst conditions and presupposes some damage during storms whose magnitude frequently exceeds that for which the drainage system is designed.

- Flood Proofing
  - Flood proofing measures help greatly in the mitigation of distress and provide immediate relief to the population in flood prone areas. It is essentially a combination of structural change and emergency action, not involving any evacuation. The techniques adopted consist of providing raised platforms for flood shelter for men and cattle, raising the public utility installation especially the platforms for drinking water hand pumps and bore wells above flood level, promoting construction of double-storey buildings wherein the first floor can be used for taking shelter during floods.
  - In case of urban areas, certain measures that should be taken up as soon as flood warning is received, are installation of removable covers such as steel or aluminium bulk heads over doors and windows, permanent closure of low level windows and other openings, keeping store counters on wheels, closing of sewer wells, anchoring and covering machinery and equipment with plastic sheets, etc.
  - In the existing developed areas, possibilities of protecting against submergence or relocating to safer areas vital installations like electricity sub-stations/ power houses, telephone exchanges, the pumping stations meant for drinking water supply etc., will be seriously examined and appropriate measures will be undertaken by the state governments/SDMAs, to make them safe against floods.
- Flood Forecasting and Warning
  - Flood forecasting enables us to be forewarned as to when the river is going to use its flood plain, to what extent and for how long.



Flood Forecasting & Warning system in India

Flood forecasting (FF) enables us to be forewarned as to when the river is going to use its flood plain, to what extent and for how long. The forecast of a flood may be for the water level (stage forecast), discharge (flow forecast) and area likely to be submerged (inundation forecast) at various points/particular stations at a specific time. Of all the non-structural measures for FM, which rely on the modification of susceptibility to flood damage, the one which is gaining sustained attention of the planners and acceptance of the public is flood-forecasting and warning. A nationwide flood forecasting and warning system covering major inter-state rivers has been established by the Central Water Commission (CWC). The system under CWC is often supplemented by the states that make arrangements for advance warning at other stations strategically important to them. The CWC also extends FF services to such stations at the request of the states concerned. With reliable advance information/warning about impending floods, loss of life and property can be reduced to a considerable extent. People, cattle and valuable assets can be shifted in advance to safer places.

Methodology

Flood forecasting services include the following phases:

- Data Collection:
    - Real time hydrological data viz. gauge and discharge and meteorological data, viz. rainfall, are the basic requirements for the formulation of a flood forecast. The hydrological and hydrometeorological data from over 945 stations in the 62 river sub-basins are daily collected, analysed and utilised for formulation of flood forecasts. While most of the hydro-meteorological data are observed and collected by the field formations of CWC, FMOs of the IMD supply the daily rainfall data of their rain gauge stations besides synoptic situation including heavy rainfall warning for next 24 hours and range of quantitative precipitation forecasts for various river basins to the respective FF centres of the CWC. The CWC provides communication facilities to the FMOs in transmission of rainfall data of rain gauge stations located at the various CWC gauge and discharge stations.
- Transmission of Data to the Forecasting Centers
    - Transmission of data on a real-time basis from the hydrological and hydrometeorological stations to the flood forecasting centers is a vital factor in the FF system. Landline communication i.e., by telephone/telegram was the commonly used mode for data transmission in FF services till the beginning of the 1970s. The communication is mainly by VHF/ HF wireless sets at the data observation/collection sites and at the FF centers. There are over 500 wireless stations of the CWC all over the country for communication of real-time data related to flood forecast. During the flood season, the data is communicated two to three times in a day. The frequency of transmission is increased to an hourly basis, if the flood situation so demands. Thus, the CWC is maintaining a reliable and quick system of data transmission .
- Data Processing and Formulation of Forecasts
    - Historical data like gauge, discharge and rainfall are utilised for the development of techniques for formulation of forecasts on a real-time basis. Forecasts are formulated at the FF stations by predicting river stage/inflow with time of occurrence. After receipt of the hydrological and meteorological data from field formations, the data is processed in FF centers/control rooms to check its consistency and the data is modified, if any inaccuracy is found, before using in forecast formulation. All the forecasting centres of the CWC have been provided with computer facilities for data processing. The inflow forecasts are mainly formulated by using rainfall runoff correlation developed for the particular catchment. Computer-based watershed model MIKE-11, developed under CWC-DHI collaboration, is being used for inflow forecasts. Computers enable frequent updating of predictions based on the observed part of the flood hydrographs of FF and base stations during the flood period.

- The forecasts obtained from the coaxial correlation diagram or mathematical models/ computerised watershed models are modified, if required, to obtain the final forecast based on the prevailing conditions in the river and heavy rainfall warnings etc. In the CWC, the forecasts are formulated by a dedicated and experienced team of hydro-meteorologists and hydrologists.
- Forecasts (stage/inflow) are issued whenever the river stage at the FF site exceeds or is likely to exceed a specified level called warning level of the site which is fixed in consultation with the concerned state government. The warning level is generally 1 m below the danger level of the site, although there is no-common format designed for issuing flood forecasts by various field divisions, as forecasts are issued according to the users convenience. In the forecast, the current date and time of issue of forecast, present water level/inflow and anticipated water level/inflow with corresponding date and time are normally included.Dissemination of Flood Forecasts and Warnings.

- Dissemation of Flood Forecast & warning:
  - The final forecasts are then communicated to the user agencies such as the concerned administrative and engineering authorities of the state/central governments including railways, defence and other agencies connected with flood protection and DM by special messenger/ telegram/wireless/ telephone/fax/e-mail etc. Flood forecasts are also passed on to the All India Radio (AIR), Doordarshan and local newspapers for wide publicity in the affected area.

The Central Water Commission's Flood Forecasting Network in India

The CWC's FF network covers most of the flood prone inter-state river basins in the country. The CWC is presently issuing flood forecasts for 175 stations of which 147 stations are for river stage forecast and 28 for inflow forecast.

River Basin- wise Distribution of FF Stations:

• Ganga and its tributaries	87	
• Brahmaputra, and its tributaries	27	
• Barak and its tributaries	05	
• Eastern rivers	09	
• Mahanadi basin	04	
• Godavari basin	18	
• Krishna basin	09	
• West flowing rivers	15	
• Pennar	01	Total 175

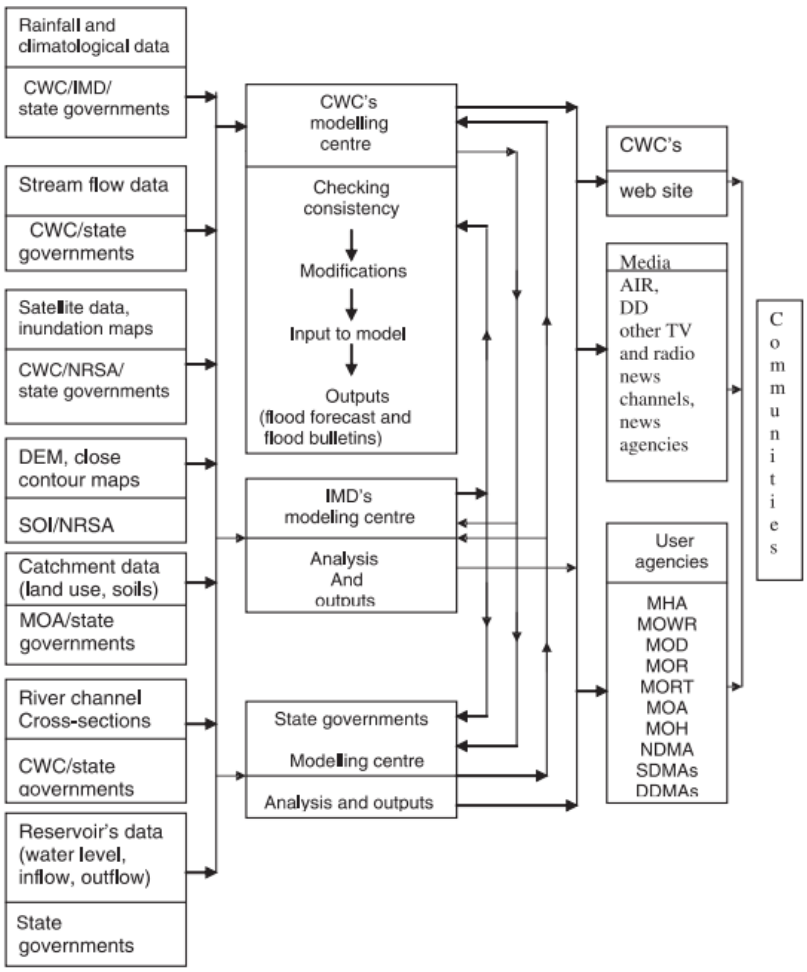
Expansion and Modernisation of Flood Forecasting Services

Expansion and modernisation is a continuous process. The CWC has undertaken various expansion and modernisation schemes to cover more areas and to make forecasting more efficient and reliable. The IMD has also taken up the expansion of its network of Automatic Rain Gauges. The Ministry of Earth Sciences (MOES) is making efforts for the procurement of 12 Doppler Weather Radars (DWRs) for continuous monitoring of evolving extreme weather phenomena including heavy rainfall events along the coastal areas apart from tracking cyclones. Gradually, the DWR network would cover the whole country and in the process all the major river basins as well.

The CWC, IMD and the state governments will increase the density of the basin-wise network of rain gauge and river gauge stations and establish basin-wise system of FF and early warning. Various FF initiatives, as listed below, will be taken by the CWC, IMD and the states.

- Data collection: Data will be collected using IMD, CWC and Bureau of Indian Standards (BIS) approved automatic sensors for rainfall and river flow measurements. A centralised mechanism for collection, archival and distribution of hydrological data from various river basins will be established on priority basis.
- Data transmission: Data will be transmitted using modern automatic telemetry data transmission techniques e.g. satellite, VSAT, Internet/e-mail, mobile phones etc.
- Flood forecast and impact assessment models: Computer- based comprehensive catchment scale hydrological and hydrodynamic models interfaced with flood plain inundation mapping tools will be developed.
- Forecast dissemination: Forecast will be disseminated using computer networks and satellite e.g. Internet, e-mail, VSAT, the terrestrial communication network, connectivity of the National Informatics Centre (NIC) etc.
- Flood hazard mitigation model: Basinwise flood hazard mitigation models will be developed.
- Damage assessment and quantification models: Damage assessment and quantification models will be developed on priority.
- Advisories for flood relief routes: Advisories for facilitating flood relief routes will be formulated and issued.
- Value addition: Flood forecasts and warnings will be formulated, preferably, in the local language, in a format which is simple and easily understandable by the administrators and common people as well. CWC will also improve the usefulness of the forecasts and warnings by marking the area likely to be inundated, location of flood shelters etc. on the map of the area.

Flowchart for Flood Forecasting and Early Warning



DROUGHTS

Drought is a natural hazard that differs from other hazards as it has a slow onset, evolves over months or even years and affects small pockets to a large regional expanse. Its onset and severity are often difficult to determine. As a result, there is a lack of urgency in response. Like other hazards, the impacts of drought span economic, environmental and social sectors and can be reduced through mitigation and preparedness. Because droughts are a normal part of climate variability for virtually all regions, characterised by extended periods of water shortage, it is important to develop contextual plans to deal with them in a timely, systematic manner as they evolve. Experience has shown that the democratic forms of governance have handled droughts more efficiently, as demonstrated by the situation in India before and after independence. India has managed droughts through a set of progressive and innovative measures like Drought Prone Areas Programme (DPAP), Desert Development Programme (DDP), Integrated Watershed Development Programme (IWDP) and the National Watershed Development Programme for Rainfed Areas (NWDPRA) etc. The Department of Land Records, in the Ministry of Rural Development, has now brought DDP, DPAP and IWDP together, under a comprehensive programme named, the Integrated Watershed Management Programme (IWMP). This programme is to be implemented under the Common Guidelines on Watershed Development. Other factors such as global warming and climate change have made the incidence of droughts even more difficult to predict and their management more complex. The value of prevention, preparedness and mitigation is now gaining recognition the world over. In India in particularly, after 2005, there has been a paradigm shift from the erstwhile relief-centric response to a proactive prevention, mitigation and preparedness-driven approach for conserving developmental gains and also to minimise loss of life, livelihood and property.

Drought conditions have been widespread in North Africa, the Mid-East, West Asian countries, India, China and are also known to occur in North Central, and South America. The increased frequency and intensity of extreme weather conditions such as droughts, floods, heat/cold waves, cyclones, delayed or early onset of rains, long dry spells, early withdrawal, during the last two decades, have been attributed to global warming.

With more than 300 river basins in India, some being shared by two or more countries, drought conditions will continue to exacerbate international water conflicts. Growing concerns over a potential increase in the frequency and severity of drought, along with the mounting evidence of the expanding vulnerability of countries to drought, underlining the importance of placing greater emphasis on pro-active drought policies and preparedness is a must.

The Indian Situation

The traditional approach to drought as a phenomenon of arid and semi-arid areas is changing in India too. Now, even regions with high rainfall, often face severe water scarcities. Cherrapunji in Meghalaya, one of the world's highest rainfall areas, with over 11,000 mm of rainfall, now faces drought for almost nine months of the year. On the other hand, the western part of Jaisalmer district of Rajasthan, one of the driest parts of the country, is recording around 9 cm of rainfall in a year. Total rainfall increases generally eastwards and with height. Increase in precipitation is high at an elevation of around 1,500 metres in the Himalaya Mountains. With average annual rainfall ranging between 20 cm to over 1000 cm, the primary challenge is to store this precious water for the dry season that may follow. The droughts in Odisha State, which has an average rainfall of 1100 mm, remain a matter for continuing concern. Conditions of water scarcity in the Himalayan region are also not uncommon. Thus, drought is just not the scarcity or lack of rainfall, but an issue related to water resource management. The requirement of over 80-90 % of the drinking water and over 50 % for irrigation is met from groundwater in India. The control of this resource is with the owner of land. Without effective and large scale rainwater harvesting, only limited recharge can take place. An earlier analysis of incidence of droughts over the last two centuries in India does not show any increase in the frequency of drought in the recent years. However, the severity appears to have increased.

Drought Risk

Drought Risk Vulnerability to drought is aggravated by a region's risk of water shortage and the exposure of the communities to the problems arising therefrom. If nations and regions are to make progress in reducing the serious consequences of drought, they must improve their understanding of the hazard and the factors that influence vulnerability. The frequency of occurrence of meteorological drought at various levels of intensity and duration defines the drought hazard for drought-prone nations and regions. It is critical to understand this hazard and its incidence across space and over time to establish comprehensive and integrated drought early warning systems that incorporate climate, soil and water supply factors such as precipitation, temperature, soil moisture, snow pack, reservoir and lake levels, ground water levels, and stream flows.

Classification of Droughts:

Drought results from a long continued dry weather and/or insufficient rain, which causes loss of soil moisture, depletion of underground water supply and reduction of stream flow. Drought is frequently defined according to disciplinary perspective. The National Commission on Agriculture in India defines three types of droughts: meteorological, agricultural and hydrological. Meteorological drought is defined as a situation when there is significant decrease from normal precipitation over an area (i.e. more than 10 %). Hydrological drought results from prolonged meteorological drought manifested in depletion of surface and subsurface water resources. It must be noted that hydrological drought could occur even when the rainfall is normal, if there has been a substantial reduction in surface water holding capacity. Agricultural drought is a situation when soil moisture and rainfall are inadequate to support healthy crop growth. Drought proofing measures are taken before the crop is planted such as Improving Water Holding Capacity (WHC) of soil through organics/silt, land configurations etc. Drought management measures are those initiated during the crop growing period (in situ conservation, reduction in plant population, supplemental irrigation etc.) Most classifications emphasise physical aspects of drought, particularly in the context of agriculture and crop production, although its impacts are widespread across several sectors including non-farm sector. The impact, response and interventions would vary depending on at what point of time in a crop calendar there is a water or soil moisture deficit.

Generally, three situations are recognised:

a) Early season: Delayed rainfall (delayed onset of monsoon), prolonged dry spells after onset;
b) Mid-season: Inadequate soil moisture between two rain events; and
c) Late season: Early cessation of rains or insufficient rains.

<u>Climate Variability</u>

The IMD recognizes

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

<u>Vulnerability Analysis Using Multiple Criteria</u>

- Meteorological – rainfall, temperature etc
- Soils - depth, type, available water content etc
- Surface water use - percent irrigated area, surface water supplies
- Ground water – ground water availability/ utilization

- Crop – cropping pattern changes, geospatial land use, crop condition, anomalies of crop condition etc.
- Socio-economic – population of weaker sections, size class of farm holdings.

Impact of Droughts

Mostly, the impact attributable to drought is extensive/comprehensive, sometimes even difficult to identify. The problem is further compounded by the fact that drought invariably is handled as a 'crisis situation' and a short-term problem. At the household level, individuals perceive drought as a natural hazard, beyond human control. Both lead to different kinds of approaches and solutions. They also lead to many undesirable consequences.

In the long run, defining drought only as a crisis situation or a natural phenomenon beyond human control merely serves to undermine the confidence and capabilities of the people to respond to drought. As a result, they become more and more dependent on the government and expect relief on a larger scale and for a longer time. Social resilience is undermined leading to beliefs that nothing else is possible, that there is really no remedy that will promote self-dependence.

The impact of a drought on the overall economy of the country is evident both at the macro and micro levels. It is either direct or indirect and varies in nature and intensity. The extent and intensity of drought impact is determined by prevailing economic conditions, the structure of the agricultural sector, management of water resources, cereal reserves, internal and external conflicts etc. Micro level impact is largely on the entitlement to produce and procure food, depending upon the social structure, class, village and household resource endowments.

The direct impact of drought is generally classified under four categories, viz. physical, social, economic and environmental. The relative and absolute magnitudes of each impact will however, depend on specific regional characteristics. Droughts cause a loss of assets in crops, livestock and productive capital as these are immediate consequences of water shortage. The lingering impact is felt in the lack of quality seeds in the subsequent season.

Impact Analysis

In the industrial sector, agro-based industries are directly affected. Lower domestic production of agriculture-based inputs for agro-processing units reduces non-agricultural production and employment opportunities. Availability of water for domestic consumption also diminishes. This has implications for health and household activities, including substantial increase in the time spent on collecting water. As water becomes scarce, competition among and within sectors usually increases. Droughts have other important implications for government policies, as it reduces tax revenues through declines in income, employment and exports.

On the expenditure side, the government is faced with increased expenditure on relief, social welfare, health and water supplies, consumption-related subsidies on food distribution, and the logistical costs of drought related imports. The law and order structure is put under greater pressure by a rise in crime, in turn associated with temporary unemployment, migration and increased destitution.

In addition, there are likely to be pressures for the increased provision of subsidies and credit to the affected productive sectors, including public utilities. Increased budgetary pressures, resulting from lower revenues and higher expenditure, are usually met by either external and internal borrowings, higher taxes or the imposition of new taxes. Also, reallocation of planned government expenditure might occur, within or among sectors and also, between capital and recurrent spending with attendant opportunity costs.

Droughts have a range of indirect, secondary effects as well. Generally, the secondary impact is on regional inequality, employment, trade deficits, external debt and inflation. The micro level impact at village and household levels, are

equally important. Drought may result in a considerable intensification of household food insecurity, water related health risks and loss of livelihoods in the agricultural sector.

Government Agencies in context of Drought Management:

1. National Rainfed Area Authority (NRAA)

The Government of India, set up the National Rainfed Area Authority (NRAA), under the Ministry of Agriculture in 2006, to address the issue of drought mitigation on a long-term basis. The NRAA has been set up as an institution of experts to provide knowledge inputs with reference to systematic upgrading and management of the country's dry-land and rain-fed agriculture. The NRAA aims to infuse convergence and synergy into the numerous ongoing water conservation and watershed development programmes and monitor their implementation. It will focus on issues related to landless and marginal farmers, particularly their farming practices and livelihood systems.

The NRAA's mandate is to:

- evolve common guidelines for all schemes of different Ministries including externally aided projects for development of Rain-fed/Dry-land farming systems;
- coordinate and bring convergence within and among agricultural and wasteland development programmes being implemented in rain-fed areas of the country;
- suggest modalities to strengthen National and State-level institutions, concerned with the Rain-fed/Dry-land areas, and establish institutional linkages with prioritized watersheds; and
- evaluate the effectiveness of completed watershed and concurrent evaluation of on-going programmes.

2. **India Drought Management Centre (IDMC)**

The 2nd Administrative Reforms Commission has recommended setting up of a National Drought Management Institute. The Government has accepted the recommendations and the DAC is considering setting up of IDMC. This Centre will be set up as an autonomous body under the DAC, which will initiate plans for its establishment. IDMC will have adequate operational flexibility and freedom in operation and functioning to enable innovative and creative experimentation. It will have on-line access to the data/information/reports of IMD, CWC, CGWB, MoA, MoES, ICAR, NRSA and DMC of State Governments. IDMC will help in selecting appropriate drought mitigation and preparedness measures and methodologies. It will provide guidelines for implementing those measures and monitor the progress, and also undertake impact-assessment and evaluation of the response system.

State DMCs and IDMC will:

- take up harmonization and reconciliation of data/information;
- supplement and complement each other;
- be responsible for providing scientific / technical support sought by the DMC and will be involved in training/capacity building of professionals/government officials; emphasize more on inter-state, national and international issues;
- provide solutions for water shortage, food shortage and malnutrition; and
- work in a mission mode approach on the lines of Incident Response System (IRS), although drought is not a incident.

