UNIT –V

DISASTER MANAGEMENT : APPLICATIONSAND CASE STUDIES AND FIELD WORKS

5.1 Landslide Hazard Zonation : Case Studies

Landslide hazard is commonly shown on maps, which display the spatial distribution of hazard classes (Landslide Hazard Zonation). Landslide hazard zonation refers to “the division of the land in homogeneous areas or domains and their ranking according to degrees of actual / potential hazard caused by mass movement”

Landslide failures have caused untold number of causalities and huge economic losses. In many countries, economic losses due to landslides are great and apparently are growing as development expands into unstable hillside areas under the pressure of expanding populations.

The factors causing this expected augmented activity are :

- Increased urbanization and development in landslide prone areas.
- Continued deforestation of landslide prone areas, and
- Increased regional precipitation caused by changing climate patterns.

At least 90 % of landslide losses can be avoidable if the problem is recognized before the development or deforestation begins. Hence, there is a dire need for identification of existing and potential unstable slopes.

5.1.1 Uses of Landslide Hazard Zonation

The LHZ maps have multi uses, some of which are listed below.

- The LHZ maps identify and delineate unstable hazard-prone areas, so that environmental regeneration programmes can be initiated adopting suitable mitigation measures.
- These maps help planners to choose favorable locations for sitting development schemes such as townships, dams, roads and other developments.
- General purpose master plans and land use plans.
- Discouraging new development in hazard prone areas.
- Choice of optimum activity pattern based on risk zones.

- Quick decision making in rescue and relief operations.

5.1.2 Mapping Scale for Landslide Hazard Analysis

The amount and type of data has to be stored in a GIS for landslide management depends very much on the level of application, or the scale of the project management.

Natural hazards information should be included routinely in development planning and investment project preparation. Development and investment projects should includea 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.

International Association of Engineering Geologist's monograph on engineering geology, can also be distinguished in landslide hazard zonation.

- National Scale (<1:1000,000)
- Regional and Synoptic Scale (1:100,000 - 1:1000,000)
- Medium Scale (1:25,000 - 1:50,000)
- Large Scale (1:5,000 - 1:15,000)
- Site investigation Scale (>1:2,000)

The regional mapping scale is mean for planners in the early phases of regional development projects or for engineers evaluating possible constraints due to instability in the development of large engineering projects and regional development plans. Medium scale hazard maps can be used for the determination of hazard zones in areas affected by large engineering structures, roads and urbanization. The level of application is typically that of a municipality. The use of GIS at this level is intended for planners to formulate projects at feasibility levels.

5.1.3. Landslide Hazard Zonation in Darjeeling Himalayas

- Landslides pose serious threat to human settlements, transportation, natural resources management and tourism in the Himalayan Region in India.
- Darjeeling Himalayas in West Bengal province are no exception, where every year during the monsoon period (between June and September), loss of human lives and colossal damage to properties take place due to slope instability.
- Darjeeling region witnessed devastating landslides in July 2003 resulting in the death of tens of people and complete disruption of communication network during the heavy

rainfall.

- Geological Survey of India (GSI) has initiated on priority basis an integrated multidisciplinary programme on Landslide Hazard Zonation (LHZ) mapping of the entire Darjeeling region following the tragedy, to demarcate various zones based on their susceptibility to failure and suggest mitigative measures for minimizing the losses caused by the landslides.

5.1.4. Geological set up

- The Darjeeling area in West Bengal, India is bound by Nepal Himalayas in the west, Sikkim Himalayas in the north, Bhutan Himalayas in the east and by the alluvial plains in the south.
- One of the most important factors contributing to the landsliding in study area is its complex geomorphological, geological and seismo-tectonic setup.
- The hill ranges of Darjeeling area are highly rugged, structurally-controlled and are constantly under the highly dynamic and active denudational (erosional) processes. Major Himalayan tectonic elements namely Main Boundary Thrust(MBT) and Main Central Thrust (MCT) traverse the southern parts of the area.
- The MCT separates the Proterozoic high grade rocks of Chutang Formation (present in the north) from the lower grade schists of Gorubathan Formation and Palaeozoic Gondwana sediments.
- These rock formations are tectonically separated from the Siwalik sediments (Plio-Pleistocene age) by the MBT (Geological Map of India 1998).

5.2 Earthquake Vulnerability Assessment of Buildings and Infrastructure :

5.2.1 Case Studies

This primer will help you in preparing yourself before and during the disaster caused by earthquakes, and how to cope with such a disaster.

- An earthquake is the sudden motion, trembling or shaking of the ground due to the rapid release of energy.
- Most earthquakes are due to movement of large slabs of rock called tectonic plates. When the plates slide or move against each other, the plates may be bent orstretched.

The bending or stretching stores energy. Sooner or later, the plates break and shift. When thebreak happens, the stored energy is released in the form of waves, which we feel as earthquake.

- The waves spread out from the focus or source of an earthquake in all directions. As the waves travel away from the focus, they grow gradually weaker. So, the ground generally shakes less far away from the focus.
- Most earthquakes occur along the boundaries of the tectonic plates. If you live close to a plate boundary, you will experience more earthquakes than if you lived far from the boundary.

5.2.2 Earthquake Measurement

- Every time there is an earthquake, we always hear or read the words intensity and magnitude in the radio, on television, and in newspapers. Both terms describe the strength of an earthquake.
- Intensity is based on the effects a person experiences during an earthquake, and on the damage caused by the earthquake.
- Magnitude depends on the energy produced by an earthquake. Below is the scale used in measuring the intensity of earthquakes in the Philippines.

Intensity I. Scarcely perceptible

- People under favorable circumstances can feel it.
- Delicately balanced objects are disturbed slightly.
- Still water in containers move back and forth (oscillates) slightly.

Intensity III. Weak

- Felt by many people indoors, especially in upper floors of buildings.
- Vibration is felt like the passing of a light truck. Some people feel dizzy and nauseated.
- Hanging objects swing moderately.
- Still water in containers oscillates moderately.

Intensity IV. Moderately strong

- Felt generally by people indoors and some people outdoors.
- Light sleepers are awakened. Vibration is felt like the passing of a heavy truck.
- Hanging objects swing considerably. Dinner plates, glasses, windows and doors rattle. Floors and walls of wood-framed building creak. Parked cars may rock slightly.
- Water in containers oscillates strongly.
- Rumbling sound may sometimes be heard.

Intensity V. strong

- Generally felt by most people indoors and outdoors. Many sleeping people are awakened. Some are frightened; some run outdoors. Strong shaking and rocking are felt throughout the building.
- Hanging objects swing violently. Dining utensils clatter and clink; some are broken. Small, light and unstable objects may fall or overturn.
- Liquids spill from filled open containers. Standing vehicles rock noticeably.
- Shaking of leaves and twigs of trees is noticeable.

Intensity VI. Very strong

- Many people are frightened; many run outdoors. Some people lose their balance. Motorists feel like driving with flat tires.
- Heavy objects and furniture move or may be shifted. Small church bells may ring. Wall plaster may crack. Very old or poorly-built houses and man-made structures are slightly damaged though well built structures are not affected.

Intensity VII. Destructive

- Most people are frightened and run outdoors. People find it difficult to stand in upper floors.
- Heavy objects and furniture overturn or topple. Big church bells may ring. Old or poorly built structures suffer considerable damage. Some well-built structures are slightly damaged. Some cracks may appear on dikes, fish ponds, road surface, or concrete hollow block walls.

Intensity VIII. Very destructive

- People panic. People find it difficult to stand even outdoors.
- Many well-built buildings are considerably damaged. Concrete dikes and foundations of bridges are destroyed by ground settling or toppling. Railway tracks are bent orbroken.

Intensity IX. Devastating

- People are forcibly thrown to the ground. Many cry and shake with fear.
- Most buildings are totally damaged. Bridges and elevated concrete structures aretoppled or destroyed.
- Numerous utility posts, towers and monuments are tilted, toppled or broken. Water and sewer pipes are bent, twisted or broken.