3. **IMD**
4. **State Level & District level Organizations**
5. **Central Water Commission**
6. **National Centre for Medium Range Weather Forecasting**
7. **National Remote Sensing Centre**

Drought Assessment and Risk Analysis

National guidelines on Drought Management will reduce risk by developing better awareness and understanding of the drought and the causes of societal vulnerability. The principles of risk management will be promoted by building greater institutional capacity through the improvement and application of seasonal and shorter-term forecasts, integrated monitoring and drought early warning systems and connected information delivery systems, developing preparedness plans at all levels of governance, adopting mitigation actions and programmes, and creating a safety net of emergency response programmes that ensure timely and targeted relief.

Indicators

Drought indicators are identified from the types and the impact of drought. The impacts of drought are listed as environmental, economic or social. Among the environmental indicators one could include, rainfall, water level in the reservoirs and other surface storage systems, ground water depth and soil moisture. A robust data base that is comparable over time and progressively captures micro-level details has to be built and constantly updated. For each indicator thresholds need to be fixed contextually, to define intensity of the problem. A normal rainfall succeeding a few years of drought would not wipe out the cumulative effect the earlier droughts. On the social and economic front, data relating to trends in agricultural commodity prices, land distribution, copping pattern, changes in copping calendar, sown area, productivity, livestock density etc. have to be built and updated.

When drought begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water. Soil water will be rapidly depleted during extended dry periods. If precipitation deficiencies continue, then people dependent on other sources of water begin to feel the effects of the shortage.

Drought Monitoring

Drought in the Indian region is monitored from the progress of the onset and the withdrawal of the southwest monsoon. Weather forecasts is broadly classified into three categories viz.

1) short range forecast (validity for less than 3 days),
2) medium range forecast (validity from 3-10 days), and
3) long range forecast (validity for more than 10 days).

These forecasts are issued by the Indian Meteorological Department through the All India Radio, the Doordarshan and various Newspapers. The National Centre for Medium Range Weather Forecasting in the Department of Science and Technology disseminates weather related information through its network of Agro-Met Advisory Service units located mainly in the State Agricultural universities and ICAR institutes.

Agricultural Drought

Agriculture is the first sector to be affected by drought. Within the agricultural sector, marginal and small farmers are more vulnerable to drought because of their dependence on rain fed agriculture and related activities. As a consequence, they face much greater relative loss of assets, thus widening disparities between small and large farmers. Also, as unemployment increases purchasing power decreases- credits shrink and the cost of credit increases. Consequently, the vulnerable segments are either forced to migrate, work at lower wages or live in near hunger conditions.

Pressure and fear of losing social status due to drought induced poverty forces farmers to take drastic steps like suicides In order to understand the diversity of coping strategies, it is necessary to explore the social, political and institutional factors that provide contexts for these individual perceptions. Perceptions, however, are not static and will shift over time or are expressed differently under altering circumstances.

Thus perceptions of drought and the associated risks are crucial to formulate appropriate relief and mitigation policies. Perceptions also shape the responses to drought and the confusion on what drought is, which will cause difficulties in dealing with the hazard.

Some of the difficulties are:

- Drought is perceived as a slow onset phenomenon because its onset and end are often difficult to identify;
- Drought is generally viewed as a transient phenomenon. As a result, it is usually not taken seriously after the rains occur; it is considered as a calamity and managed as an event.
- The direct impacts of drought such as the withering crops, dry watering points, reduced forage for livestock etc., are obvious. Second and third order effects, such as price rise, increased food imports, surges in rural-urban migration rates, are often not recognized

Hydrological Drought

Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., stream flow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system.

Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, stream flow, and ground water and reservoir levels. As a result, these impacts are out of phase with impacts in other economic sectors. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that is almost immediately discernible to agriculturalists, but the impact of this deficiency on reservoir levels may not affect hydroelectric power production or recreational uses for many months.

Also, water in hydrologic storage systems (e.g., reservoirs, rivers) is often used for multiple and competing purposes (e.g., flood control, irrigation, recreation, navigation, hydropower, wildlife habitat), further complicating the sequence and quantification of impacts. Competition for water in these storage systems escalates during drought and conflicts between water users increase significantly. Although climate is a primary contributor to hydrological drought, other factors such as changes in land use (e.g., deforestation), land degradation, and the construction of dams all affect the hydrological characteristics of the basin. Because regions are interconnected by hydrologic systems, the impact of meteorological drought may extend well beyond the borders of the precipitation-deficient area. Like an agricultural drought, this can be triggered by more than just a loss of rainfall.

Drought Declaration

Different States adopt different methodologies for drought assessment, preparation of drought memoranda, drought declaration and assessment of magnitude of relief required. The administrative units for drought declaration also differ from State to State; while some States consider ‘talukas’ as units, some ‘mandals’ and others ‘districts’. The time of declaration also differs from state to state. States making drought declarations in the beginning of the season take into account the impact of subsequent developments.

Declaration of drought, traditionally, is recommended after the estimates of crop production are obtained through Annewari/ Paisewari. Generally those areas where Annewari/ Paisewari is less than 50 percent, the areas is considered to be affected by a drought. Final figures in respect of Kharif crops are available only in December, while those for Rabi crops are available in March.

Currently the crop yield assessment arising out of crop cutting experiments are the basis for the declaration of drought and intervention regarding conversion of term loans by the banks. The crop cutting experiments are conducted by the Department of Economics and Statistics. The number of crop cutting experiments is increasing and it is taking more time to arrive at the decisions relating to declaration of drought and benefits to the affected farmers through change in the loan terms and input subsidies for the subsequent sowing season.

Immediate Measures

With a view to ensuring timely declaration of drought, based on objective considerations, the following steps will be taken:

- The Drought Monitoring Cell (DMC) in the States will receive and collate the weather data from multiple sources across the state like IMD, Irrigation Department, Department of Agriculture, Ground water Department;
- Data on water levels in reservoirs/ tanks, ground water etc. will be received weekly from the concerned departments;
- This work of collection and collation at district level will be done by the existing departments and the information will be supplied to DDMA and SDMA;
- The data received from sub-district level through District and State level will be made available online.
- The Drought Management Information System of DAC will be revamped, institutionalized and made operational with the support of State DMCs.
- The DMC will prepare weekly status of weather and crop condition on the following indicators:
    - Rain fall deviations at taluka/block level;
    - Number and length of the dry spell at taluka/block level;
    - Progression of crop area sown at district/taluka level;
    - Satellite derived indicators such as Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and interpreted maps/images provided by NRSC and ISRO; e. Soil Moisture;
    - Ground water availability map;
- Declaration of drought will be done in a timely manner preferably in three phases (1)
    - end of July,
    - end of September
    - end of November;
- Declaration in each phase will account for the beneficial effects of rainfall from the time of previous declaration and change in the agricultural situation;
- Interim relief measures will commence from the middle of the season;
- The final relief measures will be implemented after the final declaration at the end of the season;
- After declaration of the Drought, the SDMA Secretariat will take steps to approach the Centre for financial and other assistance;

Prevention and Preparedness

Prevention and Preparedness means predisaster activities designed to increase the level of readiness and improvement of operational and institutional capabilities for responding to a drought. Drought prevention and preparedness involve water supply augmentation and conservation (e.g. rainwater harvesting techniques), expansion of irrigation facilities, effective dealing with drought, and public awareness and education. Transport and communication links are a must to ensure supply of food and other commodities during and just after a drought. Successful drought management requires community awareness on the mitigation strategies, insurance schemes for farmers, crop contingency plans, etc.

Basic to drought management in the Indian context is the delineation of drought prone areas. At the block level, the following indicators are generally used:

1) Drought Prone Area Delineation (Block/Mandal)
   Criteria and data base
   I. Rainfall (long term average - 30 to 50 yrs) (Short Term average – 5 to 10 yrs for giving real picture as rainfall pattern may change over the period for e.g. Cherapunji);
   II. Cropping pattern (past 3 to 5 yrs);
   III. Available supplement irrigation (well, tank, ponds, ground water etc.);
   IV. Satellite derived indicators (last 10 years);
   V. Soil map; vi. Ground water availability map;
   VI. Cattle population and fodder demand;
   VII. Socio economic data;
   VIII. Other water demands like for drinking, industrial use etc.; and . Collection and creation of data base and spatial framework for analysis
2) Gradation of Drought Prone Areas (High, Moderate, Low):
   Areas should also be graded on the basis of degree of drought proneness since it would affect the steps required for greater preparedness. This would require multiple criteria approach that includes
   I. Sensitivity to Rainfall Variation;
   II. Frequency of Occurrence of Drought; and
   III. Vulnerability of Community (people and livestock) to Drought

Monitoring of Drought

Having delineated drought prone areas and their gradation one could move on to the criteria for monitoring relevant indicators. The monitoring indicators will be:

- Rainfall and other associated weather parameters;
- Crop health (based on satellite derived NDVI and field reports);
- Available ground water (variation in ground water table) and surface water resources; and
- Migration and impact on community;

Mitigation

Mitigation actions, programs, and policies are implemented during and before drought to reduce the magnitude of risk to human life, property, and productive capacity. Emergency response will always be a part of drought management, because it is unlikely that government and others will anticipate, avoid, or reduce all potential impacts through mitigation programs. A future drought event will also exceed the “drought of record” and the capacity of a region to respond. However, emergency response will be used lesser and only, if it is consistent with the longer-term drought policy goals and objectives.

Considering the increase in the frequency of droughts in different parts of the country, it is necessary that there is a shift in public policy from drought relief to drought mitigation measures. These measures are important for adapting to climate change, restoring ecological balance, and bringing development benefits to the people.

Given the severity of drought in dry areas, a central challenge for researchers is to devise technologies that lend greater resilience to agricultural production under this stress system. One way in which they have responded successfully to the challenge is by developing varieties of major food crops that are drought tolerant or escape drought through early maturity.

These mitigation measures are related to integrated soil, water and forest management, and will form part of soil conservation, watershed development and forestry programmes.

The mitigation measures to be taken will include:

- Conduct of pilot studies in all categories of drought prone areas for suggesting long term mitigation measures.
- Convergence of lessons learnt from studies carried out by CRIDA, International Crop Research for Semi-arid Tropics (ICRISAT), IMD, NRSC, ICAR, and other institutions.
- Cloud-seeding as a possible measure of mitigation will be considered.
- Measures for reducing the impact of climate change on drought.
- On-farm water management, defined as a systems approach towards controlling water on a farm in a manner that provides for the beneficial management of water for satisfying the irrigation and drainage needs, consists of components such as irrigation, drainage, water sources and sinks etc. Each component must be selected and operated in accordance with the needs and limitations of the other components.
- Judicious use of surface and groundwater
- Cloud seeding in Drought Prone regions of India
- Micro Irrigation Systems
- Post-Harvest Management : India suffers an estimated food grain and agriculture produce loss of Rs 50,000 crores every year due to the lack of adequate post-harvest infrastructure and inefficient supply chain management by the country's farmers. India loses about 35-40% of the fruits and vegetable produce due to improper Post Harvest Management. A loss estimated at Rs 40,000 crores per year! India wastes fruits and vegetables every year equivalent to the annual consumption of the United Kingdom. To avoid the Post-Harvest Losses a chain of cold storages, need to be created along with Post Harvest Management practices like pre cooling, cold storages and refrigerated transport. Pre-harvest losses due to diseases and pests need to be minimized through better management practices. In the absence or lack of proper pre and post-harvest crop management the impact of drought gets compounded.
- Water Conservation, Storage Structures and Management
- Afforestation with Bio-diesel species.

Note: Dear Students,

Most of the topics are covered in these notes provided by me. If by chance any topic is left, let me know & you also have a look of that topic in books or internet.

These are detailed notes. Study thoroughly and practice writing them.

YOU CAN MAKE THEM BRIEF IF YOU WANT BUT PROPERLY.

Don't be over confident that we know DM & it is an easy subject. Mostly students fails in this subject, just because of their over confident.

Unit 3 – Geological Based Disasters

Topics: Earthquake, waves, magnitude & intensity scale, direct & indirect impact of earthquake, seismic zones in India, factors, Indian Standard guidelines for RCC and Masnory structures, prevention and preparedness for earthquake, Tsunami, Landslide, Snow Avalanche.

Glossary of Important Definitions:

- Disaster: A catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, and degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.
- Disaster Management: A continuous and integrated process of planning, organising, coordinating and implementing measures which are necessary or expedient for prevention of danger or threat of any disaster; mitigation or reduction of risk of any disaster or its severity or consequences; capacity building; preparedness to deal with any disaster; prompt response to any threatening disaster situation or disaster; assessing the severity or magnitude of effects of any disaster; evacuation, rescue and relief; and rehabilitation and reconstruction.
- Earthquake: An earthquake is a series of vibrations on the earth's surface caused by the generation of elastic (seismic) waves due to sudden rupture within the earth during release of accumulated strain energy.
- Non-Structural Measures: Non-engineered measures to reduce or avoid possible impacts of hazards such as education, training, capacity development, public awareness, communication etc.
- Structural Measures: Any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure
- Risk Assessment: The determination of the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods, and the environment.
- Seismic Hazard: Seismic hazard in the context of engineering design is defined as the predicted level of ground acceleration which would be exceeded with 10% probability at the site under construction due to occurrence of earthquake anywhere in the region, in the next 50 years.
- Seismic Retrofitting: The structural modifications to upgrade the strength, ductility and energy dissipating ability of seismically deficient or earthquake-damaged structures.
- Seismic Strengthening: The process of enhancing the strength of existing structures to make them resistant to seismic activity, ground motion or soil failure due to earthquakes.
- Vulnerability: The degree of loss to a given element at risk or set of such elements resulting from the occurrence of a natural phenomenon (or manmade) of a given magnitude and expressed on a scale from 0 (no damage) to 1 (total loss).

Earthquake Risk and Vulnerability in India

- According to the latest seismic zone map of India (see Figure 1 – IS:1893, 2002), about 59 per cent of India's land area is vulnerable to moderate or severe seismic hazard, i.e., 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

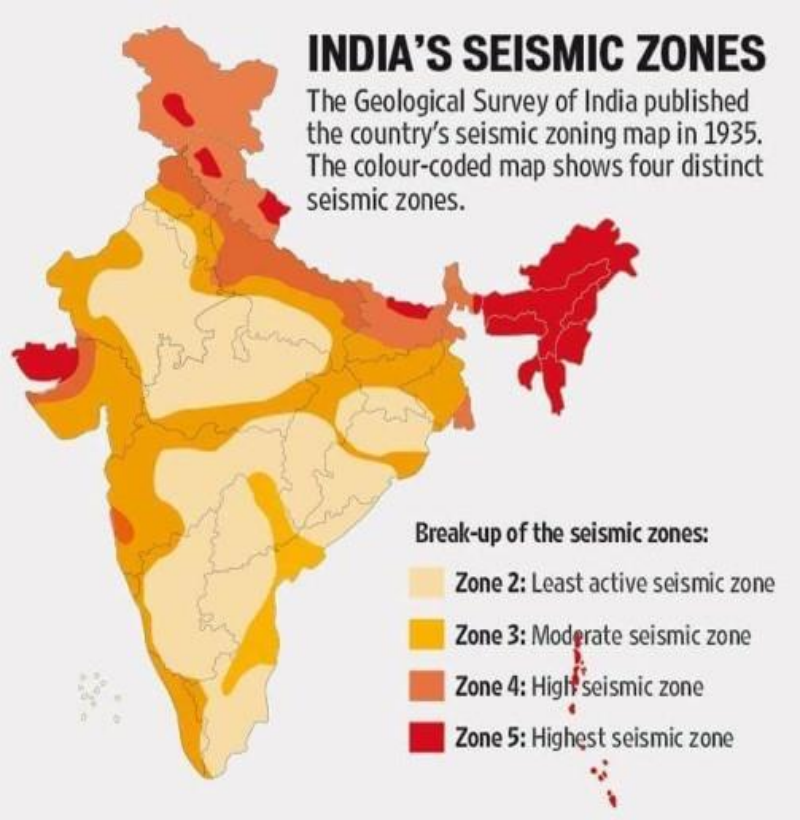
imperative to incorporate seismic risk reduction strategies in various aspects of urban planning and construction of new structures. During the period 1990 to 2006, India has experienced 6 major earthquakes that have resulted in over 23,000 deaths and caused enormous damage to property, assets and infrastructure.

- 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: 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.

Critical Areas of Concern for the Management of Earthquakes in India

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.

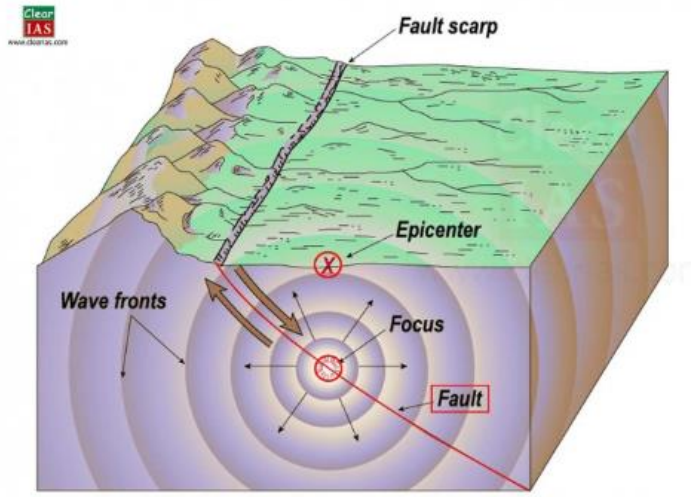


Seismic Zones	% of Geographical Area	
II	41.40	
III	30.40	58.6%
IV	17.30	
V	10.90	

Earthquakes

An earthquake is shaking or trembling of the earth's surface, caused by the seismic waves or earthquake waves that are generated due to a sudden movement (sudden release of energy) in the earth's crust (shallow-focus earthquakes) or upper mantle (some shallow-focus and all intermediate and deep-focus earthquakes).

A seismograph, or seismometer, is an instrument used to detect and record earthquakes.



Focus and epicentre

- The point where the energy is released is called the focus or the hypocentre of an earthquake.
- The point on the surface directly above the focus is called epicentre (first surface point to experience the earthquake waves).
- A line connecting all points on the surface where the intensity is the same is called an isoseismic line.

Foreshocks and aftershocks

Usually, a major or even moderate earthquake of shallow focus is followed by many lesser-size earthquakes known as aftershocks.

A mild earthquake preceding the violent shaking movement of an earthquake is known as a foreshock.

Swarms

- Large numbers of small earthquakes may occur in a region for months without a major earthquake.
- Such series of earthquakes are called earthquake swarms.
- Earthquakes associated with volcanic activity often occur in swarms.
- Earthquake swarms can serve as markers for the location of the flowing magma throughout the volcanoes.

Causes of Earthquakes

- Fault Zones:
  - The immediate cause of most shallow earthquakes is the sudden release of stress along a fault rupture (crack) in the earth's crust.
  - Sudden slipping of rock formations along fault rupture in the earth's crust happens due to the constant change in volume and density of rocks due to intense temperature and pressure in the earth's interior.
  - The immediate cause of most shallow earthquakes is the sudden release of stress along a fault rupture (crack) in the earth's crust.
  - Sudden slipping of rock formations along fault rupture in the earth's crust happens due to the constant change in volume and density of rocks due to intense temperature and pressure in the earth's interior.
- Plate tectonics:
  - Slipping of land along the faultline along convergent, divergent and transform boundaries cause earthquakes.
  - Reverse faults (convergent boundary) are associated with the most powerful earthquakes, megathrust earthquakes, including almost all of those of magnitude 8 or more.
  - Megathrust earthquakes occur at subduction zones, where one tectonic plate is forced underneath another. E.g. 2004 Indian Ocean earthquake.
  - Strike-slip faults, particularly continental transforms, can produce major earthquakes up to about magnitude 8.
  - San Andreas Fault is a transform fault where Pacific plate and North American plate move horizontally relative to each other causing earthquakes along the fault lines.
  - Earthquakes associated with normal faults (divergent boundary) are generally less than magnitude 7.
- Volcanic activity:
  - Volcanic activity also can cause an earthquake, but the earthquakes of volcanic origin are generally less severe and more limited in extent than those caused by fracturing of the earth's crust.
  - Earthquakes in volcanic regions are caused by the consequent release of elastic strain energy both by tectonic faults and the movement of magma in volcanoes.
  - Such earthquakes can serve as an early warning of volcanic eruptions, as during the 1980 eruption of Mount St. Helens
  - There is a clear correspondence between the geographic distribution of volcanoes and major earthquakes, particularly in the Circum-Pacific Belt and along oceanic ridges.
  - Volcanic vents, however, are generally several hundred kilometres from the epicentres of most major shallow earthquakes, and many earthquake sources occur nowhere near active volcanoes.
- Human Induced Earthquakes:
  - Human Induced Earthquakes refers to typically minor earthquakes and tremors that are caused by human activity like mining, large scale petroleum extraction, artificial lakes (reservoirs), nuclear tests etc.
  - The 6.3 magnitude 1967 Koynanagar earthquake occurred near the Koyna Dam reservoir in Maharashtra and claimed more than 150 lives. There have been several earthquakes of smaller magnitude since then.
  - Some geologists believe that the earthquake was due to reservoir-triggered seismic activity.

- The 2008 Sichuan earthquake, which caused approximately 68,000 deaths, is another possible example. It is believed that the construction and filling of the Zipingpu Dam may have triggered the earthquake.

Earthquakes based on the depth of focus

Earthquakes can occur anywhere between the Earth's surface and about 700 kilometres below the surface. For scientific purposes, this earthquake depth range of 0 – 700 km is divided into three zones: shallow, intermediate, and deep. Shallow focus earthquakes are found within the earth's outer crustal layer, while deep focus earthquakes occur within the deeper subduction zones of the earth.

- Shallow earthquakes are 0 – 70 km deep.
- Intermediate earthquakes are 70 – 300 km deep.
- Deep earthquakes are 300 – 700 km deep.

Of the total energy released in earthquakes, about 12-15 per cent comes from intermediate earthquakes, about 3-5 per cent from deeper earthquakes and about 70-85 per cent from the shallow earthquakes. A quake's destructive force depends not only on the energy released but also on location, distance from the epicentre and depth. On 24 August 2016, a 6.2 earthquake rocked Central Italy killing about 300 people. An even bigger 6.8 hit Myanmar the same day killing just a few people. Italy's quake was very shallow, originating within 10 kilometres underground. By contrast, the quake in Myanmar was deeper — 84 kilometres.

Seismic Waves

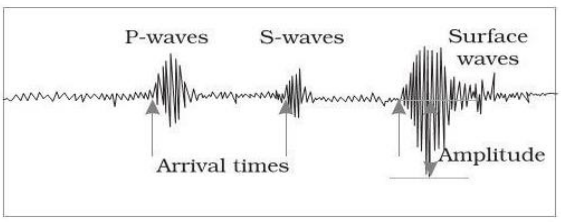
Seismic: relating to earthquakes or other vibrations of the earth and its crust. Seismic waves are waves of energy that travel through the Earth's layers and are a result of earthquakes, volcanic eruptions, magma movement, large landslides and large human-made explosions. The refraction or reflection of seismic waves is used for research into the structure of the Earth's interior. The terms seismic waves and earthquake waves are often used interchangeably.

How seismic waves are produced?

- The abrupt release of energy along a fault (sharp break in the crustal layer) causes earthquake waves.
- Rock layers along a fault tend to move in opposite directions due to the force excreted on them but are held in place by counteracting frictional force exerted by the overlying rock strata.
- The pressure on the rock layers builds up over a period and overcomes the frictional force resulting in a sudden movement generating shockwaves (seismic waves) that travel in all directions.
- The point where the energy is released is called the focus or the hypocentre of an earthquake.
- The point on the surface directly above the focus is called epicentre.
- An instrument called 'seismograph' records the waves reaching the surface.

Types of Waves:

1. Body Waves – P waves & S waves
2. Surface Waves – L waves & Rayleigh waves



Body waves

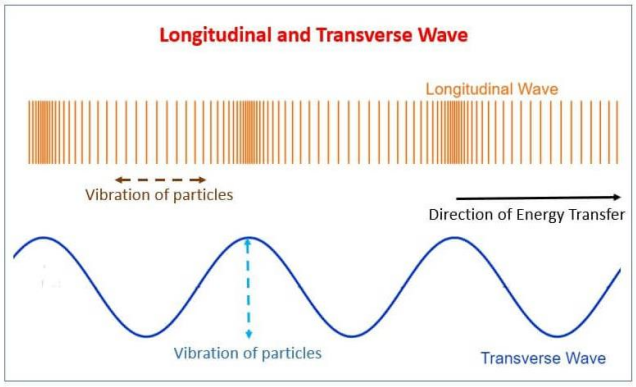
Body waves are generated due to the release of energy at the focus and move in all directions travelling through the interior of the earth. Hence, the name body waves.

There are two types of body waves:

- The P-waves or primary waves (longitudinal in nature — wave propagation is similar to sound waves),
- The S-waves or secondary waves (transverse in nature — wave propagation is similar to ripples on the surface of the water).

Primary Waves (P-waves)

Primary waves are called so because they are the fastest among the seismic waves and hence are recorded first on the seismograph. P-waves are also called as the longitudinal waves because the displacement of the medium is in the same direction as, or the opposite direction to, (parallel to) the direction of propagation of the wave; or compressional waves because they produce compression and rarefaction when travelling through a medium; or pressure waves because they produce increases and decreases in pressure in the medium.



P-waves creates density differences in the material leading to stretching (rarefaction) and squeezing (compression) of the material.

These waves are of relatively high frequency and are the least destructive among the earthquake waves. The trembling on the earth's surface caused due to these waves is in the up-down direction (vertical). They can travel in all mediums, and their velocity depends on shear strength (elasticity) of the medium.

Hence, the velocity of the P-waves in Solids > Liquids > Gases. These waves take the form of sound waves when they enter the atmosphere. P-wave velocity in earthquakes is in the range 5 to 8 km/s.

The precise speed varies according to the region of the Earth's interior, from less than 6 km/s in the Earth's crust to 13.5 km/s in the lower mantle, and 11 km/s through the inner core.

Why do P-waves travel faster than S-waves?

P-waves are about 1.7 times faster than the S-waves.

P-waves are compression waves that apply a force in the direction of propagation and hence transmit their energy quite easily through the medium and thus travel quickly.

On the other hand, S-waves are transverse waves or shear waves (motion of the medium is perpendicular to the direction of propagation of the wave) and are hence less easily transmitted through the medium.

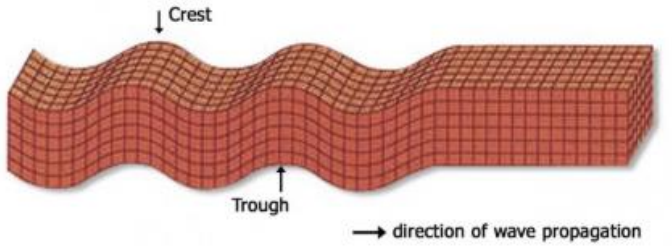
P-waves as an earthquake warning

Advance earthquake warning is possible by detecting the non-destructive primary waves that travel more quickly through the Earth's crust than do the destructive secondary and surface waves.

Depending on the depth of focus of the earthquake, the delay between the arrival of the P-wave and other destructive waves could be up to about 60 to 90 seconds (depends of the depth of the focus).

Secondary Waves (S-waves)

Secondary waves (secondary they are recorded second on the seismograph) or S-waves are also called as transverse waves or shear waves or distortional waves. They are analogous to water ripples or light waves.

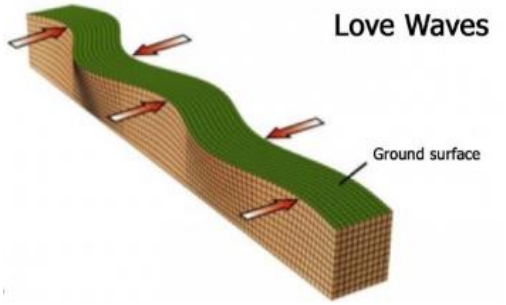


Transverse waves or shear waves mean that the direction of vibrations of the particles in the medium is perpendicular to the direction of propagation of the wave. Hence, they create troughs and crests in the material through which they pass (they distort the medium). S-waves arrive at the surface after the P-waves.

These waves are of high frequency and possess slightly higher destructive power compared to P-waves. The trembling on the earth's surface caused due to these waves is from side to side (horizontal). S-waves cannot pass through fluids (liquids and gases) as fluids do not support shear stresses. They travel at varying velocities (proportional to shear strength) through the solid part of the Earth.

Surface waves (L-Waves)

The body waves interact with the surface rocks and generate new set of waves called surface waves (long or L-waves). These waves move only along the surface. Surface Waves are also called long period waves because of their long wavelength. They are low–frequency transverse waves (shear waves).



They develop in the immediate neighbourhood of the epicentre and affect only the surface of the earth and die out at smaller depth. They lose energy more slowly with distance than the body waves because they travel only across the surface unlike the body waves which travel in all directions.

Particle motion of surface waves (amplitude) is larger than that of body waves, so surface waves are the most destructive among the earthquake waves. They are slowest among the earthquake waves and are recorded last on the seismograph.

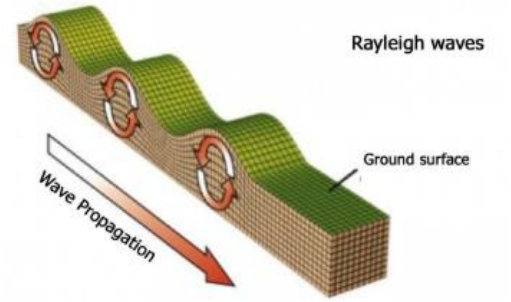
Love waves

It's the fastest surface wave and moves the ground from side-to-side. Confined to the surface of the crust, Love waves produce entirely horizontal motion. Love waves have a transversal (perpendicular) movement and are the most destructive outside the immediate area of the epicenter. Love waves can be devastating. This kind of surface waves causes horizontal shifting of the earth during an earthquake. They are much slower than body waves but

are faster than Rayleigh. They exist only in the presence of semi-infinite medium overlain by an upper finite thickness.

Rayleigh waves

A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Because it rolls, it moves the ground up and down and side-to-side in the same direction that the wave is moving. Most of the shaking and damage from an earthquake is due to the Rayleigh wave.



Seismic Waves			
Type (and names)	**Particle Motion**	**Typical Velocity**	**Other Characteristics**
P,Compressional, Primary, Longitudinal	Alternating compressions ("pushes") and dilations ("pulls") which are directed in the same direction as the wave is propagating (along the raypath); and therefore, perpendicular to the wavefront	$V_P \sim 5 - 7$ km/s in typical Earth's crust; >~ 8 km/s in Earth's mantle and core; 1.5 km/s in water; 0.3 km/s in air	P motion travels fastest in materials, so the P-wave is the first-arriving energy on a seismogram. Generally smaller and higher frequency than the S and Surface-waves. P waves in a liquid or gas are pressure waves, including sound waves.
S, Shear, Secondary, Transverse	Alternating transverse motions (perpendicular to the direction of propagation, and the raypath); commonly polarized such that particle motion is in vertical or horizontal planes	$V_S \sim 3 - 4$ km/s in typical Earth's crust; >~ 4.5 km/s in Earth's mantle; ~ 2.5-3.0 km/s in (solid) inner core	S-waves do not travel through fluids, so do not exist in Earth's outer core (inferred to be primarily liquid iron) or in air or water or molten rock (magma). S waves travel slower than P waves in a solid and, therefore, arrive after the P wave.
L, Love, Surface waves, Long waves	Transverse horizontal motion, perpendicular to the direction of propagation and generally parallel to the Earth's surface	$V_L \sim$ 2.0 - 4.5 km/s in the Earth depending on frequency of the propagating wave	Love waves exist because of the Earth's surface. They are largest at the surface and decrease in amplitude with depth. Love waves are dispersive, that is, the wave velocity is dependent on frequency, with low frequencies normally propagating at higher velocity. Depth of penetration of the Love waves is also dependent on frequency, with lower frequencies penetrating to greater depth.
R, Rayleigh, Surface waves, Long waves, Ground roll	Motion is both in the direction of propagation and perpendicular (in a vertical plane), and "phased" so that the motion is generally elliptical – either prograde or retrograde	$V_R \sim$ 2.0 - 4.5 km/s in the Earth depending on frequency of the propagating wave	Rayleigh waves are also dispersive and the amplitudes generally decrease with depth in the Earth. Appearance and particle motion are similar to water waves.

Magnitude versus Intensity

Magnitude and Intensity measure different characteristics of earthquakes. Magnitude measures the energy released at the source of the earthquake. Magnitude is determined from measurements on seismographs. Intensity measures the strength of shaking produced by the earthquake at a certain location. Intensity is determined from effects on people, human structures, and the natural environment.

Magnitude	Intensity
It is a quantitative measure of the actual size of the earthquake.	It is a qualitative measure of the actual shaking at a location during an earthquake.
Normal numbers are used to determine the magnitude of earthquake.	Intensity is assigned as Roman Capital Numerals.
The Richter Scale (called Local Magnitude scale) is used to measure the magnitude. There are other magnitude scales, like the moment magnitude, Body Wave Magnitude, Surface Wave Magnitude, and Wave Energy Magnitude. These numerical magnitude scales have no upper and lower limits; the magnitude of a very small earthquake can be zero or even negative.	There are many intensity scales. Two commonly used ones are the Modified Mercalli Intensity (MMI) Scale and the MSK Scale. Both scales are quite similar and range from I (least perceptive) to XII (most severe).
The scale is obtained from the seismograms and accounts for the dependence of waveform amplitude on epicentral distance	The intensity scales are based on three features of shaking – perception by people and animals, performance of buildings, and changes to natural surroundings.
When an earthquake occurs, its magnitude can be given a single numerical value on the Richter Scale.	When an earthquake occurs, its intensity is variable over the area affected by the earthquake, with high intensities near the epicenter and lower values further away. These are allocated a value depending on the effects of the shaking.
The magnitude of is not the base of design of structures since the same magnitude would have various intensities at different locations.	Structures are designed to withstand particular levels of intensity of shaking, and not so much the magnitude. The peak ground acceleration (PGA) is one way of quantifying the severity of the ground shaking which is used in the earthquake resistance of structures
An increase in magnitude (M) by 1.0 implies 10 times higher waveform amplitude and about 31 times higher energy released.	
Seismographs used to record earthquakes magnitudes.	The intensity value is determined from the observable effects of the shaking on people, on manmade structures and their contents, and on the landscape.

Calculating Earthquake Magnitude

The magnitude of an earthquake is a number that allows earthquakes to be compared with each other in terms of their relative power. For several decades, earthquake magnitudes were calculated based on a method first developed by Charles Richter, a seismologist based in California. Richter used seismograms of earthquakes that occurred in the San Andreas fault zone to calibrate his magnitude scale.

Two measurements are factored together to determine the Richter magnitude of an earthquake: the amplitude of the largest waves recorded on a seismogram of the earthquake, and the distance to the epicenter of the earthquake. The maximum amplitude seismic wave – the height of the tallest one – is measured in mm on a seismogram. The distance to the epicenter must also be taken into account because the greater the distance from

the earthquake, the smaller the waves get. The effect of distance is factored out of the calculation. There is no upper limit defined for the Richter scale, but after a century of seismograph measurements, it appears that rocks in the earth release their stress before building up enough energy to reach magnitude 10.

The Richter scale was found to not transfer very well from the San Andreas fault zone, a transform plate boundary, to the much more powerful earthquakes that occur at convergent plate boundaries, particularly subduction zone earthquakes. Therefore, the Richter scale has been replaced by the moment magnitude scale, symbolized as Mw.

The moment magnitude scale is broadly similar to the Richter scale, but it takes more factors into account, including the total area of the fault that moves during the earthquake, and how much it moves. This produces a magnitude number that is a better indicator of the total amount of energy released by the earthquake. Because the moment magnitude scale has replaced the Richter scale, we will assume from here on that we are referring to moment magnitude, not Richter magnitude, when we speak of earthquake magnitude.

The magnitude scale portrays energy logarithmically to approximately base 32. For example, a magnitude 6.0 earthquake releases about 32 times as much energy as a magnitude 5.0 earthquake. A magnitude 7.0 releases about 32 × 32 = 1024 times as much energy as a magnitude 5.0 earthquake. A magnitude 9.0 earthquake, which rarely occurs, releases over a million times as much energy as a magnitude 5.0 earthquake.

Ranking Earthquake Intensity

Earthquake intensity is very different from earthquake magnitude. Earthquake intensity is a ranking based on the observed effects of an earthquake in each particular place. Therefore, each earthquake produces a range of intensity values, ranging from highest in the epicenter area to zero at a distance from the epicenter. The most commonly used earthquake intensity scale is the Modified Mercalli earthquake intensity scale. Refer to the Modified Mercalli Intensity Scale page on the US Geological Survey Earthquake Hazards Program website for an abbreviated version.

Magnitude	Average number per year	Modified Mercalli Intensity	Description
0 – 1.9	>1 million	—	micro – not felt
2.0 – 2.9	>1 million	I	minor – rarely felt
3.0 – 3.9	about 100,000	II – III	minor – noticed by a few people
4.0 – 4.9	about 10,000	IV – V	light – felt by many people, minor damage possible
5.0 – 5.9	about 1,000	VI – VII	moderate – felt by most people, possible broken plaster and chimneys
6.0 – 6.9	about 130	VII – IX	strong – damage variable depending on building construction and substrate
7.0 – 7.9	about 15	IX – X	major – extensive damage, some buildings destroyed
8.0 – 8.9	about 1	X – XII	great – extensive damage over broad areas, many buildings destroyed
9.0 and above	< 1	XI – XII	great – extensive damage over broad areas, most buildings destroyed

- **Comparison of Magnitude & Intensity Scale:**

Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 – 3.0	I
3.0 – 3.9	II – III
4.0 – 4.9	IV – V
5.0 – 5.9	VI – VII
6.0 – 6.9	VII – IX
7.0 and higher	VIII or higher

Modified Mercalli scale of earthquake intensity:

- Not felt. Marginal and long-period effects of large earthquakes.
- II. Felt by persons at rest, on upper floors, or otherwise favourably placed to sense tremors.
- III. Felt indoors. Hanging objects swing. Vibrations are similar to those caused by the passing of light trucks. Duration can be estimated.
- IV. Vibrations are similar to those caused by the passing of heavy trucks (or a jolt similar to that caused by a heavy ball striking the walls). Standing automobiles rock. Windows, dishes, doors rattle. Glasses clink, crockery clashes. In the upper range of grade IV, wooden walls and frames creak.
- V. Felt outdoors; direction may be estimated. Sleepers awaken. Liquids are disturbed, some spilled. Small objects are displaced or upset. Doors swing, open, close. Pendulum clocks stop, start, change rate.
- VI. Felt by all; many are frightened and run outdoors. Persons walk unsteadily. Pictures fall off walls. Furniture moves or overturns. Weak plaster and masonry cracks. Small bells ring (church, school). Trees, bushes shake.
- VII. Difficult to stand. Noticed by drivers of automobiles. Hanging objects quivering. Furniture broken. Damage to weak masonry. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices. Waves on ponds; water turbid with mud. Small slides and caving along sand or gravel banks. Large bells ringing. Concrete irrigation ditches damaged.
- VIII. Steering of automobiles affected. Damage to masonry; partial collapse. Some damage to reinforced masonry; none to reinforced masonry designed to resist lateral forces. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed pilings broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
- IX. General panic. Weak masonry destroyed; ordinary masonry heavily damaged, sometimes with complete collapse; reinforced masonry seriously damaged. Serious damage to reservoirs. Underground pipes broken. conspicuous cracks in ground. In alluvial areas, sand and mud ejected; earthquake fountains, sand craters.
- X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water

thrown on banks of canals, rivers, lakes, and so on. Sand and mud shifted horizontally on beaches and flat land. Railway rails bent slightly.

- XI. Rails bent greatly. Underground pipelines completely out of service.
- XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air.

Effects of Earthquake:

- **Shaking and ground rupture**
  - Shaking and ground rupture result in severe damage to buildings and other rigid structures.
  - Ground rupture (crack along the fault) is a major risk for large engineering structures such as dams, bridges and nuclear power stations.
- **Landslides and avalanches**
  - Earthquakes, along with severe storms, volcanic activity, coastal wave attack, and wildfires, can produce slope instability leading to landslides, a major geological hazard.
- **Fires**
  - Fires are a major source of damage after earthquakes. Ground rupture and liquefaction can easily rupture natural gas mains and water mains, both contributing to the ignition of fires and hindering the efforts to control them.
  - Earthquakes can cause fires by damaging electrical power or gas lines.
  - More deaths in the 1906 San Francisco earthquake were caused by fire than by the earthquake itself.
- **Soil liquefaction**
  - Liquefaction and subsidence of the ground are important effects which often are the cause of much destruction in earthquakes, particularly in unconsolidated ground.
  - Liquefaction is when sediment grains are literally made to float in groundwater, which causes the soil to lose all its solidity. Soil liquefaction occurs when water-saturated soil temporarily loses its strength and transforms from a solid to a liquid. Soil liquefaction may cause rigid structures, like buildings and bridges, to tilt or sink.
  - Subsidence can then follow as the soil recompacts. Sand blows, or sand volcanoes, form when pressurized jets of groundwater break through the surface. They can spray mud and sand over an area a few meters across.
  - All of these effects pose a grave danger to buildings, roads, train lines, airport runways, gas lines, etc. Buildings have actually tipped over and sunk partway into liquefied soils
- **Tsunami**
  - Megathrust earthquakes can produce long-wavelength, long-period sea waves due to abrupt movement of large volumes of water.
- **Floods**
  - Flooding can come from many sources such as broken water main pipes, dams that fail due to the earthquake and earthquake-generated tsunamis. When an earthquake breaks a dam or levee along a river, the water from the river or the reservoir floods the area, damaging buildings and maybe sweeping away or drowning people.
  - Small tsunamis, called seiches occur on lakes shaken by earthquakes and are usually just a few feet high. These small tsunamis are capable of destroying houses and uprooting trees.
  - Earthquakes may cause landslips to dam rivers, which collapse and cause floods.