Intensity X. Completely devastating

- Practically all man-made structures are destroyed.
- Massive landslides and liquefaction, large-scale subsidence and uplifting of land forms and many ground fissures are observed. Changes in river courses and destructive seiches in large lakes occur. Many trees are toppled, broken or uprooted.
- To determine the strength and location of earthquakes, scientists use a recording instrument known as a seismograph

5.2.3 Epicenter and earthquake measurement

- Scientists locate the epicenter by noting how long it takes for the seismic waves to arrive at different seismograph stations. From the arrival time, seismologists can calculate how far the source of the earthquake is from each station.
- A circle is drawn around each station using the calculated distance as the radius. Given three stations, the minimum number needed, there will be three circles. Theintersection of the three circles is the epicenter of the earthquake.

5.2.4 Case Study : Earthquake Vulnerability Assessment of Buildings inUttarkashi Township of Uttarakhand using RADIUS

- Uttarkashi Township is the district headquarters of Uttarkashi district, and is one of the most vulnerable towns in Uttarakhand when it comes to various natural disasters.

- The natural calamity in the form of floods and landslides were the most recent events that struck the town.
- Also, the town is seismically vulnerable too with the calamity of 1991 earthquake in the region.
- The present study tries to put things on perspective about the seismic vulnerability of buildings in the region, estimating the damage if an earthquake ofseismic intensity and magnitude of as in 1991 struck the town again.
- The study area is the municipality town administratively divided into nine wards.The Ward No. 3 of Gyansu and Ward No. 5 of Gangori making the western and eastern boundary respectively.
- There is also a good settlement on the southern bank of the river, but the municipality only covers the northern bank of the river with the area of 2.51 sq.kms. The town has crescent shape with a considerable amount of longitudinal variation.
- Thus the average length of town is manifold of the average breadth. The perimeter of the town is 15.86 km, mostly covering the lengths along the River Bhagirathi in the south and southeastern extremities, while the Varunavat Parvat marks its northern boundary.
- The town is located in the longitudinal valley of river Bhagirathi, the south and southeastern boundaries are marked by the Bhagirathi, while a small area in the north-eastern flank of town is drained by Asi Ganga, a tributary of Bhagirathi. According to 2012-13 survey of Municipal Corporation, Uttarkashi, the town has 3184 buildings in total.
- There was significant damage to many buildings in the past earthquake of 1991.
- The number of buildings has grown since then, but so is the craft in the building. Now, most of the buildings are reinforced concrete frame building with brick infill construction and are taking over the stone masonry construction that is more prevalent at the time.
- The scenario taken has the same occurrence time as the original earthquake on 2:53 am in the morning.

- The present study analyses and calculate the damages to a prospective earthquakeof same magnitude and intensity as that of Uttarkashi strikes it again.

5.3 Drought Assessment : Case Studies

- Drought is fundamentally the resultant of an extended period of reduced precipitation.
- It is viewed through its impacts such as soil moisture, streamflow, crop yields, etc.
- As such, the question of predictability of drought must extend to those quantities as well. Nevertheless, in developing an understanding of drought and its predictability, it is useful to first consider the physical mechanisms that cause precipitation deficits and how they vary by time scale.
- Availability of varied definitions of drought reflects the complexity of the natural disaster cum hydrologic extreme.
- Studies were conducted on drought assessments using different techniques (conventional such as estimation of relevant hydrologic parameters and advanced such as Remote Sensing technique, GIS software, etc.) in varied domains of dry land agriculture, rural / urban contexts, etc.

5.3.1 Drought Studies using Remote Sensing and GIS - Case Study

- National Remote Sensing Agency of India has assessed the drought based on the analysis of vegetation index map and the greenness map as well as vegetation index statistics for bimonthly periods for each taluka.
- The satellite based drought assessment and monitoring methodology was developed based on the relationship obtained between previous years
- Normalized Difference Vegetation Index (NDVI) profiles with the corresponding agricultural performance available at district level and their relative difference in the current year.
- The National Agricultural Drought Assessment and Monitoring System (NADAMS) in a view of the whole country coverage, envisages the use of data from NOAA satellites with 1.1 km resolution, for generation of weekly composited Normalized Difference Vegetation Index (NDVI) maps of country.
- The NDVI is a transformation of reflected radiation in the visible and near infrared

bands of NOAA AVHRR and is a function of green leaf and biomass.