Key Criteria	Direct Impact	Indirect Impact
Food Security	Loss of food stock, crop yields and livestock	Decreased food access from purchase, due to loss of income
	Damage to people's homes and business premises	Lack of basic food necessities
	Destruction of infrastructure and equipment	Disruption of food production, markets and transportation systems
	Damage to markets and supply routes	Decreased food availability
	Loss and injury of family members and workforce	Increase in price of staple food
	Damage to irrigation systems	Reduced income for farmers
Health & Nutrition	Many severe injuries requiring extensive treatment: • High levels of fractures, blunt trauma, wounds and crush syndrome. • Morbidity and mortality resulting from trauma, asphyxia, dust inhalation in collapsed buildings (acute respiratory distress), or exposure to the environment (i.e. hypothermia). • Burns and electroshocks	Overcrowded health structures • Increased portion of the population handicapped.
	Severe damages to structure and equipment of health facilities can lead to an interruption in basic health care services.	• Lack of access to basic healthcare • Overcrowded health structures • Deterioration of nutritional status, famine and illness may occur if victims does not have access to health care
	Decaying corpses and carcasses on the streets	Psycho-social problems due to unclean environment and confrontation with corpses • Carcasses of livestock can represents a risk to human health as a direct source of disease from vectors that may be attracted to the area, and decomposition products contaminating the air and water
Water Supply	Disruption of water distribution systems due to: • Interruption of electric power, hampering water supply • Total or partial destruction of water intake, transmission, treatment, storage and distribution system. • Rupture of distribution pipes, damage to joints between pipes or tanks. • In case of pipe material like Asbestos Cement, the pipes may develop hairline cracks which expand once the water pressure increases.	Consumption of contaminated water: potential risks of waterborne diseases • Insufficient quantity of water available per person and per day • Increased distance to functional water source.
	Urban water system contaminated due to: • Leaks or destruction in sewerage systems causing sewage contamination to water sources and supply system • Ground water contamination due top underground storage tanks, septic tanks, municipal landfills and/or agricultural activities • Shallow groundwater contamination due to effluent, or outflow from septic tanks, cesspools and privies • Deep groundwater polluted by underground storage tanks	

	• Overflowing of industrial drainage system causing chemical contamination to water sources and supply systems.	
Sanitation	• Destruction and/or damages to (public and/or private) existing latrines • Destruction and/or damages to sceptic tanks and underground excreta disposal systems	• People defecating in the water, thereby contaminating water sources • Contamination of water by damaged sceptic tanks or disrupted excreta disposal underground systems • Overcrowded sanitation facilities can filled up and/or overflowed remaining functional latrines • Increasing presence of vectors • Increase in communicable diseases • Lack of available and functional latrines can force women to wait after dark to be able to use an (open air) latrine in privat
Waste – Urban/Rural	• Destruction or damage of existing waste disposal structures. • Large amount of rubble. Materials can be standard construction materials (e.g. chips of wood, brick and metal, and blocks of concrete. concrete, stone, etc.), as well as hazardous wastes, including asbestos from housing insulation and damaged water supply lines, stored fuels, lubricating oils, industrial materials, medical waste from clinics/hospitals, and possibly radioactive waste from X-ray devices Loss of basic hygiene items for personal and domestic uses	Accidental releases to ground water • Disruption and/or overwhelmed waste collection system • Shortage of waste disposal facilities in (overcrowded) displaced centres • Altered drainage patterns. Land surface alterations may increase flooding in areas previously not at risk. Existing drainage channels, canals may be clogged with waste or muds, again inducing altered patterns of runoff and creating flood situations Lack of clean water needed for basic hygiene practices • Increase in communicable diseases • Lack of access to basic hygiene items for personal and domestic uses (disruption of market supply, lack of income).

Structural and Non-structural Earthquake Mitigation Measures

Mitigation would remain the key and the most effective strategy to reduce the risks of earthquake. Broadly mitigation strategies are twofold: structural and non-structural. Structural mitigation measures generally refer to capital investment on physical constructions or other development works, which include engineering measures and construction of hazard resistant and protective structures and other protective infrastructure. Non-structural measures refer to awareness and education, policies techno-legal systems and practices, training, capacity development etc. The structural and non-structural prevention/mitigation measures for the earthquake hazard are mentioned below:

Task	**Activities**	**Responsibility**
Land Use Planning	To undertake micro-zonation study according to priority area • To provide or make available seismic micro-zonation map • Provide vulnerability and risk assessment map	• Revenue Dept. • COR • Science & Technology Dept. • ISR • SDMA
Development and Enactment of Building Codes and Standards	Enactment of building codes and construction standards • Enforcement of codes / Land use regulations o Restricting development activity in highly seismic risk zone o Shifting of economic activities to less risk areas o Compliance with land use ordinances • Amendment of Town Planning Act and development of regulations to include seismic building codes and standards • Amendment in Panchayats Act, Rules and bye-laws • Revision of General Development Control Regulations	UD & UHD Dept. • Panchayat & Rural Housing Dept • R & B Dept. • Municipal Commissioners • All line Dept.
Earthquake Resistance Design for Different Seismic Zones	To develop earthquake resistant design features for the construction of public utility structures • To develop earthquake resistant design features for the construction of residential structures • To develop and promote earthquake resistant construction in rural and semi-urban areas • To provide earthquake resistant design for incorporating in different types of structures to the line departments • To develop earthquake resistant design features for the housing constructed under various government sch	Revenue Dept., • COR • R & B Dept. • Panchayat & Rural Housing Dept
Retrofitting of Existing Structure	• Create a database of existing structure in the State o Public o Private • Identify the available resources • Identify structures that require retrofitting • Prepare a scheme/programme for retrofitting • Prioritising structures especially, critical/lifeline structures	• Revenue Dept. • R & B Dept. • UD & UHD Dept. • Panchayat & Rural Housing Dept
Removal of Unsafe Buildings	• Inventory of unsafe buildings • Identify the potential loss due to removal of building • Formulate suitable financial/assistance packages • Empowering the implementing agencies to execute the task.	• Revenue Dept • UD & UHD • Panchayats, RD & RHD Dept • Finance Dept • RD Dept • R & B Dept • Local Self Govt.

Monitoring of Seismic Activities	• Establish seismological network and round the clock monitoring • Dissemination of information and reporting • Conduct seismological research	• Science & Technology Dept. • ISR • IMD • CWC
Non-Structural Measures		
Planning	• Establish Techno-legal regime for ensuring compliance of earthquake resistant design and construction practices in all new constructions • Prepare earthquake management plan o Prepare departmental action plan and SOP for earthquake hazard o Conduct mock drills at regular intervals o Update the plan as per the requirement o Monitor similar activities at district & taluka level	• Revenue Dept. • COR • All line depts. • Dist. Collectors • Municipal Commissioners • Disaster Mamlatdar
Capacity Building	• Develop earthquake hazard IEC materials for Publication & Distribution • Organize training programmes, seminars and workshops • Include disaster related topics in School and college curriculum • Encourage favourable taxation/ incentive • Development of Rapid Visual Screening procedures and Detailed Vulnerability Assessment	• Revenue Dept. • COR • GSDMA/GIDM • Information Dept. • Education Dept. • Finance Dept./ UD & UHD Dept./Panchayat & Rural Housing Dept.
Awareness	• To disseminate earthquake risk to general public residing in earthquake prone zones • Media campaign for awareness generation in general public	• SDMA • Information Dept.
Community Based Disaster Management	• Strengthening capacity of local self government entities to understand local vulnerability and risk, earthquake prevention needs, preparedness and response capabilities through participatory approach	• Revenue Dept. • COR • GSDMA • UD & UHD Dept./Panchayat & Rural Housing Dept.
Encourage Earthquake Engineering	• Include earthquake engineering topics in curriculum • Provide professional training about earthquake resistance construction to engineers and architects • Provide training to masons • Encourage soil and material testing in laboratories	• Education Dept. • GIDM • R & B Dept. • GSDMA • UD & UHD Dept. Science & Tech. Dept.
Safety Audits	Carrying out structural safety audit of all critical lifeline structures • Regular conduction of Fire Safety Audits and Electrical Safety Audits • Licensing and certification of professionals • Compliance review by professionals of PRIs and ULBs	• Revenue Dept., • R & B Dept. • UD & UHD Dept • Panchayat & Rural Housing Dept. • Other line Dept.

Earthquake Preparedness & Prevention

What happens during an Earthquake?

Criteria	Example	Effect
In case of load bearing structure	Mid Rise Flats Single Storey Residential Building	The load bearing walls act as a stiff box. The weakest point in this box is the openings for doors and windows and the junction between the wall and slab.
		Most serious damage occurs when diagonal cracks appear in the walls themselves; they should be checked by an engineer immediately.
		Cracks are most likely to appear at the corner of the openings diagonally, in piers between consecutive windows placed horizontally. The shorter these cracks are, the less damage has occurred.
Framed Structure	Open Ground Storey/Buildings on Stilts	The presence of walls in the upper storeys makes them much stiffer than the open ground storey. Thus, they move almost together as a single block. As the columns in the open storey are not strong enough in resisting sideways shaking from the earthquake, they get severely damaged, subsequently leading to collapse of the super structure. Experience has shown that buildings on stilts do not perform well in earthquakes unless the column and beam connections on the ground floor have been specially designed to withstand the shaking load.
	Mid-rise framed Structures without open ground storey	RCC frames bend due to horizontal forces. This affects the joints of the columns and beams. They may crack.
	Mid-rise Frame Structures with projected balcony and with open ground storey	In this case the frame above the ground floor is projected from the columns and enclosed with walls. During the earthquake it is the columns that carry the upper part of the building. These columns are affected the most during the shaking.
	Tower Block with open ground storey	Due to the height, the horizontal force during an earthquake may cause the buildings to sway in both directions.
	Tower Block with Podium	The podium tends to move horizontally during an earthquake. At the same time the tower will bend due to the horizontal force. The most affected area is the floor above the podium. This level should be checked carefully

Inspection of the Building:

If you live in a multistoried building and if you are not sure it has been designed to resist earthquake forces, the first step that needs to be taken is to sensitize your fellow residents and the neighbourhood about the damages and losses they may face in an earthquake. The next step would be to get your building reviewed for earthquake safety by a competent and experienced structural engineer.

Sequence in which Structural Elements are to be checked:

- Corner Columns and beams

- Peripheral Columns and beams
- Cantilevered beams (for Balcony covered framed buildings)
- Stair walls and columns and lift walls
- Columns at upper levels
- Water tanks
- Infill and partition Walls
- As a precautionary measure the beams and columns as well as their junctions at all levels must be checked.

Non-Structural Elements:

Ways to reduce damage to and injury from the contents of your home.

- Brackets at top or, sides secure the shelves from toppling off.
- Metal or, wire guardrails will also help keep objects from falling off open shelves
- Metal plastic or, wood ledge barriers prevent objects from sliding off the shelves.
- Picture frames, bulletin boards and mirrors will fall during an earthquake if they are not securely fastened to the wall.
- Do screw closed screw-eye to hang up picture frame/ bulletin boards/ mirrors.
- Secure your equipment/ computer in the work place
- Secure your water tank

Strengthen/Retrofit your building

- Horizontal Seismic Belts just above the lintels of Door and Window opening
- Horizontal belts just below the roof
- Vertical Seismic Belts at wall junctions (L & T junctions)
- Seismic belt around doors and windows containing galvanised welded steel wire mesh as reinforcement
- Seismic belts around the gable wall

Things to Do Before an Earthquake:

- Be sure that the proper structural design and engineering practices are followed while constructing a house.
- Evaluate the structural soundness of buildings; strengthen/ retrofit if necessary.
- While building your house make sure it is designed for your safety. See that your building is designed and built as per the norms laid by the BIS codes.
- BIS has published following seismic codes:
    - IS: 1893 (Part I), 2002, Indian Standard Criteria for Earthquake Resistant Design of Structures
    - IS: 4326, 1993, Indian Standard Code of Practice for Earthquake Resistant Design and Construction of Buildings
    - IS: 13827, 1993, Indian Standard Guidelines for Improving Earthquake Resistance of Earthen Buildings
    - IS: 13828, 1993, Indian Standard Guidelines for Improving Earthquake Resistance of Low strength Masonry Buildings
    - IS: 13920, 1993, Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces
    - IS: 13935, 1993, Indian Standard Guidelines for Repair and Seismic Strengthening of Buildings
- If you are living in a house/flat, work to improve its safety.
- If you are looking for a place to stay, you should look for safety.

What to do During an Earthquake?

- During earthquakes, drop to the floor, take cover under a sturdy desk or table, and hold on to it so that it doesn't move away from you. Wait there until the shaking stops.
- If you are in a structurally sound building, stay there.
- If you are inside an old weak structure, take the fastest and safest way out.
- Do not use elevators.
- After the shaking stops, take the staircase to reach open space.
- If you are not near an exit or, you are situated in highrise building/ upstairs stay inside. Do not panic;stay calm and take necessary action.
- If you are near an exit, leave the building as soon as possible. Do not rush to the exit point. Get out calmly in an orderly manner.
- Move away from power lines, posts, walls, false ceiling, parapet, falling flower pots and other elements that may fall or, collapse.
- Stay away from buildings with glass panes.
- Do not attempt to cross bridges/flyovers, which may have been damaged.
- When driving a vehicle pull to the side of the road and stop.
- If you are on a steep hillside, move away in case of landslides and falling rocks

INDIAN STANDARD GUIDELINES FOR EARTHQUAKE RESISTANT STRUCTURE

India, has a geophysical position that makes it earthquake resistant. This is why when Nepal witnessed the massive destruction of life and property, we felt only tremors. However, we must keep in mind that the entire Northeast, Uttarakhand, Gujarat and Himachal Pradesh are some of the highly earthquake- prone areas in India. Besides, many other zones like Delhi-National Capital Region also fall under high-risk category. In view of that, the country has to be ready in case of a disaster and more so in constructing earthquake-resistant structures. And this is why the government has put in place several measures.

The standards maintained for mitigating the hazards of Earthquake are mentioned beneath:

- Criteria for Earthquake Resistant Design of Structures (IS 1893:1984)
    - This standard mainly deals into earthquake resistant design of buildings and gives a map showing seismic zones based on the seismic intensity. The provisions made are applicable to all structures such as elevated structures etc.
- General provisions and Buildings (IS 1893 (Part 1):2002)
    - Standard contains design criteria, including design spectrum, main attributes of buildings, seismic zoning & coefficients of area that are general in nature and applicable to all structures.
    - These provisions of this standard ensure that no structure suffer damage from the sudden movement in the earth's crust.
- Industrial Structures Including Stack Like Structures (IS 1893(Part 4):2005)
    - Mainly dealing with quake proof industrial design, this standard ensures that the structures possess minimum strength to withstand minor earth quake which has been seen occurring frequently in many parts of the country.
- Earthquake Resistant Design and Construction of Buildings (IS 4326:1993)
    - From general principles on earthquake design to guidance in selection of construction materials, providing seismic strengthening of concrete buildings.

  - The provisions laid are applicable for high risk zones 3, 4 and 5.
- Improving Earthquake Resistance of Earthen Buildings (IS 13827:1993)
  - This standard is for earthen structures in Seismic zones 3, 4 & 5. As per the guidelines, structure design should be light with simple rectangular plan and of single. Here qualitative tests have been suggested for the suitability of soil.
- Improving Earthquake Resistance of Low Strength Masonry Buildings (IS 13828:1993)
  - The guidelines focus on special features of structure design and construction in order to improve earthquake resistance of low-strength masonry buildings. The provisions made are applicable in all 2-5 seismic zones.
  - The various provisions of IS 4326:1993 pertaining to general principles and special construction features for low-strength masonry buildings dealt with in this standard.
- Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces (IS 13920:1993)
  - This covers all design requirements, including detailing of monolithic reinforced concrete buildings so as to provide them with good ductility and adequate toughness to resist severe seismic shocks without collapse.
- Seismic Evaluation, Repair and Strengthening of Masonry Buildings (IS 13935:2009)
  - It includes selection of construction materials and techniques for repair and seismic strengthening of buildings damaged from earthquakes. It also covers the provisions of IS 4326 and IS 13828 that deals with seismic damageability assessment and retrofit of existing masonry buildings to upgrade seismic resistance of the structures.
- Criteria for Safety and Design of Structures Subject to Underground Blasts (ISS 6922:1973)
  - This standard specifically deals with the safety of structures and all buildings during underground blasts constructed in materials like concrete, brickwork as well as stone masonry.

TSUNAMI

- A tsunami is a series of great sea waves caused by an underwater earthquake, landslide, or volcanic eruption. More rarely, a tsunami can be generated by a giant meteor impact with the ocean.
- Tsunami (pronounced soo-NAH-mee) is a Japanese word. Tsunamis are fairly common in Japan, and many thousands of Japanese have been killed by them in recent centuries.
- An earthquake generates a tsunami if it is of sufficient force and there is violent movement of the earth to cause substantial and sudden displacement of a massive amount of water.
- A tsunami is not a single wave but a series of waves, also known as a wave train. The first wave in a tsunami is not necessarily the most destructive. Tsunamis are not tidal waves.
- Tsunami waves can be very long (as much as 60 miles, or 100 kilometers) and be as far as one hour apart. They are able to cross entire oceans without great loss of energy. The Indian Ocean tsunami traveled as much as 3,000 miles (nearly 5,000 kilometers) to Africa, arriving with sufficient force to kill people and destroy property.
- Where the ocean is deep, tsunamis can travel unnoticed on the surface at speeds up to 500 miles an hour (800 kilometers an hour), crossing an ocean in a day or less. Scientists are able to calculate arrival times of tsunamis in different parts of the world based on their knowledge of water depths, distances, and when the event that generated them occurred.
- A tsunami may be less than a foot (30 centimeters) in height on the surface of the open ocean, which is why they are not noticed by sailors. But the powerful shock wave of energy travels rapidly through the ocean as fast as a commercial jet. Once a tsunami reaches shallow water near the coast, it is slowed down. The top of the wave moves faster than the bottom, causing the sea to rise dramatically.
- Geological features such as reefs, bays, river entrances, and undersea formations may dissipate the energy of a tsunami. In some places a tsunami may cause the sea to rise vertically only a few inches or feet. In other places tsunamis have been known to surge vertically as high as 100 feet (30 meters).
- Most tsunamis cause the sea to rise no more than 10 feet (3 meters). The Indian Ocean tsunami of December 2004 caused waves as high as 30 feet (9 meters) in some places, according to news reports. In other places witnesses described a rapid surging of the ocean.
- Flooding can extend inland by a thousand feet (300 meters) or more. The enormous energy of a tsunami can lift giant boulders, flip vehicles, and demolish houses. Knowledge of the history of tsunamis in your area is a good indicator of what is likely to happen in a future tsunami event.
- Tsunamis do not necessarily make their final approach to land as a series of giant breaking waves. They may be more like a very rapidly rising tide. This may be accompanied by much underwater turbulence, sucking people under and tossing heavy objects around. Entire beaches have been stripped away by tsunamis.
- Many witnesses have said a tsunami sounds like a freight train. The 2004 Indian Ocean tsunami could rank as the most devastating on record. More than 200,000 people lost their lives, many of them washed out to sea.

How Often do Tsunami occurs?

- On the average, there are two tsunamis per year in the Pacific Ocean somewhere, which cause damage near the source.
- Approximately every 15 years a destructive tsunami occurs in Pacific.

- The destructive tsunami on Dec 26th, 2004 on the Indian Coast in terms of its impact seems to have occurred for the first time in the history.

Warning Signs

- An earthquake is a natural tsunami warning. If you feel a strong quake do not stay in a place where you are exposed to a tsunami. If you hear of an earthquake be aware of the possibility of a tsunami and listen to the radio or television for additional information. Remember that an earthquake can trigger killer waves thousands of miles across the ocean many hours after the event generated a tsunami.
- Witnesses have reported that an approaching tsunami is sometimes preceded by a noticeable fall or rise in the water level. If you see the ocean receding unusually rapidly or far it's a good sign that a big wave is on its way. Go to high ground immediately.
- Many people were killed by the Indian Ocean tsunami because they went down to the beach to view the retreating ocean exposing the seafloor. Experts believe that a receding ocean may give people as much as five minutes' warning to evacuate the area.
- Remember that a tsunami is a series of waves and that the first wave may not be the most dangerous. The danger from a tsunami can last for several hours after the arrival of the first wave. A tsunami wave train may come as a series of surges that are five minutes to an hour apart. The cycle may be marked by a repeated retreat and advance of the ocean.
- Stay out of danger until you hear it is safe. Survivors of the Indian Ocean tsunami reported that the sea surged out as fast and as powerfully as it came ashore. Many people were seen being swept out to sea when the ocean retreated.
- A tsunami surge may be small at one point of the shore and large at another point a short distance away. Do not assume that because there is minimal sign of a tsunami in one place it will be like that everywhere else.
- Tsunamis can travel up rivers and streams that lead to the ocean. Stay away from rivers and streams that lead to the ocean as you would stay away from the beach and ocean if there is a tsunami.
- It's always a good idea to keep a store of emergency supplies that include sufficient medications, water, and other essentials sufficient for at least 72 hours. Tsunami, earthquake, hurricane—an emergency can develop with little or no warning.