5.4 Coastal Flooding : Storm Surge Assessment

- Floods can be caused by unusually high tides, or storm surges. Land in estuarine areas (enclosed coastal body of brackish water) can be at particular risk of flooding as high river flows, marine tides and storm surge effects can act either alone or in combination to produce high water levels.
- Storm surges are episodes of high sea level caused by strong winds, oftenincreased further by unusually low air pressure.
- Storm surges usually affect in the fall and winter seasons, when strong lowpressure systems pass by offshore.
- During a storm surge, periods of strong winds drive water towards the shoreline, significantly increasing the sea level.
- If the wind is blowing towards an estuary, the surge effect can be boosted even more, as the water is funneled into the estuary area.
- The longer strong onshore winds persist, the greater the surge effect.
- Low air pressure literally sucks the sea surface upward, and this effect can besignificant with intense low pressure systems.
- Sea levels can be raised over a metre above normal tide predictions. The impact of a storm surge may be offset if there is coastal sea ice present, although if the ice breaks up, it can add to the damaging effect of flooding and wave action.
- Storm surges can also be caused by tropical storms systems (hurricanes).

5.4.1 Fluvial Floods (River Floods)

- A fluvial, or river flood, occurs when the water level in a river, lake or stream rises and overflows onto the surrounding banks, shores and neighboring land. The water level rise could be due to excessive rain or snowmelt.
- The damage from a river flood can be widespread as the overflow affects smaller rivers downstream, which can cause dams and dikes to break and swamp nearby areas.
- To determine the probability of river flooding, models consider past precipitation, forecasted precipitation, current river levels, and well as soil and terrain conditions.

- The severity of a river flood is determined by the duration and intensity (volume) of rainfall in the catchment area of the river.
- In hilly or mountainous areas, floods can occur within minutes after a heavy rain, drain very quickly, and cause damage due to debris flow.
- To determine the probability of river flooding, models consider past precipitation, forecasted precipitation, current river levels, and well as soil and terrain conditions.

5.4.2 Pluvial Floods (Flash Floods and Surface Water)

- A pluvial flood occurs when an extreme rainfall event creates a flood independent of an overflowing water body.
- A common misconception about flood is that you must be located near a body of water to be at risk.
- Yet pluvial flooding can happen in any location, urban or rural; even in areas with no water bodies in the vicinity. There are two common types of pluvial flooding:
- Surface water floods occur when an urban drainage system is overwhelmed and water flows out into streets and nearby structures.
- It occurs gradually, which provides people time to move to safe locations, and the level of water is usually shallow (rarely more than 1 meter deep). It creates no immediate threat to lives but may cause significant economic damage.

5.4.3 Coastal flooding

- Coastal flooding is the inundation of land areas along the coast by seawater. Common causes of coastal flooding are intense windstorm events occurring at the same time as high tide (storm surge) and tsunamis.
- Storm surge is created when high winds from a windstorm force water onshore, this is the leading cause of coastal flooding and often the greatest threat associated with a windstorm.
- The effects increase depending on the tide - windstorms that occur during high tide result in devastating storm surge floods.
- The onshore and offshore topography also plays an important role. To determine the probability and magnitude of a storm surge, coastal flood models consider this

information in addition to data from historical storms that have affected the area.

5.4.4 Assessing Fluvial Flood Risk in Urban Environments : A Case Study

- Nowadays, floods are among the most impactful calamities regarding costs. Looking at the natural hazards damage data collected in the International Disaster Database (EM-DAT), it is observable a significant increase over the past four decades of both frequency of floods and associated costs.
- Similarly, dramatic trends are also found by analyzing other types of flood losses, such as the number of people affected by floods, homeless, injured or killed.
- To deal with the above-mentioned rise of flood risk, more and more efforts are being made to promote integrated flood risk management.
- According to KULTU Risk methodology, two major classes of data are considered to evaluate flood risk damage : hydraulic data as regards Hazard and economic information to assess Exposure and Vulnerability.
- This study shows the possibility to extend the lesson learned with the Eilenburg case study in other similar contexts.
- The economic impact of floods has grown significantly over the past four decades.
- In particular, looking at the natural hazards damage data provided by the International Disaster Database one can see a significant increase in terms of frequency of floods and related costs.