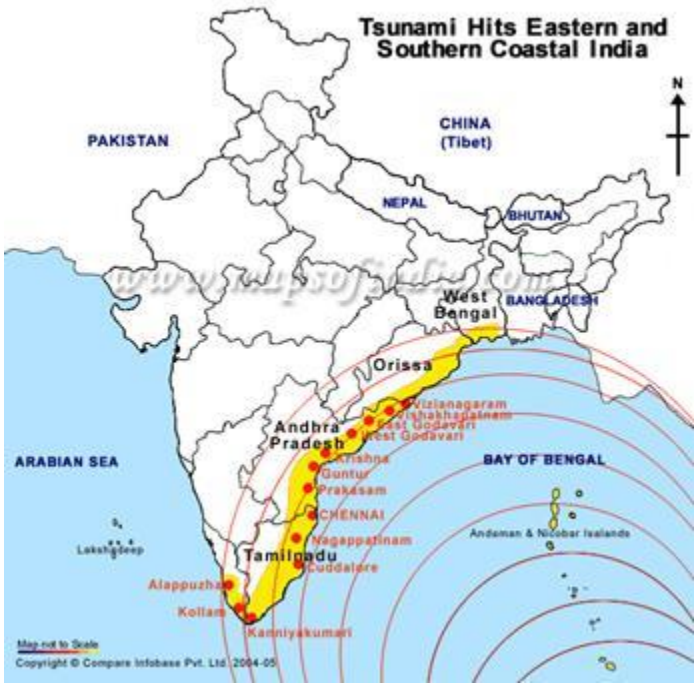
Specific Measures for safety from Tsunamis/Storm Surges

Structural measures:

1. Construction of cyclone shelters
2. Plantation of mangroves and coastal forests along the coast line
3. Development of a network of local knowledge centers (rural/urban) along the coast lines to provide necessary training and emergency communication during crisis time (e.g. centers developed by M.S. Swaminathan Foundation in Pondicherry).
4. Construction of location specific sea walls and coral reefs in consultation with experts
5. Development of well designed break waters along the coast to provide necessary cushion against cyclone and tsunami hazards.
6. Development of tsunami detection, forecasting and warning dissemination centres.
7. Development of a “Bio-Shield” - a narrow strip of land along coastline. Permanent structures, if any in this zone with strict implementation of suggested norms. Bio-Shield can be developed as coastal zone

disaster management sanctuary, which must have thick plantation and public spaces for public awareness, dissemination and demonstration.

8. Identification of vulnerable structures and appropriate retrofitting for tsunami/cyclone resistance of all such buildings as well as appropriate planning, designing, construction of new facilities like:
    a. Critical infrastructures e.g. power stations, warehouses, oil and other storage tanks etc. located along the coastline.
    b. All other infrastructure facilities located in the coastal areas.
    c. Public buildings and private houses
    d. All marine structures
    e. Construction and maintenance of national and state highways and other coastal roads



Non-Structural Measures:

1. Strict implementation of the coastal zone regulations (within 500 m of the high tide line with elevation of less than 10 m above mean sea level).
2. Mapping the coastal area for multiple hazards, vulnerability and risk analysis upto taluka /village level. Development of Disaster Information Management System (DIMS) in all the coastal states.
3. Aggressive capacity building requirements for the local people and the administration for facing the disasters in wake of tsunami and cyclone, 'based on cutting edge level'.
4. Developing tools and techniques for risk transfer in highly vulnerable areas.
5. Launching a series of public awareness campaign throughout the coastal area by various means including AIR, Doordarshan & Other Media.
6. Training of local administration in forecasting warning dissemination and evacuation techniques.
7. Awareness generation and training among the fishermen, coast guards, officials from fisheries department and port authorities and local district officials etc., in connection with evacuation and post tsunami storm surge management activities. Regular drills should be conducted to test the efficacy of the DM plans.

8. Studies focusing on the tsunami risk in India may be taken under NCRM project.

Actions Required in Coastal Areas for Protection against Tsunami / cyclone mitigation

To achieve the satisfactory level of disaster mitigation in coastal areas, following activities need to be carried out.

- Revision of Coastal Zone Regulation Act in wake of tsunami storm surge hazards and strict implementation of the same. The current Coastal Regulations Zone (extract) is attached as Appendix A to this chapter. This responsibility may be given to respective state disaster management authorities. A special task force for this purpose may be constituted comprising the representatives from various departments of the government and other relevant organizations (e.g. Departments of Forestry, Fisheries, Soil Conservation, Town and Country Planning Organization, Navy, Coast Guard, IMD, ISRO/DOS etc.)
- A state of the art EOC may be established with in the authority for monitoring purpose.
- Initiating disaster watch (bay watch) safety measures along important beaches in the country, providing round the clock monitoring, warning, lifeguard facilities & creation of website for missing personal etc.
- Organization of sensitization workshops on cyclone/tsunami risk mitigation in various states for senior bureaucrats / politicians for these states.
- Organizing drills on regular basis to check the viability of all plans and to check the readiness of all concerned.
- Training of professionals, policy planners and others involved with disaster mitigation and management programmes in the states.
- Retrofitting of important buildings
    - Fire stations / police stations/ army structures/ hospitals.
    - VIP residences / offices/ railways, airport, etc.
    - Schools/colleges
    - Hazardous industries
    - Other critical structures (i.e. power stations, warehouses, oil and other storage tanks etc).
- Designing incentives: Providing legislative back up to encourage people to adopt cyclone, tsunami resistant features in their homes e.g. tax rebate in terms of house tax and/or income tax.
- Developing public –private partnerships.

WHAT ELSE CAN BE DONE?

1. Disaster Management Information System must be built in every district of the country linked with each other, available on the web and also in public libraries. We should know where are the inventories available of critical equipments, skills, resources and information and how can one access them on voluntary or payment basis. The database of various services and infrastructure in private, public and voluntary sectors should be updated regularly. Every college should take responsibility for collecting and updating information about certain categories of services or equipments. Simple information such as about ham radio operators can be put on the web without fail.

2. Just as we have national services scheme, we must now think of national disaster management volunteers who would receive training and be empowered to organize themselves as effective teams for helping local communities around them. No amount of state help can substitute for community based structures for self help. Supreme Court had passed judgments and given advice for starting courses on disaster management in various educational institutions. Have we ever monitored how many such courses exist and what quality of preparedness has been achieved?

3. The major tragedy will begin when the media will get interested in new issues, fight among some other politicians or corporate games. Resources would be required for repairing and building the primary school buildings, primary health centres, livestock, clinics, tree climbing devices for palm workers, herbal and other medicines, mat making machines, and machines which can use materials from damaged trees and bio waste, old bamboo scrap, processing machine for various edible and non-edible oilseeds, etc. A proper rehabilitation plan will have to be built for each village affected by the disaster with proper accountability structure. The accounts of every investment must be made public and people should be able to know how much funds were mobilized by which NGO or government agency and how were they used for the purpose.

4. In cases where fishing communities or island based indigenous / tribal communities have been affected very severely, long term rehabilitation plans have to be initiated. These plans must learn from the mistakes made in earlier rehabilitation projects.

5. There is very important need to document the experience of the damage caused and ensuing suffering along with the coping strategies of local communities and administration. Some novel lessons would emerge.

6. One of the major problems in relief is that what is needed where is often not known to the people who want to provide support. The result is that lot of materials get wasted or misdirected. We need to put a spreadsheet immediately on the web pointing out village wise needs, contact persons' names and addresses so that civil society efforts can be targeted more efficiently. We had tried to put an inventory management system in place after Gujarat earthquake with the help of our students and faculty. The students had stacked the relief material received from all over the country in Kutchh and given assorted sheets to the Relief Commissioner. Where we failed was to link this system with GIS so that one could track the deliveries, collect the response and also avoid pilferages. It will be useful if some of the IT firms in Chennai would volunteer to create such a GIS so that people can update the demand and supply information and every unit of material is optimally utilized.

7. The psychological rehabilitation is no less important. The children affected the by the shock and tragedy are particularly vulnerable. The arrangements for adoption of orphan children with proper community care have to be put in place.

8. It is very disheartening to hear that in large number of cases of dead people, the Public Health authorities have been reportedly hesitant in maintaining proper records. It might save the state and central governments some money from the compensation fund but it would certainly inflict damage on the social conscience of the society. If the rehabilitation funds reach late, they are as good as not given. Unless central government ensures delivery of compensation through community control systems within next 24 hours, the fairness in the system will become more and more difficult to achieve with every passing day. While we still need immediate help, the long term rehabilitation must be simultaneously planned.

LANDSLIDE HAZARD—An Introduction

Humans have had to face the impact of natural hazards from time immemorial. Natural hazards such as earthquakes, landslides, avalanches, floods, cyclones, droughts, and volcanic eruptions of varying magnitudes have repeatedly been the cause of calamities. According to statistics, natural hazards are believed to account for up to 4 per cent of the total annual deaths world-wide, besides causing enormous economic losses and uprooting habitation. It has also been observed that casualties resulting from natural hazards are not evenly distributed throughout the world, but are more concentrated in developing countries, partly due to their higher population densities and lack of preparedness.

Landslides form a significant component of the natural disasters that affect most of the hilly regions round the globe. Recent studies on global landslide disasters indicate that some of the highest risk landslide disaster zones are located in Colombia, Tajikistan, India, China, and Nepal where the estimated number of people killed per year per 100 sq. km area was found to be more than one. Historical records indicate that the highest number of lives lost to a single landslide event were in the earthquake-triggered landslide disaster in Kansu Province of China in 1920. Another well known landslide event of the last century was an earthquake-triggered debris avalanche in 1970 on the slopes of Mt. Huascaran, Peru, which advanced with an average speed of 320 km/hr, burying the towns of Yungay and Ranrahirca, killing more than 18,000 people. Similarly, in Europe, the 1963 Vaiont reservoir slide in North-Eastern Italy, resulted in the death of 2,000 people.

Although the term landslide in the strict sense may be defined as a process involving the downward and outward movement of a part of the slope forming material due to the action of gravity, other forms of mass movements like falls, flows, topples and creeps are generally included in the term landslides. This document also considers snow avalanches as within the ambit of landslide management**.**

Landslide Vulnerability and Risk in India

India's vulnerability to landslides is seen in the threat of landslides to our housing and infrastructure, farms and fields, vast stretches of border roads and railway lines, hydro-electric and water supply installations, transmission line projects, aerial ropeways, open cast mines, tunnels, heritage buildings and monasteries, pilgrim routes, and tourist spots. Having defined the terms landslide hazard, vulnerability, and risk, it follows that the scientific approach to dealing with the perceived threat is to first establish landslide hazard and vulnerability scenarios for reliable risk analyses.

Vulnerability to landslides can be evaluated only if we know the exposure to landslide hazard and our preparedness to face that hazard. Vulnerability will be close to nil in the case of well managed and protected slopes. It will be the maximum for unprepared populations living on slopes with a proven history of landslides. This vulnerability to landslides can be reduced by creating a culture of safety through careful land use planning, timely and appropriate engineering intervention, conscientious maintenance of slopes and connected utilities, early warning, public awareness, and preparedness. We need to develop a culture of quick response to managing disasters to reduce the impact of landslide disasters.

Landslides are a natural hazard that affect at least 15 per cent of the land area of our country, covering an area of more than 0.49 million sq. km. Landslides of different types occur frequently in the geo-dynamically active domains in the Himalayan and North-Eastern parts of the country as well as relatively stable domains in the Western Ghats and Nilgiri hills in the Southern part of the country. Besides, sporadic occurrences of landslides have been reported in the Eastern Ghats, Ranchi Plateau, and Vindhyan Plateau as well. In all, 22 States and parts

of the Union Territory of Pudducherry and Andaman & Nicobar Islands of our country are affected by this hazard, mostly during the monsoons.

The Himalayan mountain ranges and hilly tracts of the North-Eastern region are highly susceptible to slope instability due to the immature and rugged topography, fragile rock conditions, high seismicity resulting from proximity to the plate margins, and high rainfall. Extensive anthropogenic interference, as part of developmental activities, is another significant factor that increases this hazard manifold. As a result, the landscape in the Himalayan and North-Eastern regions is highly susceptible to reoccurrence of landslides. The Ambutia landslide, located on the picturesque tea garden clad hill slopes around the Kurseong town in Darjeeling is probably the largest such landslide in Asia.

Similarly, the Western Ghats, overlooking the Konkan coast, though located in a relatively stable domain, experience the fury of this natural hazard due to steep hill slopes, overburden and high intensity rainfall. The Nilgiri hills located at the convergence zone of the Eastern Ghats and the Western Ghats bear the innumerable scars of landslides due to their location in a zone of high intensity and protracted rainfall where overburden is sensitive to over-saturation.

There are more than 25 river dam projects on the river Ganga and its tributaries in the hills alone. A number of tunnels and towers for microwave, television, and power transmission dot the hilly areas. Quarrying and mining, for example, in the Doon valley, Jhiroli (Almora) and Chandhak (Pithoragarh) have inflicted heavy damages to the slopes and the associated environment.

IMPACTS

Landslide disasters have both short-term and long-term impact on society and the environment. The short-term impact accounts for loss of life and property at the site and the long-term impact includes changes in the landscape that can be permanent, including the loss of cultivable land and the environmental impact in terms of erosion and soil loss, population shift and relocation of populations and establishments.

Like in any other disaster, the most affected are the socio-economically weaker sections of the society who inhabit the vulnerable areas. They have meagre sources of livelihood, which when wiped out by a hazard, leaves them without any food or shelter. Apart from this, the injuries and casualties suffered add to the woes of the affected families. The biggest loss is that of private and government property, as well as damage to/destruction of infrastructure and heritage structures.

The frequent obstructions caused to the movement of traffic by numerous landslides during the rainy season, sometimes for days together, particularly in the Himalayan and North-Eastern regions of the country, bring untold misery to the people inhabiting the villages and townships in the landslide-prone hilly regions.

Landslides also reduce the effective life of, and returns from hydroelectric and multipurpose projects by adding an enormous amount of silt load to the reservoirs.

Landslide dams result in the flooding of large upstream areas. Further, if the dam fails, it causes flooding and large-scale devastation in downstream areas. Also, solid landslide debris can ‘bulk’ or add volume and density to otherwise normal stream flow or cause channel blockages and diversions creating flood conditions or localised erosion. Landslides can also cause overtopping of dams resulting in flash floods and/or reduced capacity of reservoirs to store water.

Landslide Management in India

Landslide hazard management in India had till now been confined to ad-hoc solutions of site specific problems and the implementation of immediate remedial measures including debris removal, and dumping of this debris either down slope or into a river. The aim of these Guidelines is to manage landslide hazard through an institutional mechanism, by following a systematic approach that includes both short-term and long-term planning after a study of the hazard, vulnerability and risk assessment.

Landslide hazard management involves measures taken to avoid or mitigate the risk posed by landslide hazards. The most important role in this process is played by the local government machinery. Once information is received about the probability of landslide occurrence within its jurisdiction, it initiates steps to warn the communities living in the area about the risk involved and tries to convince landowners/ dwellers to shift to safer places. Moreover, further development is avoided in such high risk zones. Mitigation strategies might not be possible in every landslide hazard prone area both due their high cost and the indifferent attitude of the public. Efforts to reduce risk are also made by road construction and maintenance agencies by implementing required treatment measures.

Government Policies and Initiatives

- The Government of India (GoI) has been quite concerned about the management of natural calamities since a long time. The task of Disaster Management (DM) was earlier entrusted to the Ministry of Agriculture (MoA) since only droughts and floods were considered major national natural calamities. Here too, the main focus was on post-disaster response i.e., conducting relief operations in the affected areas.
- The devastating Malpa tragedy resulting from a landslide that occurred along the Kailash Mansarovar route in the Kumaon Himalayan region in August 1998 acted as an eye-opener for the GoI as far as landslide disasters are concerned. It decided to set up task forces for Landslide Hazard Zonation (LHZ), Geotechnical Investigations and Land Use Zonation and Regulation. The Geological Survey of India (GSI) was identified as the nodal agency for LHZ while the Department of Science and Technology (DST) and the Ministry of Environment and Forests (MoEF) were identified as nodal agencies for the other two task forces, respectively. Consequently, the Department of Mines (DoM) constituted a task force to review the existing methodologies for LHZ study, to prioritise areas/belts for its study and to recommend a plan for the preparation of macro/meso/micro LHZ maps.
- There are many government departments and organisations which are engaged in landslide hazard studies and hazard management in the country. These include the GSI, Central Road Research Institute (CRRI), Central Building Research Institute (CBRI), Indian Institute of Technology, Roorkee (IIT-R), Wadia Institute of Himalayan Geology (WIHG), Department of Space (DoS), National Remote Sensing Centre (NRSC), Defence Terrain Research Laboratory (DTRL), Bureau of Indian Standards (BIS), some academic institutions, and individual experts. The Snow and Avalanche Study Establishment (SASE) under the Ministry of Defence (MoD) is the institution engaged in studying snow avalanches. In addition, the Border Roads Organisation (BRO) is the principal agency responsible for the construction and maintenance of roads in almost all the hilly regions of the country and DST has been funding Research and Development (R&D) activities that include different types of landslide investigations.
- The CRRI's major activities include geological and geotechnical investigations of landslides, landslide hazard potential and risk analysis, instrumentation, monitoring, and prevention of landslides. The CRRI has published reports on landslide correction techniques, application of geo-textiles, deep trench drains,

and promotion of jute based geo-textiles, etc. The CRRI has also prepared a partial database of over 200 landslides in different parts of the country.

- The Central Scientific Instrumentation Organisation (CSIO), a national instrumentation laboratory, has installed an instrumentation network for landslide monitoring at Mansa Devi, Haridwar in 2006.
- The Landslide Hazard Atlas of India containing small scale maps was published jointly by the Building Materials and Technology Promotion Council (BMTPC) and Anna University in 2004.
- In collaboration with the International Centre for Geohazards and the Norwegian Geotechnical Institute, the DST is establishing a National Geotechnical Facility (NGF) in Dehradun. The NGF aims to have state-of-the-art facilities in geotechnical sciences and to provide a platform for building capacities in geotechnical investigations and research. This will also help in networking the institutions within the country which have facilities and technical manpower. It is expected that the NGF will provide inputs for DM related activities in designing/retrofitting underground and surface level structures.
- The Central Water Commission (CWC) has been the lead agency for assessing the hazard potential of landslide dams in the country and its vicinity.

THE SNOW AVALANCHE HAZARD

Introduction

The snow avalanche, a common occurrence in snow covered mountainous regions, is a slide of snow mass down a mountainside. This is a rapid downslope movement of a large detached mass of snow, ice, and associated debris such as rocks and vegetation. Small avalanches, or sluffs, occur in large numbers, while large avalanches that may encompass slopes a kilometre or more in length with millions of tons of snow, occur infrequently but cause most of the damage. Humans have been exposed to the threat of sliding snow for as long as they have inhabited mountainous regions. A large avalanche can run for many kilometres, and result in massive destruction of forests and anything else that comes in its way. These threats are felt in the Indian context as well. Most recently, snowfall of up to 2m occurred at many places on the higher reaches of the Pir Panjal range between 16–20 February 2005, resulting in avalanches at several places in Anantnag, Doda, Poonch, Pulwama, and Udhampur districts of Jammu and Kashmir. Over 300 people lost their lives.

Types of Avalanches

There are two basic types of avalanches, loose snow avalanches and slab avalanches. These are further sub-divided according to whether the snow involved is dry, damp or wet, whether the snowslide originates in a surface layer or involves the whole snow cover (slides to the ground), and whether the motion is on the ground, in the air, or mixed.

Loose snow avalanches form in snow masses with little internal cohesion among the individual snow crystals. When such snow lies in a state of unstable equilibrium on a slope steeper than its natural angle of repose, a slight disturbance sets progressively more and more snow in downhill motion. If enough momentum is generated, the sliding snow may run out onto level ground, or even ascend an opposite valley slope. Such an avalanche originates at a point and grows wider as it sweeps up more snow in its descent. The demarcation between sliding and undisturbed snow is diffuse, especially in dry snow. Though very common, most dry, loose snow avalanches are small and few achieve sufficient size to cause damage. With the onset of melting, wet loose snow avalanches become common. Most of the latter, too, are small, but they are more likely to occasionally reach destructive size, especially when confined to a gulley.

Slab avalanches originate in snow with sufficient internal cohesion to enable a snow layer, or layers, to react mechanically as a single entity. The degree of this required cohesion may range from very slight in fresh, new snow (soft slab) to very high in hard, wind drifted snow (hard slab). A slab avalanche breaks free along a characteristic fracture line, a sharp division of sliding from stable snow whose face stands perpendicular to the slope. The entire surface of unstable snow is set in motion at the same time, especially when the cohesive snow lies on top of a weak layer. 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. The mechanical conditions leading to slab avalanche formation are found in a wide variety of snow types, new and old, dry and wet. They may be induced by the nature of snow deposition (wind drifting is the prime agent of slab formation), or by internal metamorphism. Slab avalanches are often dangerous, unpredictable in behaviour, and account for most of the damage.

Avalanches composed of dry snow usually generate a dust cloud when the sliding snow is whirled into the air. Such slides, called powder snow avalanches, most frequently originate as soft slabs. Under favourable circumstances, enough snow crystals are mixed with the air to form an aerosol which behaves as a sharply bounded body of dense gas rushing down the slope ahead of the sliding snow. This wind blast can achieve high velocities, to inflict heavy destruction well beyond the normal bounds of the avalanche path.

Wet snow avalanches move more slowly than dry ones and are seldom accompanied by dust clouds. Their higher snow density can lend them enormous destructive force in spite of lower velocities. As wet slides reach their deposition zones, the interaction of sliding and stagnated snow produces a characteristic channelling. Direct action avalanches are the immediate result of a single snow storm. They usually involve only fresh snow. Climax avalanches are caused by a series of snow storms or a culmination of weather influences. Their fall is not necessarily associated with a current storm or weather situation.

Causes of Snow Avalanches

Avalanches form as soon as the force of gravity on the snow cover exceeds its mechanical strength. To be caused, an avalanches needs a steep slope, snow cover, a weak layer in the snow cover, and a trigger to initiate movement. Snow avalanches may occur on any slope where enough snow is deposited in the right circumstances. Snow does not accumulate significantly on steep slopes; also, snow does not flow easily on flat slopes. Most avalanches of dangerous size therefore originate on slopes with inclinations of between 30 degrees and 45 degrees. On slopes from 45 degrees to 50 degrees, sluffs and small avalanches are common, but snow seldom accumulates to sufficient depths to generate large snow slides. Convex slopes are more susceptible to avalanches than concave slopes.