5.4.5 Urban Pluvial Flooding : A Qualitative Case Study of Cause, Effect and Nonstructural Mitigation

- Historically, flood risk management in the United Kingdom has mainly concentrated on river and coastal flooding, yet flooding from surface water runoff is a risk to urban areas.
- A comprehensive study of the causes, the impact and the consequences as well as the management of serious pluvial flooding in Heywood, Greater Manchester, in 2004 and 2006 revealed that the victims of the floods were unprepared, ill- informed and confused as to responsibilities before, during and after the event.
- Householders had to rely on their insurers for loss mitigation, but the response of the

insurance industry was varied and inconsistent, and there were difficulties in buildingin resilience after the event.

- In 2006, only one property was on the Office of the Water Regulator DG 5 Registeron the basis of previous flooding.
- Thus the area falls between the responsibilities of the Local Authority (LA), the environment agency and the water utility.

Kerala Floods - Case Study

- Kerala recently witnessed one of the worst floods in its history. Twelve out of14 districts were affected.
- More than 450 human lives were lost and resulted in destruction valued at more than ` 25,000 crore.

Be prepared for possible mega-disaster

- Often, disasters come without clear notice or warning, and hence we need to be prepared to launch a large response involving multiple stakeholders at different levels all the time.
- Failure to do this will only escalate the human casualties, suffering and damage to property.

Learn ways to manage water

- A large part of India is prone to hydrological disasters on account of drought, floods and cyclones.
- At various levels, need to learn to manage scarcity as well as excess water.
- Growing urbanisation and effects of climate change are forcing us to do this with greater urgency.
- Need to take a careful look at integrated dam management, proper contour and precipitation inundation maps, formulate effective land management laws and ensure their enforcement.

Disaster management instruments

- The centre and different state governments have formulated acts, plans, protocols and other instruments for effective disaster management in the country.
- The 2005 Disaster Management Act enacted by Parliament, 2016 National Disaster Management Plan from National Disaster Management Authority (NDMA), various Guidelines from NDMA, state government acts and notifications are some of them. There should be a concerted effort to put these guidelines and plans into action.)

Better forecast and effective synergy

- Weather forecasting needs to become more effective.
- To achieve this, not only the science of forecasting but also its dissemination and follow-on actions after the forecast need to be improved. Agencies such as India Meteorology Department (IMD), Central Water Commission (CWC) and Indian National Centre for Ocean Information Services (INCOIS) should have pre- notified national and state-level agency liaison protocols for appropriate information and warning.

Plan for critical infrastructure

- Significant public resources are invested to set up critical infrastructure such as airports, railway stations and others.
- They need to have appropriate disaster management plans to ensure they are well protected from disasters.
- It is sad to see some critical infrastructure facilities like airports which were critical to mounting a response were shut as they were impacted.

Ensure better coordination

- This is one area where there is always scope for improvement.
- Worldwide, different governments are dealing with this issue with great attention.
- A situation where multiple stakeholders come together suddenly needs to be coordinated well to make response effective, and this is easier said than done.
- NDMA issued an Incident Response System (IRS) guidelines in 2010, to strengthen disaster response management and planned event management (such as Kumbh Mela).
- This is pertinent in large disasters as multiple agencies such as Military, National

Disaster Response Force (NDRF), Fire Services, Police, Coast Guard and others come together for search and rescue operations. Unified Command involving these agencies will help in common planning and clear demarcation of geographies for effective rescue and response action.

Promote support to NGOs

- It is once again demonstrated that the NGOs can move in quickly and support relief efforts in a meaningful manner.
- Due to their flexibility, NGOs are able to address the specific needs of the survivors.
- NGOs need resources to undertake their efforts and the government should help NGOs and promote their efforts to enable them to raise resources.

Strengthen local capacities

- The fishing community of Kerala moved quickly and participated in rescue operations shoulder to shoulder with the national rescue agencies.
- This very well demonstrates the importance of local capacities to deal with disasters.
- There should be clearly articulated efforts to strengthen community capacities to cope with disasters.
- Suitable system and operational procedures should also be in place to extend government support to local community efforts during disasters.

5.5 Forest Fire : Case Studies

5.5.1 Forest fire

- The most common hazard in forests is forests fire.
- Forests fires are as old as the forests themselves.
- They pose a threat not only to the forest wealth but also to the entire regime to fauna and flora seriously disturbing the bio-diversity and the ecology and environment of a region.
- During summer, when there is no rain for months, the forests become littered with dry senescent leaves and twinges, which could burst into flames ignited by the slightest spark.

- The Himalayan forests, particularly, Garhwal Himalayas have been burning regularly during the last few summers, with colossal loss of vegetation cover of that region.
- Forest fire causes imbalances in nature and endangers biodiversity by reducing faunal and floral wealth.
- Traditional methods of fire prevention are not proving effective and it is now essential to raise public awareness on the matter, particularly among those people who live close to or in forested areas.

5.5.2 Causes of Forest Fire

Forest fires are caused by natural causes as well as man-made causes

- Natural causes - Many forest fires start from natural causes such as lightning which set trees on fire. However, rain extinguishes such fires without causing much damage. High atmospheric temperatures and dryness (low humidity) offer favorable circumstance for a fire to start.
- Man-made causes - Fire is caused when a source of fire like naked flame, cigarette or bidi, electric spark or any source of ignition comes into contact with inflammable material.

- **Environmental causes** are largely related to climatic conditions such as temperature, wind speed and direction, level of moisture in soil and atmosphere and duration of dry spells.
- Other natural causes are the friction of bamboos swaying due to high wind velocity and rolling stones that result in sparks setting off fires in highly inflammable leaf litteron the forest floor.
- **Human related causes** result from human activity as well as methods of forest management. These can be intentional or unintentional, for example :

5.5.3 Wildland Fire Behaviour Case Studies

- This work presents the extension of a physical model for the spreading of surface fire at landscape scale. In previous work, the model was validated at laboratory scale for fire spreading across litters.
- The model was then modified to consider the structure of actual vegetation and was

included in the wildland fire calculation system Fore fire that allows converting the two-dimensional model of fire spread to three dimensions, taking into account spatial information.

- Two wildland fire behavior case studies were elaborated and used as a basis to test the simulator.
- Both fires were reconstructed, paying attention to the vegetation mapping, fire history, and meteorological data.
- The local calibration of the simulator required the development of appropriate fuel models for shrubland vegetation (maquis) for use with the model of fire spread.
- This study showed the capabilities of the simulator during the typical drought season characterizing the Mediterranean climate when most wildfires occur.
- In this paper, two wildland fire behavior case studies were reconstructed to test the performances of a physical model of fire spread coupled with Forefire simulator.
- Fuel models were developed to consider typical shrubland vegetation for these Mediterranean areas.
- The asynchronous front tracking method used to propagate the fire front allowed simulating both case studies with a computational time significantly lower than real time (about 30 s simulation for 4 hours of spreading).
- Such simulation times opens the way for new practices in wildfire simulation, where many fighting scenarios can be tested in a short amount of time and many virtual fires can be started from a large number of possible ignition points.
- The sensitivity of the model to wind field and fuel models was studied. It was shown that custom fuel models improve the coherency of the simulation. These fuel models are characterized by a higher live to dead fuel ratio, in comparison with the standard fuel model FM4 of Anderson
- Enhancements of the simulation system are planned in order to model the cooling effect of the wind during counterflow fires and to take into account the effects of the relative humidity on the fire dynamics during the night.

5.6 Man made disasters

- These are mostly caused due to certain human activities. The disasters themselves could be unintentional, but, are caused due to some intentional activity. Most of these are due to certain accidents - which could have been prevented - if adequate precautionary measures were put in place : Nuclear leaks, chemical leaks, terrorist attack, structural destroy etc.
- Actions taken depend in part on perceptions of risk of those exposed.

5.6.1. Bhopal gas tragedy

The Bhopal disaster, also referred to as the Bhopal gas tragedy, was a gas leak incident in India, considered one of the world's worst industrial disasters.