Avalanches are released (spontaneously or artificially) by an increase in stress (e.g., by fresh snow) and/or a decrease in strength (e.g., by warming or rain). Though internal metamorphism or stress development may sometimes initiate a snow rupture, avalanches are often dislodged by external triggers. Ice fall, falling cornices, earthquakes, rock falls, thermal changes, blizzards, and even other avalanches are common natural triggers. Avalanches can also be triggered by loud sounds such as shouts, machine noise, and sonic booms. In the absence of external triggers, unstable snow may revert to stability with the passage of time as long as no avalanche occurs. The rheology of snow cover is similar to that of ice as both are visco-elastic materials that exhibit creep behaviour over time. Snow deforms continually without fracturing as the load on top of it increases. However, the loading rate is critical. Heavy snow fall over a short duration leads to a greater probability of avalanche occurrence. A snow fall of 1m in one day is far more hazardous than 1m over three days.

The complete path of an avalanche is made up of a starting zone at the top where the unstable snow breaks away from the more stable part of the snow cover, a run-out zone at the bottom where the moving snow and entrained debris stop, and a track that runs between the two zones. The air blast zone is usually in the vicinity, but not necessarily continuous with the lower track or run-out zone. In some cases it may even run way up the slope across the valley from the avalanche path.

In general the run-out zone is the critical area for land use decisions because of its otherwise attractive setting for development. Avalanches run on the same paths year after year, the danger zones often being well known in normal circumstances. Exceptionally uneventful weather intervals lasting for many years may produce exceptional avalanches which overrun their normal paths and even break new ones where none existed for centuries. Avalanche prone lands may pass many winters or even decades without a serious avalanche.

Avalanches are not confined to specific terrain features: they may follow narrow gullies or ravines for all or a part of their path, they may occur on broad, uniform slopes or even ridges and spurs. The longitudinal profiles of the paths may be concave, convex, or stepped. On stepped paths, small avalanches will often stop on a bench some distance down the tract while larger ones will run the full length of the path.

The Impact of Snow Avalanches

The forces generated by moderate or large avalanches can damage or destroy most manmade structures. The debris from even small avalanches is enough to block a highway or rail-road. Avalanches are extremely destructive due to the great impact forces of the rapidly moving snow and debris and the burial of areas in the run-out zone. Structures not specifically designed to withstand these impacts are generally totally destroyed. Where avalanches cross highways, passing vehicles can be swept away and destroyed, killing their occupants.

In general, land use within an avalanche area should not include buildings intended for winter and early spring occupancy. Ordinarily, use of avalanche areas in the summer does not constitute any hazard. Structures including power lines, highways, railroads, and other facilities that are placed in avalanche paths and run-out zones should be designed for expected impact even if other preventive measures are implemented.

Early Warning Systems against Snow Avalanche Hazards

There are two basic methods of anticipating an avalanche hazard. One is the examination of the snow cover structure for patterns of weakness, particularly those leading to slab avalanches. The second method is the analysis of the meteorological factors affecting snow depositions. In practice the two methods overlap and both are used. Emphasis on either one or the other depends on the local climate, pattern of snowfall, snow type, and avalanche characteristics. Both apply principally to winter avalanches in dry snow. Forecasting wet spring avalanches depends on knowledge of the heat input to the snow surface.

Rising temperature during a storm accompanied by rising new snow density tends to cause avalanching, while falling temperatures have the opposite effect. New snow precipitation intensity is a significant factor, as it represents the rate at which the slopes are being overloaded.

Wet snow avalanches are generated by the intrusion of percolating water (rain or snow melt) in the snow cover. The rapid rise in temperature quickly alters snow behaviour, while the water itself reduces snow strength. Water accumulating on an impervious crust provides an especially good lubricating layer for slab release. The most extensive wet snow avalanching occurs during winter rains or the first prolonged melt period in spring, when

water intrudes into previously subfreezing snow. Snowmelt due to solar radiation is the most common cause of wet snow avalanches.

Snow cover, terrain and atmospheric parameters are the major inputs for forecasting of snow avalanches. It is difficult to obtain the required information from the remote regions of the Himalayas using conventional ground based techniques, as there are several limitations due to the inaccessibility and ruggedness of the terrain, the lack of infrastructure facilities, and limited information on the region. Satellite remote sensing is the most efficient tool for these purposes, especially for large, rugged, and remote areas. For gathering the latest terrain information on avalanche-prone areas, snow cover and atmospheric parameters, optical [MODIS, AVHRR, AWiFS, WiFS, LISS-III, PAN, Cartographic Satellite (CARTOSAT), IKONOS, Quickbird] and microwave (AMSR-E, SSM/I, Radarsat, ENVISAT) imagery can be used. The latter is useful in weather conditions where cloud cover obstructs remote observation by other means.

Avalanche Control Strategies

The need for study of snow bound areas has increased manifold with the increasing necessity of developing communication routes, development of winter tourism, construction of hydroelectric projects and transmission lines in snow bound areas. Snow avalanches have long posed a threat to the indigenous populations of the Himalayan and Trans-Himalayan mountains. Land use intensification due to population growth, new transportation routes, defence related activities and tourism are raising this level of risk.

Obviously, the most desirable and effective protection against avalanches is to situate buildings, roads, and other valuable developmental projects in areas free from avalanches. However, as the population grows and more hazardous sites are considered for development, advanced planning and strictly enforced zoning and construction practices appear to be the best solutions. In some cases, even these are not adequate to completely eliminate the risk of avalanches, and acceptable risks must be defined, especially in the case of roads, power lines and railroads. These risks can, however, be reduced considerably if appropriate structural controls are employed.

Since avalanche prone areas can be identified, the safest and probably best mitigation procedure is to avoid construction of buildings or any type of structure involving winter use in these areas. Agricultural and recreational activities that take place during the non-avalanche months are relatively safe. Other uses that could be considered are those that do not involve permanent unprotected structures in the avalanche path or those that could be moved or closed down during high avalanche-risk periods.

Methods of avalanche control include structural terrain modification to deflect the sliding snow away from the fixed facilities to be protected, or to actually prevent the avalanche release, and the planned release of small snow slides with explosives before snow accumulation increases their destructive potential to unmanageable proportions.

Explosive techniques have been used for the deliberate release of avalanches for many years. The theory behind this technique is to cause many smaller, controlled avalanches and thus avoid large unpredictable destructive avalanches. Explosive control has been very effective in areas with easy access to avalanche starting zones and ones that can tolerate many small snow slides without causing damage. Detailed information in the form of an inventory on current and past snow-packs and avalanche conditions should be made available for this technique to be safe and effective. However, explosive control may be unfeasible in areas with human habitation.

Engineering structures for the control of snow avalanches are of the following four types:

i. Supporting structures in the starting zone built on the upper part of the avalanche path to prevent avalanches from initiating, or to retard movement before it gains momentum. Massive earth or stone walls and terraces; rigid structures made from wood, steel, aluminium, prestressed concrete, or a combination of these materials; and flexible supporting structures called 'snow nets' constructed of steel cables or nylon straps and held up by steel poles, are examples of these.
ii. Deflecting and retarding structures in the run-out zone to keep the moving snow of an avalanche away from structures in critical locations. These are massive structures usually made of earth, rock, or concrete located in or near the avalanche track or run-out zone.
iii. Retarding structures are usually earth mounds or large concrete structures called breakers or tripods. The additional roughness and cross currents set up by these structures usually stop all but large, dry snow avalanches.
iv. Direct protection structures are built immediately adjacent to the object to be protected, or in a few cases, incorporated into the design of the object itself. Avalanche sheds or shelters are merely roofs over roads or railroads that allow avalanches to cross the road/railroad without interrupting or threatening the traffic.

In actual practice it is common for many different types of structures to be used on a single path.

In India, the responsibility of dealing with the different aspects of avalanches rests with the SASE. The BRO, with a vast network of roads in the high altitude snow-bound areas of Leh in Jammu and Kashmir, Sikkim, Arunachal Pradesh, Himachal Pradesh, and Uttarakhand, plays a major role in the operation of snow-avalanche clearance. The BRO strives to keep vital lines of communication open in these snow-bound regions through a slew of measures like the use of modern snow cutting equipment/snow cutters/snow sweepers, conventional dozers, experienced work-force, total station survey instruments, etc.

The SASE and BRO are responsible for the identification and monitoring of snow avalanches. The SASE will be responsible for the zonation of avalanche prone areas and the forecasting of snow avalanches. Central and state governments in association with the BRO will be responsible for implementing clearance and control strategies against identified snow avalanches.

Government Initiatives:

Consultations were initiated by the NDMA for the development of Guidelines for the coordinated and systematic management of landslide hazard. The main objective of the Guidelines on Landslides and Snow Avalanches is to generate awareness of the various aspects of the landslide hazard in India and to suggest suitable action to reduce both— the risks and costs associated with this hazard. Accordingly, the Guidelines envision an improved administrative response, bringing together the relevant scientific, engineering, construction, planning, and policy capabilities of the Nation to eliminate losses from landslides and other ground failure hazards.

The long-term mission of these Guidelines is to develop a strategy that encourages the use of scientific information, maps, methodology, and guidance for emergency management, land use planning, development, and implementation of public and private policy to reduce losses from landslides and other ground failure hazards. It is also important for the strategy to define the role of local, state and national level bodies in combating this hazard. In addition, the Guidelines describe the required government policies at the national and state levels, institutional arrangements, financial arrangements, and planning for safe national development.

While a good deal of work has already been done to improve management of landslides and snow avalanches, there are many areas which require special focus and emphasis in the future. Important among these are:

i. Hazard Zonation Mapping.
ii. Geological and Geotechnical Investigation.
iii. Landslide Risk Treatment.
iv. Monitoring and Forecasting of Landslides.
v. Regulation and Enforcement.
vi. Awareness and Preparedness.
vii. Capacity Development.
viii. Response.
ix. Research and Development.
x. Implementation of the Guidelines— Preparation of Landslide Management Plans.

BMTPC – ATLAS

In order to bridge the gap between research and development and large scale application of new building material technologies, the erstwhile Ministry of Urban Development, Government of India, had established the BUILDING MATERIALS AND TECHNOLOGY PROMOTION COUNCIL in July 1990.

The Council strives to package proven innovative technologies for the benefit of entrepreneurs interested in setting up manufacturing units in tiny, small, medium and large scale sectors.

There has been a demand for setting up such an apex institution in order to provide an inter-disciplinary platform to various agencies under Central and State Governments and the private sector for scaling up proven technologies to enhance their wide-spread use and for assisting commercial production as well as systematic dissemination of appropriate technology for the benefit of the construction of appropriate technology for the benefit of the construction agencies and different sections of the population.

The Council is structured to undertake the task of the extension and application of technologies and materials developed by research institutions on the ground with the backing of financial institutions and enabling regulatory environment.

Hon'ble Prime Minister, Shri Narendra Modi, released the Third Edition of Vulnerability Atlas of India on the occasion of Global Housing Technology Challenge - India (GHTC-India), Construction Technology India 2019 Expo-cum-Conference on 2nd March, 2019 at New Delhi.

The third edition of Vulnerability Atlas of India, brought out by BMTPC, is collation of the existing hazard scenario for the entire country and presents the digitized State/UT-wise Hazard Maps with respect to Earthquakes, Winds & Floods for district-wise identification of vulnerable areas. This edition contains additional digitized maps for Thunderstorms, Cyclones and Landslides.

The Atlas also presents the district-wise Housing Vulnerability Risk Tables based on wall types and roof types as per 2011 Census Housing data. The Atlas is a useful tool not only for public but also for urban managers, State & National Authorities dealing with disaster mitigation and management.

Note: Dear Students,

Most of the topics are covered in these notes provided by me. If by chance any topic is left, let me know & you also have a look of that topic in books or internet.

These are detailed notes. Study thoroughly and practice writing them.

Don't be over confident that we know DM & it is an easy subject. Mostly students fails in this subject, just because of their over confident.

UNIT 4 – MAN-MADE DISASTERS

Topics: Use of remote sensing & GIS in Disaster Mitigation & Management; Chemical & Industrial Hazard; causes & factors, pre & post disaster measures, control; Indian Standard Guidelines & Compliance; fire hazards: Classification as per Indian Standards, Fire risk assessment; escape routes, fire fighting equipments, classification of buildings, fire zones, occupancy loads, capacity & arrangements of exits.

Use of remote sensing & GIS in Disaster Mitigation & Management:

Remote sensing is the science of collecting information about the object, area or phenomenon without making any physical contact with the object. Humans with noses, eyes and ears are constantly smelling, sensing and hearing things from their surroundings. So they also have the quality of remote sensing. In order to study the areas, object or phenomenon on the surface of the earth, which is commonly known as target, remote sensing is the most popular technique.

Conventionally, remote sensing detects the features of the earth's surface by analyzing and interpreting the multispectral electromagnetic radiations emitted or reflected by the surface of the earth. For analyzing these different wavelengths, scanners are used, which is situated at various platforms like aircrafts, satellites etc.

GIS: Geography has played a vital role and develops civilizations from Stone Age to modern days. Geographical information in the form of spatial database has served the human society for their advancement. The discoveries, planning for better living and in fact the modern civilization has achieved much by using the knowledge of abstract geography.

GIS refers to the system used to define and characterize the earth and other geographical features over it, for the purpose of analyzing spatially referenced information. The information acquired is used to solve real-life problems. The use of spatial data in real life involves data acquisition, storage, manipulation, maintenance and output. The location of important spatial information such as mountains, hills, river flows etc., accompanied with attributes like their sizes, heights, areas, velocity of flow simultaneously are collected by manipulation through GIS

GIS and remote sensing are incredibly useful and effective tools in disaster management. These technologies have been the object of substantial interest for all countries and bodies concerned with space and in exacting emergency services and disaster management. In disaster management, the objectives of the disaster experts are to monitor the situation, simulate the complicated disaster occurrence as accurately as possible so as to come up with better prediction models, suggest appropriate contingency plans and prepare spatial databases.

Mitigation of natural disasters can be successful only when detailed knowledge is obtained about the expected frequency, character, and magnitude of hazardous events in an area. Many types of information that are needed in natural disaster management have an important spatial component. Spatial data are data with a geographic component, such as maps, aerial photography, satellite imagery, GPS data, rainfall data, borehole data etc. Many of these data will have a different projection and coordinate system, and need to be brought to a common map-basis, in order to superimpose them.

We now have access to information gathering and organising technologies like remote sensing and geographic information systems (GIS), which have proven their usefulness in disaster management.

First of all, remote sensing and GIS provides a data base from which the evidence left behind by disasters that have occurred before can be interpreted, and combined with other information to arrive at hazard maps, indicating

which areas are potentially dangerous. The zonation of hazard must be the basis for any disaster management project and should supply planners and decision-makers with adequate and understandable information. Remote sensing data, such as satellite images and aerial photos allow us to map the variabilities of terrain properties, such as vegetation, water, and geology, both in space and time. Satellite images give a synoptic overview and provide very useful environmental information, for a wide range of scales, from entire continents to details of a few meters.

Secondly, many types of disasters, such as floods, drought, cyclones, volcanic eruptions, etc. will have certain precursors. The satellites can detect the early stages of these events as anomalies in a time series. Images are available at regular short time intervals, and can be used for the prediction of both rapid and slow disasters. Then, when a disaster occurs, the speed of information collection from air and space borne platforms and the possibility of information dissemination with a matching swiftness make it possible to monitor the occurrence of the disaster.

Natural hazard information should be included routinely in developmental planning and investment projects preparation. They should include cost/benefit analysis of investing in hazard mitigation measures and weigh them against the losses that are likely to occur if these measures are not taken. GIS can play a role at the following levels:

- National level
- State level
- District level
- Block level
- Ward or village level
- Site investigation scale

Many disasters may affect large areas and no other tool than remote sensing would provide a matching spatial coverage. Remote sensing also allows monitoring the event during the time of occurrence while the forces are in full swing. The vantage position of satellites makes it ideal for us to think of, plan for and operationally monitor the event.

GIS is used as a tool for the planning of evacuation routes, for the design of centers for emergency operations, and for integration of satellite data with other relevant data in the design of disaster warning systems

In the disaster relief phase, GIS is extremely useful in combination with Global Positioning Systems (GPS) in search and rescue operations in areas that have been devastated and where it is difficult to orientate. The impact and departure of the disaster event leaves behind an area of immense devastation. Remote sensing can assist in damage assessment and aftermath monitoring, providing a quantitative base for relief operations.

In the disaster rehabilitation phase GIS is used to organize the damage information and the post - disaster census information, and in the evaluation of sites for reconstruction. Remote sensing is used to map the new situation and update the databases used for the reconstruction of an area, and can help to prevent that such a disaster occurs again.

One of the main advantages of the use of the powerful combination techniques of a GIS, is the evaluation of several hazard and risk scenarios that can be used in the decision -making about the future development of an area, and the optimum way to protect it from natural disasters.

Remote sensing data derived from satellites are excellent tools in the mapping of the spatial distribution of disaster related data within a relatively short period of time. Many different satellite based systems exist nowadays, with different characteristics related to their spatial-, temporal- and spectral resolution. Remote sensing data should generally be linked or calibrated with other types of data, derived from mapping, measurement networks or sampling points, to derive at parameters, which are useful in the study of disasters. The linkage is done in two ways, either via visual interpretation of the image or via classification. The data required for disaster management is coming from different scientific disciplines, and should be integrated.

Data integration is one of the strongest points of GIS. In general the following types of data are required:

- Data on the disastrous phenomena (e.g. landslides, floods, earthquakes), their location, frequency, magnitude etc.
- Data on the environment in which the disastrous events might take place: topography, geology, geomorphology, soils, hydrology, land use, vegetation etc.
- Data on the elements that might be destroyed if the event takes place: infrastructure, settlements, population, socioeconomic data etc.
- Data on the emergency relief resources, such as hospitals, fire brigades, police stations, warehouses etc

Disaster mapping

Disaster mapping is the drawing of areas disturbed through excessive natural or manmade troubles resulting in loss of life, property and national infrastructures. It is normally possible to define the area affected by the disruption. The delineation can occur through the use of ground-based observations or through the use of remote sensing devices such as aerial photographs or satellite images. From the information gathered, it is possible to map the effected areas and provide information to the relief supplying groups.

Disaster mapping is a tool for assessing, storing and conveying information on the geographical location and spread of the effects, or probable effects of disasters. The difficulty with traditional manual maps is that they are tedious and time consuming to prepare, difficult to update and inconvenient to maintain. Remote sensing is emerging as a popular means of map preparation while GIS can be used for storage, analysis and retrieval. Under remote sensing techniques, maps can be prepared using satellite data or aerial photographs and then digitised and stored on computers using GIS software.

Disaster maps generally show risk zones as well as disaster impact zones. These are marked areas that would be affected increasingly with the increase in the magnitude of the disaster. These could include landslide hazard maps, flood zone maps, seismic zone maps, forest fire risk maps, industrial risk zone maps etc.

Landslides

Landslide hazard zone mapping involves a detailed assessment and analysis of the past occurrences of landslides in conditions of their location, size and incidence with respect to various geo-environmental factors that cause landslides and mass movements. Landslide hazard zonation map included a map separating the draw out varying degrees of predictable slope stability. The map has an inbuilt factor of forecasting and hence is of probabilistic nature. Depending upon the methodology adopted and the comprehensiveness of the input data used, a landslide hazard zonation map is able to provide help concerning some or all the following individual factor maps:

- Landslide location
- Slope steepness

- Land use/ landcover
- Geology or lithology
- Density of drainages
- Rainfall

Preparation of an inclusive landslide hazard zonation map needs intensive and continued efforts. A huge quantity of data on lots of variables covering large slope areas has to be collected, stored, sorted and evaluated. Finally, the level of risk sliding has to be assessed and zonation maps prepared. The use of aerial photographs, satellite images and adoption of remote sensing techniques helps in the collection of data. For storage, retrieval and analysis, adoption of computerised techniques would be useful. Hazard zonation maps have different uses. Some of them are as follows:

- Preparation of development plans for cities, dams, roads, and other development works
- General purpose master plans and land use plans
- Discouraging new development in hazard prone areas
- Selection of best activity pattern based on risk zones
- Quick decision making in rescue and relief operations.

Earthquakes

Earthquake data collected by the National Seismic Telemetry Network for the past one hundred years was analysed using a computer. Epicentre parameters were resolute. Most of the epicentres tend to cluster along the plate boundary where the Himalayan Collision Zone was formed. The epicentre maps are used to prepare seismic hazard map. Seismic zoning map is in the code for designing earthquake resistant structures. Apart from the earthquake data, geological factors, structural design, soil data etc., are used to prepare building codes. These codes are used to design earthquake resistant structures in the region. Up-gradation of this code is a continuous procedure. The building code is assessed from time to time. The different zones point to vulnerability from seismic turbulence and help in reviewing the vulnerability probable.

The state of Sikkim experiences earthquakes at a relatively high frequency on the seismic hazard zonation map under zone IV. All districts of Sikkim lie in zone IV. The earthquake risk or possible damage is due to a combination of seismic hazards, vulnerability of the built surroundings and the exposure. The damage during recent earthquakes in India has demonstrated the need for seismic risk assessment that is able to forecast the consequences of earthquakes. A comprehensive earthquake risk assessment for Sikkim has been performed for seismic intensity obtained from the micro-zonation of the state.

RS and GIS is used to help manage the impact of earthquakes and other disasters by

- Assessing risk and hazard locations in relation to populations, property, and natural resources
- Integrating data and enabling understanding of the scope of an emergency to manage an incident
- Recommending preventive and mitigating solutions
- Determining how and where scarce resources should be assigned
- Prioritizing search and rescue tasks
- Identifying staging area locations, operational branches and divisions, and other important incident management needs
- Assessing short- and long-term recovery operations Remotely sensed data make us able to depict disturbed vegetation, denuded hill slopes, and shallow landslides etc. in the natural terrain. The identification of risk

areas, rate of destructions/causalities and understanding of post and pre disaster scenario becomes easy to understand by using GIS and remote sensing derivation of hazard zonation maps.

Role of GIS and remote sensing in flood management:

Advancements in the remote sensing technology and the Geographic Information Systems (GIS) help in real time monitoring, early warning and quick damage assessment of flood disasters. A Geographic Information System is a tool that can assist floodplain managers in identifying flood prone areas in their community. With a GIS, geographical information is stored in a database that can be queried and graphically displayed for analysis. By overlaying or intersecting different geographical layers, flood prone areas can be identified and targeted for mitigation or stricter floodplain management practices.

Remote Sensing can be very effective for flood management in the following way:

- Detailed mapping that is required for the production of hazard assessment maps and for input to various types of hydrological models.
- Developing a larger scale view of the general flood situation within a river basin with the aim of identifying areas at greatest risk and in the need of immediate assistance.

Remote sensing and GIS technique has successfully established its application in following areas of flood management such as flood inundation mapping, flood plain zoning and river morphological studies Satellite remote sensing provides synoptic view of the flood-affected areas at frequent intervals for assessing the progression and recession of the flood inundation in short span of time which can be used for planning and organizing the relief operations effectively.

Remote sensing can effectively be used for mapping the flood-damaged areas. Satellite remote sensing based morphological studies are quite useful in following areas:

- To identify the changes in river course over a time period.
- To identify the erosion prone areas along the river course
- To study the efficacy of flood management structures

Satellite Remote Sensing and GIS techniques have emerged as a powerful tool to deal with various aspects of flood management in prevention, preparedness and relief management of flood disaster. They have greater role to play as an improvement over the existing methodologies. GIS is ideally suited for various floodplain management activities such as, base mapping, topographic mapping, and post-disaster verification of mapped floodplain extents and depths. Remote sensing and GIS techniques can replace, supplement or complement the existing flood management system. Extensive use of these technologies have great prospect in creating long-term database on flood proneness, risk assessment and relief management.

Role of GIS and remote sensing in Cyclone management:

The radar can be utilized to find out the location of the cyclonic storm more accurately when the system comes within radar range. In addition it can find out convective cloud cluster, wind distribution, rainfall rate etc. Various Techniques are available for Track Prediction of the storm as mentioned below:

- Methods based on climatology, persistence and both Climatology & Persistence (CLIPER).
- Synoptic Techniques – Empirical Techniques.
- Satellite Techniques.

- Statistical Techniques using climatology, persistence and synoptic.
- Analogue Techniques.
- Numerical weather prediction models.

The Early Warning System

Indian Meteorological Department (IMD) is authorized to monitor and give warnings regarding Tropical Cyclone (TC). Data resources are crucial to early forecasting of cyclones. Satellite based observations are being extensively utilized. Satellite integrated automated weather stations have been installed on islands, oilrigs and exposed coastal sites.

The goal of any warning system is to maximize the number of people who take appropriate and timely action for the safety of life and property. All warning systems start with detection of the event and with people getting out of harm's way. Such warning systems encompass three equally important elements namely; Detection and Warning; Communication and Response.

The second stage of "Cyclone Alert" is sounded 48 hours in advance of the expected commencement of adverse weather over the coastal areas. Forecasts of commencement of strong winds, heavy precipitation along the coast in association with arrival of cyclone are issued at the alert stage.

The third stage warning known as "Cyclone Warning" is issued 24 hours in advance. Landfall point is forecast in this stage of cyclone warning. In addition to the forecasts for heavy rains and strong winds, the storm surge forecast is also issued.

Search and Rescue Operation

Search, rescue and evacuation procedures are carried out immediately after disaster strikes a certain area. These are major operations, usually performed by local volunteers, voluntary organizations and district and state agencies. The basic aim of all such operations is to ensure the survival of the maximum possible number of victims. A plan is worked out with the help of local people through aerial surveys and appropriate steps are then taken by the various teams involved to carry out the operations.

Damage Assessment

During cyclone, Remote sensing data provide timely and detailed information that are required by the authorities to locate and identify the affected areas and to implement corresponding damage mitigation. It is essential that information be accurate and timely, in order to address emergency situations i.e. dealing with diversion of inundated water, evacuation, rescue, resettlement, water pollution, health hazards and handling the interruption of utilities etc. Some important spatial outputs produced and analyzed in real time. The disaster extent maps, real time monitoring by remote sensing data and of damage to buildings and infrastructure maps were prepared. Moreover, meteorological reports based on real-time remote sensing data are required to show intensity/estimates, movement and expected duration of rainfall for the next 3 hours.

Cyclones are one of the catastrophic natural disasters that affect many countries around the globe, causing considerable loss of human lives, Agricultural loss, and loss of property in coastal areas. The life span of the tropical cyclones is measured in days or weeks. No other atmospheric disturbance combines duration, size and violence more destructively than tropical cyclones. Remote sensing and GIS inputs are useful and used to save innocent lives and for impact assessment to infrastructure and properties. Remote sensing and GIS are used

operationally for early warning and monitoring of Tropical cyclones also it help to disaster managers for damage assessment and relief operations.

FIRE HAZARD INTRODUCTION:

Fire pose a major threat to various occupancies in India. Almost every day some fires are reported by media across the country. These fires not only resulted in the loss of many precious life and injuries to many but also inflicted heavy property loss. During the last two decades there was a vibrant growth in the construction activities in India, especially in high rise buildings. Because of its peculiar nature, fire in residential buildings, in particular, high rise buildings, become more complex and the salvaging operations become more difficult and sometimes even resulting in many deaths and huge property losses. The rapid modernisation of Indian Industry have made the scenario more complex. Awareness towards fire safety had not been quite forthcoming. This article will focus on the overall scenario on the existing fire safety regulations in India and the effectiveness of these regulations for combating the potential fire hazards.

MAIN REGULATIONS:

Fire services in India came under the Twelfth Schedule of the Constitution of India, under the provisions of Article 243W of the Constitution. The performance of the functions listed in the Twelfth Schedule comes under the domain of Municipalities.

Regular fire services in India was established about 215 years back. The service was first established in Bombay in 1803, followed by Calcutta in 1822, Delhi in 1867 and Madras in 1908. As per the report released by the Ministry of Home Affairs in 1997, there were 1754 fire stations with 5149 fire appliances/vehicles and 50,730 fire professionals are functioning PAN India. In addition to above, there were 278 trailer-made fire stations operating exclusively in industrial sectors.

Presently fire prevention and firefighting services are organised by the concerned States and Union Territories. It may be added here that the fire brigades in India remain heterogeneous in character and majority of them continue to remain ill-equipped and differently organised.

The National Building Code (NBC), which is the basic model code in India on matters relating to building construction and fire safety. Fire prevention and fire protection is a state subject. The primary responsibility for fire prevention and fire protection lies primarily with State Governments. The rules for fire prevention and fire protection are laid in the form of State Regulations or Municipal By-Laws.

National Building Code:

The National Building Code is published by Bureau of Indian Standards. The first edition of the NBC was published in 1970. This edition was revised in 1983, 1987 and 1997. The second edition of the NBC was published in 2005. The third edition of the NBC was published in 2016, incorporating the latest developments in the construction activities in the country.

The main objective of NBC is to specify measures that will provide that degree of safety from fire, which is practical and can be reasonably achieved. The Code insists upon compliance with minimum standards of fire safety necessary for building occupants and users. For ensuring compliance of fire protection equipment/installations to the laid down quality requirements, it is desirable to use such equipment/installation duly certified under the BIS Certification Marks Scheme.

The NBC classify the buildings into the following 9 groups: These groups have been subdivided into various categories. The NBC also deals with three types of fire zones and four types of constructions.

The Part 4 (Fire and Life Safety) of NBC, which contain the fire safety norms through detailed provisions on fire prevention, life safety and fire protection. The fire protection, which not only deals with fire prevention and fire protection but also gives guidance by specifying the standards for construction, plumbing, electrical installations including wiring, lighting, ventilation, heating and air conditioning, safety sanitation, active and passive fire protection systems, etc. It mentions the restrictions of buildings in each fire zone, classification of buildings based on occupancy, the demarcation of fire zones, limitations of height, types of building construction according to fire resistance of the structural and non-structural components and other restrictions and requirements necessary to minimise danger to life from fire, smoke, fumes or panic before the building can be evacuated.

The Code recognizes that safety of life is more than a matter of means of egress and accordingly deals with various matters which are considered essential to the safety of life. The Code therefore covers provisions relating to means of egress covering various components thereof namely exit access, exit and exit discharge. It also covers provisions relating to fire protection of various occupancies through portable and fixed firefighting installations

State Regulations:

By and large, the State fire prevention and fire safety act & rules complement the National Building Code. Many of the NBC Code provisions have been incorporated by various State Governments and Local Bodies in their own building regulations. For example, the acts & rules enacted by states like Maharashtra and Gujarat are aimed to improve overall status of fire safety measures in their respective states. Some of the Acts/Rules regarding fire prevention and fire protection enacted by various State Governments are listed in Table 02. It may be seen from Table 02, that some of the State Governments are yet to update their Act and Rules.

Often a question has been raised by many that who will be responsible for providing the required fire protection and prevention system in a building or in an occupancy. The acts and rules enacted by the State of Maharashtra has well defined on these points. According to the Section 3 of the Fire Prevention and Life Safety Measures Act, 2006, the developer, owner, occupier or whatever name called shall comply with all the fire and safety measures adhering to the National Building Code of India, and as amended from time to time, failing which it shall be treated as a violation of the Act. It means that the onus of maintaining the fire safety installations in a building or in an occupancy is the responsibility of the owner or occupier.

Related Regulations:

Apart from the specific State Acts and Rules stated above, a number of legislations are available on matters relating to fire prevention, fire protection and some of them are listed in Table 03. Amongst these, the Factories Act and State Factories Rules are important ones. The Section 38 of the Factories Act, 1948, emphasises, the obligations of the occupier, which include (i) to adopt all practicable measures to prevent the outbreak and spread of fire, (ii) to provide safe means of escape, (iii) to maintain the firefighting equipment properly and (iv) to familiarise all the workers with the means of escape during fire and train them in steps to be taken in a fire accident. The Section 37 of the Factories Act, 1948, also prescribes detailed measures to prevent explosions hazards. The State Factories Rules, framed under the Factories Act, have prescribed in detail, all the steps to be taken to prevent fire hazard.

Codes and Standards:

IS Codes

BIS has formulated more than 150 standards on fire safety in buildings and firefighting equipment & systems and important ones are: Code of practice for fire safety of building (IS 1641 to IS 1646), electrical generating and distributing stations (IS 3034), cotton textile mills (IS 3079), rubber and plastic (IS 11457 Part 1), libraries and archives (IS 11460), iron and steel industries (IS 13694), hotels (IS 13716), educational institutions (IS 14435); fire detection and alarm systems (IS 2189); first aid fire extinguishers (IS 2190); internal hydrants and hose reels (IS 3844); temporary structures and pandals (IS 8758); fire protection-safety signs (IS 12349); external hydrant systems (IS 13039); fixed automatic sprinkler fire extinguishing systems (IS 15105); gaseous fire extinguishing systems (IS 15493); HFC 227ea (IS 15517); water mist system (IS 15519); portable fire extinguishers (IS 15683); long range foam monitors (IS 15811); fire detection and alarm system (IS 15908), etc.

OISD Standards

Oil Industry Safety Directorate (OISD) is a technical directorate under the Ministry of Petroleum and Natural Gas of Government of India, who formulates and coordinates the implementation of a series of self-regulatory measures aimed at enhancing the safety in the oil & gas industry in India. OISD had issued a number of standards and the important ones are: OISD STD 114 (Safe handling of hazardous chemicals); OISD STD 116 (Fire Protection Facilities for Petroleum Refineries and Oil/Gas Processing Plants); OISD STD 117 (Fire Protection Facilities for Petroleum Depots, Terminals, Pipeline installations & Lube oil installations).

Classification of Fires:

1. Class A: Wood, Paper, Cloth, trash & other ordinary material
2. Class B: Gasoline, Oil, paint & other flammable liquids
3. Class C: May be used on other fires involving live electrical equipments without risk to the operator.
4. Class D: Combustible metal & metal alloys
5. Class K: Cooking medial- Vegetable oil or animal oil or fats

COMPLIANCE:

Many commercial and residential buildings in particular high-rise buildings, have been found flouting fire safety norms. Many occupiers or societies do not bother to conduct regular maintenance of the fire prevention systems installed in their buildings.

Though Fire Safety Audit is found to be an effective tool for assessing fire safety standards of an organization or an occupancy, there is no clear cut provisions in any of the fire safety legislations in India, regarding the scope, objectives, methodology and periodicity of a fire safety audit. However, the NBC 2016, recommends for periodical fire safety inspection by the key personnel of the occupants of the building to ensure fire safety standards.
As far as industrial buildings, are concerned, the statutory authorities like State Factory Inspectorate, insist for fire safety audit by external agencies, depending on the type of activity and the nature of the materials handled in the building.

Various rules made it mandatory for building owners and residents to conduct half-yearly fire safety audits and submit the report to the fire department. No doubt, it is a good measure and other states too, can follow this. However, entrusting the responsibility of conducting the fire safety audit to the 'Licensed Agencies', has created

some confusions, because the same agency has also been entrusted with the work of (i) installations of firefighting systems in an occupancy with a certification under Form 'A' and (ii) carry out the maintenance of firefighting systems and issue half-yearly certificate under Form 'B' in every January & July.

In practice, Form 'B' certification is regarded as Safety Audit, which is not at all a right thinking. Perhaps, this arrangement has resulted in diluting the scope and methodology of the audit itself. Moreover, entrusting the audit work to the same 'Licensed Agencies', who had either installed or carried out the maintenance work of firefighting systems in an occupancy, is not at all justified. It is also doubtful whether the so called 'Licensed Agencies' have the required calibre / expertise in conducting an effective fire safety audit. So in effect, it seems that the fire safety audit has become a mere ritual.

CONCLUSION:

Hazard Identification & Risk Assessment (HIRA) can be focused to identify potential hazards. A comprehensive fire safety audit can address the inherent fire hazards associated with the day to day activities in an occupancy and recommend measures to reduce the potential fire hazards.

In India, although there are many rules and regulations, codes and standards related to fire safety, these are seldom followed. Laxity in following fire safety measures caused many major fires in various occupancies and some of them even resulted in catastrophes. It was observed that most skyscrapers in Mumbai continue to overlook the fire safety norms compliance certificate. Several prominent high rises in New Delhi are at a high risk of turning into fire traps. Most high rises in and around Connaught Place don't have fire safety certificates. About 90% buildings in Chennai are fire traps.

If you want to reduce the fire incidents in the country, Fire Safety Audit should be made mandatory for all over India and the audit work should be entrusted to Third Party Agencies, who have expertise in it. It is reasonable to have a fire safety audit in every year in every occupancy. Above all, the success of fire prevention and fire protection mainly depend upon the active co-operation from all personnel in an occupancy. Remember, prevention is better than cure.

FIRE LOAD

Classification—Fire load is the amount of heat in kilocalories which is liberated per square metre of floor area of a compartment by the combustion of the contents of the building and any combustible parts of the building itself. This amount of heat is used as the basis for classification of occupancies.

The fire load is determined by multiplying the weight of all combustible materials by their calorific values and dividing the figure by the floor area under consideration.

Different materials having the same weight and same calorific value may present different hazards on account of their other properties, such as ease of ignition, speed of burning, and liberation of heat and fumes. Thus, some mateirals are more readily ignited than others, again, some burn more rapidly than others, some materials when heated on fire liberate dangerous fumes, and some may readily cause ignition of other materials.

The content of a building are rarely distributed uniformly over the whole floor area. From the fire protection point, it would be undesirable to have all combustible material concentrated on a fraction of the floor area, as the average taken over the whole area would not give a true representation of the actual conditions, and the resulting effects

on the structure immediately surrounding would be out of all proportion to these expected on the basis of average fire load.

CLASSIFICATION OF BUILDING BASED ON OCCUPANCY

General Classification—All buildings should be classified, according to the use or the character of occupancy in one of the following groups:

- Group A residential buildings— These should include any building in which sleeping accommodation is provided for normal residential purposes, with or without cooking or dining or both facilities, except any building classified under Group C.
- Group B educational buildings— These should include any buildings used for school, college or day-care purposes involving assembly for instruction, education or recreation and which is not covered by Group D.
- Group C institutional buildings— These should include any building or part thereof, which is used for purposes, such as medical or other treatment or care of persons suffering from physical or mental illness, disease or infirmity; care of infants, convalescents or aged persons and for penal or correctional detention in which the liberty of the inmates is restricted. Institutional buildings ordinarily provide sleeping accommodation for the occupants.
- Group D assembly buildings—These should include any building or part of a building, where groups of people congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purposes, for example, theatres, motion picture houses, assembly halls, auditoria, exhibition halls, museums, skating rinks, gymnasiums, restaurants, places of worship, dance halls, club rooms, passenger stations and terminals of air, surface and marine public transportation services, recreation piers and stadia, etc.
- Group E business buildings—These should include any building or part of a building which is used for transaction of business(other than, that covered by Group F and parts of buildings covered by **3.1.1**) for keeping of accounts and records and similar purposes, professional establishments, service facilities, etc. City halls, town halls, court houses and libraries should be classified in this group so far as the principal function of these is transaction of public business and keeping of books and records.
- Group F mercantile buildings— These should include any building or part of a building, which is used as shops, stores, market, for display and sale of merchandise, either whole-sale or retail.
- Group G industrial buildings—These should include any building or part of a building or structure, in which products or materials of all kinds and properties are fabricated, assembled, manufactured or processed, for example, assembly plants, laboratories, dry cleaning plants, power plants, pumping stations, smoke houses, laundries, gas plants, refineries, dairies and mills.
    - The hazard of occupancy, for the purpose of the Code should be the relative danger of the start and spread of fire, the danger of smoke or gases generated, the danger of explosion or other occurrence potentially endangering the lives and safety of the occupants of the buildings.
    - Hazard of occupancy should be determined by the authority on the basis of the character of the contents and the processes or operations conducted in the building, provided, however, that the combustibility of the building, the flame spread rating of the interior finish or other features of the building or structure are such as to involve a greater than the occupancy hazard, the greater degree of hazard should govern the classification.
    - Where different degrees of hazard of occupancy exist in different parts of a building, the most hazardous of those should govern the classification for the purpose of this code, except in as far as hazardous areas are segregated or protected as specified in the code.

- Group H storage buildings—These should include any building or part of a building, used primarily for the storage or sheltering (including servicing, processing or repairs incidental to storage) of goods wares or merchandise (except) those that involve highly combustible or explosive products or materials), vehicles or animals, for example, warehouses, cold storage, freight depots, transit sheds, storehouses, truck and marine terminals garages, hangars (other than aircraft repair hangars) grain elevators, barns and stables.
    - Storage properties are characterized by the presence of relatively small number of persons in proportion to the area. Any new use which increases the number of occupants to a figure comparable with other classes of occupancy should change the classification of the building to that of the new use, example, hangars used for assembly purposes, warehouses used for office purposes, garage buildings used or manufacturing.
- Group J hazardous buildings—These should include any building or part of a building which is used for the storage, handling, manufacture or processing of highly combustible or explosive materials or products are liable to burn with extreme rapidity and/or which may produce poisonous fumes or explosions for storage, handling, manufacturing or processing which involve highly corrosive, toxic or noxious alkalis, acids or other liquids or chemicals producing flame, fumes and explosive poisonous, irritant or corrosive gases; and for the storage, handling or processing of any material corrosive gases; and for the storage, handling or processing of any material producing explosive mixtures of dust which result in the division of matter into fine particles subject to spontaneous ignition.

FIRE ZONES

Demarcation—The city or area should, for the purpose of the code, be demarcated into distinct zones, based on fire hazard inherent in the buildings and structures according to occupancy (*see* 3), which should be called the 'Fire Zones'.

Number and Designation of Fire Zones

The number of fire zones in a city or area under the jurisdiction of the authority depends upon the existing layout, types of building construction classification of existing buildings based on occupancy (*see* 2) and the expected future development of the city or area. In large cities on areas, three fire zones may be necessary, while in smaller ones, one or two may be adequate.

The fire zones should be made use of in land use development plan and should be designated as follows:

- *Fire Zone No. 1*—This should comprise areas having residential (Group A), educational (Group B), institutional (Group C), assembly (Group D), small business (Subdivision E-1) and retail mercantile (Group F) buildings, or areas which are under development for such occupancies.
- *Fire Zone No. 2*— This should comprise business (Subdivisions E-2 and E-3) and industrial buildings (Subdivisions G-1 and G-2) except high hazard industrial buildings (Subdivision G-3) or areas which are under development for such occupancies.
- *Fire Zone No. 3*— This should comprise areas having high hazard industrial buildings (Sub-division G-3), storage buildings (Group H) and buildings for hazardous uses (Group J) or areas which are under development for such occupancies.