- It occurred on the night of 2-3 December 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh, India.
- A leak of methyl isocyanate gas and other chemicals from the plant resulted in the exposure of hundreds of thousands of people.
- A government official declaration in 2006 stated the leak caused 558,125 injuries including 38,478 temporary partial and approximately 3,900 severely and permanently disabling injuries.
- There were mass funerals and mass cremations as well as disposal of bodies in the Narmada River. 170,000 people were treated at hospitals and temporary dispensaries. 2,000 buffalo, goats, and other animals were collected and buried.
- The early effects of exposure were coughing, vomiting, severe eye irritation and a feeling of suffocation.
- Owing to their height, children and other people of shorter height inhaled higher concentrations.
- The events in Bhopal revealed that growing industrialization in developing countries without concurrent evolution in safety regulations could have terrible consequences.
- Even without enforcement, international standards could provide norms for measuring performance of individual companies engaged in hazardous activities.
- Local governments clearly cannot allow industrial facilities to be placed within urban areas, regardless of the evolution of land use over time. Industry and government need to bring proper financial support to local communities so they can provide medical and

other necessary services to reduce morbidity, mortality and material loss in the case of industrial accidents.

- The Bhopal disaster could have changed the nature of the chemical industry and caused a reexamination of the necessity to produce such potentially harmful products in the first place.
- Safety procedures were minimal and neither the American owners nor the local management seemed to regard them as necessary. When the disaster struck there was no disaster plan that could be set into action.
- We need to introduce a system of laws which will make them liable for higher standards of safety.
- Prevention is better than cures. Lesson learned from this manmade disaster is to understand the nature of disaster before it occurs and implement better disaster management system in place.
- When series of accidents occurred frequently in Bhopal plan, if prevented on time properly by Union Carbide India Limited they could avoided this nightmare.
- The dead may not have been so unlucky after all. The end came horribly, but at least the nightmare was brief.

Mitigations of Such Disaster in Future

The lessons we learn from this unfortunate accident have had a significant impact on process safety and how we should be educated and trained to prevent future accidents :

- **Safety culture :** No safety measures that can prevent an accident if there is not a safety culture that governs the behaviour of management and employees. In Bhopal this basic pillar was not present or was weak.
- **Safety management :** In 1984 safety management systems were not widely established, although there were recommendations and procedures such as PSM (Process Safety Management) from DuPont or the Center for Chemical Process Safety (CCPS) from the American Institute of Chemical Engineers. There were two major accidents in 1984 (Bhopal and the explosions of PEMEX in Mexico), which created the need for an organized and systematic approach

- **Intrinsically safe design :** The application of the principles of intrinsically safe design are those that offer the best results. In Bhopal the main cause of the disaster was unnecessary storage of large quantities of MIC, which ultimately was what caused the mass poisoning.
- **Knowledge transfer based on learning from accidents**. The Bhopal accident still provides valuable lessons after 30 years. Concepts such as "zero accidents" or "total inherent safety" arose as a result of accidents in 1984 as well as what was coined by Professor Trevor Kletz, one of the fathers of modern chemical safety: "Why should we publish accident reports?".

Mitigations of Such Disaster in Future

- **Tell the truth -** After the Chernobyl disaster, the authorities failed to alert the public to the danger for three days, putting thousands of lives at risk.
- Today, there is still a need for total transparency when it comes to nuclear accidents.
- **Evacuate -** Soviet authorities were initially in denial over the extent of the crisis and failed to move people living close to the reactor to safety in the hours and days after the incident.
- If they had acted sooner, countless lives would have been saved.
- **Closely monitor radiation levels in food -** A report from the UN's scientific committee on the effects of atomic radiation found that a rise in thyroid cancer was the only substantial medical legacy of Chernobyl in the general population.
- The cancers came about because Soviet authorities allowed children to continue to drink heavily contaminated milk.
- As a result, many children received high doses of radiation to the thyroid.
- **Comply with safety rules -** International reports have blamed the poor design of the Soviet RBMK (High Power Channel-type Reactor), a lack of safety culture at the plant and errors by operators for the Chernobyl disaster.
- The accident illustrates the importance of complying with basic safety principles for nuclear power plants.