Change in the Fire Zone Boundaries— When the boundaries of any fire zone are changed, or when it is intended to include other areas or types of occupancies in any fire zone, it should be done by following the same procedure as far promulgating new rules.

Overlapping Fire Zones

When any building is so situated that it extends to more than one fire zone, it should be deemed to be in the fire zone in which the major portion of the building or structure is situated.

When any building is so situated that it extends equally to more than one fire zone, it should be deemed to be in the fire zone having more hazardous occupancy buildings.

Temporary Buildings

Temporary buildings should be permitted only in Fire Zones No. 1 and 2 as the case may be, according to the purpose for which these are to be used, by special permit from the authority for a limited period and subject to such conditions as may be imposed in the permit. Such buildings should be completely removed on the expiry of the period specified in the permit.

OCCUPANCY LOADS

Building Bye Laws Part 4 sets out the standard space requirements of various parts of a building and those of light and ventilation. Some of these items depend on the number of persons who would normally occupy the building, for which the occupant load should be worked out from table here under:

S.No.	Type of Occupancy	Occupant Load per 100 sq m. of Plinth or Covered Area
1.	Residential	8.00
2.	Educational	25.0
3.	Institutional	6.60
4.	Assembly (a) with fixed or loose seats and dance floor (b) without seating facilities including dining rooms	 166.6 66.6
5.	Mercantile (a) street floor and sales basement (b) upper sale floor	 33.3 16.6
6.	Business and industrial	10.0
7.	Storage	3.3
8.	Hazardous	10.0

The occupant load in dormitory portions of homes for the aged, orphanages or mental hospitals etc. where sleeping accommodation is provided shall be calculated at not less than 13.3 persons per 100 sq.m.

EXIT REQUIREMENTS

General The following general requirement shall apply to exits:

a. Every building meant for human occupancy shall be provided with exits sufficient to permit safe escape of occupants in case of fire or other emergency.
b. In every building exit shall comply with the minimum requirement of this part, except those not accessible for general public use.
c. All exists shall be free of obstructions.
d. No buildings shall be altered so as to reduce the number, width or portion of exits to less than required.
e. Exits shall be clearly visible and the routes to reach exits shall be clearly marked and signs posted to guide the occupants of floor concerned.
f. All exit ways shall be properly illuminated.
g. Fire-fighting equipment where provided along exits shall be suitably located and clearly marked but must not obstruct the exit way and there should be clear indication about its location from either side of the exit way.
h. Alarm devices shall be installed to ensure prompt evacuation of the occupants concerned through the exits, wherever required.
i. All exits shall provide continuous means of egress to the exterior of a building or to an exterior open space leading to a street.
j. Exits shall be so arranged that they may be reached without passing through another occupied unit, except in the case of residential buildings.

Types of Exits

a. Exits shall be either horizontal or vertical type. An exit may be doorway, corridor and passage to an internal staircase or external staircase, ramp or to a verandah and/or terraces that have access to the street or to roof of a building. An exit may also include horizontal exit leading to an adjoining building at the same level.
b. Lifts escalators and revolving doors shall not be considered as exits.

Arrangement of Exits

a. Exits shall be so located so that the travel distance on the floor shall not exceed 22.50 m. for residential, educational, institutional and hazardous occupancies and 30.0 m. for assembly, business, mercantile, industrial and storage occupancies. Whenever more than one exit is required for a floor of a building they shall be placed as remote from each other as possible. All the exits shall be accessible from the entire floor area at all floor levels.
b. The travel distance to an exit from the remote point shall not exceed half the distance as stated above except in the case of institutional occupancy in which case it shall not exceed 6.0 m.

Capacity of Exits

The capacity of exits (staircase, ramps and doorways) indicating the number of which persons could be safety evacuated through a unit exit width of 50 cm shall be as given below:

S.No.	Group of Occupancy	Number of Occupants		
		Stairways	Ramps	Doors
1	Residential	25	50	75
2	Educational	25	50	75
3	Institutional	25	50	75
4	Assembly	40	50	60
5	Business	50	60	75
6	Mercantile	50	60	75
7	Industrial	50	60	75
8	Storage	50	60	75
9	Hazardous	25	30	40

FIRE PROTECTION REQUIREMENTS

Buildings shall be planned, designed and constructed to ensure fire safety and this sha1l be done in accordance with part IV Fire Protection of National Building Code of India, unless otherwise specified in these Bye-Laws. In the case of buildings (identified in Bye-Laws No. 7.1) the building schemes shall also be cleared by the Chief Fire Officer.

1. First Aid /Fixed Fire Fighting /Fire Detection Systems and other Facilities

Provision of fire safety arrangement for different occupancy from. SI no. 1 to 23 as indicated below shall be as per Annexure 'A' 'B' & 'C'.

- Access
- Wet Riser
- Down Comer
- Hose Reel
- Automatic Sprinkler System
- Yard Hydrant
- U.G. Tank with Draw off Connection
- Terrace Tanks
- Fire Pump
- Terrace Pump
- First Aid Fire Fighting Appliances
- Auto Detection System
- Manual operated Electrical Fire Alarm System
- P.A System with talk back facility
- Emergency Light
- Auto D.G. Set
- Illuminated Exit Sign
- Means of Escape
- Compartimentation
- MCB /ELCB
- Fire Man Switch in Lift

- Hose Boxes with Delivery Hoses and Branch
- Pipes Refuge Area

STATIC WATER STORAGE TANK

AUTOMATIC SPRINKLERS

Automatic sprinkler system shall be installed in the following buildings:

i. All buildings of 24 m. and above in height, except group housing and 45 m. and above in case of apartment /group housing society building.
ii. Hotels below l5 m. in height and above 1000 sq m. built up area at each floor and or if basement is existing.
iii. All hotels, mercantile, and institutional buildings of 15 m. and above.
iv. Mercantile building having basement more than one floor but below 15 m. (floor area not exceeding 750 sq m.)
v. Underground Shopping Complex.
vi. Underground car / scooter parking /enclosed car parking.
vii. Basement area 200 sq m. and above.

FIXED CARBON DI-OXIDE / FOAM / DCO WATER SPRAY EXTINGUISHING SYSTEM:

Fixed extinguishing installations shall be provided as per the relevant specifications in the premises where use of above extinguishing media is considered necessary by the Chief Fire Officer.

FIRE ALARM SYSTEM

All buildings of 15 m. and above in height shall be equipped with fire alarm system, and also residential buildings (Dwelling House, Boarding House and Hostels) above 24 m. height.

CHEMICAL HAZARDS

Chemicals are used to make virtually every man-made product and play an important role in the everyday life of people around the world. The chemical industry is the third largest industrial sector in the world. It is also a major economic force. Worldwide, it employs some 10 million people and generates billions of euros in shareholder value and tax revenue for governments.

A chemical hazard is a type of occupational hazard caused by exposure to chemicals in the workplace. Exposure to chemicals in the workplace can cause acute or long-term detrimental health effects. There are many types of hazardous chemicals, including neurotoxins, immune agents, dermatologic agents, carcinogens, reproductive toxins, systemic toxins, asthma genes, pneumoconiotic agents, and sensitizers.

Common causes for chemical accidents are deficiencies in safety management systems and human errors, or they may occur as a consequence of natural calamities or sabotage activities. Chemical accidents result in fire, explosion and/or toxic release. The nature of chemical agents and their concentration during exposure ultimately decides the toxicity and damaging effects on living organisms in the form of symptoms and signs like irreversible pain, suffering, and death.

Meteorological conditions such as wind speed, wind direction, height of inversion layer, stability class, etc., also play an important role by affecting the dispersion pattern of toxic gas clouds. The Bhopal Gas tragedy of 1984—the worst chemical disaster in history, where over 2000 people died due to the accidental release of the toxic gas Methyl Isocyanate, is still fresh in our memories. Such accidents are significant in terms of injuries, pain, suffering, loss of lives, damage to property and environment. A small accident occurring at the local level may

be a prior warning signal for an impending disaster. Chemical disasters, though low in frequency, have the potential to cause significant immediate or long-term damage.

Risks Posed by HAZCHEM

Increased industrial activities and the risks associated with HAZCHEM and enhanced vulnerability lead to industrial and chemical accidents. Chemical accidents may originate in the manufacturing or formulation facility, or during the process operations at any stage of the product cycle, material handling, transportation and storage of HAZCHEM. Vulnerability is sometimes compounded due to the location of Major Accident Hazard (MAH) industries closer to densely populated areas. Chemical and industrial accidents generally occur due to technical failures that can be anticipated. The risk associated with them can thus be predicted and reduced effectively by identification of risk areas, risk assessment and designing pre-operative measures. The occurrence of chemical accidents and probability thereof, manifesting in a disaster, remain a cause of concern.

Sources of Chemical Disasters

Chemical accidents may originate in:

i. Manufacturing and formulation installations including during commissioning and process operations; maintenance and disposal.
ii. Material handling and storage in manufacturing facilities, and isolated storages; warehouses and godowns including tank farms in ports and docks and fuel depots.
iii. Transportation (road, rail, air, water, and pipelines).

Causative Factors Leading to Chemical Disasters

Chemical disasters, in general, may result from:

i. Fire: This is the most frequent of the hazards however the consequences are generally less. The effect of fire on people usually takes the form of skin burns and is usually dependent on the exposure time and the intensity of the heat. Fire can also produce toxic fumes like Acrolein, Carbon monoxide and Cyanides. Physical structures can be damaged either by the intensity of the heat or combustion. It may also have an effect on essential services like power and instrumentation which can cause an escalation of the incident
ii. Explosion: Explosions are usually heard from far away as a ‘bang’. This is the result of a shock wave. This overpressure can kill people but usually the indirect effects of collapsing buildings, flying glass and debris causes far more loss of life and severe injuries. There are different types of explosions which include gas explosions and dust explosions. Gas explosions occur when a flammable gas mixes with air and is exposed to an ignition source. Dust explosions occur when flammable solids, especially metals, in the form of fine powders are intensively mixed with air and ignited.
iii. Toxic release: Sudden releases of toxic vapours have the potential to cause death and severe injuries several miles from the release point. They are carried by water and air. Their release into public sewage systems, rivers, canals and other water courses, either directly or through contaminated water used in fire fighting can result in serious threat to public. The number of casualties depends on the weather conditions, population density in the path of the cloud and the effectiveness of the emergency arrangements.
iv. Poisoning
v. Combinations of the above.

Chemical disasters may occur due to process deviations concerning the chemistry of the process, pressure, temperature and other identified parameters with regard to the state of the substance i.e., solid, liquid or gas, proximity to other toxic substances and the probability of a runaway reaction due to the incidental mixing of two or more HAZCHEMs with dissimilar properties. In addition, it may be due to hardware failure, resulting in large-scale spills of toxic substances (in any form) due to loss of containment, or an explosion. Further, Boiling Liquid Expanding Vapour Explosion (BLEVE) may occur due to sparks, shocks or frictional forces on the chemicals during transportation.

The effects can be further compounded by the micro-meteorology of the area, wind speed and direction, rate of precipitation, toxicity/quantity of chemical released, population in the reach of release, probability of formation of lethal mixtures (fuel-air or other mixtures) and other industrial activities being performed in closer vicinity.

Initiators of Chemical Accidents

A number of factors including human errors could spark off chemical accidents with the potential to become chemical disasters. These are:

1) Process and Safety System Failures:
    a. Technical errors: design defects, fatigue, metal failure, corrosion etc.
    b. Human errors: neglecting safety instructions, deviating from specified procedures etc.
    c. Lack of information: absence of emergency warning procedures, nondisclosure of line of treatment
    d. Organizational errors: poor emergency planning and coordination, poor communication with public, noncompliance with mock drills/exercises etc., which are required for ensuring a state of quick response and preparedness.
2) Natural Calamities: The Indian subcontinent is highly prone to natural disasters, which can also trigger chemical disasters. Damage to phosphoric acid sludge containment during the Orissa super cyclone in 1999 and the release of acrylonitrile at Kandla Port, during an earthquake in 2001, are some of the recent examples.
3) Terrorist Attacks/Sabotage: Vulnerability to chemical disasters is further compounded by likely terrorist and warfare activities, which include sabotage and attack on HAZCHEM installations and transportation vehicles.

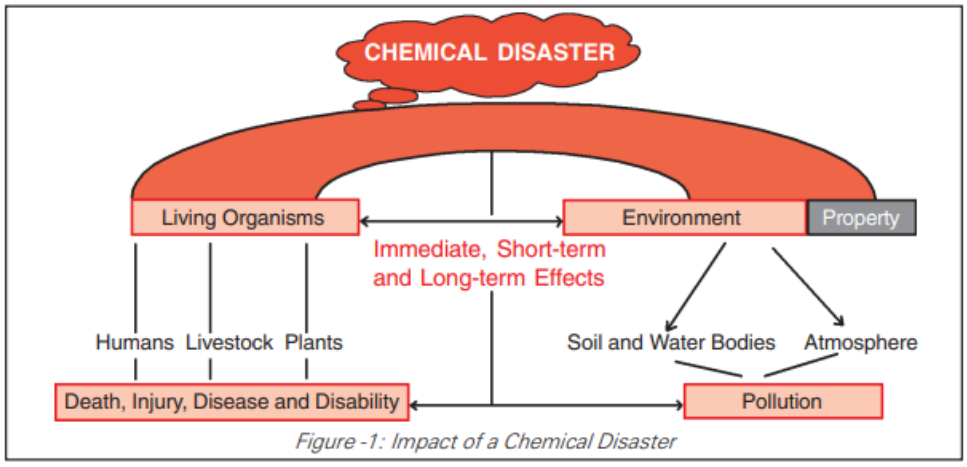


Figure -1: Impact of a Chemical Disaster

Impact of Chemical Disasters

In addition to loss of life, the major consequences of chemical disasters include impact on livestock, flora/fauna, the environment (air, soil, water) and losses to industry as shown in Figure 1. Chemical accidents may be categorised as a major accident or a disaster depending upon the number of casualties, injuries, damage to the property or environment. A major accident is defined in the Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989, issued under the Environment (Protection) Act, 1986, whereas 'disaster' is defined in the DM Act, 2005.

OBJECTIVES OF INDUSTRIAL SAFETY/ Why do we need do study this?

- Understand the harmful effects of industrial hazards.
- Define the relationship between hazard and risk.
- Explore the routes of exposure to industrial hazards.
- Shed lights on type of toxicity by industrial hazards.
- Know the most toxic environmental hazardous substances.
- Industrial safety is needed to check all the possible chances of accidents for preventing loss of life and permanent disability of any industrial employee, any damage to machine and material as it leads to the loss to the whole establishment.
- It is needed to eliminate accidents causing work stoppage and production loss.
- It is needed to prevent accidents in industry by reducing any hazard to minimum.
- It is needed to reduce workman's compensation, insurance rate and all the cost of accidents.
- It is required to educate all members regarding the safety principles to avoid accidents in industry.
- It is needed to achieve better morale of the industrial employees.
- It is required to have better human relations within the industry.
- It is needed to increase production means to a higher standard of living

EFFECTS OF CHEMICALS EXPOSURE ON HUMAN BODY

- Skin burn,
- Ache,
- Anthrax,
- Ulcer in hand, nose, etc.
- Cancer,
- Irritation on windpipe,
- Many chemicals can cause severe burns, if they come in contact with living tissue
- Living tissue may be destroyed by following chemical reactions:
    - Dehydration by strong dehydrating agents,
    - Digestion by strong acids and bases,
    - Oxidation by strong oxidizing agent.
- Chemical Hazards Can Enter and Harm the Body by Four Main Routes:
    - Absorption through the skin;
    - Inhalation;
    - Injection; and
    - Ingestion

DIFFERENT WAYS OF CHEMICAL HAZARDS CAUSE HARM

- Catching fire
- Explosive or reactive
- Corrosive.
- Irritant
- Causing chronic organ damage over time
- Causing an allergic reaction
- Causing genetic or reproductive harm

The effects of exposure not only depend on the chemical, its concentration, route of entry, and duration of exposure, but may also be influenced by personal factors such as the individual's smoking habits, alcohol consumption, medication use, nutrition, age, and sex.

Major Chemical Accidents in India

Following the Bhopal Gas Disaster in 1984, major incidences of chemical disasters in India include a fire in an oil well in Andhra Pradesh (2003); a vapour cloud explosion in the Hindustan Petroleum Corporation Limited Refinery (HPCL), Vishakhapatnam (1997); and an explosion in the Indian Petrochemicals Corporation Limited (IPCL) Gas Cracker Complex, Nagothane, Maharashtra

TYPES OF CHEMICAL HAZARDS

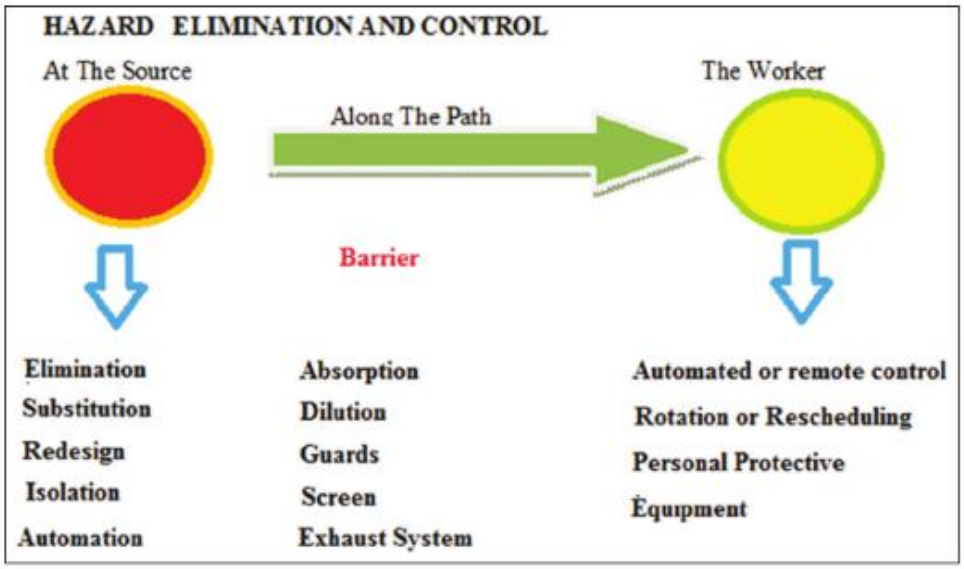
Chemical hazards are toxic, corrosive, irritant, carcinogenic, flammable, and mutagenic.According to workplace hazardous materials information, chemical hazards are classified as:

- Class A
  - Compressed gas.
  - Dissolved gas or liquefied gas.
- Class B
  - Flammable gases.
  - Flammable and combustible liquids.
  - Flammable solid.
  - Flammable aerosols.
  - Reactive flammable material.
- Class C
  - Oxidizing materials - oxidizer and organic peroxide.
  - Oxidizer: Chlorates, nitric oxide, peroxides, permanganates, perchlorates, nitrites, nitrates, and easily oxidize metal powder.
  - Organic peroxide: Tetra hydro furan, diethyl ether, dioxane, and methyl isobutyl ether.
- Class D
  - Poisonous and infectious materials e.g.: Cyanides, tea salts, and asbestos
- Class E
  - Corrosive materials. e.g.: Inorganic acids and bases, hydrogen fluoride.
- Class F

- Dangerous reactive materials. e.g.: Ethylene dioxide, organic azides, Na, Li, Ca.
- Pyrophosphoric materials. e.g.: White phosphorous, diethyl aluminum chloride, and lithium.

Technical Activities/Initiatives by the GOI:

- Initiatives in Installations
  - Major Accident Hazard Control System
  - Hazard Analysis Studies of Industrial Pockets
  - GIS-based Emergency Management System
  - Environment Risk Reporting and Information Systems (ERRIS)
  - Emergency Response Centres (ERCs) and Poison Control Centres
  - Capacity Development
  - Control Room Concept
  - National Networking of Emergency Operation Centres (EOCs)
  - Responsible Care (RC)
  - Mutual Aid Response Group (MARG)
- Initiatives in Storages
  - Inventory of Isolated Storages
- Initiatives in the Road Transport Sectors
  - Vulnerability and Risk Assessment of Transportation of HAZCHEM
  - Hazardous Material (HAZMAT) Emergency Response Van
- Parallel International Efforts
  - International Labour Organization (ILO)
  - Awareness and Preparedness for Emergencies at the Local Level (APELL) Project
  - United Nations (UN) International Strategy for Disaster Reduction (ISDR)



References:

1. NDMA & NIDM Guidelines
2. Nair, R.R. – Equipment for Fire Protection, Industrial Safety Review, November 2012.
3. Nair, R.R. – Evacuation System for High-Rise Buildings, Industrial Safety Review, July 2013.

4. Alappad, Vinod – Fire Risk Assessments, Industrial Safety Review, January 2016.
5. Alappad, Vinod – Hazard Identification & Risk Assessment in Workplaces, Industrial Safety Review, November 2015.
6. National Building Code of India, 2016 edition – Bureau of Indian Standards, New Delhi.
Veeraraghavan, R. and Nair, R.R. – Fire Technology (CEP Publications) Bangalore, All India Council for Technical Education, 2002.

Note: Dear Students,

Most of the topics are covered in these notes provided by me. If by chance any topic is left, let me know & you also have a look of that topic in books or internet.

These are detailed notes. Study thoroughly and practice writing them.

Don't be over confident that we know DM & it is an easy subject. Mostly students fails in this subject, just because of their over confident.