5.7 Space Based Inputs for Disaster Mitigation and Management and FieldWorks Related to Disaster Management

India is prone to many natural disasters like floods, landslides, cyclones, forest fires, earthquakes, drought, etc. Satellites provide synoptic observations of the natural disasters at regular intervals that helps in better planning and management of disasters.

Disaster Management Support (DMS) Programme, comprehensively addresses various aspects of natural disasters in the country, using space based inputs. ISRO disseminates relevant information in interactive geo-spatial domain through various geoportals like Bhuvan, National Database for Emergency Management and MOSDAC for the administrators to better understand the impact and for improved decision support.

ISRO provides the satellite based near real time information support to Central Ministries / Departments and State Ministries / Departments, prior during and after major natural disasters. In addition, ISRO also provides capacity building in use of Space technology inputs in Disaster Management Support.

A. Cyclones

Preparedness

With large coast line, India is susceptible for cyclones. It is important to understand the impacts of cyclone, with respect to its earlier footprints, low lying areas, etc, wherein satellite images provide such inputs

Early warning

ISRO uses geo-stationary and low earth orbit satellites for providing experimental inputs on cyclogenesis, cyclone track, cyclone intensity. INSAT series of satellites with frequent imaging provide the cyclone parameters for near real time analysis.

Response

Near real time information on inundation due to cyclones is derived, using optical and microwave SAR data and the information is provided to the concerned departments. During 2018, ISRO provided information on inundation to Odisha, Andhra Pradesh States during TITLI, PHETHAI, etc.

B. Floods

Preparedeness

Based on integration of historic satellite datasets acquired during major floods indifferent States, flood hazard map layers were prepared for Assam, Bihar, Odisha, Andhra Pradesh, Uttar Pradesh, West Bengal and Entire Country.

Early Warning

Using hydrological modelling of satellite and ground based hydro-meteorological inputs and digital elevation models, experimental spatial flood early warning systems are established for selected river reaches like Andhra Pradesh (Godavari), Odisha (Mahanadi) and Assam (Brahmaputra).

Response

Near real time information on flood inundation is derived on an operational basis using optical and microwave SAR data and the information is provided to the concerned departments of Kerala, Assam, Bihar, Uttar Pradesh, Odisha and Andhra Pradesh States.

C. Landslide

Preparedness

Landslides cause huge damages, particularly along pilgrim routes. ISRO prepared Landslide Hazard Zonation maps for pilgrim routes in Himachal Pradesh, Uttarakhand and Meghalaya.

Early Warning

Experimental Landslide Early Warning System for Rainfall Triggered Landslides is carried out for the following routes namely Rishikesh-Badrinath, Rishikesh-Uttarkashi-Gaumukh,Chamoli-Okhimath Rudraprayag-Kedarnath and Pithoragarh-Malpa in Uttarakhand during specific seasons.

Response

Near real time information on landslides is derived regularly during major landslide events in the country and disseminated through Bhuvan geoportal. Areal extent of landslide is also estimated using satellite data and DSMs. In addition, in case of river blockade due to landslide, necessary inputs are provided to Govt. from time to time.

Landslides Hazard Zones

Landslide hazard zonation maps were prepared for selected pilgrim routes in the country. These zones are delineated based on geological, topological and anthropogenic factors. These factors include lithology, soil, slope, drainage, lineament, land use, etc. At present these maps are available for pilgrim routes in Himachal Pradesh, Uttarakhand, Meghalaya in addition, event-based and seasonal landslide inventory is also carried out. The information on landslide inventory and hazard zones help the decision makers for better planning in these areas.

D. Forest fires

Preparedness

ISRO prepares Forest Fire Regime maps using historical forest fires observed from satellite data. These maps help in identifying critical areas where forest fires are prevalent and the average duration of forest fires. These details help the decision makers.

Early warning

Many attempts are made to use multi-criteria approach in GIS environment to provide early warning and vulnerability maps. More research in such area further continued on experimental basis.

Response

ISRO regularly prepares Forest Fire alert maps using satellite data and provides to FSI and other State Forest Departments. This near real time data dissemination throughBhuvan Geoportal and SMS alerts help forest department for taking quick action. During 2018, burnt area assessment was done for Uttarakhand, Jammu & Kashmir and Tamilnadu